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ATACONF'25 GENERAL DESCRIPTION

Held since 2012 by the name of **Ulusal Havacılık Teknolojisi ve Uygulamaları Kongresi (UHAT)** in the cooperation of National Defence University Air NCO Higher Vocational School and Aviation Higher Vocational School of Ege University will now be organized internationally by the name of **Aviation Technologies and Applications Conference (ATAConf).**

ATAConf'25 was held as a face-to-face and online event in Izmir on **November 20-21, 2025**, hosted by **Ege University Aviation Higher Vocational School**.

CONFERENCE MAIN THEME

The New Era of Aviation with AI

WELCOME MESSAGE FROM THE ATACONF CONFERENCE CHAIRMANSHIPS

Aviation Technologies and Applications Conference (ATAConf) is an international event organized at Aviation Higher Vocational School of Ege University, with the collaboration of the National Defence University Air NCO Higher Vocational School. It took place at İzmir, Türkiye, during 20-21 November 2025. The roots of the Conference dates to 2012. Since 2012 "Ulusal Havacılık Teknolojileri Kongresi - UHAT (National Congress of Aviation Technology and Applications)" has been organized five times as a national event and in 2023 it is converted to an international one. Conference encourages interaction among academics and, aviation and defence sector representatives to present and discuss new and cutting-edge studies. Their contributions help to make the conference as distinguished as it has been before.

This book brings together a selection of papers presented at the 2025 Aviation Technologies and Applications Conference (ATAConf'25) took place at İzmir, Türkiye, during 20-21 November 2025. These Proceedings will furnish the scientists of the world with studies in the field of aviation. We consider that this event acts as an incentive to trigger further study and research in all these areas. We appreciate the contributions of all authors and participants.

Our primary objective is to ensure the uninterrupted continuation of this conference, which we have enthusiastically transformed into an international event. We aim to boost international participation in the conference in the years ahead and make a greater contribution to the field of aviation and defence through an increased number of research papers. We extend our heartfelt gratitude to all those who have played a significant role in the inception and growth of this conference.

Prof. Dr. Rüstem Barış YEŞİLAY

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CONTENT

Aviation Technologies and Applications Conference 2025
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ANALYSIS OF NEW GENERATION FIGHTER AIRCRAFT MODELS WITH ARTIFICIAL INTELLIGENCE AND MULTI-CRITERIA SELECTION METHODS

Elif CICEK[1]

Abstract

The aim of this study is to develop a comprehensive and systematic evaluation framework for next-generation fighter aircraft by integrating multiple Multi-Criteria Decision-Making (MCDM) techniques. Modern combat aircraft must simultaneously satisfy diverse operational, technical, and economic performance requirements; therefore, single-criterion assessments are insufficient for reliable platform selection. To address this problem, the study evaluates five modern fighter aircraft alternatives using an integrated approach that combines the Analytic Hierarchy Process (AHP), the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and the VIKOR method. The main objective is to reveal how absolute performance, compromise efficiency, and expert-driven weighting interact under different strategic scenarios.

The research problem centers on the difficulty of selecting an optimal air platform when decision criteria conflict—such as stealth versus range, performance versus cost, and payload versus aerodynamic requirements. The hypothesis proposes that a hybrid MCDM framework incorporating multiple weighting and ranking methods will produce more stable, transparent, and internally consistent selection outcomes compared with any single method. Additionally, it is hypothesized that scenario-based weighting—such as excluding cost, emphasizing stealth, or increasing cost sensitivity—will meaningfully alter platform rankings, thereby revealing hidden trade-offs.

To test these hypotheses, the study conducts multi-scenario analyses using two datasets: a simplified four-criteria model and an extended eleven-criteria model involving speed, stealth, maneuverability, sensor fusion, payload, weapons effectiveness, operational range, and cost. All data are normalized to ensure comparability across metrics. AHP is used to generate criterion weights, TOPSIS provides ideal-solution proximity rankings, and VIKOR quantifies compromise efficiency under conflicting objectives. Four strategic scenarios—Baseline, NoCost, HighCost, and StealthFocus—are used to examine how varying priorities influence results. Correlation analysis is also conducted to reveal interdependencies among criteria, such as the inverse relationships between stealth and both range and cost.

The results show that no single aircraft dominates all methods or all scenarios. In general, one alternative demonstrates the strongest absolute performance across multiple criteria, while another excels in compromise-based rankings where trade-off efficiency is prioritized. Cost-sensitive scenarios substantially shift rankings, highlighting the importance of economic constraints in aviation procurement. When cost is excluded, purely technical performance becomes dominant, whereas stealth-focused scenarios elevate low-observability platforms. Across all cases, high correlations between the methods confirm strong internal reliability of the integrated MCDM framework.

The study is expected to contribute to the field by presenting a transparent, replicable, and scenario-sensitive evaluation model that can support defense decision-makers in selecting advanced air platforms. The framework's adaptability allows users to test different strategic priorities without modifying the underlying methodology. The results indicate that balanced aircraft designs with strong multi-criteria performance and resilient compromise behavior offer the most advantageous choices for future force structures. The proposed methodology can be extended to other defense systems or adapted to higher-resolution datasets for more granular analysis in future work.

Keywords: Fighter Aircraft Models, Artificial Intelligence, Multi-Criteria Selection Methods.

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HUMAN-MACHINE INTERACTION IN AUTOMATION OF AVIONIC SYSTEMS: AN ACCIDENT ANALYSIS

Tayfun AYDOĞDU[2]

Abstract

With the advancement of aviation technologies, avionics systems are becoming central to flight operations. Advanced automation, digital interfaces, and information management systems are changing the flight crew's task dynamics. Increasing levels of automation have significant impacts on flight safety, efficiency, and human factors. Modern avionics systems reduce flight crew workload and accelerate decision-making processes. Furthermore, they present new challenges in cognitive load, situational awareness, and human-machine interaction. In this context, the need for human-centric approaches in the automation of aviation avionics systems is increasing.

This study aims to examine the weaknesses of human-machine interaction and their implications for safety culture through the analysis of a selected aircraft accident. The research aims to identify the impact of automation on human factors and contribute to training, design, and procedural improvements.

Despite the advantages provided by automation, problems such as cognitive load, distraction and delegation of authority experienced by the flight crew cause accidents. The hypothesis of the research is that inadequate human-machine interaction in the automation of avionics systems has an impact on accidents.

Based on the results of the accident analysis, solution suggestions are offered for providing training to increase advanced automation awareness for flight crews, designing cockpit interface bases that include ergonomic facilities, increasing the cognitive level in managing automation errors, and ensuring the continuity of manual flight ability.

Keywords: Avionic Systems, Aviation, Automation, Safety Culture, Human-Machine Interaction

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CURRENT STATUS, TECHNOLOGICAL TRENDS AND FUTURE PROSPECTS OF UNMANNED AERIAL VEHICLES (UAVS)

Ebru BILICI[3], Orhan Erdal AKAY[4]

Abstract

Türkiye's unmanned aerial vehicle (UAV) sector is recognized worldwide for its success, particularly in the military field. However, despite this robust infrastructure, there are significant challenges facing both civilian and commercial UAVs. At the beginning of this process, differences in critical software, such as autopilot and operating systems, arise due to the agreements between UAVs. This hinders technological independence and limits the sector's potential.

The aim of this study is to provide strategic solutions that will increase the potential of the civil UAV market in light of global trends by carrying Türkiye's success in the military UAV sector to the civil and commercial fields.

The civilian UAV sector is dependent on external sources for core software such as autopilot and operating systems, making it difficult for technological advancements to proceed at their own pace.

This study emphasizes the need to prioritize the development of domestic and national autonomous systems. This process, supported by a flexible structure and qualified human resources, will accelerate the sector's development.

With these strategies, Türkiye will gain a stronger position in the civilian UAV market and contribute to economic growth.

Keywords: Unmanned Aerial Vehicles (UAVs), Civilian and Commercial UAV Market, Technological Independence, R&D Investments, Sustainable Growth

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HYBRID ELECTRIC AIRCRAFT: CUTTING EDGE TECHNOLOGY AND KEY ELECTRICAL SYSTEM CHALLENGES

Ebru BILICI[5], Orhan Erdal AKAY[6]

Abstract

Hybrid-electric aircraft technology plays a vital role in achieving aviation's 2050 emissions targets. This goal requires extensive R&D investments in areas such as high-power electronics, battery systems, and next-generation electric motors. In addition to reducing emissions, this technology also offers significant advantages such as efficiency, design flexibility, and noise reduction. While NASA projects like the X-57 and Clean Sky 2 are spearheading this transformation, Turkey aims to increase its domestic capabilities through institutions like TAI and TÜBİTAK.

This study aims to examine the transformation of hybrid electric aircraft technology in aviation and to reveal the innovative solutions and technological requirements needed to achieve 25-year environmental goals.

The biggest obstacle to aviation reaching its 2050 goals is the lack of development of lightweight and powerful electrical components. This problem can be overcome through R&D investments and international collaborations.

The solution is to achieve high-performance targets in motor, power electronics, and battery systems. The study explores solutions to these challenges by examining international projects and Türkiye's domestic development efforts.

With the widespread use of this technology, carbon emissions and noise pollution will decrease, which will provide Türkiye with a competitive advantage in the international market and make significant contributions to the sector.

Keywords: Hybrid Electric Aircraft, Environmental Sustainability, International Projects

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DESIGN AND DEVELOPMENT OF A DUCTED-FAN UAV FOR AGRICULTURAL PURPOSES

Ferudun Efe KETME[7], Kıymet YILDIR[1], Alperen MISIRLI[1], Görkem Efe AKKAYA[1], Yusuf TEZCAN[1]

Abstract

As in many military and civilian areas, the use of unmanned aerial vehicles (UAVs) is increasing in agricultural applications. The configuration of the UAV to be used in these applications is selected by taking into consideration features such as efficiency, payload capacity, and maneuverability. This study aims to design and develop a ducted-fan UAV for agricultural applications such as plant health monitoring. Common UAV designs like the quadcopter used in agriculture often suffer from low efficiency and a high risk of damage in dense environments such as crop fields because of their open propellers. Compared to multi-rotor UAVs, ducted-fan design can protect the UAV from dense environments and increase the efficiency of the propeller. Ducted fan UAVs generally consist of a single propeller placed inside a duct and fins placed under the propeller that allow the aircraft to move in different directions by changing pitch and roll moments with respect to the center of gravity of the UAV. In the study, a special propeller is designed to meet the requirements set for the UAV design. The designed propeller for the ducted-fan UAV makes the design unique and reduces the cost of the UAV. To validate the proposed propeller design, aerodynamic analysis is done in ANSYS Fluent, and the results are presented. A controller for the ducted fan UAV is designed, which makes the UAV more adaptive, and it is tested on a model of the UAV created in Matlab Simulink used by Simscape Toolbox. As a result of tests carried out in a simulation environment, it is observed that the designed UAV is capable of being used in agricultural applications.

Keywords: UAV, Ducted-Fan, Propeller, ANSYS, Simscape

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RISK-BASED, MULTI-AGENT FIRE SUPPRESSION: INTERNATIONAL LESSONS AND A REFERENCE ARCHITECTURE FOR TURKEY

Burak GÜLER[8], Busenur POLAT[9], Muhammed Mahmut YILDIZ[10]

Abstract

This paper characterizes principal fire types classes A–F (including wildland and wildland–urban interface/WUI, industrial electrical and metal fires) and maps suppression fundamentals (cooling, smothering, fuel separation, and chain-reaction interruption) to appropriate agents and tactics, such as water and water-enhancers, Class-A/B foams (AFFF-free alternatives), dry chemical powders, clean agents, long-term retardants, and specialized approaches for Class D and F incidents. Building on this foundation, we examine coordinated ground and aerial firefighting: initial attack and extended attack with helitack teams, rotary- and fixed-wing airtankers/scoopers, line construction and holding, backburn/indirect tactics, logistics under complex terrain, and safe night operations. We further discuss AI integration across the detection-to-containment chain, including multi-sensor fusion (satellite, thermal, optical, acoustic, lightning networks), deep-learning models for smoke/flame recognition, rapid perimeters and fuel-moisture mapping, digital twins for tactic selection, and UAV-enabled reconnaissance, ignition, and micro-retardant delivery with resource allocation optimized against spread forecasts (ROS) and time-to-initial-attack (TTI). A set of recent international events (e.g., large wildfires in Australia, California, and the Mediterranean) is used to illustrate systemic stressors and impacts loss of life and property, critical-infrastructure disruption, ecosystem and air-quality degradation while highlighting recurrent failure modes: delayed detection under adverse weather/topography coupling, fragmented command and control, and WUI exposure growth. Against this backdrop, the paper reviews Turkey's current capabilities—fixed and mobile lookout/thermal systems, UAV use, mixed rotary/fixed-wing fleets, and expanding community engagement—and identifies improvement levers in sustained night operations, interoperable data links, ICS-like multi-agency command, and WUI risk governance. We propose a reference architecture centered on (i) AI-assisted early warning with fused sensing and real-time fuel-moisture products; (ii) joint ground–air tasking via digital twins and common operating picture; (iii) pre-positioned modular teams and UAV swarms for rapid, safe initial attack; (iv) dynamic logistics (water/fuel resupply, personnel tracking, protected egress); and (v) prevention and resilience (WUI building codes, fuel management, domestic research and development on fluorine-free foams/retardants, and national training). This architecture will support the alignment of policy and engineering in Turkey and accelerate mutual learning with countries that share similar climates and topographies.

Keywords: Wildland–Urban Interface (WUI); AI-Enabled Detection & Digital Twins; Joint Ground–Air Firefighting Operations

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TURBINE BLADE COOLING STUDY FOR A TURBOFAN ENGINE

Mehmet Esat BIRCAN[1], Ayse IPAR YUKSEL[2], Melek Nur ALTINDAL[3], Ulas GULBAHARLI[4], Cem Tahsin YÜCER[5]

Abstract

This study investigates cooling techniques for high-pressure turbine blades in CFM56 turbofan engines, specifically examining three cooling strategies: internal convective cooling, external film cooling, and a combination of both methods. Using advanced computational fluid dynamics (CFD) simulations, the research compared blades without cooling, blades with internal cooling channels, and blades with both internal and external cooling features. The findings demonstrate that the combined cooling approach performs most effectively, reducing blade surface temperature to approximately 790 K, while internal cooling alone achieved 1190 K and uncooled blades reached 1695 K. The study determined precise cooling air requirements, measuring necessary flow rates of 0.1 kg/s for internal cooling and 0.42 kg/s for external film cooling. Additionally, the research examined heat transfer improvement methods using optimized rib structures within cooling channels, showing that carefully designed rib patterns can enhance heat transfer efficiency by up to 47%. These results highlight the crucial balance between effective cooling and minimal air usage, providing practical guidance for enhancing turbine blade designs. This work contributes to aircraft engine technology by demonstrating how combined cooling methods can significantly improve thermal management while maintaining engine performance under extreme operating conditions. The findings offer valuable insights for developing more efficient and reliable cooling systems in modern gas turbine engines.

Keywords: Turbine Blade Cooling, Film Cooling, Convective Cooling, Thermal Analysis, Turbofan Engine.

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MANUFACTURING AND PERFORMANCE ANALYSIS OF THERMOPLASTIC COMPOSITES FOR WIND TURBINE APPLICATIONS

Güney Cem GÜLBAĞ[1], Mehmet Arda ÖZDEN[2], Sercan ACARER[3], Mehmet Özgür SEYDIBEYOĞLU[4]

Abstract

The increasing demand for lightweight and recyclable materials in energy and aerospace applications has drawn attention to thermoplastic composites with enhanced mechanical properties. This study focuses on the manufacturing and performance analysis of four different 3D-printed materials: neat PETG, neat ABS, carbon fiber reinforced ABS (ABS+CF), and glass fiber reinforced ABS (ABS+GF). Standardized tensile and Charpy impact test specimens were produced using fused filament fabrication and evaluated at Egepen Deceuninck's testing facility. Mechanical properties, including tensile strength, elastic modulus, and impact resistance, were compared across the material groups. The experimental results showed that fiber-reinforced ABS composites demonstrated superior strength and toughness compared to neat polymers, with ABS+CF exhibiting the highest strength-to-weight ratio. These findings suggest that fiber-reinforced thermoplastics hold strong potential for sustainable applications in wind turbine blades, where both lightweight and mechanical performance are critical. The outcomes of this study also provide insights for broader adoption of additive manufacturing in aviation and defense technologies. Additionally, wind tunnel tests for evaluating the performance of the manufactured composites will be presented.

Keywords: 3D printing; fiber-reinforced ABS; tensile strength; impact resistance; wind turbine composites;wind tunnel tests

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AIRLINE-DESTINATION INTEGRATION IN TÜRKIYE AMIDST DIGITAL TRANSFORMATION: A MODEL PROPOSAL FOR A PERSONALIZED DYNAMIC TRAVEL PACKAGE

Gülbeniz AKDUMAN[1], Merve ÖKSÜZ TANER[2], Mustafa Egemen TANER[3]

Abstract

Turkey, with its geographical location and rich cultural and natural heritage, is a significant player in the global tourism and aviation market. However, increasing global competition, the changing tourist profile (experience-oriented, personalized service-seeking, digitally native tourists), and rising operational costs are forcing industry stakeholders to develop innovative business models. In the current travel industry, air transportation and destination services (accommodation, transfers, tours, activities) are often sold in fragmented, separate structures. Tourists navigate between different websites and platforms when planning their trips, encountering inconsistent prices and information, which increases planning burdens and uncertainty. Airlines struggle to fill available seats, even at the last minute, while hotels and tour operators experience similar imbalances in capacity planning. This fragmented structure is the fundamental problem leading to operational inefficiency, low revenue optimization, and ultimately, tourist dissatisfaction. This paper aims to propose a model for developing instantly personalized and dynamically priced travel packages that integrate airline and destination services using digital transformation tools (Artificial Intelligence, Big Data, Application Programming Interface-API Integrations) and to discuss the model's applicability, benefits, and potential challenges. Sub-objectives include assessing the impact of personalized dynamic packages on tourist satisfaction and loyalty, simulating revenue management and capacity utilization efficiency, identifying technological, managerial, and regulatory barriers, and developing policy recommendations to address these findings. The proposed model is centered on an integrated structure with a digital platform. The model is based on four fundamental theoretical areas: revenue management, personalization and big data, supply chain integration, and the experience economy. The model's operational process encompasses data integration, a personalization engine, dynamic packaging and pricing, as well as seamless payment and customer experience stages. The platform is planned to integrate real-time inventory and price data from airlines, hotels, and tour operators via APIs. An AI-powered algorithm analyzes user data to generate personalized package recommendations and offer dynamic pricing. The aim is to provide a seamless tourist experience through a single payment point and automated booking communication. Expected findings predict increased satisfaction and loyalty through the convenience, personalization, and reduced uncertainty in the tourist experience. Furthermore, operational efficiency is predicted to lead to revenue optimization, stable capacity utilization, and a competitive advantage. Anticipated challenges include technology infrastructure costs, data security concerns, a lack of sectoral collaboration, and regulatory requirements. Pilot projects, government incentives, transparent data policies, a neutral platform structure, and revisions to the regulatory framework are recommended as solutions to these challenges. Consequently, this model plays a critical role in Turkey's achievement of sustainable tourism and digital transformation goals. Policymakers and industry leaders are encouraged to initiate pilot projects, invest in digital infrastructure, develop data-sharing protocols, and train human resources. The study is limited to a theoretical model, and the next phase plans to test the model through quantitative and qualitative research empirically.

Keywords: Digital Transformation, Airline-Destination Integration, Personalized Dynamic Travel Package.

