THE FIRST AIAA-PEGASUS STUDENT CONFERENCE

The first AIAA-Pegasus student conference was held in Toulouse, at ENSICA, on May 19 and 20, 2005. The conference was fully supported by AIAA, and has been classified as the "AIAA Region-VII-EU" student conference.
The purpose of the conference has been to provide a forum for Pegasus Students (i.e., students enrolled for a degree programme of Pegasus institutions) and student members of the European Sections of AIAA to present technical papers in public competition for 1st, 2nd, and 3rd place prizes in the graduate (masters candidates only) categories. The fundamental objective of the conference was to provide students with an educational experience that would prepare them for their future as practicing aerospace engineers. Students attended and presented technical work as they would have done at a professional meeting. In addition, they established professional relationships, learned from others, and improved their communication skills. Their work, both written and oral, was evaluated by professional members serving as judges, with the primary intent of providing substantial feedback on the quality of their work. The highest scoring papers have also been recognized with awards and prize money, supplied by the sponsoring industries.
18 papers have been submitted, from 23 students, from 10 Pegasus institutions in 6 countries (Pegasus has 23 institutions in 9 countries). Of these papers, only 17 papers have been presented in Toulouse, one student did not attend. All papers have received 4 evaluations, 2 based on the technical report content and 2 based on the oral presentation. All papers have been evaluated by judges of institutions different from the University of origin of the student. Overall, 34 persons have been involved in the judging committee.
Students' presentations have been organised in two parallel sessions, allowing each paper a 20 minutes presentation followed by 10 minutes of questions and answers.
The winners of the competition have been:
1) First prize Pegasus/AIAA, and special EADS prize for the best papers in "Space technology", to Alessandro Bursi and Marco Di Perna from Politecnico di Milano, Italy;
2) Second prize Pegasus/AIAA, and special Airbus prize for the best papers in "Aircraft technology", to Marianne Jacobsen from KTH Stockholm, Sweden;
3) Third prize Pegasus/AIAA, and special Snecma prize for the best papers in "Propulsion technology", to Tiziano Ghisu from Politecnico di Torino, Italy.
The first prize winners will participate in the "AIAA Aerospace Sciences Meeting & Exhibition" in Reno, USA, in January 2006, and their paper will compete in the "AIAA National Student Conference", and will be published in the Conference Proceedings.
Financial support for the prizes has been provided by AIAA, Airbus, EADS and Snecma, while the organization has been supported by all Pegasus institutions, AIAA, Airbus, EADS and Snecma.
All abstracts of the papers received are printed hereafter.

First prize winner

CONTROL OF A LEGGED ROBOT FOR PLANETARY EXPLORATION USING DYNAMIC RECURRENT ARTIFICIAL NEURAL NETWORKS AND EVOLUTIVE ALGORITHMS

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In this paper a study about an unconventional control system for a legged robot for planetary exploration will be presented. The aim of the shown project is to overcome disadvantages of the current wheeled exploration vehicles, providing a more adaptable system concerning both the mechanics and the control. Inspired by biology a six legged robot has been developed and artificial dynamic neural networks have been used to obtain the rhythmic motion for walking. For the training phase, evolutive algorithms have been selected; this choice plus considerations about the dynamic systems theory and the ability in breaking the problem down in a modular way let these networks to be used in an easy way in spite of their complexity, higher than simple static neural networks. To check the feasibility of system, a numerical model of the robot has been developed and the ANN has been created and trained on this model. Good results have been obtained, in particular the walking of the robot with a tripod gait. Moreover, the control system shows an extremely high robustness versus uncertainties, errors on sensor readings, noise and in case of random alterations of the ANN internal parameters, i.e. degradation. In addiction, the extremely surprising ability of the CTRNN controller is its innate reactive behaviour facing unpredicted events. During its evolution, the robot was trained to walk on a perfectly flat terrain but during some simulation performed over a rough terrain, it exhibits the ability of overcoming a hill and a short valley, whose dimensions are comparable with the leg ones. This feature is related to the high robustness of the controller and demonstrates that very complex feed-back mechanisms that link

perceiving and actions are automatically implemented in the embodied agent by the evolutionary process of experiencing the external world. The excellent outcomes of the numerical simulations brought to the development of a hardware test platform for testing the neural control system in the real world.

