Training the youth on environmental challenges of aviation

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Introduction

Profound changes are needed to build the future of aviation. Young people will be the leaders of tomorrow's aviation. Their training in environmental issues is therefore essential to meet the challenge of sustainable aviation. This article brings together contributions from four universities around the world, focusing on their training programmes, research projects and certificates for sustainable aviation.

Training the Next Generation of Aviation Sustainability Leaders at the University of Waterloo

Emerging from the COVID19 pandemic, the aviation industry is facing unprecedented challenges associated with projected shortfalls of aircrew, the rapid evolution of technology, and associated negative environmental impacts. These challenges align with three pillars of sustainability – social, economic, and environmental. Keeping the sector viable tomorrow will require innovation in research and education.

FIGURE 1: Social, Economic, and Environmental Sustainability

Waterloo Institute for Sustainable Aeronautics (WISA)

To help address these challenges, the University of Waterloo in Canada launched the Waterloo Institute for Sustainable Aeronautics (WISA) in 2021. WISA is a multi-disciplinary research and teaching institute with more than 75 professors from all six Faculties at the university, cutting-edge facilities and labs, and hundreds of affiliated graduate students.

Research

Diversity of expertise and perspectives generate the fresh ideas necessary for meaningful change. WISA researchers collaborate across traditional disciplines, aligning with themes of sustainability. Waterloo experts in optometry are working with neuroscientists to study eye movements as an indicator of pilot competence, while psychologists analyze training scenarios to optimize learning retention. They work alongside engineers and mathematicians who use that data to build artificial intelligence models to optimize pilot training in the future, thus supporting social sustainability.

Environmental researchers are evaluating the design of flight paths and engine technologies for greater efficiency and fuel savings (which also benefit economic sustainability). Others are examining sustainable fuels, electric and hydrogen propulsion, and battery technology that will help the industry meet emissions targets.

Education

The University of Waterloo is home to Canada's largest university-level aviation program, which approximately 300 future pilots studying on campus. WISA researchers work directly with student pilots and industry professionals at the Region of Waterloo International Airport to understand pertinent challenges and collaborate on impactful research.

To support aviation education internationally, the University of Waterloo joined forces with ICAO's Global Aviation Training (GAT) office on the Aviation Fundamentals (AviFUN) e-learning course. This 22-hour course was designed to give new and transitioning professionals a broad introduction to the different sectors that make up the rich fabric of international aviation. In 2021 alone, AviFUN was completed by hundreds of learners from 99 different countries.

Collaborative Aeronautics Program

The aviation industry has a rich history of educating learners in the practices of aeronautics. However, some of the pressing challenges facing aviation extend beyond these boundaries. Cybersecurity, emissions modelling, artificial intelligence, green propulsion technologies and other sustainability factors will require new skillsets. Future leaders will require disciplinary expertise from parallel fields, along with competency in the acumen and practices of international aviation.

FIGURE 2: WISA research crosses disciplinary boundaries, designed to be different, instead aligning under the three pillars of sustainability

Towards this ambitious goal, the University of Waterloo will soon launch an entirely new approach to graduate aviation education. The Collaborative Aeronautics Program (CAP) will allow Master's and Doctoral students to enroll in one of a variety of programs from the six Faculties across campus (Environment, Health, Math, Engineering, Arts, and Science). During their studies, learners will come together to study aeronautics, tackle industry-provided design challenges, and complete aeronautics-applied research guided by world-leading professors in their specific discipline. Waterloo graduates will have their degree titles enhanced with "– Aeronautics". With a target to enroll up to 50 graduate students each year, into a diverse range of disciplines at Waterloo, the CAP represents a pipeline of talent to future-proof our sector.

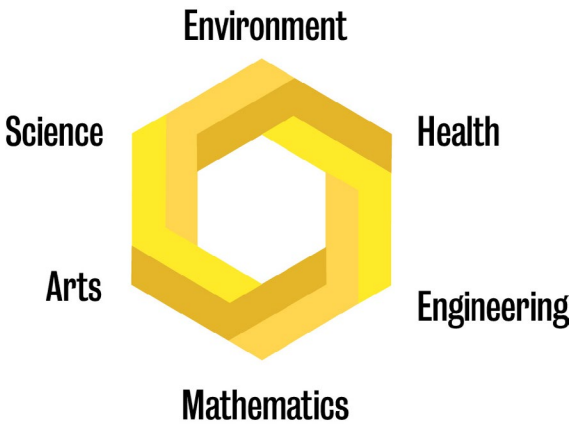


FIGURE 3: All six faculties at the University of Waterloo are participating in the Collaborative Aeronautics Program

Conclusion

Many voices can play a part in reimagining aviation for the sake of the planet, the industry and the people who rely on its viability. To achieve net-zero targets the aviation industry needs a combination of innovative new technologies, investment in talent, and cross-sector partnerships.

