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GMAERO2023 Abstract Book

Global Meet on
Aerospace and Aeronautical Engineering

June 15, 2023 | Webinar

PRIME MEETINGS
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FOREWORD

Dear Colleagues,

The Prime Meetings takes the pleasure to invite you to the Global Meet on Aerospace and Aeronautical Engineering (GMAERO2023) will be held as a webinar during June 15-17, 2023.

GMAERO2023, is an annual meeting organized with the intend of being a platform for researchers, engineers, academicians as well as industrial experts from all over the world to present their research results and development activities in Aerospace and Aeronautical Engineering.

A wide-ranging scientific program consisting of plenary lectures, keynote lectures, Invited lectures, parallel sessions, as well as poster sessions for young scientists covering all topics in Aerospace and Aeronautical Engineering will be scheduled. This conference provides a wonderful opportunity for you to enhance your knowledge about the newest interdisciplinary approaches in Aerospace and Aeronautical Engineering.

Moreover, the conference offers a valuable platform to create new contacts in the field of Aerospace and Aeronautical Engineering, by providing valuable networking time for you to meet great personnel in the field.

We would like to strongly encourage you to submit your abstracts and register to attend in order to share your achievements in the fields of Aerospace and Aeronautical Engineering.

We cordially invite the scientific community to participate in what promises to be a memorable meeting in June 2023 .

Best regards,
Rebecca
Program Secretary
GMAERO2023
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Voltage Controlled Topologically Protected Wave Propagation in Dielectric Membrane-type Acoustic Meta materials

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Abstract

Topological acoustic Meta materials have attracted enormous research attention in recent years. A significant hallmark of these structures is that they can support interface modes that are robust to structural disturbance and protected by topology. However, most of the studies are often limited to the passive structures that manifest wave propagation at fixed frequency ranges. In view of the shortage of non-passive topological acoustic Meta materials, this work has a primary motive to study the active control of topologically protected wave propagation in soft dielectric membrane-type meta materials (MAM) based on quantum spin Hall effect (QSHE). The unit cell of the periodic structure is designed with C_{6v} symmetry. Then, the plane wave expansion method is adopted to analytically capture the system dispersion properties. A finite element model is further developed and excellent convergence with the analytical result is presented. By adjusting locations of spraying discs in the honeycomb unit cell, mode shape inversion is observed, separating the topologically trivial state from the nontrivial counterpart. Consequently, the topologically protected interface modes (TPIMs) are observed. Additionally, an electrical voltage that lies within the locking-up limit is applied to MAM to actively control the working frequency of the TPIM. Further, several waveguide paths are designed to control the robust wave propagation in the structure. Conclusively, a voltage-controlled topological Meta material is designed to actively tune the working frequency range of the device.

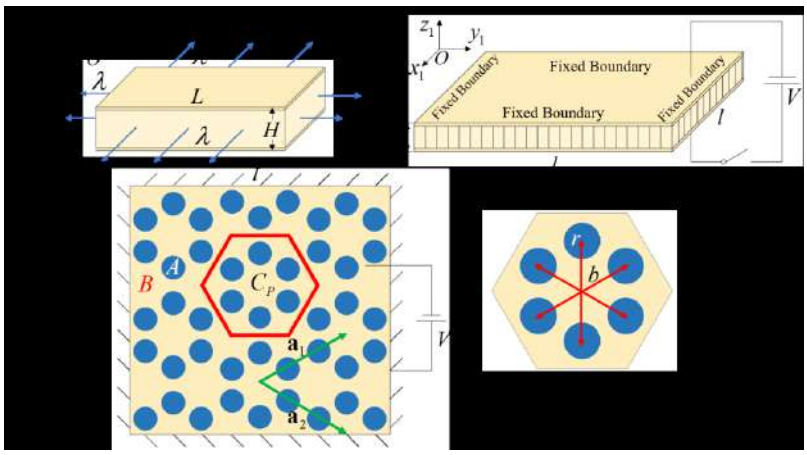

Fig 1. (a) Initial state of MAM applied with equi-biaxial pre-stretch in an XOY plane; (b) fixed boundary is applied to the deformed MAM controlled by an applied voltage; (c) top view of MAM after spraying heavy metallic particles on both sides; (d) unit cell of MAM.

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Chen, Z.Zhou, W., & Lim, C. W.(2021). Tunable frequency response of topologically protected interface modes for membrane-type Meta materials via voltage control. Journal of Sound and Vibration, 494, 115870.

Chen, Z., Wang, G., Zhou, W., & Lim, C. W.(2021). Elastic foundation induced wide bandgaps for actively-tuned topologically protected wave propagation in phononic crystal beams.International Journal of Mechanical Sciences, 194, 106215.

Biography

Prof IR Lim is currently a registered professional engineer (RPE). He received a first degree from University Technology Malaysia, a Master's Degree and PhD from National University of Singapore and Nanyang Technological University, respectively. Prior to joining City U, he was a post-doctoral research fellow at Department of Civil Engineering, The University of Queensland and Department of Mechanical Engineering, The University of Hong Kong. Prof. Lim is also a visiting professor at various universities including the University of Western Sydney, Dalian University of Technology, etc. He has expertise in vibration of plate and shell structures, dynamics of smart piezoelectric structures, Nano mechanics and simplistic elasticity. He is the Editor for Journal of Mechanics of Materials and Structures (JoMMS), Associate Editor (Asia-Pacific Region) for Journal of Vibration Engineering & Technologies (JVET), Associate Editor for International Journal of Bifurcation and Chaos (IJBC), International Subject Editor for Applied Mathematical Modelling (AMM), and also on the editorial board of some other international journals. He has published among one of the well-selling titles in Engineering Mechanics entitled "Symplectic Elasticity", co-authored with W.A. Yao and W.X. Zhong, as recorded in April 2010 by the publisher, World Scientific. He has published more than 300 international journal papers, accumulated more than 3000 independent citations, and one of the papers was granted the IJSS 2004-2008 most cited article award. He was also awarded Top Referees in 2009, Proceedings A, The Royal Society.

