PEGASUS STUDENT CONFERENCE 2023

Session 1A - paper n. 1 – time: 9:00 **(Classroom) Aula 5**

Session Chair: Giorgio Guglieri

Judges: Giorgio Guglieri, Scott Delbecq

Title of Paper: ADCS Design for a Sounding Rocket with Thrust Vectoring

Author(s): Pedro dos Santos

Institution: Instituto Superior Técnico, Portugal

Abstract
This paper addresses the development of an Attitude Determination and Control System (ADCS) for a sounding rocket using Thrust Vector Control (TVC). To design the ADCS, a non-linear six-degrees-of-freedom model for the rocket dynamics and kinematics is deduced and implemented in simulation environment. An optimal attitude controller is designed using the linear quadratic regulator (LQR) with an additional integral action, and relying on the derived linear, time-varying, state-space representation of the rocket. The controller is tested in the simulation environment, demonstrating satisfactory attitude tracking performance, and robustness to model uncertainties. A linear parameter estimator is implemented to provide real-time estimates on the aerodynamic forces and moments. These estimates are used by an adaptive controller that computes the gains in real-time after correcting the statespace model. Finally, a navigation system is designed, based on measurements available onboard, to provide accurate estimates on the rocket's state. The ADCS is the result of the integration of the attitude control and navigation systems, with the complete system being implemented and tested in simulation, and demonstrating satisfactory performance.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/dosSantos-IST_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1A - paper n. 2 – time: 9:25 **(Classroom) Aula 5**

Session Chair: Giorgio Guglieri

Judges: Fernando Lau, Scott Delbecq

Title of Paper: Application of Optimal Control Techniques to the Parafoil Flight of Space Rider

Author(s): Michele Lucrezia

Institution: Politecnico di Torino, Italy

Abstract
The Space Rider program falls within the framework of ESA activities for the design of affordable and sustainable reusable aerospace vehicles. Among the greatest challenges for this mission is the design of the Guidance, Navigation & Control (GNC) subsystem for the re-entry phase. The final stage of the latter consists of an autonomous flight under parafoil that must guarantee a smooth and precise landing. In order to ensure compliance with the requirements in terms of landing accuracy and ground speed constraints at touchdown, the GNC subsystem must be able to counterbalance the effect of the wind during the flight and guarantee an upwind landing. A key role in this regard is played by what is commonly referred to as the Terminal Guidance phase i.e., the final part of the descent under parafoil where the vehicle performs the final approach to the designated landing point. The study presented in this work has been developed at the AOCS/GNC department of SENER Aeroespacial and the objective is to design a complete solution for managing the Terminal Guidance phase of a Space Ridertype case. This includes a guidance algorithm based on a direct method to generate an optimal solution for the trajectory, a path-tracking procedure, and a guidance logic that allows for a correct implementation within the whole GNC software. The optimal terminal guidance algorithm has then been implemented within the six-degrees-of-freedom simulator developed by SENER Aeroespacial demonstrating an excellent functioning for the proposed problem.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Lucrezia-PoliTO_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1A - paper n. 3 – time: 9:50 **(Classroom) Aula 5**

Session Chair: Giorgio Guglieri

Judges: Fernando Lau, Scott Delbecq

Title of Paper: Towards Robust Stability Design for Rotorcraft-Pilot-Coupling: Pilot Modeling and Sensitivity Analysis

Author(s): Pierfilippo Mancini

Institution: Politecnico di Milano, Italy

Abstract

In this paper, the vertical dynamics of the aeroelastic rotorcraft-pilot system known as the vertical bounce phenomena, is investigated. This particular interaction is caused by the airframe vertical vibrations that are transmitted to the collective lever through the pilot upper-body and fed back in the rotorcraft aeromechanics, eventually leading to dangerous situations. The aim is to provide analytical pilot and helicopter models to perform a sensitivity analysis of the coupled system to several design parameters and flight conditions in order to better understand which parameter is mainly involved in the loss of stability. Different simplified pilot models are proposed, whose dynamic characteristics are based on a more complex multibody model response through which the pilot left arm dynamics is identified. The helicopter model involves the vertical rigid dynamics along with the rotor structural dynamics. The dynamic response of the coupled system is reported, involving the proposed analytical pilot models and compared with the experimental results. The influence of different inceptor parameters is investigated and design criteria are discussed. Additionally, the effects of the take-off maneuver on the system stability is analyzed, considering both the landing gear dynamics and the
change in pilot’s limb muscle impedance due to the central nervous system.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Mancini-PoliMI_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1A - paper n. 4 – time: 10:15 **(Classroom) Aula 5**

Session Chair: Giorgio Guglieri

Judges: Fernando Lau, Scott Delbecq

Title of Paper: Modeling, simulation, and control of a formation of multirotor aircraft for transportation of suspended loads

Author(s): Elia Costantini

Institution: Alma Mater Studiorum - Università di Bologna, Italy

Abstract
The work presented in this thesis aims to contribute to the innovation in the Urban Air Mobility and Delivery sector and represents a starting point for air logistics and its future scenarios. The dissertation focuses on modeling, simulation, and control of a formation of multirotor aircraft for cooperative load transportation, with particular attention to the stabilization of payload swing motion. Starting from the mathematical model of two identical multirotors, formation-flight-keeping and collisionavoidance algorithms are implemented to ensure the safety of the vehicles within the formation and that of the payload. Then, a mathematical model for the suspended load is implemented, as well as an active controller for its stabilization. The focus of this section is thus represented by the analysis of payload oscillatory motion, whose kinetic energy decay is investigated. Several test cases are presented to establish the most effective and safe strategy in light of future aerospace applications.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Costantini-UniBO_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1B - paper n. 1 – time: 9:00 **(Classroom) Aula 15**

Session Chair: Miguel Hermanns

Judges: Raffaello Mariani, Agnieszka Kwiek

Title of Paper: Method development for the use of Smoothed-Particle hydrodynamics simulations for vehicle soiling analysis

