5th International Workshop on Numerical Modelling in Aerospace Sciences
NMAS 2017
17 - 18 May 2017, Bucharest, Romania

BOOK OF ABSTRACTS

Organizers

Romanian Space Agency
ROSA

INCAS – National Institute for Aerospace Research
“Elie Carafoli”
(under the Aegis of the Romanian Academy)

“Politehnica” University of Bucharest
UPB
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TOPICS

1 – Launchers propulsion technologies and simulations of rocket engines
2 – Flight dynamics simulation
3 – Modelling of structural problems in aerospace airframes
4 – System design for small satellites

Invited Speaker

Identification and Validation Methodologies for the Turbofan Modeling of the Business Aircraft Cessna Citation X

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Abstract: The Research Aircraft Flight Simulator (RAFS) for the Cessna Citation X, one of the fastest business aircraft today, is used at the academic research laboratory in active controls, avionics and aeroServoElasticity LARCASE at ETS in Montreal, Que., Canada since 2010. This simulator, designed and manufactured in collaboration with CAE Inc., is equipped with a flight dynamics Level D (highest level of certification) toolbox, and was acquired with Canadian research funds from the MDEIE and NSERC. Various research projects were performed at the academic level using this Research Aircraft Flight Simulator as flight tests bench. In other words, due to its highest certified level D flight dynamics, the RAFS flight test results are used as real aircraft flight test data for experimental validation of the novel methodologies here presented. The aircraft and the turbofan of this aircraft were modelled separately. The proposed here turbofan model aims to predict the thrust and the fuel consumption for flight cases expressed in terms of altitudes, Mach numbers and Throttle Lever Angles. Two methodologies were used to determine the turbofan model. The first methodology was used to determine the turbofan model using a new identification and validation approach. This approach has used a new optimization algorithm in order to tune the models parameters with the set of identification flight test data. Another set of data was further used in order to validate the identified model. The second methodology has used a combination of a grey and a black box approaches. In the grey approach, the unmeasurable parameters were identified to tune the model, and thus to reduce the global error between the model and the simulation data. The black box approach was used also with an optimization algorithm to approximate the outputs as polynomial functions of the inputs. Using these methodologies, the results were found to be accurate.

Key Words: turbofan model, experimental validation, optimization algorithm, polynomial functions, research aircraft flight simulator, business aircraft
Translation versus rotation motion and their continuum-discrete simulation

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Abstract: Formally, the turbulence problem is to solve the Navier-Stokes equations subject to initial and boundary conditions. At present, it is possible to obtain fully resolved solutions at moderate Reynolds numbers via direct numerical simulations of Navier-Stokes equations. However, the important point is that looking at the behavior of a particular solution does not solve the problem, since any particular solution (which is not in an analytical form) may not contribute much to the understanding of the basic physics of turbulent flows. The “start-up” of a flow from rest evolves mostly impulsively when the starting acceleration exceeds the acceleration of gravity and flow is strongly disturbed at solid boundary generating here turbulence. From the analyzes of the flow nearest wall, we show using an illustrative example how the neglecting of such large accelerations (constant viscosity and boundary vorticity flux) and approaches failing to describe the essence of turbulence, that is the origin of turbulence and it’s self-sustaining.

Key Words: Laminar-turbulent transition, Shear turbulence, Rotor-translational flow model

Clos Guidance Algorithm for a Generic Surface to Air Missile

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Abstract: The paper presents a simulation study of Command to Line-Of-Sight (CLOS) guidance algorithm applied to a Low-to-Medium Altitude Air Defense (LOMAD) System. In this type of guidance the target tracking system and the guidance computer are not part of the missile itself, rather they are part of the firing unit. Tracking is accomplished using radar, optical, laser, or infrared systems. The tracking system tracks both the missile and the target. The target and missile ranges, elevations, and bearings are fed to a guidance computer. Consequently, using the position and position-rate information, the guidance computer determines the missile normal and lateral acceleration commands. The acceleration commands are fed to the missile via a command uplink. The system block diagram is shown in Figure 1.

Figure 1. System block diagram for Command Guidance
A 3 DOF simulation model of the missile and the maneuvering target has been simulated in simulink environment. The missile model comprises of a thrust phase of 2.2 seconds in which it attains Mach 2.0 and thereafter is able to glide & maneuver for approximately 15 seconds before the velocity drops to Mach 0.9 because of drag and gravity momentum loss. During the midcourse phase the target and missile position is fed to the guidance computer in polar co-ordinate system R (range), θ (elevation), ψ (azimuth). The information provided to the guidance computer is the position vector of the target \([R_t, \theta_t, \psi_t]\) and the missile \([R_m, \theta_m, \psi_m]\) as well as the rates \([dR_t/dt, d\theta_t/dt, d\psi_t/dt]\) The missile range rate \(dR_m/dt\) is also measured. The guidance objective is to minimize the miss distance for both maneuvering and non-maneuvering targets moving at speeds ranging from 40 m/s to 440 m/s and dive angles up to 20º.