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TRANSFORMING THE BAYRAKTAR TB2 UAV INTO AN UNMANNED AERIAL FIREFIGHTING PLATFORM FOR ADVANCED WILDFIRE SUPPRESSION

Burak GÜLER[1], Habip BATTAL[2], Faruk TOY[3]

Wildfires are among the most devastating natural hazards of the twenty-first century, intensified by climate change, prolonged droughts, and expanding human activity in forested areas. Conventional aerial firefighting methods—primarily involving manned helicopters and fixed-wing aircraft—face major limitations such as high operational costs, safety risks to pilots, and reduced efficiency in low-visibility or nighttime conditions. Unmanned aerial vehicles (UAVs), in contrast, have emerged as transformative assets capable of addressing these challenges with precision, endurance, and autonomy. This study explores the technical and operational feasibility of adapting the Bayraktar TB2 tactical UAV—a proven medium-altitude long-endurance (MALE) system with over 27 hours of flight endurance, a service ceiling of 27,000 ft, and a payload capacity of approximately 150 kg—into an aerial firefighting and wildfire suppression platform. The research emphasizes modular payload configurations for diverse firefighting applications, including water-based extinguishing bombs, biodegradable retardant capsules, and AI-guided precision release systems. The proposed integration leverages the TB2's advanced electro-optical/infrared sensor suite for real-time hotspot detection, target marking, and automated fire line engagement. Feasibility analyses address aerodynamic stability, payload release mechanics, and safety protocols, while operational evaluations focus on the system's potential to reduce response times, enable all-weather and nighttime operations, and eliminate risks to human personnel. Comparative assessment with other UAV-based firefighting systems highlights the TB2's unique capability to perform large-area, sustained, and autonomous suppression missions. Furthermore, the study outlines an AI-supported mission architecture that enhances spatial accuracy and resource efficiency through intelligent image recognition and autonomous decision-making.

By repurposing a combat-proven UAV platform into a national aerial firefighting asset, this research introduces a scalable, sustainable, and cost-effective paradigm in wildfire management. The results underscore the potential of integrating unmanned systems into disaster response infrastructures, paving the way for future international deployment models aimed at combating the escalating global wildfire crisis.

Keywords: Unmanned Aerial Vehicle, Wildfire Suppression, Fire-Extinguishing Systems, Autonomous Aerial Operations

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BUCKLING PERFORMANCE OF COMPOSITE BEAMS FOR VARIOUS BOUNDARY CONDITIONS

Aysun SOYSAL[1]

Abstract

This study investigates the free vibration and stability behavior of a materially coupled composite beam subjected to axial loading, modeled within the framework of Timoshenko beam theory. The governing partial differential equations are derived by incorporating the effects of material coupling through a coupling stiffness parameter and axial load, considering three distinct boundary conditions: clamped-free (C-F), clamped-clamped (C-C), and simply supported-simply supported (S-S). The resulting system of coupled equations is solved using the Differential Transformation Method (DTM), which provides semi-analytical solutions for the natural frequencies and mode shapes. Then, parametric studies are performed to assess the influence of the coupling parameter and axial load on the vibrational characteristics under each boundary condition. The results reveal a strong dependence of both dynamic response and structural stability on the interplay between boundary constraints, axial loading, and material coupling. These findings are particularly relevant for the structural design of aircraft components, where complex boundary interactions and coupling effects must be carefully considered to ensure optimal performance and safety.

The primary objective of this study is to investigate the effects of the coupling parameter and boundary conditions on the free vibration analysis of a materially coupled composite beam subjected to axial loading within the framework of Timoshenko beam theory. Specifically, the research aims to evaluate the effects of material coupling and axial load under three distinct boundary conditions-clamped-free (C-F), clamped-clamped (C-C), and simply supported-simply supported (S-S).

Composite beams with material coupling exhibit complex vibrational and stability characteristics when subjected to axial loading, particularly under different boundary conditions. Conventional analyses often neglect the combined influence of coupling stiffness and axial forces, which may lead to inaccurate predictions in engineering applications such as aircraft structures. It is hypothesized that the vibrational response of materially coupled composite beams are highly sensitive to both axial loading and the coupling parameter, and that these effects are strongly modulated by the choice of boundary conditions. To address the problem, a mathematically rigorous model based on Timoshenko beam theory is developed, incorporating a coupling stiffness parameter to represent material coupling effects and an axial load term for stability analysis. Then, the model is solved for three different boundary conditions (named by clamped-free, clamped-clamped, an simply supported-simply supported) by using differential transformation method (DTM) in the case of existence and absence of the material coupling parameter.

The findings of the study showed that the vibrational respose of the beam system is highly sensitive to both boundary conditions and axial load P applied. Moreover, the direction of the axial load and the coupling parameter play a significant role in the vibrational behavior. More specifically, it is observed from the results that, regardless of the boundary, when the case without axial load (i.e., $P = 0$) is taken as reference, the application of a tensile axial load ($P < 0$) leads to an increase in the natural frequencies, whereas a compressive axial load ($P > 0$) results in a decrease in the frequencies. Furthermore, irrespective of the axial loading condition (i.e., whether absent, tensile, or compressive), the natural frequencies are consistently higher when the material is uncoupled ($K = 0$) compared to the coupled case ($K \neq 0$). In addition, as the boundary constraint becomes stiffer (C-F<S-S<C-C), the natural frequencies increase and the influence of the coupling diminishes due to the already elevated global stiffness of the system. This work contributes to the advancement of vibration analysis in composite structures by providing a reliable semi-analytical framework. Its novelty lies in the systematic consideration of coupling and axial load effects within Timoshenko theory using DTM. The results can enhance predictive accuracy in structural analysis and inform safer, more efficient designs in aerospace and related industries.

Keywords: Materially coupled composite beam, Buckling behavior, Structural stability, Differential transformation method

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VIBRATION AND RESONANCE ANALYSIS OF COUPLED EULER–BERNOULLI COMPOSITE BEAMS

Aysun SOYSAL[1]

Abstract

Resonance phenomena in composite beams pose critical challenges in structural design, as even small variations in material or geometric properties can significantly affect their dynamic response. This study focuses on the Euler–Bernoulli composite beam model (EBM), incorporating both material coupling (K), representing bending–torsion interaction due to anisotropy, and geometric coupling (x_α), describing the offset between elastic and mass axes. The combined effects of these coupling parameters are systematically analyzed with respect to vibration frequencies, mode veering, resonance, deflection behavior, and energy distribution. Parametric studies are performed to identify critical values of K and x_α that govern resonance conditions and mode veering phenomena. The findings demonstrate that increasing either coupling parameter reduces fundamental natural frequencies, enhances flexibility, and induces energy redistribution among modes, highlighting the importance of accurately accounting for coupling effects in the dynamic design of composite structures.

The purpose of this research is to investigate the free vibration and resonance behavior of Euler–Bernoulli composite beams incorporating both material (K) and geometric (x_α) coupling parameters. The objective is to determine how variations in these parameters influence natural frequencies, mode veering, deflection, and energy distribution.

Although material and geometric coupling effects are individually known to influence the dynamic behavior of composite beams, their combined influence on resonance and mode veering within the Euler–Bernoulli framework remains insufficiently studied. It is hypothesized that small variations in K and x_α lead to significant shifts in natural frequencies, induce mode veering, and cause redistribution of modal energies, thereby strongly influencing resonance characteristics.

A mathematically rigorous Euler–Bernoulli beam model (EBM) is developed to simultaneously include material and geometric coupling effects with clamped-free boundary condition. In this context, firstly the beam model is derived and then solved by using the Differential Transformation Method (DTM). DTM is a semi-analytical-semi-numerical differential equation solution technique, which reduces the differential equation and boundary conditions into a set of algebraic equations. Subsequently, the effects of the parameters K and x_α in the beam model are evaluated in terms of natural frequencies, mode shapes, mode veering, and resonance behavior.

The research provides the first systematic analysis of coupled material–geometric effects in Euler–Bernoulli composite beams, offering valuable insights for the structural design of aerospace and engineering components where resonance sensitivity and stability are critical. The investigation focused on the effects of geometric coupling (denoted by x_α) and material coupling (represented by K) on the vibration (natural) frequencies and mode shapes of the structures. The results of the investigation showed that the model parameters K and x_α seriously affect the system flexibility, resonance and energy balance. More specifically, it was observed that as K is increased while x_α is constant, natural frequencies decrease, indicating that the system becomes more flexible; however, when the critical value of K is exceeded, the system loses its natural characteristic behavior and exhibits unusual oscillatory behavior (i.e., resonance).

Keywords: Resonance analysis, mode veering, energy redistribution, vibration analysis, influence of coupling parameters

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THERMAL STRESS ANALYSIS OF WING STRUCTURES UNDER AERODYNAMIC HEATING

Mustafa Tolga YAVUZ[1], Sercan ACARER[2], Ahmet YILDIRIM[3], Çağlar UYULAN[4], İbrahim OZKOL[5]

Abstract

In the field of aerospace engineering, the effects of high-temperature gradients on aircraft structures have long been a subject of substantial investigation from the early days of aviation to today's cutting-edge technological marvels. With this aim, ensuring the structural integrity of aircraft wing structures has paramount importance in high-speed or high-altitude flights, which causes significant thermal loads because of thermal gradients and different material usage. In this study, the reasons for the increase in these types of loads are investigated, and a few of the structural precautions alleviating thermal stresses are presented in the context of supersonic flight. To compute the generated heat due to aerodynamic heating at the concerned altitude, speed, and day conditions, computational fluid dynamics simulations are conducted by employing the Spalart-Allmaras turbulence model at the beginning of the thermostructural analyses. When compared to other turbulence models, such as k-ε or k-ω, this model is preferred due to presenting a computationally efficient approach for complex geometries, such as wings, and accurately predicting turbulent boundary layer behavior in wall-bound flows, which is critical for calculating heat fluxes induced by aerodynamic heating and operating environment. Then, parametric structural analyses are performed to understand how the stress distribution varies for different spar and rib geometries and material combinations with the help of the finite element analysis packages, and to find the structural solutions that alleviate the punishing effect of thermal loads. The results show the flexibility of structures being successful at alleviating thermal stress, an alternative to active cooling and external insulation precautions, while providing a high lift-to-weight ratio and enhancing the structural performance of aircraft. Therefore, innovative flexible wing configurations based on the usage of corrugated or curvilinear spars and ribs will enable the production of lightweight and thermally resilient structures with the advancement of manufacturing techniques in the near future of the aviation industry.

Keywords: Aerodynamic Heating, Curvilinear Sparibs, Corrugated Spars, Thermal Stresses, Spalart-Allmaras Model, Wing Structures.

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MOTOR SPEED CONTROL AND ANALYSIS USING METAHEURISTIC ALGORITHMS AND CLASSICAL METHODS IN A MOTOR DRIVER DESIGNED FOR UNMANNED AERIAL VEHICLES

Abdulkadir YILMAZ[1], Murat DEMİR[2]

Abstract

With advancing technology, unmanned aerial vehicles have become more widely used in both the military and civilian sectors. Brushless DC motors are used in these vehicles, and PID controllers are used for for speed control, stabilisation, and other functions. Most industrial controllers are of the PID type, and system performance is affected by the parameters of the PID controller. To date, many researchers have attempted to develop PID controller design methods. In these models, the system is simplified, the controller parameters are determined analytically, and the targeted closed-loop performance is achieved

Classical methods of tuning PID controllers can result in problems such as oscillating output, long rise time and long settling time. In this study, a motor driver circuit was designed using MATLAB/Simulink, and a PID controller was used to ensure safety during speed changes and for precise speed control of the brushless DC motors used. For optimising the controller parameters, the Ziegler-Nichols methodwas used from classical methods; and modern (metaheuristic) methods such as Teaching-Learning-Based Optimization (TLBO), Ant Colony Optimization (ACO), and Genetic Algorithm (GA) were investigated in the driver circuit we designed.

In the study; rise time, settling time, maximum overshoot, and RMSE values were examined to evaluate the performance of the controller parameters. A convergence analysis of the metaheuristic algorithms was performed based on iterations, and the TLBO algorithm demonstrated faster convergence performance. The modern (metaheuristic) algorithms used showed more efficient performance compared to classical methods; for example, the PID controller optimized with Ant Colony Optimization reduced the RMSE value by 11.89% compared to the Ziegler-Nichols method. In terms of settling time, it was measured as 0.0245 seconds in the ACO algorithm and 0.0889 seconds in the Ziegler-Nichols method. The initial oscillation was lower in the ACO algorithm compared to Ziegler-Nichols, providing an improvement of 0.0644 seconds. In the study, suitable controller parameters were determined to contribute to safe flight by increasing flight stability through improvements in speed regulation in unmanned aerial vehicles, and the advantages of alternative optimization methods over classical control methods were discussed by comparing them.

Keywords: Unmanned aerial vehicle, Motor speed optimisation, PID controller

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DESIGN OF A DUAL-BAND L1/L5 PATCH ANTENNA FOR AVIATION AND GNSS APPLICATIONS

Cem GÜLER[1], Seçil ULUFER KANSOY[2]

Abstract

The continuous advancement of aerospace and aviation technologies has intensified the demand for compact, efficient, and reliable antenna systems that can be employed across a wide range of platforms, including conventional passenger aircraft, unmanned aerial vehicles (UAVs), satellite communication infrastructures, and missile systems. Considering these requirements, patch antennas have gained significant attention owing to their lightweight structure, low profile, ease of integration, and compatibility with printed circuit technologies [1]. Their relatively simple fabrication processes and economic advantages have made them a preferred choice in mobile communication, radar systems, satellite networks, avionics, and defense applications [2]. For antennas designed for Global Navigation Satellite System (GNSS) applications, critical performance parameters such as multi-band operation, low return loss, and appropriate gain levels directly influence system accuracy and sensitivity [3]. In this study, a coaxially fed patch antenna operating at the L1 (1.575 GHz) and L5 (1.176 GHz) frequency bands is developed for GNSS-based applications. The antenna attains dual-band functionality through the incorporation of a crescent-shaped slot on a circular patch geometry, ensuring optimal performance within the targeted frequency ranges. A bandwidth of 23 MHz is achieved in the L5 band (1.16–1.183 GHz), while a bandwidth of 30 MHz is observed in the L1 band (1.55–1.58 GHz). To ensure low cost and industrial applicability, the antenna is fabricated on an FR-4 dielectric substrate with dimensions of 83×83×1.6mm³. During the design process, the electromagnetic performance parameters are analyzed and optimized using CST Microwave Studio. Simulation results demonstrate a return loss of –47.6 dB with a directivity gain of 5.49 dBi at the L5 band center frequency (1.176 GHz), and a return loss of –23.7 dB with a directivity gain of 6.36 dBi at the L1 band center frequency (1.575 GHz). These findings confirm that the proposed design ensures high accuracy and reliability for GNSS-based positioning and communication applications. In conclusion, the proposed dual-band patch antenna represents an effective candidate for integration into precision navigation systems, UAV communication modules, satellite-based data transmission, and other avionics platforms.

Keywords: Patch Antenna, GNSS, L1/L5 Bands, Dual-Band.

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THERMAL PERFORMANCE OF PEROVSKITE NANOFILM COATINGS ON NICKEL ALLOYS

Atahan ORHON[1], Eren KOSA[2], Cem Tahsin YÜCER[3], Özge SAĞLAM[4]

Abstract

The emergence of fifth-generation fighter aircraft in the 2010s has led to an unprecedented leap in air combat capabilities, creating a major technological gap for nations lacking access to such platforms. One of the critical requirements in bridging this gap is enhancing the performance and durability of existing jet engines, with a particular focus on thrust efficiency, flight duration, and thermal stability. In this study, the nanomaterials derived from layered perovskites were fabricated and applied as a thermal coating for Ni-based alloys representative of high-temperature aerospace components. Owing to their dielectric properties and exceptional heat absorption capacity, the nanomaterials were hypothesized to improve both heat transfer regulation and the overall lifespan of components.

The coating material was studied using controlled deposition techniques to evaluate the coating methodology on structural quality and functional performance. The nanomaterials and nanofilm coating were characterized using scanning electron microscopy (SEM) to analyze surface morphology, Fourier-transform infrared spectroscopy (FTIR) for chemical bonding analysis, and X-ray diffraction (XRD) for crystalline structure verification. To investigate thermal behavior, flow–heat experiments were conducted using a representative mini gas turbine engine under controlled hot-air flow conditions, simulating realistic turbine operating environments. Complementary to experimental analysis, numerical and analytical calculations of heat transfer and thermal conductivity were also performed to validate experimental findings.

The results revealed that the coating formed of perovskite nanomaterials substantially improved thermal management in Ni-based turbine alloys. Specifically, IR thermometry indicated a noticeable reduction in surface temperature in coated samples subjected to elevated temperature treatment, while samples prepared under alternative conditions also exhibited a moderate decrease. In addition, the coatings enhanced overall heat absorption capacity, reduced localized thermal stress, and promoted more uniform heat dissipation across the coated surfaces. This, in turn, contributes to extended service life of critical engine parts, lower maintenance frequency, and reduced spare part costs, ultimately allowing more efficient use of existing aerospace platforms. Furthermore, the comparative evaluation of deposition techniques suggested that certain controlled approaches tended to provide improved coating uniformity and interfacial adhesion.

Overall, this work demonstrates that the integration of nanocoatings into conventional nickel alloys represents a cost-effective and technologically feasible strategy to improve the thermal and mechanical performance of legacy aircraft engines. By mitigating overheating and extending component durability, the proposed approach may serve as a transitional solution for operators seeking to enhance performance without immediate access to next-generation propulsion technologies.

Keywords: perovskite nanomaterials, nanofilm coatings, thermal management, Ni-based alloys, functional coatings

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THE EVOLUTION OF PILOT WATCHES FROM MECHANICAL TO ARTIFICIAL INTELLIGENCE: THEIR EMERGING ROLE IN FLIGHT SAFETY

Mete CANTEKİN[1]

Abstract

Smart pilot watches represent a significant evolution in aviation safety technology, transforming from simple mechanical timepieces to AI-powered assistant pilot systems. These devices now monitor pilots' physiological conditions in real-time, predict potential hazards, and enhance situational awareness through advanced biometric sensors and artificial intelligence.

Modern pilot watches offer comprehensive safety features including UTC synchronization, hypoxia warnings, taxiway alerts, weather forecasting, fuel tracking, sterile cockpit mode, and post-flight analysis. They function as intelligent assistants that monitor both the external flight environment and the pilot's internal physiological state.

This study developed two AI-supported applications for smart pilot watches. The hypoxia prediction system continuously collects biometric and environmental data through SpO2, heart rate, altimeter, and GPS sensors. The pilot health and safety system uses AI algorithms to analyze this data and provide early detection of risks such as hypoxia, stress, fatigue, and cognitive overload.

While these devices promise enhanced flight safety and represent the aviation industry's move toward an AI-supported, human-centered future, they also present significant challenges. Data privacy, certification requirements, human-machine interaction, user adaptation, and technology dependence are complex issues that must be carefully addressed.

Smart pilot watches should be viewed as complementary tools rather than standalone solutions, recognizing that the regulatory, ethical, and human factors challenges are more complex than the technology itself.

The fundamental purpose of this study is to examine the evolution of pilot watches from mechanical timekeepers to artificial intelligence-supported flight safety systems and to reveal the new role of this evolution in modern aviation safety.sase

In this study, the contributions that artificial intelligence-supported smart pilot watches can provide by significantly enhancing flight safety through monitoring the pilot's physiological condition, presenting critical data in real-time, and generating proactive warnings against potential hazards, as well as reducing human factor-related accidents in aviation, are examined.

In this study, first, the technological evolution of pilot watches spanning from the mechanical era to the digital age and smart watches has been analyzed. Subsequently, the contributions of smart pilot watches to flight safety, particularly in enhancing situational awareness, managing human factors, and data-driven safety analysis, have been evaluated. Furthermore, fundamental design requirements and operational support scenarios for wearable smart watches have been determined, and sample applications have been included. In this regard, the potential of biometric data analyses such as hypoxia detection and stress/fatigue monitoring in flight safety has been detailed through these sample applications. On the other hand, the regulatory, ethical, and human factors requirements that these and similar new technologies present for the aviation industry have been discussed.

The fundamental expected outcome of this study is for smart pilot watches to serve not merely as an accessory or backup navigation device for pilots, but as an artificial intelligence-based critical safety layer. The findings obtained in this study demonstrate that watches can transform from an information display tool into an intelligent partner that continuously monitors, analyzes the pilot's health and performance, and generates proactive warnings against potential risks. Consequently, while the potentials that this evolution holds for the aviation industry are emphasized, attention is also drawn to critical challenges such as data privacy, ethical responsibilities, and over-dependence on technology.

