# ABSTRACT BOOK

May30th-Jun1st

# ISUDEF'22

International Symposium on Unmanned Systems and the Defense Industry

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*Tahir Hikmet Karakoç - Soledad Le Clainche - Xin Chen*
*Ali Haydar Ercan - Alper Dalkıran*

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*Betül Özcan - Dilara Patatur Kılıç - Kemal Keleş*

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# International Symposium on Unmanned Systems and the Defense Industry 2022

## ISUDEF'22 Abstract Book

International Sustainable Aviation and Energy Research Society


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International Symposium on Unmanned Systems and the Defense Industry 2022 (ISUDEF'22) Edited by Prof. Dr. T. Hikmet Karakoc, Assoc. Prof. Soledad Le Clainche, Asst. Prof. Xin Chen, Asst. Prof. Ali Haydar Ercan, Asst. Prof. Alper Dalkıran.

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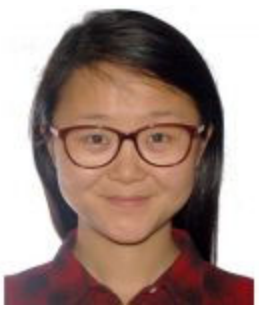
This book contains abstracts submitted to International Symposium on Unmanned Systems and the Defense Industry 2022 (ISUDEF'22).

**T. Hikmet Karakoç**
Symposium Founding Chair

**Soledad Le Clainche**
Symposium Chair



**Xin Chen**
Symposium Chair

## Message from the Symposium Chairs

It is a great pleasure to invite you to the International Symposium on Unmanned Systems and the Defense Industry 2022 (ISUDEF'22), which will be held in a Hybrid Mode on May 30 – June 1, 2022.

Unmanned systems are one of the fastest growing and widely developing technologies in the world, offering a number of possibilities for a variety of research fields, including the defense industry. As we are in an era in which there is continuous progress in unmanned systems and homeland defense, we would like to invite researchers, scientists, engineers, practitioners, policymakers, and students to the International Symposium on Unmanned Systems and the Defense Industry to exchange information, present new technologies and developments, and discuss the future direction, strategies, and key priorities moving forward.

ISUDEF'22, an international, multi-disciplinary symposium, aims to address current topics on unmanned systems and the defense industry in such broad areas as aerial, naval and land applications, avionics, and radar systems & air defense. Specifically, researchers may wish to present their solutions and insights on such topics as platform designs, AI integration, robotics, and autonomous systems to provide innovative solutions to the challenges facing the homeland defense industry, along with civilian applications.

ISUDEF'22 will include several keynote presentations, specialized sessions, workshops, and oral & poster presentation sessions from participants on the different subjects submitted. We look forward to welcoming you to this remarkable event in May-June 2022.

Sincerely,

Hikmet Karakoç (Symposium Founding Chair), Soledad Le Clainche & Xin Chen (Symposium Chairs)

## Lifetime Honorary President of SARES

Maximillian Platzer

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## Keynote& InvitedSpeakers

Cristina Barrado, Universitat Politècnica de Catalunya, Spain
Anibal Ollero Baturone, Universidad de Sevilla, Spain
Esteban Ferrer, Universidad Politécnica de Madrid, Spain
Oscar Flores, Universidad Carlos III de Madrid, Spain
Luis Enrique Moreno Lorente, Universidad Carlos III de Madrid, Spain
Pedro Paredes, National Institute of Aerospace, USA
Ivette Rodriguez, Universitat Politècnica de Catalunya, Spain
Marco Rosti, Okinawa Institute of Technology, Japan
Ricardo Vinuesa, KTH Royal Institute of Technology, Sweden
Nadir Yılmaz, Howard University, USA

## Industrial Special Session

Miguel Martin Acosta, AIRBUS, Spain
Daniel Martínez Bastida,SENER, Spain
Graciano Carrillo, Microflown Technologies, Spain
Adelaida García-Magariño,INTA, Spain
Eugenio Sillero Herrero, GMV Aerospace and Defence, Spain
Zachary Wayne Hughes, INTA, Spain

Jose Insenser, AIRBUS, Spain

Antidio Viguria Jiménez, CATEC, Spain

Juan Carlos Plaza del Pino, INTA, Spain

Felix Terroba Ramirez, INTA, Spain

Rubén Moreno Ramos, Capgemini Engineering, Spain

David Aguiar Rodríguez, AIRBUS, Germany

Miguel Angel Vilaplana Ruiz, AIRBUS, Spain

## Student UAV Workshop

Orhan Aras, Eskisehir Technical University, Türkiye

Pegasus UPIIG, Unidad Profesional Interdisciplinaria de Ingenier´ıa campus Guanajuato Silao de la Victoria, Guanajuato, Mexico.

TULPAR UAV, Universidad Necmettin Erbakan, Konya, Türkiye

Kürşat Çiçin, Universidad Necmettin Erbakan, Konya, Türkiye

Jesus Morales Lopez

David Cvetković, University of Belgrade, Belgrade, Serbia

Ali Malçok, Dokuz Eylul University, İzmir, Türkiye[1]

Kiran Shaukat

Mustafa Azer, Eskisehir Technical University, Türkiye

Stefan Jančić, University of Defence, Military Academy, Belgrade, Serbia

Marcos Linares Bayón, Universidad Politécnica de Madrid, Madrid, Spain

# CONTENTS

# KS01
# Deputy director of the ICARUS research group at UPC

**Dr. Cristina Barrado**

*Universitat Politècnica de Catalunya, Spain*

**Abstract**: Unmanned aircraft are becoming available to most purchasers due to their decreasing costs and increasing functionalities. While this fact opens the opportunity to new business and growth, it also represents a potential threat to the manned aviation, to the protection of sensitive areas and to the National defense. Counter-drone systems are a set of sensors and actuators that, supported by software, are able to detect and neutralize an unmanned aircraft flying in a forbidden area. Rapidly most readers will remember the unfortunate events that in the winter of 2018-19 caused major economical lost to two London airports. Since then many airports have been installing detection systems to be able to take the good and safe decisions on future alarms. Still, the actuator systems of the counter-drone solutions are not well resolved. This keynote willpresent a counter-drone solution based in an unmanned autonomous aircraft. This is, an unmanned aircraft known as interceptordrone, trained to neutralize a flying threat in an area that needs to be protected. The trainingprocess usesDeep Learning, a technique that combines deep reinforcement learning with deep neural networks.

# KS02
# Bioinspired Aerial Robotics

**Anibal Ollero Baturone**

*Universidad de Sevilla, Spain*

**Abstract**: In this presentation I will introduce the motivation, main characteristics, and potential applications of bioinspired aerial robots. Particularly, I will present the prototypes developed in the GRIFFIN Advanced Grant of the European Research Council, by including dynamics, aerodynamics, control, perception and mechatronics aspects. Thew presentation will include flying experiments, perching in constrained places, and manipulation. Furthermore, it will introduce the H2020 AERIAL-CORE and the hybrid prototype developed in this project.

# KS03
# New Avenues in Computational Fluid Dynamics

**Professor Esteban Ferrer, PhD**

*Universidad Politécnica de Madrid, Spain*

**Abstract**: We present our latest developments in high order computational fluid dynamic, which are included in our open source discontinuous Galerkin frameworkHORSES3D. Recent developments allow us to simulate challenging multiphysics including turbulent flows, multiphase and moving bodies, using local p-adaption and fast multigrid time advancement. In addition, we also present recent work that couple Neural Networks techniques and high order simulations.

# KS04
# Actuation Strategies for Flow Control in Aircrafts. The Role of Coherent Structures

**Professor Ivette Rodríguez, PhD**

*Universitat Politècnica de Catalunya, Spain*

**Abstract**: The aerodynamic performance of the wing of an aircraft during take-off and landing operations is significantly affected by boundary layer interaction with the fluid coming from the fairings and the nacelle, as well as the flow separation that occurs in the slat section of the wing. Active flow control (AFC) techniques such as synthetic jets have emerged as promising techniques to improve the aerodynamic performance. Actually, it has been shown that AFC devices can reduce the fuel burnt during the operations of take-off and landing by adding momentum and keeping the flow attached to the wing surface. In this talk, we explore the role of the active flow control techniques in the boundary layer of an aircraft in high-lift configurations by means of zero net mass flux jets acting on different zones of the wing. The JAXA high-lift configuration Standard Model in a landing configuration with the high lift devices deployed is selected. Moreover, in order to gain more physical insight and to advance in the design of new flow control strategies, coherent structures in the boundary layer of an un-actuated and actuated three-element high-lift wing are analised, in order to identify the coherent structures that contribute the most to the viscous drag and that affect the aerodynamic efficiency of the wing.

# KS05
# Fast Marching Method: Application of The Eikonal Equation to UAV Path Planning Problems

**Luis E. Moreno, Full Professor**

*Universidad Carlos III de Madrid, Spain*

**Abstract**: The Fast Marching method was developed to solve the Eikonal equation. The FM method simulate the propagation front of a wave originated at a point or surface and provides the shortest arrival time at each point of a grid. Posteriorly using a gradient descend method is possible to extract the shortest time path from and initial point to a destination point. Depending on the speed propagation defined at grid cell the front wave propagates in a different way and it is possible to change the characteristics of the path plan generated by the method. Different applications of the method to solve different problems in UAVs are shown, from 3D path planning, level-imposed flights in complex urban environment, to coverage area path planning or formation path planning to demonstrate the practical possibilities of the Fast Marching method.

# KS06
# Turbulence in Flexible Canopy Flows

**Marco Edoardo Rosti, Assistant Professor**

*Okinawa Institute of Technology, Japan*

**Abstract**: Complex flows resulting from the interaction between surfaces coated with textures of slender filaments (canopies) and turbulent shear flows are commonly found in nature. In particular, the interaction between turbulent fluid flows and a bed of filamentous solid elements is a relevant research subject with many applications in several fields. Here, by means of fully resolved direct numerical simulations, we investigate the turbulent flows modulated by the presence of flexible canopies. To this aim, a series of numerical experiments are performed in order to collect new data: in particular, two non-dimensional numbers have been varied: i) the Cauchy number, defined as the ratio between the drag exerted by the canopy on the flow and the restoring force of the canopy due to its rigidity; ii) the density ratio between the canopy and fluid densities, that regulates the relative buoyancy of the canopy immersed in the fluid flow.

# KS07
# Green Hypergolic Propellants for Space Propulsion

**Professor Nadir Yılmaz**

*Howard University, USA*

**Abstract**: As the use of satellites increases for communication, space and defense applications, there is a greater need for environmentally friendly, high-performance propellants. While hydrazine based hypergolic propellants are easily combustible and provide high performance solutions, they are highly toxic and pose a significant threat to the environment. In this work, hypergolic propellant formulations based on silane and triethylaluminum are discussed in terms of their vacuum specific impulse, density vacuum specific impulse and solid exhaust products, and compared to traditional hydrazine propellants.

