THE FOURTH AIAA-PEGASUS STUDENT CONFERENCE

First prize winner

OPTIMIZATION OF FLOWER CONSTELLATIONS: APPLICATIONS IN GLOBAL NAVIGATION SYSTEM AND SPACE INTERFEROMETRY

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This paper shows the optimization of the Flower Constellations for two possible applications. First, an application in Global Navigation System is proposed, improving the Global Navigation Flower Constellation through an optimization algorithm. This method is general and allows to find a wide variety of solutions. Better Geometric Dilution Of Precision values are obtained with 30 satellites comparing the results with the existing GPS, GLONASS and Galileo GPS. Then, an application in high resolution space interferometric imaging system to observe far stars with 5 satellites and a resolution of 800 km is presented. This paper underlines the relation between the coverage gained and the image number of pixels. In order to deal with the equations ruling the Flower Constellations both the optimization problems are studied with Genetic Algorithms..

Second prize winner

IMPLEMENTATION OF A HOVER, TRANSITION, AND LEVEL FLIGHT CONTROLLER FOR A SINGLE-PROPELLER INDOOR AIRPLANE

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Throughout the development of unmanned aerial vehicles (UAVs) efforts have mainly been focused on either range, speed, and duration capabilities, where fixed-wing UAVs have prevailed, or on maneuverability and hover capabilities, where rotary-wing UAVs have been the vehicle of choice. This paper presents the combination of these capabilities in an off-the-shelf available fixed-wing vehicle with the capability to autonomously take off, hover, transition to and from level-flight, and perch on a vertical landing platform. These maneuvers are all demonstrated in the highly space constrained environment of the Real-time indoor Autonomous Vehicle test Environment (RAVEN) at MIT. By complimenting fixed-wing UAVs with the capabilities generally limited to rotary-wing vehicles, the desirable speed and range performance of a fixed-wing aircraft in level flight can be complimented by hover capabilities that are typically limited to rotary-wing vehicles. The combination of fixed-wing and rotary-wing UAV capabilities renders transition capable UAVs ideal for missions in areas where spatial constraints are dominant. The ease of support and maintenance are clear benefits attributed to vehicles with these features, but the unprecedented advantage lies in the flexibility in application supported by the ability to be rapidly deployed and relocated to and from areas previously inaccessible to fixed-wing aerial vehicles.

Third prize winner

THE EFFECTS OF DENTS ON THE FATIGUE BEHAVIOUR OF DENTED STRUCTURES STIFFENED BY LASER BEAM WELDED STRINGERS AND THE DRESS OUT APPLICABILITY

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During the life of an aircraft, small damages (the dents) can occur on the surface of the fuselage. They can be due to in-flight impacts with hail storms and birds, or they can be due to ground impacts during handling and taxi manoeuvres. In this work, the effects of dents are investigated in the nearness of stringers welded by laser beam. Tests are run on dented coupons to verify the fatigue performances of damaged structures. Furthermore the reparability of dents with the dress out is checked with a test on a full scale test panel. Actually the dress out is already used as a repair method, so the test tries to extend the current limits of applicability. The results from the test have allowed an extension to the current dress out applicability, increasing the allowable dent depth.

ASTEROID 99942 APOPHIS MISSION OPTIMIZATION WITH PSO METHODOLOGIES

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In the last years great attention has been given to the asteroid 99942 Apophis: researches demonstrated the risk of an impact on Earth in 2036. Although the probability of the collision is low, it is very interesting to investigate missions towards this asteroid. This paper aims at studying low thrust trajectories, that permit approaching Apophis’ orbit with a direct method based on Particle Swarm Optimization. This methodology is applied to solve a problem of great complexity when compared to the usual PSO applications. Two different propulsion systems are investigated: solar sails and electric propulsion. In particular, trajectories with minimum transfer time for solar sails and with minimum propellant consumption for electric thrusters are sought. As a result, a minimum transfer time of about 350 days for a solar sail with a characteristic acceleration of 0.5 mm/s^2 and a propellant consumption of about 16% of the initial mass for the electric thruster.