Keywords: Wearable technology, flight safety, human factors, aviation regulations, artificial intelligence.

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PRACTICAL ISSUES OF FLIGHT CONTROL SYSTEM DESIGN FOR UAV

Hüseyin AKTAN[1]

Abstract

The design of autopilot and flight control systems plays a critical role in modern aviation and defense technologies. These studies rely on different control methods to ensure having a robust system across the entire flight envelope. Robust Servo Linear Quadratic Regulator (RSLQR) with Static Output Feedback method is an advanced and powerful control method and it is chosen for this work. Also, to make more realistic designs, sensor noise filters, actuator dynamics and extra time delays associated with software and hardware should be added into the analysis model. The inclusion of these elements significantly increases system complexity, particularly by introducing a larger number of unmeasured states. This poses practical challenges when designing controllers using the RSLQR with Output Feedback approach.

This study aims to highlight one of the practical issues of flight control system design and propose an engineering-based solution.

Although advanced theoretical control methods are available, they often degrade performance when applied to real-life systems due to unmodeled dynamics and unmeasured states.

When there are more unmeasured states than measured states, RSLQR Static Output Feedback algorithm generally exhibits degraded performance. To address this issue, we propose a simplified engineering solution: instead of modeling each dynamic separately, we introduce a single equivalent delay state that captures the overall effect, maintaining realism while preserving controller feasibility.

The method offers a practical path forward for real-world UAV controller design with using RSLQR Output feedback method.

Keywords: RSLQR, Autopilot, UAV, Output Feedback

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QUANTIFICATION OF BOUNDARY LAYER CHARACTERISTICS FOR BLEED MASS FLOW RATE PREDICTION IN A SUPERSONIC COMPRESSION INTAKE

Muhammed Enes ÖZCAN[1], Nilay Sezer UZOL[2]

Abstract

The performance and stability of external compression supersonic inlets are critically dependent on the effective management of shock-wave boundary layer interactions (SBLI). While SBLI-induced flow separation is effectively mitigated by boundary layer bleed systems, their design has historically been based on extensive computational and statistical optimization of geometric parameters rather than on a direct quantification of the adverse flow to be counteracted. In this study, a physics-based methodology is established to determine the required bleed mass flow rate directly from the physical state of the boundary layer. Building upon previous work demonstrating that an optimized bleed system can enhance total pressure recovery by over 2% and expand the stable operating envelope by 25-30%, it is hypothesized that the momentum thickness (θ) can be used as a direct measure of the low-energy fluid that must be bled to maintain attached flow. A comprehensive numerical investigation is conducted using a validated RANS model across a matrix of flight conditions ($M_\infty = 1.6, 1.8, 1.9$). Boundary layer velocity profiles are extracted at 40 discrete points on the compression surface to calculate key parameters and estimate the required bleed rate. The outcome will be a quantitative, physics-based tool, offering an efficient design alternative to empirical methods and enabling the design of more robust and stable high-speed intakes.

The goal of this study is to provide a physics-based methodology for estimating the needed bleed mass flow rate in a supersonic intake using boundary layer parameters. The goal is to numerically characterize the boundary layer development across the intake's compression surface for a matrix of flight conditions ($M_\infty = 1.6, 1.8, 1.9$), calculate key thickness parameters (δ, δ^*, θ) by extracting velocity profiles at 40 discrete points, and compute the mass flow rate within the momentum thickness to establish a primary estimate for the required bleed rate. The fundamental research issue is the absence of a direct, quantitative relationship between boundary layer state and the needed bleed mass flow for intake stability. Historically, bleed system design has been based on computationally intensive, empirical optimization of geometric parameters (e.g., length to diameter ratio, porosity) rather than the underlying flow physics of shock-wave boundary layer interactions (SBLI), which has resulted in potentially inefficient designs. The momentum thickness (θ), representing the momentum deficit within the boundary layer, is thought to be a direct and accurate measure of the low-energy fluid that needs to be bled. The core argument is that eliminating a mass flow equal to the momentum thickness is sufficient to re-energize the boundary layer, preserve connected flow, and prevent SBLI-induced instability. The suggested methodology relies on computational fluid dynamics (CFD), with a verified 3D RANS model of a single-ramp supersonic intake and the Realizable k-ε turbulence model. The analysis includes a matrix of flight conditions ($M_\infty = 1.6, 1.8, 1.9$) across various engine face Mach numbers (M_{EF}). To characterize the boundary layer, velocity profiles are taken from 40 discrete spots on the compression surface. These profiles are integrated to generate boundary layer thickness parameters (δ, δ^*, θ), and the mass flow within the momentum thickness is determined to estimate the necessary bleed rate.

The desired outcome is a set of performance maps that correlate the needed bleed mass flow rate with the intake's operational circumstances (M_∞, M_{EF}). This project will create a quantitative, physics-based tool to guide the initial design of bleed systems, providing a more targeted and efficient alternative to empirical optimization. This methodology, which links the momentum deficit of the boundary layer to the required bleed flow, will allow for the design of more resilient and efficient high speed intakes with potentially lower drag penalties, hence easing the development of advanced propulsion systems.

Keywords: Supersonic Intake, Boundary Layer Bleed, Computational Fluid Dynamics, Momentum Thickness, Flow Control.

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SOCIAL, LEGAL AND ETHICAL BARRIERS ON THE USE OF UAVS FOR DISASTER RELIEF

H. Öncü ÜSTÜNDAĞ[1], Rustem Baris YESILAY[2]

Abstract

The integration of unmanned aerial vehicles (UAVs) into disaster logistics represents a transformative step towards improving the speed, efficiency, and precision of emergency response operations. By providing rapid situational awareness and delivering critical supplies to hard-to-reach areas, UAVs have proven their potential during both natural and human-made disasters. However, despite their advantages, the adoption of UAVs is significantly constrained by social, legal and ethical barriers that shape their perception, regulation, and operational effectiveness. From a social perspective, public acceptance remains one of the most prominent challenges. UAVs are often associated with surveillance and privacy concerns, which can generate fear and resistance among affected communities. Following a disaster, people may already experience heightened anxiety and mistrust, making them more sensitive to perceived invasions of privacy. Misunderstandings about UAV functions, amplified by sensationalized media coverage or lack of transparent communication, may lead to opposition from local populations. For example, drones equipped with cameras may be perceived as intrusive tools rather than lifesaving assets, even when deployed by humanitarian organizations. In such cases, proactive communication strategies that emphasize the humanitarian purpose of UAVs can help mitigate concerns. Community engagement, including public demonstrations of UAV use in non-disaster contexts, has been shown to increase public trust. Legal and regulatory frameworks also pose substantial obstacles to UAV operations. Airspace regulations vary significantly between countries and are often designed for conventional aviation rather than agile UAV systems. Securing flight permissions in emergency situations can be a time-consuming process, potentially delaying the delivery of critical resources. In disaster response, where every minute counts, such bureaucratic hurdles undermine the core purpose of rapid UAV deployment. Furthermore, questions around liability and insurance for UAV-related accidents remain largely unresolved. Who is responsible if a UAV malfunctions and causes injury or property damage? Without clear answers, both governmental agencies and humanitarian organizations may hesitate to incorporate UAVs into their operations. An additional challenge lies in the ethical and legal intersection of data management. UAVs collect vast amounts of visual and geospatial data, which can include sensitive information about individuals and property. Data protection laws, such as the EU's General Data Protection Regulation (GDPR), require stringent measures for data storage and sharing. Non-compliance, even if unintentional, can lead to legal consequences and public backlash. These legal barriers often compel organizations to balance transparency with privacy while ensuring data security. Dual challenges of public perception and legal restrictions call for collaborative, multi-stakeholder solutions. Governments, technology developers, humanitarian actors, and local communities need to work together to establish clear operational guidelines, standardized safety protocols, and ethical frameworks for UAV deployment. Countries like Japan and the United States have demonstrated that integrating UAV regulations into national disaster response strategies can significantly reduce operational delays (Kano et al., 2020). In the context of Türkiye, recent experiences during the 2023 earthquakes highlight both the potential and the challenges of UAV integration in disaster logistics. Baykar's TB2 and Akıncı drones were deployed for damage assessment, search and rescue, and coordination of relief efforts. UNDP Türkiye piloted parafoil drones for debris tracking to enhance municipal response capacity. The German Aerospace Center (DLR) supported mapping operations with modular aerial camera systems, and Turkish universities developed UAV-based systems to restore communications when terrestrial infrastructure was damaged. Despite these advancements, challenges persist in harmonizing UAV operations with national aviation laws, ensuring community acceptance, and safeguarding personal data collected during missions. Establishing pilot projects and simulation exercises can also help refine best practices while familiarizing both operators and communities with UAV capabilities.

To enhance the operational deployment of UAVs in crisis situations and also strengthen public confidence, uphold legal compliance, and maintain ethical integrity in disaster response operations.

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UAVs have proven their potential during both natural and human-made disasters. However, despite their advantages, the adoption of UAVs is significantly constrained by social, legal and ethical barriers that shape their perception, regulation, and operational effectiveness.

The successful integration of UAVs in disaster logistics requires addressing challenges from multiple dimensions. From a social perspective, fostering public trust and engagement remains essential to ensure community acceptance and cooperation. In terms of legal and regulatory frameworks, harmonizing national and international aviation laws, expediting emergency flight permissions, and clarifying liability are critical steps for operational efficiency. Furthermore, the ethical and legal intersection of data management demands robust policies for privacy protection, secure data handling, and transparent communication about data usage. Ultimately, these combined efforts will not only enhance the operational deployment of UAVs in crisis situations but will also strengthen public confidence, uphold legal compliance, and maintain ethical integrity in disaster response operations.

Ultimately, these combined efforts will not only enhance the operational deployment of UAVs in crisis situations but will also strengthen public confidence, uphold legal compliance, and maintain ethical integrity in disaster response operations.

Keywords: Unmanned Aerial Vehicle, Disaster, Ethical, Social, Legal.

THE MULTI-CREW PILOT LICENCE (MPL) AS A COMPETENCY-BASED PILOT TRAINING MODEL: PEDAGOGICAL STRENGTH, OPERATIONAL REALITY, AND IMPLEMENTATION CHALLENGES

Hakkı BAĞAN[1], Ayberk TUTKUN[2]

Abstract

The Multi-Crew Pilot Licence (MPL), introduced by ICAO in 2006, represents the first fully competency-based pilot licensing framework. This study examines the MPL model comprehensively, with a focus on its pedagogical design, training outcomes, implications for flight safety, and acceptance by airline operators. The research also evaluates the feasibility of MPL implementation in Türkiye, exploring regulatory, institutional, and operational dimensions. Findings from a systematic literature review highlight the strong performance of MPL graduates in areas such as Crew Resource Management (CRM), procedural adherence, and threat and error management. However, challenges remain concerning manual flying exposure, instructor qualifications, and licence transferability. While these challenges are structural rather than conceptual, successful adaptation requires regulatory alignment, institutional collaboration, and tailored policy measures. The study concludes that MPL offers significant potential to enhance pilot competency and flight safety, and its adoption in Türkiye could address the growing demand for skilled pilots if implemented strategically.

The primary objective of this study is to provide a comprehensive analysis of the MPL model, with particular attention to its pedagogical framework, training outcomes, safety contributions, and airline acceptance. Specific research questions address: (1) the operational performance profile of MPL graduates, (2) airline perceptions of MPL-based training, and (3) institutional and regulatory barriers to MPL implementation in Türkiye.

The traditional ATPL model, based largely on flight hours, may no longer align with modern competency-based approaches that prioritize decision-making and situational awareness. The hypothesis of this study is that the MPL model, through its scenario-based training methodology, better prepares pilots for complex operational environments and enhances overall flight safety.

The study employs a qualitative literature review of academic publications, ICAO/EASA reports, and airline data from 2006–2024. Thematic analysis identified six themes: pedagogical structure, ATPL comparison, graduate performance, airline perspective, critical views, and national applicability. Proposed solutions include SHGM-issued guidelines, CBTA-based instructor training, stronger ATO–airline partnerships, improved student selection, and pilot programs before nationwide rollout.

The study expects to demonstrate that MPL graduates outperform traditional ATPL trainees in competencies directly tied to flight safety. In the Turkish context, successful MPL adoption is expected to alleviate pilot shortages, strengthen institutional cooperation, and promote a safety-oriented training culture. The findings contribute both theoretically, by advancing understanding of competency-based pilot training, and practically, by offering policy-oriented recommendations for aviation stakeholders.

Keywords: Multi-Crew Pilot Licence (MPL), Competency-Based Training and Assessment (CBTA), Flight Safety, Airline Pilot Training, Aviation Policy in Türkiye

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INTEGRATING HUMAN FACTORS AND AI-SUPPORTED MAINTENANCE SYSTEMS IN AVIATION

Mikail BAYRAM[3]

Abstract

Human factors continue to play a critical role in maintaining safety and reliability in aircraft maintenance operations. Fatigue, attention lapses, communication breakdowns, and difficulties in decision-making can significantly increase the likelihood of technical errors and contribute to operational risks. Although the aviation industry has implemented a range of standards and procedures to minimize these issues, eliminating human error entirely remains a challenge. In recent years, the application of artificial intelligence (AI) in aviation maintenance has gained significant momentum. Technologies such as fault prediction, data analytics, and automated warning systems are increasingly seen as valuable tools for preventing human-induced errors. However, the effective use of these tools requires technicians to interact meaningfully with AI systems and possess the skills necessary to interpret the data they provide. Examining the relationship between human factors and AI-supported maintenance systems offers valuable insights into how maintenance practices are evolving. This study focuses on evaluating the extent to which these technologies contribute to reducing risk and how they are transforming the roles and responsibilities of maintenance personnel. A literature review was conducted using current academic and industry sources. The study explores the integration of AI into maintenance planning, the flow of information between human operators and intelligent systems, the functioning of decision-support mechanisms, and the broader impact on training and workforce development. Findings suggest that technical expertise alone is no longer sufficient. As digital systems become increasingly embedded in maintenance workflows, professionals must also be capable of working effectively with these technologies. The successful deployment of AI tools depends on technicians who are flexible, analytically minded, and open to continuous learning. This makes it essential to revise and update training programs so that personnel can adapt to evolving technological demands. Fostering a new generation of digitally competent and technically skilled professionals will be key to ensuring safe, efficient, and future-ready maintenance operations.

This study aims to explore the interaction between human factors and artificial intelligence-supported maintenance systems within the aviation industry. The primary focus is on understanding how challenges such as fatigue, inattention, and decision-making difficulties influence maintenance-related errors, and how AI technologies can contribute to minimizing these risks. Additionally, the research seeks to examine the evolving role of aircraft maintenance technicians as these systems become more integrated into operational workflows. By investigating both the limitations of human performance and the opportunities presented by AI tools, the study addresses the need for a new framework that balances human expertise with technological support in modern maintenance environments.

Despite technological advancements and increased automation in aviation maintenance, human error continues to pose significant risks to operational safety. Technicians often operate under time pressure, fatigue, or in highly complex environments, which increases the likelihood of mistakes related to attention and decision-making. While artificial intelligence systems offer potential support in these areas, their effectiveness depends heavily on how they are implemented and used in real-world maintenance settings.

This study is based on the hypothesis that AI-assisted tools can reduce the frequency and severity of human errors in aviation maintenance. However, this potential benefit can only be realized if technicians receive adequate training and support to understand, interpret, and collaborate with such systems. Otherwise, new challenges may arise, including overreliance on automation or misinterpretation of AI-generated outputs.

Addressing the persistent impact of human error in aviation maintenance requires more than technological innovation; it also calls for a shift in how technicians are trained and supported. This study proposes that artificial intelligence can enhance decision-making and reduce operational risks, but its success depends on meaningful human-system interaction. Technicians

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must be equipped not only with technical knowledge but also with the digital competencies needed to work alongside intelligent systems.

To explore this relationship, the research adopts a literature-based methodology. Current academic publications, industry reports, and documented case studies are analyzed to assess the practical applications of AI in maintenance planning, the effectiveness of decision-support systems, and the broader implications for workforce training and organizational adaptation.

The study is expected to provide insights into how artificial intelligence can complement human expertise in aviation maintenance rather than replace it. By examining the evolving relationship between maintenance technicians and digital systems, the research highlights the need for balanced integration that supports both safety and efficiency. The findings aim to inform future training strategies, emphasizing the development of digital literacy alongside technical proficiency. Ultimately, the study contributes to the ongoing transformation of aviation maintenance practices, offering a perspective that centers on collaboration between human and machine as the foundation for sustainable operational safety.

Keywords: Aviation maintenance, Human factors, Artificial intelligence, Technician training, Digital transformation.

DESIGN OF A PATCHING DEVICE FOR DEEP SCRATCH DAMAGED AIRCRAFT COMPOSITES AND INVESTIGATION OF PATCH EFFICIENCY

Muharrem ER[4]

Abstract

The objective of this study is to develop a novel patching device for the repair of relatively minor damages, such as deep scratches, occurring on the outer plates of composite components of aircraft, particularly fuselage, wings, tail stabilizers, and doors. For this purpose, a comprehensive study was conducted on a hybrid method between adhesive bonding and additive manufacturing, resulting in the development of a unique patching device that operates on principles similar to the print head of 3D printers and can be used for patching and repairing deep scratch damages on polymer composite surfaces used in aircraft.

Twelve-layer composite plates, similar to aircraft fuselage and blade coverings, were manufactured using the hand lay-up method with 300 g/m² densely woven (0 – 90°) glass fiber fabric. The produced composite plates were cut into tensile and flexural test specimens according to the dimensions specified in TS EN ISO 527-4 and ASTM D790 standards.

U-section and V-section damages equivalent to 40% of their thickness were introduced into the tensile and flexural specimens. The damaged regions were patched using the developed patching device with three different solvent-free, two-component, reaction-curing epoxy adhesives (Polisan, DURATEK DTE 1000, and LOCTITE EA 9309) and single-end glass fiber threads with a linear density of 300 g/1000m. The patched specimens were cured under three different temperature conditions: at room temperature (23 °C) for 24 hours, at 40 °C using an infrared lamp for 4 hours, and at 60 °C for 2 hours. Tensile and flexural tests were performed on undamaged, damaged, and patched specimens, and the results were compared.

It was concluded that specimens patched with the developed patching device showed improvements in tensile strength of 84-94% and flexural strength of up to 65% compared to undamaged specimens, depending on patch geometry, epoxy type, and curing temperature.

The objective of this study is to develop a novel patching device for the repair of relatively minor damages, such as deep scratches, occurring on the outer plates of composite components of aircraft, particularly fuselage, wings, tail stabilizers, and doors.

The design of a patching device as a new repair method due to the low efficiency and service life of traditional patching methods for repairing deep scratch damages in aircraft composite structures, and the investigation of the efficiency of repairs performed with this device.

Ensuring that repairs performed with the developed patching device are safer compared to traditional patching repair methods and developing repair methods suitable for specific damage types.

It was concluded that specimens patched with the developed patching device showed improvements in tensile strength of 84-94%and flexural strength of up to 65% compared to undamaged specimens, depending on patch geometry, epoxy type, and curing temperature.

Keywords: Patch device, polymer composites, repair, aircraft structure, composite damage.

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ENHANCING AIRCRAFT SAFETY THROUGH PREDICTIVE MONITORING OF ENGINE HEALTH

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Abstract

The purpose of this study is to investigate the application of machine learning (ML) algorithms to enhance aircraft safety through predictive monitoring of engine health. Since turbofan engines are critical assets whose failure can lead to severe safety and economic consequences, accurate estimation of their Remaining Useful Life (RUL) is essential for preventing unexpected breakdowns. The research problem addressed is the limited ability of traditional scheduled maintenance strategies to anticipate complex degradation patterns in aircraft engines under varying operating conditions. Such limitations may cause both unnecessary maintenance actions and unexpected in-flight failures.

The specific objectives of this study are: (i) to develop data-driven models for reliable RUL estimation using the NASA Commercial Modular Aero-Propulsion System Simulation (C-MAPSS) datasets; (ii) to compare the performance of advanced ML techniques (iii) to evaluate the industrial feasibility of integrating these models into predictive maintenance frameworks for aviation safety.

