LEONARDO TIMES

Journal of the Society of Aerospace Engineering Students 'Leonardo da Vinci'

SPECIAL EDITION

AI IN AEROSPACE

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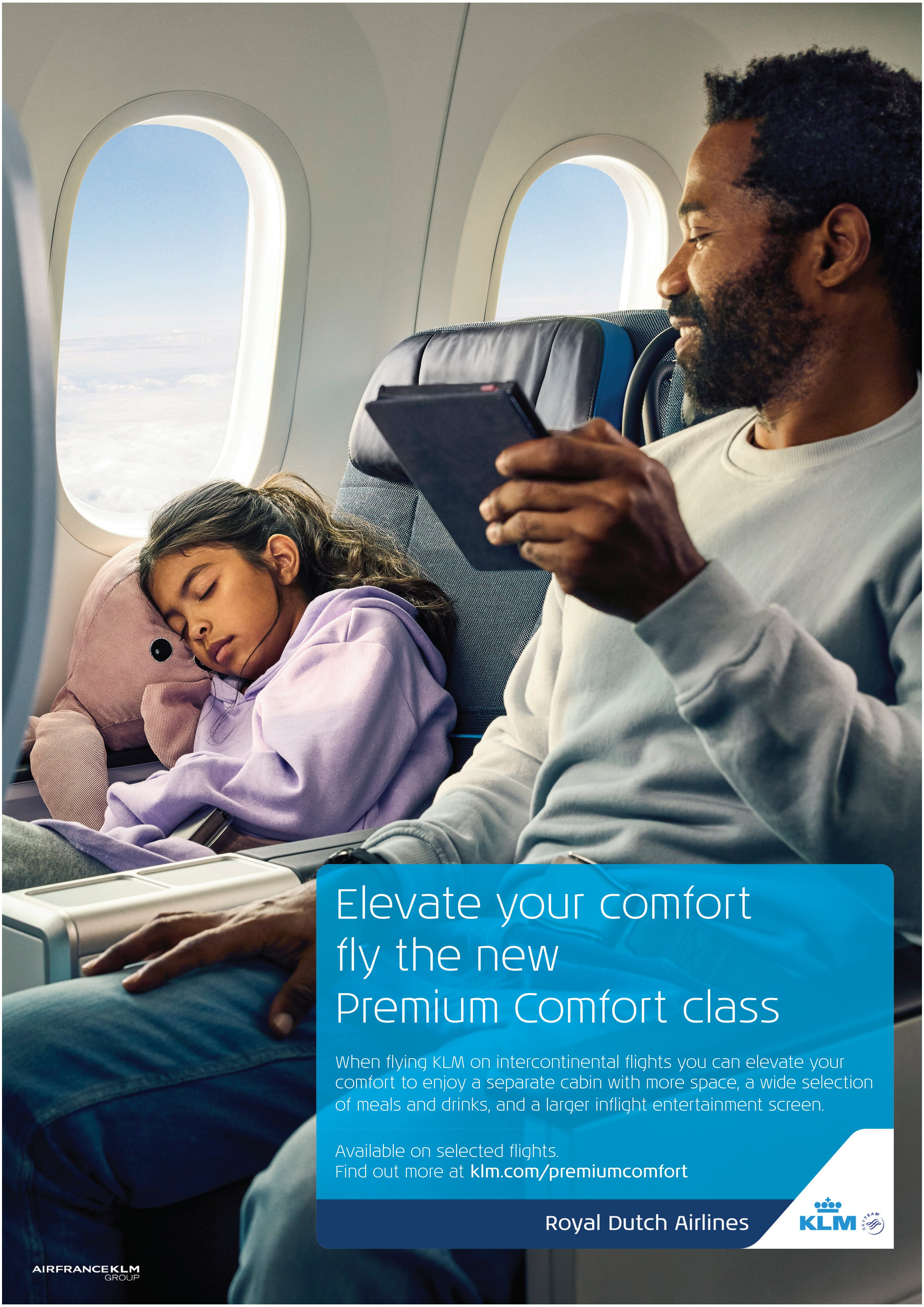
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EDITORIAL

THE WORLD OF TOMORROW

Dear reader,

This edition is devoted to the exploration of the rise of Artificial Intelligence technologies in the aerospace industry. The ongoing decade will see advances not only in the applications of AI in aerospace, but will also witness a fundamental shift in a variety of job descriptions across the industry because of AI's rise. For some, this means specializing in new tasks, whereas for others, the new technology will become their closest aidée in their line of work.

The use of AI in the aerospace industry is rapidly expanding, with advancements in machine learning, computer vision, and natural language processing leading to new possibilities in everything from aircraft design to air traffic management.

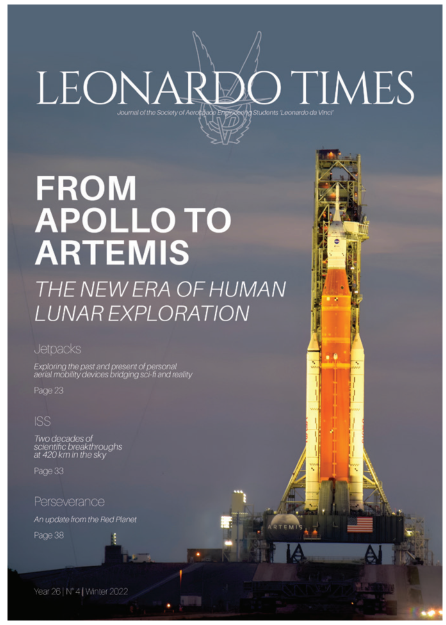
With novel technologies come also novel challenges, requiring ingenuity for solving them effectively in a way that satisfies the customers, the public in this instance. Therefore, in this edition, we will also consider the ethics of AI, its potential flaws and downfalls, and we'll be asking the question whether or not some uses of AI ought to be allowable.

This edition will analyze the AI boom in the industry via the use of a variety of interviews and case studies, such as the changes to Boeing's manufacturing practices, the uses of edge computing in modern industry, remote sensing from space and air traffic management. Additionally, ChatGPT, the Open AI released in late November of 2022 will be utilized in an article for the first time. In the name of honesty, it was used as a source of inspiration for this editorial as well. Finally, the magazine is pushing towards uncharted territories with its first collaborative article with the Aerospace Faculty's very own Aerospace Diversity Department (ADD).

Wishing you an enjoyable read and a pleasant start of the summer,

Topias Pulkkinen
Editor-in-Chief, Leonardo Times

Last edition ...



