



Thesis abstracts

This section presents the abstract of most recent Master or PhD thesis related to aerospace technology and management

Study of internal boundary layer downwind of coastal cliffs with application to the Brazilian Launching Center of Alcântara

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Key-words: Internal boundary layer, Alcântara Launching Center, Wind tunnel, Immersed boundary, Coastal cliffs.

Abstract: The development of the Internal Boundary Layer (IBL) generated inside the Atmospheric Boundary Layer (ABL), due to a neutral wind incident at 90° on a coastal cliff, and caused by step changes of both the surface level and roughness. Observational data, numerical simulations and wind tunnel experiments were used. Numerically, two-dimensional DNS simulations with the immersed boundaries method for ocean-cliffs of diverse heights and geometric forms were effected. The code was validated with wind profiles observed on a 70-meter anemometric tower (AT) and punctual velocities measures on masts up to 15 m. With the code validated, simulations for various cliff heights and wind velocities, plus a case study for the 40 m ocean-cliff of the Alcântara Launching Center (2°19' S; 44°22' W) were carried out. The Reynolds number (Re) varied from 10² to 10⁷, and for the atmospheric cases it is greater than 10⁶. Also, experiments in a wind tunnel (WT) adapted to emulate the ABL over coastal-cliffs were made, limited to Re equal to 7.5 x 10⁴. These emulations were numerically well simulated, concerning the height of the IBL, and the occurrence of a re-circulation bubble (RB) near the edge of the cliff, as visualized with the Particle Imaging Velocimetry (PIV) technique. The experiments, including a model of the Mobile Integration Tower (TMI) at 150 m from the edge mentioned, showed another RB at the top of the TMI plus a less intense one upwind, which affected the flow starting at 125 m from the edge. In addition, experiments were carried out in the WT with wind incidences of 55° e 45°, which showed the 3D

nature of the flow, with results similar, but less severe, to those due to the 90° incidence. Thus, this demonstrates that the 2D simulations with the numeric code actually constitute the most extreme case concerning the wind incidence on ocean-cliffs. So, the results of this study are of great value to determine extreme scenarios caused by winds downwind of ocean-cliffs. Finally, this is the first numerical study of the mechanical IBL generated by a topographic step change which combines WT experiments and micrometeorological observations, and also presents empirical expressions for the results.

Barriers and facilitators in the technology transfer to the space sector: case study of partnership programs of the Brazil (AEB) and USA (NASA) space agencies

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Keywords: Technology transfer, Technology innovation, Partnership programs, Space agencies.

Abstract: The level of requirement of the society in order to satisfy its needs has been increasing progressively, as well as the technology complexity of goods and services offered. In order to follow this evolution, the technology innovation process needs to achieve a certain level of efficiency and effectiveness that be able to articulate all players of the innovation process in the network cooperation, in other words, there is no place for solitary organizational work. Partnerships are required to produce new products and processes to achieve its goals and promote a better quality of life. The space sector has an important role, such as the earth climate monitoring and preventive medicine equipments that were developed

from technologies used for space applications. Therefore, similarly to other countries, Brazil has transferred technologies to its space sector through partnership programs, though sometimes without success. The assumption of this study was “the effectiveness of technology transfer in the partnership programs can be achieved by overcoming the barriers in the process through specific facilitators”, and it was based on the international experience of space programs and literature review. The aim of this dissertation was to identify critical factors between players in the technology transference process on the Brazilian space sector. The methodology used was based on case studies of five partnership projects and involved three universities and four R&D institutes in the Brazilian partnership program called *Uniespaço*, which is coordinated by the Brazilian Space Agency (AEB). The NASA’s innovative partnership program was also studied in order to know the organizational arrangement and the technology transfer facilitators between players in the US space sector system of innovation and production. The main results of this dissertation were two new conceptual models; the first was based on critical factors of TT between technology generators and users, such as technology maturity level, adaptation of new technology versus user’s technological culture, and the ability of absorbing technology and innovation; the second model was the result of the dynamics of partnership formation and the impact of social players involved in the TT process.

