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UPB

The 39th "Caius IACOB" Conference on Fluid Mechanics and its Technical Applications

28 - 29 October 2021, Bucharest - Romania

BOOK OF ABSTRACTS

VIRTUAL CONFERENCE

Bucharest - Romania
2021

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Agenda

Day 1 | Thursday, 28 October 2021

Time (CET)		Plenary ROOM (Clik to join the Virtual Meeting)
9:40	10:00	**Welcome and introduction** by the Conference Chairman Dr. Eng. **Catalin NAE**, President & CEO, INCAS – National Institute for Aerospace Research "Elie Carafoli", Bucharest, Romania Dr. Math. **Stelian ION**, "Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics of Romanian Academy, Bucharest, Romania
Plenary 10:00 – 10.40		**Chair: Catalin NAE** *(INCAS)*
10:00	10.40	**"Motion of social masses: Application of modelling with measures to pedestrian flows"** Plenary Lecture speech by Prof. Dr. habil. **Adrian MUNTEAN** | Department of Mathematics and Computer Science, Karlstad University, Sweden, Centre for Societal Risk Research (CSR), Karlstad University, Sweden
10:40	11:00	**Break**

ROOMs Session 11:00 – 12:40		ROOM 1 Clik to join the Virtual Meeting ROOM 1	ROOM 2 Clik to join the Virtual Meeting ROOM 2	ROOM 3 Clik to join the Virtual Meeting ROOM 3
Session Title		**Mathematical Modeling**	**Technical Applications**	**WORKSHOP ASRO/CT 72** **Aeronautica si spatiu**
Session Chair(s)		**Alexandru M. MOREGA** *(UPB)*	**Mihai-Victor PRICOP** *(INCAS)*	**Valentin BERCA** *(ASRO)* **Peter KALMUTCHI** *(ASRO)*
11:00	11:20	S4.1 **Variational and numerical analysis of a thermal fluid-structure interaction problem** ***Alexandra CIOROGAR,*** *Ruxandra STAVRE*	S5.1 **A review on applications and technologies for flexible-winged-based UAVs** ***Radu-Călin PAHONIE,*** *Ciprian LARCO*	**INVITATIE** **AGENDA** ***WORKSHOP ASRO/CT 72*** **LISTA INVITATI**
11:20	11:40	S4.2 **Dam Break Problem. Numerical Simulations.** *Stelian ION,* *Dorin MARINESCU,* ***Stefan Gicu CRUCEANU***	S5.2 **An extended comparison between BOS, thermal-calibrated and color-filter schlieren** ***Emilia-Georgiana PRISĂCARIU,*** *Tudor PRISECARU*	
11:40	12:00	S4.3 **Multiscale modeling and analysis for reaction-diffusion processes in composite media** ***Claudia TIMOFTE***	S5.3 **Generalized optimization of supersonic ramp intakes in ideal and thermally perfect gas** ***Mihai-Victor PRICOP,*** *Mihaita Gilbert STOICAN,* *Dumitru PEPELEA*	
12:00	12:20	S4.4 **Three-layer Hele-Shaw displacement with intermediate non-Newtonian fluid** ***Gelu PAŞA***	S5.4 **RANS-based global performance analysis of a four-seater general aviation aircraft** ***Ioan-Laurențiu PĂDUREANU,*** *Ștefan BOGOS,* *Dorin BÂRSAN,* *Bogdan RUSU*	
12:20	12:40	S4.5 **Thermal flows in fractured porous media** ***Dan POLIŞEVSCHI,*** *Isabelle GRUAIS*	S5.5 **Conceptual design of a Dandelion and Maple seed based Micro Unmanned Aerial Vehicle** ***Aynul HOSSAIN***	**11:00 | 13:00** ***WORKSHOP ASRO/CT 72*** **13:00 | 13:20 Break**
12:40	13:20	**Break**		

ROOMs Session 13:20 – 14:40		ROOM 1 Clik to join the Virtual Meeting ROOM 1	ROOM 2 Clik to join the Virtual Meeting ROOM 2	ROOM 3 Clik to join the Virtual Meeting ROOM 3
Session Title		Mathematical Modeling	Technical Applications	Basic Methods in Fluid Mechanics
Session Chair(s)		**Stelian ION** *(ISMMA)*	**Mihai-Victor PRICOP** *(INCAS)*	**Valentin BUTOESCU** *(INCAS)*
13:20	13:40	S4.6 **Cooling the photovoltaic panels by natural and forced convection** ***Florin SĂFTOIU,*** ***Alexandru M. MOREGA***	S5.6 **Performance analysis of electric aircraft configurations** ***Ionut BUNESCU,*** *Mihai-Vladut HOTHAZIE*	S1.1 **The truth on gravity and terrestrial global warming** ***Horia DUMITRESCU,*** *Vladimir CARDOŞ,* ***Radu BOGATEANU***
13:40	14:00	S4.7 **Numerical analysis of the aging heat treatment of Aluminum alloy plates** ***Alexandru M. MOREGA,*** ***Marin PETRE,*** *Alin A. DOBRE,* *Yelda VELI,* *Alexandra V. NECOLA*	S5.7 **Low-speed airfoil shape optimization using high-fidelity CFD analysis** ***Mihai-Vladut HOTHAZIE,*** *Ionut BUNESCU,* *Mihai-Victor PRICOP*	S1.2 **Wing in Ground Effect: A new Method for Modeling a Wavy Surface** ***Valentin Adrian Jean BUTOESCU***
14:00	14:20	S4.8 **Some practical remarks in solving partial differential equations using reduced order schemes obtained through the POD method** ***Alexandru SOLOMON,*** *Valentin Claudiu OLTEI,* *Alina BOGOI*	S5.8 **Fast inviscid transonic airfoil optimization using a nonlinear potential solver** ***Georgiana ICHIM,*** *Sterian DANAILA,* *Mihai-Victor PRICOP*	S1.3 **Low Speed Propeller Optimization** ***Alexandra STĂVĂRESCU,*** *Mihai-Victor PRICOP,* *Georgiana ICHIM,* *Ion FUIOREA*
14:20	14:40	S4.9 **Numerical Estimation of Pressure Loss in Labyrinth Seals** ***Ruxandra Maria Ileana MATEI,*** *Sterian DĂNĂILĂ*	S5.9 **Experimental investigations on rheological properties of biogreases** ***Alexandru Valentin RADULESCU,*** *Irina RADULESCU*	S1.4 **Comparison between Compressible and Incompressible Solvers in OpenFoam** ***Adrian CHELARU,*** *Cristian Constantin ANDREI*
14:40	15:00	**Break**		
Time (CET)		**Plenary ROOM (Clik to join the Virtual Meeting)**		
Plenary 15:00 – 16:20		**Chair: Catalin NAE**, President & CEO, INCAS		
15:00	15:40	**"Dynamics of immiscible liquids in rotational motion"** Plenary Lecture speech by Prof. Dr. Eng. **Corneliu BALAN** and Diana BROBOANA, Ana-Maria BRATU | REOROM Laboratory, University POLITEHNICA Bucharest, Romania		
15:40	16:20	**"Prediction of a Flight Dynamics Model for the Unmanned Aerial System UAS-S4 from Hydra Technology"** Plenary Lecture speech by Prof. Dr. Eng. **Ruxandra Mihaela BOTEZ** | École de Technologie Supérieure, Université du Québec, LARCASE, 1100 Notre Dame West, Montréal, Qué., Canada, H3C-1K3		
ROOMs Session 16:25 – 17:25		ROOM 1 Clik to join the Virtual Meeting ROOM 1	ROOM 2 Clik to join the Virtual Meeting ROOM 2	
Session Title		Equations of Mathematical Physics	Technical Applications	
Session Chair(s)		**Sterian DANAILA** *(UPB)* **Stelian ION** *(ISMMA)*	**Mihai-Victor PRICOP** *(INCAS)*	
16:25	16:45	S2.1 **Smooth interface analysis in Kelvin-Helmholtz instability** ***Ilinca-Laura BURDULEA,*** *Alina BOGOI*	S5.10 **Aerodynamic assessment of a Vertical Take-Off and Landing rocket vehicle in hover and ground proximity** ***Dumitru PEPELEA,*** *Alexandru-Iulian ONEL,* *Alexandru-Gabriel PERŞINARU*	
16:45	17:05	S2.2 **Acoustics pressure estimation due to thickness noise of a hovering helicopter** ***Cosmin MICH,*** *Alina BOGOI*	S5.11 **Free-free vibrations analysis of the aircraft IAR-99 HAWK based on a new and modern finite element model** ***Tudor VLADIMIRESCU,*** *Ion FUIOREA,* ***Tudor VLADIMIRESCU-jr***	
17:05	17:25		S5.12 **Design and development of a set of reentry capsule wind tunnel models to achieve the aerodynamic characterization at all angles of attack** ***Mihăiță Gilbert STOICAN,*** *Mihai Victor PRICOP*	
End of the 1st Day of the 39th "Caius Iacob" Conference, Virtual Conference				