**Figure 2. Command guidance geometry**

Following mathematical model has been used to compute the guidance command:

\[
G_z = K_1 R_m (\theta_m - \theta_t) - K_2 R_m \frac{d\theta_t}{dt} \frac{R_t - R_m}{R_m - R_t} \tag{1}
\]

\[
G_Y = K_1 R_m (\psi_m - \psi_t) \cos \theta_t - K_2 R_m \frac{d\psi_t}{dt} \frac{R_t - R_m}{R_m - R_t} \cos \theta_t \tag{2}
\]

Where \(K_1, K_2\) are the guidance gains and \(G_z, G_Y\) are the normal and lateral acceleration commands. In the present study the guidance gains have been optimized to minimize miss distance. The LOS error of the missile in elevation and azimuth plane has also been studied to determine whether the missile will remain in direct line-of-sight of the target during the entire tracking phase.
Numerical Analysis of Mixed Flows Turbofan Performance Prediction versus Design Parameter Variation

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Abstract: The study conducted in this paper intends to express the influence of certain jet engine design parameters on the design and off-design performance prediction; the numerical simulations have been obtained from in-house codes, developed for the mixed flows turbofan, which is the most challenging, due to its complexity, from the aero – thermo - gas dynamics standpoint. For many technical applications, there is a demand for estimating the engine's performances, at different flight and operating regimes. The accuracy is strongly influenced by the input data, i.e. the engine's main parameters (airflow rate, turbine inlet temperature and pressure ratio) and other parameters which express the intensity of the pressure, velocity, work or power losses. Some of the main parameters can be found in jet engines catalogue, others, in lack of the manufacturer's Engine Deck, must be identified. The parameter identification is completed when the performances (such the thrust and specific fuel consumption) are retrieved from numerical simulations, close enough to the prescribed or given data records. The influence of the most significant parameters on the accurate prediction of the mixed flows turbofan performances is determined.

Key Words: Mixed Flows Turbofan, performance prediction, design parameter, numerical simulation

Determination of a Two Variable Approximation Function with application to the Fuel Combustion Charts

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Abstract: Following the demands of the design and performance analysis in case of liquid fuel propelled rocket engines, as well as the trajectory optimization, the development of efficient codes, which frequently need to call the Fuel Combustion Charts, became an important issue. An efficient solution of this problem is presented in this paper; the author has developed an original approach to build an approximation function, of two variables: the chamber pressure and the nozzle exit pressure ratio. The numerical algorithm based on this two variable approximation function is more efficient due to its simplicity and prospects for increased rate of optimization codes.

Key Words: approximation of two-variable functions, fuel combustion charts, liquid propulsion, rocket engines
The numerical simulation of the rocket nozzle shape influence over the performances

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Abstract: This paperwork is about the study of the shape influence of a rocket nozzle over the engine’s performance using the numerical methods CFX. The study was made calculating the performances of a rocket engine with liquid hydrogen and liquid oxygen, taking into account the geometric dimensions and there is described a comparison study between two different shapes of a rocket nozzle, the cone-shaped and the bell-shaped. The simulations were made using the commercial code, ANSYS and the computing grid was generated with the Gambit program. Due to the simulations there are shown the effects of the flow inside the nozzle and the influence of the two shapes over the propulsion force. Numerical simulations will be made for the rocket nozzle for several altitudes of the atmosphere and will see expansion flow field. Read these values in the outlet of the nozzle and will make comparisons with analytical results.

Key Words: numerical simulation, rocket, nozzle, performances

Optimum design of filament-wound composite solid rocket motor cases

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Abstract: Composite filament winding is an important fabrication technique of solid rocket motor cases. The present study investigates the optimum design for filament-wound composite solid rocket motor cases, subjected to geometrical limitations, winding conditions and failure criteria. Generally, a typical solid motor case is basically a double-dome right circular cylinder with openings in both ends and cylindrical extensions called skirt. The objective is to determine a feasible winding angle, ply lay-up, thickness and dome contour, which are the driving factors to overcome the manufacturing limitations and to increase structural stiffness. To investigate the mechanical behavior, analytical and numerical methods such as preliminary design with netting theory, analysis with classical theory of laminated shells and analysis with finite element method are employed. Netting analysis, presented by B. W. Tew, is the design approach considered to approximate the hoop and helical thickness and the dome shape of the filament-wound case. The ply sequence for carbon/epoxy filament-wound composite consists of alternating helical wraps (±α) with 90° or hoop wraps. Progressive failure analysis is imposed to the composite pressure-vessel with geodesic end domes. Results reveal that filament-wound composite solid rocket motor case with geodesic and variable domes shows better mechanical behavior.