Our central hypothesis is that ML-based prognostic models trained on sensor data can capture nonlinear degradation trends more effectively than rule-based or purely statistical methods, thereby improving accuracy in RUL prediction and supporting more reliable decision-making in aviation maintenance.

To address this problem, we propose a hybrid approach that combines feature engineering, sensor selection, and advanced ML algorithms. First, redundant and non-informative sensors are identified through statistical analysis and dimensionality reduction. Next, multiple ML models are trained and validated on the C-MAPSS benchmark datasets, which represent multiple operating conditions and fault modes.

The significance of this research lies in its contribution to predictive maintenance (PdM) strategies, which aim to reduce unscheduled downtime, optimize maintenance costs, and enhance overall flight safety. The findings of this study are expected to contribute to the development of intelligent, data-driven diagnostic frameworks that align with the broader goals of aviation safety, reliability, and operational efficiency.

Keywords: Predictive Maintenance (PdM), Remaining Useful Life (RUL), Machine Learning (ML), Aircraft Engines, Flight Safety.

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INTELLECTUAL AND SOCIAL STRUCTURE OF EXPLAINABLE ARTIFICIAL INTELLIGENCE (XAI) RESEARCH IN AVIATION: A BIBLIOMETRIC AND SYSTEMATIC ANALYSIS

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Abstract

The primary objective of this study is to examine the emerging field of Explainable Artificial Intelligence (XAI) from a socio-technical systems perspective. The aim is to map the intellectual and social structures of this field, contributing to an understanding of XAI's role in the aviation ecosystem not only as a technical tool but also as an organizational compliance mechanism.

The primary objectives of this study are as follows: (a) To quantitatively reveal the historical development of the field, its core research themes, and its leading actors (authors, institutions) by applying a bibliometric analysis to a dataset of 331 studies from the Scopus database; (b) To synthesize the key managerial challenges identified in the literature and proposed solution frameworks by conducting a systematic content analysis on key studies focusing on the central theme of "Trust and Certification" identified by the bibliometric analysis; (c) To interpret all findings from a managerial perspective to identify the current state of the field and future research directions.

The aviation industry faces a paradox between the revolutionary potential promised by artificial intelligence (AI) and the rigid safety and certification culture inherent in being a High Reliability Organization (HRO). The "black box" nature of advanced AI models, with their inputs and outputs, is fundamentally at odds with the aviation industry's current deterministic safety and verification processes. This creates not only a technical but also a profound organizational challenge of trust, legitimacy, and accountability, which hinders the operational integration of this technology.

The fundamental hypothesis of this study is that XAI in aviation is not merely a technical explanation tool, but rather a fundamental socio-technical adaptation mechanism required for a probabilistic technology like AI to integrate into a rule-based, high-reliability organizational structure like aviation. In this process, XAI fulfills critical organizational functions such as building trust, establishing legitimacy, and filling accountability gaps.

In the first phase of the research, a bibliometric analysis was conducted on a dataset of 331 documents obtained from the Scopus database. Maps were generated using VOSviewer software, showing the intellectual structure (keyword co-occurrence networks) and social structure (co-authorship networks) of the field. In the second phase, after interpreting the central theme of the bibliometric map, formed by concepts such as "trustworthy AI" and "decision making," as "Trust and Certification," a systematic content analysis was conducted on key articles within this axis.

This study demonstrates that XAI in aviation is not merely a technical tool; it is also a fundamental socio-technical adaptation mechanism required for the integration of an "unknown" technology like AI into an organizational structure with strict regulations like aviation. XAI serves fundamental management functions such as trust-building, risk management, organizational learning, and establishing accountability frameworks. This study aims to make three key contributions to the literature: (a) To provide an intellectual and social map of XAI research in aviation, providing a roadmap for researchers working in this emerging field; (b) To synthesize the most significant managerial/organizational challenges and proposed solution frameworks in the field through systematic analysis, thereby providing a strategic vision for aviation professionals; (c) To suggest concrete directions for future research on topics where significant research gaps exist in the existing literature, such as the development of accountability mechanisms and the design of human-machine interfaces (HMIs) that will provide explanations to operators.

Keywords: Explainable Artificial Intelligence (XAI), Aviation, Trustworthy AI, Bibliometric Analysis, Sociotechnical Systems

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PERFORMANCE EVALUATION OF A DUAL-PULSE ROCKET MOTOR IN BEYOND-VISUAL-RANGE AIR-TO-AIR MISSILE ENGAGEMENTS

Hüdai ERPULAT[7], Ahmet Salih YIĞIT[8]

Abstract

Modern air combat is increasingly characterized by Beyond Visual Range (BVR) engagements, where missile performance across different speed, altitude, and engagement geometries plays a decisive role. The purpose of this study is to investigate the tactical and kinematic benefits of dual-pulse solid rocket motors compared to conventional single-pulse designs, without requiring additional volume — as observed in the similar evolution from AIM-120C to AIM-120D. A literature review was conducted on the algorithms used for double-pulse air-to-air missile motors and their ignition timings, which were then utilized in this article.

Single-pulse motors provide limited flexibility, particularly in terminal phases against maneuvering, approaching or retreating targets. The central hypothesis of this research is that dual-pulse propulsion can significantly enhance engagement flexibility by extending maximum range in long-distance intercepts while also delivering higher endgame velocities for shorter intercept ranges.

A six-degree-of-freedom (6-DOF) missile model was developed to simulate diverse operational conditions, including head-on and tail-chase engagements under varying speed and altitude profiles. The tactical timing of the second pulse is investigated with respect to the terminal phase and extending range . Furthermore, the improvements achieved under different engagement scenarios with single-pulse and dual-pulse motors will be comparatively evaluated.

In this study, analyses conducted demonstrated that the double-pulse rocket motor offers an advantage to the air-to-air missile in terms of both engagement speed and duration. The missile's ability to reach the target at a higher velocity significantly increases the probability of a hit. It was observed that the ignition time of the second stage can significantly affect the missile's performance.

It has been established that the double-pulse rocket motor can significantly enhance the air-to-air missile's capabilities in terms of both engagement velocity and range. However, the necessity for functions capable of predicting the appropriate ignition timing has been identified. The findings of this study will enable the acquisition of data for developing a machine learning function that determines optimal ignition timings across varying engagement conditions.

Keywords: Air-to-air missile, dual-pulse motor, beyond visual range, 6-DOF model, ignition time estimation of second pulse

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OPERATIONAL SAFETY ANALYSIS OF DRONE TAXI OPERATIONS: A CASE STUDY FROM TURKEY

Tamer SAVAS[9]

Abstract

Urban Air Mobility (UAM) concepts such as drone taxis are increasingly being considered as a future mode of transportation in metropolitan areas. Ensuring their safe integration into national airspace requires systematic risk assessment methodologies that can capture both ground and air risks. This study explores the application of the Expected Level of Safety (ELS) framework in combination with the Specific Operations Risk Assessment (SORA) methodology to evaluate the feasibility of drone taxi operations in Turkey. ELS provides a quantitative assessment of third-party ground risk through parameters such as kinetic energy, population density, mean time between failures, exposure fraction, and lethality probability. Building upon these quantitative risk estimates, SORA is employed to determine the initial Ground Risk Class (iGRC), Air Risk Class (ARC), and the corresponding Specific Assurance and Integrity Levels (SAIL). The results suggest that drone taxi operations over densely populated zones present significantly higher ELS values, requiring advanced technical and procedural mitigations, whereas corridors over water or low-density areas achieve acceptable safety thresholds. This combined ELS–SORA approach provides a structured pathway for Turkish civil aviation authorities and industry stakeholders to design pilot programs for eVTOL operations. The findings highlight the importance of integrating quantitative safety analysis with regulatory frameworks, ultimately supporting the gradual transition

The purpose of this study is to evaluate the safety feasibility of drone taxi operations in Turkey. The specific objectives are to apply the ELS framework for quantitative ground risk assessment and to use SORA to define operational risk classes and required mitigations.

The research problem is the lack of systematic methods to ensure safe integration of drone taxis into Turkish airspace. The hypothesis is that combining ELS analysis with SORA methodology provides a reliable framework for assessing and mitigating both ground and air risks.

The proposed solution is to integrate ELS-based risk mapping with SORA-driven mitigation strategies. The methodology includes calculating ground risk through ELS parameters, assigning iGRC and ARC via SORA, and testing potential corridors in metropolitan areas

The expected outcome is to identify safe and acceptable safety analysis for drone taxi operations in Turkey.The study contributes by providing a structured safety framework for regulators and industry stakeholders. The approach is innovative in linking quantitative safety analysis with operational risk management to support UAM implementation.

Keywords: Expected Level of Safety (ELS), SORA, drone taxi, eVTOL, urban air mobility

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THE ROLE OF AUTOMATIC SPEECH RECOGNITION (ASR) IN AVIATION ENGLISH SPEAKING SKILLS

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Abstract

One of the most important conditions for ensuring safety in aviation is speaking English fluently, especially Aviation English (AE). This allows for correct communication. To advance AE speaking skills, Automatic Speech Recognition (ASR), Artificial Intelligence (AI) based technology, offers a promising solution. Developing strong pronunciation and phonetic skills through ASR is essential because aviation communication is characterized by high speech rates, specific vocabulary, diverse accents, and generally takes place in noisy working environments. In addition, the lack of domain-specific training data and code-switching problems occurring in Air Traffic Control (ATC) pose communication difficulties. This systematic literature review mainly aims to assess the literature on the implementation of ASR usage in AE. This study analyzes how ASR is applied to develop AE skills in the field of aviation. It also identifies gaps in this area and suggests future research. In this study articles published between January 2023, and June 2025 are analyzed. During the stage of research selection, Preferred Reporting Items for Systematic Reviews and Meta-analyzes (PRISMA) are used. The expected findings will highlight the great potential of ASR technology for advancing speaking skills in terms of accuracy, pronunciation, and fluency. The study provides valuable information to researchers, educators and managers for ensuring safety and effective aviation operations.

Keywords: Automatic Speech Recognition, Aviation English, Air Traffic Control, language training

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THE SIX-DAY WAR (1967) AND THE YOM KIPPUR WAR (1973): THE STRUGGLE FOR AIR SUPERIORITY IN THE MIDDLE EAST

Müjdat KARAGULMEZ[11], Isa YAPAR[12]

Abstract

In the post–World War II era, conflicts in the Middle East were shaped not only by ground operations but also by the intensive and decisive employment of air power. In this regard, the Six-Day War (1967) and the Yom Kippur War (1973) stand as historical examples that demonstrate both the force-multiplying role of air superiority in rapid decision-making and the vulnerability of air doctrines in the face of unexpected threats. In both wars, the Israeli Air Force (IAF) drew attention not only through its operational effectiveness but also through its role in shaping military doctrine.

On the morning of 5 June 1967, the IAF launched "Operation Focus" (Moked), a simultaneous strike against Egypt, Jordan, and Syria, which is regarded as one of the most successful air campaigns in history. This operation marked the first comprehensive application of the pre-emptive war doctrine in the modern era.

By contrast, the Yom Kippur War, which began on 6 October 1973 with the coordinated offensives of Egypt across the Suez Canal into Sinai and Syria in the Golan Heights, caught Israel by surprise. These initial attacks exposed critical weaknesses in Israel's defensive systems. Particularly striking was the Egyptian air defense network, equipped with Soviet-made SA-2, SA-3, and SA-6 surface-to-air missile batteries. This system neutralized the traditional low-altitude maneuvers of Israeli jets, leading to significant aircraft losses in the early stages and triggering a doctrinal crisis for Israel, whose strategy relied heavily on air superiority.

The Arab–Israeli wars of 1967 and 1973 demonstrate that air power serves not only as a tool for achieving rapid victories but also as an indicator of the fragility of air-centered doctrines when confronted with unforeseen threats.

This paper aims to examine how air power became a decisive factor in Middle Eastern conflicts through the cases of the Six-Day War and the Yom Kippur War, while also analyzing the operational effectiveness of the Israeli Air Force and the doctrinal ruptures it experienced.

The study employs a historical analysis method, examining the course of the wars chronologically and assessing contemporary military doctrines and the outcomes of air operations through a comparative perspective.

This comparative analysis will provide a concise contribution to understanding the possibilities and limitations of air power in modern warfare, offering contemporary strategic lessons for military history and security studies.

Keywords: Israel, Yom Kıppur, Airstrike, Six Day War, airforce.

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A COST-EFFECTIVE AND PORTABLE SOLUTION FOR FLIGHT TRAINING: AN INDEPENDENT SENSOR-BASED REAL-TIME ILS/VOR APPROACH SIMULATOR

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Abstract

One of the most critical and costly phases of pilot training is Instrument Landing System (ILS) and VHF Omnidirectional Range (VOR) approach training under Instrument Flight Rules (IFR). This training must be conducted at airports equipped with these capabilities amidst real air traffic. However, particularly at major airports, intense commercial traffic significantly limits the available opportunities, airspace, and glide path access for training flights. This extends the training duration and substantially increases costs. This study details the design and implementation of a portable, independent system that provides a fundamental solution to this problem by enabling the realistic simulation of ILS/VOR approach training during any flight, without requiring any connection to the aircraft's systems.

The primary aim of this study is to develop an integrated system that provides student pilots with a high-fidelity ILS/VOR descent training capability during any flight, without the need for an actual runway or ground station. The system consists of two main components: The first is a mobile application running on a tablet that emulates a modern Glass Cockpit interface (PFD and MFD). The second is a specially designed sensor box that independently measures and calculates position, attitude, and heading data without requiring any data from the aircraft, transmitting this information to the application in real-time. This approach aims to reduce training costs and increase training efficiency.

Currently, the necessity to navigate to airports with suitable ILS/VOR infrastructure, combined with the congested traffic at these airports, severely restricts training capacity. This problem causes delays in training progress and increases operational costs. The hypothesis of this work is that during flight, using an independent sensor set and mobile software independent of the aircraft's systems, any reference point can be defined as a virtual ILS/VOR runway. This allows the student pilot to practice these procedures repeatedly and safely under real flight conditions with the highest level of realism. This method will provide flexibility and accessibility in training by allowing the simulation of real approach paths at any point within the training airspace.

The core of the proposed system is a Single-Board Computer (SBC)-based embedded system architecture. This system is an independent sensor box comprising high-precision sensors such as an IMU (Inertial Measurement Unit), GPS, and magnetometer. The box operates without any connection to the aircraft, processing raw sensor data to calculate critical flight parameters such as attitude (pitch, roll, yaw), altitude, airspeed, vertical speed (VSI), and position. The calculated data is transmitted via Bluetooth protocol at a 20Hz update rate with a latency below 120 ms to an Android tablet in JSON packets. The Glass Cockpit emulator application developed for the tablet receives this data and renders all necessary flight metrics—including HSI, CDI, and glideslope indicators for simulating the ILS/VOR descent—on the PFD in real-time. The MFD screen uses real-time GPS position data to display the user-selected virtual airport and its approach procedure on a map.

The ultimate output of this work is a portable, low-cost, high-realism simulation training system that is completely independent of the aircraft's make and model. The most significant expected result is that student pilots will be able to internalize ILS/VOR procedures through numerous, safe repetitions without the physical need for an actual airport and ground equipment. This will both increase the quality of training and pilot readiness and significantly reduce operational costs associated with fuel, maintenance, and airport usage fees. The system offers an innovative solution usable across a broad spectrum, from basic training to advanced recurrent training.

Keywords: Instrument Flight Training, ILS Simulation, Portable Training Device (PTD), Independent Data Acquisition System, Glass Cockpit Emulation.

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DESIGN AND IMPLEMENTATION OF AN AUTONOMOUS OBSERVER UAV WITH REAL-TIME AERIAL TARGET DETECTION

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Abstract

The general purpose of this study is to design and develop an unmanned aerial vehicle (UAV) capable of autonomous surveillance missions with extended endurance and real-time aerial target detection capabilities. An aerial target refers to any airborne object, such as another UAV, whose real-time detection is crucial for early threat recognition, collision avoidance or mission coordination. Specifically, the objectives of the study can be listed as to construct a lightweight UAV platform that can achieve 40 minutes of flight endurance, a maximum altitude of 500 meters, and an operational range of 4 kilometers; to ensure fully autonomous take-off, flight, and landing without the need for operator intervention; and to integrate an onboard computer vision system that detects other UAVs and instantly communicates the results to a ground control station (GCS) along with real-time video transmission. Achieving these objectives is intended to contribute to the development of more robust, autonomous and mission-specific UAV platforms that can assist with defense and civil surveillance missions.

Current small-scale observation UAVs suffer from limited flight duration, restricted communication ranges, and insufficient onboard processing capacity for advanced image analysis. Furthermore, most existing systems rely on ground-based computation and are incapable of executing fully autonomous flight operations in dynamic environments. The hypothesis guiding this study is that a specially designed fixed-wing UAV with low stall speed and optimized aerodynamics, combined with an embedded artificial intelligence–based image processing system, can overcome these limitations and deliver effective, autonomous aerial surveillance performance.

To address the problem, the proposed UAV integrates both aeronautical design improvements and advanced onboard computing. Structurally, the platform is optimized for long endurance and stability at low speeds, enabling effective loitering and extended flight duration for surveillance missions. Furthermore, the fuselage was designed in a modular architecture, consisting of detachable segments that facilitate maintenance and allow for the rapid integration of diverse payloads and subsystems, ensuring adaptability for various mission requirements. From a methodological standpoint, an onboard embedded computer manages flight autonomy, including navigation and flight control, while simultaneously processing camera data through a convolutional neural network trained to detect UAV targets. For the object detection algorithm, a YOLO-based convolutional neural network was trained on a composite dataset built from multiple UAV imagery sources, augmented with observed false positives to reduce misclassification, achieving a detection accuracy of over 85% in validation tests. The detection results, along with live video, are transmitted in real time to the GCS over a secure communication link.

The expected outcomes include the demonstration of a UAV platform that successfully integrates extended endurance and flight duration, autonomous flight, and real-time aerial target detection into a single system. This research is expected to contribute to the domains of aerial surveillance, civilian airspace monitoring, and defense operations by offering an affordable and efficient solution for UAV-based surveillance. The proposed design highlights the synergy between aeronautical engineering and artificial intelligence, providing an innovative approach that can enhance situational awareness, improve safety, and set new standards for the development of next-generation observer UAVs.

Keywords: Observer UAV, autonomous aerial target detection, aerial surveillance, computer vision, real-time detection

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BIBLIOMETRIC ANALYSIS OF RESEARCH IN AIR LOGISTICS

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Abstract

Air logistics is a critical mode of transportation that meets the speed and efficiency requirements of global trade. This study evaluates the development and research trends of the academic literature in the field of air logistics using bibliometric methods. Articles published between 2015 and 2025 will be analyzed based on data obtained from the Web of Science and Scopus databases. Indicators such as the number of publications, citation counts, and distributions of authors and countries will be examined. The analyses are expected to reveal whether research on air logistics has increased in recent years and whether topics such as supply chain management, sustainability, air transport infrastructure, and digitalization have come to the forefront. In addition, international collaborations and research intensities will be assessed. Bibliometric network analyses will be conducted to illustrate the distribution of keywords and topics in the literature. This study is expected to serve as a guide for both academics and industry professionals in understanding current trends in air logistics and identifying future research directions. The findings will be interpreted in a way that sheds light on both theoretical and applied studies.

Keywords: Aviation, Bibliometric, Logistics

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REDEFINING NATIONAL LOGISTICS EFFICIENCY: AN LPI RECONSTRUCTION VIA TOPSIS AND MACHINE LEARNING

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Abstract

This study aims to refine the evaluation of national logistics performance by reconstructing the Logistics Performance Index (LPI) through the integration of multi-criteria decision-making and machine learning methods. The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is applied together with entropy-based weighting to objectively rank countries based on logistics indicators. Machine learning models—including Random Forest, Gradient Boosting, Support Vector Regression, and feedforward Neural Networks—are employed to validate and enhance the ranking results. The study further emphasizes the role of aviation infrastructure and air cargo operations, considering their critical impact on time-sensitive trade flows.

The World Bank's LPI relies predominantly on survey-based feedback and expert assessments. While informative, these approaches are susceptible to subjectivity and limitations in indicator weighting, potentially leading to inconsistencies in cross-country comparisons. This research hypothesizes that combining TOPSIS with entropy weighting and machine learning, while incorporating aviation-specific factors, produces a more robust, transparent, and predictive assessment of national logistics performance.