LOAD FACTOR COMMAND LOOP FOR AN UAV USING DIRECT LIFT CONTROL

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In 2006 the student project *"IFSys"* was launched at the TU Berlin's *Institute of Aeronautics and Astronautics*. The objective of the project is to gain expertise and to provide students with a chance to combine theory and practical work within various fields of aeronautical engineering by developing an Unmanned Aerial System (UAS). Design objectives resulted in a propeller driven model airplane that is equipped with elevator, rudder, ailerons and trailing-edge flaps, which can directly influence the aircraft's lifting force. As part of the development process an automatic flight control system has been designed to lead the aircraft along a predefined flight route, enabling 4D navigation. With the concept of *Direct Lift Control* (DLC) the deficiencies of the conventional longitudinal control system without DLC, using the elevator to change angle of attack and hence control lift, can be eliminated and gust suppression can be improved. In this paper, the design of an inner control loop for the UAV's longitudinal motion, using two different strategies to incorporate DLC-flaps into the control system, is presented. A concept with the trailing-edge flaps as primary control element and a flap augmented elevator control concept are compared and examined regarding their feasibility for the UAV. Results show, that the flap augmented system is preferable, due to the not sufficient flap efficiency. This control concept allows precise control of aircraft longitudinal motion. Finally, the impact of time delays on control quality is examined.

CREATION OF AN AERODYNAMIC DATA SET FOR FLIGHT SIMULATION IN MATLAB ENVIRONMENT

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The project SimSAC is a FP6 program whose objective is the development of a software chain for aircraft conceptual design. The present project is focused on the validation of the SimSAC approach by means of the development of an Airbus A330 aerodynamic model. Already existing tools have been used to achieve this goal; stability and control characteristics are provided by DATCOM and the aerodynamic model has been assembled in J2 Universal Kit in order to perform trim and time response analysis. This model has been then linked to Simulink for real time flight simulations purposes. Aircraft performance data have been evaluated for several flight conditions, including high lift devices effects. All the predicted dynamical modes of the A330 have typical response times and high damped ratios that provide desirable control characteristics

STRUCTURAL DESIGN OF A SEAPLANE FLOAT MADE OF COMPOSITE MATERIAL

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Seaplanes have now a great potential market but their design and regulation are obsolete. There is the need of new floats in composite materials with the use of modern technologies. The preliminary design of a new float made of composite material is considered; the project is adapted on a medium size aircraft. Preliminary parameters of the float are evaluated (shape of the float, watertight compartments) to define the general arrangement of the float. Water loads at alighting on water are computed by Wagner Momentum Theory as worst loading condition. Multilayer composite is chosen. Preliminary aeronautical methods are used to analyse the proposed structure.

TIME-RESOLVED SIMULATION OF THE FLOW IN A 1.5-STAGE AXIAL LOW PRESSURE TURBINE WITH SHROUDED ROTOR BLADES

Florian C. T. Danner and Giovanni A. Brignole

Within the scope of this study the interaction between the shroud leakage and main flow of an axial turbine was investigated numerically and validated against existing experimental data. The simulations were carried out on a 1.5-stage experimental low pressure turbine at 500 rpm design speed applying time-resolved as well as steady-state 3D-FANS equations. The computational domain comprised $5.3 \cdot 10^6$ grid points including the entire geometry of the cavities. This research aims to identify the unsteadiness of three-dimensional flow phenomena ruling the flow field especially near casing and shroud as well as to quantify loss generating mechanisms. The comparison of the steady flow solution to the time-resolved computation discloses the intensity of flow fluctuations and surveys the necessity to regard unsteadiness during the design process. This provides the basis for further research to decrease secondary losses.

IMPLEMENTATION OF MAGNETIC BEARINGS FOR MINIATURISED ATTITUDE CONTROL WHEELS

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Conventional mechanical suspension of flywheels reaches its limits when considering high speed applications as well as longterm space missions. Therefore, alternative rotor suspension systems have to be investigated. An opportunity for high speed low noise suspension are magnetic bearings that provide levitation of the rotating component. This work focuses on the impact of a magnetic bearing on a momentum/reaction wheel system.