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Virtual Conference

Day 2 | Friday, 29 October 2021

Time (CET)		Plenary ROOM (Clik to join the Virtual Meeting)
9:30	09:45	**Welcome and introduction** by the Conference Chairman Dr. Eng. **Catalin NAE**, President & CEO, INCAS − National Institute for Aerospace Research "Elie Carafoli", Bucharest, Romania Dr. Math. **Stelian ION**, "Gheorghe Mihoc-Caius Iacob" Institute of Mathematical Statistics and Applied Mathematics of Romanian Academy, Bucharest Dr. Fiz. **Adriana STEFAN**, President of the Scientific Council of the INCAS − National Institute for Aerospace Research "Elie Carafoli", Romania
09:45	10:30	**The "Caius IACOB" – Prize Award Ceremony** **The "Nicolae TIPEI" – Prize Award Ceremony** **The "Gheorghe VASILCA" – Prize Award Ceremony** - **Tribute presentation of awards** by Dr. Eng. **Victor MANOLIU** *(INCAS)* - **The winners' speech**
10:30	11:00	- **Presentation of the awarded works**
11:00	11:20	**Break**

ROOMs Session 11:20 – 13:50		ROOM 1 Clik to join the Virtual Meeting ROOM 1	ROOM ROOM 2 Clik to join the Virtual Meeting ROOM 2
Session Title		**Dynamical Systems**	**Technical Applications**
Session Chair(s)		**Laurentiu MORARU** *(UPB)*	**Marius Alexandru PANAIT** *(INCAS)* **Mihai-Victor PRICOP** *(INCAS)*
11:20	11:40	S3.1 **Regarding the Linear and Linearized Responses of an Airplane in a Gust** ***Laurentiu MORARU,*** *Marius STOIA-DJESKA*	S5.13 **Numerical prediction of transonic airfoil buffet** ***Mihai Leonida NICULESCU,*** *Ruxandra Maria Ileana MATEI*
11:40	12:00	S3.2 **Satellites FDI system design using sliding mode observers** ***Florin-Adrian STANCU,*** *Adrian-Mihail STOICA*	S5.14 **Analog versus Digital Anti-Aliasing Filtering in Modern Data Acquisition** ***Marius Alexandru PANAIT***
12:00	12:20	S3.3 **Automatic approach procedure of a flying vehicle on a mobile platform using backstepping controller** ***Florin COSTACHE,*** *Sandra-Elena NICHIFOR,* *Mihaela-Luminița COSTEA,* *Achim IONIȚĂ*	S5.15 **The Fly-by-Light system for military aircrafts** *Ilie NICOLIN,* ***Bogdan Adrian NICOLIN***
12:20	12:40	S3.4 **Automatic landing procedure of a flying vehicle on a mobile platform using optical flux** ***Sandra-Elena NICHIFOR,*** *Florin COSTACHE,* *Mihaela-Luminița COSTEA,* *Achim IONIȚĂ*	S5.16 **Failure Mode and Effect Analysis for military nose landing gear project** *Ilie NICOLIN,* ***Bogdan Adrian NICOLIN***
12:40	13.00		S5.17 **De-icing of aircraft on the ground and means of environmental protection** ***Cornel DINU,*** *Ion FUIOREA*
13.00	13.20		S5.18 **Neural Network and Linear Programming Aircraft Boarding Strategy based on Passengers Preference** ***Mihai Alexandru BARBELIAN,*** *Cornel DINU,* *Casandra Venera PIETREANU*
13.20	13.50		S5.19 **Prezentare Cluster INVENTIKUS** ***Radu DIMA*** ***Dragos BORDESCU*** ***Ciprian OROS***

End of the 2rd Day of the 39th "Caius Iacob" Conference, Virtual Conference

CONFERENCE TOPICS

S1. Basic Methods in Fluid Mechanics
S2. Equations of Mathematical Physics
S3. Dynamical Systems
S4. Mathematical Modeling
S5. Technical Applications

Events associated with of the conference:

- WORKSHOP ASRO/CT 72 Aeronautica si spatiu – 28 October 2021
- The “Caius IACOB” Prize Award Ceremony – 29 October 2021
- The “Nicolae TIPEI” Prize Award Ceremony – 29 October 2021
- The “Gheorghe VASILCA” Prize Award Ceremony – 29 October 2021

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CONFERENCE TOPICS

1. Basic Methods in Fluid Mechanics
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- The “Nicolae TIPEI” Prize Award Ceremony
- The “Gheorghe VASILCA” Prize Award Ceremony

Table of Contents

Plenary Lectures

Prediction of a Flight Dynamics Model for the Unmanned Aerial System UAS-S4 from Hydra Technology

Ruxandra Mihaela BOTEZ

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Abstract: *The Unmanned Aerial System UAS-S4 Ehécatl is developed and manufactured by Hydra Technologies of Mexico which, except for its infrared thermal sensor system, is the first of its type to be completely designed and manufactured in Mexico. It is named after Ehecatl, the Aztec God of Winds [1]. At our Research Laboratory in Active Controls, Avionics and Aeroservoelasticity LARCASE, new methodologies for the UAS-S4 modeling and simulation for the UAS-S4 were developed ([2]- [7]).*
In this abstract, the UAS-S4 controller was developed based on its flight dynamics. The UAS-S4 performance was then evaluated based on a methodology in which the cost function was reduced. The flight dynamics model was developed for a number of 216 trim conditions.
In this methodology, the three models embedding centroid was computed after the three closest neighbors' obtention of the operating point in the flight envelope. Then, the new model was generated by interpolation between the centroid and the operating point models. Then, the number of trim models was augmented up to a number of 3,642 unique state-space representations. Then, a bench-marking algorithm based on the Support Vector Regression (SVR) methodology was used, as training samples could not be linearly separated.
Then, in terms of results, the regression performance was evaluated in terms of prediction accuracy. The average Mean Absolute Percent Error (MAPE) was used as performance index; for the longitudinal dynamics model, a value of 2.31% was obtained for the average MAPE, therefore it was concluded that the SVR algorithm was efficient. The Root Locus diagram, which represents the eigenvalues variations of both predicted and trim models, was another measure of the efficiency of the SVR algorithm, and therefore, it contributed to demonstrate the accuracy of the UAS-S4 predicted model.

Key Words: Unmanned Aerial Systems, flight dynamics, root locus, Support Version Regression, Mean Absolute Percent Error

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Dynamics of immiscible liquids in rotational motion

Diana BROBOANA[1], Ana-Maria BRATU[1], Corneliu BALAN*,[1]

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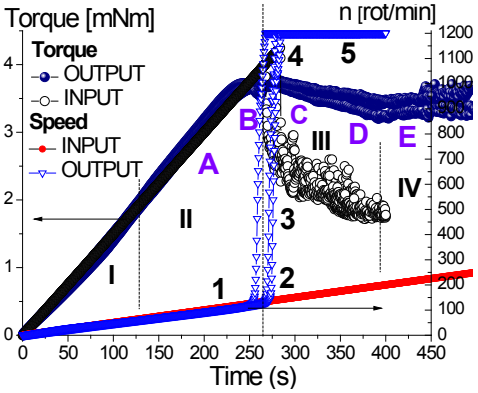
Abstract: *This work is dedicated to the experimental investigations of the interface's stability between two immiscible liquids. In a confined cylindrical vessel, two viscous liquids are put in motion by the rotation of an upper conic disk, connected with the MCR 301 Anton Paar rheometer. The dynamics of the interface is simultaneously visualized with two digital cameras (60 fps and 4000 fps, respectively). The rotational speed (n) and the torque (T) are measured, one of the two being the INPUT or the OUTPUT, Fig. 1. Samples with different densities and rheological properties have been tested (water, oils, viscoelastic fluids, honey), the controlled parameters of the performed experiments being the Weber and Reynolds numbers. The main goals of the study are: (i) to identify for each tested pair-samples the flow regime corresponding to the Kelvin-Helmholtz (KH) instability (if it exists), (ii) to correlate the interface topology with the measured T(n) diagram and with the fluids properties, (iii) to detect the existence of the critical/bifurcation points using the experimental phase diagrams: T(n) and T(dT/dt) or n(dn/dt), at controlled speed/torque experiments.*
The T(n) plot from Fig. 1a discloses four regimes, visualized in Fig.1b: I. Linear (interface is symmetric deformed but water doesn't reach the upper disk, not shown); II. Quasi-linear (A, 1); III. Transition (C-D, 3-4); IV. Chaotic (E, 5). The regimes II and III (B and 2 in Fig. 1b) are separated by a bifurcation; beyond that point the patterns of the speed input test are different from the torque input test (in both experiments the input is a controlled ramp in time, Fig. 1a). The KH wavy pattern is observed in both experiments at the onset of the regime III (C, 3 in Fig. 1b). The tests performed with different fluids shows all the four regimes from Fig. 1a, but the KH instability is not present below a critical value of the interfacial tension.