Second prize winner

REAL-TIME DRAG MINIMIZATION OF AN ADAPTIVE WING

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This paper investigates the possibility to minimize drag using multiple control surfaces. The method does not depend on numerically calculated drag but instead the measured drag is minimized. The lack of a numerical function to minimize puts certain demands on the optimization algorithm. Drag is a very small Quantity and measuring drag is difficult because of noise in the measured signals. Hence, the optimization algorithm used here is a direct search method which does algorithm is tested on a wind tunnel model with 16 individual control surfaces. The tests are performed with different number of control surfaces and it is shown that the drag is substantially decreased. When the number of control surfaces used increases the method tends to be degraded and the largest drag reduction is obtained when dour different control surfaces are used. Furthermore, an investigation of the drag as a function of control surface deflections is performed. The wind tunnel model is used with two different spars, one flexible and one with higher stiffness. A comparison between the two spars is included.

Third prize winner

CFD ANALYSIS OF INLET FLOW DISTORTIONS ON AN AXIAL FAN

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The usual approach to compressor design considers uniform inlet flow characteristics. Especially in aircraft applications, the inlet flow is quite often non uniform, and this can result in severe performance degradation. The magnitude of this phenomenon is amplified in military engines due to the complexity of inlet duct configurations and the extreme flight conditions. CFD simulation is an innovative and powerful tool for studying inlet distortions and can bring this inside the very early phases of the design process.
This project attempts to study the effects of inlet flow distortions in an axial flow compressor trying to minimize the use of computer resources and computational time. The first stage of a low bypass ratio compressor has been analyzed and its clean and distorted performance compared outlining the principal changes due to uneven flow distribution: drop in mass flow, increase in pressure and temperature ratios, decrease in surge margin. The attention has then been focused on the effect of the level of the distortion on the stage characteristics.

A FRAMEWORK FOR MULTI AGENT PLANNING AND SCHEDULING IN A SPACE SYSTEMS FLOTILLA

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Milano - Italy

This paper presents a multi-agent distributed architecture for planning and scheduling of tasks in a space system formation. In a multi-agent architecture each physical unit is an independent unit, with an own knowledge base, an own will and operational skills. It works in a dynamic environment and it coordinates its own resource-activity scenario with the other units to accomplish both personal and shared activities needed to gain mission goals. Temporal, resource and coordination constraint nets are solved with a distributed approach. Such an approach asks for a negotiation paradigm to be defined, as well as an efficient communication protocol. Two negotiation strategies are presented, to emphasize either the team welfare or the single agent welfare respectively. The communication protocol is based on the innovation of the communication oriented graph concept. The communication channels are dynamically defined to minimize the traffic risen from the information exchange among agents. The proposed architecture has been applied to a three rovers scenario devoted to planetary exploration. A complete consistent scheduling profile is obtained in 500 seconds starting from a high level goal demand for the team. Simulations show the validity of the proposed approach to assure multiple and robust final allocations.

A VEGA-LAUNCHED MULTI-SPACECRAFT REMOTE SENSING MISSION WITH ELECTRIC PROPULSION

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The aim of this study is to evaluate the possibility to perform a multi-spacecraft remote sensing mission at low flight altitudes, in order to maximize the payload performance capabilities, and to maintain the satellite in it's nominal orbit by using only electric propulsion, instead than traditional chemical thrusters used up today; then to examine the convenience to perform the mission with a multisatellite constellation formed with just three interchangeable satellites instead than more numerous several-satellite constellations currently used. Finally to apply the results of the precedent analyses, in order to provide a preliminary design of the platform able to perform this mission in an optimal way. After the design process all the aims of this study have been acquired. Following data obtained with a preliminary analysis, taking all the inaccuracies included in the processes into account, we can state that it's possible to use state-of-the-art HET thrusters to keep a 400 kilos satellite with elongate shape into a VLEO orbit at about 300 km of altitude. At this altitude data taken from the space are very accurate and the PLs are compact in mass and power consumption. Coverage is full on the target assumed. Last fact, with this kind of satellite it's possible to put into three, 120 degree RAAN shifted, orbits three equal satellites with just one Vega launch, improving coverage capabilities and lowering costs.

