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Abstract Summaries

Technical Session 1A: Aerodynamics and Control (I)

AeSSA2019-01: Stabilization Control for a Quadrotor Based on Fuzzy Model Reference Adaptive Control.

Authors: Makhabane Molapo*, Bhekishipho Twala

In this paper, we propose the design of a hybrid of a model reference adaptive controller (MRAC) and fuzzy logic, which is expected to stabilize the quadrotor experiencing malfunctions and disturbances during a flight and further improve the prediction of systems faults in an aircraft. We demonstrate the performance of the proposed approach as a representative case study (the control of a nonlinear automotive actuator). The preliminary simulation results show the proposed method as promising when dealing with aircraft uncertainties.

AeSSA2019-02: Numerical implementation of the Power Balance Method for Boundary Layer Ingestion

Authors: Ngonidzashe Enock Mutangara*, Lelanie Smith, Kenneth John Craig

New aircraft developments are made to improve aircraft performance and efficiency, one such method is to integrate the propulsion in the airframe. This allows for boundary layer ingestion (BLI) which shows promise of significant power benefits. However, these benefits are difficult to quantify as the propulsion system and the aircraft body becomes meticulously integrated. The thrust and drag become coupled and are not easily differentiable making conventional performance analysis methods inapplicable. The power balance method (PBM) addresses this concern quantifying the performance of aircraft with respect to their mechanical flow power and change in kinetic energy rates.

AeSSA2019-03: An Investigation of the Prandtl 1933 Bell-Shaped Lift Distribution and its Potential Future for Flight

Authors: Andrew Lloyd Allcock*

Technical Session 1B: Satellite Technology

AeSSA2019-04: SmallSat mini-constellations for IOT solutions in Southern Africa
Authors: Guido Schwartz*, Sias Mostert

Space technology offers the possibility of a ubiquitous infrastructure across the whole of Africa, including underserved areas. Establishing space infrastructure requires a large number of knowledge bases and contributing elements. Small satellite technology has advanced to the point of developing space infrastructure to be optimised for a specific application. The Internet of Things, have taken Machine 2 Machine (M2M) communication to the next level of integrating the communication devices with the reachability of the internet. Supporting the last mile through an IoT constellation ensures that the services are provided across the whole continent, regardless of remoteness. The paper will provide an overview of the planned constellation.

AeSSA2019-05: Microwave sub-assemblies using Selective Laser Melting
Authors: Davids V. P, Maharaj R. A.

AeSSA2019-06: Fluid Loop Inertial Actuator
Authors: R. W. Glatthaar, R. A. Maharaj, J. Barrington-Brown,

In orbit, a satellite's attitude is its' orientation with respect to an inertial frame of reference. For a satellite's successful mission, its' attitude must be controlled. The attitude control actuation is based on the conservation of angular momentum. Traditionally this is implemented using reaction/momentum wheels, having the disadvantage of requiring lubrication to prevent mechanical wear causing moving part imbalances. Instead of conserving angular momentum using a rotating solid mass, torque or angular momentum vectors can be generated by controlling the flow rate of a pumped fluid. The Fluid Loop Inertial Actuator uses a pumped fluid for angular momentum conservation.

Technical Session 2A: Aerodynamics and Control (II)

AeSSA2019-07: Vision Based Stability Augmentation and Attitude Control

Author: Dean van Aswegen*

Conventional stability augmentation and attitude control rely predominantly on acceleration and/or gyroscopic sensors. The same results can be achieved using only images from a simple low resolution camera. The images are passed through a convolutional neural network which outputs a corrective action to be taken to adjust the aircraft attitude for steady level flight. The network is trained through imitation learning, where it learns from the corrective actions taken by a human agent in a given undesirable attitude.