# KS08
# Fluid-Structure Interaction in Bioinspired Aerodynamics

**Oscar Flores, Associate Professor**

*Universidad Carlos III de Madrid, Spain*

**Abstract**: From the aerodynamic efficiency of migratory birds to the maneuverability of hummingbirds, or the versatility of dragonflies, Nature's small flyers (and swimmers) excel in every aspect of locomotion. Consequently, there is considerable interest in the engineering community in developing bioinspired drones that generate lift and thrust with flapping wings/fins. However, the number of designs that reach the expected performances is relatively low. Part of the problem is the complex interplay between the low-Reynolds number aerodynamics of the flapping wings/fins, their flexibility, and the dynamic response of the drone in a non-uniform free-stream, resulting in a very rich non-linear problem with a huge parametric space. In this talk, I will discuss recent results obtained by my research group on two configurations of increasing complexity, where the flexibility of the wings and the interactions between wings and wakes are paramount for the generation of thrust. First, I will present results from numerical simulations of a pair of high-aspect-ratio flapping wings in tandem configuration, loosely based on the wings of dragonflies. I will show how the aerodynamic response is influenced by the spanwise bending of the wings and by the interaction of the hindwing with the forewing's wake. Second, I will present results from numerical simulations of a pair of self-propelled flexible flappers of small span, akin to two fish swimming in line. I will discuss how the flappers adjust their relative position because of the hydrodynamic interactions. The talk will conclude with some ideas on how to apply these results to the development of bioinspired devices.

# KS09
# Practical Method for Hypersonic Boundary-Layer Transition

**Pedro Paredes, PhD**

*National Institute of Aerospace, USA*

**Abstract**: An accurate boundary-layer transition prediction method integrated with computational fluid dynamics (CFD) solvers is pursued for hypersonic boundary-layer flows over slender hypersonic vehicles at flight conditions. The geometry and flow conditions are selected to match relevant trajectory locations from the ascent phase of the Hypersonic International Flight Research Experimentation 1 (HIFiRE-1) flight experiment, namely, a 7-degree half-angle cone with 2.5 mm nose radius, freestream Mach numbers in the range of 3.8–5.5, and freestream unit Reynolds numbers in the range of $3.3 \times 10^6$–$21.4 \times 10^6$ $m^{-1}$. Earlier research had shown that the onset of transition during the HIFiRE-1 flight experiment correlated with an amplification factor of $N \approx 13.5$ for the planar Mack modes. However, to incorporate the N-factor correlations into a CFD code, we investigate surrogate models for disturbance amplification that avoids the direct computation of stability characteristics. The results demonstrate that the application of the broadly used approach, which is based on a database of stability characteristics for locally similar profiles, leads to large, unacceptable errors in the predictions of amplification factors. We propose and demonstrate an alternate approach that employs the stability computations for a canonical set of blunt cone configurations to train a convolutional neural network model that is shown to provide improved transition predictions. Finally, the convolutional neural network model is found to outperform the linear stability calculations for under resolved solutions.

# KS10
# Modelling and Controlling Turbulent Flows Through Deep Learning

**Associate Professor Ricardo Vinuesa**

*KTH Royal Institute of Technology, Sweden*

**Abstract**: The advent of new powerful deep neural networks (DNNs) has fostered their application in a wide range of research areas, including more recently in fluid mechanics. In this presentation, we will cover some of the fundamentals of deep learning applied to computational fluid dynamics (CFD). Furthermore, we explore the capabilities of DNNs to perform various predictions in turbulent flows: we will use convolutional neural networks (CNNs) for non-intrusive sensing, i.e. to predict the flow in a turbulent open channel based on quantities measured at the wall. We show that it is possible to obtain very good flow predictions, outperforming traditional linear models, and we showcase the potential of transfer learning between friction Reynolds numbers of 180 and 550. We also discuss other modelling methods based on autoencoders (AEs) and generative adversarial networks (GANs), and we present results of deep-reinforcement-learning-based flow control.

# ISS01
# INTA Research on Flow Control Devices in Cities for Urban Air Mobility

**Dr. Adelaida Garcia-Magariño**

*Instituto Nacional de Técnica Aeroespacial "Esteban Terradas" (INTA)*

**Abstract**: Unmanned Personal Vehicles are being developed to be used in cities thus allowing air mobility in urban areas in a near future. This new concept of "Urban Air Mobility" poses a challenge in many aspects being one of them the aerodynamic flows inside the cities. Previous works studying the heliport placement in city areas led to the conclusion that the roof of some building would be the best option. However, the landing and take-off of aircrafts is hindered by a recirculated bubble formed at the top of the building. In this presentation, the latest related research conducted by INTA in Spain is presented. In particular an experimental study performed on the flow around buildings and the way to modify it in order to increase the number of possible placements is presented. In this study, fifteen modifications of the roof of the building produced by several control devices are proposed to reduce the abrupt change in the aerodynamic flow generated at the edge of the building. A scaled model of the building with these modifications was tested in the low-speed wind tunnel at INTA, using Particle Image Velocimetry technique. The flow fields around the building with and without the modifications were compared. It was found that for one of the modifications the recirculated bubble has completely disappeared, while for the other three the reduction has been more than 60%.

# ISS02
# New Technologies for Highly Autonomous UAS

**Dr Antidio Viguria**

*CATEC (Advanced Center for Aerospace Technologies)*

**Abstract**: This presentation will review the latest technology developments in CATEC that increments the autonomy level of unmanned aerial systems. The increase of the autonomy level in UAS is critical to increase the safety of the operations, and also, its efficiency specially in multi-UAS operations in order to reduce the workload of the UAS operator. These new developments include for example the use of on-board sensors to automatically navigate in GNSS-denied environments, dynamic and real-time multi-UAS cooperation, and use of sensors for automatic detect and avoid of obstacles and other aerial vehicles.

# ISS03
# Application of Unmanned Systems on Military Operations

**Mr. Daniel Martínez**

*SENER Aeroespacial*

**Abstract**: The use of Unmanned X (generic) Vehicles (UXVs) in military operations or emergency situations represents one of the most important innovations of recent years, specifically in the field of Unmanned Aerial Vehicle (UAVs). Undoubtedly UXVs exploitation will grow in the coming years with the massive introduction of other autonomous systems in different fields of application (ground, air, surface or submarine) and the increase of capabilities to work collaboratively between systems (swarms) and people. The use of such UXV systems has a direct impact in reducing the exposure of operators and soldiers to associated risks. Such systems can also improve the efficiency and performance of the operative to provide tactical superiority and provide robust and reliable solutions in very demanding conditions. Developments of autonomous platforms have experienced a significant and useful evolution in the civilian field in the last decade, but these are systems that usually operate in structured or controlled environments (e.g. ground vehicles operating in paved and correctly signposted roads). In the case of UXVs for military use, they must be able to operate also in unstructured environments (without roads, without signs and all types of terrain) and face situations of GNSS signal and/or communications denied or degraded where the unmanned systems must take decisions against potential threats (IEDs, electronic warfare, enemy fire, etc.).Therefore, deployment of autonomous UxVs in military applications poses many technological challenges to be faced from the operations point of view, such as: interoperability (machine-machine and human-machine), robust and secure communications, handling of large amounts of data, autonomous decision-making or precise positioning without GNSS signal.

# ISS04
# Present and Future of UAS in Spain

**David Aguiar Rodriguez**

*Eurodrone Marketing Lead- Airbus Defence and Space*

**Abstract**: Airbus will present the current challenges in the UAS industry and its vision towards the future of UAS in Spain.

# ISS05
# Artificial Intelligence Aided GNC for Autonomous Operation of RPAs

**Dr. Eugenio Sillero Herrero**

*GMV Aerospace and Defence*

**Abstract**: In the present operational scenarios for the use of RPA new conditions and threats need to be taken into account. From the one hand, the classical reliance on GNSS/IMU hybridization for the navigation solution computation cannot be further relied one as the widespread use of GNSS denial hinders its performance in real operational theatres. On the other hand, the proliferation and advances in other navigation data sources pushes the urge of improving the data fusion techniques in order to maximize the gains provided by these new sensors. Both factors contribute to the need of evolving our classical approach to GNC, especially for systems that need to perform under little human supervision. Indeed, for autonomous systems we need to implement ways of interpreting data and exploiting information in a combined and resilient way. These new approaches shall enhance the robustness of the GNC systems of RPA, providing immunity to specific attacks, and shall allow the increase in precision of the data and awareness for enabling autonomous decision making. In the presentation, the speaker will summarize the new approaches to GNC takin into account new data sources and using Artificial Intelligence algorithms for enhancing the GNC system performance. Hints on the use, limitation and certification considerations and constraints will be presented and discussed.

# ISS06
# Structural Health Monitoring of Remote Piloted Air Systems

**Félix Terroba Ramírez, PhD**

*INTA (National Institute for Aerospace Technology)*

**Abstract**: Over the last 10 years INTA has integrated structural health monitoring systems (SHMS) in its RPAS projects such as SIVA, MILANO and DIANA with the aim of detecting damage, obtaining flight or ground loads or monitoring the status of composite repair patches. The sensor technology used in our structural health monitoring systems is Fiber Bragg Grating Sensors (FBGS) that have important advantages in the aerospace field. The presentation will show the different projects carried out, the different architectures used, and the results obtained.

# ISS07
# Acoustic Vector Sensor Applications For Source Localization

**Graciano Carrillo Pousa**

*Microflown Avisa B.V.*

**Abstract**: Acoustic Particle Velocity based sensors provide broadband directional sound information in small form. The use of arrays or distributed networks of acoustic vector sensors provide benefits over pressure transducer-based solutions. Several industrial applications of acoustic vector sensors are shown for sound-based source localization.

# ISS08
# Innovation in Unmanned Systems – Large Manufacturers and Small Drones

**Jose Insenser**

*Airbus*

**Abstract**: The Airbus evolution in UAS spans several decades and has gone along the authors´ professional journey. From large national and international programs, public funding programs and research programs, to open innovation, academia, startups, and intrapreneurship endeavors, this journey has been dirty and dangerous, but certainly not dull. Using both classic development models, technology evaluation and maturation, modelling and simulation, and flight tests, and –on the other side of the fence- agile and other innovative methodologies, UAS are a key pillar of many Airbus systems and while UAS are no longer considered an innovation in themselves, the range of missions and capabilities they can perform with an advantage over the alternatives is still enormous. We may showcase prominently our Eurodrone MALE RPAS, the high-altitude pseudo-satellite (HAPS) capable of flying for months at a time, a ship borne rotary wing UAS, or a smart distributed network that connects UAS and manned platforms to operate as a team. But it is the small drone allowing a proof of concept, a minimum viable product, a way of solving quickly a customer problem, developed quickly and on a limited budget. What it is the fertile ground for many ideas and many innovators.

# ISS09
# Icing and UAS

**Juan Carlos Plaza del Pino**

*INTA*

**Abstract**: Today manned aircraft are used to conduct icing flight tests. Airplanes flying in icing conditions are exposed to risks, especially with icing conditions outside the CS-25 appendixes. In addition, this kind of testing is expensive. UAS have a low risk and lower operational cost for this type of flight testing, but icing is a major concern for UAS attempting to fly in bad weather, due to flight altitude and size. In addition, the increasing use of UAS in both military and civilian environments requires the ability to operate in all types of weather conditions, including icing. Icing and its associated hazards to aircraft will be explained, along with the differences for the specific case of UAS. The applicability of different anti-icing and de-icing systems on UAS will be discussed. The different detection strategies will also be pointed out. INTA has several UAS available. An overview of them will be given and a characterization and integration process will be explained for flight in icing conditions.