Development of SiC piezoresistive sensors aiming aerospace system applications

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Keywords: Silicon carbide, Piezoresistive sensors, Microfabrication, MEMS (Micro Electro Mechanical Systems)

Abstract: This thesis evaluates the potential of silicon carbide (SiC) films produced by two techniques enhanced

by plasma, PECVD (plasma enhanced chemical vapor deposition) eRF magnetron sputtering, for the development of piezoresistive sensors. The developed works covered all steps of synthesis and characterization of the films as well as the study processing steps for making resistors and pressure sensors. PECVD technique was used to produce a set of five samples of SiC films using a SiH₄, CH₄ and Ar gas mixture under different SiH₄ flow. In situ doping of the film was performed by the introduction of nitrogen gas during the deposition process. A set of six samples was produced by RF magnetron sputtering of a stoichiometric SiC (99.5% purity) in Ar and N₂ atmosphere. During the depositions, only the nitrogen flow was varied. SiC films obtained by two techniques were submitted to thermal annealing under argon atmosphere at 1000°C for 1h. Chemical, structural, morphological, electrical, mechanical and optical properties of the SiC films, before and after thermal annealing, were investigated by Rutherford backscattering spectrometry (RBS), Raman spectroscopy, Fourier transform infrared spectroscopy (FTIR), x-ray diffraction (XRD), atomic force microscopy (AFM), four points probe, nanoindentation and transmission/reflection measurements in order to determine the films with suitable characteristics for the development of sensors. The etching process by RIE (reactive ion etching) plasma of the films using a SF₆ and O₂ gas mixtures to produce the structures of the sensors was studied. In order to study the piezoresistive properties of the films deposited, SiC resistors with Ti/Au electrical contacts were fabricated. An experimental setup was mounted to determine the electrical resistance changes as a function of applied mechanical stress. One SiC resistor was glued near the clamped end of a steel beam and on free end were applied different forces. The electrical resistance of the SiC resistor was measured for each force applied on the beam. This experiment allowed to determine the piezoresistive coefficient and gauge factor of the films deposited. The influence of temperature on the electrical resistance of the resistors was evaluated for temperatures up to 250°C. Finally, a methodology for the design, fabrication and packaging of a prototype of piezoresistive pressure sensor based on SiC film is showed. The developed prototype was tested and presented an average sensitivity of 2.7 mV/psi.

Proposed model to simulate faults in the electrical network service used by sounding rockets

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Key-words: Airborne systems, Electrical networks, Sounding rockets.

Abstract: This work presents the proposals for computational models to represent the main grounding schemes and equipment used in the electrical network service used by sounding rockets with the goal of enabling the operational verification and technical viability in the context of electrical power distribution. In these models, the conditions of nominal operation and in fault are simulated, and the latter is carried out at strategic points in the electrical network with the purpose of determining maximum power achieved by the system under these conditions. The current values obtained in these simulations are mainly used as a guide in choosing the distribution of power best suited to be used by the electrical network service and the determination of electrical characteristic requirements that the equipment should possess in order to meet the nominal conditions and support the possible faults that can affect the system. The satisfactory results obtained in the simulations of the computer models designed to represent the grounding schemes and equipment belonging to the electrical network service used by sounding rockets presented in this paper indicate that the models are consistent with and appropriate to the intended purposes.

Operational analysis of the solid propellant mixer system by Petri nets

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Keywords: Mixer system, Solid propellant, Petri nets.

Abstract: In the current process of composite solid propellant manufactory used in rockets like VLS, developed by the Aeronautics and Space Institute, two systems are dedicated to mix and homogenize the raw material present

in the propellant. These systems are called Macerador I and Macerador II. With the objective of modernizing the process, we chose to automate the operation of Macerador II. In this context, this work presents the use of Petri's Net, to represent the current architecture of automation used in the operation and control of Macerador II. These models are tested in various sequences of simulations to discover if this model works according to original process of manufacture. In these simulations, the properties of Petri nets related to conservation, vivacity and conflicts of "confusion" and "death" are evaluated. The results of these evaluations show that the proposed models are able to represent the main states achieved by the equipments used to mix and homogenize, and accordingly changes are suggested to prioritize safety and efficiency in the use of this architecture.

Petri nets applied to algorithm analysis for self-test of spatial vehicles integration tower

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Keywords: Self-test, Integration tower for spatial vehicles, Petri nets.

Abstract: The Satellite Launcher Vehicle (VLS) designed in Brazil needs to be integrated in a special pad named Launch Pad. The structure of this pad has much equipment such as Rolling Bridge, Elevator, Platforms, Sliding Doors, Trucks and other to support the tasks of integration, tests and launch. The procedures of these tasks expose people to danger (risks) inherent to aerospace sector, building a situation where it is strategic to ensure security by the test of each equipment before it is use by the control system. This work presents the algorithm and the model to represent a proposal of a system that runs the Built-in Self Test (BIST) in actuator and sensors of each piece of equipment of the launch pad by Petri Nets. Computational simulations are done on this model to test properties of Petri nets like conservation, liveness and conflicts. The positive results obtained by these simulations ensure

that the proposed algorithm will be capable of detecting failures during the execution of the BIST on the equipment of the Launch Pad.