AeSSA2019-08: The Aerodynamic Performance of an Aerofoil in Tri-sonic Ground Effect

Authors: S. R. Morrow*, H. Roohani, B. W. Skews, I. Gledhill, B. J. Evans*

Inspired by the world land speed record vehicles, the Thrust and Bloodhound Supersonic Cars (SSC); this investigation considers the influence of ground effect and acceleration on the aerodynamic performance of an aerofoil accelerating in ground effect from subsonic to supersonic speeds. Using Fluent as the computational fluid dynamic solver, a steady state analysis of the RAE 2822 aerofoil at two different ground clearances was used to evaluate the influence of ground effect. The effects of acceleration were considered by comparing the steady state results against transient models with extreme accelerations of 175g.

AeSSA2019-09: Shock Wave Curvature Induced by Rapid Pitching Motions of a Wedge in Supersonic Flow

Authors: T. Missing*, B. W. Skews, H. Roohani

A test rig has been developed to pitch wedges in burst motions in a supersonic wind tunnel to study incident shock wave curvature induced by rapid surface pitching. Strong curvature has been observed, particularly during sharp decelerations at steep incidence. Numerical simulations show that compression and expansion waves induced along the accelerating surfaces of the wedge are responsible for this shock wave curvature. In extreme cases, compression waves may steepen to form a secondary shock wave.

AeSSA2019-10: Continuous Ant Colony Optimization for Sliding Mode Controller Parameter Tuning for an Autonomous Quadrotor

Author: Lindokuhle J Mpanza*

This paper presents an optimal tuning mechanism for a sliding mode controller (SMC) used to control a quadrotor. The objective of the project, initially, was to develop techniques for optimally tracking the vertical ascent, attitude and heading of a quadrotor helicopter. An ant colony optimization (ACO) algorithm is used to tune eight SMC parameters. A continuous variation of the ACO algorithm is presented. The performance of the continuous ACO is compared to the SMC tuned manually and one tuned using genetic algorithm (GA). Through numerical simulations it is shown that the ACO-SMC performs comparably to the GA-SMC and better than the manual tuned-SMC. The inherent SMC high frequency chattering is solved by employing a saturation function in the control laws. From the simulation results it is evident that the application of continuous ACO is suitable for use to tune SMC parameters in order to improve the quadrotor performance objectives that were specified.

Technical Session 2B: Aircraft performance and design

AeSSA2019-11: Monte Carlo Simulation of Supply and Demand on Payload limited Routes
Authors: Stefan Poprawa*, Laurent Dala

Large commercial aircraft by design are typically not capable of transporting maximum fuel capacity and maximum payload simultaneously. Beyond the maximum payload range fuel requirements reduce payload capability. Varying environmental conditions further impact payload capability noticeably. An airline's commercial department requires prior knowledge of any payload restrictions, to restrict booking levels accordingly. Current forecasting approaches use monthly average performance, at, typically, the 85% probability level, to determine such payload capability. Such an approach can be overly restrictive in an industry where yields are marginal, resulting in sellable seats remaining empty. Monte Carlo simulation principles were applied to model the variance in environmental conditions, as well as in the expected payload demand. The resulting forecasting model allows the risk of demand exceeding supply to be assessed continually. Payload restrictions can then be imposed accordingly, to reduce the risk of demand exceeding supply to a required risk level.

AeSSA2019-12: Aircraft Simulation Platforms for High-Fidelity Mission Training
Authors: Oom L*, Naidoo D and Haselum S

The suite of aircraft simulation platforms developed create an integrated team training environment for improved crew mission readiness. The platforms include fixed-wing and rotary-wing flight trainers with aerial fire-fighting and airborne observation add-ons. The platforms use the Presagis products and custom solutions; including high-fidelity aircraft dynamics, helicopter underslung load dynamics, fire propagation physics and camera sensor effects. The airborne observation trainer will be used to train the German Federal Police and other crews will be engaged to train on the platforms. Future development will include infra-red physics modelling, augmented reality headsets for pilots and certification of the simulators by authorities.