For that purpose different magnetic bearing concepts are compared and the required force characteristics are derived. Furthermore, a design procedure for magnetically levitated momentum/reaction wheels is introduced. The design procedure takes mass, volume and power requirements as well as the desired momentum capability into account. The developed models are used to design a reference flywheel system.

ANALYTICAL AND FEM MODELS OF STRUCTURES WITH CRACKS

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A new finite element model has been implemented to analyze the effects that the presence of a crack inside a plate structure has on the dynamic behavior of the plate itself. Various authors have faced the problem by using finite elements models. One of these approaches, developed by Krawczuk, has inspired the present work. It is a plate finite element, having four nodes and three degrees of freedom in each node and a transverse internal non-propagating open crack. Starting from this formulation, a new model has been implemented and the obtained results have been compared with those of Krawczuk and with those obtained by means of a FEM commercial code. The obtained results show that the accuracy of the finite element method has been increased. At last, an experimental analysis has been conducted, in order to verify the level of accuracy of the above-mentioned method.

H_∞ ROBUST CONTROL FOR ADAPTIVE OPTICS SYSTEM

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We apply robust control technics to an adaptive optics system including a dynamic model of the deformable mirror. The dynamic model of the mirror is a modification of the usual plate equation. We propose also a state-space approach to model the turbulent phase. A continuous time control of our model is suggested taking into account the frequential behavior of the turbulent phase. We suggested a multimodal control, thereby an $H\infty$ controller is designed in an infinite dimensional setting. A significant improvement is obtained due to the multivariable nature of the control problem involved in adaptive optics systems. This new approach concerns especially the ground-based telescopes

PREDICTION BEHAVIOR OF COMPOSITES BEFORE AND AFTER LOST OF STABILITY

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Response of structure on load can be described like deformation energy spent or work done. In case of loading the structure comes through series of states and goes along certain energy curve. But if it suddenly begins to go along other energy branch, it is named structure instability or buckling. One of large part in scope of stability tasks is buckling of shells or thin-walled structures, respectively.

NEAR OPTIMAL PLANNER FOR HIGHER ELEVATION LANDING

J.Boada, J. Benito and K. D. Mease

Mars Entry, Descent and Landing (EDL) technology development is moving towards the goal of increasing the capability of landing at higher elevation sites. In previous work, an entry guidance algorithm called EAGLE, for Evolved Acceleration Guidance Logic for Entry, was developed. A new entry trajectory planner based on optimal trajectories is presented. The new planner is compared to an existing planner by integrating them in EAGLE and simulating entries for a variety of off-nominal conditions.

ADVANCED MONITORING FUNCTIONS OF A-SMGCS

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The diploma thesis aims to improve safety and efficiency of aerodrome surface operations by means of A-SMGCS. The results of this diploma thesis could also contribute to the advanced runway safety nets based on A-SMGCS operations. It is concerning the A-SMGCS monitoring functions operations at two European airport sites: Prague Ruzyne Airport and Charles de Gaulle Airport. The first objective was to verify the monitoring functions operations at Prague Ruzyne Airport. And the other one related to Charles de Gaulle Airport was to propose the controlling aid for the aerodrome control tower controllers in terms of better situational awareness, conflict detection and possibility of clearance verification in connection with the electronic stripping.

DEVELOPMENT OF A MATHEMATICAL PILOT MODEL FOR HELICOPTER FLIGHT MECHANICS APPLICATIONS

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A mathematical pilot model for helicopter dynamics has been developed. It is implemented on the linearized model of a A109K2 machine in hovering condition, which has been obtained from a comprehensive A109K2 model developed with Flightlab. Through analytical simulation of some specific maneouvres and the frequency response analysis, the setting of the pilot parameters is executed to achieve the validation of the pilot model. Finally, relations between pilot gains, aircraft dynamic response and type of maneouvre performed are analyzed.