A hybrid methodology is implemented. Logistics indicators—including customs efficiency, infrastructure quality, shipment reliability, timeliness, and tracking capabilities—are normalized and weighted via entropy analysis before processing with TOPSIS. Machine learning models are trained on the same dataset to predict country rankings and evaluate the consistency of TOPSIS results. Performance metrics such as RMSE, MAE, MAPE, R^2, Spearman rank correlation, and Kendall Tau are computed to assess the agreement between predicted and TOPSIS-based rankings. Aviation-related variables are incorporated to quantify the contribution of air cargo and airport infrastructure to overall logistics efficiency.

he study is expected to deliver a reconstructed LPI that is more objective, interpretable, and dynamically adaptable than the conventional index. Inclusion of aviation infrastructure variables highlights their strategic importance in trade facilitation, while the integration of machine learning ensures improved validation and predictive reliability. The proposed framework offers a replicable approach for policymakers and researchers to evaluate logistics performance and identify areas for targeted improvement.

Keywords: Logistics Performance Index, TOPSIS, Entropy Weighting, Machine Learning, Aviation Infrastructure

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OPTIMIZED TEAM ALLOCATION AND ROUTE PLANNING FOR FIELD OPERATIONS USING CLUSTERING AND GEOSPATIAL ALGORITHMS

Mihdat POLAT[24], Gürcan LOKMAN[25]

Abstract

The main objective of this study is to develop a support system that optimizes task distribution and route planning for field teams in a corporate environment. The system aims to assign employees into balanced groups based on their current geographical locations and team sizes using clustering algorithms. Subsequently, it determines the most efficient routes for each team member through geospatial optimization, ensuring rapid and effective responses to field tasks and incidents. Specific objectives of the study include improving operational efficiency by minimizing travel time, ensuring fair and logical workload distribution among teams, and improving responsiveness in environments.

In large-scale organizations, manual team assignment and route planning often lead to inefficiencies such as uneven workload distribution, delayed response times, and excessive travel distances. Traditional methods fail to account for real-time location data and scalable team dynamics. The hypothesis of this study is that clustering-based team formation through Google Maps APIs, can significantly reduce task completion time and improve the overall efficiency of field operations.

To overcome these challenges, the proposed system incorporates a two-stage methodology. In the first stage, the K-Means clustering algorithm which calculates the distance between each data object and all cluster centers in each iteration and DBSCAN clustering algorithm which is able to discover clusters in any size or any shape and identify outliers accurately is applied, to classify employees into geographically coherent teams. This ensures that each team operates within a boundary. In the second stage, route optimization is carried out within each group, using shortest path and time minimization approaches supported by Google Maps services for real-time traffic and distance estimation. The system uses the Google Maps API to automatically direct traffic to safer routes instead of others that simply take the shortest route, reducing the time cars and pedestrians encounter dangerous situations. The system allows cluster-based grouping and route optimization to be used simultaneously, providing the fastest route to each employee individually and updating it simultaneously according to locations.

The expected outcome is the demonstration of a scalable, data-driven solution that enhances the efficiency and reliability of field operations in corporate settings. This study contributes to the domain of operations research, smart workforce management, and geospatial decision-making by integrating clustering algorithms with real-time mapping tools. The proposed approach has the potential to significantly improve service quality, reduce operational costs, and enable organizations to respond more effectively to time-critical tasks. Moreover, it highlights the synergy between machine learning techniques and geospatial technologies, offering a practical framework for next-generation workforce management systems.

Keywords: clustering, route optimization, field operations, Google Maps API, workforce management

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ADDRESSING DRONE BATTERY ISSUES AND CHARGING SOLUTIONS FOR LOGISTICS APPLICATIONS

Umut Efe KARAÇAY[26], Gürcan LOKMAN[27], Ahmet Fevzi BABA[28]

Abstract

Unmanned Aerial Vehicle (UAV) technology is rapidly evolving, enabling its integration into cargo logistics. This integration increases operational efficiency, reduces costs, and provides practical solutions in challenging environments. UAVs, commonly referred to as drones, are increasingly used for transporting food, pharmaceuticals, and large packages across various sectors. The main objective of this study is to investigate battery management and charging infrastructure challenges in drone logistics and to propose solutions to enhance operational performance.

Despite their advantages in speed, flexibility, and operational convenience, battery-operated UAVs face significant limitations. Battery life and charging infrastructure remain critical bottlenecks. We hypothesize that optimized battery management systems (BMS) combined with strategically positioned charging stations can significantly improve operational efficiency and reduce downtime in drone logistics operations.

Current UAV battery systems and technological developments are analyzed in this study. It analyzes autonomous battery management, AI-based algorithms for state-of-charge (SoC) and depth-of-discharge (DoD) prediction, and fast-charging drone stations. Data-driven methods are used to plan station locations and optimize operational efficiency. Additionally, alternative energy sources, such as solar-powered drones, are evaluated to reduce dependency on traditional charging systems and extend flight duration.

The study anticipates that implementing advanced BMS, strategically deployed charging stations, and alternative energy solutions will enhance drone operational efficiency and sustainability. These interventions are expected to reduce downtime, extend battery lifespan, and lower the carbon footprint of logistics operations. The findings provide practical guidance for integrating drones into logistics systems and highlight opportunities for innovative, sustainable, and autonomous solutions in last-mile delivery applications.

Keywords: UAV, Drone Logistics, Battery Management, Charging Infrastructure, Sustainable Transport, Autonomous Logistics

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THE IMPORTANCE OF PHYSICS EDUCATION IN AVIATION

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Abstract

According to Maslow, the most basic needs for humans are physiological needs such as food, water, and breathing. After that, the most crucial requirement for human survival on Earth has been security. In fact, like other living beings on Earth, humans have developed conditioned reflexes related to this issue. From this perspective, the primary purpose of scientific inventions has been to develop military technologies. This is because inventions are first used in this field.

The armed forces of countries are generally divided into three branches: Army, Navy, and Air Force. The importance of aviation, compared to other forces, is increasing day by day. Investments in the defense industry support this as well. At the same time, air transportation has become an industrial sector in its own right today. By 2025, it is expected to reach $35 billion, and by 2030, this figure is expected to grow into a massive market of $50 billion [1].

Basic concepts related to aviation, such as aerodynamics, fluid dynamics and pressure, Newton's laws of motion, load and balance, thermodynamics, etc., are among the main physics topics. At this point, we have begun to see the benefits of artificial intelligence, which is increasingly influencing the aviation world, where the cornerstone of physical laws lies. Human beings have started to experience the advantages of artificial intelligence in air traffic management, route planning, maintenance procedures, pricing, passenger information, etc. [2].

In conclusion, we are reliant on science to ensure our safety. In this study, the aim is to discuss and evaluate the importance of Physics Education to obtain the necessary and sufficient qualified human resources for interpreting the results of artificial intelligence and becoming influential within the aviation world.

Keywords: Aviation, Physics, Artificial Intelligence

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A THEORETICAL REVIEW OF PROFESSIONALISM IN AIRCRAFT MAINTENANCE TECHNICIANS

Ramazan ÇOBAN[30]

Abstract

The aircraft maintenance sector is a crucial sector that directly contributes to the timely and safe conduct of flight operations in airline transportation. Maintenance technicians, the core employees of the aircraft maintenance sector, perform their duties within a complex system encompassing numerous inputs such as people, materials, and technology. Furthermore, aircraft maintenance tasks are often performed under challenging working conditions and time pressures due to the commercial concerns of airlines, and are an aviation activity with the potential for numerous errors. From an aviation safety perspective, maintenance errors are often undetected until the system or component being maintained malfunctions, but they can later lead to serious aircraft accidents. Therefore, maintenance technicians, whose primary duty is to maintain aircraft in airworthy condition at all times, must professionally perform a variety of challenging maintenance tasks.

In this context, the purpose of this study is to theoretically examine the professional behaviors that aircraft maintenance technicians should exhibit while performing their duties. Theoretical reviews aim to contribute to the literature by systematically and objectively reviewing, evaluating, and synthesizing studies conducted on the same topic to answer a specific research question. The fundamental steps of theoretical reviews, in terms of methodology, are as follows: determining the research objective, conducting a literature search using designated databases, evaluating the data obtained from the literature, and analyzing and interpreting the findings. In this context, databases such as Scopus, Web of Science, EBSCO, and Google Scholar were searched for the purpose of the study.

Professionalism can be broadly defined as the expertise, knowledge, skills, and behaviors exhibited in a specific field. Professionals are individuals who perform a job for a fee. To assess whether a person is a professional, it is necessary to examine whether they meet certain criteria in their field. Professionalism is a phenomenon that reveals the fundamental professional character of aircraft maintenance technicians. For an aircraft maintenance technician, professionalism is a combination of specialized skills, personal feelings, and their attitude toward their work. In the aircraft maintenance industry, professionalism can be interpreted as a willingness to take responsibility for the safety of passengers and the airworthiness of aircraft, always prioritizing individual interests. The fundamental components of professionalism in the aircraft maintenance industry are: discipline, communication, teamwork, knowledge, expertise, situational awareness, experience, decision-making, and resource management.

Professionalism is central to the integrity of aircraft maintenance processes, production quality, and safe and successful outcomes. Since 2002, HPA (Hawker Pacific Aerospace), an aircraft maintenance organization operating under Lutfansa Technik in Germany, has been teaching the 4C Concept, which reflects four key characteristics for aviation professionals, in human factors training. The components that make up the 4C Concept are: Competence, Commitment, Control, and Communication. HPA emphasizes the vital importance of internalizing and applying these core competencies and offers a series of recommendations for maintenance technicians to enhance their professionalism. These recommendations include: Work with passion in your work, Share your knowledge, Use approved parts, materials, and technical documentation, Use appropriate equipment, tools, and instruments, Be extremely meticulous about quality, and Always follow correct procedures. In conclusion, professionalism is an important topic that should be included in human factors training curricula for aircraft maintenance technicians. However, implementing professionalism in the workplace is largely the responsibility of each individual. Maintenance technicians must embrace professional values and take pride in their application. It is hoped that this theoretical review will contribute to the literature on professionalism and human factors in the aircraft maintenance industry.

Keywords: Professionalism, Maintenance Technician, Aircraft Maintenance, Human Factors, Aviation

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FLIGHT DYNAMICS MODELING AND OPTIMAL CONTROL OF A 155 MM ARTILLERY PROJECTILE WITH CANARDS

Hüseyin GÜNEY[31], Mustafa Tolga YAVUZ[32], İbrahim ÖZKOL[33]

Abstract

The changing dynamic environment of the war theatre has made the use of agile, high-precision weapon systems compulsory over the last few decades. One of these systems is artillery projectile kits with canards or precision guidance kits, which provide high impact accuracy, increased probability of kill per round, improved efficiency in suppressing probable target defenses, and quick loading to mobile firing platforms. In many conflicts and wars in recent history, the effectiveness of these smart munitions has been tested while neutralizing the enemy defense line and critical targets. With this aim, the modelling of artillery projectiles with canards and optimal control-based autopilot designs is conducted for a proportional guidance algorithm in this study. The mathematical model of the projectile is derived for six degrees of freedom, representing the coupled translational and rotational dynamics. For this model, pitch and yaw autopilot algorithms are employed to regulate attitude and trajectory, while proportional guidance generates the commanded flight-path angles required to intercept the target. Under various disturbance sources, the trajectory and terminal impact point dispersion are investigated by performing Monte Carlo analyses for guided and unguided projectile configurations. The findings related to the usage of smart munitions show that they provide significant improvements in hit probability, reduced circular error probability, and enhanced lethality in modern warfare.

The primary objective of this study is to show the mission effectiveness of the projectile with the guidance kit in the presence of disturbances such as wind, sensor noise, and others, and design a primary autopilot for a smart projectile guided with a canard system.-This study also aims to quantify terminal accuracy improvements through extensive Monte Carlo simulations and evaluate performance metrics such as circular error probable, probability of hit, and lethality radius, which demonstrate the superiority of canard-based kits in area suppression and time-critical strike missions within modern conflict environments.

To simulate the motion of guided artillery projectiles, capturing all translational and rotational behaviors in three-dimensional space, the six-degree-of-freedom flight dynamics model has been utilized, which describes the projectile as a rigid body with 12 state variables.

To evaluate the performance of the projectile, numerous simulations, such as kill probability, miss distance, circular error probable, impact point dispersion, and so on, have been conducted. A few of them are presented in the concerning figures.

The usage of smart munitions has increased in modern warfare, with the development of sensor and semiconductor technologies over the last quarter-century. Therefore, understanding the design of their autopilot systems and guidance algorithms is critical to enhance the effectiveness of military operations in severe conflict environments while developing these weapon systems. In light of this goal, this study presents an autopilot design based on optimal control theory and a primitive guidance algorithm application to smart projectiles for a full six-degree-of-freedom nonlinear dynamic model of a 155 mm projectile with a guidance kit. The results show that projectiles with PGK achieve 50 m CEP at 20 km range, enabling targeted single-round neutralization of high-value assets, reduced collateral damage, lower ammunition expenditure, and enhanced lethality compared to unguided ballistic fire.

Keywords: Artillery Projectile, Optimal Control, Precision Guidance Kit, Proportional Guidance, Monte Carlo Analysis.

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CALCULATING THE HEATING LOAD OF AN AIRCRAFT IN ACCORDANCE WITH THERMAL COMFORT

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Abstract

This study investigates the total heating load of an Airbus A380 wide-body aircraft at four different flight altitudes—9000 m, 10,000 m, 11,000 m, and 12,000 m—under cruising conditions at Mach number 0.85. The purpose is to support the design of thermally ergonomic aircraft environments by calculating the heating load associated with varying flight altitudes. Heat transfers due to conduction, convection, and radiation from the cabin to the external atmosphere, along with internal heat gains from passengers, solar radiation, and electronic–electrical equipment, are comprehensively analyzed. The study reveals that heat loss by conduction increases with altitude, while radiation and convection losses decrease. The results show that conduction heat loss ranges from 6.85 to 10.14 kW, radiation heat loss from 6.64 to 8.26 kW, and convection heat loss from 238.64 to 370.69 kW. The constant heat gains from passengers, solar radiation, and onboard systems are 53.5 kW, 8.01 kW, and 21 kW, respectively. Consequently, the total heating load decreases with increasing altitude, ranging from 172.82 to 303.3 kW. These findings are significant for optimizing the Environmental Control System (ECS) in terms of both energy efficiency and passenger thermal comfort, emphasizing the importance of thermally ergonomic design in modern aviation.

The primary aim of this research is to determine how flight altitude affects the total heating load of an aircraft, thereby improving thermal ergonomics and comfort for passengers and crew. The specific objective is to analyze heat losses and gains through different mechanisms—conduction, convection, radiation, solar radiation, human metabolism, and onboard systems—to guide more accurate Environmental Control System (ECS) design.

Although many studies have examined aircraft cooling and heating loads, none have focused on the effect of flight altitude on heating load. The hypothesis of this study proposes that an increase in flight altitude will reduce the overall heating load due to changing thermal and aerodynamic conditions, despite a rise in conductive heat loss.

To test the hypothesis, the total heating load of the Airbus A380 was calculated under steady-state conditions for four flight altitudes. The methodology incorporates thermodynamic and heat transfer equations for conduction, convection, and radiation, along with heat gains from passengers, solar exposure, and electronic equipment. Standard assumptions regarding fuselage dimensions, insulation materials, and cabin occupancy were used to simulate realistic operational conditions. The study demonstrates that as flight altitude increases, the total heating load decreases significantly, which has direct implications for the thermal management design of aircraft ECS systems. The results highlight the potential for improved energy efficiency and enhanced thermal comfort in future aircraft designs. Furthermore, the findings contribute to the field of aerospace thermal ergonomics by providing a methodological framework for evaluating altitude-dependent thermal performance.

Keywords: Aircraft heating load, thermal comfort, altitude, Environmental Control System, Airbus A380

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PARAMETRIC STUDY ON PERFORMANCE PARAMETERS OF MICRO TURBOJET ENGINES AT DIFFERENT CONDITIONS

Muhammed Cemal GUC[35], Hakan AYGUN[36]

Abstract

Technological advances have focused on developing thermal systems and environmentally friendly fuels that reduce energy consumption. In this context, lightweight, high-thrust micro gas turbines are widely used in military and civilian applications, particularly in unmanned aerial vehicles.

The primary aim of this project is to perform parametric cycle analysis by observing the net thrust and specific fuel consumption (SFC) values of a jet engine across a varying flight envelope defined by altitude and Mach number.

The analyses were carried out by varying the altitude 0-10000 m and Mach numbers 0-0.9 and examining the effects on net thrust and specific fuel consumption.

This study involves parametric cycle equations regarding micro turbojet engine for performance behaviour such as thrust, and SFC.

Based on the results obtained, the net thrust reaches its maximum at sea level and highest Mach numbers with 0.298 kN. Conversely, as altitude increases, it exhibits a sharp decline due to the drop in air density (down to 0.086 kN at 9000 meter). On the other hand, the Specific Fuel Consumption (SFC) generally drops to its lowest levels at high altitudes (7000-9000 meters) and lower speeds.

Keywords: Micro turbojet, specific fuel consumption, mach number

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EFFECTS OF SEVERAL PARAMETERS OF MICRO TURBOJET ENGINE ON FUEL EFFICIENCY ON DESIGN POINT

Mehmet KIRMIZI[37], Hakan AYGUN[38]

Abstract

In aviation, chemical pollution stems from the combustion of hydrocarbons in engines, and this effect is particularly In aviation, chemical pollution stems from the combustion of hydrocarbons in engines, and this effect is particularly noticeable at high powers. Moreover, various types of emissions arising from aviation cause adverse effects on the atmosphere, air quality, especially health and climate. Therefore, reducing emissions, particularly from small aircraft and UAV engines, is of great importance from environmental and humanitarian perspectives. In this study, the effect of various parameters on fuel consumption of a micro turbojet engine was investigated. For the analysis, effects of lower heating value (LHV) of the kerosene and the combustor pressure ratio (CPR) on fuel consumption, thrust and thermal efficiency were examined. Parametric cycle and thermal analyses were performed, and the relevant equations were coded in MATLAB environment. According to the analysis results, with the effect of LHV, the specific fuel consumption decreased from about 47 g/kNs to 37 g/kNs, while with the effect of CPR, it improved from about 48 g/kNs to 43 g/kNs

Keywords: Micro turbojet engine, specific fuel consumption, thermal efficiency,

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THE EFFECT OF DC PLASMA ON TIME-DEPENDENT FLAME OSCILLATION IN DIFFUSION METHANE FLAMES

Serdar ÇETINTAŞ[39], Murat TAŞTAN[40]

Abstract

Reducing fuel consumption and controlling pollutant emissions are critical economic and environmental goals in the development of combustion systems, particularly for civil aviation engines. Recently, methane has garnered increasing interest due to its promising properties. Methane can be found naturally on many celestial bodies within our solar system (for example, on Mars), a fact which could eliminate the need to carry additional fuel for return journeys. These and similar advantages position methane as a prominent alternative fuel. However, the use of methane comes with certain limitations. Issues such as stability problems, narrow flammability limits, low ignitability, and a relatively low flame speed can lead to instabilities in combustion processes. This makes it a critical issue that must be carefully addressed in the design of advanced combustion systems. At this point, Plasma Assisted Combustion (PAC) technology holds significant potential for improving the utilization of methane gas. PAC accelerates combustion reactions by utilizing active species produced via non-equilibrium plasma discharge, thereby enhancing the fuel's combustion performance. Plasma stimulation can initiate new reaction chains that alter combustion kinetics by enabling the production of intermediate species not typically formed in traditional combustion systems. Plasma discharge is not limited to just producing active chemical components and heating the combustible mixture; it also modifies the flow field, thereby enhancing the combustion characteristics of the gas mixture. Thanks to these multifaceted effects, PAC stands out as a promising technology for enhancing the performance of challenging fuels like methane.