AeSSA2019-13: Testing the Natural Dominant Configuration for Aviation
Authors: RJ Huyssen*, GR Spedding

We previously proposed a hypothesis that a single aircraft configuration exists, ideal for the majority of aircraft designs. We further proposed that the natural dominant configuration could be a candidate for this optimum configuration. Here we describe investigations of the flight mechanic suitability of the natural configuration for human aviation. An alternative wing layout and method of control were tried by radio-controlled models and full-scale tethered flight. So far, no fundamental hurdles were found to dismiss this alternative arrangement. Instead, findings encourage further exploration of the strong possibility that the natural arrangement ought to replace the current dominant configuration in aviation.

AeSSA2019-14: A robotic wingman for fighter aircraft – should South Africa explore this concept?
Author: Kevin Jamison*

Technical Session 3A: Aerospace Manufacturing

AeSSA2019-15: Fatigue life testing of locally additive manufactured AlSi10Mg test specimens
Authors: Niel Agenbag*, Chris McDuling

AeSSA2019-16: 3-Dimensional Printing of Ti-Al-Mn alloys using Laser Engineering Net Shaping (LENS)
Authors: Sibusisiwe Motha*, Dr Nthabiseng Maledi, Dr Monnamme Tlotleng

AeSSA2019-17: A Study on Post Processing of Additive Manufactured Parts
Authors: SE Hoosain, T Dlamini*, M Jordaan, G Corderley

AeSSA2019-18: Design for Additive Manufacturing of Aluminium Aerospace Parts
Authors: Stefan Rassmann*, Niël Agenbag, Andrew Allcock, Andrew Wood

Several parts from an existing aircraft platform were identified for a redesign for additive manufacturing. Their masses were optimised using finite element modelling and a single part was selected for further work which included verification of the optimisation and simulation of the manufacturing build process. Materials testing was performed to characterise the properties of the aluminium alloy (AlSi10Mg), and the test specimens were inspected using x-ray tomography. Neutron beam diffraction was used to measure the residual stresses in a sample set of test specimens, and these results were compared against values from the build simulation to validate the simulation software.

AeSSA2019-19: Aerospace Tooling Competitiveness: Evaluation of a 3D Printed Autoclave Mould in a Serial Production Environment
Author: Dr Louis Tredoux

This study investigates the technical feasibility of a polymer 3D printed autoclave mould for serial production applications by monitoring its condition as the number of moulding cycles increase. The competitiveness of lead time and cost, compared to existing proven mould manufacturing technology is also investigated. Technically the mould has been functioning well so far and further monitoring is continuing. Very significant lead time advantages exist when the printing can happen in South Africa. This opens up the window for leaning the supply chain and has several advantages, for example accommodating late stage geometry change requests from customers. The direct manufacturing cost is substantially lower than the current process.

Technical Session 3B: Aerospace propulsion

AeSSA2019-20: Analysis of Power Balance Methodology for Propulsion integration system
Authors: M.H. Lee*, K.J. Craig, L. Smith

In my research study, Drela's power balance method was validated against the conventional force-based approach on the two-dimensional model of NACA0012. The validation study of NACA0012 was performed in ANSYS Fluent, and the momentum based equation from power balance method was adapted into the simulation. The resulting drag force generated from CFD code and Drela's power balance method were comparable, exhibiting less than 1% difference between them. The results suggest that the current implementation of Drela's power balance method could be used for further analyses on the mechanical energy flow rate of the NACA0012 airfoil.

AeSSA2019-21: A Large Design Space Multidisciplinary Optimization of a Mixed Flow Micro Gas Turbine Compressor Stage
Authors: Thomas Ochabski*, Prof Johan van der Spuy, Dr Thomas Hildebrandt

A novel method of parametrization and optimization for a large design space exploration of a micro gas turbine compressor stage is presented. 48 free parameters were used to control the meridional channel, blade camber, and structural geometric features. The optimization focused on determining the optimal impeller meridional discharge (mixed flow) angle, for a predetermined set of constraints. The influence of key geometric features on design performance was assessed using a Pearson correlation coefficient map. Stage total-to-static pressure ratio, and efficiency, were strongly influenced by diffuser outlet passage height and diffuser vane wrap angle.

