Advancing Sustainable Aviation: developments in aviation sustainability from the academic perspective

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Inspiring Tomorrow's Aviation Leaders: Strategies for Environmental Education

Introduction

The aviation sector faces tremendous sustainability challenges. While technological innovations — sustainable aviation fuels, zero-emission aircraft, and advanced operational efficiencies — are critical, these solutions alone are not sufficient. Achieving the Long-Term Global Aspirational Goal (LTAG) of net-zero by 2050 will also depend on a well-prepared, environmentally literate workforce that can design, implement, and lead the industry through its decarbonization.

Youth engagement is central to this transformation. ICAO's Next Generation of Aviation Professionals (NGAP) and Assistance, Capacity-Building, and Training for Sustainable Aviation Fuels (ACT-SAF) initiatives emphasize **the need to empower new talent with interdisciplinary skills and environmental awareness.** Academic institutions play a crucial role in equipping young professionals with the knowledge and tools to understand and address aviation's complex sustainability challenges.

The Waterloo Institute for Sustainable Aeronautics (WISA) at the University of Waterloo in Canada offers strategies on how universities can support these goals through education, research, and collaboration. This article outlines several strategies employed at WISA — ranging from accessible e-learning to student-led research that can be adapted and scaled by other institutions around the world to foster a future-ready aviation workforce.

Expanding Access Through Asynchronous e-Learning

For many working aviation professionals, environmental studies were not part of the aviation curriculum when they completed their education. Equipping the global aviation community with climate literacy begins with foundational education. Recognizing that professionals and students around the world often face geographic, financial, and time-related barriers to in-person learning, a suite of asynchronous e-learning courses focused on sustainable aviation were developed within WISA (Figure 1 refers).

The Aviation Sustainability course introduces learners to the core concepts of environmental responsibility within the aviation sector, aligning with the United Nations Sustainable Development Goals (SDGs). It frames sustainability as a comprehensive, industry-wide framework for responsible decision-making, relevant to all aviation careers, from airport operations to flight dispatch and aircraft maintenance.

FIGURE 1: WISA e-Learning Course Banners.

FIGURE 2: WISA e-Learning Course examples.

Learners examine practical strategies such as fuel-efficiency initiatives, waste reduction, and stakeholder engagement, while also reflecting on how these efforts support broader global objectives like climate action (SDG 13), responsible consumption and production (SDG 12), and industry innovation and infrastructure (SDG 9). Through this lens, the course allows participants to integrate sustainability into their professional practices.

The Aviation and Climate Change course provides sector-specific climate literacy, covering how aviation contributes to climate change through carbon dioxide, non-CO_2 effects such as contrails and nitrogen oxides, and what mitigation and adaptation strategies are available. The course also explores emerging technologies and market-based measures, offering a systems-level understanding of climate solutions (Figures 1 and 2 refer).

In 2025, UWaterloo and ICAO will launch a new co-developed program called Fundamentals of International Aviation. This initiative supports ICAO's capacity-building efforts by offering foundational knowledge in an accessible format for global learners, particularly in regions where aviation training infrastructure may be limited.

These courses use instructional design strategies that enhance engagement, such as short video segments, interactive assessments, and scenario-based learning. This structure ensures that learners consume the information and can apply it, cultivating the critical thinking needed to navigate complex environmental, economic, and operational trade-offs.

Asynchronous digital education can make sustainability training available at scale, removing traditional barriers and supporting ICAO's objective to upskill current and future aviation professionals worldwide.

Student-Driven Research in Electric Aviation

In addition to online learning, hands-on research opportunities provide students with direct experience tackling environmental challenges in aviation. WISA's electric aircraft research project allows student pilots to work as part of the research team to test and analyze the performance of the Pipistrel Velis Electro, an electric training aircraft (Figures 3 and 4 refer).