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Efficient Adaptive Continuously Variable Transmission (CVT) for aerospace industry

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Abstract

The development of the automotive and aerospace industry leads to the improvement of the designs of automatic transmissions and drives and to the development of methods for monitoring and diagnosing their condition. The trend of improving transmissions comes down mainly to the endless improvement of existing designs of CVTs and variators, which inevitably leads to the complication of designs and methods for their control and diagnostics.
There is a need to create a fundamentally new simplified gearbox based on the scientific achievements of mechanics. However, the created structures remained inoperable due to the lack of theoretical justification.

The adaptive gear variator developed by the author, which has CVT functions, is a mechanism with two degrees of freedom and with an additional constraint of a fundamentally new type, called a force - speed constraint. The force - speed constraint imposes a force restriction on the movement of links, while maintaining the number of degrees of freedom in the kinematics. Monitoring the state of the developed gearbox in the form of a non-switchable gear variator is greatly simplified, since the largest number of faults occur in the control system, and there is no control system in the gear variator.
The proposed article is devoted to a theoretical description of a fundamentally new adaptive gearbox, created on the basis of the latest achievements in mechanics.

Keywords

Adaptive CVT, two degrees of freedom, additional constraint.

Biography

Ivanov Konstantin Samsonovich, born in 1935, Russian, professor, corresponding member of the Engineering Academy of Kazakhstan, STS Institute of Mechanical Engineering of the Ministry of Education and Science of the Republic of Kazakhstan. U.A. Dzholdasbekova, Head of the Laboratory of Adaptive Mechanisms. Professor of the Department of Space Engineering of AUPET, scientific supervisor of undergraduates and doctoral students.

Scientific and pedagogical experience is 58 years - 46 years at the Kazakh National Polytechnic University and 12 years - at the Almaty University of Power Engineering and Telecommunications named after G. Daukeev.

The main scientific activity is related to his scientific discovery "The effect of force adaptation in mechanics" and is aimed at studying the structure, kinematics, and dynamics of adaptive mechanisms and drives of machines with variable technological resistance for aerospace engineering, robotics and general mechanical engineering. Author of 580 scientific and methodological works, including 8 monographs and 122 copyright certificates, inventions and patents of the USSR, Kazakhstan, Russia, WIPO and Germany.

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Aerospace CFRP Composites High-quality Femtosecond Laser Processing

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Abstract:

Carbon fiber reinforced polymer (CFRP) has been widely used in the aerospace industry because of its excellent properties. Compared with traditional machining, laser processing is a competitive method for high-quality CFRP processing because of the advantages of non-contact, high precision, and high quality. However, the high-quality laser homogeneous processing and selective processing of CFRP still face serious challenges, such as obvious heat affected zone (HAZ) and resin residue or fiber breakage. The novel methods of temporally shaped femtosecond laser and multifunctional protective layer assisted femtosecond laser processing are proposed for high-quality homogeneous processing and selective removal of CFRP. Temporally shaped femtosecond laser can effectively regulate the electron excitation process of carbon fiber and resin during the action of laser pulses, achieving the minimality or maximization of their ablation threshold difference for homogeneous cutting or selective removal of CFRP, respectively. The processing damage of CFRP cutting is significantly inhibited and the HAZ is greatly reduced. The high-quality surface where the resin is completely removed without any damage of carbon fiber can be also realized successfully. Besides, by introducing the multifunctional protective layer consisting of Al foil and PI film, the undesired low-energy part of Gaussian laser is effectively hindered from deposition onto the CFRP due to the synergic effect of horizontal heat conduction of Al foil and vertical thermal insulation of PI film. This significantly reduces the heat accumulation and thermal damage, and effectively inhibits the entrance expansion, which result in extremely small HAZ and taper. Through optimization, the CFRP holes with ultra-low HAZ width, extremely small taper and complete smooth sidewall surface can be achieved. Our methods show great potential to dramatically improve the processing quality and broaden the applications of aerospace CFRP composites.

Keywords

CFRP; Femtosecond laser; Homogeneous processing; Selective processing.

Biography

Xin Li has completed her PhD from Tsinghua University, China and postdoctoral studies from Beijing Institute of Technology, China. She is awarded with national excellent young-scientist award of NSFC (2019) and the program for new century excellent talents in university (2013). She is honoured with the second prize of national natural science award of China (2016) and the first prize of natural science award from Ministry of Education of China (2015). She has published more than 72 papers in reputed journals.

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Dynamic design of equipment components based on mechanical metamaterials

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Abstract

This report introduces the fundamental and applied basic research work in the metamaterial-based mechanical functional components. Firstly, a series of design methods for lightweight thin-walled plate/shell acoustic metamaterial structures are reported, and the low-frequency regulation theory of thin-plate structures on mechanical waves is established. Moreover, a series of performance enhancement methods for lightweight and subwavelength metamaterial structures in broadband low-frequency ranges are developed, and some methods to enhance low-frequency broadband performance through material-structure integration design and cross-scale synergetic design are proposed. In addition, the applications of sound insulation metamaterial components, sound absorption metamaterial components and vibration absorption metamaterial components in aircraft, automobiles and other equipment and products are systematically introduced.

