MP - AER

DISSERTAÇÕES DE 2021 A 2024

SUMÁRIO

DISSERTAÇÕES DO ANO DE 2024

Título: CONCEPTUAL DESIGN OF AN ADAPTIVE NACA AIR INTAKE TYPE USING SHAPE MEMORY ALLOY.
Autor: Amanda Correia Gonçalves
Turma: 30
Data da Defesa: 10/09/2024
Orientador: Alfredo Rocha de Faria
Coorientador: Henrique Bockmann Alves
Abstract: Shape memory alloys (SMAs) are unique metallic alloys that possess the ability to "memorize" or retain a previous form when subjected to certain stimulus such as thermomechanical variation. The global interest in these materials, along with their growing number of applications in industry and adoption by competitors in the aeronautical field, highlights the necessity of studying this technology to maintain market competitiveness. Moreover, the drive for greener aviation makes the idea of improvements that can reduce aircraft fuel consumption very attractive. The focus of this research is to develop a conceptual design for a mechanism utilizing SMA to regulate the aperture of NACA (National Advisory Committee for Aeronautics) type air intakes for the air management system (AMS) of a commercial aircraft. The mechanism must be adaptive, allowing for variable opening based on the system's flow requirements during different phases of flight, significantly reducing drag during cruise. A methodology was developed to support the solution design process in this work, adapting aspects of the Stage-Gate process, combined with principles from the PDCA (Plan, Do, Check, Act) cycle. Based on this methodology, five concepts were proposed, addressing aspects necessary for an initial design stage including the conceptualization and geometry of the device, component sizing, weight calculation, actuation method, safety mechanisms, and employed alloy. The design requirements were identified, along with relevant parameters for analyzing the performance of the concepts. Methods for determining these parameters — identified as energy demand, stiffness, and actuation time — were proposed and applied in the development of each concept, enabling their evaluation and comparison. Strengths and weaknesses of each solution were presented, with solution number 2, consisting of a long bundle of Nitinol wires fixed at the free edge of the door, identified as the most promising due to its significant advantages in terms of stiffness and energy consumption. Finally, key points of attention were high- lighted for future implementation studies, such as joint strength, actuation time, and the fatigue behavior of Nitinol.

Título: TOPOLOGY OPTIMIZATION OF THE MAIN FITTINGS OF THE PYLON-WING CONNECTION IN A COMMERCIAL AIRCRAFT.
Autor: Beatriz Balbuena Blat
Turma: 30
Data da Defesa: 30/09/2024
Orientador: Alfredo Rocha de Faria
Coorientador: Wagner Alves Toledo
Abstract: The structural design of an aircraft is a challenge always focused on finding the most efficient structural concept possible, in order to develop an increasingly competitive product. One of the ways to achieve this is to try as much as possible to reduce the structural weight without changing its performance. The objective of the

present work is to perform a topology optimization study of the pylon-wing connection fittings of a commercial aircraft to find an optimal configuration for these components in terms of stiffness. In order to accomplish the objectives, different mass distributions will be studied and comparisons will be made with the reference model, in order to select the best solution.

Título: LINEAR PARAMETER-VARYING FLIGHT CONTROL LAW DESIGN FOR A FLEXIBLE AIRCRAFT USING DIFFERENT SCHEDULING PARAMETERS.
Autor: Caio Vasconcelos Pereira
Turma: 30
Data da Defesa: 07/10/2024
Orientador: Antônio Bernardo Guimarães Neto
Coorientador: Fernando José de Oliveira Moreira
Abstract: In this dissertation we present the Linear Parameter Varying (LPV) technique used to synthesize control laws for aircraft with structural dynamics throughout a range of different flight conditions. A flexible aircraft has its vibration modes' frequencies coupling with those of the rigid body dynamics, and thus the overall dynamics of the airplane becomes more complex. The complexity increases further when taking into consideration that the airplane can fly in different flight conditions, each one of them affecting different dynamics on the aircraft. Instead of using multiple controllers nested in different control loops for controlling rigid-body and vibration separately, the LPV control allows a single loop controller in charge of the entire dynamics. Also, instead of multiple control laws for different flight conditions, it allows the use of multiple flight conditions to synthesize a controller focused on its response across the entire flight envelope, and whose parameters vary according to the flight condition. The objectives of this dissertation are then to build a new LPV controller, making use of different parametrization approaches and techniques with the goal of improving controllers already present in the literature, reducing its synthesis computational time, reducing sensitivity or improving response performance, following on previous works done on the subject. During this dissertation a new parametrization is presented, making use of the dynamic pressure and the Mach number to characterize the flight condition that the plane finds itself in. New basis functions are also tested, along with new weight functions, due to changes made in the reduced-order model. Furthermore, a controller using the previous works' parametrization, with altitude and Mach number, is synthesized using the new model order reduction and weights. Lastly, linear simulations are made across the flight envelope, in order to compare the controller effectiveness with both parametrizations, where analyses are performed on the reference tracking response and on the poles' position in the closed-loop system.

Título: EVALUATION OF A HUMAN-ROBOT COLLABORATION CONCEPT FOR AERONAUTICAL DRILLING WITH TEMPLATE.
Autor: Caique Carvalho Silva
Turma: 30
Data da Defesa: 04/12/2024
Orientador: Wesley Rodrigues de Oliveira
Coorientador: João Marcos Gomes de Mello
Abstract: The aerospace industry, characterized by high-precision and complex

processes, constantly seeks innovative solutions to optimize its production. This master's thesis investigated the feasibility and benefits of integrating collaborative robots (cobots) into the aeronautical process with drilling template.
Aircraft assembly heavily relies on precise drilling procedures, representing a significant portion of the workload. To improve costs, efficiency, quality, and ergonomics in aerospace manufacturing, there is an urgent need to explore automation solutions, such as cobots, to replace traditional manual drilling methods.
Objectives included evaluating the technical feasibility and benefits of incorporating cobots into the drilling process of aircraft components, as well as mapping the current drilling process, defining the human-robot collaboration process, assessing the capabilities of cobots in drilling, analyzing the use of conventional metal drilling templates and those manufactured by 3D printing, and improving ergonomic conditions for operators while evaluating the quality of the drilling process. The study was conducted in collaboration with the Aeronautical Technological Institute (ITA) and Embraer.
Through this dissertation, a methodological framework for evaluating the technical feasibility of employing cobots in aeronautical manufacturing was developed for systematic analyses regarding the implementation of cobots in the aeronautical process with drilling template, followed by an evaluation of the experimental results. The results obtained demonstrated that the use of cobots can significantly increase efficiency, process flexibility, and the quality of drilled parts, as well as the ability to reduce ergonomic risks for operators.

Título: CONSTRUCTION OF A DATABASE OF AIRCRAFT TRAJECTORY CONFLICTS AND MITIGATION MANEUVERS USING REAL DATA COLLECTED BY A FLIGHT TRACKING TOOL.
Autor: Camilla Santos Silva
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Data da Defesa: 09/12/2024
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Coorientador: Fernando José de Oliveira Moreira
Abstract: The rapid expansion of air traffic in recent years has led to a critical analysis of air traf- fic management strategies. The complexity of airspace operations has increased due to substantial growth in the number of flights, increasing the burden on Air Traffic Control Officers (ATCOs) to ensure airspace safety and efficiency. To address this challenge, in- corporating improved automation in conflict detection and resolution has emerged as a key solution. Automation has the potential to significantly support ATCOs in manag- ing complex airspace scenarios and assist ATCOs in Conflict Detection and Resolution (CD&R). This research focuses on creating a dataset based on ADS-B flight trajectory data, trajectory conflicts and maneuvers performed that can be used in research focusing on this automation. The dataset constructed in this work is available in CSV format in a github repository[3]. It was based on ADS-B data collected over 23 days, obtaining 528 conflict samples. It is composed of the moment of the conflict and information from the aircrafts involved in that conflict: latitude, longitude, altitude, heading, speed and climb/descent rate. It also presents the start and end times of the performed maneuver to resolve this conflict associated with the respective information, as well as its classification given in terms of change of course, altitude, speed or their combination. Furthermore, the trajectories of

these aircraft are available to assist in understanding the conflict. This research also provides a tool to visualize all the data generated which is available in a github[4] repository. Finally, this work aims to carry out an exploratory analysis of the amount of data available in the dataset and the parameters used in the construction of the data set, as well as providing examples of conflict detection and resolution through each type of maneuver.

Título: PROBABILISTIC BUCKLING ANALYSIS OF COMPOSITE STIFFENED PANELS UNDER AXIAL COMPRESSION AND SHEAR LOADS.
Autor: Eloi Antonio Triaca
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Data da Defesa: 03/09/2024
Orientador: Alfredo Rocha de Faria
Coorientador: Paulo Roberto Zanella Pasquali
Abstract: Composite materials have been increasingly applied to design more lightweight and durable aircraft structures. However, their structural response is more uncertain due to their complex behavior and manufacturing. Under a traditional structural design methodology, certification requirements are satisfied by the selection of margins of safety that compensate material, geometrical and load uncertainties, which often leads to heavier and more costly structures. One alternative to better account the influence of these uncertainties is the probabilistic design approach, which consists in designing structures based on the evaluation of their failure probability, which is computed by a structural reliability analysis. In this regard, this work aimed the investigation of a framework for computing the failure probability by local buckling of omega-stringer stiffened laminated composite plates under combined axial compression and shear loads, considering uncertainties associated to their material and geometrical properties. The local buckling response was selected as the focus of the study since it is a major driver for the design of primary aircraft structures. To achieve this main objective, two specific objectives had to be accomplished: (1) firstly, a semi-analytical model capable of computing the local buckling load of the stiffened panel under the specified loading conditions was implemented; and (2) different methods for the structural reliability analysis were implemented and evaluated for a specific case study. This evaluation consisted of a comparative analysis which investigated the accuracy and computational efficiency of the four implemented reliability estimation methods. In addition, the effectiveness of using a global sensitivity analysis to filter the most influential properties prior to the reliability analysis was assessed as well. Based on the results obtained for the investigated case study, the probability of failure by buckling for the investigated case study was computed for several loading combinations, and recommended practices for the reliability analysis framework were established, considering its applicability in probabilistic structural design procedures.

Título: CORE DESIGN METHODOLOGY FOR NOVEL COMPACT HEAT EXCHANGERS.
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Data da Defesa: 04/12/2024

Orientador: Guilherme Borges Ribeiro
Coorientador: Sandro Tavares Conceição
Abstract: The present thesis aims to propose a methodology for studying novel compact heat exchangers (HXs), focusing on modern manufacturing techniques, such as Additive Manufacturing (AM), to facilitate the creation of novel core concepts for these HXs. In addition to the methodology, this work investigates an airfoil-based heat exchanger concept, drawn from the range of modern HX concepts studied in the literature review, both to validate the proposed method and to assess hypotheses regarding its potential application in the case study, based on the aircraft from FutPrInt50 (2023).
The proposed methodology is based on a sensitivity analysis using virtual experimental testing through Computational Fluid Dynamics (CFD) modeling of the heat exchanger's air side. From this analysis, the performance of the proposed HX is defined through analytical equations regressed from the CFD results and applied to lumped-parameter models that simulate the thermal dynamics of the heat exchanger. Using these formulations, various sizing cases are generated for data analysis and compared, both nondimensionally and dimensionally, with conventional plain, wavy, and louver finned-tube HXs.
In conclusion, this thesis validates the robustness and feasibility of the proposed methodology, providing well-supported conclusions about the proposed heat exchanger relative to conventional options. Furthermore, although certain hypotheses regarding the airfoil-based HX's potential were refuted, given its inferiority to typical exchangers in optimizing frontal area and heat transfer area, this work identifies an alternative application for this HX, which demonstrates a strong advantage in volume optimization. This finding suggests that, while not fully applicable to the evaluated case study, the novel heat exchanger has potential in other industrial applications where volume and mass reduction are prioritized over frontal area reduction.

Título: STRUCTURAL PERFORMANCE COMPARISON BETWEEN CONVENTIONAL AND INTEGRATED DESIGN: AIRCRAFT WINDSHIELD FRAME STUDY OF CASE.
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Data da Defesa: 02/09/2024
Orientador: Alfredo Rocha de Faria
Coorientador: Lucas Rafael Hara Motta
Abstract: The design of an airplane is a complex, multidisciplinary task that involves aerospace, structural, electrical, mechanical, as well as aeronautical materials, and many other engineering fields. Due to this complexity, the aircraft manufacturing market is highly competitive and demanding in terms of technology, innovation, and safety. This situation makes the costs associated with this context an important variable. One of the main costs related to manufacturing a new product is the cost of manufacturing and raw materials. An alternative for cost reduction in the airframe design context is the integration of different parts into a monolithic structure. In some contexts, this integration can reduce manufacturing time and raw material costs. Therefore, this work is dedicated to developing an integrated structural design of the windshield frame of an executive aircraft. This involves performing structural analysis, comparing it to the original solution, and evaluating the potential for reducing raw material and manufacturing costs. A review of the fuselage design rationale was conducted, and preliminary sizing, analysis, and structural idealization were discussed. Fuselage loads, according to FEDERAL AVIATION ADMINISTRATION, Departament of Transportation, 2016, were calculated, and the

described structural idealization was applied to the case study to estimate normal and shear stresses on the windshield's fuselage boundary stations. FEM models were developed to evaluate both structural designs. Rupture, compression, buckling, crippling, fasteners, and joints were analyzed. Both the conventional and integrated designs proved to be structurally viable concepts and exhibited similar margins of safety in strength analyses. However, the integrated concept demonstrated superior results in fastener and joint analyses, while the conventional concept excelled in rigidity-related analyses. Additionally, a manufacturing assessment was conducted, where the integrated concept succeeded in reducing assembly time, though it significantly increased costs compared to the conventional design.

Título: DESIGN OF CONTROL LAWS FOR THE TRANSITION PHASE OF A LIFT-PLUS-CRUISE EVTOL AIRCRAFT.
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Data da Defesa: 26/08/2024
Orientador: Davi Antônio dos Santos
Coorientador: Yasser Mahmud Abdalah
Abstract: Urban Air Mobility (UAM) is an emerging transportation mode that demands a revolutionary aircraft design. In this context, electric vertical takeoff and landing aircraft (eVTOL) have become a prominent trend in aviation, offering the lift-plus-cruise configuration as a promising solution. This design allows for extended flights with the wing generating lift during cruise while retaining the ability to hover and perform vertical takeoff and landing using vertical rotors. These distinct operational modes create an opportunity to adopt nonlinear control schemes that provide a valid control approach across all flight modes and offer greater robustness against parameter uncertainties. This dissertation addresses the rigid-body dynamic modeling, simplified aerodynamics, and flight control of a lift-plus-cruise eVTOL aircraft during hovering, transition, and horizontal flight phases. The Newton-Euler method is employed for the nonlinear equations of motion, the vortex lattice method for simplified aerodynamic modeling of the wing and tail surfaces, and a reformulated vortex particle method for vertical propulsion. Additionally, the dynamics of the control surfaces and the propulsion system are modeled based on available literature. Three control and control allocation architectures are proposed, each dedicated to the hovering, transition, and horizontal flight phases, respectively. Depending on the flight phase, a proportional-derivative position or proportional velocity control is adopted, while for attitude control, a sliding mode or proportional-derivative control formulation is used. Furthermore, a guidance algorithm and scenario definition are implemented, adhering to certification constraints for the safe operation of this type of aircraft. The control laws are evaluated in a real-time 3D simulation environment, allowing for visualization of the aircraft's behavior. The simulation results demonstrate that the lift-plus-cruise aircraft is capable of transitioning from rest to horizontal flight in a stable manner, validating the control architecture, while adhering to the guidance algorithm and meeting the takeoff trajectory requirements established in the document Second Issue of the Special Condition for vertical take-off and landing (VTOL)-capable aircraft.

Título: AUTONOMOUS FLIGHT AND THE FUTURE OF COCKPITS.
Autor: Guilherme Henrique Bortolotto

Turma: 30
Data da Defesa: 12/09/2024
Orientador: Anderson Vicente Borille
Coorientador: Douglas Gonçalves de Albuquerque
Abstract: The pursuit of flight safety is driving a gradual evolution in cockpit design towards automation, as human error remains the primary cause of most aviation accidents. With the rise of fully autonomous aircraft, a shift in perspective will place passenger experience at the center of cockpit design. This dissertation presents an outlook on the evolution of cockpit design through a set of four innovative aircraft concepts, incorporating insights from industries more advanced in automation, such as the automotive industry, while addressing certification complexities from the aviation industry. This field is scarcely explored by academic research, so a replicable procedure was developed to holistically converge multiple resources to analyze future trends in aviation. A key contribution of this research is to unveil promising cockpit design solutions for transitioning towards the future of autonomous aviation, such as enhanced vision cameras, lighting patterns, facilitated access, innovative controls, retractable sidestick, interchangeable seat orientation, commands through personal devices, projectors, photochromic windows, symmetric lofting, no duplicated commands, integral panel, and side panels. Cockpit designs that aid in visualization and understanding of these ideas were generated by artificial intelligence (AI), filling a literature gap by demonstrating how AI can enhance the design thinking process. Four concepts were proposed: a cargo turboprop designed for autonomous retrofit; an autonomous executive aircraft that enables passengers to pilot; a charter turboprop monitored by a safety pilot; and a commercial jet for single-pilot operations with crew rest area.

Título: A WAYPOINT - BASED 4D AIRCRAFT TRAJECTORY PLANNER CONSIDERING WIND FORECAST DATA.
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Turma: 30
Data da Defesa: 04/09/2024
Orientador: Rubens Junqueira Magalhães Afonso
Coorientador: Fernando José de Oliveira Moreira
Abstract: This work proposes a trajectory planning strategy for the cruise flight of commercial aircraft, taking into account the effects of wind on their movement. To this end, an optimal control problem is formulated in which the optimization variables are the waypoints to be followed by the aircraft between its starting point and its destination. In contrast to previous work, where the optimization variables consisted of all the control variables (lift coefficient, engine throttle and heading) at each instant, the use of waypoints requires an aircraft model with closed-loop control. It is therefore necessary to design controllers that allow the aircraft to follow these waypoints throughout the flight and to use the closed-loop model in the optimal control problem. On one hand, the model used for optimization is made more complex by including additional states, such as the values of the integrators of the Proportional-Integral (PI) controllers. On the other hand, the number of optimization variables and the computational time required to solve the optimal control problem are significantly reduced. As an additional advantage, the definition of waypoints allows a subsequent closed-loop operation despite mismatches between the wind field used in planning and the effective one during flight simulation. The robustness of the planning

has been evaluated through several closed-loop simulations, taking into account the mismatch between the wind used to determine the waypoints and the simulated wind during the flight. For this purpose, the wind field was used at the same location during the flight simulation, but at different time intervals from those used in the planning, in order to emulate a delay between the determination of the waypoints, their communication to the air traffic control authorities, the approval of the flight plan, and their actual use to define the route flown. The results showed that planning was effective in reducing fuel costs even with a reduced number of waypoints. However, the robustness evaluation showed that only in cases where the reduction was more significant could it be maintained with the delay between planning and execution.

Título: MAINTAINABILITY ANALYSIS WITH QUANTIFIABLE ERGONOMICS FOR PRODUCT DEVELOPMENT USING AN IMMERSIVE VIRTUAL REALITY TOOL.
Autor: Júlia Renata Schenckel de Oliveira
Turma: 30
Data da Defesa: 05/09/2024
Orientador: Henrique Costa Marques
Coorientador: Fábio Mitsuhiko Simomura
Abstract: Maintainability is an inherent property of a product that takes shape during the development process and is highly influenced by the decisions made in the early stages of the project. Traditional methods for maintainability analysis rely on non-immersive 3D simulations, which demand a considerable amount of work time and computational resources. This approach also lacks sensory perception, making the assessment of maintainability aspects challenging, since they depend on specialist knowledge. Immersive simulations can enhance this analysis, yet their use remains limited, especially when it comes to the evaluation of quantitative aspects of maintainability. Also, there is a need for a method to deliver a quantifiable response regarding the influence of maintainability attributes in the analysis of different configurations during the development of new products. So, the aim of this work was to propose and verify a new immersive methodology using a Virtual Reality (VR) collaborative tool to assess both qualitative and quantitative aspects of maintainability of concepts being studied during early stages of a new product development. An experiment was conducted with 21 participants who performed a maintainability analysis using the proposed methodology to compare two project proposals (A and B) in two different case studies. Before conducting the maintainability analysis, it was necessary to identify which maintainability attributes could be evaluated through VR and how to do it. The best solution between the two evaluated proposals was indicated by TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), a decision support method. This work also explored the quantitative aspect of ergonomics using a VR immersive approach combined with OWAS (Ovako Working Posture Analysis System), a posture classification method. This work's achievements showed great potential for the proposed methodology, which became evident by some participants' interest in starting to use the VR tool in their daily work routines.

Título: A MODEL-BASED FRAMEWORK FOR SPECIFICATION OF AUTOMATED LAYUP MACHINES.
Autor: Leon Silveira Abramovith
Turma: 30
Data da Defesa: 11/12/2024
Orientador: Luis Gonzaga Trabasso
Coorientador: João Marcos Gomes de Mello
Abstract: The Systems Engineering (SE) and Model-Based Systems Engineering (MBSE) methodologies are used in the Product Development process to enhance the integration between technologies and make the decisions more assertive. In this work, concepts from those methodologies are applied to Process Development, with an automated layup machine used in the aeronautical industry as the system of interest. This research objective is to develop a model that defines a structured process, thus guiding engineers throughout the selection of an automated layup machine in the early stages of the development of an aircraft. Hearings were conducted with several aeronautical industry professionals to assess the current state of SE and MBSE application in the industry, and bibliographical research was conducted to use Systems Design techniques in the construction of the model. Professionals were also heard with respect to automated layup machines: from those hearings, functional and morphological representations of the machines were constructed and the parameters of interest for the model were defined. Finally, the model was developed, and then evaluated in three application cases. The results showed that the model is useful and brings value to the verification of the resources needed to manufacture an aircraft; however, parameters adopted within the model still need to be calibrated, which is an opportunity for future works.

Título: DESIGN OF FLIGHT CONTROL LAWS FOR LATERAL DYNAMICS TO MITIGATE PILOT INDUCED OSCILLATIONS.
Autor: Leonardo Scaravelli
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Data da Defesa: 03/09/2024
Orientador: Flavio Luiz Cardoso Ribeiro
Coorientador: Daniel Drewiacki
Abstract: This work presents flight control laws design techniques for the lateral dynamics of a flexible aircraft, aiming to reduce the tendency for Pilot Induced Oscillations (PIO). Two commonly cited causes of this phenomenon are addressed in this study: the introduction of phase lag by notch filters and rate saturation of actuators. Then two possible solutions are presented for each of these causes: using aeroelastic feedback to replace notch filters, eliminating its phase-delay; and using roll spoilers for lateral control in order to reduce deflection rates at the ailerons. The effects of aircraft structural flexibility are evaluated using models with nominal and increased flexibility. The performances of the designed architectures are compared in bank-to-bank maneuver simulations and in terms of the *bandwidth vs. phase-delay* criterion. The use of roll spoilers was proved to be effective in avoiding saturation conditions. On the other hand, simulation results for architectures using aeroelastic feedback showed oscillations with higher amplitudes than those observed in architectures employing notch filters. This result occurred because the separation between the rigid body and flexible modal frequencies was significant enough, even for increased aircraft structural flexibility, so that the phase delay introduced by the filters did not affect the response. Nonetheless, parametric studies conducted in this work also showed that in cases where filters are applied at frequencies closer to those of the rigid body modes, there is indeed a degradation in the system's dynamic response, in which case replacing the filters with flexible modal feedback becomes advantageous.

Título: COST ANALYSIS OF AUTOMATED LAMINATION MACHINES FOR COMPOSITE MANUFACTURING.
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Data da Defesa: 12/12/2024
Orientador: Luís Gonzaga Trabasso
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Abstract: Life cycle costs of a complex product tend to be about 75% committed by design phase. Consequently, the application of cost engineering techniques becomes an important tool to obtain more accurate cost estimates, aiming to manufacture more competitive products.
In the context of composite materials manufacturing, there is a desire for investment in automated technologies, due to the improvements in efficiency, productivity and quality brought about by automation. However, obtaining precise pricing details remains a challenge and subject to wide variations, as particularities of the process, the high customization level present in these machines, and the competitiveness inherent to the market. As aviation industry continues to adopt advanced automated solutions, determining the most cost-effective equipment becomes critical to maintain competitiveness and operational efficiency.
The interest of this work is to evaluate a method for comparing composite lamination machines based on the acquisition cost supporting decisions on adopting an automated composite layup process in early stages of aeronautical product development.
The research begins by mapping cost estimating processes relevant to equipment acquisition in the manufacturing sector. The automated composites lamination process is analyzed, with particular emphasis on identifying the primary parameters affecting machine costs, such as production capacity, material compatibility, and technological features. A comparative method is then proposed to systematically assess automated solutions in terms of cost, leveraging pricing data from various manufacturers. Finally, the method is applied to three application cases in the context of the aeronautical sector, enabling an evaluation of its effectiveness and providing guidance for manufacturers seeking to optimize their investment in automated lamination.

Título: THERMOFORMING PROCESS SIMULATION OF A TYPICAL THERMOPLASTIC COMPOSITE RIB.
Autor: Luana Pereira Refundini
Turma: 30
Data da Defesa: 13/09/2024
Orientador: Mauricio Vicente Donadon
Coorientador: Paulo Roberto Zanella Pasquali
Abstract: Following the increasing need for the use of composites in aerospace applications and the high cost involved in experimentally testing the best processing conditions, this project aims to simulate different manufacturing variables for thermoforming thermoplastic composites with woven reinforcement, such as lay-up orientation on tooling, blank thickness and ply-tool friction. Using a representative part of a horizontal stabilizer rib produced in carbon fiber and polyetheretherketone (CF/PEEK) fabric, the main goal was to find some of the manufacturing parameters that could

minimize wrinkle formation during thermoforming. The method used was Finite Element simulation in addition to a non-orthogonal model implemented in ABAQUS/Explicit software, aiming to include the impact of large deformations. The manufacturing variables were compared using the simulations variables: shear strain, draping angle, and fiber volume fraction ratio. The study did not yield conclusive results on the manufacturing defects by itself, as none of simulated configurations presented wrinkling onset. Nevertheless, a process completely frictionless proved to be ineffective for industrial application; despite presenting a lower conforming load compared to other studied conditions, the absence of friction can produce other manufacturing defects such excessive displacement of the blank.

