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Research • Career insights • Activities

Preparing the world for the next generation of flying machines

Professor Jean-Marc Frayret

"A photo realistic picture of an environment to illustrate what advanced air mobility is and to promote education in the field of industrial engineering applied to AAM" prompt, ChatGPT5.2 Thinking, OpenAI, 09.01.2026, ChatGPT App on a Mac

Preparing the world for the next generation of flying machines

Advanced air mobility could revolutionise how we transport people and goods. The technology for new aerial vehicles, focused on sustainability and automation, is developing fast – but to make them a reality, we need to understand how they can integrate into today's world. In Canada, **Professor Jean-Marc Frayret**, of the **Polytechnique Montréal**, and his colleagues at the **SDG Institute of Advanced Air Mobility** are using advanced 'digital twin' simulations and other industrial engineering techniques to research how technologies such as drones, flying taxis and vertiports could move from science fiction to reality.

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PROFILE

Fields of research
Industrial engineering; aeronautics; business administration; computer sciences

Research project
Advanced air mobility research in Canada

Funders
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Talk like an ...

industrial engineer

Advanced air mobility (AAM) — a rapidly-emerging aerospace sector focused on systems that support next-generation air transport

Aerospace — the science and industry of aircraft and spacecraft

Digital twin — a virtual representation of a physical system, object or process that uses real-time data to support design and operations decisions

Demographic — relating to different groups within a population of people

Drone — a flying device that can be controlled remotely

Hybrid — combining two or more energy sources (eg., a hybrid car can run on electricity or petrol/diesel)

Optimise — making something the best it can be (for example, the most energy efficient)

Vertiport — a take-off and landing site for aircraft that take off and land vertically

Flying cars, electric planes and AI-powered delivery drones are regular features in science fiction, but it might not be long until they become a reality. However, it is not as simple as developing these technologies and releasing them into the world. Before these technologies can become part of our daily lives, a few conditions must be in place, such as supporting infrastructure and networks, operational knowledge and societal acceptance.

These new technologies are known collectively as advanced air mobility (AAM). "AAM is a new transportation system that uses innovative aircraft, often electric or hybrid, that are capable of vertical take-off and landing," says Professor Jean-Marc Frayret of Polytechnique Montréal and the SDG Institute of Advanced Air Mobility. This transportation includes the movement of people and goods in both urban and regional contexts and opens up a wide range of possibilities: air taxis, flying ambulances, and drones of all sizes and capabilities, to name a few. "AAM can help reduce the carbon footprint of existing mobility systems, provide new flexible transportation options, accelerate supply chains and enable advanced data collection," says Jean-Marc.

Why Canada?

The SDG Institute of Advanced Air Mobility is based in Montréal, Canada, and for good reasons. "Montréal is recognised as a global aerospace hub, home to major manufacturers and a highly developed industrial ecosystem closely connected to local universities and colleges," explains Jean-Marc. "More broadly, Canada has a uniquely rich environment for studying and deploying AAM, combining real-world

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complexity with world-class expertise." The region has a wide array of terrains and environments, from fields to forests to cities. "This geographical variability is matched by Canada's extreme climatic variability," says Jean-Marc. "From winter snowstorms to summer heatwaves, we can test AAM systems under many different environmental conditions."

Urban centres like Montréal suffer from severe traffic congestion and have a high demand for sustainable transport alternatives – challenges that AAM could provide solutions to. In contrast, Canada's rural northern communities are very hard to reach over land, which impacts the services, resources and opportunities they can access. AAM could potentially connect these communities, offering easy transport of both people and resources between remote and highly-populated areas.

Preparing for take-off

Integrating such radically different vehicles into our current system will not be straightforward – which is where scientists, managers, social scientists and engineers, like Jean-Marc and his team, come in. "AAM is not just about new aircraft and propulsion technologies," he says. "Its success depends on building a complete ecosystem of interconnected social and technical systems." This will involve a huge shift in societal infrastructure, but the team is up for the challenge.