Biography

Dr. Fuyin Ma received his BS in Engineering Mechanics from the Taiyuan University of Science and Technology, MD in Automobile Engineering from the Shanghai University of Engineering Science, and PhD in Mechanical Engineering from Xi'an Jiaotong University. He served as Research Assistant in Department of Physics at the Hong Kong University of Science and Technology from 2015 to 2016, Lecturer in School of Mechanical Engineering at Xi'an Jiaotong University from 2016 to 2019, and is currently the Associate Professor in School of Mechanical Engineering at Xi'an Jiaotong University. Professor Ma has published over 50 refereed English journal publications (with more than 1300 cites, 3 Outside Covers, two Invited Tutorials, 2 ESI Highly Cited papers) and presented over 20 oral reports at international meetings and conferences (with 3 Keynote Reports and 5 Invited Speeches). He is an Advisory Panel members of Journal of Physics D: Applied Physics, Associate Editor of Frontiers in Materials, Associate Editor of Frontiers in Mechanical Engineering, Editorial Board of Coatings, peer review of Advanced Materials, Applied Energy, Small, Mechanical Systems and Signal Processing, Composite Part B, Composite Structures, Journal of Sound and Vibration, International Journal of Mechanical Sciences, Journal of Physics D: Applied Physics, Smart Materials and Structures, Journal of Vibration and Control, Applied Acoustics, et al. Dr. Ma's research is in the area of Acoustics and Mechanical dynamics. His research interesting includes acoustic metamaterials, acoustic metasurface, phononic crystal, time-reversal acoustics, acoustic focusing, acoustic imaging, vibration control, ultrasound medical, et al.

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How Centrifugal Force Eliminates Weightlessness and Provides Artificial Gravity in a Space Station

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Abstract
Theoretical and experimental study of the possibility of modelling artificial gravity in the Russian city of Izhevsk, located at an altitude of 200 m above sea level, was carried out under the conditions of Earth's gravity. To create a stable and long-lasting artificial gravity, centrifugal force was used, which was created by circular rotation of solid and liquid objects by changing the value of the radius of rotation and the value of angular velocity in the horizontal plane. It has been shown that the value of artificial gravity increases with increasing radius of rotation and angular velocity. Therefore, increasing the radius and/or speed of rotation allows to increase the value of artificial gravity up to the desired value, including 9.8 m/s^2. The peculiarity of creating such artificial gravity is that under conditions of rotation of a volumetric object having significant dimensions, some parts of the object can be influenced by different gravitational force if they are at different distances from the rotation center. In other words, parts of a rotating object that are at different distances from the center of rotation are subjected to different gravitational forces due to different acceleration forces. This pattern is known as the Coriolis force [1]. In particular, it has been calculated that when rotating horizontally at a speed of about 10.5 revolutions per minute, artificial gravity can reach a value of 9.8 m/s^2 if the rotation radius is about 8 m.

The mentioned regularities were used to develop a rotating disk bed, which when rotating creates artificial gravity with the gravity force vector toward the feet. The point is that such gravity vector prevents pathological redistribution of blood supply in conditions of weightlessness by increasing the gravity of the blood column exerted by it on the legs. The bed in question is made of an inflatable mattress with the shape of a flat round disk having a radius exceeding by 5 cm the height of the tallest astronaut of the team, placing the astronauts' sleeping bags with their back parts on the disk surface in a position where their head ends are as close to the disk center as possible, the bags' axial lines are radial, the bags are fixed and provide keeping them with astronauts' bodies on the bed surface in one plane with its angular rotation up to 30 rotations per minute.
Calculations show that during angular rotation of the disk with a frequency of 12-14 revolutions per minute, on the surface of which the bodies of astronauts weighing 70-80 kg are located radially and motionless, on its circumferential line of radius 170-210 cm, i.e. near the ankles and feet of astronauts, the force of artificial gravity develops of about 30-40 kg. Therefore, increasing angular rotation to a frequency of 30 revolutions per minute (i.e., 2 times) increases by 2 times the force of gravity in each part of the astronaut's body. Therefore, it is inexpedient to increase rotation frequency of the disk more than 30 revolutions/minute.

Keywords
Space station; gravity; Centrifugal force; Angular velocity.

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Biography

MD, Professor Aleksandr Urakov is Head at the Department of General and Clinical Pharmacology at Izhevsk State Medical Academy and Leading Researcher, Department of Modeling and Synthesis of Technological Structures, Institute of Mechanics, Udmurt Federal Research Center, Ural Branch, Russian Academy of Sciences, Russian Federation. He defended his doctoral dissertation at Kazan State Medical University in Russia, published about 200 scientific articles in various journals, developed 230 inventions in various fields of knowledge and led 38 postdoctoral students and doctors to a successful defense of their dissertations.

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Principle, System Integration and ML Algorithms for Ultrasonically Catalyzed Single-Sensor E-Noses

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Nanjing University of Aeronautics and Astronautics, Nanjing, China

Abstract
High-performance gas sensing and electronic noses (E-noses) have huge potential applications in human health diagnoses, food industry, environmental safety, internet of things, chamber air quality monitoring, etc., due to the merits such as point-of-care testing, easiness to operate, simple and light structure, low cost, etc. My research group proposed the ultrasonically catalyzed gas sensing method in 2017, and then successfully applied the method into high-performance gas sensing and single-sensor E-noses. This lecture gives the detailed research results in this respect, the first part of this lecture includes principle of the ultrasonic catalysis in gas sensing, and structure and characteristics of the gas sensors catalyzed by gas borne ultrasound. In the second part, working principle and algorithms of ultrasonically catalyzed single-sensor e-noses, is given and explained, as well as the structure, system design and gas discrimination performance. The algorithms applied in the E-noses include the k-method, R-C method and machining learning methods. It shows that the ultrasonically catalyzed gas sensors have much better sensitivity and lower detection limit than the conventional ones, and ultrasonically catalyzed single-sensor E-noses have strong capability of gas discrimination and concentration measurement.