Título: PRELIMINARY SIZING OF ELECTROMECHANICAL ACTUATORS APPLIED TO THE FLIGHT CONTROL ACTUATUIN SYSTEM OF TRANSPORT AIRCRAFT.
Autor: Lucas Schroeder
Turma: 30
Data da Defesa: 12/09/2024
Orientador: Luiz Carlos Sandoval Goés
Coorientador: Lauro Rocha Borges
Abstract: The aviation industry is undergoing a significant transformation towards More Electric Aircraft (MEA), driven by the need to reduce carbon emissions and enhance fuel efficiency, in line with IATA's vision to reduce aviation CO2 emissions by 2050. One promising approach is to replace traditional hydraulic and pneumatic systems with electromechanical components. While Electromechanical Actuators (EMAs) promise numerous advantages such as reduced weight, improved efficiency, and simplified maintenance, their adoption in primary flight control actuation systems (PFCAS) presents challenges related to safety, redundancy, backlash, thermal management, and power demands.

Tools are demanded to quantify these potential benefits, given the necessity to justify the investment and the risks associated with this technological shift. This dissertation addresses these challenges by developing a system-level multi-physical model of EMAs, utilizing existing sub-model libraries from Siemens Amesim. The EMA model enables the validation of top-level specifications during the early stages of PFCAS development. Amesim libraries encapsulate the relevant physics, offering validated, well-documented, and numerically robust models. Utilizing these libraries is a prudent approach to mitigate risks and accelerate development.

The research also focuses on developing a modular tool to size PFCAS based on different actuator architectures across various commercial aircraft sizes, creating and validating an optimization strategy (using CMA-ES) to determine the optimal EMA design parameters for specific aircraft requirements. A case study is presented to demonstrate the model's and tools' potential in helping the assessment of the claimed benefits and trade-offs associated with transitioning to EMA-based PFCAS.

Título: STUDY OF FAILURE MODES IN ELECTRIC PROPULSION ARCHITECTURE APPLIED TO AIRCRAFT.
Autor: Marcio Luiz Pinto da Silva Junior
Turma: 30
Data da Defesa: 11/09/2024

Orientador: Rubens Junqueira Magalhães Afonso
Coorientador: Renato de Souza Mariano
Abstract: This dissertation focuses on evaluating failure modes in an electric propulsion architecture associated with an aircraft that performs vertical take-offs and landings (eVTOL). To achieve this objective, the dynamic behaviors of the main components of the electrical propulsion system architecture were modeled. This setup includes a lithium-ion battery, a two-level inverter, and a permanent magnet synchronous motor (PMSM) coupled to a propeller. In this context, simulations were conducted to analyze failure modes, including phase-to-phase short circuits and motor phase loss. Using MATLAB/Simulink® software, two architectures were evaluated, one associated with a single three-phase winding PMSM motor, and another with a dual three-phase winding motor, also known as a six-phase motor. In addition to simulating failure modes, this work also evaluated strategies to mitigate the impacts of these situations, with the aim of transforming scenarios that could potentially be catastrophic into circumstances that ensure the operational capability of the propulsion architecture.

Título: METHOD FOR PRIORITIZING PRODUCTIVE UNITS FOR IMPLEMENTATIONOF INDUSTRY 4.0: A STRATEGIC APPROACH.
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Data da Defesa: 06/12/2024
Orientador: Luís Gonzaga Trabasso
Coorientador: Gléverson Fabner Conde Lemos
Abstract: The objective of this research is to develop a decision-making tool applicable to the prioritization of productive units (PU) within a manufacturing company in the process of implementing Industry 4.0 strategies. PUs are defined as independent entities concerning processes, products and location, for example, the final assembly line of a commercial aircraft, from an aeronautical industry. Enhancing production lines to Industry 4.0 is a growing priority for major industries. However, with limited resources, it is essential to strategically allocate efforts and investments to production units that offer the highest returns for the company. Decisions are often influenced by leadership preferences or favor more proactive and open areas, which may not always align with the company's best interests. The proposed PRIORI4.0 method introduces a structured approach that incorporates insights from all relevant areas, delivering a prioritized roadmap of production units to focus on for optimal results. Through an exploration of multi-criteria decision methods, portfolio analysis tools, and prioritization techniques, a method for effectively ranking PU has been developed. This method is built on a strategic foundation, consistently applied throughout the research, while aligning closely with the company's overall strategic objectives. In essence, this research endeavors to gather data that supports the evaluation of optimal opportunities, providing a structured approach for ranking productive units. The method was applied in an aerospace company, targeting a scope of eight PUs that encompassed all stages of production to ensure comprehensive representativeness. The process engaged twelve professionals who aligned on seven key criteria to evaluate the PUs.

Título: A SEMI-ANALYTICAL MODEL FOR STRESS ANALYSIS OF COMPOSITE LUGS.
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Turma: 30
Data da Defesa: 30/08/2024
Orientador: Maurício Vicente Donadon
Coorientador: Pedro Higino Alonso de Passos Cabral
Abstract: A methodology based on the Rayleigh-Ritz approach was developed to analyze composite lugs modeled as rectangular laminates with a circular hole under general boundary conditions. A realistic load distribution was considered along the hole, simplifying the complexities of contact models. The first ply failure loads of two different layups under axial and transverse loads were verified against the NASTRAN finite element code. Additionally, layup and geometric optimization of a composite lug was performed to maximize the first ply failure load under axial load. The optimized laminate's failure loads were compared to those of a quasi-isotropic laminate with loads applied in different directions. Verification showed that the predicted failure loads differed by a maximum of 1.6% from the results obtained from NASTRAN. Furthermore, the optimized lug exhibited a 23.3% increase in axial failure load compared to the quasi-isotropic lug.

Título: METHODS FOR ADJUSTING THE DLM MODEL FOR HIGH MACH NUMBERS.
Autor: Matheus Melo Monteverde
Turma: 30
Data da Defesa: 18/12/2024
Orientador: Roberto Gil Annes da Silva
Coorientador: Michelle Fernandino Westin
Abstract: Understanding and addressing the complexities of the flutter phenomenon in transonic flows is of great importance for the aeronautical industry. Transonic flows involve aero- dynamic effects arising from air compression and shock waves formation. The inherent nonlinearity of transonic flows diminishes the precision of traditional linear theories.
To enhance this aspect, linear computational methods are frequently employed in con-junction with correction methods based on more representative data of the flow, obtained from Computational Fluid Dynamics (CFD) or wind tunnel tests.
This work provides a concise review of the physical phenomena present in transonic flows, transonic aeroelasticity, and explores the determination of aeroelastic stability with the application of the Modified Enhanced Correction Factor Technique.
Within the scope of this study, the AGARD 445.6 wing—an extensively investigated transonic case in the literature—is selected. The proposed adjustment method is compared against both without correction and experimental data, in order to evaluate its capability to represent the changes in the aeroelastic stability boundary that arise from nonlinearities and other phenomena typical of the transonic regime.

Título: STRUCTURAL ANALYSIS OF AN AIRCRAFT COMPONENT SUBJECTED TO RANDOM VIBRATION.
Autor: Murilo Henrique Dias Scofoni
Turma: 30
Data da Defesa: 05/12/2024

Orientador: Alfredo Rocha de Faria
Coorientador: Rebeca Kusmitsch Luz
Abstract: This work presents a detailed study on the analysis of random vibration applied to aircraft structural components using the semi-analytical Three-Band Technique. This technique was employed to evaluate fatigue damage induced by random vibration, enabling the prediction of a component's service life even before its manufacturing.
The research was motivated by the severity of random vibration, which excites all frequencies simultaneously in three directions, posing significant challenges to the design of structural components in terms of integrity and reliability. The study assessed the performance of a structural component subjected to different reinforcement iterations, considering changes in parameters such as thickness, material, and manufacturing strategies. Additionally, alternative solutions were explored, such as using materials with superior fatigue properties and adopting new manufacturing processes to improve the component's fatigue resistance and service life.
The results demonstrated the effectiveness of the technique in identifying critical regions and proposing modifications that significantly increased the component's service life. These findings highlight the relevance of employing this tool in the early stages of structural development, where there is greater flexibility to implement changes in the design concept.
It is concluded that addressing random vibration in the initial design phase of aircraft components is essential to ensure safety, reduce operational costs, and increase aircraft availability. Future work includes experimental validation using real-world data and the application of advanced optimization tools to further enhance the results.

Título: MULTIPLE FLEXIBILITY MATRICES IN HIGHLY FLEXIBLE WING FLUID-STRUCTURE ANALYSIS.
Autor: Orlando Gabriel de Lima Almeida
Turma: 30
Data da Defesa: 20/09/2024
Orientador: Flávio Luiz de Silva Bussamra
Coorientador: Angelo Antonio Verri
Abstract: In the commercial aviation market segment, for the business model to be economically viable, it is important to develop technologies focused on reducing aircraft fuel consumption and lowering operating costs. One approach is to build wings with a higher elongation to reduce induced drag, but this can be problematic from an aeronautical engineering point of view. One of the difficulties in developing these wings, usually referred to as “very” or “highly flexible” wings, is predicting the design aerodynamic load. Although there is a certain amount of published work on this subject, there are specific needs in the aeronautical industry to make its implementation viable in loads technology, which is mainly looking for fast and accurate solutions for thousands of load scenarios. An approach commonly used by the industry requires the use of a single numerical flexibility matrix for the undeformed wing with linear structure assumptions and aerodynamic databases generated in wind tunnels or numerically. This is a very reliable process for predicting loads on low and regularly flexible wings, which has been validated over the years. However, with the evolution towards more flexible wings, the usual approach can produce inconsistencies due to the geometric non-linearities that come into existence. Therefore, the aim of this work is to develop a new industrial methodology for the analysis of highly flexible wings, based on the use of multiple flexibility matrices in different deformation conditions, taking into account the geometric non-linearities of the structure

arising from the large displacements. The pazy wing was used to evaluate the new methodology and compare it with the results obtained with the higher fidelity fluid-structure interaction (FSI) model; The new methodology was able to generate results for vertical displacements, rotations and loads that were satisfactorily close to the reference models. The new methodology produced results with a processing time of around 1.80 seconds, while the reference FSI model processing time was over 5000 seconds.

Título: COUPLED STRESS AND FINITE FRACTURE MECHANICS METHODS IN NOTCHED LAMINATES ANALYSIS.
Autor: Rafael Gollner Bayão
Turma: 30
Data da Defesa: 05/09/2024
Orientador: Maurício Vicente Donadon
Coorientador: Amauri Gavazzi
Abstract: The aerospace sector heavily depends on composite laminates, pursuing materials that offer high specific strength. However, the characterization of these materials often involves costly experiments. In this sense, analytical methods that quickly predict material behavior are vital in the early stages of aircraft design where quick evaluations are crucial. For laminate composites the residual strength in plates with open hole is a very important property. For instance, open holes are very common in aeronautical industry, due fastening, system allocation and weight relief purposes. Moreover, results of open-hole analysis are commonly used to define laminate composite allowables through progressive damage analysis. The main objective in this work is to evaluate the performance of using coupled stress and finite fracture mechanics criteria applied to open-hole analysis of composite laminates. It was implemented coupled methods based in both Whitney and Nuismer (1974) Pointwise Stress Criterion (PSC) and Average Stress Criterion (ASC), which are benchmarking in notched laminate analysis. The coupled criteria introduce the use of characteristic distances from hole edge which are simultaneously dependent on material properties and geometrical aspects. The effects and results of this approach are evaluated against the constant distances used for the stress criterion. The coupled criteria require using of Fracture Mechanics equations, thus, it was evaluated the impact of applying different stress intensity formulations and orthotropy influence. Furthermore, techniques for estimating the material fracture toughness were explored as potential ways in reducing experimental testing. In summary, this work elucidates the potential and limitations of using the coupled criteria in open-hole analysis of composite laminates. These methods led to accurate results in material residual strength prediction for structures with damages or riveted parts. Moreover, the studied criteria presented great potential for preliminary design, enabling to reduce experimental costs commonly required in early stages of development.

Título: NUMERICAL OPTIMIZATION OF THE ENTRAINMENT EFFICIENCY OF SUPERSONIC AIR-TO-AIR EJECTORS.
Autor: Renan Balbinotti Kops
Turma: 30
Data da Defesa: 11/09/2024
Orientador: Vinicius Malatesta
Coorientador: Ramon Papa

Abstract: This work presents a methodology for using surrogate modelling to optimize the geometry of a supersonic air ejector pump by utilizing a database built from Computational Fluid Dynamics (CFD) results. The selected case study is an ejector pump due to its simple geometry, complex flow, and wide range of applications, both in current aeronautical solutions and future technologies. The CFD results were obtained using the Generalized K-OMEGA (GEKO) model, following previous literature that indicated its close agreement with experimental data in ejectors. An initial set of points was generated using SFLHS (Space-Filling Latin Hypercube Sampling), and second- and third-order polynomial regressors, the log-linear regressor, a neural network regressor, radial basis function regressor, and the methods of Ordinary, Universal, and Neural Network Kriging were compared. The methods based on the log-linear regressor, radial basis functions, and the third-order polynomial resulted in significant errors in at least one of the macro parameters evaluated for the ejector. Other models had similar performances, with Universal Kriging being chosen as the best predictor. The model was refined using an infill methodology that combined global exploration and local exploitation around the Pareto front, obtained with an optimization algorithm that maximized the Entrainment Ratio and Pressure Ratios, while constraining the ejector outlet temperature to T_{out} > 320 K. The infill procedure was run until the surrogate prediction error in the pareto region converged to a desired value. The methodology was able to find ejectors geometries that improved the Entrainment Ratio performance (the ratio of secondary to primary mass flow at the ejector inlet) by 11.6 % for a pressure ratio (outlet pressure over inlet pressure) of 0.97, and by 108.1 % for a pressure ratio of 1.05, when compared to the baseline ejector.

Título: COMPUTATIONAL ASSESSMENT OF DIFFERENT STRATEGIES FOR PLY DROP-OFFS IN LAMINATES.
Autor: Róger Ghedin Pereira
Turma: 30
Data da Defesa: 03/12/2024
Orientador: Alfredo Rocha de Faria
Coorientador: Amauri Gavazzi
Abstract: The adoption of composite materials by the aerospace industry has revolutionized aircraft design, offering an excellent strength-to-weight ratio. As the use of composites increases rapidly in aviation, the challenge of managing changes in the composition of a laminate along its length, caused by the termination of one or more layers, also known as ply drop-offs, is of high importance due to its potential to induce stress concentrations and, consequently, compromise structural integrity. Ply drop-offs are necessary as a way to change the strength of laminates subject to loads varying along their length, for example in aircraft wing panels, so as to reduce weight. This thesis employs computational finite element method methodology using Abaqus software to numerically explore and compare design strategies to mitigate the detrimental effects of ply drop-offs in laminated composites. Different laminates containing drop-offs subject to a traction force in the drop-off direction were analyzed and the generated stresses obtained. A study of internal and external drop-offs was executed, as well as studies varying the stagger distance (distance between successive drops) and drop-off order for cases with multiple drop-offs. The studies found that the external drop-offs create much larger stresses than internal ones and should be avoided. In relation to stagger distance, it was found that dropping multiple plies at the same location induces greater stresses, so should also be avoided, and that the stagger distance is not very relevant as long as the resin pockets created do not overlap. The drop-off order study showed little sensitivity to the position of

the plies in the laminate, but showed that it is beneficial to drop the less stiff (in the load direction) plies last.

Título: SIMULATION AND PERFORMANCE ANALYSIS OF THERMOELECTRIC COOLERS FOR AIRCRAFT ELECTRONICS.
Autor: Thales Roger Alves de Paula
Turma: 30
Data da Defesa: 11/10/2024
Orientador: Izabela Batista Henriques
Coorientador: Everton Luiz Salles
Abstract: This work presents a comprehensive investigation into the practical application of thermoelectric modules for managing the temperature of aircraft electronics. It includes a detailed review of the principles of thermoelectric cooling, the proposal of a novel method for estimating thermoelectric coefficients, the development of simulation models and the validation of these models through laboratory tests. The thermoelectric cooler is a device that uses the Peltier effect to convert direct current into heat flow. It can be employed in aircraft components that need to operate under a wide range of temperatures. One of the main advantages of this technology is that it allows the thermal load to be maintained at temperatures below ambient, while also being a smaller and potentially lighter system than the compressor-based solutions. The aim of the study is to assess the feasibility and performance of thermoelectric coolers (TECs) in aerospace applications, particularly focusing on their ability to maintain optimal operating temperatures for electronic components. Results show that the developed models and estimated coefficients achieved good agreement with the data acquired in laboratory, presenting errors of up to 1.8 °C in the steady-state simulations. The simulations of the cooling system under flights conditions demonstrated that the system was capable of maintaining the electronics enclosure temperature well below the maximum allowable limit. When supplied with constant 12 V the temperature of the load was maintained bellow 40 °C, and was below 30 °C at the end of the flight. However, it also indicates that the total heat dissipation might be increased by up to six times in the studied case, with an average electrical demand of 573 W if no voltage control is applied.

Título: DYNAMIC LI-ION BATTERY-CELL MODELLING FOR AERONAUTICAL ALTERNATIVA PROPULSION APPLICATION.
Autor: Víctor Andrei Rosa da Silva
Turma: 30
Data da Defesa: 01/10/2024
Orientador: Carlos Cesar Aparecido Eguti
Coorientador: Thiago José Lima
Abstract: The objective of this work is to develop a dynamic modeling project of a lithium-ion battery (LIB) cell for application in alternative aeronautical propulsion. It contains the motivations, given the global context of aviation; an explanation of the concepts of electric and hybrid-electric aeronautical propulsion, as well as its state-of-the-art in the market; a presentation of the topologies of chemical composition of lithium-ion batteries and their characteristics; and finally the main proposal which consists in the development of the dynamic model of a lithium-ion battery cell considering the influence of temperature for analysis of its use in fully electric propulsion. The dynamic model of the Samsung INR18650-20R battery and the load profiles are simulated in the MATLAB

software using the MATLAB Simulink tool. The main expected result of this work is to obtain a battery model based on an equivalent electrical circuit that presents accuracy similar to the reference bibliography and that has simple usability for simulation of mission profiles of hybrid propulsion or all-electric propulsion aircraft.

Título: FLIGHT MECHANICS ANALYSIS COUPLED WITH CFD.
Autor: Victor Hassun Sarmento
Turma: 30
Data da Defesa: 12/09/2024
Orientador: Vinicius Malatesta
Coorientador: Marcos Heinzelmann Junqueira Pedras
Abstract: Flight Mechanics Analyses are usually performed using aerodynamic databanks. Those databanks may present limited fidelity in envelope regions with nonlinear effects predominance and, consequently, may not be suited to predict non-linear flight mechanics behavior of the aircraft. Additionally, coupling the flight mechanics simulations with CFD may be cheaper than perform flight tests. Therefore, this work aims to use non-inertial CFD capabilities, available on open-source CFD code SU2, to extend flight mechanics simulations potential. The proposed approach is, until now, not well explored in Academy and the authors who have already adressed the subject to increase fidelity on accuracy of flight mechanics simulations, did not present the software coupling strategy and, hence, this work will allow the development of a tool that can be used in the development of future technological research.

Título: EVALUATION OF BUILD UP ORIENTATION AND SUPPORT STRUCTURES IN TI6AL4V LBPF ADDITIVE MANUFACTURING USING NUMERICAL SIMULATION.
Autor: Victor Hugo de Abreu Nigri
Turma: 30
Data da Defesa: 01/10/2024
Orientador: Anderson Vicente Borille
Coorientador: Marcio Fernando Cruz
Abstract: This thesis investigates the complexities of the Laser Powder Bed Fusion (LPBF) process with a focus on understanding how the buildup orientation of printed metal parts affects deformation due to residual stresses. The research is driven by the increasing significance of additive manufacturing in the aerospace industry and the critical need for accurate simulations to prevent process failures, as observed in industrial applications. Additionaly, the study aims to evaluate the accuracy of MSC Simufact software in simulating these components and to analyze the errors associated with varying the inclination angle of parts during simulation. A comprehensive methodology combining experimental and simulation-based approaches was carried out. The study explored the physical phenomena inherent to the LPBF process, such as heat transfer and material flow, and systematically examined the effects of buildup orientation of printed metal parts on resulting deformation. Despite initial expectations, the results revealed no significant correlation between the buildup orientation angle and deformation due to residual stresses. However, a relationship was identified between the volume of support structures used during the process and the accuracy of the simulations, suggesting that insufficient mesh refinement in the support structures might lead to increased simulation errors. The findings contribute to the broader understanding of the LPBF process and highlight critical areas for

improvement in simulation practices. Specifically, the research underscores the need for more refined meshing techniques and optimized support structure designs to enhance the accuracy of virtual predictions in LPBF. The dissertation concludes with proposals for future work, including the refinement of simulation models, exploration of alternative simulation tools, and further investigation into the optimization of process parameters.

Título: LINEAR PARAMETER-VARYING FLIGHT CONTROL LAW DESIGN FOR THE LONGITUDINAL DYNAMICS OF A FLEXIBLE AIRCRAFT.
Autor: Victor Hugo de Oliveira Pinto
Turma: 30
Data da Defesa: 13/09/2024
Orientador: Antônio Bernardo Guimarães Neto
Coorientador: Fernando José de Oliveira Moreira
Abstract: This dissertation proposes applying the LPV (linear parameter varying) technique to the integrated design of control laws for the longitudinal dynamics of flexible aircraft. The main objective is to ensure the stability and performance of the closed-loop system within the flight envelope, preventing flexible modes from adversely affecting the aircraft's behavior. To achieve this objective, performance and flying quality criteria related to the aircraft's rigid-body dynamics are integrated with criteria for attenuating aeroelastic modes in a single design. The longitudinal dynamics present a particularly complex challenge due to the closer proximity of the short-period and the first aeroelastic modes' frequencies, leading to greater aeroelastic interactions compared to the more widely studied lateral-directional dynamics. The LPV technique has the potential to reduce performance degradation that typically occurs when filters are added later in the design process to attenuate the aeroelastic response. Additionally, comparisons with the more traditional H∞ control technique will be conducted to assess the effectiveness and advantages of the proposed LPV approach. This study aims to enhance knowledge in controlling flexible aircraft, focusing on improving stability and safety, and ultimately enabling the development of more efficient aircraft and a greener future.

Título: IDENTIFICATION OF CHALLENGES FOR AUGMENTED REALITY IMPLEMENTATIONS IN AIRCRAFT MANFACTURING.
Autor: Victor Melo de Almeida
Turma: 30
Data da Defesa: 04/09/2024
Orientador: Emilia Villani
Coorientador: João Marcos Gomes de Mello
Abstract: The rapid advancement of Augmented Reality (AR) technologies has sparked interest in their application across various industrial sectors, particularly manufacturing. The potential of AR technologies to enhance manufacturing processes such as assembly, training, and quality control has been extensively studied. However, there has not been widespread adoption of this technological category within the industry. For AR applications to succeed, a comprehensive understanding of the challenges involved is crucial. This paper aims to investigate and identify the most common obstacles encountered in the implementation of AR applications in the manufacturing sector. Initially, a preliminary flowchart was developed based on data gathered from the literature to identify the current technological status of AR. Subsequently, interviews were conducted with experts involved in AR projects to identify and prioritize the obstacles encountered in

implementing this technology. The identified challenges were then discussed in order of relevance, using data from the literature and experiments conducted in this study. Finally, the collected knowledge was incorporated into the initial flowchart, making it more complete and more specific to AR applications in manufacturing. By identifying and discussing the obstacles faced by operators and engineers, it is anticipated that this work will not only contribute to the existing body of knowledge on AR technologies but also stimulate further research on the topic and improve the success rate of AR applications in real-world manufacturing scenarios.

Título: DESIGN OF AN INTEGRATED DOOR STRUCTURE FOR AN EXECUTIVE AIRCRAFT.
Autor: William Corbelli
Turma: 30
Data da Defesa: 02/09/2024
Orientador: Alfredo Rocha de Faria
Coorientador: João Aparecido Lopes
Abstract: The aircraft door has several functions, including providing access to the cabin, ensuring aerodynamic smoothness, serving as an emergency exit, ensuring the structural continuity of the fuselage, as well as providing pressurization sealing. Similar to other structural components, doors are composed of various primary parts. The assembly of these components requires a significant amount of labor hours, which leads to an increase in manufacturing costs and higher levels of stress concentration in the component due to material removal from the parts that make up the final structure. The objective of this study is to design and structurally dimension a passenger door for an aircraft using an integrated structure (without the presence of joints), aiming to compare the structural performance between the current industry-standard door model and the proposed one. To achieve this objective, the study was based on the aircraft designed during phase 3 of the Engineering Specialization Program, considering the structural configuration of the fuselage and the loads calculated during the preliminary studies. The analysis began with a structural simplification, from which the structural behavior of the fuselage section was obtained. This led to the definition of two door structures, one conventional and the other integrated. Both structures were designed using a finite element model and considering static failure criteria (material strength, stability, joints, and fasteners). The study compared the structural performance of an integrated door and a conventional door structure, finding the integrated door slightly superior due to lower mass. However, the sizing process did not consider fatigue life, impacting operational cycles and final structural weight. The integrated structure had lower costs for assembly time and manufacturing, suggesting a preference for it. Despite these advantages, the conventional door structure was deemed better due to preliminary studies.