# ISS10
# Challenges and Issues of AI-Driven Autonomous Flight

**Miguel Martin Acosta, Chief Engineer UAS R&D**

*Airbus Defense and Space SAU*

**Abstract**: Autonomous flight is one of the most amazing capabilities, as well as a necessary one, for the future of aviation. Both in the civil environment -drones and flying taxis immediately come to mind- and in the defense sector, the ability to fly without human intervention is seen as a key enabling technology for completely new missions and services. In this context, the autonomous flight is inextricably linked to artificial intelligence -more specifically to machine learning-, where a series of challenges and issues arise that need to be addressed from a technological point of view, but also critical in terms of regulations. The aerospace industry must demonstrate that having hundreds or thousands of AI-driven machines flying autonomously over the sky is safe, and only this confidence will allow the resounding success of autonomous flight.

# ISS11
# Participation in Panel Discussion on UAV/UTM

**Miguel Ángel Vilaplana Ruiz**

*Airbus*

**Abstract**: Breve introducción a los retosque afronta el futuro ecosistema U-space para ser capaz de contribuir a habilitar futuras operaciones de Movilidad Aérea Urbana a gran escala de manera segura, rutinaria y eficiente. Detalles a concretar con la organización del panel.

# ISS12
# Surrogated Models for Data Analysis and Simulation

**Dr. Rubén Moreno Ramos**

*Capgemini Engineering. Aeronautical Space and Defense*

**Abstract**: The use of surrogated models has been progressively extended in the industry as a way to create simulation models that can be used for co-simulation of different systems or disciplines. As such, they significantly reduce the computational cost and enable multidisciplinary simulations and general optimization. An additional feature of such surrogated models, and even more those based on Dynamic Mode Decomposition, is the ability to extract intrinsic characteristics of the existing simulations snapshots, both in the spatial and time dimensions. When applied to test data, in opposition to frequency or time domain methods, allow the engineer to extract flow patterns, mode shapes, and the corresponding time characteristics, with increased robustness and less human intervention.

# ISS13
# ASPRID - Airport System Protection from Intruding Drones

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**Abstract**: ASPRID is a response to the request made from SESAR under the exploratory research view that deals with the ongoing problem of protecting airport operations from drone intrusions under a holistic and operationally oriented approach. The ASPRID project evaluates the vulnerability of an airport under different types of threats posed by intruding UAVs and develops possible ways of response involving the interactive relationships between the various airport critical elements. Real-time risk analyses are used to evaluate the threat's impact on operations, thereby establishing an adequate level of alert, a response or degraded mode of critical element operation and if required, neutralization of the threat itself.

# 001
# Use of (PET-G) Material in Mini-Scale Unmanned Surface Vehicle (USV) For Additive Manufacturing

**Alperen Doğru, Ayberk Sözen, and M. Özgür Seydibeyoğlu**

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**Abstract:** This study aims to determine the material performance of additive manufacturing methods, which enable flexible designs against rapidly changing market needs with a high benefit/cost ratio to meet the increasing defense needs of countries. In addition, the design of an unmanned surface vehicle (UVS) resistant to sea conditions has been realized and produced by additive manufacturing. Advantages such as freedom of design, on-site manufacturing, and low cost in low-volume production have made additive manufacturing methods the focus of today's production method and research topic. Among the additive manufacturing methods, Fused Filament Fabrication (FFF) is the most cost-effective and widely used method. In today's small craft sector, boats made of thermoplastic material are replacing metal hulls and thermosetting matrix composite hull boats day by day. Although composite boats with thermoplastic or thermosetting matrix have limitations in terms of size, it can be said that they are ideal for small USV. In this study, resistance analysis of the forms of 3 different boats was made with finite element and empirical methods. The hull form, which exhibits the lowest resistance value, was produced using the FFF method using PETG co-polymer developed from environmentally friendly PET material. Cruise and field tests were carried out. Material performances were determined to be used in the production of small-scale USVs with the FFF method, and the mini-scale USV was produced using the PETG material with the FFF method. The suitability of PETG material for marine uses was emphasized.

**Keywords:** Unmanned surface vehicle (USV), Polytene tereftalat glycol (PET-G), Additive manufacturing, Computer fluid dynamics (CFD), Autonomous surveillance.

# 004
# The Use of State Feedback Control Based on LMI to Suppress Oscillations of Payload Carried by UAV

**Renan S. Geronel[1], Ruxandra M. Botez[2], and Douglas D. Bueno[1]**

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[2]*Université du Québec, Montreal, Canada*

**Abstract:** The UAVs have been recently employed in medical transportation. However, vibrations can impact negatively on the cargo quality since these medical goods can lose their efficacy for some oscillations intensities. The proposed 7-dof UAV model considers a vibrating payload and an elastic attachment between the UAV and its payload. Proportional Derivative and Feedback Control based on Linear Matrix Inequalities are then designed to generate UAV trajectory with low payload oscillations amplitudes. Numerical results have shown a high oscillation suppression in both the UAV and its payload trajectories.

**Keywords:** Unmanned Aerial Vehicle, Medical Transportation, Payload vibration suppression, Linear Matrix Inequality.

# 005
# Impact of Free Form Deformation Control Points on the Optimization of the UAS-S45

**Mir Hossein Negahban, Musavir Bashir, and Ruxandra Mihaela Botez**

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**Abstract:** In the free-form deformation (FFD) parametrization technique, the choice of number of control points is case-dependent, and its optimum number should be found through trade-off to find its adequate value. In this study, a comparative analysis is performed to show the dependence of the final optimization results to the chosen number of control points. It is shown that that there is no considerable difference in the ultimate value of objective function, however, by having 20 control points, the value of objective function and the accuracy of the optimization by considering the feasibility and optimality criteria is deteriorated. Therefore, there should be a trade-off study in the number of control points for free form deformation block before starting the optimization process.

**Keywords:** Free Form Deformation, Gradient-based optimization, UAS-S45, FFD control points.

# 007
# An Aerodynamic Model for Gliding Snake-Bots

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**Abstract**: The snake genus Chrysopelea is notable for its ability to fly without the components we normally associate with flying. In this work, a model to predict the path and glide angle taken by such snakes or aerial robots inspired by such mechanism is described. An earlier work used for such a prediction approximately models the aerodynamic lift force by blade element theory and thin airfoil theory. In this work, the moments around the CG are accounted for. The body of the snake is rotated around appropriate axes according to these moments which varies with time. Further, the forces and moments estimated over multiple time steps are used to continually update parameters like glide angle and free-stream velocity in this study. The calculated data is intended to assess the importance of accounting for the moments in predicting the flight path. The results show that the newly developed approach shows closer agreement with experimental data than the earlier model which neglected the moment. It is intended to use this model for way-point following algorithms for such robots.

**Keywords:** Flying Snakes, Aerial Robots, Control, Arboreal Terrain, Surveillance.

# 008
# Effect of Aerodynamic Loads on Wing Deformation of Insect-Mimicking Flapping-Wing Micro Air Vehicles

**Vu Dan Thanh Le[1], Anh Tuan Nguyen[1], Ngoc Thanh Dang[1], and Utku Kale[2]**

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**Abstract:** Insect-mimicking flapping-wing micro air vehicles (FWMAVs) are currently of great research interest due to their many practical applications. Studies have shown that using a flexible wing will improve the flight characteristics and the energy efficiency of the FWMAV due to the beneficial influence of the wing deformation on the aerodynamic forces. However, in the opposite direction, the effect of aerodynamic forces on wing deformation is not straightforward. In this study, the insect-like wing is modelled by a body-spring system, combined with an aerodynamic solver based on the unsteady vortex-lattice method. The proposed model is then used for investigating the hovering flight of a hawkmoth wing. Results show that the aerodynamic loads have a considerable influence on the wing deformation.

**Keywords:** Insect flapping wing; Aerodynamic; Fluid - Structure interaction

# 009
# Influence of Gyroscopes on the Accuracy of a Nanosatellite Attitude Estimation

**Hasan Kinatas and Chingiz Hajiyev**

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**Abstract:** In order to obtain three-axis attitude information of a nanosatellite at least two reference directions are needed. Magnetometers and Sun sensors are the most commonly used attitude sensors for measuring these reference directions because they are inexpensive, reliable and require low power consumption. On the other hand, the use of gyroscopes for attitude determination is optional and having an angular velocity vector measurement may increase the accuracy of the attitude estimation system. This study discusses and compares the performance of a nanosatellite attitude estimation system with and without gyroscope measurements. A non-traditional approach is used for the estimation process where a Sun direction-Earth's magnetic field-based TRIAD algorithm and an Extended Kalman Filter (EKF) is integrated to reduce the computational load. Proposed attitude estimation system is simulated with and without gyroscope measurements and their estimation accuracies are compared. As a result of simulations, it is seen that use of gyroscopes improves the attitude estimation accuracy by up to 16%.

**Keywords:** Nanosatellite, attitude estimation, magnetometer, Sun sensor, gyroscope.

# 010
# Insertion of Shape Memory Alloy Wire with 3D Printed Thermoplastic Polyurethane Structure for Flexural Application

**Leong Shii Jang, Dayang Laila Majid, Ermira Junita Abdullah, Faisal Abdul Hamid, Elias Randjbaran, and Husam Yahya Imrana**

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**Abstract**: The shape memory alloy (SMA) wire actuator is desirable to modify the structure properties and shape morphing ability particularly for the aircraft wing application. However, directly embedded it into a matrix system caused mismatch in coefficient of thermal expansion (CTE) which further led to delamination and structure failure issues. Thus, a soft material that integrated effectively with SMA actuator to achieve shape changing while resist the external load is required. In this work, SMA wire is inserted through the gaps in corrugated 3D printed thermoplastic polyurethane (TPU) elastomeric structure to analyze the geometrical factors and its flexure performance. The flexure test results indicated that TPU with inactive SMA insertion has sustained higher flexure load with 21% increase in both flexure modulus and maximum load. However, activated SMA wire insertion demonstrated opposite behavior by increasing bending moment. Flexure test on fixed-fixed single SMA wire further supported the above finding. Moreover, SMA insertion in top eccentric from neutral axis of TPU sample achieved highest flexure modulus and maximum load followed by at bottom and neutral axis. Thus, this design approach is presented to signify the structural integrity of 3D printed TPU with SMA and flexure properties modification through SMA eccentric position.

**Keywords:** Flexure modulus, Sectional area, Shape memory alloy, soft actuator

# 011
# Using Neural Networks to Accelerate High Order Discontinuous Galerkin Simulations

**Fernando Manrique de Lara and Esteban Ferrer**

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**Abstract:** High order discontinuous Galerkin methods provide very accurate solutions when selecting high order polynomials inside each mesh element. Increasing the polynomial order improve the accuracy, but also increases the computational cost. For example, when using explicit temporal schemes, high order polynomials require more restrictive time steps. In this work, we propose to accelerate high order discontinuous Galerkin methods using Neural Networks. We train a Neural Network using a high order discretisation, to extract a corrective forcing that corrects a low order solution, to recover high order accuracy. With this corrective forcing term, we can simulate using a low order solution (low cost) and correct the solution to obtain high order accuracy. The methodology is examined for a variety of meshes and polynomial orders for the 1D viscous Burgers' equation. The result show significant accelerations specially when considering high polynomial orders.