Keywords
E-Nose; Ultrasound; ML; Integration.

Biography
Junhui Hu received his Ph.D. Degree from Tokyo Institute of Technology, Tokyo, Japan, in 1997, and B. E. and M. E. degrees in electrical engineering from Zhejiang University, China, in 1986 and 1989, respectively. Currently he works for Nanjing University of Aeronautics & Astronautics, China, as a full professor. His research interest is in ultrasonic sensors and actuators, ultrasonic nano fabrication, ultrasonic micro/nano/molecular manipulations, etc. He is a Chang-Jiang Distinguished Professor, China, and an IAAM Fellow. He authored and co-authored more than 300 publications, including more than 100 full SCI papers, two books, 1 editorial review in an international journal and more than 60 disclosed/empowered China and Japan patents. He is the sole author of monograph book “Ultrasonic Micro/Nano Manipulations: Principles and Examples” (2014, World Scientific). He has given more than 30 keynote/invited lectures at international conferences, and his research work has been highlighted by 7 international scientific media. He served lots of international conferences as a Technical Program/Organizing/Scientific Committee member, and was the chairman of five international conferences. He was awarded the title of valued reviewer by Sensors and Actuators A: Physical and by Ultrasonics, and won the Paper Prize from the Institute of Electronics, Information and Communication Engineers (Japan) as the first author in 1998. Presently, he is an editorial board member of four international journals, board member of Chinese Acoustical Society and member of its academic work committee, and deputy director of expert committees on

electronic information materials and devices, and on Aerospace materials, Chinese national scientist think tank for materials and devices.

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Addressing Space Sustainability with Autonomous Electro Dynamic Tether Deorbit Devices

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2Università degli Studi di Padova, Via Venezia 1, 35131, Padova, Italy
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[5]David Hubert, Rocket Factory Augsburg AG, Berliner Allee 65, D-86153 Augsburg, Germany

Abstract

Since the beginning of the space era in 1957, humanity has launched in space more than 6.250 rockets and 13.630 satellites and most of these space crafts are still orbiting Earth. Exposed to the harsh space environment, tanks and batteries may explode generating clouds of debris that trigger collision with other space objects in a never-ending chain reaction known as Kessler syndrome. According to the latest European Space Agency report, there are currently more than 36.500 debris larger than 10 cm, 1 millionof debris from 1 to 10cm and 130 million of debris from0.1to1cm.
Space community agrees that there is an urgent need for taking action to improve the situation. An opportunity for addressing the space debris problem exits for the Low Earth Orbit up to 1200km altitudewhere most of the debris are located. In Low Earth Orbit, it is possible to use Electrodynamics tethers (EDT) to exchange momentum between the spacecraft and the Earth's magnetosphere without using propellant. Electrodynamics tethers (EDT) are a long conductors attached to the satellite and deployed along the local vertical that can be used to generate current and drag force through the interaction with the ambient plasma and the geomagnetic field. EDT technology has been demonstrated several times in the past decades, including the dedicated Plasma Motor Generator NASA mission in 1993 and the manned Space Shuttle mission STS-75 in 1996. The tether technology has considerably evolved during the last decades increasing performances and reducing mass and envelope and new experimental tether missions have been launched recently like TEPCE (NRL 2019) and Drag racer (Tethers Unlimited 2020). In March 2019, the European Commission granted to a European consortium industrially led by SENER Aeroespacial a 3M€ FET-OPEN project entitled Electrodynamics Tether technology for Passive Consumable-less deorbit Kit (E.T.PACK). The consortium designed, manufactured and tested a Deorbit Device prototype based on EDT technology reaching Technology Readiness Level equal to 4. In September 2022 European Commission granted a 2.5M€ EIC-TRANSITION project to continue the development of the demonstrator up to flight qualification in 2025.

The Deorbit Device (DD) demonstrator is a standalone 24-kg satellite with the objective to

demonstrate the performances of the improved EDT solution and validate its very-compact deployment system. The DD is composed of two modules that will separate in orbit extending a 500-m long tape-like tether. The deployed bare-Aluminum tether will capture electrons from the ambient plasma passively and the circuit will be closed with the ionosphere plasma by using a miniature active electron emitter. E.T.PACK tether will take advantage of several novelties with respect to the mission flown in the past that will allow to optimize the system volume and mass. Once successfully demonstrated in orbit, the team plans to develop a suite of EDT systems capable of deorbiting spacecraft upper stages and satellites between 200 and 1000kg from an altitude up to 1200km in a few months. EDT technology can be a game changer providing a concrete solution to the space debris proliferation problem.

Keywords
Space Debris; Electro dynamic Tether; Deorbit; Space Sustainability .