"One facet of this new ecosystem that we're focusing on is 'vertiports' – the places where AAM vehicles can take off, land, recharge and board passengers or cargo," says Jean-Marc. "This includes both high-tech hubs in urban areas and simple landing pads in remote areas." Jean-Marc's team is developing advanced decision-support systems to facilitate this process, considering suitable vertiport locations, energy requirements and how such ports will operate day-to-day.

In addition to designing, building and supplying these facilities, policymakers will need to design measures to effectively manage this new influx of vehicles. "This will require a new generation of air traffic management tailored to low-altitude operations, including unmanned vehicles," says Jean-Marc. "Unlike traditional air traffic control, this system will consist of digital, automated systems designed to coordinate both piloted and autonomous aircraft." Getting these systems right is crucial – errors could result in catastrophe. But a smooth system could enable fine control of many aircraft at once, far beyond what humans could achieve manually.

Digital twins

To trial such systems before they become a reality, Jean-Marc and his team use simulations. "A digital twin is a virtual replica of a physical system that simulates, predicts and optimises real-world performance," explains Jean-Marc. "Digital twins can represent individual aircraft, vertiports or even the entire mobility network of a city." An important factor that distinguishes digital twins from traditional systems is that they are directly connected to live operational data – meaning they evolve over time. "We can test scenarios such as weather disruptions, emergency landings or passenger demand peaks in a safe virtual environment," explains Jean-Marc. "This supports decision-making in the real world around the development and eventual operation of AAM systems." These models will lay the groundwork for new AAM systems, as well as build societal confidence in these technologies. "We have to integrate societal realities," says Jean-Marc. "This includes seasonal challenges, demographic diversity and social acceptance." One aspect of this involves demonstrating how economically feasible AAM systems are – that, financially, they can be created and maintained. Another aspect involves thinking about how wider society will respond to these changes. Many people will have serious reservations about these technologies and how they may be used or abused. "Citizens must perceive AAM as beneficial, fair, safe, and not disruptive or elitist," says Jean-Marc. "This means they must be designed and implemented with these perceptions in mind."

What's next?

The team's research is in its early stages but has already made significant leaps. "We have a running vertiport simulation model that enables us to study the flow of passengers through the travel process," says Jean-Marc. "This means we will soon be able to assess the relationship between passenger experience and vertiport design features."

The team has also begun creating a 3D model of Montréal's airspace and how it is currently used, with the aim of integrating AAM systems to understand how all airspace users can coexist. "For the rest of the programme, we need to recruit students!" says Jean-Marc. "The work and ideas of the next generation of industrial engineers are essential for our success."