**Keywords:** Deep learning, neural network, High order discontinuous Galerkin.

# 013
# Coherence in Turbulent Canopy Flows: A Study of the Flow Patterns

**Christian Amor[1], Alessandro Monti[1], Marco Edoardo Rosti[1], and Soledad Le Clainche[2]**

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**Abstract:** This work presents the coherent structures found in dense and submerged rigid filamentous canopies in a turbulent open-channel flow. The flow structures are characterized by means of the higher order dynamic mode decomposition (HODMD) method. We represent large-size coherent structures that extend throughout the streamwise direction, and we identify flow instabilities near the canopy edge leading to their breakdown. These structures are present in both the outer and inner regions of the canopy, although they look uncorrelated. We find that dense filamentous canopies stimulate the coherence of the flow, even if the turbulence levels are high.

**Keywords:** Turbulent flow, canopy flow, streak breakdown, coherent structures.

# 014
# PD Controller with Particle Swarm Optimization for Satellite Attitude Control

**Mehmet Fatih Erturk and Chingiz Hajiyev**

*Istanbul Technical University, Istanbul, Türkiye*

**Abstract:** In this study, a PD controller is used as an attitude controller with using only magnetic actuator. Gain of the PD controller is tuned by a particle swarm optimization to increase the pointing accuracy of an Earth oriented satellite. While deterministic approach is used, increased on the performance of the satellite controller is observed.

**Keywords:** Attitude Control, PD Controller, Gain Optimization.

# 015
# A Predictive Physics-Aware Machine Learning Model for Reacting Flows

**Adrián Corrochano[1], Rodolfo S. M. Freitas[2], Alessandro Parente[2], and Soledad Le Clainche[1]**

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*[2]Université Libre de Bruxelles, Bruxelles, Belgium*

**Abstract:** In this work, a predictive reduced order model based on a combination of proper orthogonal decomposition and deep learning architectures is analyzed to predict the evolution in time of the thermodynamic states of a reacting flow database. The complexity of this type of flow resides in the multiscale nature and the transient behavior of the physical states. For solving the first problem, different scaling methods have been applied and compared to the case without scaling the variables. The results show that the scaling methods used improve the prediction error for all the variables studied. The temporal modes related to the periodic behavior of the flow are better predicted by the algorithm than the transient ones, as expected. Methods based on deep learning architectures, as the one presented in this paper, can be suitable to generate high-fidelity databases with a low computational cost. These databases can be useful to improve the efficiency in combustion in aircraft, as well as reducing the pollutants produced in combustion systems.

**Keywords:** Reacting Flows, Machine Learning, Neural Networks Reduced Order Models.

# 016
# Rendezvous and Docking for Space Vehicles

**Mert Sever and Tuncay Yunus Erkeç**

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**Abstract:** Today, technology in the field of space is developing rapidly. In this direction, the scope and importance of studies in space is gradually expanding. Expanding space studies have created high spacecraft capabilities and precision operational processing requirements, creating the curiosity of reaching other planets and objects. In this context, rendezvous and docking problems have emerged. In this study, the docking problem was tried to be solved for two objects moving in the same orbit, and the amount of thrust required for docking was calculated using a global navigation satellite system (GNSS) based system. With this study, the basic logic for the solutions and simulations of more complex problems to be created in the future has been tried to be examined.

**Keywords:** Docking, Rendezvous, Two-body, Kalman Filter, GNSS.

# 017
# Effect of The Grids Span on a Biomimetic UAV

**Rafael Bardera[1], Ángel Rodriguez-Sevillano[2], Estela Barroso[1], and Juan Carlos Matías[1]**

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**Abstract:** Birds can reduce the induced drag using an elongation of the wings called primary feathers. In this paper, a numerical analysis of a biomimetic Unmanned Aerial Vehicle (UAV) that imitates that elongation at its wings is presented. Specifically, the UAV has a rectangular wing and three grids at the tip of the wing that changes the lift distribution over the wing. The effect of the grids span has been compared using Computational Fluid Dynamics (CFD) for the UAV without grids and for 1/3, 2/3, and fully extended grids. The aerodynamic forces (lift and drag) has been obtained under different flight conditions in order to compare the differences in aerodynamic efficiency for each grid span configuration. In general, an increase of grids span translates into a significant increase of more than 20% in lift and aerodynamic efficiency of the UAV during cruise flight.

**Keywords:** UAV, Biomimetic, Wingtip, Grids, Aerodynamic Efficiency, CFD.

# 019
# Shallow Neural Networks and Turbulent Flows

**Rodrigo Abadia-Heredia[1], Marco Crialesi-Esposito[2], Luca Brandt[2], and Soledad Le Clainche[1]**

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**Abstract:** Air-assisted atomization is one of the dominant forcing used to induce breakup in liquid jets. This process is defined by the simultaneous injection of a low-momentum liquid jet and a high-momentum air stream along the same direction, separated only by a thin solid plate. The interaction between the two phases generates an instability that manifests itself in the generation of droplets following the breakup of these liquid sheets. In this work, we study the performance of a Reduced Order Model (ROM), which combines dimensionality reduction techniques with deep learning architectures, to predict the flow dynamics once trained on simulation data.

**Keywords:** Turbulence, Deep Learning, Artificial Neural Networks, Fluid Dynamics, Multiphase Flows.

# 020
# Data-driven Methods Beyond Aerospace Field

**N. Groun, B. Begiashvili, E. Valero, J. Garicano-Mena, and S. Le Clainche**

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**Abstract:** Understanding fluid dynamics problems in the aerospace industry is a challenging endeavor: complex physical phenomena need to be described and quantified. In the latter years, data-science techniques have arisen as a powerful tool to tackle these problems. In this contribution, we focus on a fully data-driven technique, the higher order dynamic mode decomposition (HODMD). We describe first the technique, departing from its solid mathematical foundations, and justify its capabilities. We show next the applicability of HODMD to a complex fluid dynamic problem, a compressible, turbulent jet. Finally, we exploit the fully data-driven nature of the tool to show the general applicability of the HODMD method to other complex data types. Specifically, medical dataset.

**Keywords:** Fluid dynamics, higher order dynamic mode decomposition, data-driven methods, aerospace.

# 021
# Modeling and Simulation of Double Acting Hydro-Pneumatic Suspension System for 6x6 Terrain Vehicle with Different Performance Parameters

**Kaan Berke Ulusoy[1], Bensu Değirmenci[1], Derin Türedi[1], Erkin Filiz[1], Mustafa Karaman[2], and Erhan İlhan Konukseven[1]**

*[1]Middle East Technical University, Ankara, Türkiye*
*[2]Gazi University, Ankara, Türkiye*

**Abstract:** Hydro-pneumatic suspensions are widely used, especially in heavy vehicles. In this study, a double-acting version of hydro-pneumatic suspension is studied. A dynamic model of a two DOF quarter car is created with the help of MATLAB/Simulink software. The suspension structure of a 6x6 vehicle is used as the basis for kinematic relationships. The tire properties are considered in the model as an additional DoF to achieve more realistic results. 10 tons carrying capacity 6x6 vehicle tire parameters used in the tire model. The resulting dynamic model was analyzed for a road profile representing a bump.

**Keywords:** Double Acting Hydro-Pneumatic Suspension, Dynamic Modelling, Quarter Car for Rough Terrain Vehicles.

# 022
# Inspection of Welding Joints Using Topological Derivative Methods

**Sergio Muñoz and María-Luisa Rapún**

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**Abstract:** This work deals with the detection of defects in welding joints of steel plates. We will process measured data at a set of receivers obtained in non-destructive tests by using a very powerful mathematical tool called the topological derivative. The performance of the method will be illustrated in a simplified model in two dimensions covering highly demanding situations that include defects of different sizes and a reduced number of emitters and receivers.

**Keywords:** Welding joint inspection, Inverse problem, Defect detection, Non-destructive testing, Multifrequency, Topological derivative.

# 023
# Machine Learning to Reconstruct Aeronautical Databases with Deep Neural Networks

**Paula Díaz, Adrián Corrochano, Manuel López-Martín, and Soledad Le Clainche**

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**Abstract:** In this work, two different interpolation methods are compared with the aim at reconstructing complete aeronautical fields. The first method consists on applying Singular Value Decomposition to the database, combined with linear interpolation. In the second method, the linear interpolation will be replaced by a neural network with the aim at improving the results. The two methods have been applied to reconstruct an Atmospheric Boundary Layer field. The results show that using neural networks improves the error made in the interpolation by two orders of magnitude. In addition, the neural network provides quite accurate results, reconstructing the stationary variables of the Atmospheric Boundary Layer.

**Keywords:** Interpolation, ABL, Neural Networks, data-driven methods.

# 027
# The Analysis of Collision Avoidance in Honeybee Flights

**Shreyansh Singh[1], Rishabh Desai[1], Mandyam Veerambudi Srinivasan[2], and Sridhar Ravi[2]**

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**Abstract:** This study investigates the strategies used by honeybees (Apis mellifera) to avoid unfamiliar obstacles encountered during flight. Bees were trained in behavioural experiments to fly in a tunnel that contained a solitary vertically oriented cylindrical obstacle placed along the midline of the tunnel. Flight trajectories of bees were recorded in two conditions where the where the diameter of the obstructing cylinder was 60mm and 165mm respectively. The digitised trajectories of the bees were analysed to identify visual cues that could play a role in mediating obstacle avoidance: such as retinal angle (angular subtense of the obstacle), retinal expansion velocity (REV), and relative retinal expansion velocity (RREV). Our findings, based on analysing salient events during flight, such as the point of deceleration before the obstacle, suggest an obstacle avoidance response that is based on the RREV of the obstacle when the bee is on a collision course. This study paves the way for the design of biologically inspired unmanned aerial systems by systematically identifying some of the cues that might be used by honeybees for initiating obstacle avoidance.

**Keywords:** Obstacle avoidance, Insect flight, Honeybees, Navigation

# 028
# Numerical Investigation of a Uniform Viscous Transonic Flow Past a Rotating Circular Cylinder

**Inés Arauzo and José Miguel Pérez**

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**Abstract:** This work analyzes the transonic flow around a rotating circular cylinder by using direct numerical simulations. The combination of the uniform freestream flow with the flow due to the rotation of the cylinder generates a lift force (Magnus effect) that for transonic flows can be conditioned by the presence of a shock wave on the suction side. In addition, the dependence of lift and drag forces with the dimensional parameters of the problem has been tested. The numerical simulations have been performed with the SU2 code, which solves the Navier-Stokes equations for compressible flow using a second-order finite volume scheme combined with different convective flow reconstruction schemes; JST and HLLC. Finally, an implicit time integration scheme combined with the dual time-stepping method has been used.

**Keywords:** rotating circular cylinder, transonic flow, aerodynamics coefficients, POD (Proper orthogonal decomposition).

# 029
# Design and Analysis of Rocket Launch Vehicle for Cubesats

**Alper Şanli, Tuncay Yunus Erkeç, Melih Beceren, and Mehmet Furkan Kemalli**

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**Abstract:** CubeSat missions are changing and their number is increasing day by day due to their high efficiency. Their small size makes it easier for CubeSats to reach space. In this study, a new launch vehicle was designed to fit the CubeSat dimensions. The first design and analysis of a stable launch vehicle that will carry the 3U sized CubeSat to the stratosphere layer has been carried out. In future studies, studies of the launch vehicle that will reach the Kalman line, which is the space limit, will be carried out.