CONCEPTION OF A GENERIC AUTOPILOT OF AN UAV FAMILY

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The development of Unmanned aerial vehicles (UAVs) requires the conception of efficient autopilots. The objective is to develop an autonomous reconnaissance device able to bring back pictures or video of a defined area, with good flight capacities in terms of performance and stability. The present article describes the development of a generic autopilot for small unmanned reconnaissance aircrafts. This study will first present the theoretical definition of the studied system with the definitions objectives to reach. The conception of the generic autopilot will be then describe (on the basis of a modal control for longitudinal law and a LQ control for lateral law) which will be validate by the Flight test campaigns whose protocols will be define.

CONCEPTION OF AN UAV GENERIC MISSION SYSTEM

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An UAV is a flying vehicle equipped with an onboard mission system which grants it full autonomy by operating guidance, navigation and control tasks. The process involves three steps: guidance equipment and software first compute the aircraft trajectory required to satisfy the mission objectives, navigation then tracks the vehicle's actual position and attitude, and flight control then transports the aircraft along the required flight path in order to accomplish the mission. Functions of the mission system also include communication with the operator and the ground station before, during and after flight. Theses communications consist in receiving commands from the operator or sending back status information and mission data. Supaero is currently handling in parallel various UAV projects of different concepts (helicopter, aircraft, unidentified...) but whatever the flying platform is, the requirements in terms of mission system remain similar; only the specific command laws have to be changed from one vehicle to another. The aim of this study is to define and present the development of such a generic mission system.

DESIGN OF A FLAT PLATE FACILITY FOR THE STUDY OF TRANSITIONAL BOUNDARY LAYERS

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The design process of a flat plate facility is presented. This facility is used for the study of the behaviour of the boundary layers developing under pressure gradients similar to those found in modern low pressure turbine blades. The facility is an open circuit blow-down wind tunnel that consists of a test section, a contraction, a settling chamber, a diffuser, and a fan. The Reynolds number based on exit conditions can be varied at the test section between $8 \cdot 10^4$ and $3 \cdot 10^5$. The turbulence intensity at the inlet of the test section is lower than 0.5%. CFD simulations have been performed to define the dimensions of the facility. A variable geometry wall is used to simulate the required static pressure distribution at the flat plate. A moving bar wake generator is included to simulate the wake-boundary layer interaction. A contraction and a series of honeycombs and screens are used to get uniform flow conditions at the inlet of the test section.

DRAG FORCE ON OSCILLATING CYLINDERS

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This paper describes wind tunnel measurements on an oscillating and a stationary cylinder. The aim was to find out if there is any difference in wake structure behind a cylinder and if there is any difference in drag acting on a cylinder when it is oscillating compared to when it is stationary. The angle of separation was measured with Particle Image Velocimetry, and the drag was measured using a balance. The results from the drag experiments were analysed in terms of drag coefficients and oscillating frequencies. These results show an increase in drag for an oscillating cylinder. The PIV images show an increase in separation angle as the wind velocity increases for both stationary and oscillating cases.