a)



b)

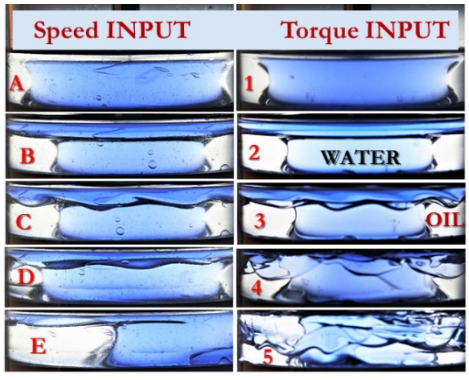


Figure 1: (a) Torque vs. speed, (b) Dynamics of the interface; samples: water (ρ=1000 kg/m^3, η = 1 mPas), oil (ρ = 950 kg/m^3, η = 1.03 Pas), interfacial tension σ = 0.056 N/m.

Key Words: *immiscible fluids, hydrodynamics instability, Kelvin-Helmholtz, rotational flow*

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Motion of social masses: Application of modelling with measures to pedestrian flows

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Abstract: *We study the motion of groups of pedestrians from the perspective of many-particle interacting systems within a heterogeneous environment - a field of research often referred to as crowd dynamics. Observable (macroscopic) crowd effects arise from the social (microscopic) interactions between individuals. In this talk, we will discuss a couple of mathematical models able to capture the time evolution of social masses exposed to very different evacuation scenarios. A special feature that makes these crowd models different from Newtonian systems, which describe successfully the evolution of non-living particles, is that mutual interactions are strongly anisotropic as they are vision-based, and hence, orientation dependent. We ask ourselves: What if pedestrians move in the dark? How can we then describe the dynamics of the flow of pedestrians? We review a selection of these models and emphasize a couple of open mathematical problems that inherently arise in this context. Particularly, we will attempt to convince the audience that "modeling with measures" has a great potential to describe successfully the evolution of social masses. More ideas around this topic can be found in Refs. [1-4].*

Key Words: *Pedestrian flows, modeling with measures, social mechanics, numerical simulations*

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Section 1. Basic Methods in Fluid Mechanics

Wing in Ground Effect: A new Method for Modeling a Wavy Surface

Valentin Adrian Jean BUTOESCU

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***Abstract**: It seems that the ground effect air vehicles are once again attracting the attention of aircraft manufacturers, [1]. That's why the present work continues the author' s studies regarding the 2D flow about a wing /aerofoil that flies over a wavy surface,[2]. This question was presented in a previous article. The method was a straightforward one, so that the wavy surface was treated as a distribution of potential singularities. Since the wavy surface must be very large (theoreticaly infinite), it introduces many unknowns when compared to the wing /aerofoil case (and it is to be remembered that only the wing is of interest, not the waves).*
To avoid the complications mentioned above, this paper proposes the use of the Green functions method. If there were no waves on the surface, a direct way would be the using the image method. But the presence of the waves complicates things. The method proposed here consists in introducing an auxiliary symmetrical fluid domain. This domain separates the flow into two symmetrically flowing areas, one of which is the area of interest, containing the wing, while the other is the symmetrical (overturned) image of the previous.
This procedure helps the author to build the Green functions that automatically satisfies the boundary condition on the wavy surface. These Green functions were used in the integral equation of the aerofoil written for unsteady flow and solved numerically. The method of solving the integral equation has been presented in detail in the previous article. It has been successfully applied to various forms of wave surfaces over which a wing is flying.

***Key Words**: wing in ground effect; ekranoplan; Green functions; unsteady flow*

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Comparison between Compressible and Incompressible Solvers in OpenFoam

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***Abstract**: The purpose of this paper is to present a comparison between two OpenFoam solvers. The geometry that was analyzed was a NACA0012 profile. The simulation was done on a 2D mesh. The two solvers that were compared were the incompressible solver simpleFoam and the*

compressible solver rhoPimpleFoam. The speed for simulation was 28m/s, which corresponds to the incompressible flow conditions. Even though the regime was incompressible, the copressible solver gave better results. Considering the fact that the NACA0012 profile is well documented in the literature, comparisons between the OpenFoam solvers and the wind tunnel results were achieved.

Key Words: *incompressible flow, OpenFoam, rhoPimpleFoam, simpleFoam, NACA0012*

The truth on gravity and terrestrial global warming

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Abstract*: For a two half millennia of knowledge from the Democrit's natural, rational atomized material conception to Newtonian, Maxwellian, Einsteinian mathematized physics, the research in the most of the cases has followed a deductive route from observable facts, as against the reality according to Mach's rigorous positivism principle. During the last century both experimental and computational technology progress have accumulated solid factual data support on the better knowledge of our current world, so the research is starting on an inductive route of the hidden/dark detailed processes as a whole. This revolutionary stage of physics, based on a holistic approach, is concerned with the relativity-gravity evolution in a quantifiable space-time universe created after the morphogenetic light explosion (or the 4D-BIG BANG). The paper presented herein contains some less known aspects on the regenerative cyclical work of the solar system as a whole, along with the specific activity of the planet-Earth as an integrated part into the solar complex. This holistic approach shows that the global warming and cosmic carbon are consequences of the gravitational perturbation engendered by out of order Venus-Earth mutual interaction. Contemporary physics is based on two postulates: a) in any physical system the relevant information is finite and b) we can always get new information about the system. But, the question which arises is: who states the relevance of information, which is a subjective affair of the scientific community including the prominent scientists. When they have failed to see essential facts, the non-solution problem remains as a long-lasting and continuing paradigmatic crisis in basic research.*
Briefly, the paper refers to the origin of gravity (Einstein, 1915) and turbulence (Kolmogorov, 1985) directly related to the thermal time concept and its birth in order to explain the gravitational phenomena through the refrigeration process of thermal energy.

Key Words: *The genuinely quantum gravity, gravitational tidal waves, double refraction of light, global warming, astrophysics*

Low speed Propeller Optimization

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Abstract: *The recent developments in technologies such as electric propulsion and battery capacity make it possible for Urban Air Mobility (UAM) to become a reality within 3 - 5 years. One of the key aspects to be studied regarding vertical take-off and landing (VTOL) systems, the vehicles in discussion for UAM, is the propeller performance. In order to obtain high-performance propellers, blade shape optimization is demanded, the present paper focusing on low-fidelity performance evaluation methods, such as blade element momentum theory (BEMT) and Larrabee's blade element/vortex formulation, and how to implement them into an optimization code. At first, an optimization BEMT code is developed, then the open-source codes QMIL and QPROP, developed by Mark Drela, are being employed as performance evaluation tools for the optimizer.*

Key Words: *propeller optimization, blade optimization, eVTOL, Blade Element Momentum Theory, Larrabee's formulation, chord optimization, twist optimization*

Section 2. Equations of Mathematical Physics

Smooth interface analysis in Kelvin-Helmholtz instability

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Abstract: *The topic of this paper is the Kelvin-Helmholtz instability, a phenomenon which occurs on the interface of a stratified fluid, in the presence of a parallel shear flow, when there exists a velocity and density difference across the interface of two adjacent layers. In particular, this paper focuses on a more realistic case compared to the basic Kelvin-Helmholtz instability which is actually, the Taylor-Goldstein problem. The Euler system is solved taking into account both smooth velocity and density profiles at the interface. Flux at cell boundaries is reconstructed by implementing third- and fifth-order WENO (Weighted Essentially Non-Oscillatory) reconstruction schemes along with the Rusanov and HLLC, Riemann flux solvers at the cell interfaces. Temporal discretization is done by applying the second order TVD (total variation diminishing) Runge-Kutta method on a uniform grid. Numerical simulations are performed comparatively for both Kelvin-Helmholtz (a vertical velocity mode perturbation is used) and Taylor-Goldstein instabilities, on the same simulation domains and the same initial conditions. We find that increasing the number of grid points leads to a better accuracy, for the combination WENO5-HLLC than WENO5-Rusanov in capturing vortices formed from the instability in shear layer.*

Key Words: *WENO reconstruction schemes,Riemann solvers, Kelvin-Helmholtz instability, Kelvin-Helmholtz, Taylor-Goldstein equation, Rusanov, HLLC, TVD Runge-Kutta*

Acoustics pressure estimation due to thickness noise of a hovering helicopter

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Abstract: *This paper investigates the contribution of the thickness noise field produced by moving slender bodies, such as rotating propeller or helicopter rotor blades. Ffowcs Williams and Hawking's analogy and Farassat theory are used in the numerical prediction of the noise generated by a moving surface. The pressure disturbance of the fluid medium caused by the motion of the NACA 5 digits airfoil blade, with high subsonic Mach tip speed of a hovering helicopter, is studied and the sound pressure levels (SPL) is determined at different number of blades, thickness ratio and distances to*

a fixed observer. The results of the comparisons confirm the conclusion that the increasing of thickness ratio or the number of blades becomes an important component in the overall noise of a helicopter.