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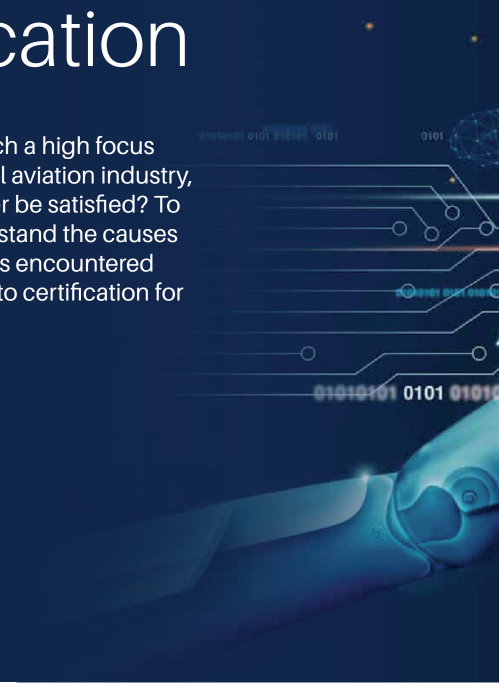

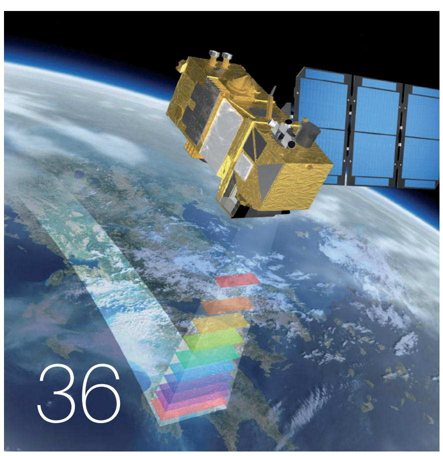

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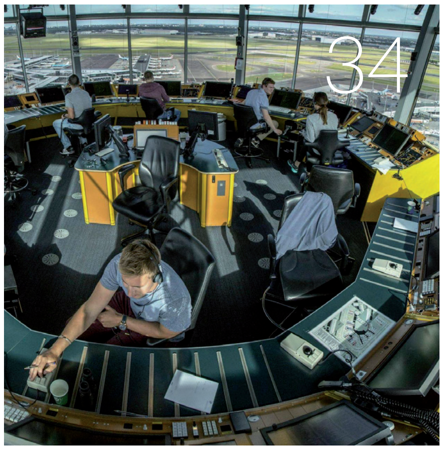
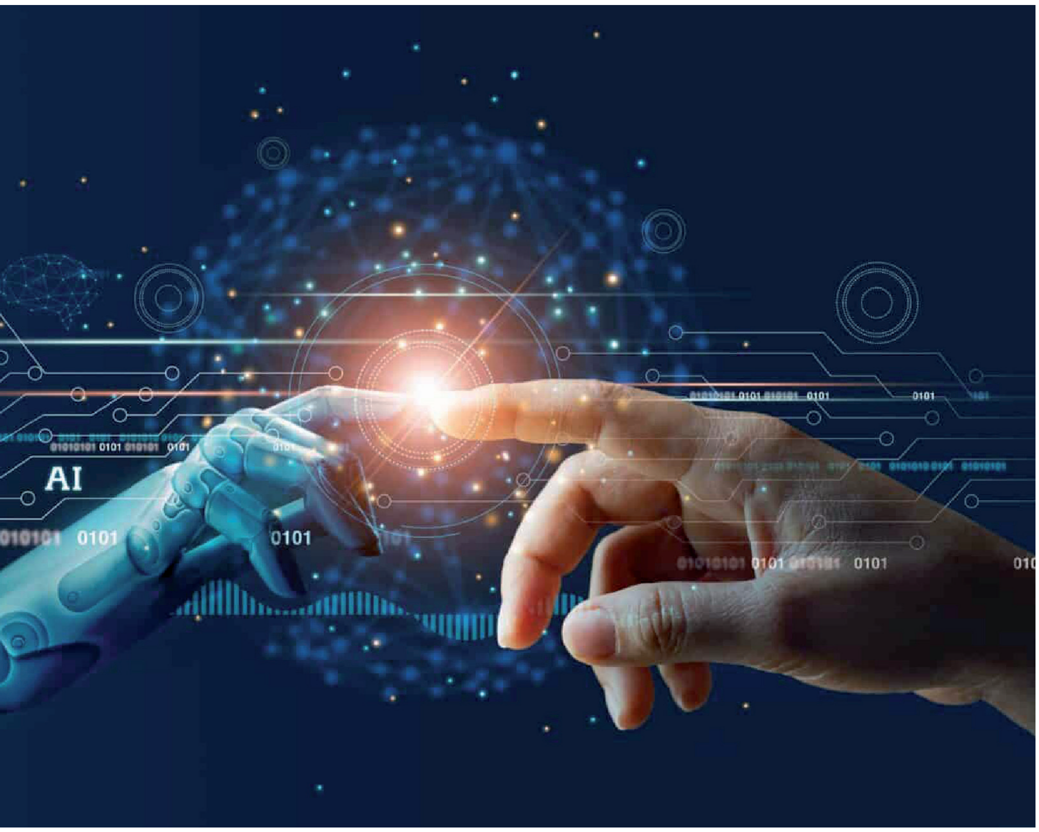
Earth observation satellites use remote sensing techniques to gather data from our planet, but artificial intelligence is expanding the number of data applications.



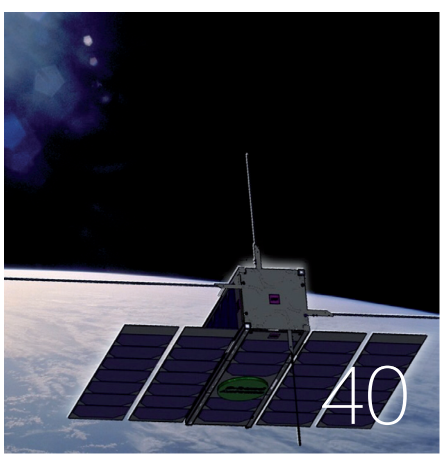
Navigating The Skies

Explore the cutting-edge technology transforming air traffic control, as well as the importance, challenges, and future of automation in ATC.



ResAErch #4

For the fourth edition of ResAErch, Leonard Times interviewed Prof. Dr Guido de Croon, Full Professor in Control and Simulation (C&O) and the Micro Air Vehicle Lab (MAVLab).