Key Words: solid rocket motor, filament winding, geodesic dome, isotensoid, composite failure criteria
Estimated vs. real orbits: SST Analysis tool (SSTAN) supporting SST services assessment focused on re-entry prediction

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Abstract: SST Analysis tool (SSTAN) was developed in the frame of P2SSTI project for ESA and it is composed of several independent inter-related modules intended for the evaluation of the performance of an SST system. These modules can be categorized into SST simulation modules and SST service analysis modules. The first category includes the Population Generation module, the Fragmentation Generation module, the Measurement Generation and Post-Processing modules and the Cataloguing module, which are used to build the core of the SST system: the catalogue objects orbiting the Earth. On the other hand, the second group includes the Re-entry Analysis module, Collision Risk module, Fragmentation Detection and Identification module, Manoeuvre identification module and the Attitude identification module. The generation of observation measurements is executed prior to the evaluation of performance of all services. Services heritage from the catalogue and thus, the cataloguing module creates the catalogue according to a configured sensors architecture. This paper presents a brief description of the functionalities of the SST service analysis modules implemented in SSTAN with emphasis on the Re-entry Analysis module. Furthermore, a detailed re-entry prediction analysis is included in order to assess catalogue performance for different SST architectures.

Key Words: re-entry, fragmentation, SST, tracking, surveillance, SSA, space derbis, simulation, estimated orbits, real orbits

Fragmentation Events Analysis Making use of Fragmentation Event Model and Assessment Tool (FREMAT)

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Abstract: The Fragmentation Event Model and Assessment Tool (FREMAT) project for ESA was completed with the objectives of simulating on-orbit fragmentations, assessing their impact on the space population and evaluating the capability of identification of fragmentation events from existing surveillance networks. In the frame of the FREMAT activity, the implementation of several algorithms related to on-orbit fragmentation events was carried out. FREMAT encompasses three individual tools: Fragmentation Event Generator (FREG), Impact of Fragmentation Events on Spatial density Tool (IFEST) and SOFT (Simulation of On-Orbit Fragmentation Tool). Fragmentation Event Generator (FREG) has been conceived to simulate fragmentation events (explosion and collisions). The second tool, IFEST, allows the evaluation of the impact of on-orbit fragmentations in the space debris population. Finally, the third tool, SOFT, has been created to simulate the determination of the type of fragmentation and the objects involved in a fragmentation event when a space surveillance network detects a number of unexpected new objects and a fragmentation event is considered a
possible cause. This paper presents a description of the algorithms implemented in this toolkit and a brief summary of their main functionalities. Furthermore, results from simulations of passed fragmentation events are reported.

**Key Words:** re-entry, fragmentation, SST, tracking, surveillance, SSA, space derbis, simulation, estimated orbits, real orbits

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**Numerical Modeling of a Self-Circulating Porous Bearing with a Wrapped-Around Reservoir**

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**Abstract:** This paper presents the numerical modeling of a self-contained, self-circulating, self-lubricating bearing using the computational fluid dynamic software CFD-ACE+ and is part of the author’s dissertation work. This bearing has a stationary porous bushing whose inner diameter faces the bearing clearance, while the outer one faces a wrap-around reservoir. The eccentric shaft generates pressure difference ensuring that the fluid circulates naturally between these two regions. This circulating mechanism, which eliminates the need of a pumping system is described and numerically simulated using the full 3D Navier-Stokes Equations for the fluid flow in the bearing clearance and the adjacent reservoir. The flow inside the porous matrix is modeled using: the Darcy law, the added Forchheimer term to account for the inertial effects when the speed increases, and the Brinkman term to account for the hydrodynamic boundary condition effects that appear at the fluid/porous media interface and for the added shear effects inside the porous media. The low pressure region is modelled using a full cavitation model, to include both vaporous and gaseous cavitation proposed by Singhal. The numerical simulations concluded that the load capacity decreases as the permeability or the reservoir depth increases.

**Key Words:** Porous bearing, wrapped-around reservoir, 3D Navier-Stokes, Darcy Law, cavitation

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**Unexpected properties of the propagations generated by some time harmonic perturbations in a 2D infinitely long straight duct satisfying different types of boundary conditions**

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**Abstract:** In this paper the propagation, generated by some explicit permanent time harmonic perturbations are presented, in a 2D straight duct, carrying a constant gas flow. The amplitude of the perturbations is not that given by the Dirac function, as it is considered in general in the literature. The boundary conditions imposed to propagations at the walls of the duct are those considered in the literature: sound-soft, sound-hard and mass-spring-dumper. Unexpected properties of the resulting propagations are revealed.