Key Words: *FW-H equation, airfoil, Mach number, acoustic pressure, airfoil thickness ratio, SPL, helicopter blade noise*

Section 3. Equations of Mathematical Physics

Automatic approach procedure of a flying vehicle on a mobile platform using backstepping controller

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***Abstract**: This paper presents the automatic approach procedure of a flying vehicle, attached to an ABB 7600 robot, and a mobile platform, attached to a Stewart platform. Due to a nonlinear dynamic behaviour, it is necessary to implement complex control, stabilization and guidance schemes. The proposed solution for this system includes the development of an algorithm based on a backstepping control method, the controller design methodology being based on Lyapunov's stability theory. The proposed command law requires that the states are known, but it is also necessary to introduce a series of state estimators. Tracking a mobile platform is critical in surveillance, reconnaissance and tracking missions, with the control methodology defining a clear distinction between translational and rotational dynamics. The proposed algorithm is developed by separating two types of states involving an inverse kinematics, known as algebraic kinematics, in which the dynamic movements of the two equipment are used. The dynamics of the ABB 7600 robot involves a movement with seven degrees of freedom, while the Stewart platform can be used with a movement of six degrees of freedom. The proposed algorithm is implemented in both Matlab software and experimental testing. This paper provides results in terms of generating dynamics for both equipment that can be used for simulating different scenarios of aerospace missions.*

***Key Words**: automatic approach, ABB 7600 Robot, Stewart Platform, backstepping, inverse kinematics, Control Lyapunov Function*

Regarding the Linear and Linearized Responses of an Airplane in a Gust

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***Abstract:** The current paper presents comparisons of linear and nonlinear longitudinal channel responses of an airplane within a vertical gust. The longitudinal equations of symmetric flight of the airplane are written to include the effect of the vertical wind and accelerations along the structure are calculated using both the linear and the liearized equations. Approximate analytical solutions are discussed as well.*

Automatic landing procedure of a flying vehicle on a mobile platform using optical flux

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Abstract: *The main approach of this work is automatic landing procedure of a flying vehicle on a mobile platform, using optical flux. The fixed point vertical landing system is achieved through image processing and navigation control, including motion detection, as well as contact time data.*
A computer vision system with a color camera with a focus on the target shall also be used to detect the landing point and to determine its position in relation to the position of the flying vehicle. The trajectory generation mode is defined by an optimal reference trajectory in order to converge from an exact initial height to the target point located on the platform, having zero relative speed. In case of vertical landing, three modules are considered, respectively a module for estimating motion through sensors, a module for generating the trajectory in which the dynamic equations of the flying vehicle are defined and a tracking control module, in which the control law is defined. Thus, a synchronization will be made between the two known systems, the platform and the vehicle, in which the horizontal and angular movements of the aircraft will be neglected for an adequate robust control. Therefore, two stages will be defined, one for stabilizing the air vehicle and the other for adjusting the automatic landing by using the optical flux.

Key Words: *optical flux, automatic vertical landing, sensors, image processing, synchronization, tracking control*

Satellites FDI system design using sliding mode observers

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Abstract: *Nowadays space missions become more complex, which push to the limit the spacecraft control systems. This phenomenon causes the developing and integration of new control systems and fault detection and isolation systems (FDI) that are more robust and efficient. In this paper an FDI system based on sliding mode observers (SMO) method is proposed. SMO are based on sliding mode control (SMC) theory, therefore will inherit SMC performances and robustness, but also the chattering effect. Chattering is the effect caused by the high frequency oscillation along the sliding surface. The SMC and SMO are suitable for nonlinear dynamics. The sliding mode FDI system is tested on a sun acquisition maneuver by using dynamics and kinematics to model the spacecraft*

nonlinear dynamic. Quaternion form of kinematic equation is used in this paper to represent the spacecraft attitude. Solar radiation pressure disturbances are considered during simulation. The objective of a FDI system is to trigger an alarm when an anomaly is present in the system. In this paper actuators and gyroscope malfunctions are proposed to be detected by means of sliding mode observers. The isolation of the malfunction is proposed to be performed in order to give the possibility to take spacecraft recovery actions. The SMO FDI relies on the evaluation of equivalent injection signal to detect and isolate the malfunction. Furthermore, based on the equivalent injection signal the fault can be reconstructed. In general the sliding motion can be ensured by using signum control action to achieve best performances and robustness of the sliding mode observers, but chattering effect is present. The chattering effect is not a critical issue for the SMO FDI due to the fact that is designed to run in software. However, is desirable to have a smooth equivalent injection signal that can be easily interpreted and have a physical meaning. Based on the equivalent injection signal a decision can be taken based on its amplitude, by taking advantage of the fact that gives information of reconstruction of fault signal. In order to smooth the discontinuity generated by signum function a continuous approximation based on sigmoid function is proposed. This technique is named pseudo-sliding due to the smoothed nature of the control action. The usage of continuous approximation function will decrease the robustness of SMO, but in this paper is shown that by properly tunning the sigmoid function good performances of SMO can be achieved without affecting the estimated states in a drastic way. The FDI SMO is based on an innovative bank of SMO designed for different malfunction cases. The observer bank contains a global SMO that is designed to work in normal conditions. Three SMO are designed to model actuator malfunctions. For every axis in part a specific SMO is designed for the malfunction case. The last three SMO are designed to model gyroscope malfunctions. As in case of actuators, for every axis in part a specific SMO is designed for the gyroscope malfunction case. The global SMO is in charge to detect the malfunction without being able to isolate it. The malfunction detection is performed by tracking the equivalent injection signal amplitude. When the equivalent injection signal amplitude exceeds a FDI threshold a flag is triggered. In order to reduce false alarms a mean window is applied on the equivalent injection signal. After a malfunction is detected the isolation procedure starts. All six SMO designed for different malfunction cases are evaluated. The injection error signals are evaluated in order to detect the observer that better replicates the malfunction by detecting the minimum of the equivalent injection error signal.

The proposed design methodology is illustrated by numerical case studies.

Key Words: *nonlinear spacecraft dynamics, sliding mode observers, fault detection and isolation, chattering, pseudo-sliding, equivalent injection signal, sliding mode observers bank*

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Section 4. Mathematical Modeling

Variational and numerical analysis of a thermal fluid-structure interaction problem

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Abstract: *The mathematical model that we study from mathematical and numerical viewpoints starts from real-life examples that highlight two aspects:*
- the variation of blood pressure depending on the ambient temperature,
- the variation of blood pressure depending on the increase of internal temperature.
The coupled physical system that describes the fluid-elastic structure interaction under the influence of temperature is linearized and then written in dimensionless variables. We associate to the physical problem a (velocity/displacement, temperature) variational formulation and we prove the existence and the uniqueness of its solution. Then, we introduce the fourth unknown function, the fluid pressure, and we show its uniqueness, result that, in general, is not true.
By means of an Uzawa algorithm, we obtain some numerical simulations in agreement to the way in which the temperature of the environment influences the blood pressure in the real life.

Key Words*: thermal fluid-structure interaction, coupled system, variational formulation, existence and uniqueness, Uzawa algorithm*

Dam Break Problem. Numerical Simulations.