Author(s): Josep Plana Riu

Institution: Universitat Politècnica de Catalunya, Spain

Abstract
In a world in which the number of sensors that monitor the surroundings of vehicles is increasing notably, ensuring the functionality of these methods is key to reduce the safety concerns for future innovations such as autonomous vehicles. In this paper, a novel method for self-soiling simulations is presented, by making use of Smoothed-particle hydrodynamics (SPH) simulations of the whirl-up process of droplets for an isolated tire and applying the results to a multiphase (Lagrangian Particle Tracking + Fluid film model) simulation that aims to model the process of droplet detachment and soiling of the vehicle. The SPH results have thus been filtered and the particle mass flow has been analyzed so that an improvement on the classical rake of injectors method is also presented, before applying them to the CFD simulations, which correspond to a proof of concept for this novel method.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Plana-UPC_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1B - paper n. 2 – time: 9:25 **(Classroom) Aula 15**

Session Chair: Miguel Hermanns

Judges: Raffaello Mariani, Agnieszka Kwiek

Title of Paper: Machine Learning-based optimization and PIV analysis of the active control of a cylinder wake via synthetic jets

Author(s): Alessandro Scala

Institution: Università di Napoli "Federico II", Italy

Abstract

The aim of the present paper is the investigation of the Synthetic Jet (SJ) based control of a cylinder wake through Linear Genetic Programming (LGP) technique and the flow field via Particle Image Velocimetry (PIV) technique. Machine Learning is a branch of Artificial Intelligence aimed at extracting knowledge and experience from big volumes of data and it is the art of building models from data using optimization and regression algorithms. A SJ is an actuator used mainly for flow control and heat transfer performances. In this work, a loudspeaker attached to an hollow cylinder is used as SJ actuator device and the optimization procedure regards the input signal sent to the device. A gradient-enriched machine learning control, know as gMLC algorithm, is used as optimization tool. A preliminary phase of analysis of the ML algorithm, in which an optimal control law is found, is conducted. The latter allows to obtain a very complex control law which is able to give a percentage drag reduction of 7.6 % with respect to the natural case and this reduction is found to be better than the one obtained by a reference sinusoidal signal characterized by a fundamental frequency of 44 Hz. After the ML analysis, an investigation via Particle Image Velocimetry is performed with the aim of of obtaining a comparison between the natural case, i.e. the uncontrolled configuration, and two different controlled cases: the optimal waveshape obtained via gMLC algorithm and the previous-mentioned sinusoidal waveshape.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Scala-UniNA_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1B - paper n. 3 – time: 9:50 **(Classroom) Aula 15**

Session Chair: Miguel Hermanns

Judges: Raffaello Mariani, Agnieszka Kwiek

Title of Paper: Effects of mixing chamber length, feedback channel head loss and nozzle-to-plate distance on sweeping jets impingement heat transfer

Author(s): Cristina D'Angelo

Institution: Università di Napoli "Federico II", Italy

Abstract
The convective heat transfer performances of sweeping jets impinging on a heated thin foil are experimentally investigated. The analysis is performed by employing the Infrared Thermography technique coupled with the heated thin foil heat flux sensor. Two sweeping jet devices, characterized by different mixing chamber lengths, are employed and their heat transfer performances are evaluated for non-dimensional nozzleto-plate distances H/w ranging between 2 and 10. Furthermore, in order to analyse different head losses conditions, the geometry of the feedback channels of the device characterized by the longest mixing chamber length has been varied. In particular, the non-dimensional parameter g/w, which represents the dimensionless minimum passage area of the feedback channel, has been introduced; six different values of g/w have been taken into account (g/w = 1, 0.83, 0.67, 0.50, 0.33, and 0.17). Time-averaged and phase-averaged analyses have been carried out in order to characterize the heat transfer behaviour of the sweeping jet devices and highlight the influence of the nozzle-to-plate distance, of the mixing chamber length and of the feedback channel head loss on such behaviour. This work shows that an excessive reduction of the mixing chamber length causes the suppression of the jet oscillation and a consequent variation in the Nusselt number distribution; furthermore, the convective heat transfer interests a wider area of the target plate as the the nozzle-to-plate distance increases while the opposite trend is observed by increasing the head losses.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/DAngelo-UniNA_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1B - paper n. 4 – time: 10:15 **(Classroom) Aula 15**

Session Chair: Miguel Hermanns

Judges: Raffaello Mariani, Agnieszka Kwiek

Title of Paper: Flow Control for Turbines Using Rotating Cylinders

Author(s): Andrew Wilson

Institution: University of Glasgow, United Kingdom

Abstract
Counter-rotating cylinder pairs were simulated in two dimensions for selected rotational speeds and spacing ratios, for both rotational directions, in unsteady Reynolds Averaged Navier Stokes (RANS) simulations to determine the effect on the flow over a turbine located between and rearward of the cylinder pair. It was determined that there was good acceleration and deceleration of flow normal to the turbine, dependant on the direction of rotation, that appears to vary linearly for both rotational speed and the ratio of cylinder diameter to distance between cylinder centres. Flow at incidence was also investigated and the acceleration/deceleration does not follow a linear pattern with changes of angle of incidence. Preliminary three-dimensional simulations were conducted to confirm two-dimensional results and to determine the extent of the span that exhibits two-dimensional like flow. A net power gain was only found for low values of rotor velocity ratio.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Wilson-UniGla_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1C - paper n. 1 – time: 9:00 **(Classroom) Aula 17**

Session Chair: Rafael Vazquez

Judges: Paolo Tortora, Salvo Marcuccio

Title of Paper: Analysis of collision avoidance manoeuvres using aerodynamic drag for the Flying Laptop satellite

Author(s): Fabrizio Turco

Institution: University of Stuttgart, Germany

Abstract
Collision avoidance is a topic of growing importance for any satellite orbiting Earth. Especially those satellites without thrusting capabilities face the problem of not being able to perform impulsive collision avoidance manoeuvres. For satellites in Low Earth Orbits, though, perturbing accelerations due to aerodynamic drag may be used to influence their trajectories, thus offering a possibility to avoid collisions without consuming propellant. Here, this manoeuvring option is investigated for the satellite Flying Laptop of the University of Stuttgart, which orbits the Earth at ~ 600 km. In a first step, the satellite is aerodynamically analysed making use of the tool ADBSat. By employing an analytic equation from literature, in-track separation distances can then be derived following a variation of the ballistic coefficient through a change in attitude. A further examination of the achievable separation distances proves the feasibility of aerodynamic collision avoidance manoeuvres for the Flying Laptop for moderate and high solar and geomagnetic activity. The predicted separation distances are further compared to flight data, where the principle effect of the manoeuvre on the satellite trajectory becomes visible. The results suggest an applicability of collision avoidance manoeuvres for all satellites in comparable and especially in lower orbits than the Flying Laptop, which are able to vary their ballistic coefficient.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Turco-UniStuttgart_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1C - paper n. 2 – time: 9:25 **(Classroom) Aula 17**