Biography
Lorenzo Tarabini Castellani is a senior system engineer with consolidated experience in complex spacesystems and in particular in satellites design, development and verification. He obtained a Master of Science in Aerospace Engineering in 1999 at the “Politecnico di Milano”. In 1999-2000 he started his career worked at the TU-München designing the Attitude and Orbit Control System the moon mission Lunarsat. In 2000 he moved to Spain where he joined GMV Aerospace and Defence. He was responsible of several European Space Agency projects including the DARWIN satellite constellation simulators, the PLANCK spacecraft navigation, the SMART-2 and Cone Xpress mission analysis and the Proba-3 Formation Flying system design. In 2008 he joined SENER Aeroespacial as system engineer of SMART-OLEV, a commercial mission aimed to provide in orbit servicing to geostationary telecommunication satellites. From 2010 to 2015 he worked as Proba-3 system engineer. In the following 4 years he was involved in ESA scientific missions (EUCLID, PLATO, SPACE RIDER) and Technology Research Projects as well as company internal products evolution. Since 2019 he is dedicating most of his time to the development of a satellite deorbiting system based on electrodynamics tether supported by the European Commission project E.T.PACK

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Challenges in Aerodynamic Analysis of Innovative High-Lift Designs for Aeronautics

Stefan Wallin*
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Abstract
Mobility in terms of air transportation is of fundamental importance for economic and social development by connecting countries, people and cultures. The ongoing global climate change enforces an urgent transfer to environmentally friendly and sustainable means of transportation, which enables the opportunity of new technologies and novel aircraft designs to fulfil the IATA Net zero 2050 vision. Introduction of sustainable aviation fuels and electric propulsion enables development of more efficient aerodynamic designs with less drag e.g. by retaining laminar flow over the wing surfaces. One of the challenges with such designs is the high-lift devices for sufficient lift during take-off and landing while preserving the lower drag during cruise conditions. Non-conventional high-lift designs must be analysed by the most advanced computational fluid mechanics (CFD) methodologies companied by experimental validation.

CFD strategies for the challenge related to innovative high-lift designs are developed within two European research projects within the European Union's Horizon 2020 research and innovation programme. In UHURA the unsteady flow around deploying and retracting Kruger leading-edge high-lift devices was studied by wind-tunnel experiments as well as advanced CDF methods. The WTM-RECYCLE project studied the installation effects of drooped morphing high-lift devices on a regional turboprop full aircraft by large wind-tunnel tests complimented by CFD.

The quality and trust in aerodynamic data computed by CFD is highly dependent on carefully chosen strategies and the accuracy of the computational setup. The computational mesh is always a compromise between accuracy and the available computational resources. A common approach when doing CFD of complex geometries with moving control surfaces and interchangeable aerodynamic devices is to apply some automatic meshing procedure, which will require a minimum of engineering work and rapid turn-around times. However, sufficiently accuracy and efficient distribution of mesh points is difficult to achieve. We will argue for carefully designed computational meshes build on principles of parameterisation which is more time consuming but enables rapid turn-around times. The computational setup, numerical methods and modelling, in particular turbulence modelling, are equally important ingredients for high accuracy. All these aspects will be further discussed in the paper/presentation.

This work was performed within the UHURA and WTM-RECYCLE projects which have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements No 769088 and 755605 respectively.

Keywords
Aerodynamics; High lift; Computational fluid dynamics; Turbulence modelling.

Biography
Stefan Wallin holds a research position at KTH. He has 30 years' experience in CFD and turbulence modelling for aerodynamics and is the author/co-author of some 40 journal publications (Orchid 0000-0001-8692-0956). He has participated in numerous national and international projects in this subject.

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Environmental Particle Behavior's in Engine Hot-Sections

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Abstract

The aircraft engine hot section is most vulnerable and failure prone to environmental particle ingestion, particularly for helicopters. The field experiences indicated that aircraft service time can be substantially reduced even lost power, due to particle ingestion. In the 21st century, the particle ingestion into gas turbines becomes more important due to two factors: (1) in pursuit of higher efficiency, engine manufacturers are increasing peak temperatures well above the softening temperature of airborne particles and (2)air quality in many areas of the world is poor.

The experimental measurements and numerical modeling of particle rebound/deposition in engine hot-sections, involve complicated physical phenomena with a rich parameter space. The current state of the art in experimental and analytical researches of environmental particle impact on engine hot- sections was reviewed, with more attention on sand particles. From these efforts, the available experimental data for model calibration/validation were identified, and a novel particle rebound/deposition model was developed. A semi-empirical approach is selected to model sand particles bouncing off metal surfaces, where the coefficients of restitution measured in a temperature range of 297 - 1323 K are used to calculate particle bounce-back velocities from metal surfaces. The novel deposition model is based on non-dimensional parameter group and analysis over more than seventy experimental datasets of particle deposition in engine hot-sections. Moreover, the metal surface temperature, one of two critical parameters in particle deposition, is also considered in the model.

The developed particle rebound/deposition model has been successfully implemented into the ANSYS CFD Premium solver, and carefully checked step by step. The model is calibrated/validated by two cases: sand [or Arizona road dust (ARD)] particle impingement on a circular plate and Mt. St. Helens volcanic ash (comparable with ARD particles in terms of chemical composition) impinging on a first- stage air-cooled nozzle guide vane (NGV). For the former case, the calibrated model predicts fairly well the variation of particle capture efficiencies with particle injection temperature. The latter case indicates that the particle capture efficiency at engine operating conditions can be properly predicted by the developed model. The calibrated/validated model has been successfully applied to a helicopter reverse-flow combustor and nozzle guide vanes. The results have revealed the environmental particle complicated behavior's (passing through, rebound or deposit at hot surfaces, or trapped inside hot components) in the combustor. Certainly, the model will be continuously improved as the relevant experimental data appears.

Biography

Dr. Lei-Yong Jiang obtained his Ph.D. degree from Institute for Aerospace Studies University of Toronto in 1995, and has been in the combustion and propulsion S&T field over 30 years with more than 130 publications and adjunct professorships from two Canadian universities. He is an active member of Combustion Fuels & Emissions Committee and the previous Chair of Coal, Biomass, Hydrogen & Alternative Fuels Committee of International Gas Turbine Institute. His research interests include gas turbine combustion, CFD applications to solve various reacting and non-reacting engineering problems, impact of environmental particles to gas turbine engines, laser diagnostics, and experimental combustion.

