



10th International Micro Air Vehicle Competition and Conference

November 17-23, 2018

Melbourne, Australia

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Preface

It is our pleasure to present the proceedings of the 10th International Micro Air Vehicle Conference and Competition, which was held in Melbourne, Australia from November 17 to 23, 2018. This event aims at exchanging the most recent findings in the rapidly expanding area of Micro Air Vehicles (MAVs). The received submissions show that this is an active field of research all over the world.

These proceedings contain forty-eight peer-reviewed scientific papers presented at the IMAV 2018. The topics of these papers range from new insights into aerodynamics in buildings to the control of large swarms of MAV with communication limitations. Together, the papers give an overview of the current state-of-the-art of the field of Micro Air Vehicles, indicating in which direction this field may develop.

Finally, we want to express the hope that the specific nature of the IMAV event (a combination of a scientific conference and a real-world competition) in combination with the open access nature of the publications, will continue to advance the state-of-the-art in this relatively young research area.

Nov 2018

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S. Watkins

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Call for Papers



The 10th International Micro Air Vehicle (IMAV2018) Conference and Competition will take place in Melbourne, Australia. The IMAV is a yearly event that combines a scientific conference with a technological competition involving Micro Air Vehicles (MAVs). This is the first time the conference has been held in the Southern Hemisphere and shall be a fantastic opportunity for international research groups to share their knowledge with a global audience. Through the conference we aim to create a forum for academics and practicing engineers to present their latest research findings in the state-of-art MAV design and application. We encourage authors to present research related to Micro Air Vehicles, research topics may range from fundamental knowledge in disciplinary topics to cross-disciplinary technological innovation and the use of MAVs to other research fields. Topics include, but are not limited to:

- Low Reynolds number aerodynamics
- Navigation in turbulent environments
- Unsteady aerodynamics
- Propulsion set and new energy sources
- Autonomous navigation
- Swarming and formation flight
- Control theory and state estimation
- Flapping wings and bi-inspired MAVs
- Computer vision for MAVs
- Obstacle detection and avoidance
- Integration of MAVs in airspace
- Novel applications for MAVs
- Active perching
- New MAV architectures
- Relayed Control and Communications
- Advanced manufacturing techniques

Exemplary papers may be selected for publishing in the International Journal of MAVS or Unmanned Systems Journal. For your paper to be selected you must register at www.imav2018.org before the start date of the conference. Abstracts should be 1 single-sided page submitted as a word or pdf. file.

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Guest Speakers

Dr. Anya Jones

Anya Jones is an Associate Professor in the Department of Aerospace Engineering at the University of Maryland, College Park, USA. She received her PhD in experimental aerodynamics from the University of Cambridge, United Kingdom, her S.M. in aeronautics and astronautics from MIT, and her B.S. in aeronautical and mechanical engineering from Rensselaer Polytechnic Institute. Her research is focused on the experimental fluid dynamics of unsteady and separated flows. Her current projects focus on wing performance in large-amplitude gust encounters, separated and reverse flow rotor aerodynamics, and flight through airwakes and other unsteady environments. Prof. Jones has been awarded the AFOSR Young Investigator Award (2012), NSF CAREER Award (2016), and the PECASE from the White House (2016). In 2017 she was awarded a Fulbright Scholar Award to the Technion in Haifa, Israel (2017-2018) and an Alexander von Humboldt Research Fellowship to TU Braunschweig in Germany (2018). She is currently chair of a NATO Research Technology Organization task group on gust response and unsteady aerodynamics, an associate fellow of AIAA, and a member of the Alfred Gessow Rotorcraft Center.

Dr. Jones' presentation will focus on MAV behavior in turbulent conditions and the ability to predict unsteady flows and mitigate their effects. One of the challenges of MAV flight is controlled flight through the unsteady environments that exist in urban areas, in airwakes, and in extreme weather. These highly unsteady flows often result in large force transients due to flow separation and the formation of large-scale vortices. The growth and motion of these vortices can have a large impact on the resulting force transient and recovery, necessitating advanced control either locally via flow control or more globally at the vehicle level. The current work focuses on wind gusts and wing maneuvers that result in changes to the relative flow that are of the same order of magnitude as the freestream flow. In these cases, flow separation is significant, so the classical linear solution for the flow does not apply and aggressive control is required. Separated shear layers emanating from the wing tend to roll up into leading and trailing edge vortices that are shed into the wake. The formation and motion of these vortices are characterized via a series of canonical experiments in an attempt to better understand their contribution to aerodynamic forcing and their relative importance as compared to other sources of airloads (e.g., added mass and virtual camber). The results are then used to construct a physics-based low order model of highly separated flows, and thus explore the possibility of predicting unsteady and transient loading, as well as gain insight as to where flow control might be used most effectively to mitigate force transients and/or hasten flow recovery.



Dr. Shane Windsor

Dr Windsor is a Lecturer in Aerospace Engineering at the University of Bristol in the UK. His research is focussed on the fluid dynamics, sensing and control involved in animal flight, and how biological inspiration can be used to improve autonomous systems. Recently his work has focussed on the dynamics of bird flight and how this can inspire the development of technologies for small unmanned air vehicles (UAVs). Previously he worked at Oxford University and the University of Auckland, looking at the biomechanics of a wide variety of different biological systems. He has recently been awarded a prestigious €2 million European Research Council Starting Grant to develop this work further over the next 5 years.

Dr Windsor's talk will focus on his recent work studying the mechanisms behind how birds are such extremely agile and efficient flyers. This will include work looking at:

- the flight stability of gliding birds of prey
- flight path planning in urban wind fields by GPS tagged gulls
- bird manoeuvring flight in windy conditions

The talk will then look at how the insights gained from biological systems can be used to develop technologies for UAVs.