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Abstract: *Dam Break is one the most used problems to test a numerical scheme that approximates a system of Shallow Water Equations. Some experimental data related to this problem can be found in the literature for various configurations, but most (numerical and experimental) results refers to the water flow on bare soil. In this talk, we analyze the Dam Break Problem with vegetation and investigate the soil erosion processes. We compare our numerical results with experimental data (when they exist) and present various scenarios related to the soil erosion and the plant cover influence on water dynamics.*

Numerical Estimation of Pressure Loss in Labyrinth Seals

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Abstract: *Turbines currently represent one of the main methods for energy production. Despite being widely implemented in engine assemblies, the efficiency of turbines still remains a problem, as reaching a greater level of efficiency is difficult. The main factor that causes low efficiency on turbines is the occurrence of leakages of working fluid. In order to control it, a number of sealing methods can be used; a widely-used sealing method is represented by labyrinth seals. The purpose of the labyrinth seals is to control the leakages that appear when the working fluid flows from high-pressure areas to low-pressure areas, as leakages influences are reflected in engine efficiency.*
The key aspect to be studied was the ever-present leakages and means to decrease it. As such, the first step of the paper was to compare a number of analytical methods for calculating the leakage that occurs in labyrinth seals, by considering different geometries, flow regimes, pressure ratios or flow velocities, and observing how mass flow rate varies. Next, a comparison between a reference parametric optimisation and a gradient-based optimisation of the labyrinth seal was made, in order to observe the differences between the two labyrinth configurations that would be obtained starting from the same geometry.

Numerical analysis of the aging heat treatment of Aluminum alloy plates

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Abstract: *The aging treatment covers stages from introducing the plates in the furnace at room temperature until their removal, respectively, after a few hours at 150 °C to 200 °C. The heat transfer inside the aging furnace, revealed through numerical simulations, makes the object of concern in the present study. We model the momentum conservation and mass conservation equations for viscous, turbulent flow using the k-ω model. The simulation results are compared with industrial tests on an indirectly heated, fuel-fired batch furnace to assess the predictive merit of the airflow inside the furnace and the quality of the thermal aging process. They help better understand the stationary heating process, assess the temperature uniformity within the plates stack, and contribute to optimizing the thermal structure and conditions of the process to match those technological requirements that are credited to improve the end product quality.*

Key Words: *heat transfer, aging treatment, forced convection, turbulent flow, finite element method*

1. INTRODUCTION

Due to the high hardness and efficient machining in particular tempers, the 2014 Aluminum alloy is often used in the aerospace industry. Its aging heat treatment, which treatment covers stages from introducing the plates in the furnace at room temperature until their removal, respectively, after 9 hours at 177 °C ± 3 °C, is a critical quality concern [1]. Therefore numerical simulations may contribute to its prediction that may result in the optimization of the aging process.

Heat transfer inside the furnace, as revealed through numerical simulations [2–6], is the object of concern in the present study. The simulation results are compared with the industrial tests on an indirectly heated, fuel-fired batch furnace to predict the airflow inside the furnace and the quality of the thermal aging process.

2. THE MATHEMATICAL MODEL

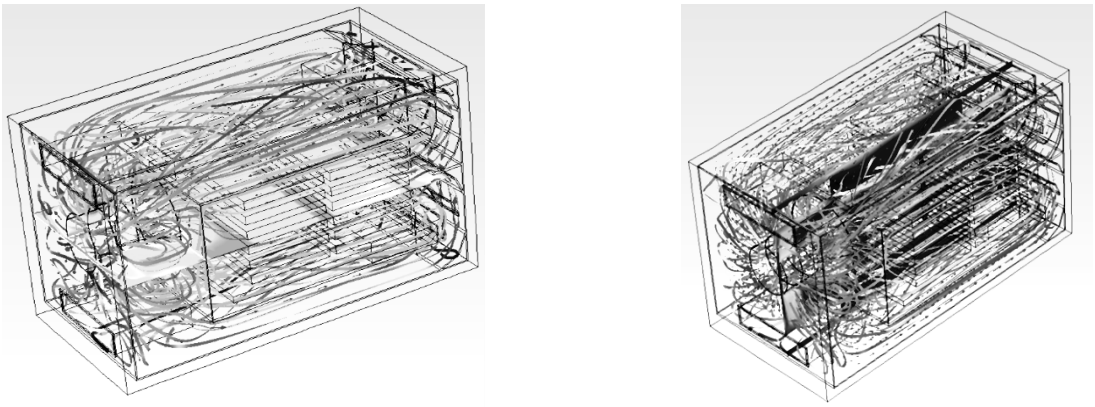
The mathematical model was developed for a Danieli batch treatment furnace with 70 tons maximum load, indirectly heated, fuel-fired for aluminum alloy plates aging treatment. The furnace is provided with last improvements in temperature control, ensuring a temperature uniformity for the workspace of ± 3 °C, in the range 80 °C – 250 °C. The heat transfer inside the furnace combines all modes, conduction (all over), forced convection (within the air streamflow), and radiation (between corresponding surfaces). The two parts of the steady-state process and solved sequentially: first the airflow and then the energy equation.

We model the momentum conservation and mass conservation equations for viscous, turbulent flow using the k-ω model, a standard two-equation turbulence model, an approximation for the Reynolds-averaged Navier-Stokes equations (RANS equations). Unlike the k-ε model, which is credited to perform well for external flow problems around complex geometries, the k-ω model is helpful in cases such as internal flows, flows that exhibit strong curvature, separated flows, and jets [7,8].

3. NUMERICAL SIMULATION RESULTS

The numerical simulations envisage a middle section of the furnace that is defined assuming geometric and heat transfer symmetry. A difficulty that is encountered in mathematical modeling of turbulent flows when using asymptotic like models such as the k-ω model is that, depending on the local flow rate driven by the fan, parts of the air stream may be either above or below the local Ma number threshold, which either enables or zeroes the last term in the r.h.s. of the momentum equation. This condition is difficult (if currently possible) to implement. In the absence of a transition model that may bridge the two forms of momentum balance, we consider two flow regimes that are set through inlet velocity boundary conditions and which are presumably satisfactorily modeled by one or the other of the two forms of momentum balance. It is then left for an *a posteriori* inspection of the local Ma number that is obtained through numerical simulation to evaluate the validity of this assumption.

Figure 1 shows off the turbulent airstream (a,b) inside the furnace empty and loaded, respectively, for steady stated operation for U_{in} = 10 m/s inlet (fan) velocity.



a) Empty furnace; U_{max} = ~10 m/s. b) Loaded furnace; U_{max} = ~15 m/s

Fig. 1 – The incompressible forced airflow inside the furnace for U_{in} = 10 m/s.

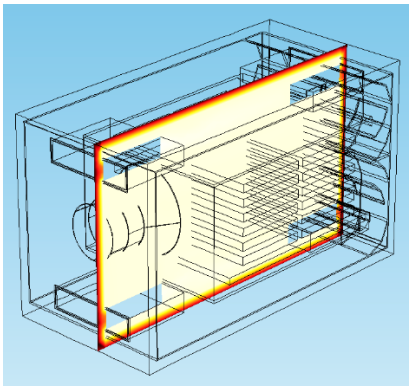


Fig. 2 – The temperature distribution for U_{in} = 10 m/s is rather uniform away from the furnace walls – red is for higher temperature. As expected, when the same heating power is used the temperature profile and range hardly change;
T_{max} = ~115 C, T_{min} = ~31 C.

Figure 2 presents the temperature distribution through a colored map slice cut-off. Remarkably, a steep drop in temperature occurs by the furnace walls (properly insulated) and rather uniform temperature distribution inside the furnace as well as within the load package (the aluminum alloy plates, when present).

4. CONCLUSIONS

Although the numerical simulation results ought to be compared with the industrial tests on the indirectly heated, fuel-fired batch furnace, the preliminary data assess their predictive merit of the airflow inside the furnace and the quality of the thermal aging process.

The simulation results help better understand the stationary heating process, assess the temperature uniformity within the plates stack, and contribute to optimizing the thermal structure and conditions of the process to match those technological requirements that are credited to improve the end product quality.