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New Approaches to Landing Systems Engineering

Martin Skote*
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Abstract

Landing Systems Engineering is a multidisciplinary topic involving a wide range of disciplines, spanning from Molecular Dynamics to Systems Integration, hence a broad spectrum of engineering disciplines overlaps, and requires intense collaboration between scientists and engineers. Furthermore, the work underpins the strategy for developing synergistic landing systems for future aircraft with alternative propulsion technologies implemented, which are required for the planned decarbonization of air travel.

The overall vision of the research is to establish new design criteria by transforming the empirical-based landing gear into a digital-model based product, hence enabling a systems-of-systems approach to the wider system and to provide opportunities for optimization and adoption of new materials and technologies. Previously, the development of landing gear has lagged behind other aircraft systems, such as lighter fuselage/wings and more efficient and quiet engines, due to the unique requirements and harsh operating conditions, while the current revolutionary development of aircraft for net-zero carbon emission flight enables new approaches to landing systems design.

The presentation will give an overview of the research on Landing Systems undertaken at Cranfield University in collaboration with industrial partners. Furthermore, results will be presented from interdisciplinary projects, including:

1. Development of an Advanced Multi-fidelity Design Tool for Landing Gear Shock Absorber
Motivation: Lighter and less bulky shock absorbers save weight and space.
Goal: A multi-physics and multi-fidelity simulation framework is created, using state-of-the-art computational methods for predicting shock absorber physics.

2. Predicting Landing Gear Joint Seal Leakage
Motivation: Leakage through seals within the landing gear is one of the causes for repair and overhaul of an aircraft, leading to excessive maintenance cost.
Goal: A numerical tool capable of predicting seal leakage is developed.

3. Friction in Landing Gear Braking Systems
Motivation: Performance of Carbon-Carbon components is integral to overall performance of aircraft braking system.
Goal: Numerical simulations are performed that captures the physiochemical micro/nano scale processes, which are utilized when modelling the brake wear on a macroscale.

4. Kinetic Energy Recovery for Commercial Aircraft
Motivation: A key target in the design of future aircraft is to minimize the energy consumption and maximising the energy recovery.
Goal: Explore fundamental science and technological solutions for conversion of kinetic energy during landing to electrical energy while enabling storage and grid distribution.

5. AI-enhanced Digital Twins for PHM Optimisation

Motivation: Predictive maintenance is a vital part for reducing the recurring cost of landing systems.

Goal: Robust and dependable condition monitoring, predictive maintenance, and prognostics and health management (PHM) regime for the aircraft systems over the entire period of their life cycle.

The outcomes from the above projects will be discussed in relation to the optimisation of the overall landing system in the context of future aircraft and airport design.

Keywords

Landing Systems Engineering; Multi-fidelity; Shock Absorber; Kinetic Energy Recovery.

Biography

Professor Martin Skote joined Cranfield University as Airbus Professor of Landing Systems Engineering in September 2018. The goal is to form and lead a group for Landing Systems Engineering, which will focus not only on the mechanical/electrical/hydraulic aspects of the landing gear, but also consider it a part of a much larger system, including airport infrastructure and air traffic management. Together with development of advanced multiphysics simulation capabilities, future innovate and disruptive technologies such as autonomous taxiing and AI-enabled predictive maintenance will be vital parts of the work. Apart from securing £ 5 million in funding, he is also supervising 6 PhD students.

Prior to his current position, he was an Assistant Professor at Nanyang Technological University in Singapore, with a research focus on turbulence, flow control and computational fluid dynamics. During his ten years at the University, he secured research grants from both industry and government funding bodies and graduated 10 PhD students.

Before taking up his academic position in Nanyang Technological University, Professor Skote worked for the Institute of High Performance Computing in Singapore, developing a numerical simulation code for air pollution dispersion simulations in collaboration with the National Environment Agency, Singapore.

His PhD in turbulence was awarded (2001) from the Royal Institute of Technology (KTH) in his native country of Sweden.

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Double-double: a revolution that makes composites better understood and used

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Abstract

Discovery of trace (Tsai's modulus) as the one and only parameter for the stiffness of composite laminates has simplified design and testing of revolutionary magnitudes. A single parameter for the strength of laminates based on the area master failure envelopes has been discovered. Having one parameter for both stiffness and strength make rating and scaling of composites feasible. Examples of this remarkable advance can make design, production and testing much simpler and rational. For testing only uniaxial tensile and compressive strengths, X and X', are needed to generate design allowable, instead of testing QI, hard and soft laminates. Many self-inflicted complexities in stacking sequence, blending and optimization can be avoided with double-double. The key feature is its 4-ply building block that is easily homogenized. It is then naturally symmetric and plies can be reduced for lightly loaded zones without change in properties. Optimization for tapering and ply drops in singles located on the exterior surfaces make laminated structures lighter, warpage free, and free of defects in the laminate interior. One-axis layup speeds up production and is less prone to error. With one parameter for stiffness and strength, composite laminates are like orthotropic metals, but lighter than metals because tapering is natural in additive manufacturing. Composites are easier with scaling, without recalculation. They are simpler to understand because their stiffness and strength have been simplified. Free download of our book on double-double is available: compositesdesign.stanford.edu. Excel-based tools for analysis and design such as Micmac's and Lam search are also available free upon request.