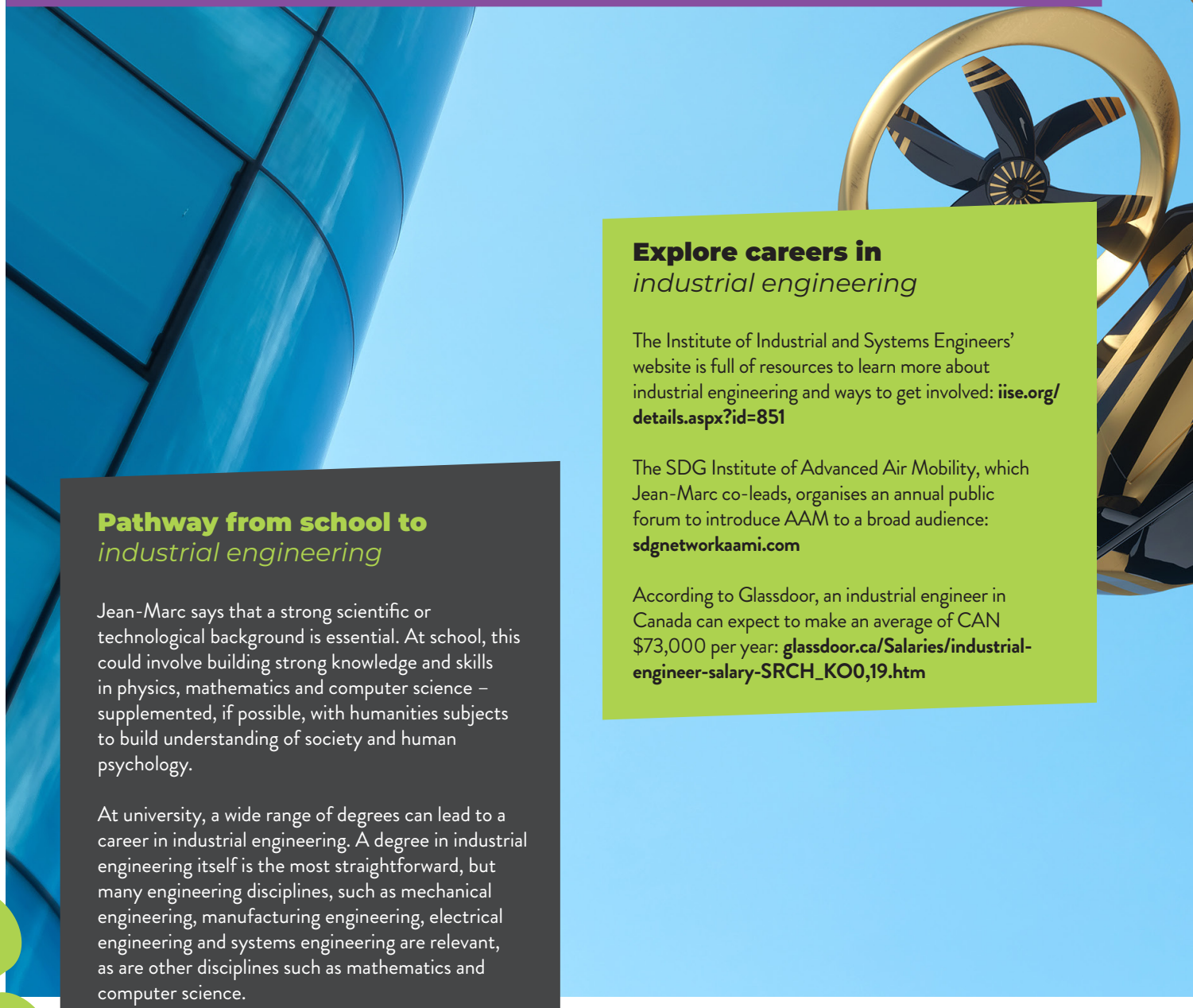
About *industrial engineering*

Industrial engineering involves the design, operation and continuous improvement of industrial processes, in particular optimising complex systems. "Industrial engineering can be applied to any complex system where people and technologies interact, which is intrinsically rewarding," says Jean-Marc. Work in this field requires many different disciplines coming together, from expertise in fundamental engineering principles through to knowledge of how societies function and develop.

And given that new technologies are always developing and become ever-more complex, careers in the sector are continually growing and diversifying. "Research opportunities in the field are virtually limitless," says Jean-Marc. "New technologies and systems are constantly emerging and must be integrated and adapted to meet societal needs such as profitability, sustainability and safety."

Advanced air mobility (AAM) is one important example of the new frontiers that industrial engineering is embracing.

"Working on AAM allows me to contribute to a creative process that is shaping entirely new forms of mobility that will have meaningful social impact," says Jean-Marc. "The field requires continuous learning and exploration of methodological and technological solutions." Given that such efforts could reshape the world as we know it, industrial engineers have a lot of responsibility – which entails exciting opportunities to work at the forefront of progress.



Pathway from school to *industrial engineering*

Jean-Marc says that a strong scientific or technological background is essential. At school, this could involve building strong knowledge and skills in physics, mathematics and computer science – supplemented, if possible, with humanities subjects to build understanding of society and human psychology.