DISSERTAÇÕES DO ANO DE 2023

Título: CONTENT-BASED IMAGE RETRIEVAL (CBIR) FOR MARINE VESSEL IDENTIFICATION
Autor: Bryan Lucas Goncalves Dos Santos
Turma: 29
Data da Defesa: 04/08/2023
Orientador: Ana Carolina Lorena

Coorientador: Juliano Elias Cardoso Cruz
Abstract: Marine surveillance and monitoring rely heavily on recognizing and identifying marine vessels. Everything from satellite imagery to infrared is used to perform this monitor- ing, but this is a costly and labor-intensive process. One way to do this identification is through images of the ships on the coast, thus allowing the identification of the maritime vessel. This method of searching a database for similar images is known as Content-Based Image Retrieval (CBIR). The objective of this work is to implement local, global and ma- chine learning based feature extraction state-of-the-art methods to the Maritime Vessels classification dataset (MARVEL) to evaluate and compare their performance in vessel identification. Considering the analyzed methods, ORB presented the best performance among the classical methods, with a mAP of 5.65%, a high inference time of 0.062 s and a descriptor of 512 × 32 values. Regarding the state-of-the-art methods, taking into account accuracy and storage space, BEiT-v2 presents a mAP of 95.05% with a descriptor of only 768 values and 85M parameters to be trained. Considering inference time, VGG-19 had a time of 0.84 s, an order of magnitude lower than BEiT-v2, whilst maintaining a high mAP of 94.99%, but uses a descriptor of 4096 values and the network has 140M parameters to be trained.

Título: A FLUID-STRUCTURE INTERACTION FRAMEWORK FOR STATIC AEROELASTIC ANALYSIS WITH SU2 AND NASTRAN
Autor: Caio Ladeia Costa Alves
Turma: 29
Data da Defesa: 17/08/2023
Orientador: Flávio Luiz de Silva Bussamra
Coorientador: Ângelo Antonio Verri
Abstract: An important technology for achieving more efficient aircraft is the use of materials and geometries that reduce aircraft weight and drag. Lightweight and slender designs result in significantly more flexible structures. Thus, tools that can evaluate the aerodynamic performance and structural behavior of highly flexible wings are of great importance to the industry. In this context, this work presents the development and application of a fluid-structure interaction framework for the evaluation of the static aeroelasticity of a very flexible wing by coupling a high-fidelity aerodynamic model to a structural model that considers the geometric nonlinearities of the structure. For this purpose, the open-source software SU2 with the RANS solution was used for the fluid-dynamic analysis and the MSC Nastran software for the nonlinear static analysis.The simulations performed using this methodology resulted in vertical displacements with good correlations between the results of other lower fidelity methodologies with a difference of up to 1.5%. In addition, it was possible to identify that the FSI methodology was able to adequately capture the coupling phenomena of the disciplines analyzed based on the comparison with wind tunnel tests. For vertical displacement the results obtained were very close to the tests, resulting in a difference of up to 5% considering the entire range of angle of attack analyzed. For the wing rotation most of the results were also very close to the test values with differences up to 8%, however, for higher values of speed (50 m/s) and angle of attack (7°) the difference reached 18%.Although, the FSI framework showed high computational cost with simulations taking up to 42 hours. Nevertheless, the analysis performed in this work showed the change of aerodynamic and structural behaviors when considering the flexibility of a wing. The aerodynamic results showed a significant increase in the lift coefficient of the wing when considering the flexibility of the wing analyzed with proposed FSI framework. The rigid wing showed increases up to 41% for

lift coefficient if compared with flexible wing. In addition, the structural results show a distinct difference in the bending moment and torsional moment along the span, with increases of up to 29% among the analyzed conditions.

Título: DESIGN FOR MANUFACTURING AND ASSEMBLY GUIDELINES TO SUPPORT DESIGNERS OF INTERIOR EXECUTIVE JETS
Autor: Camila Hamden Susin
Turma: 28
Data da Defesa: 03/02/2023
Orientador: Rodrigo Arnaldo Scarpel
Coorientador: José Victor Voltarel
Abstract: Designing a product for ease of manufacturing and assembly contributes for reduced manufacturing cost and faster production cycle. Over the years, various methodologies have been studied to enable this development, among which there is the design for man- ufacturing and assembly (DFMA). This methodology focus in making simple considera- tions, contained in a general guideline list, in the early stages of the project, regarding aspects that can affect manufacture and assembly. Embraer furniture factory (FME), located in Brazil, supplies interior furniture for some aircraft of the executive segment; however, the design and creation of these unique items are made by Embraer's inter- national team in the United States. The large distance between the locations ends up creating a communication gap between those teams, which interfere in the basic knowl- edge about FME processes that the USA team must have and consider during the design phase. This dissertation proposes the application of DFMA methodology in one monu- ment of FME production. The objective is to analyze the interior items according to the literature general guidelines and develop a personalized guidelines list to assist Ameri- can designers to conceive products that are easy to manufacture and assemble regarding FME installations. In order to achieve this purpose, action research method is followed, conducting the study alongside the daily activities of the factory. The participation bias of the method involves the personnel with interviews, soft and hard data gathering. The expected results are reduction of manufacturing cost and production cycle through a sim- plified manufacturing and assembly process.

Título: STRENGTH AND FRACTURE ANALYSIS BASED ON THE TSAI'S MODULUS APPROACH
Autor: Carlos Henrique Possebon
Turma: 29
Data da Defesa: 18/08/2023
Orientador: Maurício Vicente Donadon
Coorientador: Paulo Roberto Zanella Pasquali
Abstract: The objective of this work is to develop a methodology for analyzing laminates with notches through a novel approach of finite fracture mechanics applied to different environmental conditions. This work uses the invariant theory for composites and an equation that estimates the strength for a laminate based on the Unit Circle Criterion, both proposed by Tsai and Melo. This approach eliminates the need for extensive testing campaigns and provides a faster and more economical method for the preliminary design of composite parts resistant to damage. Additionally, the work also investigates the applicability of these concepts to composites exposed to three different environmental conditions. The research begins with a theoretical foundation covering the elastic

properties of composites at the ply and laminate levels. It reviews the Classical Lamination Theory, the invariant theory for composites, and the Tsai-Wu Criterion for ply strength evaluation. Furthermore, it explores the determination of mode I fracture toughness and proposes a new equation based on the Elastic Modulus and tensile strength of the ply (both in the fiber direction) for determining the fracture toughness of a laminate. The methodology is implemented using Matlab code, which tests the validity of the Master Ply concept and the equation for estimating laminate strength in different environmental conditions. The results demonstrate the accuracy of the approach proposed using Tsai's modulus, but the equation shown for estimating strength had less satisfactory results. The dissertation concludes by presenting a new method for estimating mode I fracture toughness using the properties of composite materials. Compared to the values taken, this method had an error of more than 30% in some cases. For this reason, its use is not recommended in industrial applications. This work highlights the scarcity of literature on the use of invariants in the context of composite fracture mechanics and suggests potential directions for future research, including the study of fracture mechanics under compressive loading. In summary, this dissertation contributes to the field by providing a methodology for preliminary design and analysis of parts manufactured from composite materials, reducing the need for extensive testing and offering engineers an economical approach to understanding the behavior of composites in the presence of cracks and holes.

Título: INVESTIGATION OF NON-DESTRUCTIVE TESTING CAPABILITES TO INSPECT TITANIUM PARTS MANUFACTURED BY LASER POWDER BED FUSION
Autor: Daniel Rabaca Panichi Vieira
Turma: 29
Data da Defesa: 10/08/2023
Orientador: Anderson Vicente Borille
Coorientador: Márcio Fernando Cruz
Abstract: To achieve the full potential of additive manufacturing in the aeronautical industry, non- destructive inspection techniques are required to certify the developed parts. However, the limitations and capabilities of each technique are not fully understood, limiting the reliability of the parts. In this context, this work identifies the main techniques that are being used, studied and developed for non-destructive inspection of Ti-6Al-4V parts manufactured by the method known as LPBF (laser powder bed fusion). It was done by developing a test specimen with defects inserted, designed with different sizes, shapes and positions in order to test if they were fabricated as designed. Furthermore, X-ray, X-ray tomography and metallography tests were carried out with this specimen so as to achieve repeatability in the manufacture of these parts. In the end, this work pretends to discover the limitations for each of these techniques and which of them are more suited to evaluate each kind of defect, taking into account the technique resolution, bias and capacity limit. It was determined that the X-rays' is capable of observing any defect above 1 mm in size, specially elongated defects. Meanwhile, tomography has shown that the defect dimensions drawn on CAD software are always bigger than the real values and has also shown that defects below 0,1 mm in size weren't able to self support themselves, getting filled with solid material. The metallography proved the presence of powder adhered to the surface of the defects, causing geometric differences in their shapes.

Título: STUDY AND ANALYSIS OF PROPELLER HARMONIC NOISE PREDICTION
Autor: David Da Silva Cavalcante
Turma: 29
Data da Defesa: 10/08/2023
Orientador: André Valdetaro Gomes Cavalieri
Coorientador: Leandro Guilherme Crenite Simões
Abstract: Urban mobility is on the verge of a huge paradigm shift with the advent of eVTOLs, which promises to revolutionize transportation in large cities. Much more Urban Air Mobility (UAMs) aircraft are expected than helicopters. In this context, it is impractical to think of aircraft as noisy as helicopters flying much more frequently, leading to discussions of noise and comfort in the urban context. At the same time, the aeronautical industry has been increasingly investing in alternative propulsion system in the context of energy transition and sustainable aviation, which encourages the use of propellers in new aircraft projects. The mitigation of noise caused by rotors and propellers is then a topic that has been prominent in debates in recent years, further stimulating research and studies in the field. Noise prediction methodologies, wind tunnel experiments and studies of new designs are some of the areas influenced by this vibrant subject. The purpose of this study is to evaluate one of the noise prediction tools known in the industry, assessing its harmonic noise prediction capabilities for propellers at different angles of attack. This required the generation of hundreds of inputs for the program, which was executed iteratively, resulting in hundreds of outputs that were then organized into a database for exploration throughout the work. Through the analysis of harmonic noise prediction for low and high angles of attack, considering different observer positions, the aim was to perceive and understand the influence of the angle of attack on the results, as well as the possible relationship between the unsteady lift coefficient calculated by the program and the resulting noise prediction. The results obtained for noise prediction considering the CL unsteady indicate a relation between noise levels and the angle of attack. This can be justified by the way the unsteady lift coefficient is calculated, causing higher angles of attack in the prediction to have correspondingly higher noise values. Additionally, it was interesting to investigate the distribution of the noise field.

Título: FLEXIBLE AIRCRAFT DYNAMICS USING A MULTIBODY APPROACH
Autor: Dimas Silverio Da Silva Junior
Turma: 29
Data da Defesa: 04/08/2023
Orientador: Flávio Luiz Cardoso Ribeiro
Coorientador: Fernando José de Oliveira Moreira
Abstract: In pursuing more competitive aircraft designs, the aeronautical industry has been exploring materials with higher yield points and lower modulus of elasticity to enhance structural efficiency. Additionally, adopting higher aspect ratios has become common to improve aerodynamic efficiency. These advancements have led to increased flexibility in aircraft structures, particularly in components like the wing. Consequently, it has become imperative to develop models capable of accurately handling large deflections and predicting the nonlinear behavior exhibited by these flexible structures. The utilization of existing software available in the market can be restrictive in such cases due to the significant nonlinearity and computational demands involved. Hence, this dissertation focuses on developing a lumped-mass model of a beam-like wing consisting of rigid elements and flexible joints connected to a rigid node. This model aims to simulate the aircraft's dynamic response using a more straightforward approach to the equations of

motion. Moreover, practical considerations such as computational resources and real-time sim- ulations are considered. The research is conducted on a simplified wing model, approx- imating its behavior as a beam-like structure previously employed in studying highly flexible aircraft. This approach strikes a balance between feasibility and computational efficiency, allowing for valuable insights into the influence of flexibility on flight dynamics. While building upon previous work, this research contributes to further understanding and refining the application of such simplified models to gain insight into the behavior of highly flexible wings. The resultant model was able to predict the behavior of the flight dynamics of the highly flexible structures with reasonable proximity to other methods available. It was possible to gain insight into the impacts of flexibility in aeroelastic phenomenons such as control reversal and simulate the flight dynamics in a disturbed condition over the calculated equilibrium.

Título: SENSOR FUSION OF AN AERIAL VEHICLES FOR URBAN AIR MOBILITY
Autor: Fabio Takeshi Asakura Okina
Turma: 29
Data da Defesa: 11/08/2023
Orientador: Marcos Ricardo Omena Albuquerque Máximo
Coorientador: Daniel Viotti
Abstract: Sensor fusion techniques have provided aircraft with more reliable, robust, and accurate navigation systems by combining data from different sensors. In the context of urban air mobility (UAM), where navigation presents challenges due to low-altitude flight and congested airspace, sensor fusion offers an opportunity to improve navigation performance. In this work, a multi-sensor fusion approach with the Error State Kalman Filter is formulated to integrate data from an inertial measurement unit (IMU), a Global Navigation Satellite System (GNSS) receiver, and a camera for fiducial marker pose detection for navigation of a UAM aerial vehicle. The navigation solution proposed is inertial based with different combinations of corrections with tightly and loosely coupled GNSS fusion, and aircraft pose estimates from fiducial markers. The filters are evaluated in Monte Carlo Simulations for consistency and accuracy. The results are validated in simulations with synthetic images for fiducial marker detections, GPS constellation models for the GNSS measurements, and stochastic models with varying biases for the IMUs. The ESKF solution with tightly coupled IMU and GNSS fusion presented the best results with an accuracy of 0.34 m horizontally and 1.26 m vertically. With the fiducial marker fusion, the error is further reduced by 33 % horizontally, 68 % vertically, and 56 % in attitude.

Título: EVALUATION OF COLLABORATIVE ROBOTS APPLICATION IN AIRCRAFT FINAL ASSEMBLY
Autor: Felipe Julian Miotto
Turma: 29
Data da Defesa: 02/08/2023
Orientador: Emília Villani
Coorientador: João Marcos Gomes de Mello
Abstract: This work presents studies for the application of Collaborative robots in the final assembly stage of aircraft manufacturing. Initially, a comprehensive bibliographical analysis was carried out in arder to understand the processes and activities involved in this stage of the aircraft production process. ln addition, the current scenario of Collaborative robotics was characterized, through the identification of applications and studies for the

implementation of Cobots in assembly processes, including cases from the aeronautical industry and from other sectors such as automotive, electrical / electronics, and metal mechanics. Different frameworks for evaluating the application of collaborative robots were identified in the literature, which allowed the development of a methodology that would allow the mapping, identification, and selection of the most appropriate application. This methodology was defined in arder to allow decision-making taking into account the balance between the expected benefits and the complexity in the development of the solution. Based on this methodology, an in-depth mapping of the final assembly processes of a single-aisle commercial aircraft was carried out, allowing the identification of eight potential applications for Collaborative robots. Such applications were then evaluated according to the criteria defined in the methodology, allowing the identification of the installation of fuselage ceiling paneis as the most suitable application to be implemented. From the definition of the application, studies were carried out for the development of a conceptual project of the robotic solution to be used, following the methodology of the system design process, part of the concept of systems engineering. Starting from the mapping and assessment of stakeholders, and needs and restrictions identification, it was possible to map the current scenario and define the future scenario within the scope of CONOPS, leading to the definition of application requirements. Finally, from the mapped requirements, a systems architecture was defined, and different solutions were identified for each component. Such solutions were evaluated through trade-off studies and simulations in a computational too!, allowing the definition of the most adequate conceptual solution for the studied application.

Título: A LUMPED MODEL FOR ICE ACCRETION IN AIRCRAFT FUEL FEED SYSTEMS LINES
Autor: Fernando Pandolfo Provin
Turma: 29
Data da Defesa: 09/08/2023
Orientador: Vinicius Malatesta
Coorientador: Andre Katchborian
Abstract: Water contamination in aircraft fuel tanks is an important issue. It leads to microbial contamination, corrosion, or ice adhesion. This adhesion at the fuel lines can break off and obstruct downstream components. As a result, research and tests are performed during the certification campaign to verify the amount of ice adhered, that is highly costly. Therefore, a greater knowledge of the phenomenon can help to minimize development costs, making the usage of a model particularly advantageous. A lumped model was created in this work to better understand the parameters' influence on ice adhesion. It employs a mass transfer analogy to explain particle movement in a multi-phase inner flow, as well as experimental data on the adhesion strength of the accreted ice. It obtained consistent results with the high Reynolds flows of the validation data while having a minimal processing cost and being able to calculate the ice accretion for 7 specific situations with maximum time of 15 hours in under 3 minutes. For lower Reynolds numbers, the inaccuracy reached 43%. It was capable of handling flow changes showing ice removal with the instantaneous increase in flow. Analyzing the model's sensitivity revealed that at high flow rates, shear stresses are significant and cause ice to be released, whereas at low flow rates, momentum transfer between layers is low and particle impingements are lower which causes low accretion. In the diameter analysis, an inversion of the increasing trend for accretion rates around the 1" tube is shown.

Título: A VISION BASED DETECTOR FOR NON-COOPERATIVE AIRBORNE OBJECTS FROM SYNTHETIC IMAGES
Autor: Iuri De Oliveira Parada
Turma: 28
Data da Defesa: 10/08/2023
Orientador: Paulo André Lima de Castro
Coorientador: Ney Ricardo Moscati
Abstract: This work implements a proof-of-concept for a computer vision based airborne object detection system intended for collision avoidance. The system shows itself to be very promising for disruptive Advanced Air Mobility applications and drone operations, besides potentially also being able to be used as a cheap alternative for collision detection in general aviation. Technology and use case analysis were conducted in order to specify requirements and map possible system applications, and the final result has been promising in regards to accomplishing the established performance goals. Additionally, an agnostic dataset generation tool has also been implemented.

Título: METHODOLOGY TO EVALUATE FLUTTER ON GEOMETRIC NONLINEAR STRUCTURAL WINGS APPLIED TO THE PAZY WING
Autor: João Flavio Bolini De Oliveira Lima
Turma: 29
Data da Defesa: 06/07/2023
Orientador: Flávio Luiz de Silva Bussamra
Coorientador: Angelo Antonio Verri
Abstract: This study investigates the nonlinear aeroelastic stability of the Pazy wing, a bench- mark for theoretical aeroelastic research analysis within the Third Aeroelastic Prediction Workshop (AEPW 3 - NASA). Different institutions were challenged to predict the static deflections and flutter behavior in this case of a highly flexible wing subjected to structural geometric nonlinearity with flutter onset and offset along the wind-tunnel test. This work presents the effort of the ITA-Embraer team in creating a methodology for matched flut- ter solution. The traditional flutter analysis is applied in a new nonlinear fluid-structure framework to explicitly account for solely the structural deflection with geometric nonlin- earity. The new aeroelastic approach was applied without adjustment in order to verify the modeling capability. First the theoretical vibration modes are presented in comparison to experimental test, which was within 3.5% difference. Then, the theoretical flutter speeds are compared to experimental results, within 3.3% difference for onset and 2.8% difference for offset. The results indicate that the matched solution approach is effective in captur- ing the flutter velocity with good accuracy, being a simplified approach for capturing the main physics behind the problem. When comparing theoretical undeformed condition to nonlinearly deformed condition, there was 26 to 41% difference in flutter speed depending on the angle of attack, highlighting the importance of performing nonlinear analysis on very flexible wings.

Título: COST-BENEFIT ANALYSIS OF INCORPORATING NEW SENSORS INTO AIRCRAFT
Autor: João Pedro Henrique De Paula
Turma: 29
Data da Defesa: 15/08/2023
Orientador: Guilherme Conceição Rocha

Coorientador: João Pedro Pinheiro Maleré
Abstract: Given the high complexity, competitiveness and intrinsic characteristics of the aviation market, its various players are always seeking to reduce operating costs in order to increase return margins and profitability. In addition, to maximize business efficiency, it is important that the airline operations follow a given schedule with the fulfillment of flights with the fewest possible delays and cancellations, thus avoiding costs such as lost opportunity. Integrated Vehicle Health Management (IVHM) is a system capable of integrating aircraft health monitoring with the management of operators, aircraft manufacturing companies, suppliers and the entire logistics chain, thus allowing access to several benefits such as reduced corrective maintenance needs, better planning of maintenance activities, better management of spare parts inventory levels, among others. The focus of this study is to calculate the costs of implementing IVHM systems and new sensors in aircraft and also to calculate the benefits of its use for operators, suppliers and aircraft manufacturers, analyzing all these costs and benefits on a monetary basis and calculating them for the complete aircraft life cycle. To do so an exploratory research was performed with the goal to better understand the studied theme and determine the existing gaps and contribution possibilities. A study case of application of new sensors regarding IVHM purposes was performed, and it was based on a fictitious aircraft designed until the preliminary design phase. After the analysis it could be observed that the addition of new sensors into aircraft with regarding health monitoring purposes can generate gains to the original equipment manufacturers, components suppliers and operators. The proposed model can aid in the decision making of implementing or not new sensors into aircraft, mainly depending on the business model and analyzed aircraft characteristics. Keywords: Systems health monitoring; Cost analysis; Sensors; Maintenance; Aircraft; Life cycle; Study case; Decision making; Aeronautical engineering.

Título: COMPARATIVE ANALYSIS OF METHODS FOR HEALTH MONITORING OF A POWER SUPPLY
Autor: Lucas Lemos Hein
Turma: 29
Data da Defesa: 21/08/2023
Orientador: Roberto Kawakami Harrop Galvão
Coorientador: João Pedro Pinheiro Maleré
Abstract: The development of Prognostics and Health Monitoring (PHM) solutions provides benefits to the aeronautical industry by enabling predictive maintenance of aircraft components, increasing their availability, enhancing safety, and reducing operational costs. With the growing use of electronic equipment in critical aircraft systems, understanding and predicting failure modes become crucial. In this context, there is a particular interest in power semiconductor devices, whose components operate under highly demanding conditions and have high failure rates. The aim of this study is to compare methodologies for predicting failures in power semiconductor devices used in power supplies. To achieve this, an existing database will be used, obtained from an experiment designed to characterize the operation of a power supply in both healthy and degraded scenarios, obtained experimentally through accelerated aging based on the Hot-Carrier Injection (HCI) principle. The analysis will focus on replicating the multivariate regression method proposed by Rodrigues et al. (2012a), with its applicability evaluated. Additionally, a second, less complex method will be proposed, allowing the identification of the power supply's health by exclusively monitoring the output channel voltages.

Título: COMPARATIVE STUDY BETWEEN COMPOSITE MATERIALS RECYCLING PROCESSES
Autor: Marco Aurelio Horban
Turma: 29
Data da Defesa: 09/08/2023
Orientador: Anderson Vicente Borille
Coorientador: Viviane Jordão Sano Prado
Abstract: With the growing usage of Carbon Fiber–Reinforced Polymer (CFRP) composites in the last decades, problems regarding the disposal of this material are continually being more evidenced. Despite recycling techniques being available, the main destiny of End-of-Life (EoL) and manufacturing waste composites still is environmentally irresponsible methods like land-filling and incineration. Nonetheless, a paradigm shift is expected in the incoming years. The current societal ecological awareness is driving the creation of environmental legislation against practices that go against the concept of the circular economy. As composite recycling becomes more relevant in the manufacturing industry, the decision between available CFRP disposal alternatives also becomes more present and complex. Therefore, the author aims to develop a decision-making tool based on a Multi-Criteria Decision-Making (MCDM) method for selecting the optimal CFRP disposal alternative. The chosen MCDM method was the Analytic Hierarchy Process (AHP) combined with Monte Carlo simulation. To achieve this objective, a brief review of the principal composite recycling and non-recycling alternatives was performed, along with the construction of a database of parameters for said alternatives. Finally, the methodology was implemented in a Python script and tested with a case study. The developed model has shown to be capable of ranking the recycling methods (mechanical, fluidized bed process, pyrolysis, solvolysis, and hydrolysis) and the non-recycling methods (incineration and landfilling) based on the user's preferences. The analysis of process data has shown a level of relation between parameters weights distribution and the assumption set prior to the case study. In general, the proposed tool not only have shown to be effective in determining the best alternative but also in the study of the particularities of each method through the analysis of weight distribution.

Título: USE OF AUGMENTED REALITY IN THE FINAL ASSEMBLY OF AIRCRAFT
Autor: Maria Cecilia Pontes Silva
Turma: 29
Data da Defesa: 31/07/2023
Orientador: Emília Villani
Coorientador: João Marcos Gomes de Mello
Abstract: This thesis presents the investigation of the use of Augmented Reality (AR) in the final assembly of aircraft. The methodology consisted of mapping the contribution of augmented reality in the industry and mapping the final assembly of aircraft, looking for activities that would benefit from this technology. An experiment was carried out with the activity that presented the most gains, the assembly of placards. The experiment was carried out with 20 participants in a cockpit and compared three different instruction methods (the conventional method, augmented reality on the Tablet, and HoloLens 2), considering different task characteristics (if the placards were in the user field of view and the numbers of placards). The outputs were time to complete the task, positioning errors, and assembly errors (parts assembled in the wrong place or orientation). The results indicated a great gain in time for assemblies performed with augmented reality, for

example, in the first experiment, few placards were positioned in the user's field of view and the HoloLens was 7 times faster and the Tablet 4 times faster than the conventional method. In terms of accuracy, the use of the conventional method presented the best result with only 1,2 mm of average error, the HoloLens presented 3,6 mm of average error, and the Tablet presented the worst average error, with a value of 4,6 mm, due to the fact that the participants found it very difficult to hold it and perform the task. In addition, the use of augmented reality presented fewer assembly errors. In 1680 assemblies, there were 48 (2,9%) errors with the traditional method, 22 (1,4%) with the Tablet, and only 1 (0,06%) with the HoloLens. The statistical analyses were performed on normalized data using a logarithmic transformation (natural log). Utilizing ANOVA, it was determined that the task characteristics and methods played a significant role in task completion time. In the context of positioning error, the method influenced the positioning error results, but the task characteristics did not influence the outcomes. The data's normality was established through the Shapiro-Wilk test. The work concludes that when very high precision is not necessary, industries can benefit from augmented reality, especially when it comes to assembly time and assembly error, reducing cycle time and rework activities.