Session Chair: Rafael Vazquez

Judges: Paolo Tortora, Salvo Marcuccio

Title of Paper: Life Cycle Assessment for Space Systems' Environmental Impact: Single Score and Considerations on Propellants

Author(s): Enrico Tormena

Institution: ISAE-SUPAERO, France

Abstract
The paper presents the work carried out by the author during a six month internship within the Clean Space Initiative of the European Space Agency (ESA). This internship was focused on tasks related to atmospheric impacts, environmental life cycle assessments, ecodesign practices and environmental regulations, which are the topics tackled within the ecodesign branch of the Clean Space Office. As a reference for the state of art, a tentative to include single score in space activities LCA has been tried by [6]. While, the main references for launchers' propellants impact can be found in [10] and [4] which focus more on the atmospheric flight phase. Finally, the most recent literature on the black carbon's effect can be found in [5] and [9].

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Tormena-ISAE_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1C - paper n. 3 – time: 9:50 **(Classroom) Aula 17**

Session Chair: Rafael Vazquez

Judges: Emmanuel Zenou, Salvo Marcuccio

Title of Paper: AstroDART: Astronomical Data Analysis and Recovery from Tracklets

Author(s): Joaquín González López-Cepero

Institution: Universidad de Sevilla, Spain

Abstract
AstroDART is a Python package that implements a pipeline for processing, analyzing, and managing files derived from sky surveys performed by land-based optical telescopes. The main goal is to develop a software capable of retrieving information about uncatalogued satellites' tracklets. In between its functionalities the following are included: Perform astrometic reduction using Astrometry.net, detect tracklets using contour tracing techniques with ASTRiDE Pythong Package, refine the detected tracklets and perform telescope calibration by comparing the observations of known objects with catalog data and obtaining the celestial coordinates of the object at the observation epoch. In addition, it produces the light curve and TDM files derived from the observations. The computation times are in the order of 15 seconds per image when no astrometic reduction is performed, increased to 50 seconds when the astrometic reduction and light curve analysis are included. The average residuals for both right ascension and declination are found to be lower than 9 arcsecs for all of the three test campaigns. These results are consistent with those obtained by similar approaches.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/LopezCepero-UniSevilla_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 1C - paper n. 4 – time: 10:15 **(Classroom) Aula 17**

Session Chair: Rafael Vazquez

Judges: Emmanuel Zenou, Salvo Marcuccio

Title of Paper: Solarcom: An object-oriented code for studying deep space communication networks

Author(s): Jordi Alcón Clemente

Institution: Universitat Politècnica de Catalunya, Spain

Abstract
Solarcom is an open-source Java software tool that calculates the data rate at which two nodes may communicate —considering the link availability— in a deep space communication network. Furthermore, when the communication may involve more than two nodes, this tool is also able to obtain the optimal communication route between the source and the destination. To do so, it implements a model, known as the Link Transfer Model, developed in a previous work. The calculation is based on radiofrequency communications and divided in three steps: first, every link is assessed for visibility, then, its data rate is calculated if the communication is feasible, and finally, a search for the optimal route in the network is performed. A former version of the code was developed to test the validity of the model. However, the need for a more flexible implementation emerged, which could provide an extensible interface for users to add custom communication logic and also ease the interaction with SPICE library routines and kernels. All without requiring modifications of the existing codebase. The current work focuses on the design and implementation of the final version of the code. The conceptual model and design of the proposed solution are discussed. Several design patterns are used to build the code. Multiple dispatch is employed to manage extensibility, and the use of metaprogramming techniques is proposed to implement a flexible data input mechanism. Finally, examples of simulations are provided to illustrate the capabilities of the code.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Alcon-UPC_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2A - paper n. 1 – time: 11:10 **(Classroom) Aula 5**

Session Chair: Francesco Franco

Judges: Fernando Lau, Bjoern Annighoefer

Title of Paper: Wind tunnel study of a VTOL-CP UAV and its V-tail for its longitudinal and directional aerodynamic characterisation. ProVANT EMERGENTIa Project

Author(s): Claudia Pérez Rus and Paula Callejo Hernando

Institution: Universidad de Sevilla, Spain

Abstract
This article presents the design, manufacturing and wind tunnel tests conducted on a 1:4 scaled Unmanned Aerial Vehicle (UAV) with Vertical Take Off and Landing (VTOL) capabilities and on its 1:2 scaled tail in V-configuration. A brief description of the models, identifying characteristic dimensions, along with the manufacturing process for the scaled models and the measurement equipment is done. Regarding the aircraft, results of the wind tunnel experiments are shown, which are conducted varying both angle of attack and sideslip angle for a wide rage of the angles, thus allowing the longitudinal and directional aerodynamic characterisation of the aircraft. The experiments on the V-tail are done varying the angle of attack and the ruddervator deflections, which allows to determine their effect on the longitudinal performance of the aircraft. Subsequent analysis, corrections considered, and validation for all the data obtained are presented. Finally, some conclusions and recommendations are drawn with the main objective of establishing a basis for future tests.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Callejo_Perez-UniSevilla_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2A - paper n. 2 – time: 11:35 **(Classroom) Aula 5**

Session Chair: Francesco Franco

Judges: Fernando Lau, Bjoern Annighoefer

Title of Paper: Computer vision algorithm for pilot assistance on approach/landing procedures

Author(s): Jesús Benito López Moreno

Institution: Euroavia / Universidad de Sevilla, Spain

Abstract
At present, in small-scale aviation, the approach and landing phases are performed visually. To facilitate the pilot's work in this phase, a system capable of detecting the PAPI and analysing the lighting configuration is being developed so that a message can be sent to the pilot with the necessary corrections for a successful, more efficient landing. The aim of this project is, thus, to study the feasibility of creating a system of camera and computer vision algorithms capable of displaying the necessary information that may assist the pilot.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/LopezMoreno-Euroavia_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2A - paper n. 3 – time: 12:00 **(Classroom) Aula 5**