**Keywords:** Launch Vehicle, Rocket, CubeSat, Design, Analysis, Stratosphere.

# 031
# The Use of Wireless Unmanned Aerial Vehicles in the Field of Defense and Current Developments

**Alpaslan Durmus, Erol Duymaz, and Mehmet Baran**

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**Abstract:** The use of UAV systems for military reconnaissance and surveillance activities is one of the most frequently used methods. However, problems related to flight time cause restrictions in the use of UAV systems in the field of defense and security. With today's developing technologies, TUAV (Tethered Unmanned Aerial Vehicles) systems have been started to be designed to overcome the flight time limitations. TUAV systems in the field of defense; It is used to ensure border security, protect forward operational bases, and establish telecommunication ports. TUAV systems offer significant advantages to military bases in many aspects in reconnaissance and observation activities. Wired UAV systems have important advantages in terms of flight time, safe flight, ease of use, autonomy, legislations, secure data transfer and deterrence. In this study, usage examples of TUAV systems in the field of defense were examined and examples of use in the field of defense were presented.

**Keywords:** Tethered UAV, Drones, UAS, Security, Defense.

# 033
# Smart Disaster Management Using Big Data Analytics

**İsmail Burak Parlak**

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**Abstract:** The direct or indirect affection of the disaster is a severe issue in the analysis of smart cities. The behavior of public information is vast and the detection of victims and potential risks is time limited. Social networks provide live information within the disaster region where the emergency & rescue organizations would reach the critical zones. However, the disaster knowledge with critical insights is generally flooded with non-rescue information which is overwhelmed through different modalities in big data analytics. Therefore, the guidance of big data represents the foundations in smart disaster management. In this study, we have focused on the 2020 Izmir earthquake which is classified as a severe earthquake in the intensity scale. The earthquake information has been retrieved using microblogs from Twitter. The dataset has been pre-processed manually and automatically. The manual labels have been trained as vector embeddings in order to generate automatic labels as a semi-supervised approach. Naive Bayes, Support Vector Machines and BERT Transformer networks have been applied on two classes. All approaches scored relevant evaluation values for disaster knowledge. Our findings presented the efficacy of big data approaches for rescue and non-rescue classes in disaster management. We conclude that smart rescue strategies would rely to big data analytics where the civil rescue teams outnumber the emergency & rescue organizations.

**Keywords:** Disaster analysis, Smart city, Natural Language Processing, Text Classification, Big Data.

# 034
# A Critical Review of Deployable Truss Masts and Proposal of a New Mast: HiDAM

**Yunus Cebeci, Murat Demirel, and Gökhan Kiper**

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**Abstract:** This paper investigates the factors which affect the packing ratio of deployable articulated truss masts and investigates the necessary design criteria for new designs with enhanced packing ratio. First, the available deployable articulated truss masts are examined, and the design parameters of these structures are worked out. Then a novel design called HiDAM is proposed with superior packing ratio compared to similar ones in the literature.

**Keywords:** Satellite components, Deployable structures, Deployable mast.

# 035
# Implementation of Trajectory Propagator for Artillery Projectiles Based on Artificial Neural Networks

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*Universidad Politécnica de Madrid, Madrid, Spain*

**Abstract:** The Guidance Navigation and Control (GNC) is one of the most prominent subsystems in weapon design. Smart munitions, as new trend in artillery shells development, need trajectory propagators as a core part of this subsystem. These propagators are deployed inside the electronic fuse and use advanced and precise models for the calculation of the point of impact. This prediction is an input for the guidance and control loops and govern the design of the navigation part. The objective of this work is to study the feasibility of using neural networks as artillery projectile trajectory propagators to replace the calculation performed on board by means of an artificial neural network, which predicts the point of impact based on initial launch conditions. For this, in this work a trajectory propagator is created within MATLAB and Simulink with a four-degree-of-freedom and five-degree-of-freedom non-linear models. With this dataset, a neural network is trained to learn the mechanics of outdoor ballistics inherent in the results of the propagator. Finally, the results of the predictions of the neural network are compared with the results of the propagator, showing a promising low error in the prediction of the neural network and their viability is analysed as possible artillery shell trajectory propagators.

**Keywords:** Ballistics, Projectile, Aerodynamics, MATLAB, Simulink, Python, Neural Network, Machine Learning.

# 036
# Manufacturing of a Hybrid VTOL UAV Using Rapid Prototyping Techniques

**Sinan Alnıpak, Turan Konyalıoğlu, İbrahim Halil Şahin, and Erdinç Altuğ**

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**Abstract:** Unmanned aerial vehicle technologies have gained serious momentum in recent years. Despite these developments, the production of a UAV still requires expensive equipment. Recently, with the developments in rapid prototyping technologies, some researchers printed and flew 3D printed UAVs, successfully. In this study, we investigate the possibility of using 3D printer technology for the manufacturing of a 3.8-meter wingspan hybrid UAV. It has been observed that it is possible to manufacture bigger UAVs with this approach, which is promising in making the production of UAVs accessible to the general public.

**Keywords:** Hybrid UAV, Rapid Prototyping, Vacuum Infusion.

# 037
# Efficient Data-Driven Algorithms to Identify Patterns in Aeronautical Industrial Problems

**Eneko Lazpita, Beka Begiashvili, Jesús Garicano, Soledad Le Clainche, and Eusebio Valero**

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**Abstract:** Numerical approaches of industrial aeronautical problems have become very popular, but a great computational cost is attached to them. A good alternative in fluid dynamics is developing reduced order models using, i.e., modal decomposition techniques such as singular value decomposition (SVD), proper orthogonal decomposition, or dynamic mode decomposition, which reduce the dimensionality of large databases extracting the most relevant features of the flow. Other techniques, like resolvent analysis, predict the flow response to some external driving force, which is suitable for flow control applications. This work briefly reviews the performance of these methodologies for the analysis of fluid dynamic databases and introduces the possibility of combining these techniques with a parallel SVD algorithm to deal with large databases, which are often encountered when solving industrial aeronautical problems.

**Keywords:** POD, DMD, SVD, resolvent analysis, data-driven methods.

# 038
# The Use of Tethered Unmanned Aerial Vehicles in the Field of Defense and Current Developments

**Alpaslan Durmus, Erol Duymaz, and Mehmet Baran**

*Ostim Technical University, Ankara, Türkiye*

**Abstract:** The use of UAV systems for military reconnaissance and surveillance activities is one of the most frequently used methods. However, problems related to flight time cause restrictions in the use of UAV systems in the field of defense and security. With today's developing technologies, TUAV (Tethered Unmanned Aerial Vehicles) systems have been started to be designed to overcome the flight time limitations. TUAV systems in the field of defense; It is used to ensure border security, protect forward operational bases, and establish telecommunication ports. TUAV systems offer significant advantages to military bases in many aspects in reconnaissance and observation activities. Wired UAV systems have important advantages in terms of flight time, safe flight, ease of use, autonomy, legislations, secure data transfer and deterrence. In this study, usage examples of TUAV systems in the field of defense were examined and examples of use in the field of defense were presented.

**Keywords:** Tethered UAV, Drones, UAS, Security, Defense

# 039
# Optimal Thermal Sensor Placement for Accurate Heat Transfer Measurements

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**Abstract:** Power electronics and battery management systems required to guide and control unmanned air vehicles produce considerable amounts of heat. To improve the endurance and reliability of UAVs it is critical to maintain and manage the operating temperature of the airframe, power electronics, and batteries regardless of the thermal load generated from the multiple heat sources in the airframe. The UAVs have internal cooling systems that use the surrounding air or exploit internal fans to mitigate the thermal load. However, in both situations: pulling ambient air or using cooling fans, its usage implies higher power demand, due to the increased aerodynamic drag or the electric consumption of the coolers, which ultimately reduces the operational time of the airframe. In this line, to mitigate the impact of the cooling requirements on the airframe range or operational envelope it is crucial to have accurate measurements of the current heat flux and evaluate the amount of cooling required to control the thermal load. In this paper, we define an approach to identify the optimum location of thermal sensors based on Kriging interpolation and simulated annealing optimizations to minimize the number of sensors required and ensure correct heat transfer characterization.

**Keywords:** heat transfer, thermal sensors, cooling.

# 041
# Time-Varying Consensus Formation Control of a Group of Quadrotor System with Collision Avoidance

**Kaan Can and Abdullah Başçi**

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**Abstract:** In this paper, a basic consensus formation control (CFC) algorithm has been proposed for a group of four rotor unmanned aerial vehicle (UAV) called as quadrotor to realize a cooperative fly in formation. The main idea is to apply the CFC algorithm on five quadrotors to realize a pentagonal formation shape from any initial positions throughout a time varying trajectory. Also, the interconnection between quadrotors is provided by a pre-defined Laplacian matrix. Moreover, in order to avoid collisions between quadrotors, a collision avoidance algorithm has been added to main hybrid control equation. The simulation results show the effectiveness of the proposed control algorithm.

**Keywords:** Graph Theory, Consensus Control, Formation Control, Unmanned Aerial Vehicles.

# 042
# Aerodynamic Effects of Airfoil Shape on Tandem Airfoil Configuration in Low Reynolds Number Transonic Flows

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*Amrita Vishwa Vidyapeetham, Coimbatore, India*

**Abstract**: The Tandem Airfoil Configuration (TAC) has various notable advantages such as reduction in span of wing, structural weight and parasitic drag. It also increases the total lift of the aircraft. Experimental or computational studies observations were made in earlier works at Low Reynolds number associated with low Mach numbers or High Reynolds Number in the Transonic regime. In this work, a 2D CFD analysis is conducted where the TAC is studied at Transonic, Low Reynolds Number flows. Such flows occur at high altitudes of around 30 km for stealth UAVs planned by the military. Such situations also occur at low altitudes in the Martian atmosphere. The aerodynamic effects of airfoil shape on TAC are observed primarily using two airfoils, Wortmann fx63137-il (Low Reynolds Number airfoil) and RAE 2822 (Transonic airfoil). Our simulations show that low Reynolds number effects are found to be dominant in the low transonic Mach regime (0.7-0.8) where Wortmann FX 63-137 shows good aerodynamic efficiency but as we move to higher transonic Mach numbers (>0.8), RAE 2822 showed better aerodynamic efficiencies for the cases tested.

**Keywords:** Tandem Airfoil Configuration (TAC), Reynolds Number (Re), Transonic Flows, Airfoils, UHAMAV, Martian UAV.

# 043
# Neural Networks to Speed Up Multiphase Flow Numerical Simulations

**León Mata, Rodrigo Abadía-Heredia, José M Pérez, and Soledad Le Clainche**

*Universidad Politécnica de Madrid, Madrid, Spain*

**Abstract:** A new method for predicting multiphase flows via neural networks is presented. The idea underlying this method is to use single-phase flow data to avoid performing multiphase flow simulations and therefore reducing drastically the computation time by approximately a factor of three. Numerical simulations have been carried out using the Volume of Fluid method to model the flow in two concentric jets. The physical mechanisms involved are analyzed via higher order dynamic mode decomposition (HODMD) and show a large number of similarities between the single-phase and the multiphase flow cases. Flow predictions are done using a recurrent neural network and the results show that it is possible to predict the temporal evolution of multi-phase flows from single-phase flow databases.