Lieutenant Colonel Keirin Joyce, CSC

Lt. Col. Joyce is currently the UAS Sub-Program Manager for the Australian Army and has been extensively involved with UAS development in the Australian Defence Force for the last 12 years. Lt. Col. Joyce is a graduate of the Australian Defence Force Academy (ADFA) with an Honours Bachelor of Aeronautical Engineering, a Masters in Aviation Management, a Masters of Aerospace Engineering, a Masters in Military and Defence Studies and a Graduate Diploma in Secondary Education (Mathematics), he is currently researching as a Doctorate of Philosophy through ADFA. Lieutenant Colonel Joyce is at the forefront of UAS development in Australia and we look forward to have him attending the conference and competition later this year.

Lt Col. Joyce' will give a talk titled: *The Australian Army's smallest aircraft. Biggest effect?* The Australian Army is the world's largest user of Nano UAS. This talk will discuss why Army has invested in such a tiny aircraft and where they see the future of Micro Air Vehicles.



Dr. Reece Clothier

Dr Clothier is currently a Principal Researcher at Boeing Research & Technology – Australia, the President of the Australian Association for Unmanned Systems (AAUS), and an Honorary Associate Professor at RMIT University. In these roles Dr Clothier has been extensively involved with the UAS development in Australia. Dr Clothier has a Bachelors in Engineering (Aerospace Avionics) and a PhD in the design and certification of UAS from QUT. His research interests include UAS autonomy, certification and safety assurance of highly autonomous systems. In 2016 Dr. Clothier was awarded the Outstanding Next Generation Professional at the Aviation/Aerospace Australia National Awards in recognition of his contribution to the Australian UAS industry. He was also the former Industry Co-chair of the Civil Aviation Safety Authority, Standards Consultative Sub-Committee for Unmanned Systems and currently serves on the General Aviation Advisory Group, which directly advises the Federal Minister of Transport and Infrastructure.

Dr Clothier's presentation is entitled "**The Safety Case Enabling Future Aviation Operational Concepts**"

What will our skies look like in a decade? It is safe to assume that there will be continued growth in the use of Unmanned Aircraft Systems (UAS) for a variety of commercial and civil applications. These applications will be diverse, encompassing point-to-point delivery, high altitude remote data collection and communication services, through to applications in emergency and law enforcement. However, UAS will not be alone. A diversity of new air vehicle concepts providing the community with an entirely new means of personal and mass transportation are expected to emerge. It is becoming apparent that our airspace will not only be much busier but will be used in fundamentally new ways. In the face of such new

levels of operational complexity, a key challenge will be in ensuring the risks to other airspace users and the communities overflown can be managed to acceptable levels. This presentation takes a look at the elements of the over-arching safety case enabling the future aviation operational concepts. The different risk factors, and the technical and operational risk mitigations available are presented for a range of UAS and urban air mobility (UAM) concepts of operation. The social and political dimensions influencing community acceptance of the risks are also explored.



Professor. Jason Scholz

Professor Jason Scholz leads research, development and showcasing of high-impact technologies for persistent autonomy, machine cognition, and human-machine integration in close partnership with overseas governments, academia and industry to deliver game changing impact for Australian Defence and National Security. He holds a Professorship (adjunct) in the IT and Engineering Department of UNSW, a PhD in Electrical Engineering from the University of Adelaide and a degree in electronic engineering from the University of South Australia. He has over seventy five refereed publications and patents, in telecommunications, signal processing, artificial intelligence and human decision making. He is an assessor for the Australian Research Council and a graduate of the Australian Institute of Company Directors.

Professor Scholz will speak about the Defence Cooperative Research Centre on Trusted Autonomous Systems. The Minister for Defence industry, the Hon Christopher Pyne MP, has announced that the first Defence Cooperative Research Centre (CRC) will focus on Trusted Autonomous Systems to deliver game-changing unmanned platforms that ensure reliable and effective cooperation between people and machines during dynamic military operations. The CRC for Trusted Autonomous Systems will receive an annual funding of \$8 million with a maximum of \$50 million over a seven year period. To be effective, Defence needs autonomous systems to be highly trusted, robust and resilient and this initiative will bring together the best researchers from industry and universities to develop the intelligent military platforms of the future. Professor Scholz will discuss the research program and highlight opportunities as it relates to Micro Aerial Vehicles.



Dr Jennifer Palmer

Dr Palmer is a member of the Aerospace Division of the Defence Science & Technology (DST) Group in Melbourne, Australia. Over the past decade, her work has focused on unmanned aircraft, including projects on hybrid-propulsion and power-management technologies for small surveillance aircraft and flapping-wing flight. Currently, Dr Palmer is engaged with academic and DST collaborators in the development of autonomous aircraft for urban missions, including surveillance, humanitarian assistance, and emergency response. Prior to immigrating to Australia from the US, she was employed at Lockheed Martin Missiles & Space in Sunnyvale, California, where her work involved analyses of missile systems and test failures. She earned a Ph.D. in Mechanical Engineering from Stanford University, with a thesis on the demonstration of advanced laser-based diagnostic techniques for hypersonic flows. Dr Palmer's presentation is entitled: **The birds and**

the bees and the MAVs. Nature can provide the inspiration for advances in aircraft technology; and in this talk, several features of biological flyers that may significantly benefit small autonomous aircraft are examined. These include flapping-wing micro air vehicles, fixed-wing aircraft, and rotorcraft, each of which can utilise intelligent control techniques exploited by insects, birds, and bats, such as swarming, gust-response, and energy-harvesting strategies.



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