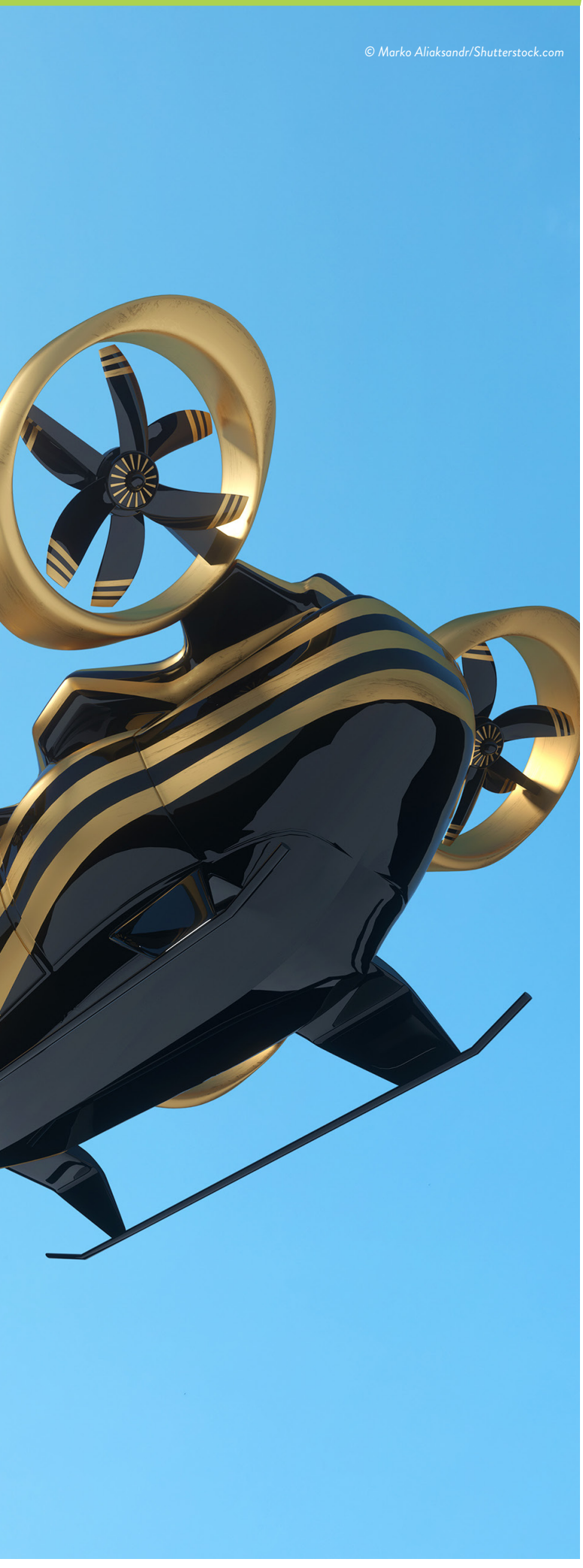
At university, a wide range of degrees can lead to a career in industrial engineering. A degree in industrial engineering itself is the most straightforward, but many engineering disciplines, such as mechanical engineering, manufacturing engineering, electrical engineering and systems engineering are relevant, as are other disciplines such as mathematics and computer science.

Explore careers in *industrial engineering*

The Institute of Industrial and Systems Engineers' website is full of resources to learn more about industrial engineering and ways to get involved: **iise.org/details.aspx?id=851**

The SDG Institute of Advanced Air Mobility, which Jean-Marc co-leads, organises an annual public forum to introduce AAM to a broad audience: **sdgnetworkaami.com**

According to Glassdoor, an industrial engineer in Canada can expect to make an average of CAN $73,000 per year: **glassdoor.ca/Salaries/industrial-engineer-salary-SRCH_KO0,19.htm**



Meet *Jean-Marc*

An industrial engineer's career can evolve in many directions over time. They will have expertise that can be applied to virtually any system with people and machines or organisational context.