A sustainable future is within reach. With WISA's approach of fostering impactful research across disciplines and educating a new generation of leaders, from diverse fields of expertise, the prospects are even better.

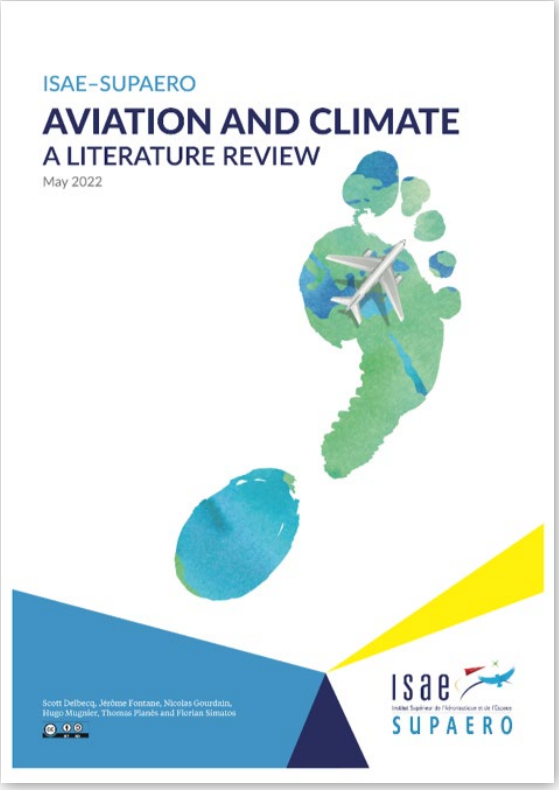
Interdisciplinary research and training at ISAE-SUPAERO to address the systemic challenges of sustainable aviation

Faced with the environmental and social challenges of the 21st century, the aviation community has a contribution to make. Higher education and research are major levers for the- transition to a sustainable society. At the Institut Supérieur de l'Aéronautique et de l'Espace (ISAE-SUPAERO) has placed these environmental challenges at the heart of our commitments. They are mobilizing their educational skills and their scientific expertise to contribute to the construction of aeronautical and space components for a sustainable society, notably to invent the decarbonized air transport of tomorrow. This so-called *Horizon commitment* towards the next generations takes many forms.

One of the first contribution to the *Horizon commitment* was to issue a reference document on the impact of aviation on the climate. Authored by 6 Faculty members, based on nearly 250 articles in the scientific literature, with a concern for rigor and a strong didactic ambition. The *ISAE-SUPAERO Aviation and Climate: a literature review*[1] (2022) shed light on this core matter and dives into details about the components of the impact and on the technological levers of action to mitigate this impact. The outcome of these science-based considerations takes the form of prospective sustainable scenarios for the future trajectory towards net-zero.

The section devoted to scenario analysis owes a "*debt of gratitude to*" a PhD student who developed the CAST platform (Climate and Aviation – Sustainable Trajectories[2]) for simulating and evaluating future scenarios for the aviation decarbonisation. Along with a "*what if* approach,"

1 https://oatao.univ-toulouse.fr/28978/1/ISAE-SUPAERO_Aviation_and_Climate_literature_review.pdf
2 https://cast.isae-supaero.fr



this open-source tool allows to play with the different levers of action to decarbonise aviation, such as the improvement of aircraft energy-efficiency, the substitution of kerosene by low carbon-intensity fuels and the volume of air traffic. It also includes simple climate and energy models in order to assess the environmental relevance of scenarios. In the future, the objective is to develop the capabilities of the tool to regionalise the scenario simulations of integrate social and economic analyses for a more systemic approach in the elaboration of transition scenarios.

ISA INSTITUTE FOR SUSTAINABLE AVIATION

The need for a systemic approach urged ISAE-SUPAERO to create the *Institute for Sustainable Aviation (ISA).* The ISA aims indeed at addressing the aviation sustainability question by bridging disciplines at the crossroad of societal, economic, scientific, and technological challenges raised by aviation sustainability.

The ISA project is built around the idea of a holistic approach, which is essential to inspire action, not only on the technological and industrial breakthrough to provide a decarbonized aircraft, but also on sustainability of the technological trajectory. This will be against the likely transition of uses, operations and markets. The ISA aims to increase the impact of our first-rate academic pool by informing the multiscale socio-economic strategy with science.

At the core of this scientific enterprise is an *Integrated Assessment Model (IAM)* for the commercial aviation section. IAMs have grown a methodological paradigm in climate science. They are also at the center of research in industrial ecology. In the economic sphere, researchers have been developing models to better understand the functioning of the economy. In the environmental sphere, researchers have been developing analytical tools to improve the accuracy and completeness of environmental assessments.