Biography

Professor Tsai's research interest is in the development of design methodology of composite materials and structures. As an emerging technology, composite materials offer unique performances for structures that combine light weight with durability. Keys to the successful utilization of composite materials are predictability in performance and cost effective design of anisotropic, laminated structures. Current emphasis is placed on the understanding of failure modes, and computer simulation for design and cost estimation.

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Design Optimization of Structural Metamaterials

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Abstract
The advent of Additive Manufacturing allows complex hierarchical structures to be realisable. Within a component an architecture internal structure can be produced, which has dramatically different maternal properties to the bulk. These structural metamaterials allow a component to be designed with both the external shape and internal tailored properties considered. However, there are a number of challenges in trying to do this, where even visualising the material properties and internal geometry becomes a challenge. Furthermore, the complex internal material properties can lead to emerging material properties through structural grading, which are different from both the bulk material and internal structural components.

In this work a formal gradient-based design optimization framework is presented, which exploits the link between small scale unit lattice geometry and parameterised homogenised material properties to result in a graded internal structure for a range of different applications. These include structural light weighting, robust design subject to uncertainty, and vibration control. Such an approach has been taken for both three dimensional structural components, as well as so-called Meta shells, where non-linear deformations can be obtained from grading and sizing of unit geometry.

The optimisation approach taken has some similarities to conventional topology optimisation where adjoint sensitivities are used to link the design variables (for example the radius or a small scale lattice) to the overall component performance. A gradient based optimiser (in this case a quasi-Newton approach using a Hessian approximation (L-BFGS)) is then used to arrive at the optimum structure. Reconstruction of the optimised geometry for 3D printing is then undertaken, followed by printing and testing.

Keywords
Design Optimization, Graded Structures, Structural Metamaterials.

Biography
Dr Rob Hewson is a Reader (Associate Professor) in the Department of Aeronautics at Imperial College London. He specialising in multiscale optimisation of structures for a range of different purposes. He obtained his PhD from the University of Leeds in 2006 before taking up an academic position. He moved to the Department of Aeronautics at Imperial College London in 2014 and works on multiscale structures of a range of different applications. These multiscale structures, also known as structural metamaterials exhibit material properties different from the bulk material from which they are made. These additional material properties can be exploited

using formal design optimisation approaches, typically using gradient based approaches similar to topology optimisation to produce the desired response. These responses can be a required stiffness for a constrained weight, a specified displacement when loaded, or a defined frequency response and mode shapes.

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Turbulent Air wake Flow Simulations of Ships in Motion

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Abstract

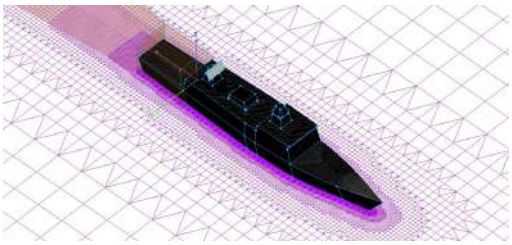
Shipboard helicopters play an important role in civilian and military applications. Shipboard operations are among the most challenging of any piloting task for fixed and rotary wing aircraft. The take-off and landing of helicopters are often performed from the landing decks of ships, which are subject to motions in six degrees of freedom. The difficulty is increased given that the landing deck is often immersed in the unsteady ship air wake. Because of the nature of bluff bodies, the separated flow and shedding vortices interact and result in an unsteady air wake with highly turbulent structures, which can significantly increase the difficulty associated with helicopter operations. This work has applications for aircraft flight in complex flow fields in many sectors of the aviation industry.

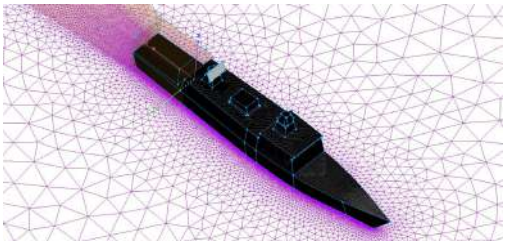
In support of Canadian industrial and defence ship design and offshore helicopter operations, a series of Ship–Helicopter Operational Limits Analysis and Simulation (SHOLAS) projects are being conducted at the National Research Council Canada (NRC) in collaboration with the Department of National Defence of Canada. Among other applications, computational fluid dynamics (CFD) air wake results were validated against in-house wind-tunnel data and used with confidence as input to produce representative air wake features in industrial high-fidelity piloted flight simulators and other investigations. This paper reports recent lessons learned during the course of the projects, in particular the influence of improper CFD grids and the effects of the ship motion solvers.

The open-source CFD code Open FOAM was employed to compute the three-dimensional unsteady incompressible flows past the NATO General Destroyer (NATO-GD) ship model. Open FOAM uses motion solvers to define the mesh displacement. The solid-body motion solver is the basic model, which allows mesh motion for which the mesh topology does not change and instead the computational mesh moves as a whole. Other Open FOAM motion solvers Modeling dynamic meshes were developed for specific conditions and applications. To handle the complex ship motions with a deforming free-surface boundary, a mesh morphing functionality based on an in-house radial basis function (RBF) is being ported to Open FOAM, and will be used to verify the numerical accuracy of the solid-body motion solver.

CFD mesh influence: The simulations were first tried on a Cartesian mesh, as demonstrated in Figure 1a. Unexpectedly, artificial ribbons were observed in the flow field over the front of the ship, as shown in Figure 2. This issue was mainly caused by transition layers between the coarse and refined zones. The grid generation software, Point wise, uses tetrahedral and

pyramids to transition layers between the hex cells in the Cartesian mesh. These simulations demonstrated that Open FOAM does not perform well with these cell types in the transition layers. To remedy this unphysical phenomenon, a tetrahedral mesh was generated, as shown in Figure 1b.