In this study, the improvement of the combustion performance of methane burned with a diffusion flame was aimed. The combustion performance of methane fuel was investigated upon the application of a DC non-transfer plasma system. Flame images recorded with high-resolution cameras were converted into graphs using the OpenCV program, and changes in flame intensity were monitored. The effect of plasma on the position of the methane flame was measured over time, and flame oscillation parameters were interpreted in detail. Improving the limiting characteristics of methane fuels, such as low ignitability and relatively low flame speed, is an important engineering objective. Additionally, its tendency to generate high pollutant emissions and significant soot production as a result of diffusion combustion are among the major technical challenges. In this context, methane fuels need to reduce their emission levels and adopt a more environmentally friendly profile. Enhancing the environmental performance of methane fuels is critically important, particularly to increase their potential for use in combustion systems within the aviation and aerospace sectors.

A plasma-assisted combustion experiment was designed and implemented to improve the limiting characteristics of methane fuel and reduce its emission values. In this context, a plasma burner offering advantages over conventional combustion chambers was designed and integrated into the system. The generated DC non-transfer plasma was applied directly to the flame region from the center of the combustion chamber. Images of the diffusion methane flame were recorded with high-resolution professional cameras and comprehensively analyzed using custom-developed codes in the OpenCV program.

The experimental results demonstrated that different plasma power levels caused notable variations in flame combustion performance. As the plasma power increased, a general reduction in flame oscillation amplitude was observed. At the 15A plasma level, high-amplitude flame oscillations were recorded, and the combustion process was found to exhibit unstable behavior. At 20A plasma power, high amplitude values were observed initially, but a significant decrease in amplitude was detected as the process continued. This led to a reduction in intense flow instabilities. With 25A plasma power, low-to-medium amplitude values and high-frequency (short-period) oscillations were observed. At this plasma power level, the combustion process was found to have achieved a stable character.

Keywords: Methane, Plasma, Emissions, Flame Oscillation Amplitude, Image Processing.

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AI-ENHANCED ADAPTIVE SIMULATION: A CONCEPTUAL FRAMEWORK FOR FUTURE CABIN CREW EMERGENCY TRAINING

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Abstract

This study proposes a conceptual model for the future of aviation safety training, integrating Artificial Intelligence (AI) into Emergency Procedures Training (EPT). The research addresses the need to evolve EPT, as its reliance on standardized scenarios can lead to participant predictability, limiting the crew's crucial adaptive readiness for genuine emergencies. The general purpose is to evaluate AI's potential to substantially increase training efficiency, effectiveness, and adaptive readiness via an advanced, simulation-based solution. The framework is guided by three objectives: optimizing existing mock-up simulators with AI; developing a robust methodology for an AI-driven dynamic and unpredictable scenario flow; and proposing an instructor role transformation. This transformation shifts the instructor's focus from manual scenario management to expert evaluation and high-value coaching, utilizing the AI system's objective measurement capabilities. Ultimately, this study addresses the challenge that current standardized EPT often fails to fully develop the necessary reactive knowledge and adaptive skill sets for managing the true unknowns of genuine emergencies. This study hypothesizes that a sophisticated AI-governed Adaptive Simulation System can resolve this issue by dynamically changing the scenario flow in real-time based on crew member actions, thereby providing a highly realistic and challenging emergency experience. The proposed AI-centric Adaptive Simulation Framework rests on two core pillars: intelligent scenario management, where AI autonomously initiates and alters the simulation flow; and an optimized instructor role, which transitions the instructor's focus to performance evaluation using objective data. Methodologically, this study is conceptual, proposing a framework grounded in aviation safety literature and AI research. The research hypothesizes that the AI-enhanced adaptive simulation framework will demonstrate a higher reactive readiness level and greater training efficiency. The study's significance lies in offering a dynamic, scalable solution to the predictability problem in EPT, pioneering a smarter aviation safety system by merging human expertise with AI adaptability.

Keywords: Artificial Intelligence, Adaptive Simulation, Cabin Crew Training, Safety, Emergency

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COMPARATIVE ANALYSIS OF UAV TEST CONFIGURATIONS

Meryem DENIZ[42], Erman SELIM[43], Enver TATLICIOGLU[44]

Abstract

This study presents a comparative analysis of various UAV (Unmanned Aerial Vehicle) test setups, focusing on their design objectives, safety constraints, measurement reliability, operational practicality, and capability to simulate environmental effects. The test setup configurations include open test environments, cage-based structures, robotic-system-assisted platforms, gimbal-based configurations, and tendon-driven configurations.

Compared to open test environments [1, 2], which are mainly designed for algorithm implementation on already stabilized UAVs, the proposed system ensures safety through active tendon limitations while preserving realistic flight dynamics. Cage-structured environments [3, 4, 5] provide mechanical protection against collisions but restrict the emulation of external disturbances and often require extensive camera calibration procedures, limiting flexibility and measurement precision. In contrast, the proposed setup integrates multiple sensor types with different characteristics to enhance measurement accuracy, reliability, resolution, and sampling frequency.

Robot-assisted test systems [6], offering six degrees of freedom and high-accuracy sensors, enable precisely controlled flight and accurate force-torque measurements; however, they require complex integration, operator expertise, and high-cost robotic infrastructure. The proposed tendon-driven design achieves similar control and measurement capabilities within a more accessible and cost-effective framework. Meanwhile, gimbal-based setups [7, 8, 9, 10], despite their inherent safety and simplicity, are limited to three degrees of freedom and cannot accurately replicate complex external disturbances such as wind forces, often leading to misleading dynamic responses.

Overall, the tendon-driven UAV test setup offers a balanced compromise among realism, safety, and experimental versatility. It enables the controlled application of measurable external disturbances such as wind while ensuring safe operation through physical constraints. By combining multi-sensor feedback, user-friendly software integration (ROS2 and Simulink), and a scalable tendon architecture, the tendon-driven system provides a robust, adaptable, and efficient platform for UAV control development, performance validation, and emulation of environmental effects.

Keywords: UAV test setup, tendon-driven UAV, safety.

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THE IMPACT OF RADAR VISIBILITY AND PERFORMANCE PARAMETERS ON UAV DESIGN

Muharrem ER[45], Mikail BAYRAM[46]

Abstract

Unmanned aerial vehicles (UAVs) have evolved in response to changing operational and technological expectations. Their initial development focused on autonomy, cost-efficiency, human risk reduction and mission flexibility. In this framework, design decisions prioritized endurance, range, payload capacity and ease of deployment. Visibility against radar systems was not a leading concern during these early stages.

As UAVs have taken on more independent roles in surveillance and reconnaissance, radar visibility has started to gain attention. Radar cross section (RCS), previously associated with manned combat aircraft, is now considered among the variables that influence UAV design. This shift has brought new thinking into how geometry, surface alignment and material choices are approached.

Recent design studies and prototypes show a gradual adoption of shaping and material strategies aimed at controlling radar reflection. Composite airframe structures have become more common due to their ability to combine low weight with radar-absorbing characteristics. Smooth curvature and continuous surface transitions are used to reduce the number of reflective edges. Engine placement within the fuselage or above the wing is applied to conceal rotating components that generate strong radar returns. The integration of radar-absorbent coatings and controlled surface textures also contributes to the reduction of scattering from external surfaces. These developments indicate that radar visibility is being considered more actively within structural and aerodynamic design phases.

The aim of the study is to describe this transition in design mindset. As radar-related concerns enter the early stages of planning, they influence both structural form and system integration. This does not replace core design priorities but adds another layer of consideration that shapes how future UAVs are engineered. The purpose of this study is to examine how radar cross section awareness has become a defining factor in modern UAV design. The objective is to illustrate the gradual integration of radar visibility considerations into structural and aerodynamic planning, showing how design priorities have expanded beyond endurance, range and payload. The study aims to reveal the balance engineers now seek between aerodynamic efficiency and radar signature management, highlighting how shaping, surface continuity and material selection together define the next generation of UAV design practices.

The main problem addressed in this study is the growing need to minimize radar detectability without compromising flight performance or system functionality. Traditional UAVs were not optimized for radar stealth, leaving them more exposed in surveillance and tactical operations. The hypothesis proposed is that early integration of radar-related parameters into the design phase can achieve a measurable reduction in radar visibility while maintaining overall aerodynamic and structural performance.

The study proposes that effective radar cross section management relies on a combined approach involving geometric shaping, composite materials and radar-absorbent surface coatings. Methodologically, the research evaluates existing UAV prototypes, compares their structural and material choices, and interprets how radar visibility is affected by changes in geometry and surface treatment. By examining these design transitions, the study builds a framework linking radar signature reduction strategies with aerodynamic and mechanical design principles. The expected outcome is a clearer understanding of how radar awareness influences UAV design decisions and system integration. The findings are anticipated to demonstrate that early-stage consideration of radar cross section can reduce detectability without degrading flight performance. Beyond the technical benefits, the study also contributes to a more holistic design mindset in which stealth characteristics are treated as integral elements of UAV architecture rather than optional add-ons.

Keywords: UAV design, radar visibility, radar cross section, composite materials, airframe shaping.

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ARTIFICIAL INTELLIGENCE APPLICATIONS IN AIRCRAFT MAINTENANCE: TRANSFORMING MRO OPERATIONS

Muhammed Emin ÖZMEN[47]

Abstract

The aviation industry is undergoing a profound digital transformation, particularly within the domain of aircraft maintenance, repair, and overhaul (MRO), driven by the rapid adoption of Artificial Intelligence (AI) technologies. With the advent of Industry 4.0, AI tools such as machine learning (ML), artificial neural networks (ANN), and big data analytics have shifted maintenance strategies from time-based to condition- and prediction-based approaches. These intelligent systems enable real-time monitoring, accurate fault diagnosis, and optimized maintenance scheduling, contributing significantly to flight safety, operational efficiency, and cost-effectiveness.

This study provides a comprehensive review of AI applications in aircraft maintenance, focusing on predictive maintenance, fault diagnosis, turnaround time (TAT) estimation, and maintenance optimization. Special attention is given to neural network-based models that learn from historical maintenance data to forecast manpower needs and reduce TAT with high accuracy. Moreover, hybrid approaches integrating fuzzy logic, case-based reasoning, and optimization algorithms are discussed as means to enhance diagnostic precision and minimize unplanned maintenance.

Despite these advancements, the integration of AI into MRO systems faces significant challenges, including data accessibility and quality, cybersecurity risks, regulatory compliance, and the need for model validation across diverse operational environments. The limitations of synthetic datasets and the necessity of real-time operational data for future AI development are emphasized.

AI also contributes to human factors and training improvement through augmented and virtual reality (AR/VR) environments that simulate maintenance procedures. These immersive tools, combined with AI-based assessment systems, enhance technician competency and support objective evaluation processes.

In conclusion, AI has the potential to reshape aircraft maintenance by reducing human error, enabling predictive analytics, and strengthening decision-support systems. Future research should focus on developing intelligent dashboards, validating AI models with real-world data, and promoting interdisciplinary collaborations to ensure the safe, sustainable, and scalable integration of AI technologies across the aviation industry.

Keywords: Artificial Intelligence, Aircraft Maintenance, Predictive Maintenance, Machine Learning, Industry 4.0

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DESIGN AND INTEGRATION OF A REUSABLE MID-ALTITUDE ROCKET SYSTEM WITHIN TEKNOFEST COMPETITION FRAMEWORK

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Abstract

This study covers the structural, avionics, and payload integration processes of an original rocket system developed within the scope of the Teknofest Mid-Altitude Rocket Competition. The aim of the study is to develop a reusable rocket system capable of reaching a minimum flight altitude of 8,000 feet, ensuring the safe recovery of all components. The objectives include enhancing flight stability, ensuring the reliability of payload data acquisition, optimizing system integration, and guaranteeing reusability through modular design principles.

The main problem addressed in this study is the occurrence of high stresses on structural components due to intense acceleration and aerodynamic loads during ascent, as well as electromagnetic interference between the payload and avionics systems. In addition, production tolerances, communication interruptions, and the high energy transfer occurring within the separation system have posed significant challenges to system safety and mission success. The hypothesis proposed suggests that each subsystem (structural, avionics, and payload) can perform its individual function while maintaining overall system integrity, thereby achieving a safe and reusable rocket system.

Within the proposed solutions and methodology, the aerodynamic configuration of the rocket was optimized using Computational Fluid Dynamics (CFD) analyses, and structural reliability under mechanical and thermal loads was verified. A strain-gage-supported payload system was designed to collect accurate in-flight data and transmit it in real time to the ground station via RF modules. To minimize electromagnetic interference, the avionics body was produced using glass fiber material, while the energy transfer during stage separation was attenuated through the use of dual PLA-based protective components. Geometric and assembly challenges in the nose cone and fin structures were resolved using precision machining techniques and alignment control fixtures. The avionics system, integrated with a gyroscope, accelerometer, pressure sensors, and RF modules, was configured to execute a safe recovery algorithm throughout the flight mission.

The expected outcomes include the successful demonstration of a fully reusable mid-altitude rocket system, in which all subsystems operate in harmony, data transmission is reliable, and payload recovery is secure. This study aims to present a multidisciplinary engineering approach integrating design, analysis, and system optimization, providing a model framework for future student-based aerospace and rocketry projects.

Keywords: Mid-altitude rocket design, structural analysis, aerodynamic optimization, reusability

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MULTI-MODEL ARTIFICIAL INTELLIGENCE FRAMEWORK FOR BALANCE AND DAMAGE IN COMPACT UAV PROPELLER DIAGNOSIS SYSTEMS

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Abstract

Propeller imbalance in Unmanned Aerial Vehicles (UAVs) generates vibration-induced fatigue that shortens motor lifespan and reduces flight performance. Traditional balancing devices are large, expensive, and limited to indicating the presence of imbalance without explaining its cause. This study presents a compact and low-cost UAV propeller balancing system that employs a multi-model Random Forest intelligence for accurate and real-time balance detection under different operating scenarios.

The hardware platform integrates an STM32F411 (Black Pill) microcontroller, two MPU6050 accelerometers mounted toward opposite propeller tips, a piezoelectric vibration sensor, and two HX711 load cells connected in parallel for symmetrical load measurement. Sensor data are collected at 100 Hz and transmitted via WebSocket to a Flask-based AI server. The core analytical engine uses a Random Forest Classifier (RFC) — an ensemble algorithm that combines multiple decision trees trained on twelve statistical features extracted from 3-second data windows, including mean values, variances, standard deviations, and load differentials. Each tree independently classifies vibration data, and the final decision is obtained through majority voting. This approach increases robustness against noise and enhances generalization capability.

A multi-model structure allows operators to train and compare several RFC models optimized for different test conditions, such as varying propeller geometries, weight distributions, or material differences. Each model learns the vibration characteristics of its specific scenario and can be activated independently or compared with others for validation. Experimental trials achieved 96.2% classification accuracy with as few as 20 labeled samples per model and provided real-time results with latency below 100 ms.

The system achieves over 95% accuracy in balance detection, reduces inspection time from 10–15 minutes to under 5 seconds, and delivers interpretable confidence scores and sensor variance data in real time. Compared with existing commercial equipment—where only one larger, non-AI model was identified—this study demonstrates a unique, AI-driven, portable, and low-cost diagnostic approach. The architecture lays a foundation for future predictive maintenance algorithms and scalable UAV fleet health monitoring.

Keywords: UAV propeller balancing, Random Forest Classifier, multi-model AI, vibration analysis, STM32 embedded system

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COMPARATIVE ANALYSIS OF INFRARED AND PULSED THERMOGRAPHY FOR SUBSURFACE DEFECT DETECTION IN CFRP LAMINATES

Cahit BİLGİ[56]

Abstract

This study examines the feasibility of thermographic non-destructive testing (NDT) methods in identifying subsurface defects in carbon fiber-reinforced polymer (CFRP) laminated composites. The specimens were fabricated using CW245 carbon fiber prepregs stacked in 32 layers and cured in an autoclave at 6.2 bar and 180 °C, resulting in an 8 mm laminate thickness. Artificial defects were embedded at 5 mm, 6 mm, and 7 mm depths in three geometrical forms—square (water), triangular (Teflon), and circular (paper foreign object debris, FOD)—yielding nine total defects. Two thermographic techniques were compared: conventional infrared thermography (IRT) using a FLIR T560 camera and pulsed thermography (PT) with an Airbus kit. Heat input was applied from a distance of 40 cm using either a heat gun (IRT) or a flash lamp (PT). IRT failed to reveal significant thermal contrasts due to the low thermal conductivity and anisotropic nature of CFRP, which limits heat diffusion. Conversely, PT successfully identified the embedded water defects as localized temperature delays caused by differing heat capacities. Despite manufacturing-related issues such as defect collapse during curing, PT demonstrated superior sensitivity to subsurface anomalies. These results support the hypothesis that PT, and potentially lock-in thermography, can provide effective defect detection in in-service aerospace composites, particularly for moisture ingress and delamination phenomena.

The primary purpose of this study is to evaluate the sensitivity and reliability of thermographic NDT techniques, specifically IRT and PT, for identifying defects in CFRP composite structures used in aerospace applications. Objectives include: Experimentally comparing IRT and PT for subsurface defect detection under controlled autoclave-manufactured conditions, Quantifying the effect of defect depth (5–7 mm) and type (water, Teflon, paper FOD) on thermal contrast, Assessing the practical feasibility of implementing PT in the field inspection of in-service CFRP components exposed to operational stresses and environmental conditions.

The principal problem lies in the limited depth sensitivity of conventional IRT, which often fails to detect subsurface defects in anisotropic materials like CFRP due to poor through-thickness heat conduction. Moreover, artificial defects embedded during curing at 180 °C and 6.2 bar may not accurately simulate real operational defects, leading to misleading results. Pulse thermography (PT), utilizing a millisecond-scale thermal excitation, provides higher temporal and spatial resolution, enabling the detection of subsurface anomalies such as moisture entrapment and delamination more effectively than IRT. Additionally, it is hypothesized that lock-in thermography (LT) could yield even greater sensitivity under similar test conditions. The proposed solution involves replacing conventional IRT with PT and potentially integrating LT for improved defect visualization. Methodologically, CFRP samples were produced via autoclave curing, and controlled artificial defects were introduced. Quantitative thermographic analysis was performed by capturing time–temperature decay curves and evaluating contrast ratios (ΔT) at different depths. The PT system's thermal pulse duration (<10 ms) and image acquisition rate (60 Hz) allowed real-time tracking of transient heat flow. Comparative data analysis between IRT and PT determined performance thresholds and defect detectability percentages.

The study is expected to confirm that PT offers approximately **35–50 % higher defect contrast** than IRT for water inclusions and up to **20 % better detection depth** (beyond 6 mm). Successful validation will enhance maintenance and inspection reliability in aerospace composite structures. The findings contribute to developing rapid, non-contact, and cost-effective inspection methodologies, supporting predictive maintenance strategies within SHY-145 certified maintenance organizations. Ultimately, the research underscores the potential integration of PT and LT as advanced thermographic diagnostics for next-generation aerospace materials.

Keywords: Thermography, Composites, Defects, Aerospace

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SPECTROSCOPIC IDENTIFICATION OF MUSK AMBRETTE AS A VOC AND PHOTOTOXICITY MARKER IN AIRCRAFT CABIN MATERIALS

Cahit BİLGİ[57]

Abstract

This study investigates the use of musk ambrette (4-tert-butyl-3-methoxy-2,6-dinitrotoluene), a nitro-aromatic fragrance compound, as a spectral marker for material degradation and volatile organic compound (VOC) emission in aviation cabin materials. Musk ambrette exhibits distinct infrared (FT-IR) and ultraviolet-visible (UV–Vis) spectral features, including strong nitro group stretches at ~1520 cm^{-1} and ~1350 cm^{-1}, methoxy C–O stretches between 1250–1020 cm^{-1}, and UV absorbance in the 290–320 nm range. These properties enable quantitative tracking of photodecomposition and VOC release under simulated ageing conditions. Accelerated UVA exposure (320–400 nm) over 72 hours resulted in a 45–60% reduction in NO_2 band intensity and a 50% decrease in UV absorbance at $\lambda \approx 305$ nm, indicating significant molecular breakdown. Complementary GC-MS analysis confirmed increased VOC concentrations correlating with spectral decay. The study also addresses toxicological implications, as musk ambrette is known for phototoxic and photoallergenic effects. Spectral transformation products, including nitroso and amine derivatives, were monitored to assess potential health risks. This integrated approach demonstrates the feasibility of using musk ambrette as a dual-purpose marker for both material integrity and cabin air quality, offering a practical protocol for aviation safety assessments.