This initiative examines how electric aircraft can be integrated into pilot training programs while reducing emissions and operating costs. Since electric aircraft have no combustion emissions during operation and are significantly quieter than conventional piston aircraft, they offer promising environmental and community benefits, especially in training environments with frequent takeoffs and landings.

FIGURE 3: Pipistrel Velis Electro E-Plane.

FIGURE 4: Electric Plane Research Assistants Zach and Caitlin.

Over the past two years at WISA, student-pilots have worked alongside professors and graduate students to complete a series of flights in the electric aircraft, collecting operational data including battery performance, climb rates, and system health under various seasonal conditions. Students are trained in flight operations and data analysis, contributing to publications and informing regulatory conversations with Transport Canada.

One student remarked that uploading data after each flight was 'one step closer to a more sustainable future in aviation', highlighting the dual benefit of experiential education and real-world contributions. The project has demonstrated that electric aircraft can operate safely and reliably even in colder Canadian climates—an important data point for expanding electric flight globally.

Beyond the environmental impact, the integration of students as research collaborators builds technical capacity and fosters early-career engagement in sustainability-focused innovation. This model of involving students in applied, solution-oriented research can be adapted in other

contexts, using available technologies to offer experiential learning opportunities that prepare youth for leadership roles in sustainable aviation.

Building Interdisciplinary Expertise in Graduate Education

Meeting global decarbonization goals requires the development of highly qualified, interdisciplinary talent capable of designing and implementing multifaceted solutions. WISA has prioritized graduate education to build this capacity, drawing on the University of Waterloo's strengths across science, engineering, environment, health, math, and the social sciences.

Graduate students affiliated with WISA are contributing to a range of sustainability initiatives, including:

- Sustainable aviation fuels (SAF) development, where chemistry and engineering students investigate feedstocks, lifecycle emissions, and fuel performance.
- Flight operations optimization, where data science and aerospace researchers collaborate to improve routing, reduce fuel burn, and integrate predictive analytics.
- AI training technologies, where psychology, health, and computer science researchers co-develop adaptive simulation and eye-tracking systems to enhance pilot training efficiency and safety.

This interdisciplinary model reflects the reality that no single field can address aviation's environmental challenges in isolation. By integrating diverse perspectives, students develop systems-thinking capabilities that align with ICAO's long-term sustainability priorities.

In many cases, these graduate students work on projects co-supervised by academic and industry partners, ensuring relevance and applicability. Their contributions feed directly into technological innovation, policy analysis, and capacity-building, whether through peer-reviewed research or industry-facing deliverables.

This emphasis on interdisciplinary talent development supports ICAO's NGAP vision and provides a replicable model for other academic institutions. Universities around the world can foster similar collaboration by creating cross-departmental research clusters, sustainability-focused student funding, and experiential learning partnerships with aviation stakeholders.

Linking Academia with Industry: The Collaborative Aeronautics Program

To further strengthen ties between education and industry, WISA launched the Collaborative Aeronautics Program (CAP), an interdisciplinary graduate training initiative that allows students from graduate programs across the university to pursue an aviation specialization alongside their primary degree.

Students in the CAP complete a shared set of aviation-focused courses and engage in team-based consulting projects with industry or government partners (Figure 5 refers). These projects are real-world design or policy challenges that range from prototyping decarbonization strategies to enhancing safety management systems or testing new training tools.

This model reflects a growing need for graduates who are not only technically proficient, but also able to work across disciplines, communicate with stakeholders, and translate academic research into actionable outcomes. For employers, it offers access to emerging talent and novel research insights; for students, it develops relevant experience and professional networks.

This approach also responds directly to ICAO's calls for academic–industry partnerships as a foundation for aviation innovation and sustainability. The CAP model demonstrates how universities can serve as both knowledge producers and implementation partners, by supporting industry needs while educating the next generation of aviation professionals.

The success of CAP has been driven by interdisciplinary collaboration across the University of Waterloo, illustrating that sustainable aviation is not the domain of engineers or climate scientists alone, but a collective responsibility requiring cross-sector cooperation.