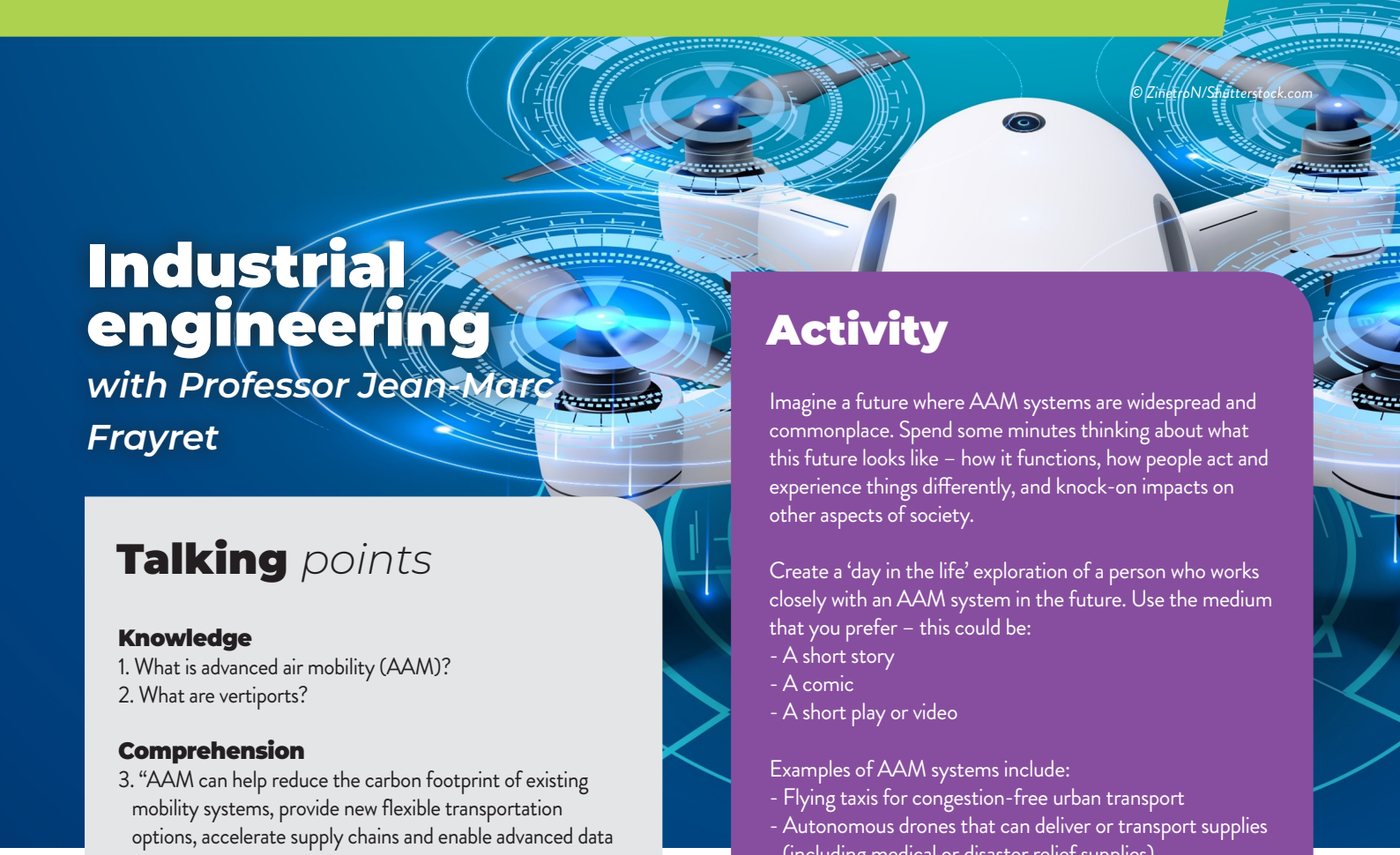
I began my career as the junior research director of an academic group. The group went on to create a long-term research consortium on forest product logistics. When we began, we had no governance structure, no established processes and no students – it felt like launching a start-up. It was both intimidating and exciting!

As a PhD student, I knew a professor whose expertise and personality naturally inspired respect. I often hoped that one day I might earn that same kind of respect from my own students. You can imagine how proud I was when a student told me that I had achieved exactly what I had aimed for.

My goal is for the SDG Institute of Advanced Air Mobility to become an internationally recognised institution. I want it to make tangible contributions to Canada's adoption of AAM, and to offer young people meaningful opportunities to build the careers they aspire to.

Jean-Marc's *top tip*

Stay curious about the world. Never stop pursuing your desire to understand how things work. One day, that drive will lead you to something that changes your life.