**Keywords:** Multiphase, Volume of Fluid, HODMD, Neural Networks.

# 044
# Installation of a Ram Air Turbine in a Fixed-Wing UAV

**María Expósito Turbak, Xin Chen, and Andreu Carbó Molina**

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**Abstract:** The aim of this project is to install a RAT turbine in a fixed-wing UAV using wind energy as a power source for its avionics in emergency situations. For this, the flight conditions in a glide performance and the power parameters necessary to control the descent have been defined. Once these data have been calculated, a turbine has been designed to provide the necessary energy. The QBlade software has been applied to design the blades and their subsequent simulation based on the BEM theory. Several airfoils and turbine configurations have been analyzed, obtaining as a result the optimal profile for the RAT turbine, the SG6043 with three blades, this being the one that offers the least resistance and reaches the required energy more efficiently. Finally, the impact of the turbine assembly on the drone system has been studied, presenting the advantages and disadvantages of the application of said technology and how it would affect the actions of the aircraft.

**Keywords:** Fixed-wing UAV, RAT, Wind Energy, Avionics.

# 046
# Assessment of UAV Operators by Human Factors Analysis and Classification System (HFACS) based on AHP

**Omar Alharasees[1] and Utku Kale[1]**

*Budapest University of Technology and Economics, Budapest, Hungary*

**Abstract**: The emergence of unmanned aerial vehicle (UAV) use and the need for skilled operators have been a cross point with the significant and highly raising accident rates compared to the manned aircraft operations which have a negative influence on UAV applicability and availability, the unacceptable light of the scare regulations challenges to reduce the number of mishaps and accident rates. The Human Factors Analysis and Classification System (HFACS) is a well-known approach for accident risk assessments that aggregates the accident causation to four main sources: (i) Organizational Influences, (ii) Supervision, (iii) Preconditions And (iv) Acts. The research introduces a novel method implementing the Human Factors Analysis and Classification System (HFACS) model combined with an analytical hierarchal decision-making model to create a questionnaire in investigating the critical factors from the UAV operators' point of view on accidents in AUVs operations. 16 UAV operators participated in a two-level hierarchal model with 4 main criteria and 15 sub-criteria.

**Keywords:** AHP, AUV, HFACS, Operators total load, Accidents, UAV Operators.

# 047
# Unmanned Aerial Vehicle Propeller Design and Production by Fused Filament Fabrication

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**Abstract:** Additive manufacturing technologies have become the focal point of research and development studies thanks to their production flexibility, increasing material diversity, and ease of access. Additive manufacturing methods have superior advantages, especially in the manufacture of parts with complex geometry, produced in small numbers, and the possibility of rapid structural change. In areas where there is no project-based and mass production such as the aviation sector, it has started to be not preferred to a significant extent. The fused filament extrusion method is the process of combining thermoplastic materials in layers through a heated nozzle. This study produced propeller designs that allow an unmanned aerial vehicle (UAV) to be used in different missions by fused filament fabrication method using pure polymer and polymer matrix composite filaments. The mechanical properties and force generation performances of the produced propellers were tested. Propellers subject to bending, buckling and centrifugal forces were manufactured using polyamide 6 and carbon fiber reinforced polyamide 6 matrix composite filaments. The production of UAV propellers by additive manufacturing using engineering plastics and composite materials is an innovative method, and it is aimed to provide benefits in interaction with UAV and three-dimensional (3D) printers, the number of which is increasing day by day.

**Keywords:** Unmanned Aerial Vehicle (UAV), Fused Filament Fabrication (FFF), Additive manufacturing, Propeller.

# 048
# Reduced-order Models Using Clustering-based Methods in Synthetic Jets

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*Université Libre de Bruxelles, Brussels, Belgium [2]*
*Princeton University, Princeton, New Jersey, USA[3]*

**Abstract:** Synthetic jets are devices of increasing importance in industry due to applications such as reducing drag in aircraft acting as an active flow control device. This work presents three different reduced-order models of synthetic jets to identify modes and instabilities in different ways. First, Higher Order Dynamic Mode Composition (HODMD) extracts information related to frequencies, while Vector Quantization Principal Component Analysis (VQPCA) and Autoencoders extract the modes with locally linear and nonlinear approaches respectively. In addition, VQPCA distinguishes regions with similar features. All these techniques are found to extract information with similarities and differences, due to their different algorithms, which may be highly relevant for future applications of flow control.

**Keywords:** planar synthetic jets, HODMD, Autoencoders, Machine Learning, VQPCA.

# 049
# Ethics and Autonomous Systems: An Ethical Landscape of Autonomous Weapons

**Aysegul Ozerdem**

*Çukurova Kalkınma Ajansı, Ankara, Türkiye*

**Abstract:** The emerging literature on AI-assisted autonomous weapons focuses more on the technical aspects of the debate and ignores the ethical issues. This article discusses whether ethical and moral values can have an impact on autonomous weapons. The thesis of the article is that the ethical double standard inherent in war may cause more global problems with unethically used autonomous weapons in the future. The issue is evaluated using just war theory and normative ethics, and potential long-term outcomes are discussed. In the first part of the article, the concepts of ethics and just war are explained. The next section discusses the connection of autonomous weapons with normative ethics and the principle of just war. It is explained how the basic ethical principles for autonomous weapons can be determined with the help of normative ethics and just war theory. It is pointed out that lethal technologies supported by artificial intelligence are prone to bias and data dependence, and legal issues in the use of autonomous weapons are discussed. The next section explains the potential consequences of unethical weapons use and points out the importance of ethical use for democratic states. The final chapter highlights the critical importance of surveillance in increasing autonomy in war within the framework of just war theory and proposes solutions.

**Keywords:** ethics, morality, autonomous technologies, autonomous weapons, just war.

# 050
# Aeroelastic Flutter Detection by High Order Dynamic Mode Decomposition Based Technics (HODMD) and Convolutional Neural Networks (CNN)

**Joseba López[1], Rubén Moreno-Ramos[1], and Soledad Le Clainche[2]**

*Capgemini Engineering, Madrid, Spain[1]*
*Universidad Politécnica de Madrid, Madrid, Spain[2]*

**Abstract:** Due to continuous scientific and technological progress, more and more sophisticated algorithms are being developed, which allow to solve difficult problems quite easily and with a high accuracy. In this paper, a very complex aeronautical problem will be treated, which consists of predicting the velocity at which a destructive phenomenon such as flutter appears, using with that aim an algorithm based on high order dynamic mode decomposition (HODMD) and another one based on convolutional neural networks (CNN). The introduction will be about the importance of developing new and more efficient methods to predict flutter, as well as a brief explanation of this phenomenon; in the method point, the HODMD algorithm and its advantages versus the conventional DMD will be discussed, and convolutional neural network (CNN) based algorithms will be introduced; then, the results obtained for both algorithms will be shown; to end up, some conclusions will be obtained.

**Keywords:** flutter, dynamic mode decomposition, convolutional neural networks.

# 051
# An Invariant Feature Space for Flow Regions Identification Using Machine Learning

**Kheir-eddine Otmani, Esteban Ferrer, and Gerasimos Ntoukas**

*Universidad Politécnica de Madrid, Madrid, Spain*

**Abstract:** An invariant feature space has been used within a probabilistic clustering approach to identify the boundary layer, wake region and outer flow regions for the flow past a circular cylinder at Re=3900. The feature space has been constructed to be independent of the coordinate frame used to generate the data, the methodology has been validated using data obtained from a high order numerical simulation. Our methodology reveals satisfactory clustering of the viscous dominated flow regions (boundary layer and wake). The identified region will be used in the future to locally adapt the mesh.

**Keywords:** Computational Fluid Dynamics, Machine Learning, Gaussian mixture, High-order discontinuous Galerkin.

# 052
# WMLES of a Small-Scale Hovering Propeller

**Jelena Svorcan and Christopher Ivey**

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**Abstract:** Propellers/rotors are usually indispensable parts of unmanned air vehicles that enable them to hover, fly and maneuver. It is therefore extremely important to understand and resolve various flow structures that are present during flight. Here, the flow around a hovering, small-scale, custom-made propeller is numerically investigated by wall-modelled large eddy simulation (WMLES). Different operating regimes, achieved by changing RPMs, were both measured and computed, and the two sets of results are compared. Additional flow visualizations in the form of instantaneous flow fields are presented. While the computed thrust and power curves follow the expected trends, slight discrepancy between the experimental and numerical values is observed. It can be attributed to differences in the two set-ups (i.e. some simplifications of the real geometry in the numerical experiment) as well as the complexity of flow transition processes (present at such small Reynolds number flows).

**Keywords:** Propeller, Turbulence, LES, Hover, Thrust.

# 053
# A Review on Fishbone Active Camber Morphing Wing Surfaces

**Emre Özbek[1], Selcuk Ekici[2], and T. Hikmet Karakoc[1]**

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**Abstract:** Morphing wing applications have been used to change various dimensional properties of aircraft. Various 2D and 3D parameters can be changed on the aircraft's wings, tail surfaces, or fuselage with these applications. Two primary schools are becoming widespread today in these application areas: mechanisms school and smart surfaces that employ shape-memory materials and smart actuators. The Fishbone Active Camber approach is a research field that focuses on controlling the deflection on the wing's trailing edge. In this approach, a tendon-like structure is designed that can be brought into desired shapes by creating tension on the wing structure. In this study, previous studies on fishbone active camber were revisited, the current situation was evaluated, and a roadmap was put forward for future studies from the authors' perspective.

**Keywords:** Morphing Wing, Fishbone, Active, Camber, FishBAC.

# 054
# Reliable Aircraft Trajectory Prediction Using Autoencoder Secured with P2P Blockchain

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*University of Tehran, Tehran, Iran[2]*

**Abstract:** In this paper a novel data-driven algorithm is designed for fault tolerant Aircraft Trajectory Prediction (ATP). The ATP model is based on Autoencoder architecture due to its excellent performance when input data provided by the GPS is deficient. The resiliency of our designed Autoencoder is examined in case of adversarial attacks. P2P Blockchain is utilized in order to ensure predicted trajectories for the GPS data failures, and adversarial attacks. Validation studies were done using a database provided by OpenSky Network, and trajectory prediction accuracy was evaluated for a variety of data failures. Performance index confirmed the Autoencoder excellent efficiency, while it was secured with P2P Blockchain in case of adversarial attacks.

**Keywords:** Trajectory Prediction, Autoencoder, Adversarial Attacks, Blockchain.

# 055
# Sensor Hybridization through Neural Networks for Terminal Guidance

**Raul de Celis, P. Solano-Lopez, and Luis Cadarso**

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**Abstract:** Improving accuracy is cornerstone for ballistic rockets. Using inertial navigation systems and Global Navigation Satellite Systems (GNSS), accuracy becomes independent of range. However, during the terminal phase of flight, when movement is governed by non-linear and highly changing forces and moments, guidance strategies based on these systems provoke enormous errors in attitude and position determination. Employing additional sensors, which are independent of cumulative errors, such as the quadrant photodetector, can mitigate these effects. This research presents a new non-linear hybridization algorithm to feed navigation and control systems, which is based on neural networks to accurately predict the line-of-sight vector from multiple sensors measurements. Simulation results demonstrate the performance of the presented approach in a 6-DOF simulation environment showing high accuracy and robustness against parameter uncertainty.