FIGURE 5: Allison Lynch, CAP PhD Student.

Conclusion

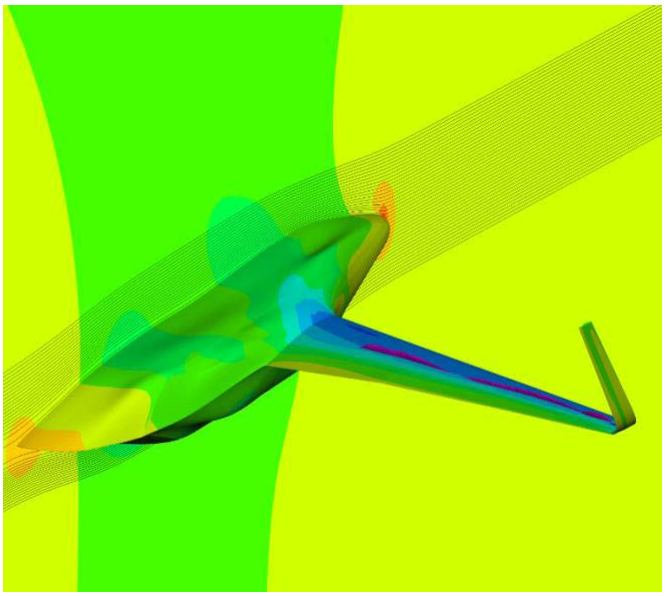
Aviation's pathway to sustainability is as much about people as it is about technology. The global community's ability to achieve net-zero aviation emissions will depend on how effectively it can mobilize, educate, and empower the next generation of aviation professionals. The strategies implemented at WISA provide one example of how academic institutions can respond to this call.

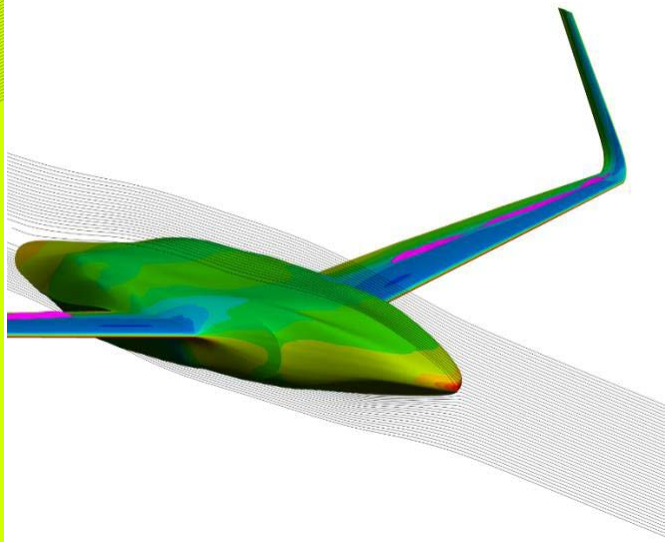
By combining accessible digital learning, hands-on research, interdisciplinary collaboration, and industry engagement, WISA's approach helps ensure that students not only understand the environmental challenges facing aviation—but are also prepared to lead in solving them. As ICAO continues to promote environmental education and innovation through its strategic initiatives, institutions around the world are encouraged to collaborate in order to foster youth leadership and build long-term capacity for sustainable aviation.

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

The University of Toronto Institute for Aerospace Studies (UTIAS) is home to the Centre for Research in Sustainable Education (CRSA). The CRSA conducts research to reduce the environmental impact of aviation and contributes to the education of the next generation of students who will have the technical and leadership skills needed by the aeronautics sector as it faces the daunting challenge to improve the sustainability of aviation. A few updates on the CRSA's activities are provided in this article.