**Key Words:** aeroacoustics; aircraft noise attenuation; rectangular 2D lined duct; uniform gas flow
On the Use of Scale Resolving Simulations for Improving the CFD - Wind Tunnel Correlation after the Buffet Onset

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Abstract: This paper is dedicated to the assessment of turbulence modelling for the aerodynamic study in transonic conditions of a long-haul business jet with a narrow fuselage, slender back swept high aspect ratio wings with fuselage mounted engines. The model of this aircraft was tested in the DNW-HST, one of the pressurized transonic facilities of the German-Dutch Wind tunnels. The CFD results were obtained using the following model: RANS Menter SST k-ε, which is the reference model, Unsteady-RANS (URANS) Menter SST k-ε and Hybrid RANS-LES (HRL) models based on the same SST model. The used hybrid RANS-LES models are: the SAS (Scale Adaptive Simulation) and the SBES model (Stress-Blended Eddy Simulation) based on the WALE model. Another feature that was investigated was the influence of the use of upwind-central reconstruction blending and the use of a dedicated laminar-turbulent transition model. A special attention was paid to properly capture the aerodynamic coefficients at angle-of-attack of 5.5 deg., corresponding to buffet. The two HRM models were tested on two grids, one created for RANS simulations and one specially created to accommodate the Scale-Resolving Simulation requirements. The buffet is an unwanted unsteady phenomenon characterized by the interaction of the shock wave and the detached boundary layer formed behind it. The final goal was to find the most economic and robust turbulence model able to capture the aerodynamic coefficients given an acceptable accuracy.

Key Words: CFD, Wind Tunnel Experiments, aerodynamic coefficients

Numerical simulations for engine risk investigations for a small launcher

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Abstract: The development of a small launcher involves interdisciplinary integration of several sub-systems, each of them associated with several risks which should be taken into account. One of the critical technologies in the launchers sector is the propulsion system, therefore it is also its greatest liability. In this research, the failure of liquid engines during the ascent phase for a small launcher is considered and the risk is assessed. The investigation is a based on an in-house 3 degree-of-freedom (3DOF) tool for trajectory computation and optimization using a genetic algorithm approach. The tool was developed as a part of the SMILE project – “Small Innovative Launcher for Europe”, under the European Commission, “Independent Access to Space – Horizon 2020”.

Key Words: small launcher, trajectory optimization, engine failure, risk.
Controlling the motion of a 3-DOF Manipulator by using PID Controllers

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Abstract: This paper mainly presents a method to model the 3-DOF manipulator with PID controller in Matlab-SimMechanics and the way to find out optimal parameters in the PID controller including: proportional gain, integral gain and derivative gain by using genetic algorithm (GA). For that aim, the 3-DOF manipulator will be simulated in order to perform a given task. The results achieved from the model show that difficulties in tuning parameters of PID controller can be solved by using GA, and SimMechanics is considered as a good virtual experiment for simulating arbitrary mechanism.

Key Words: Manipulator, GA, Simmechanics, parameters, PID controller

The evolution of Flux Vector Splitting (FVS) Schemes for the Euler and Navier-Stokes systems

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Abstract: The present paper is dedicated to the description of the FVS schemes and their application to supersonic and hypersonic flows. In hypersonic aerodynamic computations, one uses almost exclusively the upwind schemes because the central space discretization's have symmetry with respect to a change in sign; therefore, the physical propagation of perturbations along characteristics, typical of hyperbolic equations is not taken into account in the construction of numerical model. In opposition to the centered ones, the upwind schemes whose origin may be due to Courant et al. [1] are directed towards the introduction of the physical properties of the flow equations into the discretized formulation that has led to upwinding techniques such as flux vector splitting (FVS) and flux difference splitting (FDS) [2]. In general, the FDS methods such as Roe [3], Engquist and Osher [4] and Osher and Solomon [5] schemes are more expensive from the computational point of view and more prone to spurious numerical oscillations in hypersonic regime than the FVS methods [6]. For these reasons, one uses almost exclusively the FVS schemes in hypersonic aerodynamic computations. In 1982, professor B. van Leer proposed a very remarkable scheme [7], which was massively used in supersonic and hypersonic aerodynamics computations in the years '80 although B. van Leer himself [7, 8] pointed that its splitting fails to recognize the contact discontinuity, leading to excessive numerical diffusion in the near-wall region. In 1991, M.-S. Liou and C. J. Steffen have proposed a highly improved version of van Leer scheme through the extraction of pressure flux from the convective flux and the independent discretization of these two fluxes [9]. This scheme called the AUSM scheme preserves the very good behavior of van Leer scheme in supersonic and hypersonic regime and its inexpensiveness from the numerical point of view but it also gives very good results in the near-wall region because its numerical dissipation is very low. M.-S. Liou publishes improved versions of this scheme called the AUSM+ [10] and AUSM+-up [11] in 1994 and 2006 respectively. However, even the AUSM+-up has spurious numerical oscillations in rough hypersonic conditions [6]. For this reason, two Japanese researchers have proposed a new version of AUSM+-up scheme called the AUSM+-up2 through the modification of the dissipative term of pressure flux [6] but their modified scheme does not have a big success [12].