**Keywords:** Terminal Guidance, Ballistic Rocket, GNC, Neural Networks, Control.

# 056
# Performance Improvement of a Fixed-wing UAV using Model Predictive Control

**Abdurrahman Talha Yildiz and Kemal Keskin**

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**Abstract:** In this study, a model predictive control (MPC) approach for the longitudinal dynamics of a fixed-wing unmanned aerial vehicle (UAV) is proposed. The main purpose of the proposed method is to reduce inaccuracy in the control of a UAV's longitudinal movement more quickly. A simulation environment is created in MATLAB/Simulink using the mathematical model of the GTM (Generic Transport Model) with tail number T-2 developed by NASA. The problem is defined as multi-input multi-output system. In order to show efficiency of proposed method linear quadratic regulator (LQR) is also used as a comparison. Tests were carried out for speed, reliability and robustness. Obtained results demonstrates that MPC outperformed LQR.

**Keywords:** Fixed-wing UAV, Longitudinal Control, Model Predictive Control, Linear-Quadratic Control, Multi-Input Multi-Output System.

# 057
# Deep Q Network Based Controller for Vertical Take-off and Landing System

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**Abstract:** In this study, the reinforcement learning based controller algorithm design is developed to control the pitch angle of the Vertical Take-Off and Landing (VTOL) system model. The Deep Q Network (DQN) algorithm is chosen to control the VTOL system because control algorithms such as Proportional-Integral-Derivative (PID) controllers are insufficient to control the system since they do not have a structure that acts by learning about environmental effects. The pitch angle of the VTOL system is controlled with sinusoidal reference and constant reference signals. These reference signals are applied to the DQN algorithm, which uses discrete action space to maximize reward value with a predetermined reward function. The DQN algorithm is tested in the MATLAB/Simulink environment using the VTOL system's mathematical model. The tracking performances of the DQN-based controller algorithm are compared with traditional PID controllers whose parameters are tuned by PID tuner in terms of the integral absolute error, mean square error, integral square error criteria, overshoot, and settling time. The simulation results are shown via simulation studies.

**Keywords:** Reinforcement Learning, DQN, PID, VTOL.

# 058
# Process and Measurement Noise Covariance Tuning in Kalman Based Estimator Aided by SVD

**Chingiz Hajiyev and Demet Cilden-Guler**

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**Abstract:** Process and measurement noise covariance matrices are tuned for an adaptive attitude estimation of a nanosatellite at low Earth orbit based on extended Kalman filter (EKF) that is added by singular value decomposition (SVD) method. The tuning procedure compensates the measurement and process noise covariance variations. The tuning of the R matrix is simply processed in SVD, one of the single-frame methods. The tuning of the Q matrix is defined in the second stage of the Kalman based estimator design. The tuning rules are run at the same time, so the filter is capable of being robust against initialization errors, system noise uncertainties, and measurement malfunctions without an additional filter design usage.

**Keywords:** Adaptive, Robust, SVD-Aided EKF, Nanosatellite, Attitude Estimation

# 059
# Fault Tolerant Attitude Estimation for a Nanosatellite Using Adaptive Fading Kalman Filter

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**Abstract:** This study discusses a non-traditional attitude estimation algorithm for a nanosatellite using an adaptive fading Kalman filter (AFKF) to prevent filter divergence in case of attitude sensor malfunctions. The presented algorithm integrates the TRIAD algorithm with an adaptive filter to estimate the attitude accurately. The TRIAD algorithm uses magnetometer and sun sensor measurements and provides a coarse attitude estimate as the first step of the algorithm. Then, this coarse estimate is filtered via an adaptive Kalman filter which is capable of maintaining the estimation accuracy in case of a sensor malfunction. In order to verify the performance of the proposed system two simulations are performed where the magnetometer and sun sensor measurement noises are increased, respectively.

**Keywords:** Nanosatellite, attitude, Kalman filter, adaptive filtering, fault.

# 060
# A Comprehensive Model to Manage eVTOL Autonomous Operation Within City Airspace

**Behzad Baleghi and Seyyed Mohammad Bagher Malaek**

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**Abstract:** This work describes a comprehensive model for managing multiple eVTOL operating within city limits. The model is based on the fundamental fact that eVTOLs are intelligent robots with limited flying capacity, while there is no central tower to manage their operation. In this context, we have proposed a model so they can negotiate regarding their flight plan. This work describes an agent-based mathematical model that helps coordinate eVTOLs to plan a safe and efficient flight within city airspace. The players are autonomous eVTOL which are moving either passengers or goods. Different case studies reveal clear correlations between the number of operational eVTOLs, the number of landing spots on each station, and the minimum and maximum stay at each landing spot. The proposed model is scalable and allows considering a new station with a different number of landing spots. The model could also be used to examine city limits and air-travel demands. The proposed model is parametric to consider different urban areas. Further investigations might be necessary for cases where an eVTOL has to deal with an emergency and needs to land immediately at its nearest station.

**Keywords:** Urban Air Mobility, On-Demand Mobility, eVTOL Air Taxi, Autonomous, Operation Management, Vertiport, Vertistop, Multi-agent system.

# 061
# On the number of Monte Carlo Runs for Stochastic Processes

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**Abstract:** UAV applications in defense industry are increasing in recent years and most of these applications such as collision avoidance systems, target tracking, navigation and guidance algorithms are based on stochastic dynamic equations which are suitable to be analyzed by Monte Carlo simulations. The purpose of this paper is to define a strategy to select the number of Monte Carlo runs of each simulation. For this reason, a Monte Carlo simulator for UAV's trajectory estimation algorithms is used, and the computational load and accuracy of the population parameters are considered to select the number of Monte Carlo runs.

**Keywords:** Monte Carlo simulation, tracking, stochastic processes, ACAS Xu.

# SW01
# Fighting UAV "SHADOW"

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**Abstract**: Unmanned aerial vehicles are emerging as cost-effective systems against manned vehicles by finding use in both air-to-ground and air-to-air missions [1]. In the Fighting Unmanned Aerial Vehicle category organized by Teknofest, unmanned aerial vehicle systems are expected to be able to fly fully autonomously and interlock with each other in the air[2]. Within the scope of this study, an unmanned aerial vehicle platform, ground station, and ground station software are being developed by the student team and advisors. The features of the unmanned aerial vehicle platform include parameters such as speed, rate of climb, airtime, image processing capability, and heading towards the unmanned aerial vehicle it detects and evades undetected. Within the scope of the project, an unmanned aerial vehicle system called Shadow, which can detect and track other unmanned aerial vehicles in the same airspace has been developed with all its components. Shadow UAV has a wingspan of 2 meters. With a take-off weight of 3.6 kilograms, it can fly up to 30 minutes and proceed with its mission. Shadow has a 10 m/s stall speed and can reach up to 25 m/s maximum flying speed. Within the scope of its mission, Shadow UAV can take-off, detect other UAVs in the airspace, can artificially lock to the UAV it detects and then tracks its component in the air to simulate a UAV dog fight and after executing its mission or in a low battery situation can land to the ground, all autonomous.

# SW02
# Caelus, a Robust Experimental Test Fixed-Wing R/C Aircraft for Research and Development of UAV For SAE Aero Design Competitions

*Pegasus UPIIG an SAE Aero Design*
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**Abstract** Pegasus UPIIG is a student chapter of the Instituto Polit´ecnico Nacional campus Guanajuato from Mexico, founded in January 2019 that develops and builds radio controlled unmanned fixed-wing aircraft designed to fulfill the missions of the SAE Aero Design competitions. The result of the synergistic work of the areas of aerodynamics and vehicle stability, structural design, electrical and propulsive system, computer-aided design, social networks and administration, resulted in the design and manufacture of Caelus, a robust experimental test aircraft. The vehicular configuration of Caelus consists of a conventional empennage, tricycle landing gear, high wing configuration and single electrical engine. It is manufactured with aluminum, balsa wood, 3D printed structural joints reinforced with epoxy resin and marine fabric. All of this, with the aim of reducing weight without compromising the strength and integrity of the structure. In addition, Caelus has epoxy fiberglass elements strategically combined with borax in order to reduce the spread of the flame in the event of an incident. Furthermore, the fuselage was designed to achieve maximum volumetric capacity and thus, allow the team to use different payload for experimental tests. Due to the high flow interference of the fuselage, 3D-CFD analysis were performed to reduce aerodynamic drag by using wingtip devices and passive ducts to control adverse flow gradients in the root chord section of the wing and flow recirculation, and thus, improve aerodynamic performance. As result, Caelus is a light aircraft designed to achieve static stability criteria with moderate flight maneuverability and capable of fly with different size and weight of payload for research and development purposes for future team's SAE Aero Design aircraft.

# SW03
# TULPAR UAV

**Kürşat Çiçin, Ali Kankaya, İlknur Keskin, Sena Türker, Halit Hakan Hizli, Hediye Orhan, Sevim Dilara Polat, Emine Çağlar, Fatma Yalçinkaya, Kadir Arslanpinar, and Bahar Karaca**

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**Abstract**: VTOL aircraft are hybrid vehicles that can travel vertically, take off, and move off, like fixed wings. VTOL aircraft can be easily used in civilian and military areas due to their reliability and lack of track requirements. NASA's UAM (Urban Air Mobility) [1] project and the KAIA (Korea Aerospace Industries Association) civil aviation works [2] are available to accelerate urban transport research in civil aviation. Most of the work on VTOLs with tilt rotor mechanisms is theoretical work [3,5]. There are also different types of VTOL studies conducted nationally [6]. Very few of these studies have been conducted on the tilt rotor. VTOL type air vehicles are divided into tilt rotor (movable rotor) and non-tilt rotor (motionless rotor). As the Göktürk UAV team, we produced a VTOL called the TULPAR, which has a tilt mechanism with three motors. TULPAR was designed by using aircraft engineering students' simulation programs. Mechanical and mechatronics engineering students modeled unique fuselages and landing gear using CAD programs. In the production of TULPAR, a composite made of carbon fibre and epoxy was used due to its strength and lightness. In the production of the fuselage, a wooden form was used. Wings were manufactured from foam. Furthermore, their strength was increased by using glassfiber and epoxy resin composite. Electrical electronics engineering students made decisions about electronics and their installation. TULPAR has full autonomous flight ability. Additionally, it has a connection with the ground station with the aid of radio frequencies. Flight recordings are analyzed by electrical and electronic students after flight tests and then required optimizations are made. TULPAR has a payload capacity of 900 grams. Computer engineering students play an important role in target acquisition and full autonomous approach to targets. TULPAR flies on a specified route and gives the coordinates of the specific target to the ground station.