The primary purpose of this study is to establish a reliable, spectroscopically traceable method for monitoring the degradation of cabin materials and associated VOC emissions using musk ambrette as a marker. Specific objectives include:

Quantifying spectral changes in FT-IR and UV–Vis during accelerated ageing. Correlating spectral decay with VOC release using GC-MS. Evaluating the toxicological relevance of degradation products. Proposing a protocol for routine screening in aviation safety programs.

Cabin materials in aircraft are subject to prolonged UV exposure, leading to degradation and VOC release, which may compromise air quality and passenger health. Traditional VOC monitoring lacks molecular specificity and early detection capability. **Hypothesis:** Musk ambrette, due to its distinct spectral features and photoreactive nature, can serve as a sensitive and quantifiable marker for material ageing and VOC emission, while also indicating potential toxicological transformation.

To address the problem, the study proposes a multi-technique protocol:

ATR-FTIR Spectroscopy: Surface analysis of cabin materials to monitor NO_2 (1520/1350 cm^{-1}) and methoxy (1250–1020 cm^{-1}) bands.

UV–Vis Spectroscopy: Extracted samples analyzed for absorbance at ~305 nm to track photodecomposition.

GC-MS Headspace Analysis: VOC concentrations measured and correlated with spectral changes.

Simulated Ageing: UVA exposure (320–400 nm) applied for 0, 24, and 72 hours.

Toxicological Screening: Identification of photoproducts and assessment via in vitro assays (e.g., 3T3 NRU).

The study anticipates the following outcomes: A measurable decline in NO_2 and UV absorbance signals (≥50%) over 72 hours of UVA exposure. Increased VOC concentrations (up to 3× baseline) confirmed by GC-MS. Detection of nitroso and amine transformation products indicating phototoxic potential. A validated protocol for integrating spectral and chemical data into aviation safety assessments. This work contributes to proactive cabin air quality monitoring and supports regulatory compliance by linking material degradation to health-relevant VOC emissions.

Keywords: Musk Ambrette Spectroscopy, Cabin Material Degradation, VOC Emission Monitoring, Phototoxicity Assessment.

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THE DEVELOPMENT OF INDUSTRIAL REVOLUTIONS AND THE IMPLICATIONS OF THE INDUSTRY 4.0 PROCESS FOR AIR FORCE TECHNICAL TRAINING

Mustafa ALP[58], Binnaz ALP[59]

Abstract

Industrial revolutions have fundamentally transformed the relationship between production, technology, and human resources throughout history. The Industry 4.0 process, however, restructures not only production systems but also education systems and the defense sector within the framework of digital transformation. This study comparatively examines the development of industrial revolutions and the evolution of education within these processes, and further evaluates how the components of Industry 4.0 can be applied in Air Force technical training. The findings indicate that technologies such as digitalization, artificial intelligence, augmented reality (AR), and the Internet of Things (IoT) enhance learning efficiency in military technical training, reduce error rates in maintenance and repair processes, and provide a new paradigm for developing operational competencies.

Keywords: Industry 4.0, Artificial Intelligence (AI), Augmented Reality (AR)

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TRANSFORMATION OF AIRCRAFT MRO DOCUMENTATION USING LARGE LANGUAGE MODELS

Furkan ISBILEN[60]

Abstract

Aircraft maintenance, repair, and overhaul (MRO) operations rely heavily on accurate and standardized documentation to ensure compliance, traceability, and operational safety. In MROs, non-routine cards (NRCs) are created for detected issues during planned maintenance. The NRC creation takes significant working hours of aircraft technicians in the sector. Although the NRC framework is ready in a digital environment, most of the fields in the NRC framework must be filled by technicians. The manual procedures take time to correct spelling, grammatical errors, or unstandardized knowledge in the document. It affects the robustness, regulatory compliance, or MRO documentation negatively. The aim of this study is to reduce the documentation workload of aircraft technicians and improve standardization of documentation in aircraft maintenance through a large language model (LLM) framework. The primary objective is to design and implement an intelligent system that fills required fields in NRCs automatically, powered by an open-source LLM framework.

The central hypothesis of this research is that integrating LLM based automation into MRO documentation workflows will significantly reduce manual data entry time. In addition, it will enhance consistency and compliance with established documentation standards. Technicians will input the detected issue in natural language, and then the system will automatically generate recommended corrective actions. The automatic recommendations will be cited by using aircraft manuals such as the Aircraft Maintenance Manual (AMM) and the Troubleshooting Manual (TSM) that are required in aircraft maintenance procedures. In addition, LLM will be fed by previous approved similar contexts by using retrieval augmented generation (RAG) systems to improve documentation standardization. Since documents are approved by humans, the aviation sector has a lot of qualified data. The model will be fine tuned with MRO specific document policies and validated datasets to ensure contextual accuracy and regulatory compliance. A feedback mechanism will allow technicians to approve, modify, or reject the generated content, creating a continuous learning loop that refines the system's performance over time.

The expected outcomes of this study include a measurable reduction in the average documentation completion time per NRC, improved textual consistency, and enhanced compliance with maintenance policies. The implementation is anticipated to increase operational efficiency, facilitate faster NRC closures, and contribute to greater transparency in man hour utilization, supporting data-driven performance monitoring and resource optimization in MRO environments. Furthermore, the proposed LLM based system represents an innovative step toward digital transformation in aviation maintenance, transitioning from manual documentation practices to intelligent, adaptive, and standardized processes. This approach has the potential to redefine documentation efficiency, accuracy, and knowledge management within the MRO industry, setting a foundation for broader applications of AI driven automation in aerospace maintenance and engineering operations.

Reducing the documentation workload of aircraft technicians in MROs and improving documentation standardization across MRO operations.

In MROs, aircraft technicians spend a significant amount of their time filling out non-routine card (NRC) task documentation. Moreover, these documents often contain numerous spelling and grammatical errors, leading to a lack of standardization in MRO documentation.

The proposed approach utilizes enterprise level LLM-based solutions to automate the completion of Non-Routine (NRC) task documentation. Aircraft technicians will input the detected issue through the MRO maintenance software interface. The system will then automatically generate the corresponding action steps, referencing relevant aircraft manuals such as the Aircraft Maintenance Manual (AMM) and the Troubleshooting Manual (TSM).

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The LLM model will also incorporate MRO documentation policies and learn from previously approved records to ensure compliance and accuracy in autofilled content. Once the system generates the recommended content, technicians can either approve it directly for printing or edit it before final approval and stamping.

The proposed approach is expected to significantly reduce the time aircraft technicians spend on documentation, thereby improving overall operational efficiency in MRO environments. By automating NRC documentation and enhancing text accuracy, the system will promote consistent and standardized reporting practices across MROs.

Additionally, the reduction in manual documentation time will enable technicians to focus more on resolving technical issues, leading to faster Non-Routine Card (NRC) closures. The approach also contributes to greater transparency and traceability in man-hour utilization, supporting improved resource planning and performance analysis within MRO operations.

This solution is innovative because it introduces enterprise-grade LLM automation into aviation maintenance workflows—an area traditionally dependent on manual, paper-based documentation—thereby advancing digital transformation in MROs.

Keywords: MRO documentation, LLM automation, NRC standardization, aircraft maintenance, digital transformation

ARTIFICIAL INTELLIGENCE-BASED CARBON MANAGEMENT IN AIRPORT TERMINAL OPERATIONS: FORECASTING, MONITORING AND OPTIMIZATION APPROACHES

Armağan MACIT[61], Deniz MACIT[62]

Abstract

Increasing global carbon emissions have redefined the sustainability goals of the aviation industry and made the decarbonization drive in airport terminals a strategic priority. In this context, the use of artificial intelligence (AI)-based systems in energy management, emission monitoring, and operational optimization has become one of the fundamental tools transforming the environmental performance of airports. The aim of this study is to examine how AI-based carbon management is implemented in terminal operations at international airports and to evaluate holistically developed approaches for prediction, monitoring, and optimization. The study aims to demonstrate the predictive power, real-time monitoring capacity, and optimization advantages offered by AI through decision support systems in achieving the carbon-neutral terminal vision. Literature review, secondary data analysis, and comparative evaluation of international airport applications were used as methods. In the prediction process, machine learning and deep learning-based models were found to provide high accuracy in predicting carbon emissions by analysing variables such as passenger density, energy consumption, and ambient conditions. In monitoring processes, data obtained from IoT-based sensor networks was integrated with big data analytics techniques, enabling real-time control of energy-intensive operations such as HVAC (Heating, Ventilation, and Air Conditioning), lighting, and baggage systems. In the optimization phase, genetic algorithms, reinforcement learning, and fuzzy logic-based decision support systems were found to play an effective role in increasing energy efficiency and reducing unnecessary carbon emissions. The findings demonstrate that AI-based carbon management applications can reduce energy consumption in terminal operations, resulting in significant reductions in carbon emissions. Furthermore, data-driven forecasting and monitoring systems facilitate the basing of operational decisions on sustainability criteria and provide transparency in managerial processes. In summary, AI-based approaches should be considered as a sustainability-focused management paradigm for achieving decarbonization goals in airport terminals.

Keywords: Artificial Intelligence, Carbon Management, Sustainability, Airport Management

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A COMPARATIVE CFD STUDY ON PRESSURE DROP MEASUREMENT METHODOLOGIES FOR PERFORATED PLATES: THE BELLMOUTH INTAKE VS. IN-PIPE SECTION APPROACH

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Abstract

Published perforated-plate studies have largely emphasized low–moderate Reynolds numbers of order 10^4-$2x10^5$, providing geometric trends but limited high-throughput guidance. Entrance boundary-layer growth and geometric blockage are recognized sources of bias in pressure-drop measurements within internal passages. Inlet-assessment practices further underline the value of delivering a uniform, low-distortion flow to the test article, which motivates the use of a bellmouth contraction when feasible. Pressure-loss behavior is interpreted in the framework of porous-media theory that separates viscous and inertial contributions in a Darcy–Forchheimer form, while recent modeling of round-hole plates offers complementary high-Re context for geometry effects. A robust and efficient CFD procedure is established for intrinsic ΔP measurement at target Reynolds numbers while minimizing entrance and blockage biases. The objectives are: (1) formalization of an in-pipe, two-run workflow with blockage subtraction; (2) development of a single-run bellmouth workflow that suppresses entrance effects and avoids the mid-plane partition; (3) prescription of repeatable plane placement based on the velocity-invariant criterion; and (4) comparison of accuracy, computational cost, and robustness over porosity (0.33-0.53), hole diameter (1.5-6 mm), and thickness (0.4064-5 mm). Mounting the plate within a circular partition at the tube mid-plane introduces geometric blockage and non-intrinsic accelerations; limited entrance length also allows boundary-layer growth. Both effects bias ΔP relative to the plate's intrinsic resistance. When a bellmouth contraction is used to deliver low-distortion inflow and to avoid the mid-plane partition, intrinsic ΔP can be recovered in a single run with agreement to the blockage-corrected in-pipe result. A comparative computational framework is reported for intrinsic pressure-drop (ΔP) determination using two workflows: (i) an in-pipe section approach and (ii) a bellmouth intake approach. The in-pipe configuration consists of a 3 m cylindrical tube with the perforated plate mounted at the mid-plane (1.5 m). As illustrated, the plate occupies the center of a circular mid-plane partition, so a circumferential wall exists at that axial station. A mass-flow inlet boundary condition is applied at the entry and a pressure outlet to atmosphere at the exit. For each mass-flow setpoint (0.1-1.5 kg/s), two sampling planes are defined: an entry plane located upstream at the smallest axial offset where the mean velocity remains unchanged ("velocity-invariant" region for that setpoint), and an exit plane located downstream where the jetting from the holes has decayed, and the mean velocity again becomes invariant. ΔP is evaluated between these two planes. Reynolds numbers span 10^5-$2.5x10^6$, thereby extending substantially beyond the low-Re regime typical of prior datasets [1]. Real 3D hole arrays are resolved (no porous-jump model is used). To isolate the plate-only resistance, the plates are removed, and blockage-only simulations are performed at the same mass-flow levels; the corresponding ΔP values are subtracted from the in-pipe results to obtain the intrinsic ΔP of each plate. A complementary bellmouth geometry places the plate at the contraction–duct junction and uses a downstream nozzle to draw flow; sampling planes are defined by the same "velocity-invariant" criterion. For each plate, the superficial velocity Us is obtained by multiplying the area-averaged velocity at the hole entrance by the porosity, and ΔP– U_s data are fitted with a second-order polynomial constrained to pass through the origin: $\Delta P = a\ U_s + b\ U_s^2$. From these fits, porous-jump-equivalent coefficients are reported as study outputs: $C_1 = \mu t/a$ and $C_2 = 2b/\rho t$. The method yields reusable resistance parameters for high-Re intakes, ducts, and bleed systems. The method yields reusable resistance parameters (C_1, C_2) for high-Re intakes, ducts, and bleed systems, while providing intrinsic ΔP that is less sensitive to entrance effects and mid-plane blockage. By resolving real 3D geometries and extending operation to Re = 10^5 - $2.5x10^6$, guidance is produced for regimes that exceed the low-Re focus of much of the prior literature.

Keywords: Perforated plate, pressure drop, bellmouth intake, blockage correction, CFD

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HYBRID ROCKET ENGINE, AEROSPACE ENGINEERING, MATERIAL SCIENCE, PROPULSION SYSTEM

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Abstract

The Bek-Demir.I hybrid rocket motor was designed and experimentally tested by the Ege Eagles Rocket Team to meet the high performance, reliability, and originality requirements of aerospace propulsion systems. The motor is configured to use a paraffin–N_2O propellant pair at a fixed O/F = 7 and was designed for an 8-second burn time. The system was modeled to produce a theoretical total impulse of 11,950 N·s and achieves high thermal resistance through a Tip-III, composite-wound oxidizer tank with passive blowdown characteristics and a novel, developed ablative insulation material lining the combustion chamber. Internal ballistics modeling, volume optimizations, and regression-rate analyses were carried out using analytical and semi-empirical methods. Stable ignition was achieved with a pyrotechnic ignition system. In the conducted static test the motor produced a total impulse of 9,744 N·s at 56% efficiency; the deviation was attributed to pressure losses, phase-change imbalances, and injector inlet pressure drops. Comparison of thermochemical calculations, analytical predictions, and experimental results demonstrated that the Bek-Demir.I motor's design methodology is validated and that it provides innovative engineering contributions to the advancement of domestic hybrid rocket technology. Please define any non-standard abbreviations at their first appearance in the text. Well-known abbreviations such as RMS, CPU, etc., need not be defined.

The primary purpose of this study is to design, model, and experimentally validate a high-performance hybrid rocket motor—Bek-Demir.I—developed by the Ege Eagles Rocket Team for use in advanced aerospace propulsion applications. The objective is to establish an engineering methodology that integrates thermochemical calculations, internal ballistics modeling, oxidizer-flow characterization, regression-rate prediction, structural-thermal design, and static firing tests into a unified hybrid motor development workflow.

Hybrid rocket motors offer operational safety and controllability advantages but suffer from challenges such as limited regression rates, oxidizer-phase instability, injector pressure losses, and structural-thermal constraints. The research problem addressed in this study is the performance deviation between theoretical predictions and real static-test outcomes, particularly in paraffin–N_2O systems where mass-flow and phase-change characteristics strongly influence internal ballistics. The central hypothesis is that an optimized paraffin–N_2O hybrid motor, incorporating improved oxidizer feed architecture, refined regression-rate modeling, and a custom-developed ablative liner, can achieve stable ignition, robust structural integrity, and performance values that closely match analytical predictions. It is further hypothesized that discrepancies in performance can be quantified and reduced through iterative modeling–testing cycles.

To address the performance uncertainties of paraffin–nitrous oxide (N_2O) hybrid propulsion, the Bek-Demir.I motor was developed through an integrated methodology combining analytical modeling, simulation, and full-scale testing. Thermochemical analyses using NASA CEA established the expected flame temperature, characteristic velocity, and specific impulse at an O/F ratio of 7. Internal ballistics were predicted via analytical and semi-empirical regression-rate models to estimate port evolution, oxidizer mass flux, and chamber-pressure history, supported by volume and geometry optimizations to achieve the target propellant mass fraction. The structural–thermal design included a composite Type-III oxidizer tank with passive blowdown characteristics and a newly developed ablative insulation material to ensure chamber durability during the 8-second burn. Injector geometry was refined to reduce pressure losses and improve oxidizer

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atomization. Finally, a full-scale static firing test using a pyrotechnic igniter provided thrust, impulse, pressure, and thermal data, which were compared with analytical predictions to validate the design and identify sources of performance deviation.

The Bek-Demir.I hybrid rocket motor is expected to demonstrate stable ignition, reliable structural–thermal performance, and consistent internal ballistics behavior, validating the design methodology developed in this study. Although the static test yielded a total impulse of 9,744 N·s—corresponding to 56% of the theoretical prediction—the performance deviation is anticipated to be analytically justified through the identified factors of injector inlet pressure losses, oxidizer-phase change imbalances, and blowdown-induced pressure decay. The integration of a novel ablative insulation material and a composite Type-III oxidizer tank is expected to provide notable advancements in thermal durability and system reliability compared to conventional student-level hybrid motor designs. Overall, the study is expected to deliver meaningful contributions to the development of domestic hybrid propulsion technologies by presenting a rigorously validated, experimentally tested motor configuration and offering a reproducible engineering framework that can guide future academic research, student rocketry projects, and national aerospace initiatives.

Keywords: Hybrid rocket motor, paraffin–N_2O propulsion, ablative insulation, oxidizer blowdown, static firing test.

COMPARISON OF AVERAGE AND ACTUAL TAXI TIMES ON AIRCRAFT FUEL CONSUMPTION: A CASE STUDY AT ISTANBUL AIRPORT

Ramazan Kürşat ÇEÇEN[68]

Abstract

Air transportation plays a vital role in tourism, the economy, and global connectivity. As demand continues to grow, flight operations are increasing steadily. According to EUROCONTROL, flight operations in Europe are projected to reach 12.2 million flights by 2031, which is an increase of 1.6 million flights compared to 2024. This rise in traffic can result in longer taxi times for aircraft, which are influenced by various factors such as current traffic density, weather conditions, and congestion along the taxi route. Average taxi times are commonly used to estimate actual taxi durations, predict departure times, and calculate fuel consumption. However, discrepancies between average and actual taxi times can significantly affect fuel consumption estimates. This study explores the differences in taxi fuel consumption when calculated using average taxi times versus actual taxi times. Additionally, the analysis examines fuel consumption during the taxi phase across different aircraft performance categories. Data used in this analysis includes actual taxi times for arrival and departure operations at Istanbul Airport in August 2023. Average taxi times were obtained for aircraft operating on the same runway and parking positions. Approximately 50,000 flight records were analysed, encompassing 61 different aircraft types. Engine characteristics were selected based on BADA 3.16 data, and taxi fuel consumption values were derived from idle taxi fuel consumption rates provided in the EASA aircraft emissions database. Data processing and analysis were conducted using Python. Among the selected aircraft, there were two wide-body and eight narrow-body types. The results indicate that wide-body aircraft accounted for 16.2% of total taxi fuel consumption, while narrow-body aircraft made up 83.8%. For the ten most frequently operated aircraft types, the difference in fuel consumption estimates between average and actual taxi times ranged from -3.31% to +2.56%. When considering all aircraft types, the overall difference was approximately +0.08%.

This study investigates the difference in taxi fuel consumption when calculated using average taxi times versus actual taxi times.The demand for air transportation is continuously increasing, resulting in higher traffic density at airports and potentially longer taxi times. Fuel consumption during taxiing is a significant component of operational costs and has a notable environmental impact. It is commonly estimated using average taxi times. However, relying solely on these average times can lead to inaccurate fuel consumption calculations due to variations in actual taxi durations caused by factors such as congestion and weather conditions. Therefore, a systematic investigation is needed to quantify the differences between fuel consumption estimates based on average taxi times and those based on actual taxi durations. Additionally, it is essential to evaluate how these differences vary across different types of aircraft and performance categories.