Título: FINITE ELEMENT MODELING APPROACH IN COMPONENT MODE SYNTHESIS OF REAL-SCALE AIRCRAFT WITH HANGING SUBSTRUCTURES
Autor: Matheus Chuman
Turma: 29
Data da Defesa: 09/08/2023
Orientador: Flávio Luiz de Silva Bussamra
Coorientador: Angelo Antonio Verri
Abstract: Component Mode Synthesis, especially the Craig-Bampton method, is one of the most well-known solution techniques for the analysis of finite element models of large and complex structures. This technique involves dividing the entire structure into several substructures or components, and the modes of the complete structure are synthesized using the modes of its individual components. However, the applications of modal synthesis methods available in the literature are restricted to the search for substructuring to reduce computational time, generally using smaller and simpler structures. Therefore, the objectives of the present work are, firstly, to propose a method for creating a numerical model of reduced order based on a detailed model of an existing aircraft, which represents a system formed by an external load coupled to a wing, and thus evaluate the effectiveness of the reduction technique in comparison with results of full-scale tests. The first favors the use of sensitive aircraft data in the academic environment. Then, by applying the Modal Synthesis of Components, and the consequent division of the complete structure into substructures, the second objective of this work is to propose a method for the imposition of new frequencies for the vibration modes of the substructure. Thus, the third and final objective of the work is to impose experimentally obtained frequencies for the substructure vibration modes and evaluate the effect on the predictability of the complete system. The results obtained in this work for when the modal frequencies are imposed for the roll, yaw and pitch modes of the external load, is a significant improvement in the prediction of the results for the complete system (wing + external store). Roll, yaw and pitch modes go from 8 Hz, 12 Hz and 20 Hz to 12 Hz, 17.4 Hz and 42.6 Hz respectively. With this, the theoretical-experimental errors were reduced from up to 57% to just under 15% when using the vibration test's results of the complete aircraft. Thus, the insertion of experimental data in a single superelement of the reduced model proved capable of

generating good results in the complete structure of the aircraft after experimental validation.

Título: METHOD FOR THE PRIORITIZATION OF TECHNOLOGICAL PROJECTS CONSIDERING INDUSTRY 4.0 ASPECTS
Autor: Pedro Henrique Ponzoni Favero
Turma: 29
Data da Defesa: 03/08/2023
Orientador: Emília Villani
Coorientador: Gleverson Fabner Conde Lemos
Abstract: A critical aspect for organizational survivability and success is investing in the correct projects and initiatives to carry out its business strategy. Therefore, having effective decision-making processes to select and prioritize projects to compose the company's project portfolios is essential. In this context this work proposes a method for the prioritization of technological projects considering business related aspects and technological aspects related to industry 4.0. A literature review was carried out to investigate existing methodologies and the context for which the method is being proposed. Following that the proposed method is presented, which is divided into four steps, assessment, strategy definition, opportunity identification and project prioritization. A case study is then presented, in which projects in the context of final aircraft assembly were analyzed and prioritized. Which, together with the application of a perception survey, corroborates to attest the quality of the method. Finally, the conclusions of the study are presented, as well as future works to deepen the theme of the study.

Título: TRADE-OFF BETWEEN DESIGN ALTERNATIVES FOR ACHIEVING DISPATCH RELIABILITY IN AIRCRAFT DEVELOPMENT
Autor: Pedro Silveira Gomes De Paiva
Turma: 29
Data da Defesa: 22/08/2023
Orientador: Guilherme Conceição Rocha
Coorientador: Newton Hygino
Abstract: Dispatch reliability is a key performance indicator in commercial aviation. It is related to the aircraft being able to depart on schedule, not occupying the airport gate longer than allowed, which would incur increased costs. According to the FAA (FAA, s.d.), in 2019, Airlines lost approximately 8.3 billion dollars due to delays. However, the dispatch reliability is influenced by operational aspects and by the aircraft design. The former are the interactions between the airplane and the stakeholders and activities performed at the gate. It also includes the procedures and logistics employed by the operator, such as inventory and maintenance center distribution. The latter is related to the aircraft project in itself, the systems' architectures, components, materials, how reliable and maintainable it is, meaning that the product can either have a very low failure probability or easy to fix faults. Maintainability is also related to how simple the ramp activities are in relation to the airplane. The present work seeks to understand how to drive resources for reliability or maintainability in a cost-efficient way for achieving a high dispatch reliability. It presents a framework for calculating the dispatch reliability based on a component's probability of failure, inventory risk of shortage, administrative delays probability and lognormal distribution for modelling task duration. Cost-benefit analysis is also proposed by estimating the development costs and benefits and calculating the benefit-

cost ratio for performing trade-off between different engineering proposals for improving the aircraft design. Information from field is going to be gathered through interviews for understanding the operational dynamics and for obtaining data to be input in the calculations. Two case studies are presented in order to show the framework's coherence and usability. The result is a framework that can be used to raise awareness about dispatchability during the early phases of aircraft development in order to obtain a more supportable and dispatchable airplane in the entry into service.

Título: DESIGN, CONTROL AND ANALYSIS OF MORE ELECTRIC FUEL SYSTEMS
Autor: Petrus De Oliveira Tiveron
Turma: 29
Data da Defesa: 10/07/2023
Orientador: Luiz Carlos Sandoval Góes
Coorientador: André Pacheco e Silva Katchorian
Abstract: More energetic efficient engine and aircraft are needed to be in agreement with current environmental scenario and allow the increasing demand in passenger traffic to be addressed in a more sustainable manner. Several novel concepts appeared to provide an energetic improvement, such as the More Electric Aircraft (MEA) and More Electric Engine (MEE). The main objective of these concepts is to migrate all power systems to electrical. The fuel system electrification can provide an energetic gain when the concept of MEA/MEE is applied. It has a pumping system with overlapping functions between the aircraft and engine. The engine fuel pumps are driven by the accessory gear box, which is connected to the aircraft engine. They produce more fuel flow than necessary, and it is up to the fuel metering unit to control the amount of fuel that goes to the combustion chamber. It does so by bypassing the excess fuel, which creates inefficiencies on the system, opening room for improvement. This project aims to study the viability of replacing the engine fuel pumps by electrically driven ones and the removal of the aircraft boost pumps and bypass system, thus integrating the aircraft and engine fuel systems. A MEA/MEE fuel system is designed and modeled on AMESIM along with a conventional fuel system. Both are integrated with an engine model and simulated on several scenarios to compare the energetic gain in terms of shaft power off-take and specific fuel consumption. Several technical challenges arise from the selection and development of a MEA/MEE fuel system, which are highlighted on this project. The simulations performed resulted on improvements on both shaft power and SFC for the MEA/MEE fuel system, demonstrating that the fuel system electrification can provide a potential energy gain.

Título: ACCESSIBILITY SOLUTIONS FOR THE ELDERLY AND PEOPLE WITH DISABILITIES IN REGIONAL AVIATION
Autor: Silvio Romero Oliveira Do Nascimento Filho
Turma: 29
Data da Defesa: 26/07/2023
Orientador: Alison de Oliveira Moraes
Coorientador: Jerusa Barbosa Guarda de Souza
Abstract: Demographic trends in developed countries suggest that the population over 65 will represent more than 30\% of the total by the year 2030. Many of these will, over that time, experience a natural decline in their hearing, visual and cognitive abilities. In addition, the global increase in the number of passengers with disabilities in the aviation

market raises the need for airlines to offer an inclusive service to these groups, which can represent a differentiation in the market. This work proposed to apply a methodology inspired on Design Thinking, with tools such as persona mapping and user journey to carry out a study and develop proposals for solutions aimed at improving accessibility for passengers with sensory, physical and elderly disabilities. To this end, bibliographic research and study of other works that investigated the aviation market and mapped the complaints and needs of users with disabilities and the elderly were initially carried out. The result of these researches served for the definition of needs and cabin requirements for the creation of a virtual prototype of an Accessible Cabin. With this information, solutions available in the market and proposed solutions were analyzed in order to point out cabin systems that meet these criteria. It was concluded with this work that it is crucial to consider the needs of all stakeholders involved in the system for the good definition of a solution, that is, users, manufacturers and airlines, since modifications to the cabin can affect important parameters such as cost and weight, and must be made in order to address points that can really improve the user experience. Passengers with special needs represent a growing market, but their willingness to pay extra for better services must be addressed appropriately. It was also noted that for passengers with sensory impairments, it is possible to meet some of their requirements without major cabin modifications. However, research on their needs is limited and there are few solutions on the market targeting this audience. Passengers with mobility restrictions, on the other hand, present more complex challenges. Finally, the proposed Accessible Cabin concept shows the potential to improve the flight experience for passengers with special needs, potentially increasing their market share and overall satisfaction.

Título: CONCEPTUAL DESIGN OF SUPERSONIC AIRCRAFT INLETS
Autor: Victor Guinancio E Abicalil
Turma: 29
Data da Defesa: 31/07/2023
Orientador: Ney Rafael Sêcco
Coorientador: Davi Henrique Bossano Di Bianchi
Abstract: In the process of aircraft design, the first design stage is usually referred to as the Conceptual Studies phase, which is characterized by fast design iterations and exploration of a vast design space. Therefore, this phase necessitates the use of prediction methods with low computational cost, while still accurately representing the most relevant physical behaviours and parametric trends. In this context, this work presents a sizing and analysis tool for supersonic aircraft inlets, allowing for the prediction of aerodynamic characteristics of pitot, two-dimensional ramp, and axisymmetric spike inlets. These are characterized in terms of total pressure recovery, accounting for external compression and subsonic diffuser losses, and of drag, accounting for spillage, profile, wave, bleed, and bypass drag coefficients. The tool is also capable of sizing an inlet based on a design point operating condition and a few key geometric relations. Using this sizing and analysis tool, several inlets are designed and discussed, exemplifying the advantages and disadvantages of each inlet configuration as well as the effects of variations in inlet geometric parameters and operating conditions. These discussions include on-design operation for different design Mach numbers, also accounting for variations in inlet forebody length and angle as well as subsonic diffuser offset. Off-design operating conditions are also considered, consisting of variations in freestream Mach number and engine corrected mass flow rate.

DISSERTAÇÕES DO ANO DE 2022

Título: DESIGN AND ANALYSIS OF A ROBUST CONTROLLER FOR AN AIRCRAFT CABIN TEMPERATURE CONTROL LOOP
Autor: Alessandra Bitencourt Ferreira Fernandes
Turma: 28
Data da Defesa: 30/08/2022
Orientador: Alberto Adade Filho
Coorientador: Wallace Hessler Leal Turcio
Abstract: One of the main functions of the aircraft's environmental control system is to provide adequate control of the cabin temperature, which is essential to provide occupants with safety and comfort while the aircraft is in operation. Implementing its own cabin temper- ature control laws is a strategically important task for an aircraft manufacturer, allowing the company to create products that build their own brand in the market and boost their competitiveness. To perform this task, it is necessary to have an adequate knowledge of the environmental system and its particularities. The plant of this system is subject to different uncertainties and disturbances, as well as high transport delays, great thermal inertia, and variations inherent to the mathematical modeling used for control purposes. Previously designed control laws for a specific reference system did not explicitly focus on stability and acceptable performance in situations with model uncertainties and plant disturbances. As a result, the employment of robust control systems is justified in order to avoid all of the difficulties involved. This work, therefore, aims to employ the H-infinity robust control technique to carry out the aircraft cabin temperature control design, as well as the subsequent evaluation of the closed loop system's response. For a better under- standing of the system's behavior, investigations were made regarding the characteristic uncertainties present in the air distribution system, and a robustness analysis of the most internal loops of the control system. Following this, an H-infinity controller is designed using two structures for the augmented plant (Classical and Reference Models). Both structures are compared in terms of performance characteristics and robustness achieved. In addition, the behavior of these controllers is evaluated in light of the nonlinear cabin model.

Título: CRACK GROWTH RETARDATION MODELS UNDER LOAD INTERACTION
Autor: Andre Leandro Da Rosa Magalhaes
Turma: 28
Data da Defesa: 29/08/2022
Orientador: Mariano Andres Arbelo
Coorientador: Carlos Eduardo Chaves
Abstract: This work investigates the load interaction effects during fatigue crack propagation under the presence of overloads. The retardation models capable of representing the effects of plastic deformation on crack growth were identified, implemented, and verified using experimental results available in ITA. A modification of the Newman model is proposed and validated to allow the study of loads of variable amplitude with interacting overloads. Then an analytical study shows the advantages of each methodology, the implementation challenges in each case, and its limitations when applied to aeronautical structures under variable amplitude loading. The validation of the results of each model is carried out from experimental results, using specimens made of material Al 2524-T3, which is widely used in structures of EMBRAER E2 series aircraft,

the new generation of E-jets for commercial aviation. The results obtained for the material for the given boundary conditions indicate that the Wheeler model correlates adequately in the presence of overload since its empirical parameters are appropriately calibrated. The Willenborg and Gallagher models resulted in unsatisfactory crack propagation predictions, being recommended only for application in cases with a high load ratio. The modified Newman model developed in this work can represent the retard effect without the need to adjust additional empirical parameters, as long as it is submitted to a shut-off value lower than 1.5. Furthermore, other usage recommendations are indicated for each methodology.

Título: COMPARISON BETWEEN COMPUTATIONAL AND EXPERIMENTAL RESULTS OF NON-STATIONARY PRESSURE DISTRIBUTION ON A PITCH-OSCILLATING WING
Autor: Bruno De Almeida Regina
Turma: 28
Data da Defesa: 01/09/2022
Orientador: Roberto Gil Annes da Silva
Coorientador: Eduardo Silveira Molina
Abstract: The objective of this work is to obtain CFD results for the dynamic response of a wing oscillating in pitch in a transonic regime using an open-source tool. The purpose is to verify the correspondence with the experimental data as performed in the wind tunnel test for a wing model developed by Embraer. For this, in some analyzes it is proposed to impose a prescribed movement to the wing in the CFD simulations that models the bending observed in the scaled model throughout the tests as a rigid mesh movement in rolling direction. Prescribed motion parameters are extracted directly from the model's structural deformation measurement data. In addition, simulation of two test cases are performed to better understand the studied phenomena and to investigate the impact of relevant variables in this type of analysis, such as time step and mesh refinement level. The time step was identified as the most influential parameter to approximate the simulation results to experimentally obtained data. The CFD results for the Embraer wing were able to capture the main behaviors of the magnitude and phase of the non-stationary pressure coefficient on the wing, mainly for conditions of higher reduced frequencies, with an affordable computational cost.

Título: ARTIFICIAL INTELLIGENCE IN AIRCRAFT STRUCTURAL ASSEMBLY: GAP DETECTION DURING WING DRILLING PROCESS
Autor: Bruno Lima Zattoni
Turma: 28
Data da Defesa: 29/08/2022
Orientador: Emília Villani
Coorientador: João Marcos Gomes de Mello
Abstract: The presence of automation in manufacturing is usually related to data generation that can be used in artificial intelligence applications. In a wing assembly line, a robot drills thousands of holes per product and measures the hole profile with a probe. Gaps between the stacks of material induce peaks in these profiles, and cause process interruption whenever they go out of tolerance boundaries. Therefore, in this scenario, not all gaps are disclosed, and the detected ones cause unnecessary interruption. This work proposes to automatically detect the gaps by applying artificial intelligence in the hole profiles, so it tracks and reports all the gaps occurrence along the product and avoids

unneeded interruptions. A preprocessing stage interprets the hole profile in the files provided by the robots and transforms it to serve as input to the peak detecting models. Two models were developed to detect the peaks: one traditional procedural algorithm and a feed-forward neural network. A cross-check phase was added after the peak detection to validate the gap presence. Although the traditional procedural algorithm is more transparent in its rules, the neural network performs better due to its robustness in handling the process data variability, achieving an accuracy of 97%. The detected gaps can be presented in a map format to help locating them in the product. The next steps involve an automatic gap measurement that can be used to anticipate possible shimming to the next assembly stages.

Título: A COMPARATIVE STUDY OF THE URBAN E-VTOL SUPPORTABILITY INFRASTRUCTURE
Autor: Caio Goncalves Natalino
Turma: 28
Data da Defesa: 01/09/2022
Orientador: Henrique Costa Marques
Coorientador: João Pedro Pinheiro Malère
Abstract: Recently, studies about e-VTOL vehicles and their inclusion in Urban Air Mobility have been intensified, in order to establish this new mode of transport in cities, making it possible to reduce the traffic in large population centers with a faster trip, less noise and less environmental impact. The electric batteries energy density is a limiting factor to these aircraft operation. Depending on demand and their energy replenishment specification, it is possible to adopt different support infrastructure concepts, which impact fleet availability and system life cycle cost. The inefficient allocation of e-VTOL support and energy supply infrastructure incurs high life cycle costs and failure to meet the demand for vehicle utilization. Until then, heuristics and studies of e-VTOL supportability infrastructure planning and allocation do not consider life cycle costs related to the acquisition and operation of these facilities. Therefore, we propose a comparative study of the support infrastructure of two distinct concepts of e-VTOL energy replenishment, through a life cycle cost optimization model for a cost effective supportability infrastructure allocation. The model comprises the energy replenishment bases allocation from a Genetic Algorithm and the supply network definition via OPUS10 software simulation. We implemented an e-VTOL as air taxi operation in the city of São Paulo case study to verify the effectiveness of the model. The work aims to fill a gap in the literature, addressing the supportability of e-VTOL systems and drawing conclusions about which decision and resource allocation strategy are suitable for its operation as an urban air taxi, within the scope of support facilities for these aircraft.

Título: PROBABILISTIC FATIGUE ANALYSIS OF SECONDARY CRACKS IN RIVETED STRUCTURES
Autor: Carlos Augusto Paes Lemes
Turma: 28
Data da Defesa: 26/08/2022
Orientador: Mariano Andrés Arbelo
Coorientador: Antônio Fernando Barbosa
Abstract: Aeronautical structures are subjected to damages such as fatigue cracks due to their inherently cyclic loading. Therefore, it is important to understand the process of nu-

cleation and propagation of cracks for application in modern aeronautical projects that use the damage tolerant approach. In this context, there are situations in which com- ponents or structural details may present the nucleation and propagation of an initial or primary crack, and after a determined number of load cycles, it may occur the nucleation and propagation of a secondary crack, in the proximities of the primary crack, due to the load redistribution caused by the primary crack. The nucleation and interaction of primary and secondary cracks in structural aeronautical components is relevant to the design of damage tolerant structures. This work proposes an analysis methodology for the characterization of the nucleation, propagation and interaction of primary cracks (or leader cracks) and secondary cracks in aeronautical components, considering probabilistic aspects and the current practices employed for the treatment of riveted structures. The methodology developed considers a random distribution of stress by fatigue life curves (S-N), that results in cases in which secondary cracks initiate, and cases in which they do not initiate (in consequence of the catastrophic failure of the component occurring beforehand due the propagation of the primary crack). From the cases in which the ini- tiation of secondary cracks occurs, the simultaneous propagation of leader and secondary cracks is analyzed to quantify how the cracks influence each other or interact during their propagation. The results obtained indicate that the distributions of leader crack lengths at the moment the secondary initiates tend to be normal, while the distributions of sec- ondary crack lengths tend to be lognormal, in coherence with the Equivalent Initial Flaw Size methodology, currently employed in the industry. From the propagation analysis, it was identified that secondary cracks tend to grow faster than the leader cracks, and the relative sizes between secondaries and leader cracks followed the general behavior found in data from detailed fleet inspections. With this, the present work offers a contribution to improve the design of aeronautical structures with a probabilistic approach for evaluation of primary and secondary cracks, both in terms of initiation and simultaneous propagation of fatigue cracks.

Título: CASE-BASED REASONING DECISION-MAKING SYSTEM APPLIED TO THE AERONAUTICAL DIVERSION SCENARIO
Autor: Carlos Leonardo Dolcinotti
Turma: 28
Data da Defesa: 30/08/2022
Orientador: Carlos Henrique Costa Ribeiro
Coorientador: Paula Borges Olivio Cerdeira
Abstract: Within the aeronautical environment, there is rare and unplanned situations such as systems failure(s), lack of fuel, multiple failures, weather changes, changes in the flight plan or aircraft emergency situations that require the pilot to make a decision directly and quickly using his knowledge, his experience and his cognitive skills to bring the necessary safety to the flight. From this perspective, this work aims to understand in detail how the decision-making process of pilots occurs in the possibility of facing different types of problems during a flight, and later, to develop a decision-making system to help the pilot to be able to perform a faster and more efficient analysis of the situation and, therefore, proceed with the mission with its decision made. It is known that each situation has its own complexity, which means that there is an appropriate type of decision to be made for each case. Thus, it is desired to perform, firstly, the categorization of these types of decision-making for each situation encountered during the operation of the aircraft. Initially, the different types of decision-making are raised through interviews and questionnaires with pilots, taking into account the context of the present situation, taking as a reference the answers based on analyzes and experiences lived by the pilots. After categorizing each

type of decision-making and understanding its reason and its application in the scenarios discussed, a “target-scenario” was chosen, representing a category of decision-making to be studied in depth, in order to identify the best approach to solve it. This target-scenario is the case of Diversion, which is based on the pilot’s decision to change the destination airport to an alternative airport to ensure a safe landing. The approach was made so that a solution can be identified in the form of an algorithm that helps the pilot to carry out the decision-making process, thus having a shorter reaction time in the face of this failure or emergency situation in flight. The proposed algorithm was based on the application of an artificial intelligence tech- nique called Case-Based Reasoning, which was chosen according to the best suitability and performance for the chosen scenario. The objective of the developed system is to choose the most appropriate alternative airport to make the landing within the Diversion scenario. The system is capable of helping the pilot to make a faster and better decision, in order to reduce the pilots’ cognitive load, increase the degree of autonomy and mission efficiency, in addition to providing a greater margin of safety and flight performance.

Título: LIFT-DEPENDENT DRAG ESTIMATION FOR CONCEPTUAL DESIGN OF SUPERSONIC AIRCRAFT
Autor: Daniel Back Da Trindade
Turma: 28
Data da Defesa: 30/08/2022
Orientador: Ney Rafael Sêcco
Coorientador: Davi Henrique Bossano Di Bianchi
Abstract: Considering that multiple configurations are evaluated during the conceptual phase of an aircraft design, capable tools are needed to capture quickly, effectively, and with low computational cost, physical effects that will affect positively or negatively the final performance of the product. In that way, the context of the project developed here will be around supersonic flight, which can be observed on the different fronts of aeronautical products: commercial, executive, or defense once supersonic flight has been considered by some governments and companies as a possible opportunity for the development of new aircraft. Thus, the Supersonic Drag Polar is one of the key elements for the development of these future new aviation products. The drag polar has two major components: zero-lift drag and lift-dependent drag. In this sense, the objective of the work developed here is: to study and implement parametric methods for the estimation of lift-dependent drag in the supersonic drag polar, that are suitable to the Conceptual Design Phase. Thus, the methodology must be able to consider all the relevant components of the aircraft in terms of drag, taking into account the level of information available in that mentioned design stage, capturing fundamental effects, so that it can be applied in possible multidisciplinary optimization processes, thus presenting a low computational cost and balancing fidelity, flexibility, and agility. This work will also focus, in the case of the Supersonic Drag Polar, on Class II (using geometric data available in preliminary studies phase) semi-empirical parametric methods, validated and calibrated on higher fidelity data gathered from the literature or possibly generated by other computational methods. In addition, the focus of this work will consider the drag components that are of the lift-dependent type.

Título: COMPRESSION AFTER IMPACT ON A COMPOSITE STIFFENED PANEL SUBMITTED TO LOW VELOCITY IMPACT UNDER COMPRESSIVE PRELOAD
Autor: Eduardo Paixao Ritter
Turma: 28
Data da Defesa: 25/08/2022
Orientador: Mauricio Vicente Donadon
Coorientador: Paulo Roberto Zanella Pasquali
Abstract: A finite element model was developed for the simulation of low velocity impacts with compressive preload and compression after impact in composite stiffened panels. Us- ing Abaqus/Explicit solver, both intralaminar and delamination damages are considered. Model validation was performed with the comparison of numerical and experimental re- sults of pristine panel compression and impact and compression after impact. Since preloading is based in the panel critical load, a buckling analysis was also performed. The full simulations, with preload, impact and compression after impact show that com- pressive preloading tends to increase dissipated energy and panel damage and reduce the residual compressive strength.

Título: NONLINEAR STRUCTURAL ANALYSIS OF VERY FLEXIBLE WINGS WITH DEFLECTED AILERONS
Autor: Felipe Buarque Cordeiro De Melo
Turma: 28
Data da Defesa: 01/08/2022
Orientador: Flávio Luiz de Silva Bussamra
Coorientador: Angelo Antonio Verri
Abstract: As economic and environmental requirements intensify, aircraft manufacturers incorpo- rate a myriad of features in aircraft design aiming to reduce fuel consumption. One effort to save fuel is related to increasing wing aspect-ratios, improving the aerodynamic efficiency of wings. These slender wings present higher structural flexibility and are sub- jected to large deflections under operational loads. In the presence of large deflections, conventional linear structural analysis fails to predict accurate displacement and stress results. Then, nonlinear structural analysis needs to be employed for properly capturing the static aeroelastic behavior of such wings. Significant progress in investigating the effects of structural nonlinearities on the static aeroelastic behavior of high aspect-ratio wings has been made. However, authors often deem the wing geometry as a smooth sur- face, disregarding control surfaces deflections. In this context, the objective of this work is to develop an aerostructural analysis methodology to obtain static aeroelastic results considering the aileron deflections for very flexible wings. Further, the work seeks to cap- ture deviations in aerodynamic loads, in rolling characteristics, and in stress levels when comparing linear and nonlinear structural analyses in static aeroelastic rolling maneuvers of very flexible wings. To accomplish the objectives, an aerostructural tool that couples a structural solver to a full-potential aerodynamics solver with boundary layer correc- tion was developed to assess the static aeroelastic behavior of a modified version of the Pazy Wing: a highly flexible wing with deflected ailerons. The obtained results revealed that use of linear structural analysis in the aerostructural tool overestimates loads and stress results for a given angle of attack. Further, the rolling moment coefficient evalua- tions indicated that the use of linear structural analysis is not advisable for assessing the rolling characteristics of highly flexible wings as these models overpredict the wing rolling capabilities.