Integrated models combine the two approaches and provide a consequential picture of decisions made on energy flows, environmental regulation, taxation, material, and financial resource flows, by linking the physics-technical causal sphere with the socio-economic sphere. Using data assimilation technics, ISA is growing a multi-scale digital twin of aviation with increasing spatiotemporal resolution. The short-term impact will come from the dissemination of the methodologies and findings into training programs. They want to train future generations of engineers in the holistic approach.

Among those programs the Environmental Engineering Certificate, set up with support of Airbus via the Chair for Eco-Design of AiRcraft (CEDAR), enables students from the ISAE group to complete their initial engineering training with global training in environment, the focus on the consequences and perspectives for the aeronautical sector. The objective is to train engineers capable of understanding environmental issues as a whole, and to master the tools, methods and regulations related to the subject. They follow three courses on Environment and Aeronautics (61h), the aviation of the future (70h) and the Engineer in action (43h).

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Research and Education in Sustainable Aviation at the University of Toronto Institute for Aerospace Studies

Institute for Aerospace Studies
UNIVERSITY OF TORONTO
Centre for Research in Sustainable Aviation

Founded in 1949, the University of Toronto Institute for Aerospace Studies (UTIAS) is a graduate aerospace department at the University of Toronto that also teaches the Aerospace Major to undergraduate students in Engineering Science. UTIAS's mission is the pursuit of nationally and internationally recognized excellence in the education and training of students for research and leadership positions, discovery, and dissemination of new knowledge through research and scholarship, and application of knowledge to the benefit of society.

UTIAS has long recognized the importance of reducing aviation's impact on the environment and consequently formed the Centre for Research in Sustainable Aviation in 2012. Within this Centre, extensive research is undertaken toward technologies with the potential to reduce the environmental impact of aviation, including noise and emissions, with a particular focus on emissions contributing to climate change.

This research is conducted primarily by students, including Doctoral, Masters, and Undergraduate students, contributing greatly to their education on topics related to sustainable aviation. Current research projects include investigation of the combustion properties of sustainable aviation fuels, techniques for reducing noise generated by landing gear and high-lift systems, and active flow control for turbulent drag reduction. Other research includes the development of multi-fidelity multidisciplinary design tools for application to unconventional aircraft, and their application to investigation of hybrid wing-body, strut-braced wing, and box-wing configurations. It also includes the investigation of boundary-layer ingesting intakes and propulsors, design of natural laminar flow and variable-camber wings for reduced drag, and development of a solar-powered hybrid airship.

UTIAS has also hosted the UTIAS International Workshop on Aviation and Climate Change seven times since 2008. This workshop has an aim to stimulate dialogue among academia, government, and industry toward finding technological solutions to reduce the greenhouse gas emissions from aviation. The primary focus of the workshop is on technological and scientific issues. The goal is to bring together some of the world's leading experts in this area to exchange ideas, establish research priorities, and identify opportunities for collaboration.