AeSSA2019-22: The South African collection of pioneering jet engines
Author: Robert Cathro*

South African museums are in the very fortunate position of owning, preserving and displaying four of the most significant early jet engine types. The National Museum of Military History holds a single example of the BMW 003 and two examples of Jumo 004B engines. The South African Air Force Museum holds 2 examples of the Jumo 004B, one of which is sectioned, the museum holds several examples, sectioned and whole of the De Havilland Goblin engine, including an airworthy and flying example and it holds a sectioned Rolls-Royce Derwent V. The University of the Witwatersrand holds a whole Rolls-Royce Derwent V in its collection. The paper explores the South African collection through photographs of mainly the sectioned engines and extracts from engine manuals and other technical resources. The paper concentrates on the technical features of the engines, their layout, the gas path, the cooling and lubrication systems and how that influenced performance and reliability.

AeSSA2019-23:
Author: Nino Wunderlin*

AeSSA2019-24: Evaluating the effect of combustor inlet swirl on micro gas turbine performance
Authors: Lourens Jan Ferreira *, Prof Johan van der Spuy

This study evaluates the effect of combustor inlet swirl on the performance of a Micro Gas Turbine engine. Special attention is given to the fuel use and total thrust produced by the engine at various operating points. The air mass flow rate into the turbine engine is also evaluated. The turbine being evaluation is the Baird 120 KeroStart (BMT120KS) Micro Gas Turbine (MGT). This study is limited to the design of the compressor de-swirler blade outlet angles, which form part of the diffuser that is located upstream of the combustor inlet. How these angles affect the inlet swirl of the combustor and how this change in swirl correlates with the performance of the gas turbine engine is the focus of this study.

Various topics
AeSSA2019-25: Evaluating the effect of combustor inlet swirl on micro gas turbine performance
Authors: Matthew Kapp*, Nicol Carstens Marek Malinowski Adrian Parsons

Fuel cells increase the flight time of multirotors compared to LiPo propulsion, and have negligible noise and vibrations compared to petrol engine propulsion. We have developed and flight-tested a fuel cell multirotor. We have only done short flight tests, but our system should be able to fly 2 hours with no payload, compared to about 1 hour with LiPo propulsion. Significant improvements in performance of our fuel cell multirotor are expected if we optimize our initial design. The presentation will cover the following: 1) Advantages and reasons for using fuel cell propulsion in multirotors; 2) The process of development and testing of our fuel cell multirotor; 3) Overview of the different components and different types of technologies that make up a fuel cell propulsion system; 4) Challenges and misconceptions with fuel cell powered multirotors and what is being done in the world and South Africa to solve these challenges. The presentation will in summary cover the technical work we have done to develop and test a fuel cell multirotor, but it will also cover the lessons learned and insight gained through this process.

AeSSA2019-26: Preparing High School Learners for Careers in Aviation by Providing a Basic Education Matric Curriculum in Aerospace Science
Author: Alan Nelson*

The government has a prime objective, the creation of jobs to stimulate the country's economy. The lack of technical skills has been identified as one of the root causes of its economic dilemma. The need to re-imagine technology into the current High School curriculum is an imperative. Aerospace science has been identified as a unique opportunity to mitigate the current impasse.

Rocket Propulsion

AeSSA2019-27: Preliminary Design Considerations for the Upper Stage of a Smallsat Commercial Launch Vehicle
Author: Phillip Gyasi-Agyei*

AeSSA2019-28: Analysis of the Phoenix-1B Mk II Sounding Rocket Launch Failure
Author: Kai Broughton*