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Three-layer Hele-Shaw displacement with intermediate non-Newtonian fluid

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Abstract: *We study the displacement of two Stokes immiscible fluids in a porous medium, approximated by the Hele-Shaw horizontal model. An intermediate non- Newtonian polymer-solute, whose viscosity is depending on the velocity, is considered between the initial fluids. We prove that the linear stability problem of this three-layer displacement does not make sense. On the contrary, if the intermediate viscosity depends on velocity and on the polymer concentration, we obtain a minimization of the Saffman-Taylor instability.*

Key Words: *Hele-Shaw displacements, Non-Newtonian fluids, Flow stability*

Thermal flows in fractured porous media

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Abstract: *The incompressible filtration flow in the porous matrix and the incompressible viscous flow in the fractures obey the Boussinesq approximation of the Darcy-Forchheimer law and respectively, the Stokes system.*
At the interface, besides the continuity of the normal velocity, the two flows are coupled by the Saffman's variant of the Beavers-Joseph condition: the continuity of the normal component of stress and the proportionality between the tangential fluid velocity and the tangential viscous stress.
The tensors of thermal diffusion of the two phases are ε-periodic and not necessarily equal. The temperature and the heat flux are continuous at the interface. Heat sources are present in each component and a temperature distribution is imposed on the boundary of the domain.
We prove the existence and uniqueness properties of the velocity, pressure and temperature distribution, solutions of the corresponding thermal flow boundary problem. An L∞-estimate of the

temperature, uniform with respect to ε, is also presented. The way of describing the Darcy-Forchheimer law by powers of the energy norm of the inverse permeability tensor proves to be appropriate. These results have an intrinsic interest, apart from the related homogenization result. In the ε-periodic framework, we find the local problems and the effective coefficients of the two-scale homogenized system which governs the asymptotic behaviour when the Forchheimer effect vanishes, the Rayleigh number and the permeability of the porous blocks are of unity order and the Beavers-Joseph transfer coefficient is balancing the measure of the interface. It is a model concerning two coupled thermal flows, neither of them being incompressible.

Key Words*: Fractured porous media, ε-domes, two-scale homogenized system, Darcy-Forchheimer law, Boussinesq approximation, Beavers-Joseph condition*

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Cooling the photovoltaic panels by natural and forced convection

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Abstract: *One of the most significant issues of photovoltaic (PV) panels is overheating beyond the functioning limits caused by solar irradiation, the Joule effect, and thermal environmental conditions. Consequently, the diminishing efficiency of the overall PV conversion and the pending reduction in the electric power available for usage or storage. This study is concerned with the analysis of the heating of a PV panel subject to combined infrared irradiance and electric load-related Joule losses to predict and reduce the temperature of the PV panel and increase the PV conversion efficiency.*

Key Words: *heat transfer, photovoltaic panel, natural convection, forced convection, finite element method*

Some practical remarks in solving partial differential equations using reduced order schemes obtained through the POD method

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Abstract: *In this paper we want to address the subject of mathematical modeling, more precisely the optimization of algorithms for numerically solving partial differential equations. The problem proposed to be tackled in this paper is the implementation of an algorithm for solving partial differential equations in a significantly faster way than in the case obtained through applying finite difference schemes. The proper orthogonal decomposition (POD) method is a modern and efficient method of reducing the number of variables that occur as a result of applying centered difference schemes to partial differential equations, thus reducing the running time of the algorithm and the accumulation of truncation errors. Therefore, the POD method has been implemented to obtain a reduced order scheme that was applied to different partial differential equations, with some practical applications and comparisons with the analytical solutions.*

Key Words: *Reduced order method (ROM), Proper orthogonal decomposition (POD), Singular value decomposition (SVD)*

Multiscale modeling and analysis for reaction-diffusion processes in composite media

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Abstract: *In this talk, we present some recent homogenization results for a class of reaction-diffusion problems in highly heterogeneous periodic composite media containing imperfect interfaces. Across these interfaces, we suppose that the solution of the problem under study and its flux exhibit jumps. We consider different geometries for the microstructure and various forms for the functions describing the jumps involved in our microscopic problem. Several effective models are obtained, by using periodic homogenization techniques, and they are compared with the existing ones in the literature (see, for instance, [3-7, 9]). Our setting is also relevant for analyzing the electrical conduction or the calcium dynamics in living tissues [1, 2, 8, 10].*

Key Works*: homogenization, composite media, imperfect interfaces*

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Section 5. Technical Applications

Neural Network and Linear Programming Aircraft Boarding Strategy based on Passengers Preference

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Abstract: *One important target for the aircraft boarding procedure is to get all the passengers on their seats in the minimum amount of time. Another significant factor during and after the flight is given by the passenger satisfaction. This feedback is very complex in nature and depends on a high number of different elements. Several noteworthy passenger options are taken into consideration to cover the best flight conditions.*
Passenger boarding objective is modeled with a cost function and depending on their choices and minimum of the function one neural network is trained and used to predict the most suitable place for the passenger. The paper results offer a solution to aircraft passengers distribution based on their seat preference and social communication preferred application.

Key Words: *aircraft boarding strategy, linear programming, passenger seat prediction, passenger options modeling, neural networks*

Performance analysis of electric aircraft configurations

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Abstract: *In the last years, the electric propulsion used on aircrafts started to be more and more popular, being developed many concepts of aircraft with electric propulsion for different missions. The development of electric propelled aircraft based on full electric architecture implies reduced range due to the low energy capacity of batteries avaible. This fact can present a real interest for Urban Air Mobility (UAM) or Regional Air Mobility (RAM) where distances are usually below 100km, and the payload not exceed 1000kg. This study includes three parts: in the first part will be analyzed the current electric aircraft configurations, in the second part will be analyzed the typically aircraft*

architectures to identify the most efficient configuration for UAM, and in the third part will be analyzed the performances of electric propulsion considering distributed electric propulsion (DEP) and boundary layer ingestion (BLI). To identify of the most efficient electric aircraft architecture is needed a qualitative comparison of the most representative aircraft architectures (multirotor, helicopter, lift and cruise, tilt rotor, tilt wing and direct lift). The most efficient architecture found will be analyzed with different positions of propulsion system to identify the most efficient propellers-wing and propellers-fuselage interference, keeping the thrust of propellers constant.

Key Words: *Aerodynamic analysis, flight performances, electric aircrafts, urban air mobility, regional air mobility, distributed electric propulsion, electric propulsion*

De-icing of aircraft on the ground and means of environmental protection

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Abstract: *The de-icing activity of aircraft on the ground is one of the most complex handling operations and requires a good knowledge of service procedures. Due to the environmental conditions, in the low temperature, the type of precipitation existing at that time and the temperature of the aircraft surfaces, it is necessary to use a certain substance to provide protection for the aircraft from frost. Beyond these aspects related to the safety of air operations, we must also have a perspective on the environment around the airport. This paper aims to identify solutions for the management of compounds resulting from de-icing and anti-icing on the ground, which can contaminate the soil and groundwater in the vicinity of the airport.*

Key Words: *de-icing, givrare, contamination, chemical compounds*

Low-speed airfoil shape optimization using high-fidelity CFD analysis

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Abstract: *Although the aviation sector has become more fuel-efficient, the need of reducing the carbon footprint pushes aerodynamic optimization forward. Even if low fidelity methods such as panel methods coupled with viscous models are widely used in the airfoil optimization process to determine the aerodynamic performance due to their low computational time, in certain scenarios they can predict misleading results that don't reflect the physical phenomena. Hence, a verification method against high-fidelity CFD analysis is required. Although the computational time required to carry out the analysis is increased, advances in computational power have enabled the use of high fidelity models for 2D aerodynamic optimization. This paper approaches a better aerodynamic performance prediction using high-fidelity CFD analysis. The optimization process is performed using an evolutionary algorithm. In order to validate the results, a parametric study in the design space serves offers a robust reference. This study aims to compare the results obtained with different aerodynamic solvers (low-fidelity vs. high-fidelity) and different evolutionary optimization algorithms (Genetic Algorithm vs. Differential Evolution).*

Key Words: *Airfoil optimization, low-speed aerodynamics, computational fluid dynamics, high-fidelity analysis, aircraft design, optimization, evolutionary algorithms*

Conceptual design of a Dandelion and Maple seed based Micro Unmanned Aerial Vehicle

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Abstract: *In recent years, Micro Aerial Vehicle (MAV) has been attracting more attention for their potentials in civilian and military applications. To date, several MAVs concept have been proposed, which includes fixed wings, rotary wings, and flapping wings. The micro size of unmanned aerial vehicle means they can be used in confined spaces, i.e., inside buildings where their larger version would be unsuitable. But still there are many natural flyers yet to discover as universe has ten quintillion insects and over eighteen quintillion of seed. Since beginning of nature inspired MAV design it has proven the potential to offer advantages such as stealth, maneuverability, and improved propulsive efficiencies. This paper contains the challenging conceptual design of a nature inspired micro unmanned aerial vehicle. Where the geometrical shape of a Maple seed and the flight capability of a Dandelion seed has been considered in a single MAV. In the proposed design, flow*

device will be the primary propulsion system and Dandelion seed will be the secondary one. This conceptual design has potential to use less energy and extend flight duration. This design also has the potentiality to fly within a long distance. Although copying the wing motions of natural flyers is not an easy task. A possible application of such micro size aerial vehicle would be monitoring sensitive industrial environments. In addition, it is also perfect for monitoring spy missions for the military.