Título: POST-BUCKLING FATIGUE CRACK PROPAGATION ON CURVED STIFFENED PANELS
Autor: Felipe Rezende Belem
Turma: 28
Data da Defesa: 01/09/2022
Orientador: Mariano Andrés Arbelo
Coorientador: Wagner Rissardo
Abstract: In the project of aeronautical structures, the buckling phenomenon might occur in loads lower than the envelope limit loads. In these conditions, the post-buckling behaviour must be analyzed, where the load initially resisted by the buckled component is redistributed to adjacent elements and internal stiffeners. Therefore, inside the operational envelope, buckling might be frequent, resulting in cyclic loadings that may initiate crack nucleation and propagation due to fatigue. The objective of this master's dissertation is to propose a calculation methodology to quantify the effect of the stress field resulted from the post- buckling regime on the crack propagation in aeronautical stiffened panels subject to cyclic loading. Therefore, an original methodology will be proposed and validated in order to obtain the geometric correction factor of structures under buckling, allowing to quantify the propagation rate of cracks under these conditions. In this context, a modification of the Virtual Crack Closure Technique is proposed and validated, allowing to take into account the out-of-plane bending effects in the geometric correction factor for cracks propagating predominantly in Mode I. The results obtained demonstrate the relevance in considering the post-buckling effects on the crack propagation rate for the proposed stiffened panels configurations, indicating potentially non-conservative results when linear elastic analyses are considered without including the stress redistribution, inherent to loadings in the post-buckling regime.

Título: MODELING AND ANALYSIS OF LITHIUM-ION BATTERY CELLS IN THERMAL RUNAWAY EVENTS
Autor: Gabriel Menezes Da Silva
Turma: 28
Data da Defesa: 02/08/2022
Orientador: Izabela Batista Henriques
Coorientador: Thiago José Lima
Abstract: The current work aims at the understanding and modeling of Thermal Runaway (TR) events in lithium-ion cells in the context of aircraft battery applications. Such events are a major concern in terms of safety, as they may provoque intense thermal hazards, and represent an important field of studies to enable the development of new fully electric aircraft. The main goal is understanding the phenomenum and proposing strategies for mitigating its consequences during aircraft operation. The work focuses on the analysis of cylindrical 18650 cells, which are an industry standard broadly used in commercial applications. TR is modeled through Arrhenius kinetic equations and is implemented in both lumped parameter in Matlab SimulinkTM, and 3D computational simulations in Ansys FluentTM using User Defined Functions to represent electrochemical reactions. The first analysed condition is the oven test, a setup in which a single cell is exposed to a temperature controlled oven, heating and triggering exothermic reactions that lead to TR. The main objective of the lumped parameters model is validating the Arrhenius formulation to represent TR, understanding in which conditions such events occur. 3D and lumped parameter models are then compared, showing adequate correlation, and enabling the use of the 3D model in battery module installation conditions. An internal shortcircuit

is then implemented in the cell, allowing the observation of how TR is triggered by an internal heat source. This trigger cell is then placed within a battery module assembly, enabling the assessment of how TR may be induced from one cell to the others due to heat transfer. In this case, the main objective is comparing different materials in which cells are immersed. Three conditions have been tested: 1) ceramic paper fiber and 2) G7 as solid separators; 3) no special separator material, where air fills the gaps between cells within the module, with different radiative emissivity conditions at the cell surface. Considering one ISC trigger cell, TR propagation to neighbor cells is observed in none of the cases. The air interstice case with regular emissivity was found to be the most critical one, with the closest cell reaching peak temperatures as high as 136 °C in 490 s, while ceramic paper fiber was considered as the best separator material, postponing temperature increase in the closest cell (peak temperature of 132 °C at 900 s). The performed analysis highlights a method to evaluate the battery module in installation conditions considering a multi-physics model, encompassing TR reactions and heat transfer phenomena.

Título: MODELING AND NUMERICAL SIMULATION OF WATER SPRAY GENERATED BY THE LANDING GEAR OF AN AIRCRAFT ON A CONTAMINATED RUNWAY
Autor: Gabriel Silva Garcia
Turma: 28
Data da Defesa: 18/08/2022
Orientador: Jesuino Takachi Tomita
Coorientador: Luiz Tobaldini Neto
Abstract: During certification, water spray tests are conducted to demonstrate that aircraft components such as engines, APU, and airspeed and altitude sensors do not have their operation impaired by water or slush displaced by the landing gear during taxi, take-off, and landing on a contaminated runway. The ability to numerically model the complex phenomena involved in water spray tests can directly assist aircraft development and their systems. Hence, this work aimed to simulate the 3D turbulent flow of the water spray reconciling computational cost and representativeness of the phenomenon. For this, a Lagrangian approach was employed to track the trajectory of water spray particles with a diameter between 0.5 and 2 mm released from the neighborhood of a tire. The particles' dynamics are affected by gravity and the airflow around the tire, previously obtained through the classical Eulerian approach for single-phase flows. A method based on experimental data was developed to estimate the initial state of water spray particles, and interpolation of different experimental conditions was validated. Predicted water spray plume obtained by interpolation of initial results agreed with experimental data in position, height, width, and inclination. Therefore, this methodology can be employed to evaluate variations in water spray compared to a previously known condition. For example, small aerodynamic changes like introducing a winglet or varying atmospheric conditions like adding a wind component.

Título: A CASE STUDY ON THE USE OF LIQUID HYDROGEN FOR A FUEL CELL SMALL AIRCRAFT PROPULSION
Autor: Georginelly Ferreira Inacio
Turma: 28
Data da Defesa: 26/08/2022
Orientador: Pedro Teixeira Lacava

Coorientador: Carlos Henrique Belloni Mourão
Abstract: Due to social and environmental concerns about global warming and its causes and effects, restrictions on emissions have been put to guide society into a more sustainable development in the recent years. But if on the one hand, we have all regulations, on the other hand we have the aviation sector growing demand. Thus, decarbonization is a major challenge in the aviation sector. Nowadays, aviation emits yearly more than 900 million tons of carbon dioxide (CO2), and projections estimate that by 2050 this number would more than double due to fleet growth, even when considering an improvement on emissions reduction of 2.0 to 2.5% per year per aircraft. If one is to measure the total impact of the sector it is even more alarming as it does not only resume into CO2 emissions. In this context, investigations on innovative technologies arise as a means of evading this impasse. This study evaluates the feasibility of a small aircraft powered by proton-exchange membrane fuel cells (PEMFC) fed with gasified hydrogen (GH2) from a liquid hydrogen (LH2) storage. Furthermore, this configuration is also compared to Internal Combustion Engine (ICE), battery-electric, and hybrid with compressed gaseous hydrogen versions. To do so, firstly, current commercially available fuel-cells, as well as hydrogen storage systems are analyzed. Then, it is presented a proposal for hydrogen evaporation for the arrangement under appraisal. Next, a performance comparison is conducted in the SUAVE simulation platform using Energy Specific Air Range (ESAR) index of each case. It is found that for the liquid hydrogen aircraft, the heat absorbed for the evaporation of LH2 carried on board is not sufficient to perform the cooling of the propulsion system. It is proposed then an additional cooling system, and commercially available versions are explored. Also, it is analyzed the effect of storing the produced water from fuel cells operation, and a final LH2 aircraft architecture is recommended. The final LH2 aircraft configuration presents less favorable performance compared to the ICE and battery-electric versions but shows some advantages over the gaseous hydrogen version. It is identified that further improvement in propulsion and aerodynamic performances, and overall aircraft weight is required so the small aircraft powered by hydrogen can outperform the conventional ethanol combustion version.

Título: COMPARISON OF ANALOG DEMODULATION CIRCUITS FOR APPLICATIONS WITH LVDT SENSORS
Autor: Guilherme Henrique Oliveira Silva
Turma: 27
Data da Defesa: 24/02/2022
Orientador: Luiz Carlos Sandoval Góes
Coorientador: Raphael das Neves Calvo
Abstract: Trade-off analysis are expected to be performed during the conception and subsequent phases of an aircraft development. One of them regards the Flight Controls architecture –what, as almost everything that comprises a project of this type, is attached to the decision of other parameters; these, on its turn, are taken by different project teams. Thus, for example, if a sensor is shared both by the Avionics and the Flight Controls Systems, not only the data format (analog or digital) is expected to be the same for both systems, but the transmission/receipt protocol as well, in the case of digital data; otherwise, converters would be needed for any of them, and this would become another parameter in the trade-off analysis. Hence, this work intends to provide a means of comparison between two demodulation technologies, analog and digital ones, so that it may support the trade-off analysis. This demodulation is applied to a linear variable differential transformer (LVDT) model devel- oped by (FILHO, 2017) –from which two digital demodulation

algorithms are also taken, the Peak Detector and the Oversampling/Averaging –, which, on its turn, is inserted into the electro-hydraulic actuator model developed by (BALLESTEROS, 2015). Four analog circuits are designed: one that makes use of a Log-antilog analog divider; one that has the Transconductance analog divider as its core; one that uses the Lock- in Amplifier as a demodulator; and, lastly, one that is based on the Pulse-Width and Pulse-Height Modulation technique. These circuits allowed the surface position to be acquired after the demodulation process, and thus a feedback signal could be fed into the electro-hydraulic servo-valve (EHSV), closing the surface position loop.

Título: INVESTIGATION OF COMBINED NONLINEAR EFFECTS ON THE AEROELASTIC ANALYSIS OF A TYPICAL SECTION
Autor: Guilherme Simas De Souza
Turma: 27
Data da Defesa: 24/02/2022
Orientador: Roberto Gil Annes da Silva
Coorientador: Breno Moura Castro
Abstract: Aeroelasticity is a multidisciplinary field associated with the study of phenomena that appear from the interaction of the structures of the aircraft with the air that may affect the airplane's safety. The linear flutter analysis is already very well-established; however, the presence of nonlinearities may affect the linear results and should be considered for a safer aircraft design. The main purpose of the present work is to study some nonlinearities and their effects on the flutter analysis of a typical three-degree-of-freedom airfoil section, focusing on the interaction of the nonlinearities. The workflow is to model a cubic spring and Coulomb friction on the control surface degree of freedom, combining both effects and comparing the proposed Harmonic Balance approach to the time-domain simulation, validating the procedure. Then, the freeplay nonlinearity is implemented and combined to the friction to analyze in both approaches and using as a benchmark experimental data found on literature. An initial condition and velocity sweep studies are made in the time-domain approach, which is a representation of the real experiment conditions, in which the speed is incremented in small steps, and not instantly applied. The studies show, both in the frequency and time domains, that the proportionality between the freeplay size and the LCO amplitude cannot be held in the presence of friction and that the combination of nonlinearities can affect the stability of some LCO branches when comparing to the isolated nonlinearity condition.

Título: ASSESSMENT OF A THERMAL ZONAL MODEL FOR AN AIRCRAFT'S FUEL TANK
Autor: Gustavo Coelho Fialho
Turma: 28
Data da Defesa: 18/08/2022
Orientador: Izabela Batista Henriques
Coorientador: André Pacheco e Silva Katchborian
Abstract: The aircraft's fuel system is responsible for storing and delivering fuel under proper con- ditions throughout the aircraft's operating envelope. Among the relevant conditions, the fuel temperature stands out, which must not exceed lower and upper limits. Given the need to verify the fuel temperature envelope, this work aims to study the feasibility of the zonal modeling method for the thermal evaluation of the tank. This technique allows the calculation of the fluid's temperature and velocity fields from a

purely physical for- mulation, without the need for previous knowledge about the flow in the domain under analysis. This work permeates the historical development of the zonal model, with its assumptions, and introduces modifications in the formulation to adapt the method to the fuel tank context. Thus, it was necessary to introduce conditions to the equation that allowed the zonal formulation to capture the varying fuel level, with the formation of a heterogeneous air-fuel medium. In addition, the introduction of fuel also implies numeri- cal problems during the solution, due to the high compressibility of the fuel compared to gases typically used in zonal models. The solution to the numerical problems is achieved by introducing dissipative terms, which are capable of filtering high-frequency modes and reducing the model's computational cost. Finally, the accuracy of the zonal model was evaluated against a CFD model, for a representative case of a generic fuel tank. The results showed that the boundary layer effects highly impact the temperature field, which are not captured with sufficient accuracy by the zonal model. This happens because the zonal model uses only basic flow equations, which, combined with a coarse mesh, minimize the importance of small-scale effects close to the domain walls. Thus, the current state of the zonal model still does not allow its use for an aircraft fuel tank, but the results of this work indicate that future modifications may enable the application.

Título: STUDY OF EFFECTS ON THE WING'S AERODYNAMIC CHARACTERISTICS DUE TO DISTRIBUTED PROPULSION OVER THE WINGSPAN
Autor: Gustavo Jorge Resende
Turma: 28
Data da Defesa: 25/08/2022
Orientador: Vinícius Malatesta
Coorientador: Marcos Cesar Savio
Abstract: Distributed propulsion is not a brand-new concept, but due to technological limitations, it was never a viable solution to be considered in an aircraft design. Nonetheless, recent advances in electric motors and batteries, along with the need for more environmentally friendly products, have made them viable and brought these concepts to the spotlight again. This dissertation will address a wing configuration with a distributed electric propulsion system composed of two types of arrangement, one with propulsors positioned at the wingtips and the other where they are distributed along the wing leading edge. The benchmark of the analysis is NASA's X-57 "Maxwell" demonstrator, which was chosen because of the extensive literature and available data related to it. Another goal of this dissertation is to evaluate the capabilities of the VSPAERO code in modeling aerodynamic flows, from a simple case of the isolated wing to a more complex 14 rotors case. The overall results have shown that VSPAERO provides reasonable estimations for most cases.

Título: INVESTIGATION OF TI-6AL-4V POWDER REUSE AND POWDER LIFE CYCLE IN LASER-POWDER BED FUSION PROCESS
Autor: João Monteiro Neto
Turma: 28
Data da Defesa: 31/08/2022
Orientador: Anderson Vicente Borille
Coorientador: Marcos Hideki Miyasaki

Abstract: The Laser Powder Bed Fusion (LPBF) system is a broadly used metallic additive manu- facturing technology that provides attractive advantages of design freedom, material use efficiency and final part quality compared to more traditional manufacturing systems. Al- though, one of its main challenges is the cost reduction and optimization of powder use. The present work will assess the Ti-6Al-4V powder reuse in a LPBF system, proposing a reuse strategy and evaluating its effects on powder characterization and the final part quality through the cycles of reuse. A sequence of powder reuse with four builds was performed with no powder refill or top-up, to represent the most extreme condition of reuse. The powder was monitored through the analysis of powder morphology, particle size distribution and chemical composition. Specimens was built in the sequence for the analyses of microstructure analysis, apparent density, tensile strength, surface roughness and hardness. Also, the concept of ”Average Powder Age” is presented and assessed as a tool of powder reuse management, once it can provide relevant information about the powder quality, its expected impacts in final part quality and also reduce operational com- plexity. The results suggested relevant differences in powder size distribution and chemical content of the powder throughout the reuse, with an increase in the size distribution after the first use and a slight increase of Oxygen and Nitrogen contents. Tensile strength and hardness also presented an increase during the powder reuse, probably due the identified changes in the powder characterization. The analyses of powder morphology, apparent density and microstructure of built parts did not present relevant differences in the study. The Average Powder Age did not represent satisfactorily the evaluated changes in powder and final part quality, being suggested for long-term studies. The study collected valid evidences of powder reuse viability in the studied conditions.

Título: PILOT ASSISTANCE SYSTEM IN THE MANAGEMENT OF FAILURES USING REINFORCEMENT LEARNING
Autor: João Pedro Felix Amorim
Turma: 28
Data da Defesa: 30/08/2022
Orientador: Carlos Henrique Costa Ribeiro
Coorientador: Paula Borges Olivio Cerdeira
Abstract: Today, abnormal or emergency situations in flight are managed by the crew with the help of the Quick Reference Handbook (QRH). This is a handbook that contains the step-by- step of all applicable processes for certain situations in a user-friendly format. The use of the QRH works very well in scenarios where one abnormal situation happens at a time, however in situations with multiple failures the decision making and the steps to follow may not be so clear, depending on the pilot’s experience. Based on this, a work was developed to create a system to help manage multiple failures using artificial intelligence (AI) techniques with a focus on reinforcement learning. Reinforcement learning is a subcategory of machine learning in which models are trained to make decisions in sequence through trial and error, receiving a reward function as a response. This function is then used as a parameter for recalibration of the model and with the goal of maximizing it. There was a first exploration of the scenario described above in a previous work using DQN (Deep-Q-learning) based models and genetic algorithms for Air Management System (AMS) fault management. The objective of this work is to deepen the results found, trying to improve the models used and make them more representative when compared to real situations.

Título: USE OF ARTIFICIAL INTELLIGENCE TECHNIQUES FOR DEGRADATION ESTIMATION OF PNEUMATIC VALVES USED IN AERONAUTICAL SYSTEMS
Autor: Lucas De Assis Silva
Turma: 28
Data da Defesa: 31/08/2022
Orientador: Cairo Lucio Nascimento Júnior
Coorientador: Humberto Hayashi Sano
Abstract: This work aims to propose a methodology and develop diagnostic models to estimate the degradation severity of an aircraft pneumatic system valve (PRSOV - pressure reg- ulating and shutoff valve) in multi-degradation scenarios, considering friction elevation, discharging orifice clogging, and charging orifice clogging. An accurate PRSOV degrada- tion estimation can reduce operational costs and raise aircraft availability by supporting the logistics and maintenance scheduling, enabling controller reconfiguration to keep the desired performance or extend the valve end-of-life, and reducing the corrective mainte- nance costs through faster fault identification. To enable the study of the valve within the entire degradation and operating envelopes, a previously validated physics-based model developed in MATLAB/Simulink was used to generate synthetic data of the system in open loop (OL) and closed loop (CL). These data were adjusted to improve their accordance with the reality, considering, for example, the sensors' characteristics. Then, some features were extracted and used to train regression machine learning models that enable real-time diagnostics. In this procedure, six machine learning algorithms were employed to develop the models for each combination of degra- dation type and control loop configuration (OL and CL). Hence, the performance and complexity of these algorithms could be compared to define the most promising. Further- more, mainly to improve the models' performance and interpretability, some techniques were employed, such as, regressor chain (RC), feature selection, hyperparameters tuning, and models' interpretation with SHAP. The results show that the new input features developed by this work can improve the models' performance, and the smallest error was generally provided by models developed with SVR, followed by XGBoost. Furthermore, the importance of properly choosing the excitation characteristics, whether fast or slow, to stimulate a particular phenomenon is highlighted in this work. Regarding the models developed using RC, which only use be- tween 3 to 12 input features that are currently measured on the aircraft, the OL approach provided the lowest NRMSE (normalized root mean squared error) for the charging orifice clogging factor (CF), 8.4 % (2.2 % lower than in CL), and the CL approach provided the lowest NRMSE for friction and discharging orifice clogging factors (FF and DF), respec- tively 0.8 % (2.7 % lower than in OL) and 4.7 % (0.9 % lower than in OL). These errors are considerably smaller than the variations of the degradation factors from the desirable valve performance to the controller margin limits, which are 53 %, 35 %, and 40 %, re- spectively, for FF, DF, and CF. These results enable the definition of thresholds for the valve replacement before its failure and with good margins. To obtain these outcomes, the RC supported the models to distinguish the degradation coupling effects, decreasing the estimation error and/or enabling the reduction of the number of input features to obtain the same performance. Then, using SHAP, the models were interpreted, showing that most of the correlations that they captured between the input and output variables are according to the PRSOV physics.

Título: WING FLUTTER ANALYSIS TOOL FOR AIRCRAFT CONCEPTUAL DESIGN
Autor: Lucas De Oliveira Cunha
Turma: 28
Data da Defesa: 30/08/2022
Orientador: Roberto Gil Annes da Silva
Coorientador: Carlos Alberto Bones
Abstract: The current work is focused on the development of a wing flutter analysis tool adequate to the early stages of the aircraft design. Assessing flutter at the conceptual studies phase has been the main concern of several works in the field of aeroelasticity, where the most common barriers are the lack of detailed information regarding structural design and a characteristic variability and changeability of components, geometries and other relevant aspects of the wing design. The main goal is to come up with a modular, user- friendly tool, able to, from a set of input parameters adequate to the early development phases, predict and generate a faithful representation of a wing, with stiffness, inertial and aerodynamic description, already translated into a finite element model, together with a flutter analysis script ready to be run by specialized software. The model generator is written in a Python script, whereas the user interface is in the form of an Excel sheet where input variables are informed. The modular tool generates as output a complete flutter solution for NASTRAN, where the wing is represented as beam elements, in a technique industrially known as beam model or stick model, attached to lumped-mass elements. The aerodynamic model uses the doublet lattice method. From the wing planform and flight conditions data, the proposed methodology generates a simplified geometry that is sized using a calculated running loads distribution, which are used to develop the inertial and stiffness characteristics of the wing. The proposed methodology is validated using a reference complete model of a generic wing, in two steps. Firstly, the reduced order modeling technique is assessed by using the characteristics mapped from the reference wing directly into the beam and mass elements properties, showing that the proposed description of the wing yields similar displacements; modal shapes and frequencies; and flutter behavior. After, the tool's output is compared to the same reference model in terms of the achieved properties, as well as modal and flutter behaviors. The obtained results show a satisfactory fit given the premises and simplifications adopted, predicting similar flutter behavior and similar influences from selected input parameters. Finally, the tool is used for parametric analyses that showcase its potential and vocation for assessing the influences of numerous design characteristics on the aeroelastic behavior of a wing.

Título: EXPLORATORY STUDY ON SURFACE FINISHING TECHNIQUES APPLIED TO POLYETHERIMIDE PARTS MANUFACTURED BY FDM
Autor: Luiz Gabriel Sommerlatte Santos
Turma: 28
Data da Defesa: 26/08/2022
Orientador: Anderson Vicente Borille
Coorientador: Juliana da Cunha Freitas Ramos
Abstract: The aeronautical industry has great interest on using parts manufactured by Additive Manufacturing with the FDM (Fused Deposition Modeling) technique, specially for air- craft interiors application, due to its flexibility and easiness on producing complex geome- tries. However, up-to-date FDM technology does not produce parts with surface finishing that attends the requirements for this application. Current post-processing stages

are manual, which hinders the use of this technology in industrial scale. In this context, this dissertation aims to explore post-processing techniques to improve the surface finishing on Polyetherimide parts manufactured by FDM and that can be replicable to an industrial scale, aiming at the reduction of processing time, labor and guaranteeing metrological requirements.

Título: LIFE EXTENDING CONTROL TECHNIQUES FOR AERONAUTICAL PNEUMATIC SYSTEMS
Autor: Luiz Raphael Bruni
Turma: 28
Data da Defesa: 22/08/2022
Orientador: Takashi Yoneyama
Coorientador: Wallace Hessler Leal Turcio
Abstract: The design of control laws for bleed systems is well established, allowing the develop- ment of stable systems that satisfy the specified performance requirements. Therefore, this work aims to include in the current methodology the degradation reduction of bleed system valves, in order to extend the useful life of the components and reduce the air- craft maintenance cost. The pressure regulator and shutoff valve is used to develop the methodology. Through component models in Simulink® environment, control techniques that result in a longer operational life of the valve are investigated. Different control architectures are developed: baseline, the current industry practice, being the pressure the controlled variable; feedforward, with additional control action to reduce the main loop gains and increase the valve stability; and position control, which controls directly the component displacement and targets its reduction. In the latter, an observer is implemented to estimate the valve position. Furthermore, different controller design techniques are proposed and applied. System simulations provide the elements for the analysis of the control system, in particular the performance obtained and the life extension of the aeronautical component, by employing degradation and performance models. The results demonstrate substantial improvements in the operational life of the valve with the fulfillment of all the proposed requirements and small performance reductions.

Título: HUMAN FACTORS STUDY ON THE LIMITED USE OF AUGMENTED REALITY IN THE AERONAUTICAL INDUSTRY
Autor: Luiza Borba De Farias
Turma: 28
Data da Defesa: 30/08/2022
Orientador: Emília Villani
Coorientador: João Marcos Gomes de Mello
Abstract: This dissertation presents the investigation of human factors associated with the use of Augmented Reality (AR) to guide users in the accomplishment of an aeronautical struc- tural assembly. The activity of the experiment is to assemble 3D pieces into a wing rib, from the visualization of holograms projected by the AR Head Mounted Display (HMD) device. Prior to the experiment, the factors that contribute to the limited use of AR in the aeronautical industry were mapped, through a literature review and a subsequent construction of an Ishikawa diagram. Following, the factors were selected by the applica- tion of a questionnaire to people who work in technological areas (technicians, engineers, researchers, undergraduate and Ph.D. students). The chosen factors were: tasks with different features, environment light variation, AR information availability, and learning

curve evaluation. At this time, the experiments were designed to allow the variation of the selected factors. A total of four blocks of experiments were created, as follows: Tasks with different features, environment light variation, AR information availability, and learning curve evaluation. To evaluate the human factors questionnaires, including the NASA TLX, were applied, in addition to measuring the task completion time (TCT) and positioning error of the pieces. Furthermore, the results were evaluated indicating an increase in the workload for tasks involving assemblies outside the user's field of view (FOV), intense environment lighting, large information availability on the AR device, along with the visualization of the users' learning curve with the HMD AR technology.