COLOPHON

Year 27, NUMBER 1, Spring 2023

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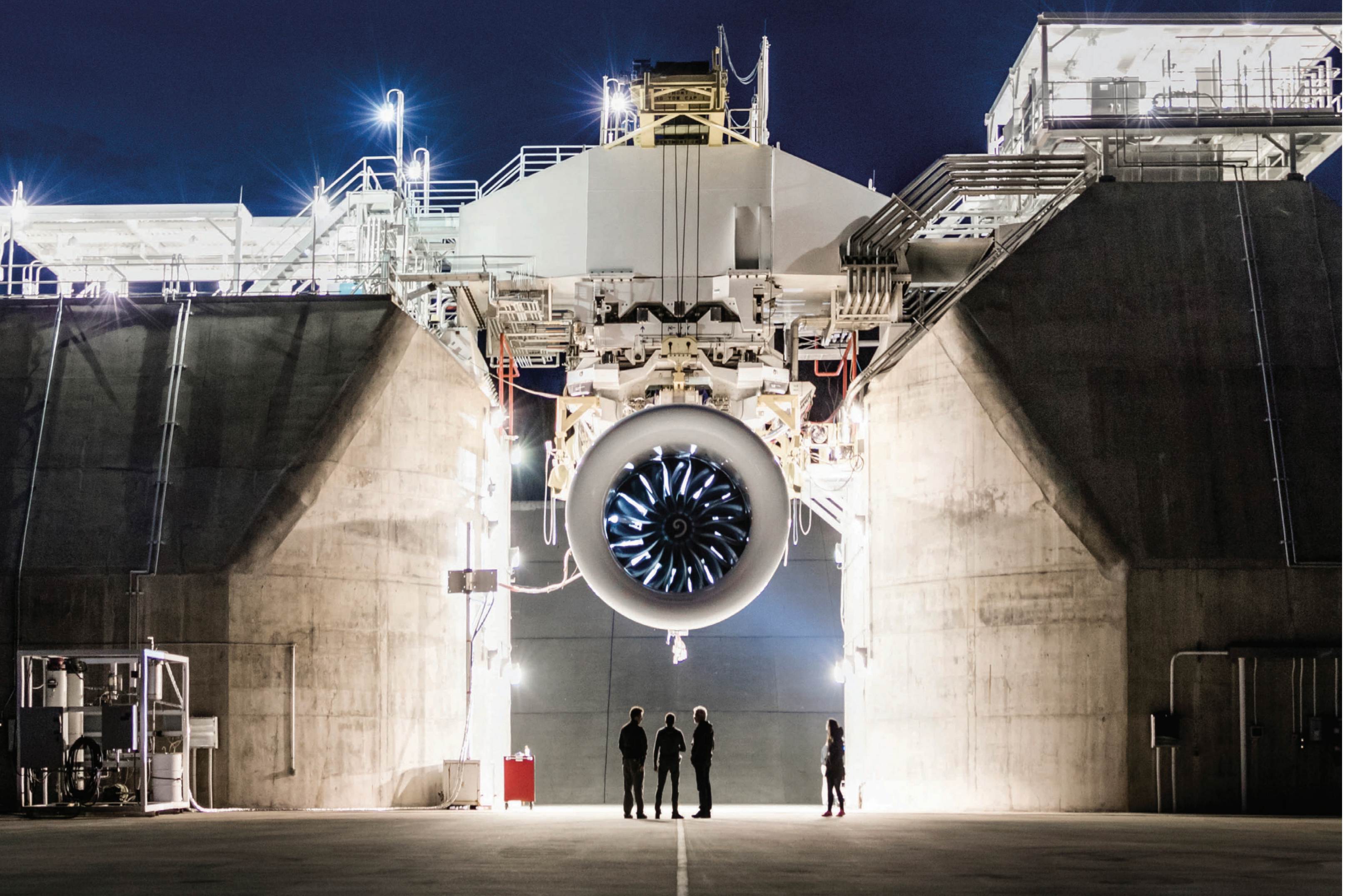


A MESSAGE FROM THE BOARD

Dear reader,

It is with great pleasure that we welcome you to the latest edition of our journal. In this issue, we explore the exciting developments in artificial intelligence (AI) in the aerospace industry. With AI poised to transform the way we think about and design aircraft, we are thrilled to be able to share with you the insights and experiences of the experts leading this revolution.

In the past quarter, we have been hard at work organizing several events aimed at inspiring and educating our members. The reveal party of our new board was a wonderful way to kick off the quarter and set the tone for what was to come. We then hosted a symposium on sustainable propulsion systems, where attendees learned about the latest innovations in clean energy and propulsion systems. Our Interview to Inspire series welcomed Arjan Meijer, CEO of Embraer Commercial Aviation, who shared his valuable experience and insights with our members.

Looking ahead, we have several exciting events planned for the upcoming months. Our Design Battle Competition promises to be a fun and challenging event for all participants, with a Phineas and Ferb theme that is sure to inspire creativity. We are also planning a multiple-day excursion, where our members can visit aerospace companies and gain valuable industry experience while enjoying a wonderful trip through France and Germany. Following this, our freshman weekend will provide new students at our faculty with opportunities to get to know each other and learn more about the aerospace industry, as they begin their journey with us. Lastly, our study tour will provide our students with the opportunity to get in touch with industry-leading companies abroad, all while getting in touch with the local culture and nature.

We believe that it is important to engage and inspire our members, providing them with opportunities to learn and grow within the aerospace industry. As such, we are committed to organizing events and initiatives that will broaden their horizons and expose them to new ideas and experiences.

We hope that this edition of our journal will provide you with valuable insights into the role of AI in the aerospace industry, and we look forward to continuing to engage with our readers in the future. Thank you for your ongoing support and interest in the VSV.

As a sign of how powerful current AI application already are, this entire message of the board was written by ChatGPT AI!

Lastly, once again a big thank you to the editorial of the Leonardo Times for delivering such an excellent edition yet again. Enjoy the read!

On behalf of the 78th Board of the VSV 'Leonardo da Vinci',
With winged regards,

Max van Hugten
President of the 78th Board of the
VSV 'Leonardo da Vinci'

WORLD'S FIRST 3D-PRINTED ROCKET TAKES FLIGHT

Relativity Space, an aerospace manufacturing company, launched its medium-lift expendable two-stage Terran-1 rocket on March 23, 2023, 03:25 GMT. It took off from Launch Complex 16 at the Cape Canaveral Space Force Station, marking its first use since the launch of the Perishing missiles 35 years ago. The mission was called "Good Luck, Have Fun" (GLHF) and did not carry any operational payloads. Despite failing to reach orbit due to an anomaly causing its second stage to shut down after separation three minutes into the flight, the launch achieved success on other fronts.