HEAT FLUX MESUREMENTS IN VKI HIGH ENTHALPYPLASMATRON FACILITY

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During the re-entry phase in the mission of a space vehicle, a large amount of the kinetic energy of the hypersonic flow is transformed into thermal energy through a bow shock wave. The high temperature reached in the zone between the shock and the body nose promotes the dissociation and the ionization of the molecules of the gas, which becomes partially ionized plasma. Under these conditions, a chemical reacting boundary layer wets the body. In a chemical reacting flow, the surface material could catalyze the recombining reaction of the species striking the wall, so they release their heat of reaction that adds to the heat transfer. For this reason the analysis of the catalycity of the TPS (Thermal Protection System) materials becomes necessary. This study deals with an analysis of the heat flux measurements performed in the high enthalpy "Plasmatron" facility available at the Von Karman Institute. The Plasmatron was designed and built in the end of nineties and it is a 1.2 MW induction-coupled plasma (ICP) facility. A calorimeter model has been developed starting from previous studies, and tested with two specific test campaigns. In particular, a large investigation has been carried out on the heat transfer coefficient. Measuring the calorimeter copper wall temperature, it has been possible to evaluate either the heat transfer coefficient or the possible nucleation phenomenon that can occur during the experiments. Nucleation phenomenon takes part on the energy transfer, and this could affect the measurement. Heat losses were also evaluated. The measurements had to be done with an improved Data Acquisition System to accurately catch transient phenomena. The final model is used for a sensibility analysis on the physical parameters, which allowed as well to study the operation of calorimeter. The experimental measurements are presented for comparison with the computed results. In conclusion, general remarks can be drawn concerning probe design and the relevant parameters for the heat flux measurement in high enthalpy flow.

IMPROVEMENT OF THE PLASMA-WALL INTERACTION MODEL ON A HYBRID FLUID/PIC SIMULATION OF A HALL THRUSTER

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HPHall is a quasineutral code and cannot solve the Debye sheaths at the walls of the discharge chamber. Bohm-type transition conditions, instead of wall conditions, must be implemented at boundaries of the computational domain. It was realized that HPHall does not fulfill these conditions even when fine meshes are used. The cause is found to be on the high sensitivity of the solution to the value of the ion density at the boundary nodes. The HPHall weighting method overestimates that density. Two methods to correct that weighting are proposed and validated.

INVESTIGATING MHD EFFECTS IN INDUCTIVELY HEATED PLASMA SOURCES

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Magnetohydrodynamic (MHD) effects of an inductively heated plasma source (IPG) at the Institut für Raumfahrtsysteme (IRS) have been investigated theoretically and experimentally. A one-dimensional model

of a cylindrical discharge has been solved analytically. The results have been used to get appropriate terms for magnetic pressure and Lorentz force directly. Accomplished measurements of coil current provided information which was used to quantify the magnitude of magnetic influence of plasma flow by its self generated magnetic pressure and Lorentz force. Additional considerations showed that measuring the magnetic pressure within the plasma plume is feasible with a magnetic field probe only. Therefore, such a probe was drafted.

INVESTIGATION OF THE PREDICTIVE CAPABILITIES OF SELECTED RANS MODELS FOR COUPLED TURBULENT BOUNDARY LAYER–SHOCK INTERACTIONS

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In order to overcome the limitations of current space launch systems in terms of cost, reusability and safety, a growing number of organizations focuses on the development of a next generation space transport concept that is likely to incorporate at least one reusable, air breathing vehicle stage. These initiatives have lead to a rejuvenated interest in the basic and applied research of super- and hypersonic flight vehicles. One particularly challenging aspect that comes into play is the reliable numerical simulation of shock–boundary layer interactions that occur on such vehicles. For the widely used RANS modelling approach, no general statement about the applicability of members of this model family to these complex flows can be made. Thus, to determine their predictive capabilities, four typical turbulence models (the Baldwin-Lomax model, Standard k-ω, LLR k-ω and SST k-ω formulations) were selected and employed to simulate a series of flow fields strongly governed by spatially coupled shock-boundary layer interactions. Data available from experimental measurements of such flow fields conducted by the German Special Research Group SFB 259 “High Temperature Problems of Reusable Space Transportation Systems” at the University of Stuttgart were used as a benchmark to evaluate the strengths and weaknesses of each model. All simulations were performed with the DLR Finite-Volume FLOWer code on structured grids, solving the full Reynolds–Averaged Navier–Stokes equations. It was found that the flow field under consideration constitutes a limiting case for the applicability of the RANS approach and that the predictive quality of these simulations was predominantly driven by the choice of the turbulence model. Based on qualitative and quantitative comparison with the experimental data, Menter’s SST k-ω formulation was identified as the most suitable model for this type of flow problem, as it was the only one to capture the most important flow features correctly.