Development of a pressure sensitive paint technique to measure surface pressure in aerodynamic models

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Keywords: Pressure sensitive paint, aerodynamics, impingement jet, flat plate.

Abstract: An optical technique of pressure measurements known as Pressure Sensitive Paint appears in the 1980s to promote a directing breakthrough on surface pressure field measurement. This technology, already developed on the main research centers, has proved to provide accurate results with high spatial resolution, which is the biggest advance in terms of conventional pressure tap measurements. Since its early studies, the PSP technique development has been continuous and progressive, part due to the improvements on the paint formulation but mostly because of the technology advances on equipment, such as CCD cameras and computers which enabled not only capturing a series of high precision images but also increasing the data-processing speed. The main objective of this work is to understand how the PSP technique performs applying it for experimental procedures development on FENG Laboratory and to add expertise to the pressure measurement techniques. The work is divided into two parts. The first one is focused on calibration procedures (a priori calibration) when the PSP system is evaluated specially in the view of the paint behavior. During this phase, some limitations on the experimental apparatus were noticed such as the low full well capacity by the CCD camera which interferes directly in the final uncertainty measurement, producing an error of at least 0,74% on the measurement of light intensity. The direct relation between the paint and the temperature which impacts the results of the pressure fields was also confirmed. The second and final phase is related to an experimental investigation of the oblique impingement jet applied to a flat plate and

compared to the conventional pressure tap measurements. The major variations of pressure were around 3000Pa to 5500Pa. The results were compared to the gross measures of the PSP system with absolute uncertainty of 1000Pa (25%). When the PSP system was smoothed by a median filter, which is very representative of the gross measurements, it presented a decrease of the measurement of uncertainty of the PSP system by around 400Pa (10%), reaching a minimum level of 225Pa (3%). The result is quite below when compared to the absolute uncertainties around 22Pa obtained for researchers abroad. The long path ahead was pointed out in order to obtain precise pressure measurements with the PSP system for low speed flows. However, the improvement demands investments mainly on the experimental apparatus, making it more sensitive and capable of measuring small variations in the luminescence intensities resulted from the small pressure variations near to the atmosphere pressure. The main result that can be applied immediately is the pressure maps provided by the high spatial resolution of the PSP technique. Despite the uncertainty figures presented in the measurement procedures, the pressure maps described efficiently the behavior of the air flow.

Characterization of the interlaminar fracture toughness of carbon/epoxy composite

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Keywords: Composites, Carbon fiber, Delamination, Interlaminar fracture toughness

Abstract: Composites are considered, for the aeronautical and aerospace industry, strategic materials since they allow reduction of structural weight of the aircraft or space vehicles keeping the performance in load bearing applications. It is essential, therefore, to obtain parameters that define the mechanical properties of the several types of composites that will be used by engineers in several application areas. The mechanical properties of structural composites are a function, among other factors, of the reinforcement and the matrix from which they are

manufactured. For laminar composites, the stacking of reinforcement fiber layers is such that the interlaminar region is the weakest in terms of mechanical properties for aerospace composites. This leads to the fact that the properties of polymer composites and the ones made with carbon or ceramic matrices have been characterized by a low interlaminar shear strength and, as a consequence, a low interlaminar fracture toughness. The present work uses the methodology described in the ASTM D 5528 standard to evaluate the interlaminar fracture toughness of carbon fiber/epoxy composite having different formulations for the epoxy matrix and different directions of crack propagation in relation to the main fiber axis.

Investigation of the mechanism of functioning of the Gas Dynamic Igniter (GDI)

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Keywords: Resonance tube, Gas dynamic igniter, Ignition systems, L15 Motor, Liquid propellant rocket engines, Propulsion.

Abstract: The main objective of this dissertation is to investigate the physical mechanism of operation of the gas dynamic igniter to enable a smooth start of the L15 engine and, also, to know the properties of the torch generated by the igniter, which will make possible to change operation parameters of the igniter to be used in other engines. A theoretical investigation of the heating mechanism of the gas injected into the resonator of the gas dynamic igniter, a mathematical model for this mechanism, including a routine of calculation and the comparison with test results will be presented in this paper. Experimentally, the resonance time and how to decrease it, the mixture ratio of the torch generated by the igniter, and how to reach a fuel-rich torch will be investigated.