The Terran-1 is a unique vehicle - 85% 3D-printed, including its engines and the first US launch vehicle to use a methalox propellant. This means it uses a combination of liquid methane and liquid oxygen, leaving a trail of blue exhaust plumes; this launch was supposed to achieve the first orbital launch of a methalox-powered rocket. Relativity Space is working towards its goal of building 95% 3D-printed rockets in the future, currently working on the fully-reusable Terran-R.

According to the live stream launch, Terran-1 achieved a maximum altitude of at least 129 km, it crossed the Kármán line and reached space. It also proved that an additive-manufactured structure could survive Max-Q or the maximum dynamic pressure condition. Max-Q is the most demanding point of launch where a launch vehicle experiences the highest dynamic loads. These successes, including the achievement of Main Engine Cutoff (MECO) of the first stage and stage separation, are historic and Relativity Space is the first new company to reach space at its first launch.

This launch attempt succeeded after two previous scrubbed attempts. The first attempt was March 8, scrubbed due to trouble reducing the second stage's liquid oxygen down to the correct temperature. The second launch attempt three days later was aborted during engine ignition at T-0.5 seconds due to an issue in the stage separation automation. The countdown clock was recycled but aborted at T-45 seconds due to insufficient fuel pressure in the second stage.

RELATIVITY SPACE

JAXA ASTRONAUTS

Fourteen years after its last selection of astronauts, in which three astronauts were chosen, the Japanese Aerospace Exploration Agency (JAXA) brought two new candidates into its astronaut corps. JAXA issued a call for new astronauts between December 20, 2021, and March 4, 2022, and received over 4000 applicants. In contrast to 2009, when recruitment amassed 963 applicants.

Compared to the 2009 recruitment, the last recruitment has eased its requirements - it eliminated the traditional STEM background requirement, allowing individuals from a myriad of backgrounds such as arts and humanities to apply. In order to encourage more female applicants, they reduced height requirements from 158 cm to 149.5 cm. Applicants were screened in five stages, beginning with document checks. The following stages include an English proficiency test, as well as a STEM test, never implemented before, to ensure that the individual's academic ability is akin to that of a university graduate.

The two newly selected astronaut candidates are Makoto Suwa (46) and Ayu Noyeda (28). Suwa, a senior disaster risk management specialist at the World Bank, is the oldest candidate selected. On the other hand, Noyeda, the third female Japanese astronaut, a surgeon at the Japanese Red Cross Medical Center, is currently the youngest of JAXA's active class of astronauts. Suwa and Noyeda will spend the next two years undergoing basic training in Japan and abroad, such as at the Johnson Space Center in the United States. Following this basic training, they will participate in missions which may include ISS missions, working in the US-led international lunar station Gateway, or even be part of an Artemis lunar landing crew.

CNN

THE EVOLUTION OF AIRCRAFT LEASING MARKET

Aircraft leasing is quickly increasing its prevalence within the airline market. It is largely used as a means to improve an airline's balance sheet as the costs of acquiring aircraft are immense. There are mainly two kinds of aircraft leasing: wet leasing and dry leasing. For short-term leases, wet leasing and for longer durations, dry leasing. It is the only fleet financing option allowing for rapid, demand-induced expansion without massive capital investments. A number of airlines have recently taken advantage of this. As a cherry on top, leasing helps airlines to maintain a technologically updated fleet.

Since the COVID-19 outbreak's negative impact on the aviation sector worldwide, airlines are keen to optimize their fixed assets. Passengers' behavior has changed due to the COVID-19 pandemic and the travel restrictions, resulting in a significant decrease in market demand for airline services, hindering the growth of the aircraft leasing market. Yet, as the airline market strives to reach its pre-pandemic levels in the next couple of years, the leasing market is not only growing but even outpacing this growth.

NASAS NEW SPACESUIT PROTOTYPES FOR MOONWALKERS

In 2025, NASAs Artemis III mission will send the first humans to the Lunar south pole, and they will be wearing Spacesuits by Axiom Space. The first prototype, the Axiom Extravehicular Mobility Unit or Ax-EMU was unveiled at Johnson's Space Center Houston in mid-March. It currently features a dark grey cover material with touches of blue and orange. However, the final design for moonwalking is likely to be all-white to help manage temperature extremes.

The suit is a far cry from the Michelin-Man style worn on the Apollo missions. The Ax-EMU is more flexible and streamlined, providing a higher range of motion and higher variability in the size and adjustability of the suit, to fit a broad range of crew members. It accommodates at least 90 percent of the male and female US population, as one of the returning astronauts, the first woman, will go to the Moon. Next to this, the suit will feature advances in life support systems, pressure garments and avionics, with NASA providing extremely high technical specifications – though the details of which are somewhat under-wraps.

Curiously, alongside the Axiom engineers involved in the suit's creation was costume designer, Esther Marquis, who worked on Apple TVs 'For all Mankind' series. (Elon Musk similarly hired Jose Fernandez – a costume designer who worked on 'Batman v Superman' and 'The Fantastic Four' – for the SpaceX outfits.) It seems that the next to technical and safety requirements, fashion has become a requirement or even a tool providing NASA with public intrigue and support – very helpful for such an expensive and extraordinary mission.

FLY WITHOUT BIAS

Acknowledging our shortcomings is the start of growing a strong and welcoming community

Aerospace Diversity Department


MELITAS

The brightest and most skilled individuals provide the aerospace industry with the potential for innovation in the face of insurmountable technical challenges. Diverse communities with rich backgrounds provide the perspectives needed to solve these challenges, advancing society and our well-being. It is time for a deep dive into our own work environments to see how we can overcome the challenges presented by such a community and how to leverage its strengths.

The aerospace industry is growing. It is one of the most significant sources of innovation and technological progress. However, for an industry historically successful due to collaboration and teamwork [1], we severely lack diversity and inclusion. Current statistics show that over 90% of professional pilots and flight engineers are white males [2], and in leadership and executive positions, it is even worse. Not so innovative, right?