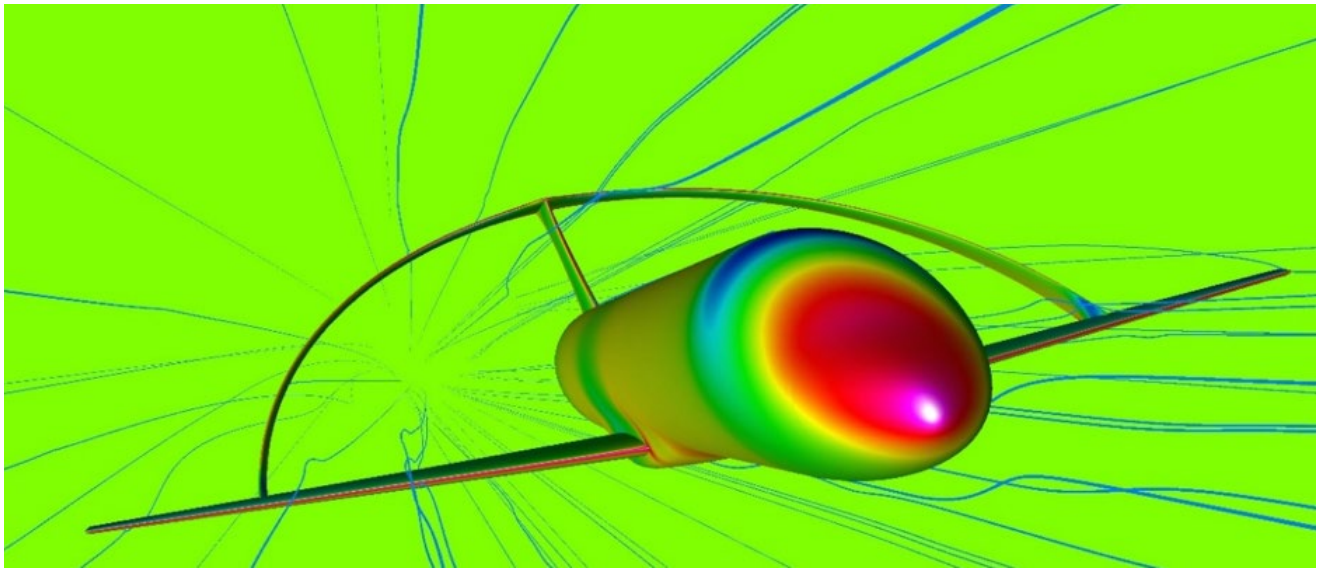

FIGURE 5: Investigation of a box-wing aircraft

All UTIAS students are invited to this event, which provides them with a comprehensive overview of current challenges and opportunities related to technological aspects of aviation and climate change. It includes speakers on topics including recent developments in atmospheric physics as well as speakers from NASA, DLR, and ONERA covering their latest research in this area.

UTIAS recognizes not only the need for new technologies to enable the elimination of fossil fuels in aviation and to improve the energy efficiency of future aircraft and engines, but also the need for graduates to have a deep understanding of environmental aspects of aviation.

The research programs in place combined with relevant courses and workshops such as the International Workshop on Aviation and Climate Change provide UTIAS graduate and undergraduate students with the necessary background in sustainable aviation. This includes policy, lifecycle analysis, atmospheric physics, alternative energy sources, and aircraft and engine technologies. Consequently, graduates of UTIAS are well prepared to play a leadership role in future efforts to address the urgent challenge to make aviation sustainable.

Developments in aviation sustainability from Griffith University

Griffith University has been providing qualifications to the aviation industry for over 25 years and is known worldwide for its innovative and student focused teaching. The aviation discipline, Griffith Aviation, based within the School of Engineering & Built Environment, has grown rapidly in recent years and now has over 800 students across undergraduate and graduate programs, the largest of its type in Australia. Its programs cover flight-training and aviation management, as well as double degree options with either engineering or information technology. Study can either be at the Nathan campus in Brisbane or fully on-line. The on-line cohort is growing, particularly international students.

With aviation sustainability being a global challenge, there is a need for universities to lead internationally on delivering the skills and expertise in this area. Aviation is arguably economically and socially sustainable, but there are major concerns about the environmental impacts from air transport. Griffith Aviation is fully aware of the environmental implications of aviation and is planning accordingly in their teaching and program development.

Griffith Aviation currently has sustainable aviation, and associated topics such as the relationship between aviation and climate change, and sustainable aviation fuels, in courses within the aviation management program. There is an optional elective to aviation students on an introduction to environmental sustainability, delivered by Griffith University's School of Environment & Science. It is expected that a dedicated aviation and the environment course will be developed moving forward, plus a short course for industry professionals. The aviation industry certainly needs upskilling in environmental sustainability.

Griffith University has had two years of their annual Aviation Reimagined seminar series, focusing on the future of air travel given the environmental concerns. Over 400 individuals registered for Aviation Reimagined webinar (see the webinar series[3]) in September 2021 and hope to further develop the series in 2022 and beyond.

The aviation industry has always been dynamic and disruptive; however, it was exacerbated during the COVID-19 pandemic. The aviation sector recovery does present an opportunity to refresh and restart, hopefully to build back greener. Aviation industry partners are beginning to engage in environmental issues and solutions. Yes, there will be some turbulence, particularly with increasing climate change concerns and external calls for the aviation industry to respond more quickly, but at least there is some movement in the right direction.

3 https://www.griffith.edu.au/institute-tourism/our-research/rethinking-aviation/aviation-reimagined-2021?fbclid=IwAR3Hd8xLJkEWMaHae8sho1MiSfV6TzbPbf30vo2fbJ0CHMg-xdvywNCmZbU

FIGURE 6: Aviation Reimagined webinar series logo

There is also a need for universities to respond responsibly in the matter of environmental sustainability for aviation, particularly when many of them, such as Griffith University, have sustainability as a core value. Griffith University agreed to reduce university aviation emissions by 25% in time for 2030.

There is an associated implementation plan to work through the implications and practicalities. Much of the focus is on reducing staff air travel, but there are other elements incorporated in terms of underpinning research, engagement with stakeholders, and innovations in data and processes. In the area of environmental sustainability for aviation, like with other global challenges, it is right and appropriate for universities to be at the forefront of the responses and solutions.