Session Chair: Francesco Franco

Judges: Fernando Lau, Bjoern Annighoefer

Title of Paper: Augmented Reality for Airport Control Tower: Analysis and Implementation of Safety Net

Author(s): Stefano Braida

Institution: Alma Mater Studiorum - Università di Bologna, Italy

Abstract
With the development of new technologies, Air Traffic Control, switched from a purely visual control to the use of radar, sensors and so on. As the industry is switching to the so-called Industry 4.0, also in this frame it would be possible to implement some of the new tools that can facilitate the work of the Air Traffic Controllers, such as Virtual and Augmented Reality. This paper describes the Safety Nets (system of defence against hazardous situations) in use within the control tower and, by developing a working concept, implement them in a Head-Up view to be tested by Air Traffic Control Operators. The results, coming from the technical test in a validation platform, show that this concept is working, and it could be leading to a future implementation in a real environment.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Braida-UniBO_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2A - paper n. 4 – time: 12:25 **(Classroom) Aula 5**

Session Chair: Francesco Franco

Judges: Fernando Lau, Bjoern Annighoefer

Title of Paper: Analyzing the Policies of Deep Reinforcement Learning Models trained for Resolving Vertical Conflicts of Drones

Author(s): Dieudonne Groot

Institution: TU Delft, The Netherlands

Abstract
The number of unmanned aircraft operating in the airspace is expected to grow exponentially during the next decades. This will likely lead to traffic densities that are higher than those currently observed in civil and general aviation, and might require both a different airspace structure compared to conventional aviation, as well as different conflict resolution methods. One of the main disadvantages of analytical conflict resolution methods, in high-traffic density scenarios, is that they can cause instabilities of the airspace due to a domino effect of secondary conflicts. Therefore, many studies have also investigated other methods of conflict resolution, such as Deep Reinforcement Learning, which have shown positive results, but tend to be hard to explain due to their black-box nature. This paper investigates if it is possible to explain the behaviour of a Soft ActorCritic model, trained for resolving vertical conflicts in a layered urban airspace, by interpreting the policy through a heat map of the selected actions. It was found that the model actively changes its policy depending on the degrees of freedom and has a tendency to adopt preventive behaviour on top of conflict resolution. This behaviour can be directly linked to a decrease in secondary conflicts when compared to analytical methods and can potentially be incorporated into these methods to improve them while maintaining explainability

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Groot-TUDelft_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2B - paper n. 1 – time: 11:10 **(Classroom) Aula 15**

Session Chair: Daniel Hanus

Judges: Tomasz Goetzendorf-Grabowski, Dario Pastrone

Title of Paper: Direct Numerical Simulation of a supersonic flow over a micro-ramp

Author(s): Matteo Blandino

Institution: Sapienza Università di Roma, Italy

Abstract
Shock-wave/Boundary Layer Interactions (SBLI) represent a major problem in many aerospace applications, such as supersonic engine intakes or wings in transonic regimes. This interaction leads to a separation in the boundary layer caused by the high-pressure gradient across the shock and flow unsteadiness. Flow control devices denominated as micro-Vortex Generators have been studied in the last fifty years. The wake behind a micro-ramp immersed in a supersonic turbulent boundary layer is investigated by means of Direct Numerical Simulations (DNS). Numerous experimental studies have been carried out to investigate the effects of the design variables on the wake properties. Building upon this knowledge, this work aims to explore to a great extent the effects behind the dimensionless number which characterize the flow, the friction Reynolds number. Experimental results will be used to obtain a comparison with the new numerical database. The vortical structures which originate in the micro-ramp wake will be analysed, as well as their effect on the overall control mechanism.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Blandino-UniRoma_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2B - paper n. 2 – time: 11:35 **(Classroom) Aula 15**

Session Chair: Daniel Hanus

Judges: Tomasz Goetzendorf-Grabowski, Dario Pastrone

Title of Paper: Flow Control on the Green Raven UAV Using Aerodynamically Shaped Vortex Generators

Author(s): Carlos Neves

Institution: KTH Stockholm, Sweden

Abstract

The purpose of this work is to design an aerodynamically shaped vortex generator setup to delay flow separation on a swept wing with dihedral of an unmanned aerial vehicle being designed. Therefore, a 2.5D CFD study of the wing was performed using the Spalart-Allmaras turbulence model. The optimization of the vortex generator setup followed a multipoint Pareto strategy to establish an optimum design of the vortex generator vanes including its airfoil cross-section. The resulting vortex generator setup achieved a respective improvement of the maximum lift coefficient and stall angle of attack with respect to the baseline wing of 26.34% and 3 deg as a counter-rotating arrangement, and of 24.02% and 2 deg as a co-rotating setup. The optimization procedure showed that the optimum cant angle of the vanes, a geometric parameter not tested in the available literature, contributed to 2.45% of the overall improvement of the maximum lift coefficient. The optimization procedure also showed that the flow separation control performance of the vortex generators is sensitive to its airfoil cross-section, and among all the airfoils tested, the S1223 cross-section showed a superior performance. Finally, the optimum height-to-boundary layer thickness ratio obtained was 1.301 and a further numerical flow visualization demonstrated that the aerodynamically shaped vortex generators designed produced a vortex system similar to that of a delta wing with a primary vortex submerged in the boundary layer, with the difference of the influence of the wing's wall on the axial flow on the creation of an additional trailing edge recirculation that rolled-up into the vortex. As a consequence of the trailing edge recirculation into the vortex system, the penalty drag of the aerodynamically shaped vortex generators was not reduced compared to that of a conventional, flat-plate vortex generator. Nonetheless, the airfoil-shaped vanes produced higher maximum lift coefficients than the flat-plate vanes configurations.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Neves-KTH_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2B - paper n. 3 – time: 12:00 **(Classroom) Aula 15**

Session Chair: Daniel Hanus

Judges: Julien Sotton, Dario Pastrone

Title of Paper: Numerical Analysis of Solid Rocket Nozzle Performance with Two-Phase Flow Effects