The popular course Sustainable Aviation will be offered again in 2025. This course offers a comprehensive treatment of sustainable aviation, taught by UTIAS faculty and guest lecturers from other universities, industry, and government. Topics range from engineering (technologies for improving energy efficiency of aircraft, alternative fuels, lifecycle analysis) to science (atmospheric chemistry) to regulatory aspects. Graduate students who take this course, as well as several others from a list of relevant courses, receive a





Certificate of Emphasis in Sustainable Aviation, which has proven to be popular with students and employers alike.

With respect to research, UTIAS faculty members collaborate extensively with Canadian industry on projects related to sustainable aviation. Extensive research to reduce noise from high-lift devices and landing gear is ongoing in collaboration with Bombardier. A major project with Pratt & Whitney Canada concentrates on contrails, an important contributor to aviation's climate change impact. UTIAS is also contributing to Bombardier's next generation of aircraft through its research on blended wing-body configuration and natural laminar flow.

The CRSA hosts the highly regarded UTIAS International Workshop on Aviation and Climate Change every two years. This invitation-only event brings together many of the world's leading experts on technological and scientific aspects related to reducing aviation's impact on climate change from academia, industry, and government. This provides leading researchers with an opportunity to exchange ideas, establish research priorities, and identify opportunities for collaboration. Moreover, UTIAS students are provided with a comprehensive overview of current challenges and opportunities related to technological aspects of aviation and climate change.

Overall, the workshops, graduate courses, and research related to sustainable aviation at UTIAS provide the students with the expertise, skills, and knowledge needed for future careers in the aeronautical sector. Graduates from UTIAS are well-prepared to contribute to the development the next generation of aircraft, engines, and fuels that will enable aviation to become sustainable.

Experiences from Griffith Aviation, School of Engineering & Built Environment

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 over 500 students across undergraduate and graduate programs. It is one of the largest aviation units in an Australian university. The 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 South Brisbane or fully online.

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. While aviation remains economically and socially vital, there are

pressing concerns about its environmental impacts. Griffith Aviation is fully aware of the environmental implications of aviation and is planning accordingly in our teaching and program development. We currently have sustainable aviation, and associated topics such as the relationship between aviation and climate change, as well as 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 the university School of Environment & Science.

In the second Trimester , beginning in mid-July of 2025, there will be a new dedicated third-year Aviation and the Environment undergraduate university course. It will be a core course for Bachelor of Aviation Management students and optional for other students across the aviation discipline, School of Engineering & Built Environment and the wider university. The Aviation and the Environment course explores the highly-specific environmental issues associated with the aviation industry. It will introduce students to environmental principles, such as Sustainable Development Goals (SDGs), climate change concepts and sustainable aviation fuels, and applies these concepts to the aviation industry. The material could be further developed as a short course for industry professionals. The aviation industry certainly needs upskilling in environmental sustainability.

Griffith University has been holding for now five years the annual Aviation Reimagined seminar series featuring industry leaders, policymakers and researchers sharing their insights about a transition to a low-carbon and climate ready future for the aviation sector. Over 500 individuals registered for Aviation Reimagined in October 2024 (see Aviation Reimagined 2024)[1] which covered three sessions:

- Decarbonizing aviation context – the economic and regulation issues;
- Managing future environmental impacts – in the air and on the ground; and
- Social licence to fly – maximising the benefits of a low-carbon transition.

There is 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. In 2022, Griffith University has agreed to reduce university aviation emissions by 25% in time for 2030. There was an associated implementation plan to work through the implications and practicalities. Much of the focus was on reducing staff air travel, but there were other elements incorporated in terms of underpinning research, engagement with stakeholders, and innovations in data and processes.

Our aviation industry partners are currently engaging in environmental issues and solutions. There is some turbulence though, with some in the industry questioning the 2050 aviation net zero commitment, whilst others advocate for more urgent action with increasing climate change concerns. **There is certainly plenty for the university sector to review, research and respond to in aviation sustainability now and in the coming years.**

1 https://www.griffith.edu.au/research/business/institute-tourism/our-research/aviation-reimagined-2024