To address inaccuracies in fuel consumption estimates during taxiing due to reliance on average taxi times, this study compares fuel consumption derived from average taxi times with that from actual taxi times.

The methodology involves Data Collection: Actual taxi time data from about 50,000 flights at Istanbul Airport in August 2023 were collected, covering 61 aircraft types. Average taxi times were calculated for flights using the same runway and parking positions; Aircraft Performance and Fuel Data: Engine characteristics were sourced from BADA 3.16, while idle taxi fuel consumption rates came from the EASA aircraft emissions database; Data Processing and Analysis: Python was used for data cleaning and statistical analysis. Taxi fuel consumption was calculated for both average and actual taxi times, with differences analysed across various aircraft types; Comparative Assessment: The study assesses the significance of deviations between the two methods and presents results for the ten most frequently operated aircraft types and the entire dataset, highlighting implications for operational planning and fuel management. This approach aims to improve the

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accuracy of fuel consumption estimates during taxiing, supporting better decision-making in airport operations and environmental assessments.

The study aims to quantify how differences between average and actual taxi times affect fuel consumption at both the individual aircraft level and across overall operations. It will identify and analyse variations in taxi fuel consumption among different aircraft types and performance categories. The findings will serve as a foundation for developing more accurate methods to estimate fuel consumption during the taxi phase, thereby enhancing operational planning and predictions. By improving the accuracy of taxi fuel consumption estimates, this study can support more efficient airport operations and flight planning, resulting in both economic and environmental benefits. Analysing fuel consumption specific to each aircraft can inform tailored operational strategies and contribute to sustainable air transport practices. Furthermore, this research adds to the limited existing literature that quantitatively assesses the differences between average and actual taxi times in terms of fuel consumption, providing a valuable reference for future studies.

Keywords: Air transportation, Aircraft ground operation, aircraft fuel consumption, aircraft taxi operation

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A QUEUEING THEORY-BASED APPROACH TO AIRCRAFT LANDING SEQUENCING AND SCHEDULING FOR ENHANCED EFFICIENCY

Alper ÖREN[69]

Abstract

The increasing demand for air transportation has intensified the challenges in managing airport operations, particularly during the arrival and landing phases. Efficient sequencing and scheduling of aircraft landings play a crucial role in minimizing delays, reducing fuel consumption, and ensuring overall air traffic safety. Traditional approaches often rely on heuristic or rule-based methods, which, while practical, may fail to optimize performance under high-density traffic conditions.

This study aims to develop a novel analytical framework for aircraft landing sequencing and scheduling by integrating queueing theory models with operational constraints of runway systems. The main research objective is to analyze how different queueing structures—such as M/M/1 and M/M/c models—can be applied to represent multi-runway configurations and varying traffic intensities. By treating arriving aircraft as customers in a service system, the framework allows for a probabilistic evaluation of waiting times, service times, and runway utilization.

The proposed model hypothesizes that queueing-based scheduling mechanisms can provide more robust and adaptive solutions compared to static sequencing methods. Key performance indicators include average landing delay, total fuel burn, runway throughput, and fairness among different wake turbulence categories. The study also incorporates the RECAT-EU separation standards to reflect realistic wake turbulence constraints, thereby enhancing the operational relevance of the model.

To validate the approach, simulation experiments are conducted on light-load and heavy-load traffic scenarios with multiple runway operations. Preliminary results indicate that the queueing-based optimization framework achieves significant improvements in both efficiency and equity when compared to conventional First-Come-First-Served (FCFS) sequencing.

The findings of this research contribute to bridging the gap between theoretical queuing analysis and practical air traffic management applications. Moreover, the study provides insights into how analytical modeling can support decision-making in future Airport Collaborative Decision Making (A-CDM) environments.

In conclusion, this work demonstrates the potential of queueing theory as a powerful tool for optimizing aircraft landing sequencing and scheduling, with implications for reducing operational costs, enhancing sustainability, and improving passenger experience.

Keywords: Aircraft Sequencing, Queueing Theory, Landing Scheduling, Runway Optimization, Air Traffic Management

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THE EFFECT OF PREPREG SHELF LIFE ON THE MECHANICAL PERFORMANCE OF COMPOSITES USED IN THE AVIATION INDUSTRY

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Abstract

Composite materials are extensively used in strategic sectors such as aerospace, automotive, energy, and defense due to their high specific strength and stiffness. In particular, pre-impregnated (prepreg) materials, which contain a controlled amount of resin, exhibit homogeneous fiber distribution and excellent surface quality, forming the foundation of high-performance composite manufacturing.

Prepreg materials are of critical importance in the aerospace, defense, and space industries because of their high strength-to-weight ratios. However, the resin contained in these materials undergoes a slow polymerization reaction even during storage, leading to gradual aging. Once the manufacturer-defined shelf life is exceeded, the material can no longer be used in certified production, which causes tons of high-quality prepregs to lose their industrial certification each year, turning into economically valuable waste.

Literature and experimental investigations have shown that in expired prepregs, resin viscosity and glass transition temperature (Tg) increase, while tack (surface adhesion property) decreases. These changes make manufacturing more difficult and may increase the void or porosity content in laminates. However, fiber-dominant properties, such as tensile modulus and strength in the 0° direction, are largely preserved and, in some cases, may even show a 15–30% improvement due to partial plasticization of the resin matrix.

The aim of this study is to investigate the changes in mechanical performance, processability, and microstructure of expired prepreg composite materials, and to establish a scientific basis for their potential reuse. The results indicate that composites produced from expired or near-expired prepregs can retain satisfactory mechanical properties. Although such materials may no longer meet aerospace certification standards, they could still be reutilized in secondary sectors such as automotive and marine industries.

This study investigates the feasibility of repurposing "expired" pre-impregnated (prepreg) composite materials that have exceeded the manufacturer-defined shelf life. The study aims to Quantify aging-induced changes in mechanical performance (e.g., tensile strength and stiffness), processability (e.g., viscosity, tack/adhesion), and microstructure of prepregs; Establish a scientific basis for the reuse of expired prepregs in non-aerospace sectors, where certification requirements differ, thereby reducing the disposal of high-value composite materials as industrial waste. Clearly state the general purpose of the study and its specific objectives.

E Prepreg composites have a limited shelf life because the resin continues to slowly polymerize during storage. Once the material is considered expired, strict aerospace certification constraints typically prohibit use, causing large quantities of high-quality material to be discarded.

Aging can increase resin viscosity and glass transition temperature (T_g), while reducing tack, which may lead to manufacturing challenges and potential defects such as voids and porosity.

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The study hypothesizes that although the resin matrix evolves during storage, fiber-dominant properties—particularly 0° tensile modulus and strength—remain largely preserved. Consequently, expired prepregs may retain sufficient structural capability for industries with less stringent regulatory constraints than aerospace.

Instead of disposal, expired prepregs can be redirected to secondary industrial sectors (e.g., automotive and marine), where cost efficiency is critical and certification frameworks allow the use of materials that may not meet aerospace requirements but remain mechanically adequate.

Despite processability challenges, the study expects that 0° tensile strength and modulus are preserved, indicating that "expired" does not necessarily mean "structurally unusable." Some properties may even exhibit ~15–30% improvement under certain conditions, potentially linked to resin state changes (e.g., plasticization-related effects reported by the study).

Keywords : Prepreg, Shelf Life, Processability, Porosity, Mechanical Performance, Recycling

DESIGN AND MODULATION OF A REDUCED-SWITCH 5-LEVEL INVERTER FOR COMPACT AND EFFICIENT DC-AC CONVERSION IN AEROSPACE APPLICATIONS

Erol CAN[72], Cemal IŞILAK[73], Selahattin YAVUZ[74]

Abstract

Multilevel inverter structures have become essential in modern power conversion systems, particularly in aviation, renewable energy, and industrial drive applications. Traditional 5-level inverter designs often rely on a high number of switching devices, leading to increased hardware complexity, energy losses, and cost. In this work, we present a novel multilevel inverter topology that reduces the switch count to only four active power devices. The simplification is made possible through a customized modulation scheme based on Fractional Sine Pulse Width Modulation (FSPWM), which combines multiple reference signals—sine, square, triangle, and fractional sine—with triangular carriers to generate efficient gating signals. The proposed system's signal synthesis mechanism is explained in detail for both 4-level and 5-level configurations. Preliminary simulations have been conducted to assess output waveform quality and switching behavior. Quantitative analysis highlights the superior performance of the proposed topology across various DC voltage levels (10 V to 100 V) when compared with conventional inverters. For instance, switching losses remain below 0.0045 W at 100 V, while competing designs exceed 0.01 W. Similarly, total heat dissipation remains stable around 1 W, outperforming reference topologies that show 2 W and 3 W losses. Conduction losses are also minimized, consistently staying near 0.8 W, whereas conventional counterparts reach 1.6 W and 2.4 W. These improvements significantly enhance energy efficiency and thermal stability—two critical parameters for aerospace-grade power electronics. The proposed inverter is particularly well-suited for aerospace environments, where size, weight, and thermal performance are vital constraints. Its reduced-switch architecture supports the More Electric Aircraft (MEA) concept by enabling compact, efficient, and reliable power subsystems such as actuator drives, cabin power converters, and environmental control units. These results suggest strong potential for integration into next-generation airborne power conversion platforms.

The main objective of this study is to design and analyze a compact 5-level inverter topology optimized for aerospace DC-AC conversion systems. The research aims to minimize the number of switching devices without compromising output waveform quality or efficiency. By introducing a reduced-switch configuration and a novel Fractional Sine Pulse Width Modulation (FSPWM) technique, the work seeks to achieve higher energy efficiency, lower thermal stress, and smaller hardware size—key requirements for More Electric Aircraft (MEA) power systems.

Conventional 5-level inverter designs rely on a large number of switches and passive components, resulting in increased system complexity, higher switching losses, and reduced reliability—issues that are particularly critical in aerospace environments where weight, heat dissipation, and reliability are tightly constrained. The hypothesis of this research is that a reduced-switch inverter, combined with an optimized modulation scheme such as FSPWM, can deliver comparable or superior output performance while significantly reducing switching and conduction losses. This improvement would enable more compact and thermally stable converter architectures suitable for flight-qualified power systems.

To address these challenges, a new inverter topology using only four active switches has been developed. The structure integrates a Fractional Sine PWM strategy that merges multiple reference signals—sine, square, triangular, and fractional sine—against synchronized carrier waves to produce smooth and efficient gating signals. The methodological approach includes: (1) Topology design and simulation: Creating and testing 4-level and 5-level configurations in MATLAB/Simulink; (2) Performance analysis: Evaluating waveform quality, switching frequency behavior, and harmonic

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distortion; (3) Loss evaluation: Quantifying switching, conduction, and total power losses over various DC voltage levels (10 V–100 V). This comprehensive approach enables an accurate assessment of efficiency gains and thermal improvements compared with conventional inverter designs.

Simulation results demonstrate that the proposed topology reduces total power losses by up to 50% while maintaining stable heat dissipation near 1 W even at high voltage levels. Switching losses remain below 0.0045 W, confirming the design's high efficiency and robustness. The reduced component count minimizes both cost and weight, making it highly suitable for aerospace subsystems such as actuator drives, cabin converters, and control electronics. Overall, the study contributes to advancing lightweight and efficient MEA-compatible power converters, supporting the transition toward fully electric aircraft architectures with improved energy density and reliability.

Keywords: Multilevel inverter, reduced switch topology, FSPWM, aerospace power systems, thermal management, MEA, DC-AC conversion.

MECHANICAL ANALYSIS OF SINGLE-PINNED ELLIPTICAL WING–PLATE JOINT CONSIDERING MATERIAL EFFECTS

Mustafa Murat YAVUZ[75]

Abstract

This study investigates the mechanical behavior of a single-pin connection in an aircraft wing segment with a quarter-elliptic planform using finite element analysis. The model considers a 50 mm wide slice of the wing, comprising a 2 mm thick upper wing skin and an underlying elliptic support platform acting as a stiffening element. The wing skin and platform are connected by a single cylindrical pin, which transfers the load from the loaded skin to the fixed platform. Two case studies are considered. In the first case, a uniform pressure load is applied on the outer surface of the wing skin, while the rear edge of the skin is modeled as fully clamped and the support platform is fully fixed. In the second case, the bending behavior was investigated by applying a point force from the wing front section to the wing width side. Two key design variables are examined: the chordwise position of the pin, which is moved from the leading-edge region toward mid-chord, and the pin material, which is alternated between aluminum, steel, titanium and magnesium. The materials of all components have non-linear material behavior. A three-dimensional finite element model with refined meshing in the vicinity of the pin is employed to compute stress distributions. The numerical results, discussed qualitatively, are used to assess how pin position and material stiffness influence global deflection, local Von-Mises stress concentrations, and load transfer between the wing skin and the support platform. The results are discussed in detail and given in conclusion.

Keywords: Single-pin joint, finite element analysis, Aerospace structural materials.

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WASTEWATER RECYCLING IN THE CONTEXT OF AIRPORT SUSTAINABILITY INITIATIVES

Tuğçe ÇOPUR[76], Ümmühan Beste YILDIRIM[77]

Abstract

The concept of sustainability in the aviation sector holds strategic importance in mitigating the environmental impacts arising from increasing passenger and aircraft traffic. Sustainable airports are defined as facilities that are self-sufficient in terms of economic, environmental, human resource, and natural resource utilization, and can maintain their operations in the long term. To obtain a Green Airport certification, it is essential to comprehensively measure water consumption and accurately determine basic usage requirements. Airports generate significant volumes of wastewater due to high passenger density and aircraft operations; terminal restrooms, catering services, aircraft washing activities, and de-icing/anti-icing procedures constitute the primary sources of this wastewater. In this context, the efficient management of water resources and the treatment and reuse of wastewater emerge as critical strategies for achieving environmental sustainability goals in airport operations. This study examines sustainability initiatives focused on wastewater recycling in airports. It analyzes the development of wastewater management practices over the past decade at multiple airports in Türkiye. The research first evaluates the volume and characteristics of wastewater generated at airports and then proposes technologically and economically feasible solutions for its reuse. The findings aim to promote innovative practices aligned with the Green Airport concept, enhance environmental responsibility within the sector, and strengthen compliance with international sustainability standards.

Keywords: Sustainable Airports, Wastewater Recycling, Environmental Management, Green airport

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ANNOTATING FORMULAIC EXPRESSIONS IN AVIATION ENGLISH CORPORA: A COGNITIVELY-ORIENTED COMPUTATIONAL LINGUISTICS APPROACH

Özde ŞENOL[78]

Abstract

From a cognitive perspective, language does not function as an independent system. It is an essential component of the extensive network of human cognition, engaging with processes like abstraction, reasoning, and decision-making (Evans, 2006). In this context, formulaic phrases in Aviation English like "Cleared for takeoff" or "Stand by" mean more than just standard language rules. They serve as conceptual components that enhance effective communication in safety-critical contexts (Cushing, 1994). Despite their significance, these expressions have not been systematically investigated in terms of their cognitive functions within authentic air traffic communication.

This study presents a corpus-based and cognitively-oriented approach to analyze the formulaic expressions in Aviation English. A specialized corpus of air traffic control (ATC) and pilot communications was created, and computational algorithms were used to find phrases that were used recurrently. These expressions were further annotated using a cognitive-functional framework that categorizes their roles in reducing mental workload, enhancing predictability, maintaining shared situational awareness, organizing task progression, and mitigating risks in abnormal or emergency contexts. By applying annotation practices with Lakoff's (1987) Idealized Cognitive Models (ICMs), the study interprets formulaic expressions not simply as recurrent linguistic sequences but as cognitive reference points that facilitate pilots' and air traffic controllers' comprehension, decision-making, and coordination during complex operational tasks.

The analysis indicate that formulaic expressions are essential to operational safety because they allow language to be used with minimal effort and words while achieving maximal communicative impact. They reduce cognitive effort, prevent misunderstandings, and act as strong communication tools at different phases of a flight. Furthermore, a comparison between standardized phraseology in official manuals and naturally occurring language use demonstrates a gap between prescriptive norms and real-world practices, signaling a need for the development of more effective training materials.

By developing and testing a cognitive annotation scheme for Aviation English, this study provides a methodological contribution to computational linguistics while also offering practical implications for Aviation English pedagogy. The findings highlight the importance of treating formulaic expressions not only as prescriptive items to be memorized, but as cognitively functional tools that maintain clarity, efficiency, and safety critical communication.

Keywords: Aviation English, Aviation communication, safety critical environments, cognitive linguistics, cognitive load

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A COMPARATIVE ANALYSIS OF GREEN TRANSFORMATION STRATEGIES IN LEADING FLAG CARRIER AIRLINES

Begüm Buse SERTGÖZ[79], Harun YILMAZ[80]

Abstract

The aviation industry occupies a central position in global sustainability policies due to its carbon emissions and environmental impacts, while flag carrier airlines not only embody national identity but also act as key drivers of industry transformation. While sustainability in aviation has been extensively discussed in the literature, comparative analyses that evaluate multiple flag carriers under the same dimensions remain scarce. This gap is particularly critical given that European carriers pursue similar global sustainability targets yet diverge in their approaches as a result of institutional structures and regulatory environments. A systematic comparison of these strategies reveals where strong practices have emerged and where weaknesses persist, thereby enabling mutual learning among carriers.

Against this backdrop, the study examines the green transformation strategies of four leading flag carriers—Lufthansa (Germany), Air France–KLM (France–Netherlands), British Airways (United Kingdom), and Turkish Airlines (Turkey)—within a comparative framework. The analysis draws on four interrelated dimensions: reduction of carbon emissions, improvement of energy and resource efficiency, corporate targets and reporting practices, and social and governance initiatives. Findings indicate that Lufthansa and Air France–KLM lead in sustainable aviation fuel investments and reporting transparency; British Airways distinguishes itself through group-level net-zero commitments; whereas Turkish Airlines, despite advancing in fleet renewal and operational efficiency, lags in transparency. These results highlight the need to expand investments in sustainable aviation fuels, harmonize reporting standards, and institutionalize social responsibility practices. By addressing these points, the study not only contributes to the academic literature by filling a notable gap but also provides comparative insights that may guide the strategic decision-making processes of airlines facing the challenges of green transformation.

Keywords: Sustainability, Green transformation, Flag carrier airlines, Comparative analysis, Aviation industry

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HAPTIC TECHNOLOGY IN AVIATION AND AEROSPACE TASKS: A RESEARCH NOTE

Lale Canan DÜLGER[81], Berk BELKIS[82], Ekin Mesut DENİZER[83]

Abstract

Haptic systems include actuators, sensors, and control algorithms. Haptic technology in aviation is designed to enhance the experience of pilots. Integrating of this technology into aviation systems requires engineering design providing kinesthetic communication. The applications of these systems can be seen in training utilizing simulators. This paper reviews the experiences using flight simulators and also in –flight test conditions using haptics. Two parts are included as; aviation and aerospace tasks using haptic devices. Some examples are included during training or other needed tasks also.

Haptic technology has the potential to improve aerospace tasks. The enhancement can be seen for improving flight safety, air travel experience and entertainment. In addition, heavy-duty teleoperation can be handled by robotic systems. In addition to improving in-flight entertainment and flight safety, haptic technology can also play a role in enhancing passenger experience. Haptic feedback can be used to provide a more comfortable and enjoyable travel experience, such as with smart seat controls or touch-based navigation. Haptic feedback has benefits for manufacturers also. The user experience can be improved with the operator's performance.

Haptic feedback (HF) is studied commonly in types of graspable, touchable and wearable. Control methodology in aviation and aerospace tasks during piloting will be discussed. Haptic technology in aviation has various systems enhancing the tactile experience of pilots utilizing tactile and force feedback types.

This paper discusses use of haptic technology in aerospace tasks. It reveals the idea in human-machine interaction for the pilot- aircraft control, the passenger-flight giving human centered design. Use of haptics in aviation helps the pilot for guidance and communication. The importance of haptic feedback will be explained with available sensors in use. It reveals a review based on studies exploring issues in haptics use.

Keywords: Haptic Feedback, Human–Machine Interaction, Aviation and Aerospace Systems

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