Author(s): Alessio Sereno

Institution: Sapienza Università di Roma, Italy

Abstract
In this work, the features of two-phase flow in solid rocket motors propulsive nozzles are analyzed with computational fluid dynamics simulations. The multiphase model adopts an EulerianEulerian approach, with two-way coupling. The attention is focused on the prediction of the performance loss due to two-phase flow, which represents one of the most important contributions to the overall specific impulse loss in solid rocket motors. A broad parametric study is conducted to identify the key factors influencing the two-phase loss, such as alumina particles diameter, chamber pressure, nozzle geometry and size, finite rate crystallization kinetics of liquid alumina droplets. Simulations results and semi-empirical models are combined to formulate a prediction of the flight specific impulse of Zefiro 9A, upper stage of current Vega launchers. Good accuracy is achieved, with an error inferior to 1% with respect to flight data.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Sereno-UniRoma_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2B - paper n. 4 – time: 12:25 **(Classroom) Aula 15**

Session Chair: Daniel Hanus

Judges: Julien Sotton, Dario Pastrone

Title of Paper: Multi-Fluid Finite Volume Formulation for the Simulation of Plasmas for Electric Propulsion Applications

Author(s): Iacopo Regoli

Institution: Università di Pisa, Italy

Abstract
Electric Propulsion is the technology providing the highest specific impulses among the currently available for Space applications. In electric thrusters, a plasma is generated by ionizing a neutral propellant, which is then accelerated using electro-magnetic fields. For this reason, a precise knowledge of the Fluid Dynamics of a plasma evolving inside and outside of the thruster is fundamental for achieving an e!cient engine design which can be obtained only using complex numerical tools. The present work proposes a numerical model for the analysis of plasma Fluid Dynamics, aiming to define a code capable of capturing the main phenomena evolving within a flow, either neutral or charged, composed of an arbitrary number of species which can interact in a user-defined number of ways. The proposed code is based on the Finite Volume Method, and the solution is advanced dividing each time-step in two: firstly, the system of equations is solved without the source term and then a correction is applied solving an ODE system without the spatial terms. Spatial discretization is achieved adopting Roe's scheme, while time discretization is performed with an Implicit Euler method. Finally, the solution of Poisson's equation yields the distribution of the Electric field. Boundary Conditions are enforced using a single layer of dummy cells. Together with "standard" BCs, common to every CFD code, the model is capable of handling non-standard ones to treat the peculiarities of interactions between plasmas and solid conductive walls, with a fixed or floating potential, and considering cases either with or without thermionic emission.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Regoli-UniPI_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2C - paper n. 1 – time: 11:10 **(Classroom) Aula 17**

Session Chair: Emmanuel Zenou

Judges: Paolo Tortora, Matteo Ceriotti

Title of Paper: Development of a Ferrofluid based Attitude Control Actuator for Verification on the ISS

Author(s): Sebastian Zajonz and Christian Korn

Institution: University of Stuttgart, Germany

Abstract
Ferrofluid-based systems provide an opportunity for increasing the durability and reliability for systems, where mechanical parts are prone to wear and tear. Conventional reaction control systems are based on mechanically mounted rotating disks. Due to inherent friction, they suffer from degradation, which may eventually lead to failure. This problem is further intensified due to limited possibility for repair and maintenance. Ferrofluid-based systems aim to replace mechanical components by exploiting ferrofluidic motion. Ferrofluids consist of magnetic nanoparticles suspended in a carrier fluid and can be manipulated by external magnetic fields. This paper describes the working principle, design and integration of a working prototype of a ferrofluid-based attitude control system (ACS), called ACS-BLDC. It is based on a stator of a brushless DC motor in combination with a rotor on a ferrofluidic bearing. The prototype will be verified in a microgravity environment on the International Space Station, as part of the Uberflieger 2 student competition of the German Aerospace ¨ Center. First ground tests deliver positive results and confirm the practicability of such a system.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Korn_Zajonz-UniStuttgart_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2C - paper n. 2 – time: 11:35 **(Classroom) Aula 17**

Session Chair: Emmanuel Zenou

Judges: Paolo Tortora, Matteo Ceriotti

Title of Paper: Optimal Planning and Guidance for Solar System Exploration using Electric Solar Wind Sails

Author(s): Francisco Javier Urrios Gómez

Institution: Universidad de Sevilla, Spain

Abstract
Electric Solar Wind Sails are a new type of spacecraft propellantless propulsion system that gathers its energy from solar wind protons and is potentially useful for interplanetary missions. With an appropriate thrust model, which can be obtained from the literature, one can study optimal orbits for interplanetary flights. The first goal of this project is to study the properties of time-optimal trajectories for missions to Mars and Jupiter using an indirect approach by applying Euler-Lagrange equations and Pontryagin's Minimum Principle, and then compute them with direct transcription methods, converting the problem into a Non Linear Programming form. Then, solar wind perturbations are added, posing a challenging saturation problem due to their high variability. Thus, guidance strategies based on Shrinking Horizon and Receding Horizon Model Predictive Control are developed, simulated and compared, yielding satisfactory results.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Urrios-UniSevilla_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2C - paper n. 3 – time: 12:00 **(Classroom) Aula 17**

Session Chair: Emmanuel Zenou

Judges: Daniel Garcia-Alminana, Matteo Ceriotti

Title of Paper: Convex Low-Thrust Trajectory Optimization with Operational Constraints

Author(s): Samuele Vaghi

Institution: Politecnico di Milano, Italy

Abstract
This paper introduces operational constraints, such as pointing requirements of scientific or navigation instruments, in guidance algorithms based on Sequential Convex Programming (SCP). State of the art optimization techniques do not account for this kind of constraints, resulting in the need of post-processing the obtained trajectories to make them compliant with the constraints. Autonomous CubeSats have limited on-board computational capabilities, therefore the possibility to obtain flyable trajectories is crucial for them. The methodologies developed to introduce the pointing constraints highlight the impact of the relative orientation of the on-board instruments on the optimal trajectories. The results obtained show that the consideration of the pointing requirements can provide precious information both for the mission trajectory and platform preliminary design.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Vaghi-PoliMI_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 2C - paper n. 4 – time: 12:25 **(Classroom) Aula 17**

Session Chair: Emmanuel Zenou

Judges: Daniel Garcia-Alminana, Matteo Ceriotti

Title of Paper: Orbit/Attitude control for rendezvous & docking at the Herschel Space Observatory