Key Words: Flux Vector Splitting (FVS) Schemes, AUSM schemes, hypersonic heating, artificial viscosity
Fig. 1. Evolution of van Leer’s FVS and AUSM-family schemes; present=2013 [6]

Preliminary Winglet Design with Emphasis of Wingtip Vortices

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Abstract: This paper presents a preliminary winglet design for a Light Sport Aircraft, based on analysis of the wingtip vortices. A comparative study of three different wing tip design, cut-off wingtip rounded wingtip and upswept winglet shows how wing aerodynamics can be improved in term of lift and drag coefficients. The simulation were performed with the aid of Ansys CFX V17 using the RANS equations and SST turbulence model. The results show improvements of the lift coefficient up to 30% by using a swept winglet. Also, the drag coefficient decreases with approx. 2%.

Key Words: wing, winglet, CFD, wingtip vortices

Comparison of different methods for fast computation of aerodynamic pressure coefficients and heat fluxes in hypersonic regime

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Abstract: The growing interest for space activities causes the need to develop fast tools, able to determine the heat flux and pressure distribution at the re-entry object wall and the aerodynamic forces and moments coefficients for hypersonic regime. This article is dedicated to the development of a quick estimation of
aerodynamics and aero-thermodynamics properties of the re-entry bodies, for all the phase of the hypersonic flow: continuum, transition and free molecular flow. An assessment of different methods for the hypersonic regime will be made and the results obtained with the developed object oriented tool will be presented and compared. Methods like Modified Newton, Dahlem-Buck for continuum flow regime, Schaaf and Chambre for free molecular regime and bridging functions for transitional regime will be analyzed.

Key Words: Re-entry, quick estimation, aerodynamics, aero-thermodynamics

Hypersonic flow numerical simulations with chemical reactions

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Abstract: One of the most difficult task of the continuous aerodynamic numerical simulations for the re-entry missions is when the regime flow is hypersonic and the altitude is under 100 km. Physical relevance of the hypersonic CFD runs can only be obtained by including real gas effects. Currently, there are used 3 chemical reactions models (Dunn and Kang model, Park ’89 model and Zeldovich model) which are in addition of the Navier-Stokes Equations. These models are simplified, taking into account only the dissociations effects and without the ionization. In this paper the reduced models are used for 2D axis symmetrical case of a 0 degrees reentry capsule at the most demanding regime such as heat and pressure loads. Comparisons between global and local parameters of the flow are provided and discussed, showing the differences among the three simplified models. All of three models are published and can easily be implemented in a high-end commercial code like Fluent.

Key Words: hypersonic CFD, chemical reactions models, heat and pressure loads.

Design of Air Traffic Control Operation System

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Abstract: In this paper is performed a numerical simulation for a different aircraft, based on the specific aircraft data that can be incorporated in the model and the equations of motions which can be consequently solved. Aircraft flight design involves various technical steps and requires the use of sophisticated software having modeling and simulation capabilities. Within the flight simulation model, the aerodynamic model can be regarded as the most complex and most important. With appropriate aerodynamic modeling, there can be numerically accurate solved the aerodynamic forces and moments acting on the aircraft’s center of gravity. These forces and moments are further used to solve the equations of motion. The development of control and computing technology makes it possible for advanced flight control strategy. The advanced control techniques tend to make the control design and their implementation much more complicated with more control loops or channels; in this line, the autopilot of modern aircrafts includes a variety of automatic control systems that aid and support the flight navigation, flight management, and perform the enhancing and/or
augmenting of the stability characteristics of the airplane. Therefore in this context it is very important to choose the dynamic that will satisfy the performance and robustness specifications.

**Key Words:** Air Traffic Control, control design, robustness, simulation capabilities

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**Dynamic Performances of the Automatic Flight Control System**

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**Abstract:** In this paper is explained why the combination of programming codes represents a true engineering tool in aircraft systems investigating. Flight safety and flying quality are extremely important to modern aviation industry. The aircraft responses, which are measured during real flight, are compared to the responses that are obtained from the simulations conducted. Typically aircraft problems consist in finding the solutions for basic work in all kind of areas, using knowledge from fields of science such as physics, mathematics and computer science. The purpose is to present such problems solved by computer simulations. Some of the advantages of performing numerical simulations are the low risk and low cost involved as compared to performing aircraft experiments. Another major advantage is the physical insight which one can gain in the behavior of the system subjected to different conditions and different values of the characteristic parameters of the aircraft’s dynamic performances.