Título: ZERO-LIFT DRAG ESTIMATION FOR CONCEPTUAL DESIGN OF SUPERSONIC AIRCRAFT
Autor: Marcos Pereira Caldas
Turma: 28
Data da Defesa: 22/08/2022
Orientador: Ney Rafael Sêcco
Coorientador: Davi Henrique Bossano Di Bianchi
Abstract: Supersonic flight is present on the different fronts of aeronautical products: commercial, executive or defense. Supersonic flight has been considered by some governments and companies as a possible opportunity for the development of new aircraft, such as sixth generation fighters. This is the case of the Tempest jointly developed by the United Kingdom and Italy, as well as private initiatives such as Aerion AS2 and the Boom Overture seeking to enter the supersonic business and commercial aviation market. Thus, estimating Supersonic Drag Polars is one of the key elements for the development of these future new aviation products. In this sense, the objective of the work developed here is: to study and implement parametric methods for the estimation of supersonic drag polar that are applicable to the Conceptual Design Phase. Thus, the methodology must be able to consider relevant components of the aircraft in terms of drag, considering the level of information available in that mentioned design stage, capturing fundamental effects, so that it can be applied in possible MDO processes, thus presenting a low computational cost and balancing fidelity, flexibility, and agility. This work will also focus, in the case of the Supersonic Drag Polar, on Class II semi- empirical parametric methods, validated and calibrated on higher fidelity data gathered from the literature or possibly generated by other computational methods. The main focus of this work will consider the drag components that are of the Zero-lift type, which include some methodologies and elements such as: the supersonic area ruling, the afterbody nozzle integration, the wing-body integration and major elements as planform and airfoil. In addition, the methods will be combined to generate the Hybrid Method, an approach to leverage the advantages of the classical methods, and improve the predictions for all the regimes from subsonic to supersonic, and as observed it has a major potential of application on the Conceptual Design of supersonic aircraft.

Título: HUMAN FACTORS IN COLLABORATIVE ROBOTICS
Autor: Mariana Porto Teixeira
Turma: 28
Data da Defesa: 31/08/2022
Orientador: Emília Villani
Coorientador: João Marcos Gomes de Mello

Abstract: In this thesis, the human factors are studied through the analysis of the user experience in Collaborative Robots (COBOTS) application in the manufacturing industry. The aim of this research is to understand the human factors in order to help deploy the COBOTS technology. To this end, an experiment using the available COBOT KUKA LBR iiwa 14R820 is designed considering the main factors that limit the use of COBOTS from the user's perspective. These factors were selected by Embraer's multidisciplinary team involved in this technology. Among the gains sought with the implementation of COBOTS, ergonomic risk reduction and employee safety enhancement are highlighted. In addition, by collecting the workload for the operator in the collaborative environment it is possible to reduce the worker's stress and fatigue while the productivity is enhanced. Finally, results obtained are also used as the foundation to draw the learning curve in this technology.

Título: FIX EFFECTIVENESS FACTOR ESTIMATE AND ITS IMPACT IN THE RELIABILITY GROWTH PROGRAM
Autor: Mariele Cristina De Oliveira Faria
Turma: 28
Data da Defesa: 01/09/2022
Orientador: Guilherme Conceição Rocha
Coorientador: Alexandre Magno Pinto
Abstract: Despite increasing their performance in the field, many complex systems still enter into service with inadequate levels of RAM (Reliability, Availability and Maintainability). Thus, several reliability growth techniques are employed to plan, estimate, and assess future reliability based on testing and corrective actions. Most of these methods are detailed in the United States Department of Defense MIL-HDBK 189C, which is one of the main references of this work. All reliability growth methods of the cited source make use of a parameter called Fix Effectiveness Factor (FEF), which, basically, defines the decrease in the failure rate after implementing some corrective action, and therefore, is essential for a good estimate of reliability growth. Currently, FEF parameter is commonly defined based on historical data and engineering judgment, what makes it, therefore, quite difficult to estimate. From there, the main objective of this dissertation is to propose a method to estimate the FEF through the engineering effort employed to test the product, analyze, and correct the failure modes found. This methodology, in turn, uses two parameters, alpha and beta to estimate the FEF. Seeking to evaluate the suggested method, two case studies are developed in this work, with data from industries from two different niches. The result found is promising because the method is capable of generalizing the FEF estimate for any industry, since the engineering effort considered is dimensionless in the process.

Título: MODELING AND PARAMETRIC IDENTIFICATION OF AN EHSA CONSIDERING THERMAL EFFECTS ON DAMPED MODE
Autor: Marina Brasil Pintarelli
Turma: 28
Data da Defesa: 19/08/2022
Orientador: Emília Villani
Coorientador: Ronaldo Horacio Cumplido Neto
Abstract: There are few academic references concerning temperature modeling in Flight Control Systems components. However, the temperature rise is not always negligible due

to the conversion of pressure energy into thermal energy, especially when the working fluid passes through small orifices, such as damping orifices and electrohydraulic servo-valves passages. Moreover, depending on fluid temperature rise, the excessive heat can eventually jeopardize equipment performance and damage its internal sub-components. In this context, this study aims to model an Electro-Hydraulic Servo Actuator (EHSA), considering its thermal effects. The development of this model allows the simulation of various environmental conditions to reduce costs over rig, in-flight tests or support the system's development. In addition, this versatility enables sensitivity tests to be carried out, focusing on the working fluid properties and constructive aspects of the system's equipment. The present study focuses on analyzing the damped modes of the EHSA. The mathematical model is implemented in a MATLAB/Simulink platform with the main equations identified. Finally, the model is adjusted by experimental data recorded during rig tests with the actual components set. Some physical parameters and boundary conditions used in the model, such as the thermal exchange coefficient, are also analyzed and identified based on the experimental data.

Título: DEVELOPMENT OF A 4D AIRCRAFT TRAJECTORY PLANNER INTEGRATED WITH WIND FORECAST DATA
Autor: Michael Pedro Nunes Nobrega
Turma: 28
Data da Defesa: 01/09/2022
Orientador: Rubens Junqueira Magalhães Afonso
Coorientador: Fernando José de Oliveira Moreira
Abstract: This work seeks to develop a cruise trajectory planner of a regional commercial aircraft taking wind effects into account in the aircraft motion, aiming at minimizing fuel burn and, consequently, gas emissions. To this end, the free version of an optimal control tool named FALCON.m, developed for MATLAB environment at the Institute of Flight Sys- tem Dynamics from the Technische Universit¨at Mu¨nchen (TUM), was used. A point mass model with three degrees of freedom and subject to wind effects is initially proposed. For the atmospheric model, historic wind velocity data from ERA5 (HERSBACH et al., 2022), the high resolution data set provided by the Copernicus Climate Change Service (C3S) Climate Data Store, were combined with the International Standard Atmosphere model (ISA). Analyses were carried out for implementation and potential simplification of the proposed trajectory planner. Then, for the same origin, destination and boundary conditions, two optimal trajectories are compared (both including wind effects and under the same wind conditions): one of them optimizing fuel consumption in a Free Route Airspace (FRA), and another one, closer to a standard route planning, flying in maximum range condition at the minimum-distance lateral path (great circle). A planner was obtained, capable of generating an optimal trajectory when the wind velocity data are correctly provided to the planner.

Título: DEVELOPMENT OF A MAINTAINABILITY PROGRAM ROADMAP: A CONCEPTUAL STUDIES APPROACH
Autor: Pedro Gabriel Pivoto Adami Batista
Turma: 27
Data da Defesa: 19/01/2022
Orientador: Farhad Firoozmand
Coorientador: Newton Hygino de Oliveira Filho

Abstract: Although all phases of product development are relevant and indispensable, the conceptual phase is notable for allowing design modifications at the lowest costs. From the point of view of maintainability, there is a historical difficulty in influencing the product design from the beginning of development due to cultural causes, such as the low availability of historical data and records of past decisions. This dissertation, therefore, studies several references in the literature and proposes a roadmap to create maintainability drivers that will lead to the elaboration of maintainability requirements. These drivers are based on three main pillars: Customers' Needs, Concept of Operations, and Maintenance Concept. Illustrative examples are presented to complement the understanding of the roadmap, showing how to use the available information in each step to create the drivers. Among the information sources suggested for the conceptual phase, this dissertation cites interviews with stakeholders, consultations to official publications and records of lessons learned, historical data, and analysis regarding the aircraft operational scenario. Finally, the roadmap uses this information to build the first version of the Maintenance Concept, from which the drivers for the conceptual stage can be obtained. The structured process that indicates how maintainability can influence the aircraft design from the beginning of development is the main contribution of this work. It is expected that the importance of maintainability in the conceptual phase be understood not only by maintenance people but also by all related development areas.

Título: LINEAR PARAMETER-VARYING FLIGHT CONTROL LAW DESIGN FOR FLEXIBLE AIRCRAFT
Autor: Pedro Rogerio De Paula Guimaraes
Turma: 28
Data da Defesa: 31/08/2022
Orientador: Antônio Bernardo Guimarães Neto
Coorientador: Fernando José de Oliveira Moreira
Abstract: Aircraft rigid-body nonlinear dynamics, added with the complexity associated with aeroe- lastic deformations make flexible aircraft flight control design a challenging problem. A way to address the problems associated with classical gain scheduling and with aeroelastic modes attenuation is the usage of Linear Parameter-Varying (LPV) control techniques. The LPV control is a multi-objective control law, similar to the well-known H-infinity (H∞), but with the advantage of considering multiple linear models for multiple design points in its synthesis, while also guaranteeing closed-loop stability for limited variations in the scheduling parameters that define the design points. This work presents an LPV control law design for a flexible aircraft with a conventional control configuration, that is, an aircraft with an elevator, ailerons and a rudder as control surfaces. First, the theoretical basis of flexible aircraft dynamic modeling and LPV control synthesis are presented. Then, the complete LPV control law design process is presented, from trimming and linearization to linear analysis and control law design. Also, the closed-loop aircraft dynamics are analyzed by means of nonlinear simulations. During the process, comparative analyzes with the H∞ controller are made. The LPV control was proven to be an adequate control technique for aircraft control problems that take into account the flexible dynamics in its design. In addition, the LPV controller considers in its synthesis multiple design points and can be easily implemented in a gain-scheduled way. The maximum allowed variation rates in the scheduling parameters are also considered, and the controller guarantees closed-loop stability for these variation rates. However, the LPV control has a synthesis computational time way higher than similar techniques, such as the H∞.

Título: UNCERTAINTY QUANTIFICATION IN A SIMULATION MODEL OF AN AIRCRAFT CABIN PRESSURIZATION SYSTEM
Autor: Rafael De Souza Cunha Bessoni
Turma: 28
Data da Defesa: 16/08/2022
Orientador: Denise Beatriz Teixeira Pinto do Areal Ferrari
Coorientador: Lucas Almeida Portela
Abstract: The critical hole area is one important parameter calculated during the design an cer- tification process of an aircraft, used to demonstrate compliance with the requirements ralated to the aircraft emergency descent. One way to calculate the critical hole is through a phenomenological model described by a set of algebraic equations, using safety margins to account for input uncertainties. This work proposes another approach: to integrate the input uncertainties into the model in order to quantify the uncertainty in the critical hole area. A framework is applied to characterize the uncertainties as aleatory or epistemic, and propagate them through the model. To display the critical hole area uncertainty we use a probability box - a graphical representation of the variable of interest that aggregates information about epistemic and aleatory uncertainties. The results compare probability boxes for distinct classifications of the variables in order to evaluate how the gain of new information about the uncertainties could contribute to reduce the output uncertainty, and examples are given about how the probability boxes may be used in the analysis of practical engineering problems. The results indicate that by propagating the uncertain- ties through the model, even accounting for a moderately high degree of uncertainty in the inputs, it is possible to achieve a higher degree of accuracy in the calculation of the critical hole, leading to a less constrained design space and allowing the analyst to have a new insight on which hole values are compliant and which are non-compliant with the certification requirements.

Título: A SEMI-ANALYTICAL MODEL FOR DESIGN OF AVIATION GASEOUS AND CRYOGENIC HYDROGEN TANKS
Autor: Thiago Araujo Santos De Oliveira
Turma: 28
Data da Defesa: 30/08/2022
Orientador: Mauricio Vicente Donadon
Coorientador: Carlos Henrique Belloni Mourão
Abstract: Considering the significance of hydrogen in aviation, and more precisely hydrogen storage, the present work intends to conduct a literature review about materials to store hydrogen as compressed gas and in the liquid state at cryogenic temperatures. It is also an objective of the present work, based on the Rayleigh-Ritz method in combination with the principle of minimum total potential energy, to initiate a semi-analytical model for the design of aviation gaseous and cryogenic hydrogen tanks. In this context, it was developed a preliminary thermoelastic stress analysis methodology to obtain static results considering both internal pressure loads and residual stress due to temperature effect. Applying the Kirchhoff-Love hypothesis, the displacement and stress field of an internally pressurized cylindrical shell was calculated. It is assumed that shape functions are the Legendre orthogonal polynomials as seen on (BARDELL; MEAD, 1989) . To evaluate the effect of the Temperature gradient of the Cure and the cryogenic service temperature, a thermoelastic stress analysis of shell composites materials was also performed. The results

obtained revealed good agreement with the analytical solution for internally pressurized metallic shells and the model was verified in comparison with Finite Element Analysis for the different lay-ups of composite materials studied. In addition, the work captured, through a literature review, the main challenges in dealing with hydrogen storage considering metallic and composite tank materials.

Título: DESIGN AND ANALYSIS OF A PREDICTIVE CONTROLLER FOR AN AIRCRAFT CABIN TEMPERATURE CONTROL SYSTEM
Autor: Thiago Ferraz Costa
Turma: 28
Data da Defesa: 01/09/2022
Orientador: Alberto Adade Filho
Coorientador: Wallace Hessler Leal Turcio
Abstract: This work aims to implement Model Predictive Control (MPC) strategies for controlling the cabin temperature of a reference aircraft, in face of the challenges in adequately controlling the system that arise from the plant's transport delays and thermal inertia. Building upon previous works and a simplified non-linear cabin model, an MPC controller is developed for the outer most control loop of a three-loop cascading architecture. The two inner most loops for controlling the pack and Trim Air Valve (TAV) dynamics are reused from the previous works since they were already considered adequate, and focus is given only to the outer most loop. MPC was chosen for this problem given its extensive and continued success history in controlling similar systems in the industry and because of its ability to handle time delays and large time constants through its use of a prediction model to calculate an optimal control sequence for the plant at every time step. A simplified second-order model is identified from the plant, capturing both fast and slow system dynamics individually using the Smith method and combining them to form a representative prediction model for the MPC to enable it to properly control the system and meet all the performance targets. The designed controller is then simulated on various linear and non-linear scenarios to evaluate its performance in terms of whether it meets the proposed performance requirements, as well as its stability, robustness in face of inherent model uncertainties and finally in terms of its computational cost in an attempt of assessing the viability of the implementation.

Título: ALGORITHM PROPOSAL FOR RESOLUTION OF AIRCRAFT TRAJECTORY CONFLICT
Autor: Thiago Rodrigues Da Costa
Turma: 28
Data da Defesa: 26/08/2022
Orientador: Rubens Junqueira Magalhães Afonso
Coorientador: Fernando José de Oliveira Moreira
Abstract: This work is concerned with resolving aircraft trajectory conflicts with optimal control techniques while enforcing the so-called supervisory constraints, i.e., restrictions that stem from human experts. The proposed algorithm is capable of resolving the conflict between two or multiple aircraft mitigating the deviation from their original route, considering real- istic restrictions while allowing the controller’s decisions to interfere in the final solution. Mixed integer linear programming (MILP) was used to solve an optimization problem with linear models encompassing the aircraft dynamics and physical and supervisory con- straints. The optimization problem was computationally encoded

using Matlab➤ and the toolbox Yalmip, while for optimization the commercial solver Gurobi ➤ was used. In addition, we sought to study ways to increase the reliability of the time needed to obtain feasible solutions, even if it introduces a suboptimal characteristic. Thus, an iterative al- gorithm was proposed using the move blocking technique to obtain solutions in faster ways and achieve characteristics close to those of an anytime algorithm, aiming to enable faster computation times and introducing a greater safety margin in the solution obtained. The study of how a possible delay affects the solution was carried out to evaluate the impact of using the quasi-anytime algorithm compared to using the original solution. The results showed that the original algorithm was able to generate different viable solutions for mul- tiple aircraft according to the constraints imposed. However, this great customization of conflict resolution also implies a greater computational effort, which impairs the imple- mentation of the algorithm for en-route applications. Using the quasi-anytime algorithm it was possible to obtain feasible solutions without introducing a delay that could harm the safety of the aircraft in the suggested maneuvers.

Título: AIRPORT RUNWAY DETECTION USING CONVOLUTIONAL NEURAL NETWORKS
Autor: Victor Andre Lima
Turma: 28
Data da Defesa: 27/07/2022
Orientador: Marcos Ricardo Omena Albuquerque Máximo
Coorientador: Ney Ricardo Moscati
Abstract: The recent advancement in computational power allowed the world to give more use of deep learning algorithms. The image processing task is on itself dat&-hungry, but showed to be of extreme importance in many fields of knowledge. ln this work, a runway detection method, for aircraft during landing phase, based on convolutional neural network is made with the motivation to reduce pilot workload, increase flight safety during landing and take new steps towards single-piloted or even unmanned commercial flights. With the results, the network could successfully converge its loss function on the training dataset and validation dataset, and inference on severa! images from test dataset and real runway images gave good results for keypoint and bounding boxes predictions. Our numerical results indicate that virtual runway images can be used in order to pretrain a network to detect real runway images, so we contribute to a cheaper and faster approach on the devel opment of such technology. Further analysis on estimatives for orientation and position of the aircraft camera from predicted keypoint indicate the work to be promising. Even being an initial work, the results gave a robust error histogram which could be easily controlled by filtering outliers and by data fusion with other sensors in real application. Overall, we contribute with results indicating that virtual training, using data augmentation methods for dataset enrichment, benefits real detection and that the keypoint predictions may be used together with pose estimation algorithm to give estimates of aircraft pose related to runway.

DISSERTAÇÕES DO ANO DE 2021

Título: NUMERICAL PREDICTION OF THE INFLUENCE OF SHIMS ON THE STRESS CONCENTRATION FACTOR OF METALIC SINGLE STRAP JOINTS
Autor: Ana Carolina Coutinho Silva
Turma: 26
Data da Defesa: 01/03/2021
Orientador: Flavio Luiz de Silva Bussamra

Coorientador: Priscila Barros Soares
Abstract: Aircraft structures are composed by a huge number of parts with different shapes, manufacturing methods, materials and other characteristics that make assembly with strict accuracy a challenge. Therefore, it is inevitable to have gaps between interface parts, so shims are often needed to fill these gaps. The use of shims increases the eccentricity of the joint, intensifying the effects of secondary bending, which is an unfavorable phenomenon for the fatigue properties of a structure and must be considered in a structural analysis. There are many studies about the influence of shims on lap joints. However, few studies have dealt with the presence of shims on single strap joints. Therefore, the main objective of this study is to evaluate the influence of shims on the stress concentration factor of this type of joint submitted to shear loads, using solid shims and Hi-LiteTM fasteners. Using statistical methods and numerical simulations, 60 configurations of joints were analyzed, considering different values for three geometrical variables: shim's thickness, plate's thickness and fastener's diameter. The joints were simulated using the finite element software Femap® and the solver Nastran® for the linear static solution SOL101. The models were created with hexahedral solid elements and it was considered a linear contact to represent the interface between surfaces. From the finite element results, the absolute stress concentration factor, the joint's stiffness and the relative stress concentration factor were calculated. It was observed that the shim's thickness and the plate's thickness are the most influencing parameters on the stress concentration factor of single strap joints. In addition, it was concluded that the presence of shims reduces the joint stiffness and this reduction is dependent on the thickness of the shim installed. Finally, it was studied the influence of the geometrical variables on the relative stress concentration factor, resulting in three diagrams that can be used in the aeronautical industry to estimate the influence of shims on single strap joints. For some values of plate's thickness, the influence of the fastener's diameter on the relative stress concentration factor was negligible.

Título: FEASIBILITY STUDY OF USING FUEL CELL IN A SMALL AIRCRAFT
Autor: Ana Lidia De Almeida Castro
Turma: 27
Data da Defesa: 19/08/2021
Orientador: Pedro Teixeira Lacava
Coorientador: Carlos Henrique Belloni Mourão
Abstract: Aircraft electrification is subject of several studies in the aeronautical field, due to the increasing need to enhance efficiency and to reduce the contribution of the aviation sector to climate change. In this scenario, the use of hydrogen (H2) fuel cells (FCs) is one means to explore new designs for propulsion electrification. Thus, this study aims to assess the feasibility of using gaseous H2 with proton-exchange membrane FCs (PEMFC) to provide electric power for the propulsion of a small aircraft. Firstly, current commercially available FC and H2 storage systems were analyzed to obtain data of these systems. Secondly, a FC powered hybrid-electric propulsion system (PEMFC and batteries) was integrated in the aircraft, considering versions with 700 bar and 350 bar H2 tanks, and then compared with versions having an internal combustion engine (ICE) and another having just batteries. For a fair comparison, the propulsion system for each version was size-fitted for the defined mission profile. Finally, further analyses were performed in hybrid systems to assess the influence of the hybridization schedule, and to identify how much effort would be necessary to have a feasible aircraft. The aircraft aerodynamics, weight, propulsive efficiency, sizing parameters and other aspects were modeled and simulated in a

virtual environment (SUAVE). The result evidenced that the ICE version has the lowest aircraft mass throughout the cruise duration range (60 min to 120 min), also having the best performance, in terms of Energy Specific Air Range (ESAR), for cruise longer than 65 min. For the airplanes with electric propulsion, the hybrid versions are more suitable in longer missions, being able to double the cruise duration of the battery version, while the battery-only version has the best ESAR for cruise shorter than 65 min. In the hybridization schedule analysis, a better performance was achieved when 60% of takeoff and climb power is provided by FC system and 40% is supplied by battery. In the sensitivity analysis, the increase in the FC specific power had the greatest influence in the performance. However, this advance was not sufficient to achieve the ESAR of the ICE version, so improvement scenarios, joining increase in FC specific power and in H2 storage specific energy, evidenced that an extreme effort would be required to make the hybrid versions viable in relation to the original combustion propulsion. Therefore, the propulsion hybridization with PEMFC, gaseous H2 and batteries is feasible for small airplanes in flights longer than 65 min, when compared to an electric propulsion with only batteries. However, although having a range extender potential, hybrid versions need great improvements in order to outperform the ICE version.

Título: A REDUCED-ORDER MULTIBODY DYNAMICS APPROACH FOR AEROELASTIC MODELING OF HIGHLY FLEXIBLE WINGS
Autor: Arthur Longo Veronese
Turma: 27
Data da Defesa: 14/12/2021
Orientador: Flávio Luiz Cardoso Ribeiro
Coorientador: Fernando José de Oliveira Moreira
Abstract: The search for more fuel-efficient aircraft is an everlasting goal of the aerospace industry. This ambition has led to some aircraft designs with a very high aspect ratio wing. In order to calculate the aircraft wing displacements, a geometrical non-linear structural model is more suitable, since the linear theories begin to get inaccurate with high displacements. Commercial software can provide a very accurate calculation of these displacements but can be computationally too expensive to use for a real-time simulation. In this context, this dissertation develops a lumped mass strain-based nonlinear structural model, and a reduced order model to further decrease the computational time of simulation while generating accurate displacement values. This work also studies the influence of nonlinear terms on the structural dynamics aiming for high-performance calculation. In the proposed model, the generalized coordinates are the element rotations connected with torsional springs enabling motion of in-plane bending and torsion. A modal decomposition and truncation model order reduction is applied to produce a nonlinear reduced order model, where the generalized coordinates are the amplitudes of the natural modes of the structure. The number of mode shapes required to provide accurate displacement results depends on the complexity of applied external force, where simpler forces such as single concentrated forces require fewer modes and more complex forces such as multiple points and distributed forces require more modes. This structural model is verified and combined with a quasi-steady aerodynamic model to provide an aeroelastic model for the full and reduced order model, the flutter speed is calculated and the time simulation is compared using both models showing that the reduced-order model was able to reduce up to 68% of computational time for the calculation of the flutter velocity and 50% for a time simulation, and still producing accurate results compared to the literature even for highly flexible

wings. This work also concluded that the high order gyroscopic term that consumes most of the computational performance can be neglected, greatly contributing to these results.

Título: ANALYSIS OF AN ENERGY DISTRIBUTION MODEL IN PICCOLOS FOR ICE PROTECTION SYSTEMS
Autor: Bruno Da Cunha Brandao Reis
Turma: 27
Data da Defesa: 18/08/2021
Orientador: Vinicius Malatesta
Coorientador: Daniel Martins da Silva
Abstract: Aircraft that have an anti-icing system commonly have a perforated tube (piccolo) that runs along the leading edge of protected surfaces. This tube must be designed in order to distribute the energy along the leading edge in an optimal way so that the surface is heated proportionally to its capacity for ice formation. In this work, a model developed by Embraer for calculating the energy distribution along the length of the tube was analyzed in order to verify and validate the code that was developed in C++ language. Initially, a study of the model implemented in the code was carried out, combining the literature study with the problem governing equations, namely mass conservation, momemtum conservation, first law of thermodynamics, equation of state for gases, heat exchange equations and headloss equations. Then, the code implementation was detailed, presenting the references used and the logic for the convergence of the model. Subsequently, results for some cases were presented and the results were analyzed to verify if they were in accordance with what was expected for the run condition. Continuing, the code results were validated with a comparison with experiments carried out by Embraer, where, with the data provided, simulation results were generated for the tested geometry and the pressure and temperature points measured were compared with the model simulated, where satisfactory results were obtained, proving the good performance and predictive capacity of the code. Finally, a robustness study was carried out, where parameters outside the common range used were tested and it was verified the existence of a region where the code is not able to reach a result due to numerical divergence. A modification in the code was proposed that allowed to resolve part of the divergence, increasing the application range of the code, but it was not able to reach convergence for common values used in piccolo tubes, being proposed the use of a version for high speed values and another for low speeds.