Author(s): Andrea Siena

Institution: Politecnico di Torino, Italy

Abstract
In Situ Resource Utilization (ISRU) will be the key for the success of many future space missions which are especially time or cost demanding. This is particularly true for the next Moon settlement mankind has decided to establish, and even further, for Mars colonization. Focusing on Moon operations, this paper presents a study carried out to assess the benefits of on-orbit servicing (OOS) exploiting lunar resources for the resupply of the Herschel Space Observatory (HSO). Herschel ended its operations in 2013 as a consequence of the depletion of its coolant, therefore an experimental mission has been envisaged to refill it. An adapted cargo spacecraft (s/c), employed in lunar gateway operations, will be supposed to depart from the Moon and reach Herschel for the resupply. Trajectory design and optimization, as well as dynamics linearization and attitude control, are the topics addressed in this study in order to obtain some preliminary data on the feasibility of these kind of missions. The results found list different trajectories that could be taken on for the mission, their ΔV cost and time of flight (ToF) and show the advantage of relying on simplified dynamics for the calculations. Moreover it is presented the methodology used to approach the observatory during rendezvous (RdV) while ensuring minimum thrusting errors of the cargo spacecraft and a continuous visibility of the space observatory. The conclusion displays some ideas on how the next studies for the mission could be carried on.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Siena-PoliTO_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3A - paper n. 1 – time: 13:50 **(Classroom) Aula 5**

Session Chair: Jan Rohac

Judges: Benedikt Badanik, Marc Chouffot

Title of Paper: Evaluation of the Impact of Operational Changes on the Optimal Number of Baggage Loading and Unloading Equipment

Author(s): Jiří Volt

Institution: Czech Technical University in Prague, Czech Republic

Abstract
The subject of this paper is an evaluation of the effect of operational changes on the final optimal number of aircraft ground service equipment, used for loading and unloading. The first analyzed change was an increase of the number of flights in the flight schedule. The second change included the closure of the apron segment. The mathematical optimization model based on the theory of linear programming is used to determine the effect of operational changes. This model can calculate the optimal number of ground service equipment for loading and unloading of the aircraft and can also be used to plan future capacities and to evaluate the impact of the operational changes. The ability to predict the required number of the airport equipment in advance could make the aircraft ground handling process more efficient. Based on the proposed scenarios, which include operation changes, and input data from V´aclav Havel Airport Prague, computational experiments were performed. The results of the experiments show how large is the impact of these changes on the optimal number of ground service equipment.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Volt-CTU_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3A - paper n. 2 – time: 14:15 **(Classroom) Aula 5**

Session Chair: Jan Rohac

Judges: Benedikt Badanik, Marc Chouffot

Title of Paper: Optimization model for flight scheduling and fleet assignment with demand-supply interactions

Author(s): Tiago Florentino Dias

Institution: Instituto Superior Técnico, Portugal

Abstract
The flight scheduling and the fleet assignment stages of an airline's planning process are important for the success of the operation and for the airline's profitability. Due to that, the present work adopts a methodology to integrate both problems, also including the interaction between the airline's supply and the passengers' demand. It is presented a model that designs an optimal network from the perspective of the airline, indicating which itineraries must be flown, at what times and with which aircraft, having the goal of maximizing the airline's operating profits and while considering the passenger's demand. Then, this optimization model includes a demand model, treated with a nested logit formulation. Once demand for traveling is naturally generated between two cities, it is made an estimation about passengers' demand regarding which itineraries to take, considering its characteristics, offered by the airline. This demand is estimated through a discrete choice model, developed with an experiment based on a survey that collects the general passengers' preferences when choosing an itinerary. Finally, a case study in Greece is analysed under different scenarios. The results demonstrated that the demand patterns shape an airline's network and that the model can suggest an improvement of an airline's network.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Dias-IST_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3A - paper n. 3 – time: 14:40 **(Classroom) Aula 5**

Session Chair: Jan Rohac

Judges: Joris Melkert, Marc Chouffot

Title of Paper: Design, realization and flight test of an integrated sensor and telemetry system for atmospheric sounding

Author(s): Antonio Turi

Institution: Università di Pisa, Italy

Abstract

Since the 50’s sounding balloon radiosoundings have been one of the most crucial methods of data gathering for weather prediction. Sounding balloons are still the only technology capable of measuring weather data in situ reaching altitudes of more than 40 km. But radiosondes have a very limited market dominated by few companies that sells onerous subscriptions for large time-spans. For many applications, dedicated , flexible, low-cost radiosoundings would represent a very important source of data, that can act as a validation for remote-sensing technologies.

Following this idea, the main goal of the work here reported was to create a low-cost radiosonde, with its unique hardware and software, and to make it available at more affordable cost and also on dedicated flights, with specially designed payloads.

The project started after a request from LaMMA, the meteorology and atmospheric physics research institute of CNR and the Tuscan Region, for a flying system capable of collecting data from the atmosphere for verifying data collected by GNSS receivers on ships at sea. The radiosonde is lifted by the most common type of high-altitude balloon, i.e., sounding balloons, which are nowadays available at very low cost from commercial vendors and freely operable.

We designed and tested a telemetry system based on a LP-WAN protocol named LoRa (Long Range) in order to collect the data from the flying radiosonde in real-time. A detailed description of the hardware and design choices is reported, with particular focus on the sensors for collecting the relevant atmospheric properties, i.e. pressure, temperature, and relative humidity. The organization of the launch phase was carried out thanks to the experience collected during these last years with dozens of launches by the Space System laboratory of the University of Pisa. In particular we studied a quick and reliable launch sequence, requiring only a small ground crew, that is easily adaptable to uncommon launch sites such as moving ships. A discussion about the testing of the system and the launch results is also reported.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Turi-UniPI_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3A - paper n. 4 – time: 15:05 **(Classroom) Aula 5**