**Key Words:** Automatic Flight Control System, computer simulations, dynamic performances

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**A Review of Basic Aspects related to Integration of the Equations of Motion. Part 2: Airplane’s Lateral - Directional Channel**

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**Abstract:** Numerical integration of the airplane’s equations of motion has long been considered among the most fundamental calculations in airplane’s analysis. Numerical algorithms have been implemented and experimentally validated. However, the need for superior speed and accuracy is still very actual, as, nowadays, various optimization algorithms rely heavily on data generated from the integration of the equations of motion. This paper presents a review of basic aspects related to the integration of airplane’s equation of motion. The discussion covers fundamentals of lateral-directional motion and lateral-directional channel stability as well as the implementation of various numerical integration methods to the lateral-directional movement. The relation between numerical integration steps, accuracy, computational resource usage, numerical stability and their relation with the parameters describing the dynamic response of the airplane is considered and suggestions are presented for a faster yet accurate numerical integration.

**Key Words:** numerical integration methods, optimization algorithms, dynamic response
End to end process of hollow spacecraft structures with high frequency and low mass obtained with in-house structural optimization tool and additive manufacturing

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Abstract: In the space sector the most decisive elements are: mass reduction, cost saving and minimum lead time; here structural optimization and additive layer manufacturing (ALM) fit best. The design must be driven by stiffness, because an important requirement for spacecraft (S/C) structures is to reduce the dynamic coupling between the S/C and the launch vehicle. The objective is to create an end to end process, from the input given by the customer to the manufacturing of an aluminum part as light as possible but at the same time considerably stiffer while taking the full advantage of the design flexibility given by ALM. To design and optimize the parts, a specialized in-house tool was used, guaranteeing a load-sufficient material distribution. Using topological optimization, the iterations between the design and the stress departments were diminished, thus greatly reducing the lead time. In order to improve and lighten the obtained structure a design with internal cavities and hollow beams was considered. This implied developing of a procedure for powder evacuation through iterations with the manufacturer while optimizing the design for ALM. The resulted part can be then manufactured via ALM with no need of further design adjustments. To achieve a high-quality part with maximum efficiency, it is essential to have a loop between the design team and the manufacturer. Topological optimization and ALM work hand in hand if used properly. The team achieved a more efficient structure using topology optimization and ALM, than using conventional design and manufacturing methods.

Key Words: end to end, in-house tool, structural optimization, topology optimization, 3D Printing, additive manufacturing, ALM, hollow, powder removal, metal powders, high frequency, low mass, space applications, mass reduction, cost saving, minimum lead time

Topology optimization of a payload adapter for a launcher

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Abstract: In the space industry a constant issue is the mass optimization of the launcher sub-systems and structure in order to increase efficiency and reduce costs. An important topic is mass reduction of a space vehicle using structural optimization in order to improve the stiffness and the shape of the structure. This paper addresses the problem of optimizing a payload adapter that connects the payload to the launcher. The
payload adapter will have to endure all the inertial forces during and after the launch. In order to reduce the mass of a payload adapter and to increase the load that can be sustained, a successful method to develop a design configuration is topological optimization. This method optimizes material distribution within a given design space, for a given set of loads, boundary conditions and constraints with the goal of maximizing the performance of the system. In order to achieve a design methodology for the future space structures a comparison will be made between the conventional and the optimized structure.

**Key Words:** structural optimization, topology optimization, payload adapter, low mass, space, launcher, mass reduction, space vehicles

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**Comparative study between random vibration and linear static analysis using Miles method for thruster brackets in space structures**

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**Abstract:** Random vibrations occur during the launch at the fastening interface between thruster brackets and basic support of satellite. These are generated in the launcher by the motion of some mechanical parts, combustion phenomena or structural elements excited by the acoustic environment. The goal of this comparative study is to find a simplified and efficient validation method using FEM PATRAN-NASTRAN software for thruster brackets in the random vibrations environment for space applications. The random vibration analysis requests complex preprocessing/postprocessing efforts and large hardware resources for various geometrical shapes. The PATRAN-NASTRAN random vibration analysis consists of frequency response analysis (111 solver) and acceleration spectral density (ASD) diagram, taking into account the natural frequencies of the bracket. The Miles method computes the root mean square acceleration ($a_{rms}$) using the natural frequencies and the ASD diagram as input. At these acceleration values is applied three sigma standard deviation, which means to multiply the $a_{rms}$ by a load factor of three. Simplified method consists of using linear static PATRAN-NASTRAN analysis (101 solver) where the $a_{rms}$ are introduced as loads. For validation of the simplified method, a comparative study was made between the random vibration and the linear static analysis. The final results are presented in detail in this article.