Título: NUMERICAL INVESTIGATION OF SUPERSONIC AIR-TO-AIR EJECTORS INCLUDING DESIGN EFFECTS ON ENTRAINMENT EFFICIENCY
Autor: BRUNO HENRIQUE BOGADO SICURO
Turma: 27
Data da Defesa: 09/12/2021
Orientador: Vinicisu Malatesta
Coorientador: Ramon Papa
Abstract: The present study proposes a CFD methodology for the simulations of supersonic air ejectors. An ejector, also referred to as jet pump, is a device in which a high-pressure jet of fluid is used to entrain low-pressure fluid. Ejectors are used for many purposes, but the process is basically the same in every case: a high-pressure fluid (motive stream) transfers part of its energy to a low-pressure fluid (induced stream) and the resulting mixture is discharged at a pressure that lies between the driving and the suction

pressures. Ejectors work without any moving parts, which increases its reliability and reduces maintenance costs significantly. These easy-manufacturing devices have many applicantions in the industry, such as jet pump compression, extraction of a secondary fluid, mixing of two streams and refrigeration. In the aeronautical field, ejectors are used in different systems of the aircraft, such as in the air conditioning, in the fuel pumping and in the pressurization and cargo heating systems. The objective of this work is to develop and to validate a CFD model of a supersonic air ejector, a device largely used in aircrafts, and to determine how its efficiency behaves when some of its geometric parameters vary, fully exploring the physical phenomena of the problem. It is important to highlight that in the aeronautical industry the competitiveness of any device intrinsically relies on its efficiency, such that a CFD model for an ejetor is indispensable for proper design. A validation process has been conducted by comparing CFD results with two supersonic air ejector experiments: one performed by NASA (National Aeronautics and Space Administration) in 1972 (HICKMAN et al., 1972), and another by Mazzelli in 2015 (MAZZELLI et al., 2015). The turbulence model was also validated with these experiments, and it was concluded that the k-ω GEKO model is able to reproduce the physics of the supersonic air ejector problem with greater accuracy than traditional turbulence models. After this validation process, the sensitivity of the Mazzelli case ejector efficiency with regards to two geometric parameters was evaluated: the nozzle exit position and the ejector mixing chamber height.

Título: OPTIMAL PRELIMINARY SIZING AND ANALYSIS OF ELECTROMECHANICAL ACTUATOR WITH BOND GRAPH
Autor: Caio Bromonschenkel Paes
Turma: 27
Data da Defesa: 23/08/2021
Orientador: Luiz Carlos Sandoval Góes
Coorientador: Raphael das Neves Calvo
Abstract: The aeronautics industry has always been looking for innovations capable of providing reductions in operational costs and, more recently, it started the search for greener solutions. The major contributor to the operational costs and gas emissions is the consumption of aviation fuel. However, maintenance activities also play an important role in the composition of operational expenses. Therefore, solutions capable of providing a higher overall energetic efficiency while requiring less maintenance are of utmost importance for aircraft manufacturers. In this context, aircraft manufacturers, research institutes and equipment suppliers have been working together to find solutions aligned with the concept of more-electric aircraft in order to replace conventional hydraulic and pneumatic systems. In the field of flight control, electromechanical actuators have been studied as a solution to replace conventional actuators, especially for the actuation of secondary control surfaces. Yet, research is still required in order to assess the performance characteristics of an electromechanical actuator and, more important, to allow the comparison with the conventional solution in terms of weight and power demand. It is also important to guarantee the correct integration between aircraft and system by evaluating its behavior when operating under adverse conditions. This work aims to allow the analysis of such characteristics in a preliminary sizing context so that the means to evaluating the actuator's power demand are available. In order to do so, the development of a methodology that should aid the decision-making process in the electromechanical actuator viability studies is proposed. The methodology consists on an actuator preliminary sizing routine which allows both demanded power and actuator mass estimation based on the project requirements and also allows observation of the actuator's sensitivity to design

variations. Furthermore, dynamic modeling of the actuator is addressed in order to validate the preliminary sizing through simulations. The proposed model is such that operations under adverse conditions can be taken into account, allowing the evaluation of its impacts on the demanded power and integration with the aircraft's supply network. This model is developed by using the bond graph method and is implemented in a computational environment, complementing the sizing aspect of the methodology by also providing the capacity to replicate the actuator's behavior when operating.

Título: RIVETING PROCESS SIMULATION TO PREDICT INDUCED DEFORMATIONS IN AERONAUTICAL STRUCTURES
Autor: Carla Veronica Zanatta
Turma: 27
Data da Defesa: 29/10/2021
Orientador: Emília Villani
Coorientador: João Marcos Gomes de Mello
Abstract: Riveting is a process widely used in aeronautical industry to assemble wing panels. The installation of rivets in the panel induces deformations that modify in its shape. In this work, a finite element model for the installation of a single rivet joining two aluminum sheets is developed to estimate the induced deformations caused by the riveting process. A 2D axisymmetric geometry is used to reduce the computational cost of the nonlinear model. The load is applied with a punch that moves with constant velocity. The simulation also contemplates the releasing of the squeeze force to evaluate the springback effect of the deformable bodies. An adaptive meshing scheme is adopted to better describe the forming of the driven head. The dimensions of the driven head and the profile of the radial expansion are presented for different installation conditions. The evaluation of the stress state near the rivet hole indicates there is no clamping pressure in the mating surface of the sheets and the compressive stresses presented in the hole edge are responsible for keeping the parts joined creating interference between the rivet shank and the sheets. The results indicate that the radial expansion in the rivet hole is directly related to the squeeze force and the formation of the driven head, which are parameters that can be controlled through the process. The driven head variation becomes smaller as the squeeze force increases due to strain hardening of the material and the increased resistance of the sheet material to hole expansion. The average expansion of the inner sheet - closest to the driven head - is significantly greater than the one of the outer sheet. This uneven radial expansion along the material thickness indicates a bending effect of the sheets also occurs.

Título: SMART CABIN DESIGN CONCEPT FOR REGIONAL AIRCRAFT
Autor: Eduardo Leite Simoes E Silva
Turma: 27
Data da Defesa: 24/11/2021
Orientador: Alison de Oliveira Moraes
Coorientador: Flavia Renata Dantas Alves Silva Ciaccia
Abstract: New technologies are increasingly being implemented in people’s daily lives and with the growth of smart devices around the globe, the users’ needs, and demands have changed in favour of more technological cities, cars, houses, and airplanes. Besides the passenger’s aspects, the implementation of smart technologies can enhance airplane operation and increase product competitiveness for airlines. Therefore, the objective of this dissertation is to design a concept of a “Smart Cabin” to be implemented on regional

airplanes from 60 to 120 seats. This objective is achieved by applying design thinking tools such as stakeholders' study, personas creation and user journey methods to determine the high-level requirements, thus, it is developed the system architecture and then, the technologies that integrate the final concept of the Smart Cabin were chosen. This concept enhances the passenger experience by granting a new level of cabin comfort, customization, and connectivity; that allows the reduction of airplane time on ground because of the real-time monitoring of airplane cabin components that enables the prediction of maintenance procedures; creates new profits and revenues opportunities for services; provides a more sustainable airplane operation and derived services; and creates new business opportunities for all companies that integrate regional aviation ecosystem.

Título: DEVELOPMENT OF A SUPPORTABILITY MODEL FOR THE INITIAL PHASES OF COMPLEX PRODUCT DESIGN
Autor: Eduardo Rodrigues Ferreira
Turma: 27
Data da Defesa: 17/12/2021
Orientador: Fernando Teixeira Mendes Abrahão
Coorientador: Newton Hygino de Oliveira Filho
Abstract: Although the importance of supportability development has long been established, in some aspects it is still neglected while developing a complex engineering system. This overlook can lead to immature products entering service, low availability, decreased mission success rate, increased logistic footprint, and high Life Cycle Costs. One of the factors contribut- ing to poor supportability development is the non-use supportability models during the early phases of the project to explore various possible solutions and compare alternatives. While it can be associated with the difficulty to model supportability in early design phases due to lack of data, uncertainty, and configuration volatility, the available models and tools are usually not integrated and used in an exploratory way but are applied to check if the proposed solution meets supportability requirements. The significant impact of early project decisions and the relative easiness to adjust the design are great advocates for the early application of a broad analysis of all supportability possibilities. Failing to do so from the beginning of the project relegates these calculations to project stages when there are far fewer possibilities, as the product configuration is already defined to some degree and change is difficult. To overcome this issue, with the use and integration of es- tablished supportability models, an exploratory approach to supportability development is proposed for the initial phases of product development. This approach can be used alongside and quantitatively support established practices and frameworks for product and supportability development. The use of this approach allows supportability to be investigated and explored in search of a better overall solution and to be part of impor- tant project decisions. These investigations can put supportability development on an optimal track since early design decisions, leading to better supportability results in the operational phase.

Título: HIERARCHICAL FINITE ELEMENT FORMULATION FOR THE FLIGHT DYNAMICS OF FLEXIBLE AIRCRAFT
Autor: Eduardo Westphal Da Cunha
Turma: 27
Data da Defesa: 18/08/2021
Orientador: Mauricio Vicente Donadon

Coorientador: Antonio Bernardo Guimarães Neto
Abstract: The common flight dynamics structural modeling is based on classical finite element method, which does not allow a quick and easy preparation of the models, to perform convergence analysis, optimizations or model update, making it less suitable for analyses in early phases of aircraft design. In this dissertation, the hierarchical finite element method is introduced, also known as p-version of the finite element method, in which the accuracy is achieved by increasing the degree p of the displacement field shape functions. This method has the potential of enhancing the structural analysis and flexible aircraft flight dynamics simulation performance overall. An example aircraft was modeled with beam elements and Bardell's series of shape functions were used in the hierarchical finite element method formulation. After the verification of the structure model, the flight dynamics of the flexible aircraft was formulated. From the Extended Hamilton's Principle, the rigid-body and elastic equations of motion were derived. The aerodynamic forces and moments were derived based on quasi-steady strip theory, followed by the propulsive loads derivation. Then, the formulations mentioned above were implemented and integrated in a flexible aircraft flight dynamics model and then the equilibrium problem was addressed and the equations of motion were linearized. Several numerical simulations were performed with different scenarios of control inputs and structural flexibility, the results of which are shown and discussed. Finally, it was concluded that the Bardell's hierarchical series of shape functions demonstrated to be suitable for modeling aircraft structures, while enabling an easy integration of the aerodynamic, propulsive and flight mechanics formulations.

Título: DEVELOPMENT OF A MAINTAINABILITY PREDICTION MODEL TO EVALUATE COMPLEX PRODUCT'S MAINTAINABILITY INDICATORS
Autor: Eliane Zaparoli Quiles
Turma: 27
Data da Defesa: 09/12/2021
Orientador: Guilherme Conceição Rocha
Coorientador: Newton Hygino de Oliveira Filho
Abstract: The maintainability of complex products is a subject that attracts attention when the product is in operation and does not meet the expected levels of performance and availability. This issue ends up bringing losses to the operator and the manufacturer, since the product's intrinsic characteristics become more costly and difficult to be modified as the product develops and matures. Therefore, considering discussions about product maintainability at all stages of its lifecycle is not only a way to reduce product's operating costs, but also a manner to identify opportunities for improvement and to strive for excellence. In order to include maintainability considerations into the Integrated Product Development (IPD), it is necessary to have an updated, effective and simplified methodology that takes into account the needs of the several people involved from product development to its operation. The present work aims to develop a model to predict the maintainability indicators of complex products, as an alternative way to assist maintainability assessments, when there is no previous data or the available data do not generate good estimatives. The model integrates quantitative and qualitative methods to assess maintainability, as a technique to help the analysis of products that are at different stages of development and that have different available sources of maintainability data. To calibrate the model and verify its applicability in a real case, data provided by an MRO workshop were used. Such data come from a Check D performed on a Boeing B727 aircraft. Through the presented methodology, it was possible to develop a model to predict

man-hours per repair indicator from responses to a simplified maintainability checklist, field data or a combination of both. The model was calibrated for structures and systems maintenance activities and it was applied to a critical activity reported in the Check. The obtained equations showed statistically significant results, demonstrating that the model is capable of adequately predicting the maintenance indicators of tasks similar to those in the study. Finally, the application of the model proposed in the case study highlighted opportunities to improve the maintainability of a structures inspection task.

Título: TESTING AN AUGMENTED REALITY SYSTEM FOR DIFFERENT USER PROFILES IN THE CONTEXT OF AIRCRAFT PARTS INSPECTION
Autor: Enner Sampaio Duarte
Turma: 26
Data da Defesa: 26/02/2021
Orientador: Henrique Costa Marques
Coorientador: Gabriel de Oliveira Cruz do Prado
Abstract: Given the increasing use of augmented reality in industry 4.0, this paper investigates the use and advantages of augmented reality (in terms of key performance indicators or KPI) applied to aircraft parts inspection compared to the basic tools used nowadays and considering different user profiles (inspection technicians). In the context of new technologies, augmented reality (also known as AR) has great potential in many aeronautical, automotive, medical, and other applications. AR promotes consistent gains in aircraft manufacturing and maintenance activities, particularly with respect to assembly and inspection time, error and mental workload reduction, and learning curve improvements for inexperienced workers. To verify these hypotheses and corroborate the application of the technology, this thesis comprises the choice of a representative inspection task (mainly in terms of complexity, inspected component size and number of executions per aircraft), the study and selection of an augmented reality system (suitable for this task) and the development of a platform including application, interface, object identification mechanism and implementation of step-by-step (or one-by-one) instructions. Then, the work conducts tests with groups of people in order to compare the results obtained by augmented reality technology with the results of Computer Assisted Instruction (CAI) tools and paper printed checklists, considering novice, intermediate and experienced technicians. During the tests, quantitative and qualitative data are collected (using standardized forms) to get the overall performance of each inspection tool. The results obtained are then analyzed and correlated with the initial hypothesis of the work. To conclude, this paper seeks to understand when and for whom (in terms of inspection experience) the augmented reality is most advantageous. This contributes for the reduction of times and costs related to inspection or assembly, and it increases the efficiency of aircraft components maintenance (or quality verification) as a whole.

Título: ACTIVE FLUTTER SUPPRESSION CONTROL LAW DESIGN FOR A FLEXIBLE AIRPLANE
Autor: Euler De Jesus Carvalho
Turma: 27
Data da Defesa: 30/11/2021
Orientador: Antônio Bernardo Guimarães Neto
Coorientador: Fernando José de Oliveira Moreira

Abstract: An active flutter suppression control law is developed for a generic flexible aircraft using the linear quadratic regulator synthesis technique with output feedback. An aircraft model readily available was provided in its linearized form around straight and level-flight trimmed conditions for various altitudes, at a constant Mach number of 0.78. An extensive exploration of the vehicle dynamics was held, in order to understand the mechanism of the various aeroelastic modes and thus drive to a better proposal of controller architectures. Three architectures were initially proposed and confronted with the design objectives after their synthesis at an altitude of 20000 ft. One of the architectures surpassed the minimum desired damping ratio and was then tested in various altitudes, showing a damping ratio improvement at neighboring altitudes for the initial flutter mode, but destabilizing other aeroelastic modes. Nevertheless, the flutter clearance envelope was extended, with the first flutter altitude decreased by 6000 ft, thus meeting the objective of postponing flutter occurrence.

Título: A PRICE MODEL FOR APPLICATION IN EXECUTIVE AVIATION VALUE-DRIVEN DESIGN
Autor: Felipe Caumo Kurcewicz
Turma: 26
Data da Defesa: 03/03/2021
Orientador: Rodrigo Arnaldo Scarpel
Coorientador: Davi Henrique Bossano Di Bianchi
Abstract: The product development cycle in the aviation industry is considered one of the most challenging projects due to the long cycle of development, huge financial costs, the necessity for well-trained manpower and many other reasons. The starting point of the project belongs to the business strategy department, which has to be on par with customer needs, market trends and competitors strategies. With that in mind, pricing models became an essential tool for decision-makers, such as managers, to initially evaluate what is considered the drivers of value and, by using those, reduce the risk of long spendings into a product badly placed or that does not attend basic market needs. When it comes to price model development, one must use historical and reliable data sets to reduce the risk of bias and to guarantee that the listed attributes were evaluated similarly. In the present work, the Business & Commercial Purchase Handbook was chosen as the data source for the development of a pricing model for the executive aviation market. Defined the data set, the price model development starts with a simplification of the explanatory aircraft attributes, taking into consideration only the variables common to all listed models. With that in mind, to not further reduce the total amount of variables and not initially remove models, the k-nearest neighbor classification method was used in order to calculate the missing data set values. Following that, the principal component regression and partial least squares regression statistical methods were used in order to reduce the dimensionality of the system into components that better explain the overall variance. These components were then used to define the regression coefficients, thus allowing price predictions from both methods. The initial results showed promising results when comparing the model to the training data set but a big error range when used to predicted new observations, indicating a development problem in a pricing model that uses all executive aircraft categories for the analysis. A single model per category is indicated for further studies and approaches.

Título: A METHODOLOGY FOR AEROSERVOELASTIC STABILITY AND RESPONSE ANALYSIS USING COMPONENT MODE SYNTHESIS
Autor: Frederico Monteiro Pinheiro Cassaro
Turma: 26
Data da Defesa: 25/02/2021
Orientador: Roberto Gil Annes da Silva
Coorientador: Eulo Antônio Balvedi Júnior
Abstract: This work presents a framework of aeroservoelastic analysis with actuators modeled using 2 types of modeling into a finite element structural model of an airplane with thousands of degrees of freedom. In these models, the control surfaces of an airplane are included and their actuator models as well. The flutter analysis of these models, including the actuator's dynamics, is named as aeroservoelastic analysis and it is used as a certification tool to show compliance with aeronautical requirements of transport airplanes. Due to the complexity of these models with thousands of degrees of freedom, modal reduction can be used. This technique reduces the model to dozens of eigenvalues and eigenvectors. However, some of local modal information is lost, specially that related to the local flexibility of mode shapes specifically associated with the control surfaces and its actuators. Hence, this work applies a Component Mode Synthesis technique, which is already included in Nastran, for the substructuring following a dynamic analysis of the finite element model. By using the Craig-Bampton method, the airplane finite element model will be divided into superelements. These will be a control surface, a rudder, for example, and the remaining parts of the airframe. Moreover, actuators models are coupled with an already reduced superelement structure, while the local support stiffness is maintained and the modal truncation effects are minimized. Modal, flutter and frequency response analyses are performed using different models of actuators and the results are compared. The advantages of this technique are explained in comparison with a conventional aeroservoelastic analysis.

Título: FACTOR-GRAPH BASED COOPERATIVE SELF-LOCALIZATION FOR A ROBOTIC SOCCER TEAM USING DECENTRALIZED PARTICLE FILTERS
Autor: Guilherme Costa Guimaraes Fernandes
Turma: PEE 26
Data da Defesa: 18/02/2021
Orientador: Marcelo Gomes da Silva Bruno
Coorientador: Stiven Schwanz Dias
Abstract: This dissertation addresses the problem of cooperative localization for a team of robot soccer players in the context of the RoboCup Soccer 3D competition. Each agent uses a camera to obtain measurements of range and bearing to both landmarks, which are previously known by all robots, and to other teammates. They are also able to measure the direction of arrival (DOA) of messages received whenever other allies in the field broadcast to the team, which can only be done by following strict communication rules. More generally, we focus on systems composed of sensor networks or robotic swarms, which typically require solving the problem of localization before more complex tasks can be performed. Our approach to solving the problem is based on factor graphs (FG) and the sum-product algorithm (SPA). We start by deriving a suitable state-space model that incorporates the system inputs and sensor measurements. Then we factorize the joint probability density function of interest in order to obtain the corresponding FG. We propose a message-passing schedule adapted to the communication restrictions and imperfect information between the agents, as imposed by Soccer 3D rules, and compute

the algorithm equations introducing hybrid Gaussian-Mixture Model (GMM) / Sequential Monte Carlo (SMC) representations of the individual messages that are passed at each node. The results are obtained using a series of Matlab® simulations, which show that the cooperative approach, when compared to the non-cooperative one, presents faster convergence and smaller errors in situation where agents do not observe landmarks for a long period.

Título: RIVETING SEQUENCE ANALYSIS AND SIMULATION IN WING ASSEMBLY
Autor: Guilherme Rossi Garcia
Turma: 27
Data da Defesa: 22/12/2021
Orientador: Emília Villani
Coorientador: João Marcos GOmes de Mello
Abstract: The aeronautical industry widely applies the riveting process during the assembly phase of aircraft manufacturing. Also, manufacturing process variables influence the quality of assembled parts, affecting costs, product, and production performance. In order to investigate one of the riveting assembly process variables - the riveting sequence - this research proposes implementing a finite element model simulation (FEA) to predict distortions caused by the riveting process and to evaluate the application of different riveting sequences on the resulting geometry of the assembly. Aiming at achieving that goal, a methodology has been defined, including a literature review of the subject and background, experimental results analysis, simulation models development and validation, and evaluation of riveting sequences through the models. The experimental tests encompass two representative specimen setups of a wing assembly - one open and one closed wing box - and by using important process variables in industry, including the riveting sequence. The impact of such factors in the geometric distortion of the wing box is accomplished using the ANOVA methodology. The results show, that the riveting sequence, considered as an isolated variable, did not present a strong correlation with geometrical distortions on the tests that were done. The non-linear model was developed in Ansys software, using static analysis formulation and applying an REU (Riveting equivalent unity) modeling strategy, balancing model accuracy and its computational costs. The sheets material model was established based on literature experimental results and the geometry was designed to be representative of specimen experimental tests. The experimental results were used for model adjustment and validation, enabling different riveting sequences evaluation. The simulation model of the open wing box setup did not present sensitivity to sequence variation, although there the closed wing box setup was successful. Sequences starting or finishing in the center of the assembled parts demonstrated a better displacement distribution and amplitude than a sequence started from the tails, representing thus a good riveting strategy aiming the resulting geometrical quality along the assembly process.

Título: TROUBLESHOOTING OPTIMIZATION USING CASE-BASED REASONING AND DECISIONS TREES
Autor: Gustavo Borba Evangelista
Turma: 26
Data da Defesa: 10/02/2021
Orientador: Guilherme Conceição Rocha

Coorientador: Wlamir Olivares Loesch Vianna
Abstract: Maintenance is a major source of operating costs for an airline. It is estimated that about 25% of the flight cost is attributed to aircraft maintenance. When a part or component presents a fault, maintenance work is usually performed to find out its root cause. This process is performed by maintenance operators. They generally follow instructions from the aircraft manufacturer itself that are compiled in manuals and other types of documentation. For fault isolation specifically, maintainers often use the Fault Isolation Manual (FIM), which presents a theoretically optimal sequence of actions that will provide an assertive decision-making support at the time of replacement/repair of parts or/and components. However, the FIM has negative points, especially inherent to its production process, that include: lack of ability to be updated using field experience and lack of flexibility in scenarios where the maintenance operator has limited resources (in general no equipment and machines for conducting tests and experiments). Given these facts, the objective of this study is to develop a tool/platform capable of providing the optimal sequence of fault isolation and correction actions to the maintainer in different cases and in an interactive way, where field experience is used to increase the level assertiveness of the troubleshooting process, as well as ensuring greater flexibility to operators' situation. In order to provide the optimal or even an improved sequence, the possibility of executing corrective actions (replaces and repairs) based on trial-and-error approach without the need of performing experimental actions to find symptoms, based on the probability of the failure modes according to the collected field experience will be analyzed. The primary comparison of this study will be focused on the cost and duration for the results from strictly FIM-guided procedures and alternative procedures that will consist of under risk decisions in different scenarios.

Título: PRELIMINARY DESIGN AND ANALYSIS OF AN EVTOL BATTERY THERMAL MANAGEMENT SYSTEM
Autor: Gustavo Mazon Braz
Turma: 27
Data da Defesa: 24/08/2021
Orientador: Izabela Batista Henriques
Coorientador: Dayvis Dias da Silva
Abstract: Urban Air Mobility seeks to solve the growing problem of transportation in big cities: the traffic jams. With new concept vehicles being designed by the major aircraft manufacturers and innovative startups new challenges arise in aircraft industry. The most promising power source for these new aerial vehicles is purely electric, such as in the eVTOLs (Electric Vertical Takeoff and Landing), that can have all its propulsion system being powered by a pack of batteries. The unique characteristics and mission of an eVTOL require a battery made up of high power consuming cells and thus this structure tends to release a great amount of energy. In order to deal with the thermal issues of high power batteries there are several cooling technologies currently in the market, such as air and liquid cooling. Then, given the power requirements of a 2-PAX eVTOL, it is developed a battery solution through cell selection and pack sizing and assembly, with a established and simplified heat generation model. As Battery Thermal Management System (BTMS), a direct liquid cooling solution based on the heat exchange theory of a bank of tubes is proposed. Using lumped parameter simulations on MATLAB/Simulink software, the system is sized according to the maximum recommended temperature and its difference across the battery cells. Then it is determined the best working parameters, regarding hydraulic power, battery volume and required coolant flow indicators. The results of the

transient simulation with the final selected parameters points to a staggered configuration with propylene glycol coolant with low hydraulic power demand and a total coolant volumetric flow of 95 GPM as the most efficient thermal management solution. It is discussed the main considerations about the operational temperature ranges and also recommended trade-offs between components durability, electrical requirements, heat dissipation and battery weight.