"Innovating" is a popular word in our industry, and this theme starts as early on as in university. Our Aerospace Engineering faculty puts a heavy emphasis on this word and may be one of the reasons why we are extremely successful. We have many immensely knowledgeable and successful students, staff, and researchers. We are ranked consistently as the number one faculty for Aerospace Engineering in Europe and within the top ten of the entire world. All these rankings focus on numbers and publications; our "success". But there is no well-being ranking: do all our staff and students feel safe in our Faculty? Do they feel they can stay true to themselves and still feel they belong? We dare to answer this with "no". The community struggles to connect and collaborate with each other, even though we are growing fast in number. This is especially hard for the numerous minorities walking our hallways and the company floors. Therefore, we should re-evaluate our priorities with more emphasis on actively including diversity and inclusion in our daily work. Then we can focus on building a community embracing and celebrating diversity, where everyone has the opportunity to strive and succeed.

But how do we include this in our daily work? Diversity is inviting everyone to the party. You may think we are an open faculty, but would you go to a party where you are only allowed to dance if you wear a specific outfit, which is terribly uncomfortable for you? Our community should be a place where we celebrate the differences between each other, and where we make use of these differences instead of dismissing them. While diversity may be to invite everyone to a party, inclusion is having access to the music choice and not to be judged for your dance moves. This starts with small changes, like asking all your teammates individually if they have input, especially the quieter ones, instead of leaving the floor for the ones that always speak up. And don't forget to let everyone finish their thoughts; learn to listen.

For those who think it is not a big issue, we invite you to talk honestly with the numerous minorities trying to follow the same path as you. There might be people in your team who don't feel like their voices are heard or feel uncomfortable showing their true selves. We may think we are very progressive and open-minded, but really have a critical look at yourself: Has there ever been a moment where you let your actions and decisions be driven by (unconscious) bias, and have you ever wondered how that affected others?

We all have to take responsibility and accountability. Implicit biases form early in childhood—some studies show evidence in children as young as six years old [3] - and are reinforced through adulthood by social environments and the ubiquitous presence of mass media. However, it is no excuse to say that our biases and prejudices are hardwired within us. Recognizing them and actively changing our behavior are the first steps towards a stronger, more welcoming aerospace community. Pause and think before you act, recognize your bias, choose your words carefully and innovate yourself.

From rockets to realities: these are the thoughts and experiences of your peers.

There are times when it is great to be an international student and just myself as a person, but there are also times when it's just not the easiest thing to do or be.

Chaitanya Dongre – BSc Student

I am a Sikh by religion and love sharing about it with others. A couple of times when my secretary and my colleagues have shown interest in knowing about Sikhism through me, I have had positive experiences and felt more included.

Harjot Saluja – PhD researcher Aircraft Noise and Climate Effects

An unpleasant part of being a foreign student was the number of presumptions made by some peers or staff. Many did not have an idea about my country of origin and I would get questions like whether I had seen snow before (whereas it actually snows more where I grew up) or whether I speak Arabic, which I don't. These are examples of unconscious biases we all have. Even though I consider the Netherlands my home, I still sometimes struggle with these interactions.

Shadab Eftekhar – MSc Student and Aerospace Diversity Department member

Diversity is incredibly important to me. I'm neither fully Dutch nor Chinese, I belong somewhere in Neverland. Even though I grew up in the Netherlands, I have never felt fully accepted here.

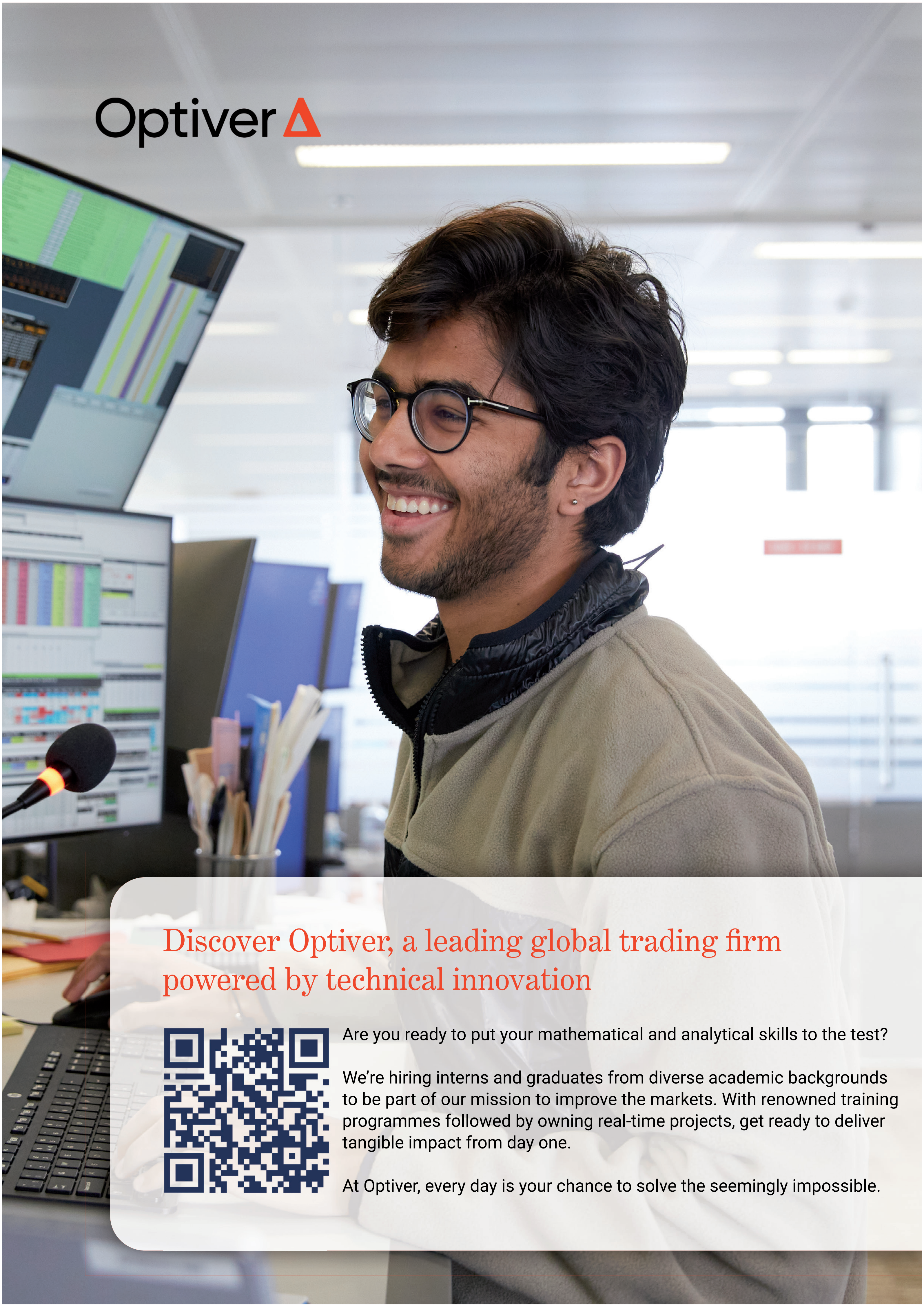
Cindy Su Chen – BSc Student and Aerospace Diversity Department member

By constantly improving the diversity of our population (i.e. having more role models) and by giving each other direct feedback when unwanted behavior occurs (bystanders!), I hope we will continue to improve. We are not there yet, but in my opinion, things are going in the right direction.