Session Chair: Jan Rohac

Judges: Joris Melkert, Marc Chouffot

Title of Paper: The effect of icing on the propulsion systems of VTOL UAS

Author(s): Karel Hylmar

Institution: Czech Technical University in Prague, Czech Republic

Abstract
Currently, the number of Vertical Take-off and Landing Unmanned Aerial Vehicles (VTOL UAVs) in operation continues to grow. This type of aircraft benefits from its good flight characteristics, comprising simple handling together with good manoeuvrability. VTOL UAVs are operated at low flight levels, close to populated areas and uninvolved people. This type of UAV is very vulnerable in the event of icing, which can cause severe degradation of aerodynamic, performance and therefore mainly flight characteristics. In the event of the VTOL UAVs' propulsion units being affected by icing, they may crash. Frost thus represents a serious operational risk for which there are currently no adequate technological and legislative solutions. For this reason, this paper deals with the proposal of a methodology for testing the effect of icing on the degradation of performance characteristics of VTOL UAVs. VTOL UAVs. Testing and exposure of propulsion systems to icing conditions took place in the climatic chamber. Several series of measurements were performed in the climatic chamber, in which the propulsion systems were exposed to a temperature of 15, of -5, of -10 and of -15 ◦C and a flow of supercooled water droplets of 1.43 g/s. The mutual comparison of the performed measurements made it possible to determine the influence of individual conditions on the decrease of the thrust, the increase of the consumed electric current and the occurrence of vibrations.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Hylmar-CTU_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3B - paper n. 1 – time: 13:50 **(Classroom) Aula 15**

Session Chair: Rabia Sehab

Judges: Daniel Hanus, Giorgio Guglieri

Title of Paper: Propulsion Integration in Blended Wing Body Aircraft

Author(s): Javier González García

Institution: Universitat Politècnica de València, Spain

Abstract
The Blended Wing Body (BWB) architecture is one of the brightest aircraft design concepts that attempt to increase airline profit while reducing pollutant emissions. It brings out many challenges, such as the greater level of dependence between the different design disciplines. The objective of this article is to deal with propulsion integration in this type of platforms, considering a previously designed airframe with top-mounted engines. For doing so, a CFD analysis is carried out, evaluating how the presence of the powerplant and the exhaust jet modifies the flow around it. It is observed how the engine and pylon geometry shift forward the shockwave over the centerbody and lead to some additional boundary layer detachment increasing drag. Consequently, some guidelines are provided for the adequate design of this region.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/González-UPV_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3B - paper n. 2 – time: 14:15 **(Classroom) Aula 15**

Session Chair: Rabia Sehab

Judges: Daniel Hanus, Giorgio Guglieri

Title of Paper: Preliminary design and simulation of a hydrogen-powered aircraft concept

Author(s): Roberto Di Giuseppe

Institution: ISAE-SUPAERO, France

Abstract
In recent years, the civil aviation sector has been deploying an increasing amount of resources to reduce its climate impact. To this end, various industrial and academic entities are coordinating efforts to find alternatives to conventional kerosene based aircraft. In the range of fuels available to power an aircraft propulsion system, hydrogen holds an advantageous position due to its high specific energy and low greenhouse gas emissions. The European Commission's Green Deal set the goal of carbon neutrality by 2050 and hydrogen is not the only solution being investigated. Sustainable aviation fuels are the main competitors of H2 because their use does not require significant modifications to the current aircraft design and airport infrastructure. However, the combustion of alternative fuels emits CO2 and their production is economically disadvantageous compared to H2. Against this background, the simulated performance of a regional aircraft with hybrid propulsion (fuel cells and ultracapacitors) is compared with the performance of the same aircraft propelled by direct hydrogen combustion.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/DiGiuseppe-ISAE_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3B - paper n. 3 – time: 14:40 **(Classroom) Aula 15**

Session Chair: Rabia Sehab

Judges: Laurynas Sisovas, Francesco Franco

Title of Paper: Optimal design of structures considering 3D printing overhang constraint through anisotropic perimeter

Author(s): Jose Antonio Torres Lerma

Institution: Universitat Politècnica de Catalunya, Spain

Abstract
One of the current challenges of the aerospace industry is the exploration of new lightweighting structures to reduce fuel consumption and limit the environmental impact. The use of topology optimization techniques allows such weight reduction, minimizing design time and cost. However, complex designs are obtained, which are only possible to manufacture with additive manufacturing. Consequently, the numerical optimization must be combined with 3D printing constraints to ensure manufacturability (minimal length scale and overhang constraints) and avoid the apparition of complex shapes and volumes with unintuitive holes. Thus, the aim of this paper is to study the feasibility of numerical designs concerning light structures, topology optimization techniques and 3D printing overhang constraint. Different case studies are defined in order to assess their feasibility. In the end, the overhang constraint is fulfilled by penalizing the anisotropic perimeter in the 3D printing direction. Results obtained show that local bars with small length scales are removed and vertical tendency orientation of bars are generally obtained. Further exploration remains in the non-linear regime.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Torres-UPC_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3B - paper n. 4 – time: 15:05 **(Classroom) Aula 15**

Session Chair: Rabia Sehab

Judges: Laurynas Sisovas, Fernando Lau

Title of Paper: Temperature compensation algorithms for guided wave structural health monitoring approaches based on distributed sensor network

Author(s): Massimiliano Olino

Institution: Università di Napoli "Federico II", Italy

Abstract
The implementation of Guided Ultrasonic Wave (GUW) based Structural Health Monitoring (SHM) approaches is greatly affected by varying temperatures. This can lead to false alarms or missed detections, reducing reliability. This paper evaluates two temperature compensation methods, Optimal Baseline Selection (OBS) and Baseline Signal Stretch (BSS), extending their applicability to a distributed sensor networks (DSN). In this sense, the effect of temperature separation between baseline time-traces in OBS and BSS are examined for multiple couples of sensors: different paths are available in a sensor network and OBS and BSS can return different temperature prediction, with several possible combinations of results available at each sensor couple. A decision strategy which uses frequent value warning to define the optimal baseline or stretching parameter is found to be effective in two experiments. These use different frequency analysis with predominantly A0 or S0 (the fundamental antisymmetric and symmetric) mode data or both. Introducing frequent value warning increases the efficiency of OBS and BSS, making use of fewer signal processing algorithms. The effectiveness of these approaches is demonstrated by quantifying Damage Indicators (DIs), which show that their performance agrees with predictions, and that compensation strategies improve detectability of damage with higher system reliability

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Olino-UniNA_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3C - paper n. 1 – time: 13:50 **(Classroom) Aula 17**

Session Chair: Salvo Marcuccio

Judges: Rafael Vazquez, Gustavo Alonso

Title of Paper: Study of the rotational state of Titan using radio tracking data of the Dragonfly mission