ON THE ACCURACY OF THE FRF ESTIMATORS FROM SINE-SWEEP DATA

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The modal identification of large aerospace structures like satellites, launcher components or aircraft prototypes, requires a great experimental effort in order to assure high quality test results. At the same time, because of the high development costs, a reduction of the test time is needed. In this paper, a test strategy capable to reduce the overall time required to perform dynamic tests is introduced. This approach uses a sine sweep signal as excitation of the test structure, to evaluate the frequency response functions (FRFs). The good compromise between the excitation level and the testing time is the key point of choosing the sine sweep excitation. Nevertheless, the accuracy of the identification results strongly depends on the non-parametric estimation method used to compute the FRFs from the sine-sweep input-output data. In this paper, the accuracy of the estimates of both the frequency response functions and the modal parameters due to different sweep rates and different FRF estimation methods will be analyzed. These methods include: harmonic estimator, straightforward Discrete Fourier Transform (DFT), frequency averaging technique, Welch’s method and Reduced Discrete Fourier Transform (RDFT). The performance of the different estimators is critically assessed using a numerical analysis on a lumped parameter system and experimental investigations carried out on both the GARTEUR scale model and the Lambert aircraft M212.

ON INSTABILITY AND ACTIVE CONTROL OF LAMINAR SEPARATION BUBBLES

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The instability characteristics of laminar separation bubbles are studied in the scope of the BiGlobal theory. This methodology studies the behavior of small, three-dimensional (two directions resolved simultaneously and the other taken as periodic) perturbations of a basic flow by numerical solutions of partial-derivative-based eigenvalue problems (EVP). The related adjoint problem studies the receptivity of the basic flow, through the solution of analogous EVP.
Flows of engineering significance, like that of the separation bubble, require resolutions for the recovery of the amplitude functions well beyond the capabilities of serial, in-core solutions of the BiGlobal EVP. A newly-developed parallel code was constructed and validated to eliminate this restriction. A model separation bubble was constructed and its linear instability and receptivity characteristics were analyzed, in a first step on the field of active flow control. The spatial regions in which the global modes feed-back is higher were identified, using the concept of structural sensitivity.

EXPERIMENTAL INVESTIGATION ON THE ACTIVITY OF VARIOUS CATALYSTS FOR HYDROGEN PEROXIDE DECOMPOSITION

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Catalytic decomposition of hydrogen peroxide is used for different purposes like propulsive applications (launcher and satellite) and gas generator (e.g. rescue systems). It is decomposed on catalytic beds which must present very good thermal and mechanical properties to resist frequent thermal shocks and high flow rates. Different catalyst configurations have been widely employed in the past (e.g. extrudates, pellets, screens and monoliths). Alta S.p.A., in the framework of an activity funded by the Italian Ministry for Production Activities linked with the development of hydrogen peroxide monopropellant thrusters using advanced catalytic beds, is conducting an extensive experimental campaign, in close collaboration with the Chemistry and Industrial Chemistry Department of the University of Pisa, with the purpose of characterizing and comparing the activity of catalysts for HP decomposition based on different active metals (Manganese Oxides, Palladium, Platinum, Ruthenium and Silver) and substrates (□-Al2O3, Si-doped Al2O3). All the presented catalysts have been obtained using different impregnation techniques according to the chemical nature of the support. Metal loadings on the ceramic substrates were determined by scanning electron microscope analysis (SEM). Activity test has been carried out using a self-designed test bench. Of the catalysts tested so far, preliminary results suggest that platinum supported on alumina offers the best performance respect to the other materials.

OPERATING LIMIT OF A PULSED DETONATION ENGINE. THE MARGINAL CASE OF DETONATION PROPAGATION

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The Pulsed Detonation Engine (PDE) represents a significant interest for new aviation propulsion systems. Although some manufacturers have already built demonstrators, PDE researches are still in progress. The marginal detonation propagation that could occur in a PDE chamber is studied here. H2 /O2/N2 mixtures were choosen as examples to show the operating limit of an aerobic PDE with a 52mm inner diameter chamber: detonation can occur up to an altitude of 17.5 km. Results can be transposed to other mixtures which, generally, exhibit wider cell size that may drastically decrease the operating flight level (the JP10 will probably not detonate in a 52mm tube beyond 5 km). Finally, a numerical approach shows that the marginal detonation regime can be simulated with a 3D cartesian code. Results agree reasonably well with experiments, although the detonation extinction cannot be yet simulated.