**Key Words:** Random vibrations, linear static analysis, 3 sigma standard deviation, acceleration spectral density (ASD), natural frequencies, von Mises stress

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**A V-stack piezoelectric actuator for active mitigation of flutter – design and laboratory tests**

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**Abstract:** The paper presents the design and the laboratory tests of the actuator developed within the UEFISCDI Project "ANTIFLUTTER DEMONSTRATOR WITH PIEZOELECTRIC ACTUATION" (AFDPA). The actuator is part of the AFDPA system – a wing model with aileron, related logistics and implemented control law. The AFDPA system will undergo tests in the subsonic wind tunnel to demonstrate that the speed
of flutter can be increased, in order to widen the flight envelope of an airplane project. In this way the main advantage of such a piezo actuator, the bandwidth, is exploited. The content of the paper refers in detail to technical solutions for amplification of the actuator output displacement, simultaneously with the optimization of useful force.

**Key Words:** Piezo actuator, flutter, control law

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**Spacecraft structures optimized for high frequency and low mass, fabricated using additive manufacturing techniques**

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**Abstract:** Reducing the cost through innovative designs, is presently the focus of very active research and development activities in the space sector. One way to achieve this is through mass reduction and shorter development time. Based on the focuses on small series production of complex parts, additive layer manufacturing (ALM) is a process which enables not only a new cycle of optimisation in terms of mass and performance but also a minimum lead time. By taking the advantage of producing almost arbitrary geometries that can be obtained using ALM, the aim of this paper is to design an aluminium part as light as possible while respecting the stiffness requirements. The optimization of the parts considered was made using specialised tools which lead to a significantly decreased number of design iterations. In order to reduce the mass furthermore while increasing the stiffness, it was considered a structure with internal cavities. Hollow structures may raise a problem of powder evacuation if the additive process is made using metallic powders. In order to avoid contamination problems of the spacecraft’s (S/C) components, it is necessary to develop closely with the manufacturer, a powder removal procedure. Using this approach it was obtained a lighter component with a lower production cost and fewer points of potential failure.

**Key Words:** structural optimization, topology optimization, 3D Printing, additive layer manufacturing, ALM, hollow, internal cavities, powder evacuation, metallic powders, high frequency, low mass, space applications, mass reduction, cost saving, minimum lead time

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**Numerical Simulation of Frangible Joint Systems used in Multi-Staged Rocket Separation**

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**Abstract:** Pyrotechnic devices are widely used in many space operations, common applications include: ignition, switching, releasing and cutting. The most common use is to initiate the flight separation sequence of subsystems, boosters, stages, fairings or satellite payloads. These devices generate a high shock environment that could have a destructive effect on the on-board hardware and structure, therefore it is necessary to have information on shock transmission and shock response. Another important aspect of the system is that it needs to be designed to confine all the explosive debris, this means the amount of explosive

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Computational Modeling of Spherical Natural Debris Impact and Penetration into Whipple Shield Targets

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Abstract: Impact and penetration problems are not limited to military, naval and civil application, incorporating a delicate area of expertise tied to Spacecraft (S/C) protection. Multiple physical phenomena are involved during penetration from fracture, failure, residual energy to friction heating. The constitutive models used for the simulation describe the response behavior of natural (meteoroid) and manufactured materials (Al2023) under different mechanical condition. A realistic base simulation, demands three axes constitutive models that describes the physical proprieties of a given material which delimits the predictive value of large scale simulations, involving thousands of degrees of freedom. Explicit transient finite element modeling of even the simplest of problems can result in widely varying results, depending on the material model and a number of different numerical parameters that must be specified in the numerical code. Numerical simulation has become a necessary tool for the study of these phenomena, since empirical and analytical approaches cannot capture all of these phenomena.

Key Words: Impact, Whipple shield, FEM, debris
Study on use of nature CUBE Sat in detecting radioactive incidents at nuclear power plant

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Abstract: I presented this work in a general form construction, programming, operation, use and applicability for civilian use of mini-satellites hereinafter called CUBE Sat. It is described in the paper: production, programming, launch, commissioning function which in this case was scheduled to oversee the creation of alerts in nature radioactive incidents that may occur at a nuclear power plant. In the chapter called CUBE Sat production, described in a general way of achieving physical form of the product, we have included in the carrying construction elements of its physical, electronic components, materials that can be used to achieve this mini satellite. In the chapter called CUBE Sat programming, I described how to input data to be transmitted, analyzed, receiving information, by personnel assigned to the ground for analysis of alarms that may occur. In Chapter mini satellite launching this I thought it needed a means by which it established to reach orbit. In Chapter commissioning and operation of CUBE Sat, we used information from the interpreting software monitoring and alarms on supervised area. In Chapter Conclusions we presented the advantages and disadvantages of using these types of mini-satellite hereinafter CUBE Sat.