Key Words: *nature inspired, micro air vehicle, vortex, flow device, micro actuator*

Fast inviscid transonic airfoil optimization using a nonlinear potential solver

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Abstract*: A procedure to perform airfoil optimization in transonic regime based on the transonic small disturbance potential equation is presented. Considering the current necessities, supercritical airfoils are a requirement in commercial aviation for reducing the wave drag thus cruising at higher speeds. Therefore, a different approach to design an airfoil at a specify operating condition is evaluated and compared with a reference airfoil, RAE2822. The core of the framework is the small disturbance theory, implemented within the TSFOIL solver. Airfoil parameterization with the Class Shape Transformation is performed as it requires less design variables than other methods, reducing the runtime in the optimization process. The objective function is the glide ratio for a single point design optimization. The aerodynamic performances of the optimal airfoil are further analyzed with CFD and compared with RAE2822. In addition, the intensity of the shock wave is assessed to determine the fesabililty of the airfoil at the required operating conditions.*

Key Words*: transonic flow, shock wave, airfoil optimization, stochastic algorithms, CST, transonic small disturbance equation, RAE2822*

The Fly-by-Light system for military aircrafts

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Abstract: *This paper presents recent documentary research of the authors, regarding the advantages of using Fly-by-Light system in Military aircrafts and understanding why Fly-by-Light (FBL) is very promising for further military aircraft development. Fly-by-Light flight system is*

characterized by the fact that input control signals from pilot, motion data and air data sensors are sent to flight control computer and from here to the actuators of control surfaces through a fiber optic cable and the feedback from actuators sensors or other signals is received in the same way, through fiber optic cable linked to the aircraft flight control computer. The first major step in the evolution of flight control systems was the replacement of mechanical flight control system with Fly-by-Wire (FBW) flight control system. The next major step is the replacement of Fly-by-Wire (FBW) flight control system with Fly-by-Light (FBL) flight control system which has some significant advantages such as: reducing the weight of the system, increasing the speed and volume of information transmitted through fiber optic (input and feedback signals), the accuracy of the signals is kept intact along the entire length of the circuit, the optical fibers do not present any risk of fire, as they carry only light signals, and the temperature, humidity and severe weather conditions do not affect the fiber optic cable, which can withstand about 0.69 - 1.38 MPa pressure without damaging the cable, unaffected by Electromagnetic Interference (EMI) and the Electromagnetic Pulse (EMP) generated by nuclear blasts. All the advantages listed above provide tactical and safety advantages for the military aircraft and its crew.

Key Words: *Fly-by-Light (FBL), Fly-by-Wire (FBW), flight control system, Military aircrafts, tactical and safety advantages*

Failure Mode and Effect Analysis for military nose landing gear project

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Abstract*: Failure Mode and Effect Analysis (FMEA) techniques were originally developed by the US military and have been used as techniques for assessing the reliability and effects of equipment failures. However, the first notable applications of FMEA techniques are related to the impressive development of the aerospatial industry in the mid-1960s. FMEA is a methodology for systematically analyzing the failure modes of a product or process, prioritizing their importance, identifying system failure mechanisms, analyzing potential failure modes and the effects of these failures, followed by corrective actions, which apply at the stage of the conceptual and detailed design of the product. All approaches to FMEA methods in the scientific literature converge to achieve three goals, namely: the ability to predict the type of failure that may occur, the ability to predict the effects of the failure on system operation and to establish steps to prevent failure and its effects on the operation of the system. The FMEA for the project analyzes the failure modes of the product and their effects in operation, as a consequence of design deficiencies and identifies or confirms critical functions. To apply the FMEA method to the project of the nose landing gear of a military training aircraft, the next steps need to be followed by: product description and identification of components; identification of functions; identification of potential ways of failure; estimating the frequency of causes of failure; appreciation of the severity of the effects; assessment of difficulties in detecting defects; calculation of the Risk Priority Number (RPN); establishing the measures and corrective actions for the analyzed project.*

Key Words*: Failure Mode and Effect Analysis (FMEA), Nose Landing Gear (NLG), military, failure modes, critical functions*

Numerical prediction of transonic airfoil buffet

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***Abstract**: In transonic flow conditions, the shock wave/turbulent boundary layer interaction and the flow separations on the suction side of airfoil could trigger flow instabilities, called the buffet. This phenomenon appears when Mach number or/and incidence angle increase. Unfortunately, the buffet can reduce the aircraft's flight envelope dramatically. The objective of this study is to predict from the numerical point of view as accurately as possible this complex phenomenon using the commercial CFD code Ansys Fluent. A special attention was given to the turbulence models because they can greatly under/overpredict the boundary layer separation and thus, the buffet phenomenon. In order to properly capture the viscous sublayer and thus the separation, the dimensionless number y+ is kept below unity for all numerical simulations. In order to capture, as accurately as possible, the shock wave, which triggers the boundary layer separation, the conservative formulation of the Navier-Stokes system is discretized with the second order AUSM+-up scheme because it is less dissipative and cheaper from the numerical point of view than the Roe method. The ONERA OAT15A transonic airfoil was chosen to describe buffet phenomena due to the availability of experimental and numerical data. The numerical results clearly show that the commercial CFD code Ansys Fluent is able to deal with this complicated phenomenon.*

***Key Words:** buffet, transonic flow, turbulence models, boundary layer separation, unsteady flow*

RANS-based global performance analysis of a four-seater general aviation aircraft

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***Abstract**: General aviation four-seater aicraft still represent a significant market segment, determining manufacturers to develop new, conventional vehicles, driven by standard piston engine, as a safe roadmap to certification. As part of the engineering work, initial global performance analysis is performed with RANS, besides the use of dedicated design tools like AAA. Given the early state of the design, a high-fidelity study was conducted in order to obtain an initial data set, using a geometry that does not include control surfaces, cooling circuit of the engine, propeller actuating disk model or small details of the fixed landing gear, as they would bring a large engineering effort, while design still evolves. At this point, simulations were performed using the cruise speed at sea level. Some key aspects were followed, as the maximum lift coefficient, critical angle of attack, and the drag at cruise. The problem of directional stability was addressed by studying two vertical tail configurations. As part of the development process, the CFD approach will give insight into physical phenomena that is out of the reach of faster, but lower-fidelity methods like potential/boundary layer (FlightStream). The resulting feedback will be used to improve the geometrical definition of the aircraft in future design iterations.*

***Key Words:** general aviation, high-fidelity, airfoil*

A review on applications and technologies for flexible-winged-based UAVs

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***Abstract**: The continued convergence of bigger UAVs towards smaller and smaller dimensions that comes together with rapid gains towards agility and swarm type applications, holds the hidden meaning of the results of novel multidisciplinary research in this field. Common characteristics ranging from the low Reynolds number flight, low energy and small load carrying capacity, to high sensibility towards airflow changes, define the small UAV field.*
Being sensitive to wind gusts and turbulent flow even with a well-defined control system, mechanical sensor load stabilizing onboard the UAVs is usually impossible due to weight constrains and hysteresis. One of the more interesting researched solutions in this case is the biomimetic flexible membrane wing. The passive control over the flow field of this type of wing surface can prevent flow separation and increase the lift to drag ratio.
This paper proposes a review of technologies used in designing and testing of different classes of UAVs that employ the use of flexible membrane type wings characterized by their hyperelastic material cover and aeroelastic behavior. Throughout its four sections, the paper underlines elements pertaining to: UAV classes and their missions and versatility, hyperelastic materials used and the technologies for design and incorporation, novel fabrication and experimental approaches, prominent results discussion and research directions. The challenges and trends in the field are highlighted. The goal is improving the understanding of flexible wing surfaces and their impact on unmanned vehicle flight and providing a comprehensive structured synthesis of the field.

***Key Words:** flexible-winged UAVs, hyperelastic materials, technologies, experimental results, biomimetic*

Analog versus Digital Anti-Aliasing Filtering in Modern Data Acquisition

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***Abstract**: As contemporary technology evolves, we see a gradual phasing out of analogue systems and their replacement with software simulations of their transfer functions running on embedded platforms, with mostly all current scientific equipment being fully digital or hybrid at least. Digital signal processing is a ubiquitous process nowadays- so do analogue methods and components still matter? This article offers insights into the traps of interfacing analogue sensors with digital interfaces, when disregarding their limitations. As we will show, the most prevalent mistake that passes unnoticed with disastrous consequences is treating analogue signals prior to digitization with no regard to available system bandwidth versus total signal bandwidth. Less serious problems arise when using improper signal filtering techniques and when applying simulated filters to certain ill-conditioned signals. Analogue systems have their well-known limitations – need for high precision components that directly translates in the quality of the signal processing, inconsistencies due to individual part parameter variation due to thermals or noise -but the digital systems that replace them*

must be carefully designed to avoid creating even bigger and more unexpected problems. There are cases when certain parts of the said systems must remain analogic in order to avoid unrepairable signal distortion and loss and cases when certain types of filtering are totally unsuitable to the task at hand.