Author(s): Roman Prokazov

Institution: Alma Mater Studiorum - Università di Bologna, Italy

Abstract
A comprehensive understanding of the rotational state of celestial bodies in the outer solar system is crucial for gaining insights into their internal structure, and potentially unlocking the secrets of subsurface oceans as potential habitats for life. The main goal of the research is to study the possibility of inferring Titan's rotational state using radio tracking data from NASA's Dragonfly mission. The study utilizes Doppler data simulated with an orbit determination program and explores the accuracy of rotational state estimation considering different variables. An analytical model of Doppler shift is also developed to understand how observables change with the mission duration. The simulation results can be useful for optimizing the Dragonfly mission's configuration for studying Titan's rotational state.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Prokazov-UniBO_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3C - paper n. 2 – time: 14:15 **(Classroom) Aula 17**

Session Chair: Salvo Marcuccio

Judges: Rafael Vazquez, Gustavo Alonso

Title of Paper: Modelling and control of interferometry formation flying mission in LEO

Author(s): Cristina Erbeia

Institution: Politecnico di Milano, Italy

Abstract
Interferometry formation flying is gaining more and more relevance because of the significant performances it could offer in the scientific arena. This work introduces the fundamental principles behind interferometry, both on a single array and on a formation. The efficiency of the interferometry is evaluated through a relative position error sensitivity analysis, e.g. by computing the percentage performance loss due to a non-nominal relative trajectory. The aim of this study is to evaluate whether there exist some errors more impacting than others, and finally to demonstrate the existence of a link between a relative displacement and a specific loss of performance, to eventually foresee where to find the input position error. The satellites' relative motion is considered in the Low Earth Orbit (LEO) environment both in unperturbed and perturbed (e.g. with J2 and drag) scenarios. The formation satellites' position control is implemented through a Proportional, Integral and Derivative (PID) controller, with a low thrust control profile. The benchmark both for nominal and non-nominal configurations is set in the FFLAS study. This work represents a starting point for evaluating the performances of both the interferometry and the control on the relative state for future remote sensing research involving relative motion.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Erbeia-PoliMI_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3C - paper n. 3 – time: 14:40 **(Classroom) Aula 17**

Session Chair: Salvo Marcuccio

Judges: Rafael Vazquez, Gustavo Alonso

Title of Paper: On-board optimization of complex profiles of mission attitude

Author(s): Catarina Da Silva Lobo

Institution: ISAE-SUPAERO, France

Abstract
The problem of spacecraft attitude guidance deals with complex mission requirements, through diverse pointing objectives and restrictions. These include pointing to a ground station, avoiding optical sensor blinding, solar panel reorientation, among others. So far, complex pointing profiles are mostly defined and optimized on-ground. This paper intends to explore the possibility of introducing an on-board definition and optimization of these profiles by developing two algorithms based on different approaches. Firstly, a Lyapunov feedback guidance rule based on an attractive and a repulsive potential will be employed, given its simplicity of computation for on-board application. Three mechanisms are introduced to deal with scenarios of higher complexity: a kinematic extrapolation, a guidance solution for intersecting keep-out cones and a temporal symmetry algorithm. Secondly, a successive convexification algorithm will be implemented, and constraints of higher complexity will be introduced. Results show that a Lyapunov feedback guidance rule presents a light-weight strategy for simple scenarios. The successive convexification, although more computationally expensive, finds a feasible solution for more complex constraints, with the drawback of being significantly dependent on the initial guess provided and the weighting of each term in the cost function.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/DaSilvaLobo-ISAE_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3C - paper n. 4 – time: 15:05 **(Classroom) Aula 17**

Session Chair: Salvo Marcuccio

Judges: Rafael Vazquez, Gustavo Alonso

Title of Paper: Orbital Maneuver Algorithms Development for In-Orbit Services Satellites Swarm Operations

Author(s): Flavia Giuliani

Institution: Sapienza Università di Roma, Italy

Abstract
In the last decades the improvement in small satellites and CubeSat technology has resulted in an increase in their capability to perform complex missions; this, along with the decrease in mission launch costs, has made swarm Rendezvous and Proximity Operation an area of great interest. In particular, swarms can be used for In-Orbit Servicing, which includes, among other tasks, refuelling, assembly and manufacturing. Using a swarm of spacecraft provides more flexibility and robustness with respect to monolithic satellites, for example in case of failure of one of the elements; however, it introduces the problem of collision between satellites of the swarm.
This work aims to: (i) study a rendezvous strategy in GEO orbit, based on Hill – Clohessy – Wiltshire equations, initially for a single satellite, that guarantees the passage through defined waypoints; (ii) develop an algorithm that uses the found strategy to compute orbital manoeuvres for satellite swarm rendezvous while minimizing the fuel consumption and satisfying the constraints on the swarm element's minimum distance, the minimum distance from the target and the correct final phasing; (iii) demonstrate that it is possible to apply, introducing some changes, the afore mentioned GEO strategy even to cases in LEO; (iv) validate the obtained results through the use of an orbit propagator.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Giuliani-UniRoma_paper.pdf

PEGASUS STUDENT CONFERENCE 2023

Session 3C - paper n. 5 – time: 15:30 **(Classroom) Aula 17**

Session Chair: Salvo Marcuccio

Judges: Dario Pastrone, Daniel Hanus

Title of Paper: Preliminary design and proof of concept of an Iodine-Powered Hall Thruster for Satellite Propulsion

Author(s): Fabrizio Tracchegiani

Institution: Università di Pisa, Italy

Abstract
This paper outlines the activities conducted at ThrustMe on the development of a 150W class Hall thruster, intended as proof-of-concept for larger scale constellation-class thruster, with the primary focus being the use of iodine as the propellant. The design work conducted is presented, starting with an overview on the thruster scaling methodology. Following this, the simulation work done on the magnetic field design is discussed. The last design subject outlined in this paper is the thermal simulation of the system, and in particular its influence on the mounting stand design. The experimental activities performed on the 150W class Hall thruster are as well presented. The magnetic circuit was characterized, verifying the correspondence with the simulations. The thruster is currently undergoing critical tests in a vacuum chamber, using xenon as a propellant, to gather valuable information about its performances. The following step will be operation on iodine propellant, using a feeding system derived from previous ThrustMe models. These tests will provide crucial insights into the thruster's capabilities and will pave the way for future tests with iodine, which is the ultimate goal of this project.

Full paper: https://www.pegasus-europe.org/wp-content/uploads/Student_Conference/papers/2023/Tracchegiani-UniPI_paper.pdf