Minisatellite Attitude Guidance using Inverse Dynamics Based on Quaternion Parametrization of Rotation

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Abstract: In previous work, based on the x-y-z sequence of rotations parameterization, an inverse dynamics simulation for minisatellite attitude guidance from one fixed attitude posture to another was performed, using either active torques punctually applied on the three axes of the satellite, or rotating reaction wheels. In this paper, a similar inverse dynamics method for minisatellite attitude guidance is implemented using the quaternion parameterization of a satellite rotation. The angular velocity vector of the rigid body, as well as the Euler’s equations of motion, are written this time in terms of the unit quaternion, instead of the x-y-z sequence of rotations parameterization.

For this quaternion parameterization, simulation results are obtained for a case study maneuver where a minisatellite is guided from one fixed attitude posture to another. No particular difficulties were encountered during the numerical integration using the Matlab ode45 solver based on Runge-Kutta schemes. The results are in good agreement with our previous results using the x-y-z sequence of rotations parameterization, as well as with the corresponding virtual experiment of this case study realized in SimMechanics.

The main advantages of the quaternion parameterization over the x-y-z sequence of rotations are: the singularities are generally avoided (quaternions present only the “spin” singularity, which never arises in smooth dynamics case studies such as our example); the “degree of nonlinearity” of the dynamics equations
Reducing the time to compute the buckling factor of an isogrid stiffened cylinder

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Abstract: Isogrid structures are configurations of stiffeners that form a regular lattice which are placed on thin plates with the aim to increase their buckling factor. Due to the isogrid’s high impact on the stability of thin structures and recent developments in the manufacturing procedures, their use in the aerospace industry has increased. In order to optimize the shape of the stiffeners, a large number of numerical simulations should be run. The problem arises when the structure to be analyzed is too large and therefore the time for execution of one stability analysis is too great. This paper is trying to solve that problem. The objective is to derive an analytical solution to axial buckling of stiffened cylinders. This is done by approximating the thin cylinder and the stiffeners as one shell with modified properties. The formula is derived from the classical theory of shell buckling. It is then implemented in a computer algebra system called Maxima, which outputs the resulting buckling factor as a function of various stiffener properties. Two types of stiffener configurations were considered: a classical square crossed by diagonals type of configuration and a dual isogrid type which is a triangle lattice with stiffeners along their medians.

Key Words: isogrid, numerical simulation, dual isogrid, aerospace, stiffener, shell, buckling factor, analytical, thin structure.

Mechanical guided waves for fuel level monitoring system

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Abstract: The mechanical guided waves have a wide range of applications for many types of equipment and devices. The monitoring of the fuel level is an important issue for any spacecraft or aircraft vehicle. For this purpose, the mechanical guided waves MGW can be used, since this method provides some major advantages in comparison with other methods. The method of mechanical guided waves MMGW is based on wide ultrasonic sensors; for most of the cases, the mechanical waves are traveling through fluid environment, such as air or fuel; for measuring the fluid level, the wave propagation through a single media at a time is, most commonly, used. The method described in this work is based on using the propagation of the mechanical guided waves through two different media, in the same time. The propagating media considered for this study will be: 1- the container wall and 2- the fuel. One of the most significant advantage of this method consists in the reduction of the measurement errors when the incident angle to the fuel level...
surface is different than 90 degree. These situations could occur when either the fuel tank is tilted or when the fuel surface is not flat; these conditions occur during almost of the aircraft/ spacecraft flight. The measurements obtained following this particular MGW method will prove not be affected by the perturbating conditions.

**Key Words:** mechanical guided waves, aircraft fuel level monitoring

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**Fuel level monitoring system using gas pressure variation monitoring**

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**Abstract:** Most of the fuel level monitoring systems is using sensors placed inside the liquid fuel tank. There are situations when this is not possible to be done due to different reasons. For such particular cases, other alternative methods, which are using sensors placed outside the fuel tank, will be necessary to be implemented. Such a method consists in monitoring the variations of the gas pressure from the tank when its volume is varied. This method could be a passive one when is monitored the gas pressure, being known the variations of the air volume or an active method, when it is produced a precise variation of the gas volume while its pressure is monitored. Both methods do not require the placing of any sensors inside the fuel tank, these sensors could be placed anywhere else, on the connected pipes to the fuel tank. The results of the measurement will not be affected by the orientation of the fuel tank related to the gravitation force direction or of its absence which happens often in case of aircrafts or other space vehicle. This feature represents one of the method’s most important advantages.

**Key Words:** aircraft fuel level monitoring, gas pressure monitoring
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