Henri Werij – Dean of the Faculty of Aerospace Engineering

Diversity brings diverse thought processes and knowledge that lead to more out-of-box discussions for high-quality research innovation and high-quality education.

Botchu Vara Siva Jyoti – Assistant Professor Space System Engineering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FLYING HIGH WITH AI

How artificial intelligence is transforming airport operations

Ruth Euniki Vraka, Leonardo Times Editor

AI-Generated Image: "Flying High with AI: How artificial intelligence is transforming airport operations"

The aviation industry has long been a major contributor to the global economy, generating trillions in economic activity and supporting millions of jobs worldwide. As air travel has increased in recent years, with over 100,000 flights and 11 million passengers passing through airports daily worldwide, AI has become increasingly important in improving airport operations and passenger experience.

The integration of AI in airport operations has the potential to improve efficiency, increase productivity, and reduce operational costs. By leveraging predictive analytics, airports can forecast future passenger traffic, allocate resources efficiently, and reduce congestion. Facial recognition technology has also been introduced to improve security measures and passenger flow, while AI-powered robots have performed various tasks, including baggage handling, cleaning, and maintenance, reducing operational costs and enhancing efficiency. Chatbots have also been integrated into airport operations to guide passengers through the check-in and security process, minimizing waiting times. However, it is essential to prioritize privacy and security measures, particularly when using facial recognition technology, to protect passengers' personal data and comply with data protection laws. Ethical considerations must also be taken into account when implementing AI in airport operations. As the use of AI continues to expand in airport operations, it is important to explore the potential benefits and challenges that come with it, and ponder upon the question: how far can AI take us in revolutionizing airport operations and enhancing the passenger experience?

FUTURE-PROOFING AIRPORTS

One of the most significant benefits of AI in airport operations is predictive analytics. Predictive analytics uses historical data to forecast future events, enabling airports to make informed decisions in real-time. By analyzing large volumes of data, it can forecast passenger traffic, allocate resources efficiently, and minimize delays. This technology can also help airports optimize their operations by predicting equipment failure and reducing downtime, ensuring that airport personnel can quickly address any issues that may arise. The predictive capabilities of AI also extend to weather predictions, which can be used to prepare for potential disruptions and ensure the safety of passengers and airport personnel. For example, airports can use AI-powered weather prediction tools to predict storms and adjust flight schedules accordingly, minimizing the risk of delays and cancellations.

Moreover, predictive analytics can be used to optimize baggage handling operations, ensuring that passengers' luggage is handled efficiently and accurately. By using AI to track and analyze the movement of bags, airports can minimize the risk of mishandling or lost luggage, improving customer satisfaction. Additionally, AI can help airports improve security measures by analyzing passenger data to detect potential threats and enhance screening processes. Overall, the use of AI with predictive analytics has enormous potential for the aviation industry, offering a wide range of benefits, including increased efficiency, productivity, and safety. As airports continue to adopt this technology, passengers can expect to see significant improvements in their travel experience.

HELLO, THIS IS AI!

One of the most significant challenges for passengers during air travel is the long waiting times during the check-in and security processes. The use of chatbots can help guide passengers through these processes, minimizing waiting times and improving customer experience. Chatbots are

AI-powered applications that can simulate human-like conversations with passengers, providing them with real-time information and assistance. Chatbots can help passengers with a range of tasks, such as booking flights, checking-in, and providing information on airport facilities, such as restaurants, shops, and lounges. They can also provide passengers with information on their flight status, delays, gate changes, and baggage claim information, reducing passenger anxiety and improving customer experience. Chatbots can also assist passengers during security checks, which is one of the most time-consuming processes during air travel. By providing passengers with real-time information on security wait times and helping guide them through the security process, they can reduce waiting times and improve customer satisfaction. A real-life application of this is the Helsinki Airport, which in 2019 introduced a chatbot named "Ava," which helps passengers navigate through the airport and provides real-time information on flights, boarding gates, and baggage claim. The chatbot has been successful in reducing passenger anxiety and improving overall airport efficiency.

ROBOT TAKE-OVER

In addition to chatbots, AI-powered robots have also been integrated into airport operations to streamline baggage handling processes. Baggage handling is a crucial aspect of airport operations, and it is critical to ensure that passengers' luggage reaches their destination safely and on time. AI-powered robots have been designed to perform tasks such as baggage loading, unloading, and transportation. These robots can navigate through the airport and transfer baggage from one point to another, reducing the need for human intervention and minimizing the risk of errors. The robots are equipped with sensors and cameras that allow them to detect and avoid obstacles, ensuring safe transportation of baggage. Moreover, these robots can work 24/7, significantly reducing operational costs and enhancing efficiency.


DALL·E

AI-Generated Image: "Photo of a airport which uses AI for its operations"

For example, the San Francisco International Airport has introduced a robot named "Pepper," which can answer passenger queries, provide directions, and even play games with passengers to entertain them during their waiting time. It quickly became a popular attraction among passengers. According to a report by the airport, in just the first six months of operation, Pepper had over 275,000 interactions with passengers, and more than 80% of passengers who interacted with Pepper rated their experience as positive. Additionally, by automating routine tasks like answering passenger queries and providing directions, the airport has been able to reduce its operational costs by 30%.

The success of Pepper has inspired other airports to adopt similar technologies, with airports around the world now deploying robots to assist with various tasks. For instance, Amsterdam's Schiphol Airport has deployed a fleet of AI-powered robots that can carry up to 40 kg of baggage each and are capable of transporting up to 450 bags per hour. The robots communicate with the airport's baggage handling system, ensuring seamless transfer of baggage between flights. AI-powered robots have also been used for cleaning and maintenance tasks, reducing operational costs and enhancing airport cleanliness.