Industrial engineering

with Professor Jean-Marc Frayret

Talking *points*

Knowledge

1. What is advanced air mobility (AAM)?
2. What are vertiports?

Comprehension

3. "AAM can help reduce the carbon footprint of existing mobility systems, provide new flexible transportation options, accelerate supply chains and enable advanced data collection," says Jean-Marc. Using the information in his article, explain how AAM can contribute to each of these four effects.
4. Why is Canada a good choice for the development of AAM systems? Give at least three reasons.

Application

5. What challenges can you foresee for the development of autonomous aircraft? How could these challenges be overcome?
6. What types of AAM vehicles might serve Canada's remote northern communities in the future? How would they support these communities?

Analysis

7. "We have a running vertiport simulation model that enables us to study the flow of passengers through the travel process," says Jean-Marc. What variables do you think are included in this simulation? How do you think their variability might affect the simulation's outputs?

Evaluation

8. "Citizens must perceive AAM as beneficial, fair, safe, and not disruptive or elitist," says Jean-Marc. How do you think industrial engineers can contribute to making sure these conditions are fulfilled? How can other professions or sectors of society contribute?
9. The Jevons Paradox states that increases in something's efficiency often leads to an increase in its consumption. To what extent do you think this might happen with AAM systems compared to today's aircraft, and why? What might this mean for society and the environment?

Activity

Imagine a future where AAM systems are widespread and commonplace. Spend some minutes thinking about what this future looks like – how it functions, how people act and experience things differently, and knock-on impacts on other aspects of society.

Create a 'day in the life' exploration of a person who works closely with an AAM system in the future. Use the medium that you prefer – this could be:
- A short story
- A comic
- A short play or video

Examples of AAM systems include:
- Flying taxis for congestion-free urban transport
- Autonomous drones that can deliver or transport supplies (including medical or disaster relief supplies)
- Hybrid/electric planes that can take off vertically

Within this exploration, include the following elements:
- How the AAM system works and integrates with other systems
- How the AAM system has impacted people and society
- What the protagonist's professional role looks like
- A challenge – something goes wrong that the protagonist must rectify

You can use Jean-Marc's article and online research to inform your exploration, but feel free to use your own creative licence too.

Once complete, share your exploration with others in the class and listen to/watch/read theirs. What common themes emerge? What were some of the most innovative ideas? To what extent do you and your classmates agree that the future of AAM will be safe and fair for all groups in society?

More *resources*

- NASA's 'Advanced Air Mobility Playbook' playlist features a range of interesting videos that explore different aspects of AAM: **youtube.com/playlist?list=PLiuUQ9asub3SwLVqDgTi0MvckjMTASRkK**
- This article and video from IBM explain how digital twins work and why they are so useful: **ibm.com/think/topics/digital-twin**
- This report from the World Economic Forum provides an overview of AAM and how it could revolutionise society: www.**weforum.org/docs/WEF_Advanced_Air_Mobility_2024.pdf**

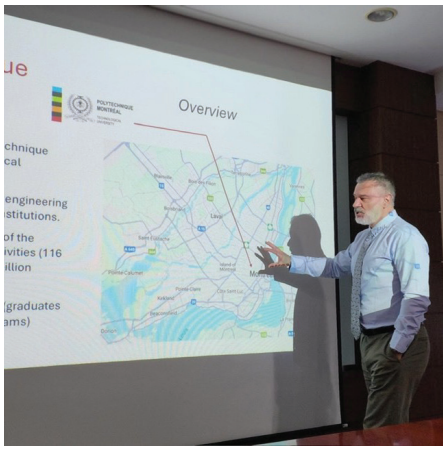


Photo *montage*

Top: *eHang eVTOL used in test flights in Abu Dhabi (presented at ICAO'S First Advanced Air Mobility Symposium, Montreal, 09/2024)*

Middle row: ***Left:*** *Presentation of the TEAM project, J.-M. Frayret (KUAM Confex, Incheon, South Korea, 2024/10)*

Right: *Presentation of Polytechnique Montréal, J.-M. Frayret (KARI, Daejeon, South Korea, 2024/10)*

Bottom: *Wisk Gen 6 Model (presented at ICAO'S First Advanced Air Mobility Symposium, Montreal, 09/2024)*

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