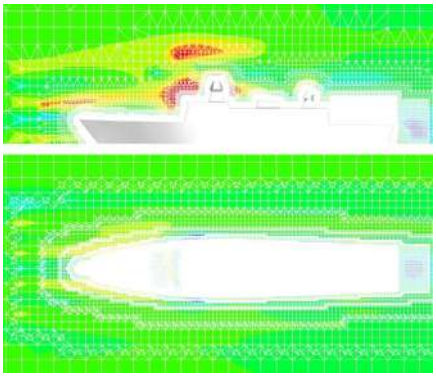




Motion solver effects: The simulations were conducted for the ship in respective heave, roll and pitch motions, at an oscillating frequency of 0.04 Hz. The effects of the two motion solvers are demonstrated in Figure 3 through Figure 5. As can be seen in the figures, the solid-body motion solver predicted the peak frequency for heave and pitch, as indicated by the power spectral density of the vertical velocity, but it did not predict the frequency when the ship was in a rolling motion. Detailed paper.

Results will be compared with the in-house wind-tunnel data and discussed in the full

Figure 1. CFD meshes.



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Hydrogen Power System for Enhancing Time of Flight of Drone Operation

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Abstract
This talk will give an introduction of the state-of-art micro solid oxide fuel cells (micro-SOFCs) using silicon-based micromachining technology to achieve a breakthrough increase in time of flight of drone operation by developing a larger lateral dimension of such electrochemical energy conversion devices. The lateral dimension of the nanoscale thin film electrolyte membrane, which the thickness is only tens of nanometer, has been chronically limited to only hundreds of micrometers scale due to the fragile thin oxide membrane. Through our unique design from the mechanics approach to relieve the stress level of the membrane, and with the help of a simple combinatorial etching process, the lateral dimension of the micro-SOFCs electrolyte membrane was increased to several millimetres scale. The technology breakthrough introduced here can further the practical application of such promising device closer to commercial manufacturing stage in the area including unmanned aviation vehicles (UAVs) or military drones which needs longer time of flight for expanding drone applications.

Acknowledgement
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J. D. Baek, Y.-J. Yoon, W. Lee, P.-C. Su, 2015, Circular membrane for nano thin film micro solid oxide fuel cells with enhanced mechanical stability, Energy & Environmental Science, 8 (11), pp 3374-3380

Keywords
Drone power source; UAV time of flight; Hydrogen power; Micro SOFC

Biography
Prof. Yoon obtains his Ph.D. degree (2009) in Mechanical Engineering with two Master degrees from Mechanical Engineering (2005) and Electrical Engineering (2008) from Stanford University. Prof. Yoon also obtains his Ph.D. minor degree in Management Science and

Engineering (2009) in Stanford University. His current research include 3D printed biosensors, drone power sources using nano thin-film fabrication, and smart manufacturing for advanced nano drone. Currently he is an Associate Professor in the department of mechanical Engineering at KAIST, a President of the University Industrial Technology Force (UNITEF), Advisor of KAIST Startup Center, Director of Center for Drone Defence Industry, Advisory Partner of Enlight Venture Capital, Venture Partner of ES Investors and Visiting Professor of Nanyang Technological University. He has published more than 120 international journal articles (SCI indexed) and 170 international conference proceeding papers, Besides his resaerch, Prof. Yoon is interested in an academic-based entrepreneur career as a start-up accelerator. For the past years, he has been actively incubating start-ups where he took the lead to raise startup funding from government entities and renowned global venture capitals.

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Emerging Green Technologies for All Classes of Aircraft

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Abstract
The focus on the greening of aviation is expressed in policies like "Fit for 55" of the EU and "Net Zero 2050" of ICAO. Those objectives depend first (i) on the implementation of breakthrough technologies and (ii) on their operational adoption on large scale. Thus, there is the need of technology development process to consider nor only (i) feasibility and efficiency but also (ii) certification and operations. The usual promising technologies related to batteries, fuel cells, hydrogen burning turbines and synthetic aviation fuels will be considered, as well as some more exotic possibilities like on-board hydrogen production and superconductivity. All classes of aircraft will be considered, from the smallest UAMs and private aircraft, to the single and twin-aisle jetliners, with regional aircraft in between. For each class of aircraft will be considered the most promising technologies to reduce environmental impact (noise and emissions) and also the associated certification/safety and operational ussies. The relative contribution to emissions of each class of aircraft, the timescale of maturation of each technology and the replacement of existing fleets will determine the rate of which greening of aviation can be implemented.

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Certification Roadmap for Emerging Manufacturing Processes for Aerospace Structural Component

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Abstract
Challenging complexities in product design and manufacturing stimulate innovation in materials, manufacturing processes and methods used in the aerospace industry. Essential safety requirements provide a unique condition for product performance and quality management in the sector. To make "learning from catastrophic mistake" a thing of the past, new and emerging technologies must undergo rigorous airworthiness certification processes. However, the existing aviation rules and regulation standards have little, if anything at all, to cover disruptive and new technologies. Definition of new rules and regulations requires extensive evidence-based testing and validation. This can be time consuming with delays that go beyond the introduction of even more new processes and technologies.
This research tries to reduce the overall time of the certification process on new and emerging manufacturing processes. Even so, the focus is given to the structural components upon which comparatively more stringent requirements are often put in place. In this research existing certification methods have been first reviewed. Then a road map with embedded detailed flow charts has been proposed for certification of innovative technologies. The proposed road map has been demonstrated through a case study of aerospace structural components utilising newly developed additive manufacturing processes and techniques.

Keywords
Certification process; Aerospace validation; Additive manufacturing; Aircraft design.