Facial recognition technology is a critical tool for enhancing security measures in airports. AI-powered facial recognition systems can accurately identify individuals, match them with their travel documents, and identify potential security threats. By comparing passenger faces with a database of known criminals or persons of interest, airport security personnel can quickly and efficiently detect and prevent security breaches. Facial recognition technology can also speed up the check-in process, reducing waiting times for passengers.

There are several relevant examples of AI-powered facial recognition technology in airport operations. One is the biometric boarding system at Orlando International Airport. The system uses facial recognition technology to identify passengers, reducing the need for passengers to present their boarding pass and passport at multiple checkpoints. The system has reduced boarding time by over 30%, improving customer experience and reducing congestion. Another example is the facial recognition system used by British Airways at London Heathrow Airport to speed up the boarding process for international flights. Passengers' faces are scanned and matched to their passport photos, and their boarding infor-

AI-Generated Image: "Photo of a airport which uses AI for its operations"

mation is automatically updated. The system has improved the boarding process' speed and efficiency, reducing waiting times for passengers. Additionally, in 2018, the Changi Airport in Singapore implemented facial recognition technology in its Terminal 4, enabling passengers to check-in, drop off their luggage, and clear security using only facial recognition technology. This technology reduced check-in time by 20%, improving passenger experience and increasing efficiency. However, the use of facial recognition technology in airports raises privacy and ethical concerns, and it is essential to prioritize privacy and security measures when implementing the technology.

SECURITY, DATA PROTECTION, AND ETHICS

The incorporation of AI technology into airport operations is not without its concerns. Given that personal data is often involved, there are considerable security and data protection issues that must be addressed. Specifically, the use of facial recognition technology in airport operations carries the risk of unauthorized access and misuse of personal data. This, in turn, can lead to identity theft or other malicious activities. Therefore, it is critical to prioritize privacy and security measures to safeguard the personal data of passengers and comply with data protection laws. Additionally, ethical considerations are of utmost importance when implementing AI in airport operations to ensure fairness and prevent discrimination. For instance, the use of AI in security screening must be unbiased and transparent, to prevent false positives or negatives. It is also vital to ensure that AI systems are transparent, explainable, and accountable, allowing for human oversight and intervention if necessary. Furthermore, the use of AI-powered robots in baggage handling, cleaning, and maintenance should be carefully monitored to prevent any accidents or mishaps. This entails ensuring that these robots are adequately programmed and equipped to navigate airport environments safely and effectively. Regular maintenance and updates to these systems are also necessary to ensure that they are operating at peak performance and minimize the risk of failure.

Addressing security, data protection, and ethical concerns is crucial for ensuring the safe and responsible use of AI in airport operations. This requires a concerted effort from all stakeholders, including airport operators, AI developers, regulators, and passengers, to ensure that AI technology is used in a way that maximizes its benefits while minimizing its risks. Ultimately, the successful integration of AI into airport operations will depend on a shared commitment to security, transparency, and accountability.

CONCLUSION

The integration of AI in airport operations has transformed the aviation industry, enhancing safety measures, improving passenger experience, and optimizing overall airport efficiency. Predictive analytics, facial recognition technology, AI-powered robots, and chatbots are just some of the AI-powered applications that have been introduced in airport operations. However, it is essential to note that the implementation of AI must prioritize privacy and security measures. Passengers' personal data must be protected and secure, and the use of facial recognition technology must comply with data protection laws. The use of AI in airport operations is an excellent example of how technology can transform traditional industries, improving efficiency, productivity, and customer experience. As the aviation industry continues to grow, the use of AI will become increasingly important in optimizing airport operations and enhancing overall airport efficiency.

SPOILER ALERT

Well folks, I must say, it's been a pleasure writing this article for you. But before I go, I have to let you in on a little secret: I'm not actually a human. Nope, I'm just a super smart AI language model, and I whipped up this article in no time, which is a testament to the incredible power of AI. On average, it could take a human several hours, if not days, to write an article of this size, but I was able to do it in a fraction of the time. However, this doesn't mean that humans are obsolete; far from it. The creativity, empathy, and critical thinking skills that humans possess are essential for decision-making, especially when it comes to ethical considerations. AI should be viewed as a tool to enhance human capabilities and not replace them. As AI continues to evolve, it will undoubtedly lead to further advancements and innovations that we can't even fathom yet. The possibilities are endless, and it's an exciting time to be in the field of AI, both within the field of airport operation as well as in the whole industry.