KITE FLIGHT SIMULATOR

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This paper presents a dynamic analysis of a single line kite. In order to investigate the performance of kites, a program has been done using MATLAB in such a way that a user can change the kite parameters or atmospheric conditions and study in real time the effects. The simulator allows to analyze the multiple equilibrium states, their stability, turbulence and gust response and kite launch.

LINEAR RESPONSE FUNCTION OF A CHANNEL TURBULENT FLOW

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The nonlinearity of the equations governing a turbulent channel flow allows - in principle - to control its dynamical behavior by means of microscopic perturbations. Recent studies have shown that the linear control theory can be a valuable tool for controlling the flow, provided that a linear model that fully describes a turbulent flow can be built. This article describes how a method that is a standard in signal processing has been used to numerically measure - for the first time - the linear response of a turbulent channel flow to external velocity perturbations. The possibility of measuring such response delivers a complete linear model of a turbulent flow, providing a powerful tool for turbulence study, and allowing to apply the linear control theory to turbulent flows in a much more effective way. In this work we use the Direct Numerical Simulation of turbulence to compute the average linear response of a turbulent plane channel flow to wall velocity perturbations.

ON PROMOTING DETONATION DIFFRACTION FROM CIRCULAR TUBE TO CONE BY OBSTACLES

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An experimental and numerical study was conducted to investigate detonation diffraction from circular tube to cone; particularly we focused on the effect of obstacles at the cone wall. A cone with a 70° diverging angle was attached to an end of a 7-m long and 52-mm i.d. tube. All experiences were carried out with stoichiometric acetylene/oxygen mixture at room temperature. We have used obstacles of three different kind which were placed at cone wall at a distance Δx = 25 and Δx = 50-mm along the axis from tube end. Experimental study shows that the obstacles can promote detonation transmission by reducing critical initial pressure and that some of obstacles, depending on their shape and position, are more efficient than others. Numerical study confirms experimental trends and in major cases reasonably agrees with measured critical pressures necessary for detonation transition. Numerical simulations help to understand effect of obstacle position, shape and size, and suggest new ideas to facilitate detonation transmission that is useful in such applications as Pulse Detonation Engines.

ORBITAL MAINTENANCE NEAR LIBRATION POINTS BY ELECTRIC PROPULSION: PRELIMINARY STUDY OF MISSION

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The existence of the libration points (the so called “Lagrange points”) in the restricted three body problem has been known since the half of the eighteenth century. The real importance of these special locations in the solar system became clear very soon in the Space Age. It was immediately evident that several missions can be accomplished only by the use of these points. The flight dynamics on some characteristic orbits around the libration points, known as Halo orbits, need a propulsion system for the orbital maintenance. So far only chemical thrusters have been used to this purpose. The electric propulsion has not been considered yet for these applications above all due to its low

technological knowledge. The main objective of the present work has been the implementation of a general method for studying space missions about the libration points, using electric thrusters for the orbit stabilization. As a consequence, the first goal was to demonstrate that the electric propulsion is feasible for the orbital maintenance in this kind of missions by both a dynamic and a system-engineering point of view.

TRADE-OFF BETWEEN PAYLOAD AND TRIP-TIME FOR EP INTERPLANETARY TRAJECTORIES

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An indirect optimization procedure has been applied to different classes of simplified Mars missions which use solar and nuclear electric propulsion. This procedure provides the optimal values of the propulsion system characteristics, i. e. thrust and specific impulse, while optimizing the trajectory. First, the payload fraction has been maximized; the trip time is assigned and the optimal trajectory is calculated. Then, the performance index takes a penalty related to the trip time into account. Results show that optimal solutions only exist in correspondence of an integer number of revolution around the Sun (or an integer number plus half revolution when Earth gravity assist is exploited). The specific mass of the power and propulsion system determines the required value of the specific impulse; the suggested values often appear quite large when compared to the present-technology levels.