# SW04
# Fuel Cell - Powered Adaptation of a Light Helicopter Design for Unmanned Missions

**Jes´us Morales L´opez**

**Abstract**: The current project is centered around the design of a light helicopter model, using the increasingly popular and evergrowing technology of hydrogen-based fuel cells, given their environmental advantages over fossil fuels. More specifically, starting from a previously calculated, statistically-based design of a light helicopter for civil use with a capacity for two passengers, the new power system has been then iteratively dimensioned and optimized for different applications: from urban and inter-urban commutes to unmanned operations, both civil and military, obtaining in this last case a model able to perform while having a minimum expected value of 50 kg in payload. This iterative methodology was carried out based on the theoretical background for aerodynamic design of helicopters, obtaining approximations of cruise and ascending/descending power, as well as the fuel required to complete the mission accounting for the current state of the art of the involved technology. In the development of the readapted version, focus was centered on the new power system, including careful considerations about the performance of its components on this application. Most remarkably, the design allows to remove transmission systems to reduce weight and considers the requirements of the needed liquid hydrogen tanks to obtain a safe and efficient location and distribution of the fuel. The fuel cell system was simulated at different altitudes to account for its limitations and the fuel storage system was optimized aerodynamically in terms of overall dimensions. After the aerodynamic calculation of the fuel cell, battery, hydrogen tanks and electric motors, a draft of the complete helicopter model was developed considering the work of previous authors on aerodynamics, materials and space distribution in order to both maximize the potential and leave room for the next steps in terms of improvement through more specific studies. Additionally, to assess the created model, a life-cycle assessment (L.C.A.) was performed, studying the environmental impact of the design compared to its predecessor and use the opportunity to discuss the current state of hydrogen production, as well as future challenges related with this technology.

# SW05
# Design of an UAV "Phoenix"

**David Cvetković, Aleksa Stefanović, Lazar Nikolić, Dušan Lazić, Milan Rakić, Marko Skakun, and Toni Ivanov**

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**Abstract**: Project "Phoenix" is a project organized by team BEOAVIA centered in the University of Belgrade for the purpose of competing in Air Cargo Challenge 2022 in Munich. Team itself consists of five subdivisions in respect to problem solving tasks of project. Subdivisions are: Aerodynamics, Propulsion, Electronics, Marketing, and Structure & Manufacturing. Every section is organized by its coordinator, who is obligated to give out tasks for their members. Those tasks are handed by project coordinator who is entitled to keep track of deadlines and also helps the group to work as a whole. Following the regulations of the competition, it is necessary to design an UAV aircraft which uses the AXI 2826/10 Gold Line V2 electric motor, a propeller and a three-cell battery. Furthermore, aircraft must fit in boxing unit with dimensions 1100x400x250 mm and also must fit in a "pre-flight" box with dimensions 1500x1500x500 mm. The mission of the ACC 2022 competition consists of following tasks: take-off, the main part of the mission and landing by caring blood transfusion bags in their cargo bay. It is imperative that take-off is executed on the 60 m runway length and then prepare for the main part of the mission. The main goal is to flight larger distance with heavier payload as possible in two minutes.

# SW06
# VOLGER UAV

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**Abstract**: The main goal of Volger UAV is to focus on the task rather than keeping the focus of the personnel in control of the UAV, who can be found in a limited number in the operation area, with piloting. It is aimed that the personnel who will control the Volger UAV will direct it by giving commands with their hands (opening/closing the fingers, moving the arm forward/backward), without trying to learn the working principles of the commander/controller. Based on the problem of empowering personnel, Volger UAV aims to create a control unit that can receive commands from the hand/arm of the personnel by converting the EEG device to an electromyogram (EMG) device. It is aimed to increase the function by adding different features to the Volger UAV. The main goal of this project is to design an aircraft for the future with the awareness of the advanced point of Türkiye in terms of unmanned aerial vehicles. Based on the literature research for the project, Volger UAV; 2D mapping capability in closed areas, following the pilot personnel from behind, escaping from objects in order to reduce the possibility of crashing and crashing of the aircraft in closed areas, and lastly, the detection of human presence in the environment using image processing methods with the camera on the aircraft is aimed. The control process of the pilotage will be created in a completely original way. Muscle signals received with EMG will be converted into commands that will direct the aircraft with advanced signal processing methods. The signal processing and machine learning algorithms to be used as optimized, and they will detect and interpret the given commands in the fastest way and with the highest accuracy rate. The control unit will include the capabilities to display information from the aircraft and detect commands while avoiding weight on the arm of the personnel. On the ground control station to be designed on the arm of the personnel, there will be an EMG that collects signals from the muscle system, as well as displaying the 2D map scanned by the aircraft and a small screen that will warn in case of human detection by the camera in the environment. The main reason for not opening both LIDAR data and camera images on the screen at the same time is to prevent the personnel from losing their focus by not making the screen on the personnel arm too large, and to prevent the control unit on the arm from reaching a size that would hinder the physical work of the personnel.

# SW07
# NUST Airworks

**Kiran Shaukat**

**Abstract**: In the case of huge fire, blood delivery, urgent supply of first aid kits, food supply and many other humanitarian aid missions where fast services are required, there is need of a device which can detect the targeted area and fulfill the requirements after some aerial reconnaissance. For this mission swarms of drones are developed. Drones will operate on a sufficiently large area for search and rescue (SAR) while delivering unique payloads to designated ground markers. Each drone will navigate towards its associated ground marker for payload delivery by using the information acquired from other drones. The developed drone can be used for a number of applications including surveillance, monitoring of flood affected areas, recording video from impassable areas etc. NUST Airworks team has selected a hexacopter as its UAV for the above mission. By utilizing a swarm of hexacopters, the team is planning to make the process more efficient and robust. The ease of scalability of the design makes it a great choice for both large scale and small-scale operations. A hexacopter offers a significant advantage in terms of stability and control. This configuration also offers motor redundancy so in case of motor failure, motor failsafe can be activated which can land the UAV safely at the specified landing point even when only four of its motors are running. Another reason for this configuration is that it enables the UAV to fly at higher altitudes and carry heavier payloads than the traditional quadcopter configuration.

# SW08
# Simulation and Design of a Low-Cost 3d Printed Quadrotor

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**Abstract**: Quadrotors emerge as one of the most promising UAVs. Their high stability and maneuverability enable accessibility in narrow environments, which combined with the ability of vertically taking off and landing results in a wide range of applications varying from surveillance to package delivery. However, quadrotors uses are usually limited by their elevated cost. This project aims to present an affordable yet effective design for a quadrotor based on a 3d printed structure and an Arduino PID flight controller. In order to achieve a deeper understanding of the flight mechanics and a better tuning of the controller, a 6DOF flight simulator is initially designed in MATLAB. Low computational cost is accomplished via quaternion rotation implementation, thus offering the possibility to add a trajectory tracking controller to emulate GPS usage without a high increase in simulation time. Structure is designed such that it can be printed in a regular, commercial 3d printer with high quality results. Flight controller is implemented in an easily modifiable code in Arduino, alongside radio signals reader and emitter and ESC controller to set motors velocity. Currently the quadrotor is undergoing testing, but showing promising results since everything is working as expected. Once real flight is achieved, a topology optimization code will be designed in order to obtain further weight savings in the structure.

# SW09
# Hydra Hydrogen Fuelled Hybrid Fuel Cell UAV

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**Abstract**: Unmanned aerial vehicles (UAVs) have become very popular around the world in the past 20 years. It is predicted that it will increase its popularity even more in the coming decades. When the development of UAVs is examined, it is seen that they were initially thought and developed only to serve military purposes. However, thanks to the widespread use of multirotor UAVs and the easy operation and operation protocols introduced by electric motors, it is seen that the number of unmanned aerial vehicles used for civilian purposes has increased much faster than for military purposes and has already surpassed this number. 2- and 4-stroke piston engines, which were generalized as internal combustion engines until the early 2000s, were seen as the primary source of propulsion for fixed-wing model aircraft and UAVs. However, brushless dc electric motors have been lightened in the process until today and their costs have been reduced with the work done. Electric motors have been able to gradually reduce the market share of reciprocating motors with their features such as quieter operation, no heat trace and less vibration. Despite the improvements realized, piston engines and turboprop class gas turbine engines are preferred in the tactical UAV class. The main reason for this preference is the inadequacies experienced in energy storage systems. Today, batteries are used in combination with electric motors. With their energy density and discharge capacity, Lithium-based batteries are the most common batteries used in the UAV industry. Among lithium-based batteries, lithium-ion electrochemistry, in terms of energy density; lithium-polymer electrochemistry stands out with its discharge capacity. Despite the improvements made, these state-ofthe-art batteries cannot match the performance of internal combustion engines in terms of long-range flights and airtime. The biggest reason for this is that as the capacity of the batteries increases, their size and weight increase considerably. This brings us to one of the biggest problems in UAVs using electric motors; The problem of short residence time. In order to solve this problem, one of the most important and sustainable alternative ways is to integrate the fuel cell system into the UAVs in a hybrid way with the battery. Although fuel cells have sub-elements such as tanks and regulators, they are 8 times lighter and occupy 6 times less volume compared to lithium-based batteries required to fly at the same time. It can be said that the fuel cell aircraft concept makes these flight times meaningful, since flying with batteries of this size will not be meaningful. As an application of this concept, the Hydra project, which is a UAV project that uses pressurized hydrogen gas as fuel and has a hybrid power system with a lithium polymer battery, was launched at Eskişehir Technical University in 2019. In the project, an unmanned aerial vehicle that will fly with a 250-watt commercial fuel cell has been designed.

# SW10
# Design of an UAV "KOS"

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**Abstract** An unmanned aerial vehicle "KOS" is project by team BEOAVIA. It consists of 52 students divided into 5 sections: Aerodynamics, Structure and Manufacturing, Propulsion, Electronics, and Marketing. Each section is managed by his own coordinator who is obliged to determine tasks for every member and set deadlines for them. Team is guided by team leader who coordinates with every section and makes sure that team works as united group. Project is designed for the purpose of competing in the New Flying Competition 2022 in Hamburg in September. Competition tasks requires to build an UAV capable of both vertical take-off and landing (VTOL) and horizontal flight. In the cruise regime it needs to record various objects on ground and to locate them during 30 minutes of flight. Those objects consist of white and red squares dimensions of 500x500 mm placed on different locations. An aircraft should have at least one maneuver with load of 2.5 g. Maximum take-off mass is 15 kg including payload with 2 kg. Mass and load both lead us to peak composite material as the main material aircraft is produced of. It provides required strength of structure with less mass which make a space for using propulsion system with higher efficiency. The main goal of the competition is to locate the objects correct with as much as possible less energy consumption.

# SW11
# Tactical Close Range Unmanned Aerial Vehicle "Eagle"

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**Abstract**: Unmanned Aerial Vehicle (UAV) systems, despite having no onboard human pilots, currently require extensive human involvement to successfully accomplish missions. Usage of UAVs has also decreased the burden on the human, where the manpower and risks during critical conditions, war fields, are reduced. UAV "Eagle" is controlled either by UAV pilot on the ground, solder in the section, or autonomously by flight control systems onboard. Being used it can contribute to the realisation of missions and tasks at tactical level, like reconnaissance from airspace, potential threats detection, three kilograms payload which can be either first aid kit, bags of blood, or to drop smaller mortar mine or any kind of light weight explosive device. It has modular head, where you can pack different type of electronic devices as radar head, day and night camera with stabiliser, etc. Communication is encrypted radio link with frequency hopping spread spectrum with maximum range of 5km/3.1miles. One more advantage of UAV "Eagle" is its manufacturing cost, which is cheap due to which there is a chance of arming every platoon section with it.