Título: AUGMENTED REALITY CASE STUDY IN AIRCRAFT STRUCTURAL ASSEMBLY
Autor: Henrique Patusco Gomes Da Silva
Turma: 27
Data da Defesa: 14/12/2021
Orientador: Emilia Villani
Coorientador: João Marcos Gomes de Mello
Abstract: This dissertation presents an evaluation of the precision and performance obtained with the use of an Augmented Reality (AR) application developed for the assembly of complex products, having as a case study the structural assembly of an aircraft's wing. The purpose of the proposed application is to evaluate the possibility of replacing paper or tablet production guides by the ones embedded in a head-mounted display (HMD). The main hardware and software resources available at the time of writing are considered, as well as their main advantages and disadvantages. The methodology used in this work starts from the construction of the Ishikawa diagram in order to identify the root causes of the limitations in the accuracy of the positioning of the holograms defined in the lenses of HMDs. Three main factors are selected for the Design of the Experiment: position of the hologram in relation to the reference (source of the system); human operator; measurement method (Augmented Reality or pachymeter). Altogether, 21 volunteers participated in the team experiment with 12 assemblies, 6 guided by the HMD and 6 using a caliper. The 6 runs for each guidance method were divided between the two possible positions for positioning the part during the assembly. The results obtained for positioning error values with RA were 0.79 mm on average, with a standard deviation of 4.92 mm, for the first mounting position (40 cm distance from the origin), and 6.68 mm averaged with 5.94 mm standard deviation for a second mounting position (1.3 m from the origin). Compared to a combined pachymeter, there was a 15% gain with no total assembly time. The work concludes that assembly scripts with RA can be used in conditions that are order of magnitude up to date, thus saving assembly time in complex tasks.

Título: AN EXPERIMENTAL STUDY ON TESTING METHODOLOGIES FOR DRAPING CHARACTERIZATION OF COMPOSITE FABRICS
Autor: Jessica De Oliveira Silva
Turma: 26
Data da Defesa: 03/03/2021
Orientador: Maurício Vicente Donadon
Coorientador: Viviane Jordão Sano Prado
Abstract: Over the years, many experimental tests have been developed in order to evaluate compos- ite materials behavior. The understanding of material behavior under specific conditions provide information that allow the manufacturing process to be optimized, thus reducing the occurrence of imperfections and errors. The architecture of the composite preform weaving influences the mechanical properties, as well as the

manufacturing process param- eters. Simulation based models accounting for fabric drapability effects may be a valuable design tool to better understand how in-mold induced fabric distortions affect the overall material performance in terms of strength and stiffness. The experimental results of this thesis proposal provided material inputs for a non-orthogonal constitutive model under development at ITA. The model enables prediction of shape distortions in dry fabrics commonly employed in resin infusion based processes and composite laminates obtained through thermoforming process. The main objective of this work was to analyze the be- haviour of dry fabric under shear stress, through the Bias Extension Test Methodology. Besides that, a methodology known as Rail Shear was used to test the dry fabrics as to have a comparison between the two methodologies. The purpose was to compare results in terms of in-plane shear stress versus shear angle and distribution of the distortion an- gle over the specimen testing area in order to choose the best configuration for draping characterization of composite fabrics. The experimental results obtained were adjusted to a curve and the corresponding curve that better fit the material behaviour provided input data to a non-orthogonal constitutive model under development at ITA.

Título: ZONAL MODELING OF HUMIDITY DISTRIBUTION IN AN AIRPLANE PASSENGER CABIN
Autor: Kevin Benetti De Paula Timmermann
Turma: 27
Data da Defesa: 23/08/2021
Orientador: Izabela Batista Henriques
Coorientador: Sandro Tavares Conceição
Abstract: This work presents the development of a zonal model for prediction of the transient hu- midity profile in aircraft cabins. The model allows evaluation of different solutions capable of providing thermal comfort to passengers, at the same time, avoiding inherent humidity problems such as condensation on the insulation blankets and electronic equipment. The zonal model was developed in Modelica language in the open source software OpenModel- ica, and is an expansion of a model from literature that performs spatial assessments of air flow and temperature distribution. The present work has an investigative approach that evaluates the dominant phenomena in the prediction of the humidity distribution, and a practical approach, focusing on the development of a low-cost computational tool to be used in the early stages of aircraft design. To determine the humidity distribution, water vapor mass balances were implemented in zones that result from cabin's internal environ- ment discretization. Convection and diffusion humidity transport equations were used to model the water vapor mass flow between the zones. In addition, a literature model was used to calculate the accumulation and transport of moisture on the walls. Evaluations have shown that humidity distribution under conditions found in aircraft cabins is little impacted by wall effects as well as humidity transport by diffusion. The proposed model applicability was evaluated in different ventilation cases, such as mixing ventilation and personalized ventilation. The latter, evaluates its ability to determine the relative humid- ity distribution in the aircraft passengers breathing zone. The developed model proved able to determine the humidity distribution in applications such as the early stages of aircraft development. This one shows high fidelity to the CFD and experimental results, in regions with low complexity air flow. The model presents greater inaccuracies for the calculation of air flow velocity distribution in regions with forced ventilation and air re- circulation. These limitations, due to the strong dominance of convection in water vapor transport, impact the accuracy of humidity distribution results.

When seeking to better predict the air flow details, the CFD still presents advantages. However, the zonal model meets its objective as a tool capable of reaching a good compromise between quality of results and computational cost.

Título: ANALYTIC HIERARCHY PROCESS FOR ASSISTING THE APPLICATION OF THE MODULAR ASSEMBLY CONCEPT IN THE INITIAL AIRCRAFT DEVELOPMENT PHASE
Autor: Leonardo Santana Perdigao
Turma: 26
Data da Defesa: 25/02/2021
Orientador: Rodrigo Arnaldo Scarpel
Coorientador: Andre Luiz Costa Quintanilha
Abstract: There is a great challenge of aircraft manufacturers to attend the lead time and meet the market demand of different aircraft models while keeping the net margin high. The higher market requirements and competitiveness in the aeronautical sector forces the aircraft manufacturers to search for assembly alternatives that reduce the production costs. The modular assembly concept, that is already known in other industries such as automotive and shipbuilding, is a potential alternative when compared to the traditional assembly. The two largest aircraft manufacturers Airbus and Boeing have examples of successful implementation of the modular assembly in their assembly line. From the possibility of implementation in other aircraft manufacturers, the present work develops a methodology using the Analytic Hierarchy Process (AHP) to assist the application of the modular assembly concept (pre-assembly of aircraft systems and components out of the main assembly line) in the initial development aircraft phase. The main objective is to support the decision of the assembly alternative with the best benefit-cost ratio in order to increase the aircraft assembly line efficiency. For this reason, nine criteria of comparison were developed and verified with specialists in the field, as follows: production cycle time, accessibility, product exposure to risk, industrial layout organization, work in process (WIP), recurring labor costs, CAPEX investments, material costs and product weight. The results from the application of an academic case study have shown that the modular assembly alternative have a higher benefit-cost ratio than the traditional assembly alternative, encouraging the company to continue the detailing of this alternative.

Título: AEROELASTIC RESPONSE CALCULATION USING DUHAMEL INTEGRAL AND ITS APPLICATIONS
Autor: Lucas Bortolotto
Turma: 27
Data da Defesa: 20/12/2021
Orientador: Roberto Gil Annes da Silva
Coorientador: Marcos Heinzelmann Junqueira Pedras
Abstract: With increasingly demanding requirements and the advancement of the field of aeroelasticity, which enabled the use of new technologies such as gust load alleviation, flutter suppression, among others, the number of aeroelastic analyses needed in the project of an aircraft is increasing. Because of that, making assertive decisions in the beginning phases of the project is a great challenge. To overcome this challenge, it is essential to have analysis tools that are fast and accurate. Many of these analyses involve the calculation of dynamic responses of the aircraft structure to gust and control surface excitation. This process requires extensive time simulations based on the solution of the aeroelastic

equations of motion. These equations are usually formulated on the frequency domain because the unsteady aerodynamic forces are well described for an oscillating airfoil. However, the Frequency Domain approach does not allow the inclusion of nonlinear terms, such as nonlinear control laws for load alleviation, which may have significant impacts on the resulting loads and whose use is becoming increasingly common in the aeronautical industry. One option to include nonlinear terms is a state-space formulation of the aeroelastic equations of motion in the time-domain. This approach has several advantages on flight mechanics and aeroservoelastic design and analysis. However, the conversion of the aeroelastic motion equations to the time-domain requires the approximation of the aerodynamic force coefficients (AFC) with rational functions of the Laplace variable. These approximations bring several disadvantages related to the accuracy, require careful adjustment, and add an excessive number of augmenting states due to the required lag terms, increasing the order of the state-space model substantially. The approach based on the Duhamel Integral presented in this work uses equations formulated in the frequency domain, eliminating the need to use Rational Function Approximations, and at the same time, allows the inclusion of nonlinear terms. In addition, this approach has the potential to reduce the number of cases to be analyzed via commercial software, e.g. MSC-NASTRAN, reducing the analysis time and optimizing the number of licenses. The objective of this work is to demonstrate this approach based on the Duhamel Integral in a typical airfoil section with a trailing edge control surface, as well as the applications in which this method promotes advantages, such as in the application of nonlinear control laws and Oscillatory Malfunction (OMF) analysis.

Título: PROPELLER SLIPSTREAM MODEL COUPLED WITH AN AERODYNAMIC OPTIMIZATION PROGRAM
Autor: Lucas Dos Santos Almeida
Turma: 27
Data da Defesa: 14/12/2021
Orientador: Ney Rafael Sêcco
Coorientador: Alexandre Pequeno Antunes
Abstract: The propeller-wing interaction makes up an important effect to be considered in the optimization of wing geometries. Despite being a subject that has been studied for quite a while, recent aeronautical concepts based on electrical propulsion have sparked interest in the optimization of propeller-mounted aircraft. Hence, this thesis aims to implement a propeller-wing interaction low-order model and to assess quantitatively the benefits of optimizing wing geometries in several propeller configurations. In this context, the interaction is defined as the influence the propeller slipstream exerts on the wing performance. To verify the advantages of propeller-wing optimized geometry, models for propeller and slipstream are implemented in an existing software for aerostructural optimization based on the lifting line theory. This model is then adapted to include the slipstream induced velocities. The implemented codes are verified using numerical and experimental data, and parametric studies are made to verify if the implementation is consistent with results found in the literature. Wing geometries are optimized using gradient-based optimization, with the code being differentiated with an automatic tool combined with the adjoint method to get derivatives of the objective and constraints. The results indicate that relevant drag reductions can be achieved when considering the slipstream effects in the optimization. The reductions are greater the more the propulsion is distributed, with reductions up to 4.61% in relation to the wing optimized without propeller-wing interaction for a given propeller thrust coefficient. Thus, optimization

results suggest it would be an error to overlook the interaction in the optimization of the wings, especially for aircraft with distributed propulsion.

Título: MODEL BASED AIRFLOW ANGLE ESTIMATION USING GPS/INS SENSOR FUSION AND APPLICATION TO UNMANNED AIRCRAFT VEHICLE
Autor: Lucas Moraes Santos
Turma: 26
Data da Defesa: 03/03/2021
Orientador: Luiz Carlos Sandoval Góes
Coorientador: Juliano Augusto Bonfim Gripp
Abstract: This work presents two methods for estimating the True Airspeed, Angle of Attack, and Sideslip Angle of a fixed-wing aircraft, using data from inertial sensors. The first estimation method was based on approximations of the aircraft vertical and lateral accelerations to synthesize Angle of Attack and Sideslip Angle data. The estimation of the True Airspeed for this method was made based on the approximation of the inertial speed. The second estimation method was based on the Extended Kalman Filter, a near-optimal state estimator for non-linear systems. With this Filter, aside from the True Airspeed, Angle of Attack, and Sideslip Angle, it was possible to estimate the Wind Speed and Direction. The estimation techniques were tested using synthetic flight data produced from flight simulations and using flight test data. Simulations ran in MATLABfi, solving the dynamic equations and employing the aerodynamic model for the C2 Unmanned Aerial Vehicle. The flight test data was also from the C2 UAV. The estimation results for the two methods are presented, compared, and discussed.

Título: MULTIBODY AEROELASTIC MODELLING OF VERY FLEXIBLE WINGS
Autor: Marko Andre Rempel
Turma: 26
Data da Defesa: 12/02/2021
Orientador: Flávio Luiz Cardoso Ribeiro
Coorientador: Fernando José de Oliveira Moreira
Abstract: The present Master's dissertation studies the applicability of lumped element multibody systems to model the aeroelasticity of wings. Two independent submodels were created for this purpose: a multibody system describing structural dynamics and a quasi-steady aerodynamic model which computes aerodynamic forces and moments. The structural model is found capable of representing geometric nonlinearities arising from large structural displacements, such as that of a very flexible wing experiencing aerodynamic loads. Furthermore it is able to describe structural dynamics of slender beams. Verification examples modelling a beam show good agreement with previous research. The quasi-steady aerodynamic model was selected so that results could be compared to benchmarks. The implementation used a strip theory approach, was implemented in three dimensions and is able to take into account time-variable wind components. The presented approach is applied to Goland's wing, which is a well-known flutter benchmark, to determine the flutter speed resulting from coupling the multibody structure to the aerodynamic model. Flutter velocities are comparable to those obtained using modal representations for structural dynamics. Finally, the modelling appoach is shown to be scalable, parametrized and modular, all of which could make it valuable in iterative environments such as during conceptual design phases of very flexible aircraft. The

multibody approach could be developed towards a model that represents both structural and flight dynamics of a very flexible aircraft such as the X-HALE, presented in Section 1.1.1.

Título: STRUCTURAL ANALYSIS OF A COMPOSITE LANDING GEAR BRACE
Autor: Marx Thezolin De Paula
Turma: 27
Data da Defesa: 08/11/2021
Orientador: Mauricio Vicente Donadon
Coorientador: Pedro Higino Cabral
Abstract: This project presents an analytical and numerical investigation of the behavior of pinned lugs on braces made of composite materials for applications in aeronautical structures under static loads. Simulations using finite element analysis were carried out in order to evaluate nonlinear effects in the material by using progressive failure models implemented in the software Abaqus. Experimental data available in the literature was used to verify the proposed models. A study of the use of composite materials for the design of a landing gear component was executed, and a comparison with an equivalent metallic part is presented.

Título: A FRAMEWORK FOR DEALING WITH THE PART FEEDING PROBLEM IN AN AIRCRAFT FINAL ASSEMBLY LINE
Autor: Meline Fonseca De Castro
Turma: 27
Data da Defesa: 18/08/2021
Orientador: Rodrigo Arnaldo Scarpel
Coorientador: Matheus Tavares Martins
Abstract: This study focuses on the part feeding problem in an aircraft assembly line, where components should be delivered to the line-side storage in kits. The decision-making process regarding the part feeding process is how the components should be assigned in kits, which is the kit formation process, and next, how the kits should be loaded in tow-trains, and finally, how to schedule these tow-trains to delivery kits in the assembly line, considering no shortage is allowed and the complexity in dealing with multiple decision problems. A mathematical optimization model was proposed with the objective of minimizing the number of tours and the time the material waits on the line before being assembled. The two-phase genetic algorithm (TPGA) was developed to support the decisions in these two problems: the assignment problem and the loading and scheduling problem. In the end, numerical instances were randomly generated based on a real-case scenario, and the efficiency of TPGA was verified in comparison with a mixed-integer linear programming model and two local search heuristics.

Título: PLASTICITY EFFECT ON FATIGUE LIFE OF AERONAUTICAL STRUCTURES CONSIDERING A VARIABLE AMPLITUDE LOADING
Autor: Natan Santos Dos Reis
Turma: 27
Data da Defesa: 16/12/2021
Orientador: Mariano Andrés Arbelo
Coorientador: Carlos Eduardo Chaves

Abstract: This work analyzes the effect of plasticity in the fatigue life of aeronautical structures that experience a variable loading scenario, by comparing a strain-based fatigue approach against a classical stress-based fatigue approach, which is lately modified to account for plastic deformation through a simple plasticity correction model. This work uses a representative loading scenario based on what airplanes experience throughout their operational life, by implementing the standardize TWIST loading sequence. Moreover, the MINITWIST was used to verify the impact of a reduced spectrum that intends to be more suitable for testing. The material analyzed was aluminum 2024-T351 alloy and the geometry considered was an open-hole plate with 5 different stress concentration factors (1.0, 2.0, 2.5, 3.0, 3.33) in order to obtain a wide range of results. Rainflow cycle counting method is used to quantify the number of cycles per flight. A stress-life curve coupled to the Smith-Watson-Topper's mean stress correction and the Palmgren-Miner cumulative damage rule is used to determine the total fatigue damage. In addition, plastic deformation effects are accounted by adjusting the maximum stresses of cycles who overcome the material yield strength, using Neuber's rule and Ramberg-Osgood equations iteratively. The numerical results show that, for the spectra considered, the consideration of plasticity effects have increased the fatigue life by approximately 23% for the maximum stress concentration factor of 3,33, but have no impact for the minimum stress concentration factor of 1.0 where plastic deformations didn't happen. Besides that, the use of MINITWIST loading spectra presented similar results of the TWIST, indicating that small amplitude load cycles do not affect much in fatigue life.

Título: HUMAN PILOT MODELING FOR AIRCRAFT STEERING CONTROL
Autor: Pablo Milheiro Novaes De Araujo
Turma: 27
Data da Defesa: 10/09/2021
Orientador: Luiz Carlos Sandoval Góes
Coorientador: Daniel Bueno Silveira Lima
Abstract: In order to assure handling qualities during taxi, takeoff, and landing, aircraft manufacturers need to design and validate aircraft ground directional control systems including steering. Regarding the evaluation of the design, several maneuvers need to be simulated using high-fidelity models of the systems and pilot control inputs. Pilot's behavior differences may interfere directly in steering systems stability. Therefore, on the Monte Carlo approach, commonly used to assure the stability robustness, the use of models that represent accurately the range of realistic behaviors of real pilots is essential. To fulfill this gap on ground directional control, a grey-box identification of human pilot behavior is proposed, in order to create tunable models for different behaviors of so-called "high and low-gain pilots", which would provide the inputs for the analysis of pilot-aircraft interaction during aircraft steering control. A three degrees-of-freedom aircraft model was used during the development of the pilot model, and also a mechanical steering system was detailed and modeled using the bond graph methodology. Several approaches for human pilot model are found in the literature to evaluate handling qualities and the pilot-induced oscillations problem during flight. A study of control techniques is carried out to evaluate the proper approach to model a pilot during steering control on the runway. An identification method is used to adjust parameters of the human pilot model for each maneuver. For the parameter identification, several maneuvers were performed using data from a real-time simulator developed for this research. The proposed parameter estimation methods use Matlab/Simulink tools to help engineers when using the methodology

proposed herein. The resulting pilot model structure considers visual references as inputs and pedal force or displacement as output.

Título: A NUMERICAL PARAMETRIC STUDY ON THE EFFECTIVENESS OF FASTENING AS DELAMINATION/DISBOND ARREST MECHANISM IN COMPOSITE STRUCTURES
Autor: Rodolfo Ferreira Viana De Melo
Turma: 27
Data da Defesa: 15/12/2021
Orientador: Maurício Vicente Donadon
Coorientador: Amauri Gavazzi
Abstract: This study aims to improve the understanding of current design guidelines for damage tolerant composite aerostructures by providing high fidelity numerical simulations results in order to investigate the effectiveness of fastening as arrest mechanism for delamination growth under pure mode I, pure mode II and mixed-mode loading. In those models, Cohesive Zone Model approach and 3D solid elements were used to represent delamination path, composite specimen and fastener. In agreement with literature references, the numerical results have demonstrated that a single fastener is sufficient to completely arrest mode I delamination growth until other failure modes take place, independent of the joint design parameters. On the other hand, pure mode II simulations became unfeasible due to the specimen sizing requirements imposed to enable crack propagation assessment after fastener. However, the mixed-mode model confirmed that mode II crack front remains present after reaching the single fastener, despite the increase in the interface crack arrest capability provided. Additionally, parametric studies were also performed to investigate the influence of some joint design parameters on the specimen's behavior for each loading case. Under mode II condition, friction coefficient combined to fastener preload, type of fit and fastener diameter appear as parameters with more influence in delamination arrestment.

Título: ARTIFICIAL NEURAL NETWORKS FOR AERODYNAMIC MODELING IN FLIGHT SIMULATIONS
Autor: Victor Hugo Araujo Diniz
Turma: 27
Data da Defesa: 03/12/2021
Orientador: Flavio Luiz Cardoso Ribeiro
Coorientador: Juliano Augusto de Bonfim Gripp
Abstract: The control laws of a fly-by-wire system are the algorithms present on the flight controls computer. The control laws interpret the pilot commands, sensors, and other space state variables, to efficiently command the control surfaces, concerning the operational limits and flight control envelope. The control of any system presumes the existence of a plant, that refers to the aircraft model. The modeling of this plant is the responsibility of the flight mechanics team, which uses traditional approaches, based on the literature, wind tunnel results, and industry experience. During the flight tests campaign, some maneuvers are selected for comparison of the modeling, identifying the system in question. The development of a representative model of an aircraft is, therefore, of utmost im- portance for many applications within the industry, such as control laws design and sim- ulation of aircraft dynamics. This aerodynamic model is highly dependent on the correct estimation of the aerodynamic stability and control derivatives, in form of equations that aim to

capture the aircraft dynamic characteristics. Although there are currently many methods in the literature that are capable of estimating these aerodynamic derivatives, many of them have restrictions within their scope of applications, due to the incapac- ity of dealing with measurement noises and atmospheric nonlinearities, for example. In this scenario, recent works with Neural Networks have proven its efficacy for evaluating the aerodynamic coefficients of an aircraft based on simulated and real flight data. Since Neural Networks are nonlinear structures, this opens the possibility to enhance the known tools, observing the limitations and advantages of Neural Networks for the evaluation of an aircraft aerodynamic model. This dissertation develops a Neural Network capable of interpreting simulated flight data for the prediction of the aerodynamic and stability and control derivatives, and eval- uation of the longitudinal aerodynamic model of an aircraft. An aircraft model whose aerodynamic coefficients are previously known was developed on Simulink, for the gen- eration of artificial flight data based on simulations. The generated data is used for the training of the Neural Network and for testing its accuracy in the estimation of the aero- dynamic coefficients, and for identifying model nonlinearities that better represent the aircraft's dynamic. The obtained results and the fact that Neural Networks deal well with nonlinear and noisy data and do not require the knowledge of an a priori model of the aircraft for identifying the coefficients present a good opportunity for developing an analysis tool to be used in the industry.

Título: CONTROL OF FLEXIBLE AIRCRAFT USING AEROELASTIC FEEDBACK TO REPLACE NOTCH FILTERS
Autor: Vinicius Martins Xavier
Turma: 27
Data da Defesa: 02/12/2021
Orientador: Antônio Bernardo Guimarães Neto
Coorientador: Fernando José de Oliveira Moreira
Abstract: The design of flight control laws for a commercial aircraft must guarantee that aeroser- voelastic interactions do not hinder performance and continued safe flight in a closed-loop system. Traditionally, notch filters are employed to attenuate the influence of struc- tural dynamics on the flight control system. However, filters add phase lag, degrading performance, making the gain tuning process iterative and expensive, until the desired performance is achieved. Furthermore, the delays caused by the filters can lead to pilot induced oscillations (PIO). This dissertation aims to propose and evaluate a methodology for designing integrated control laws, based on a flight dynamics model that includes the structural dynamics - flight dynamics of flexible aircraft. This way the methodology allows the design to include the influence of such modes in the control laws, achieving closed-loop aeroelastic stability without the inclusion of notch filters. Two different strategies, with feedback of modal variables and measured signals, are compared to the traditional filtered design, in terms of stability margins and handling qualities. At the end of this work, the difficulties found are discussed, along with the necessary modifications required for current commercial aircraft so that the presented integrated control law could be implemented.

Título: DETERMINATION OF STRESS INTENSITY FACTOR IN LAMINATED COMPOSITE PLATES WITH THROUGH-THE- THICKNESS CRACKS USING HIERARCHICAL RAYLEIGH- RITZ METHOD
Autor: Wesley Calland Serra De Almeida

Turma: 27
Data da Defesa: 17/12/2021
Orientador: Maurício Vicente Donadon
Coorientador: Amauri Gavazzi
Abstract: The application of composite materials to aeronautical structures has become highly disseminated, which demands deeper comprehension of their behavior and properties. In addition, the study of flaws in these structures is critical to comply with requirements regarding damage tolerance analysis. Stress Intensity Factor (SIF) is an important Fracture Mechanics parameter that can be used to characterize the conditions near the tip of a crack. The main goal of this work is the development of a semi-analytical model to efficiently determine SIF for laminated composite plates with through-the-thickness cracks using Hierarchical Rayleigh-Ritz Method (HRRM). An energy approach was used to model the problem and polynomial hierarchical functions, as proposed by Bardell (1989), were used to approximate out-of-plane displacement w, and in-plane displacement u and v. This method enables the through-the- thickness crack to be inserted by dividing the plate into subdomains, since different boundary conditions can be considered for each subdomain. Continuity among adjacent subdomains is ensured by a condensation matrix as proposed by Bernardino (2019). HRRM applications vary from linear static analysis, such as bending and tension problems, to eigenvalue problems, such as buckling and vibration. Linear static analysis and buckling cases were used to verify the method. The implementation used MATLAB® and the estimation of the Stress Intensity Factor followed a Strain Energy Release approach correlating the results to stress intensity parameters. The semi-analytical model was verified, and SIF results were generated for laminates with different layups, so proving the efficiency and functionality of the method and enabling a discussion about the effect of orthotropy on the stress intensification.