Key Words: *analogue systems, data acquisition, digital systems, mixed signal interfacing, analogue and digital signal processing, bandwidth, aliasing, anti-aliasing analogue and digital filtering*

Aerodynamic assessment of a Vertical Take-Off and Landing rocket vehicle in hover and ground proximity

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Abstract*: In the framework of the European Space Agency goals related to space technology, a VTOL demonstrator is being developed at INCAS as a reusable test platform to extend the capabilities for future testing campaigns. The current study is part of the aerothermodynamic package of the project and is performed towards the assessment of engine plume – ground interaction. It is important to account the aerodynamic effects on the vehicle in terms of moments/forces together with a temperature distribution on the lower parts of the vehicle and on the touchdown zone ground. The scenarios include steady state simulations at several lateral wind speeds and different ground hover distances. Also, transient state simulations were conducted in order to account for the unsteady features that may appear in the process, such as thermal loads or unsteady flow structures that could affect the stability of the vehicle. Throughout the simulations, the engine was set to a full throttle setting. It was found that the vehicle is not thermally affected by the jet plume and that the aerodynamic forces show overall small oscillations, mainly caused by the fuselage-engine cavity. However, the force amplitudes are well inside the thrust vector control capability range.*

Key Words: *VTOL demonstrator, aerodynamics, CFD*

Generalized optimization of supersonic ramp intakes in ideal and calorically perfect gas

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Abstract*: Planar intake ramps of "n" oblique shocks and one normal shock are optimized in ideal and thermally perfect gas, identifying the Oswatitsch criterion capturing in ideal gas. Optimization function is the ratio of stagnation pressures and ramp geometry is recovered out of optimal angles. To properly assess the optimization process, families of ramps are optimized across a range of Mach number from supersonic to hypersonic. Pressure recovery performance for a wide Mach range provides the consistency level of the optimization process. Besides the ideal gas model baseline,*

thermally perfect gas is used to enable a more physical solutions in hypersonic regimes and full comparisons with the ideal gas. Comparisons with reference data are very good in ideal gas for 2+1 and 3+1 ramp systems. An analysis of optimization efficiency among GA, DE and conjugate gradient methods is presented.

Key Words: *numerical optimization, supersonic planar intake*

An extended comparison between BOS, thermal-calibrated and color-filter schlieren

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Abstract*: Comparisons between quantitative schlieren techniques are scarce, but have been made before [1], none including a thermal calibrating technique. This paper represents a thermal calibration for a z-type schlieren system and integrates a comparison of 3 different schlieren techniques: thermal-calibrated, BOS (background oriented) [2] and color-filter calibrated schlieren [3]. All data obtained from these techniques will be compared to the results obtained by the simultaneous usage of a thermo- vision camera. The article aims at calculating the error and uncertainty of each measurement and therefore determining which of the described techniques offers more advantages and recommends the circumstances in which the techniques are best used, based on the nature of the studied phenomenon.*

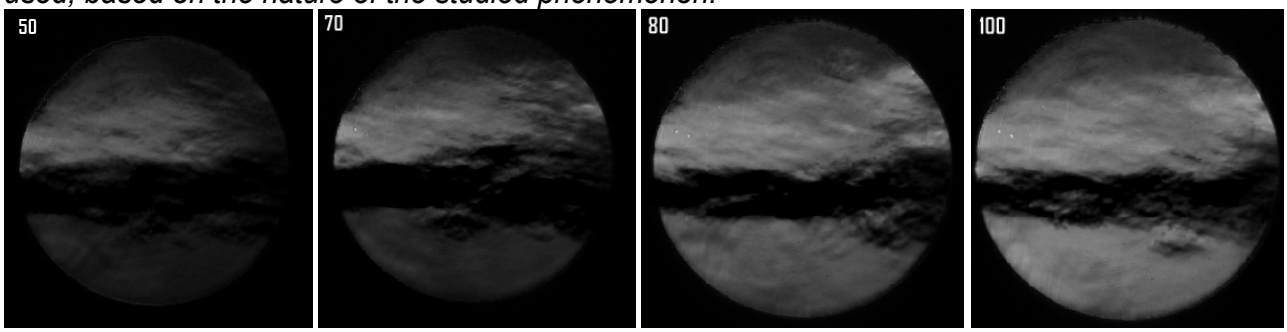

Fig. 1 Thermal Calibration images- contrast details.

Key Words: *thermal calibration, BOS, color filter, thermo-vision*

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Experimental investigations on rheological properties of biogreases

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Abstract: *In the recent years, the lubricating market is demanding new biodegradable products based on renewable resources as a consequence of progressively more strict environmental regulations. This paper is focused on the rheological study of biogreases, based on rapeseed oil and aqueous sodium stearate, additivated with graphene or graphite nanoparticles. For this study, different grease samples have been prepared and each of them were thermal analysed in the range of 20 ^{0}C … 75 ^{0}C. The rheological tests indicate that the greases have non-Newtonian behaviour, which are rheological described by the Bingham model. Finally, the thermal variation of the rheological parameters (yield stress and viscosity) was obtained, taking into account the concentration of nanoparticles.*

Key Words: *Rheology, Biogreases, Nanoparticles, Thermal analysis*

Design and development of a set of reentry capsule wind tunnel models to achieve the aerodynamic characterization at all angles of attack

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Abstract: *The space's research became one of the most important field of science in order to achieve the humanity desideratum of the exploration and human's colonisation of the space. Due to this goal, many other related fields of science and engineering are evolving, such as the launcher and re-entry vehicle technology. Nowadays, an increasing number of countries, international organisations and companies are involved in many space programs which are contributing to the evolution of the aerospace industry and space missions. One of the dangers and critical actual aspects of space activity are related to the accumulated space debris on Low Earth Orbit. The rising population of space debris increases the potential danger to all space vehicles, including to the International Space Station and other spacecraft with humans aboard, such as SpaceX's Crew Dragon or Soyuz. Some visualisations and observation of the re-entry mission phase of launchers's non-reusable stages are needed for a better quantification of the space debris resulted from the fragmentation process. To accomplish these experiments, a new generation of re-entry capsules has been developed for observation and probe sampling purpose. For a more accurate prediction of trajectory and due to the limited understanding of the dynamic instability existing at low Mach numbers for blunt body shapes, an aerodynamic assessment of the capsule has been performed in the wind tunnel. To accomplish the aerodynamic characterization for the entire range of angles of*

attack in the INCAS Trisonic Wind Tunnel, a set of different models and fixing adaptors have been designed and implemented. The main objective of this paper is to describe the entire process of the design, development and production of WT blunt body descent vehicle models.

Key Words: *blunt body capsule, wind tunnel model, aerodynamic characterisation, design and structural development*

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Free-free vibrations analysis of the aircraft IAR-99 HAWK based on a new and modern finite element model

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Abstract*: For the PHD study regarding the influence of the aircraft external stores over the aeroelasticity behavior of IAR-99 HAWK we have developed a new Finite Elements Model (FEM) with the new state-of-the-art methods and technologies available at the end of 2020.*
Creating a new Finite Elements Model (FEM) of the aircraft IAR-99 HAWK utilizing special elements, the team has decided to validate the results of the new model conducting a free-free vibrations analysis on it.
In this presentation we have described the finite elements used and their peculiarities, the finite elements model obtained for the aircraft IAR-99 HAWK and the results of the free-free vibrations analysis obtained in empty equipped configuration.
The results of the theoretical free-free vibrations obtained for IAR-99 HAWK in empty equipped configuration are presented compared to those obtained by ground tests, achieving in this way a confirmation of the accuracy of the new Finite Element Model (FEM).
The new Finite Element Model (FEM) of the IAR-99 HAWK will be versatile enough to provide an insight in the structural behavior of the aircraft regardless of the phenomenon that it is analyzed for: static stress, aerodynamic simulations, flutter, etc.

Key Words*: finite element method, FEM, finite element model, aeroelasticity, free-free vibrations, empty equipped configuration, ground vibration tests, MSC PATRAN, MSC NASTRAN*

Index of Authors

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