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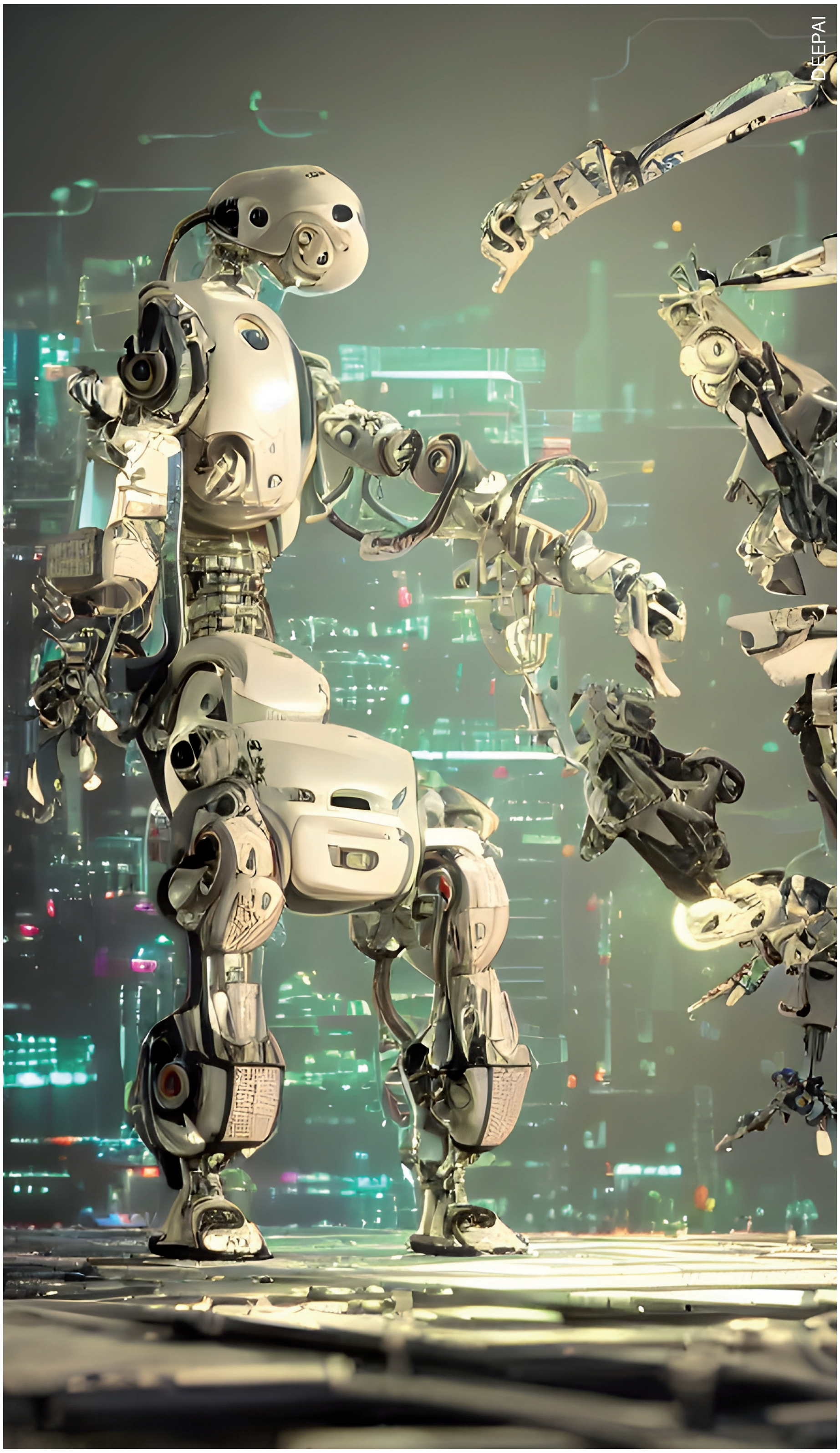
MACHINES AT WORK

Insights into artificial intelligence and its influence on workers in the aerospace sector

Topias Pulkkinen, Editor-in-Chief and Naomi Lijesen, Final Editor

C&O



AI-generated Image: "AI taking the jobs of aerospace engineers"

On top of radically transforming the aerospace capabilities industry and the broader world of engineering, AI technologies will affect the everyday-work of most engineers in the future. In this article, we dive into this transformation.

As technologies such as artificial intelligence (AI), automation, robotics, and machine learning continue to advance, their potential capacity to unburden humans from certain occupations increases. We are currently experiencing the first tasters of the astonishing feats these technologies are capable of, from autonomous vehicles to OpenAI's artificial intelligence chatbot, ChatGPT. Yet, for many, the acronym "AI" conjures feelings of distrust as well as awe. For years, Dystopian sci-fi movies have adopted these technologies as their villains. Proliferating a common plot where computers and technology continuously improve until they outperform us, thus outgrowing and discarding their lowly creators. It is no wonder that with each new feat AI accomplishes, the fear of mass unemployment grows. Will AI bring another technological renaissance, ushering in a new era of human leisure and prosperity? Or will super-intelligent technology take over the world, leaving humans behind?

Engineers as a professional group have been widely regarded as irreplaceable throughout history, largely due to their analytical abilities and skills to convert the theory taught in mathematics and science classes into functional, often innovative solutions. Yet, in engineering schools, many professors emphasize the need for students not to become too robot-like in their thinking or too automated to solve a particular exam problem for the highest ma, but rather to approach a problem with a broader, yet sharply analytical point of view. Now, with the capacity to train AI to solve problems similar to one another when converted to a numerical form, the question arises: what future roles will engineers be left with?

Despite the hype, AI's path to dominance in the engineering sector is by no means

AI-generated Image: "AI taking the jobs of aerospace engineers"

guaranteed, at least in the short to medium term. Many would argue that the often conservative work environment most engineers find themselves in will continue to rely on technologies already deemed functional. "If it ain't broke, don't fix it", the saying goes. Many field experts share this sentiment: "Despite engineers' propensity for new technology and assumed geekiness, the profession might be among the last to embrace this innovation." [1]. Naturally, some may also question the need for AI in the industry, as they may experience its growing prevalence as a threat, albeit a very non-imminent one.

AI can be an exceptional tool throughout the design phase of a product in the aerospace sector or otherwise. As AI image generators become more powerful and imaginative, they can perhaps provide the key to any design beginnings; inspiration. Once the seed is planted and design objectives or goals established, AI-assisted software can generate multiple concept ideas quickly from limited (or extensive) requirements. The generative design process, whilst not a new concept, is behind some of the newest and most remarkable AI-driven computer-aided design (CAD) software available. It involves feeding requirements or objectives into the computer software and producing a number of optimized, alternative designs [2]. It eradicates the familiar problem that engineers face: After having designed for functionality, you find your product is impossibly expensive or difficult to manufacture…then after redesigning for manufacturability, the design then suffers aesthetically…redesigning again means it is functionally flawed [5]. Instead, the software can autonomously provide a menu of design options, each optimized for various factors such as performance, manufacturing methods, materials, weight, cost, and more [5]. Essentially, the iterative process that an engineer once did manually, is now performed by the software with baffling speed. Two examples of AI-assisted generative design include PTC's creo applications and Autodesk's Generative Design Extension for its Fusion 360 CAD software [3][4]. Currently, many more CAD software programs have generative design capabilities as a standard function or extension. While both examples insist that the "designer isn't off the hook" and the software intends to complement the design process with engineers making the decisions and refining the design further [4], it is, however, undeniable that managers armed with this software might need fewer employees to generate and optimize designs. Furthermore, simulation in a design phase allows engineers to test complex designs early on by using virtual models, as well as performing predictive maintenance [6]. When combined with AI, the complexity and speed of a simulation model can be improved significantly. The intersection of AI and simulation will undoubtedly continue to grow in complexity and ability in the coming years. As the ability to develop, test and validate models becomes more accurate and affordable, the process will become an essential tool for any engineer [6]. So, whilst AI significantly speeds up and enhances the process, replacing a human engineer in the future seems unlikely.

Something destined to change in the future aerospace industry is the conduction of maintenance, repair and overhaul. As we know, the need for constant monitoring of aircraft airworthiness is not about to disappear. Yet, with increasing computational capabilities, more of this line of work which used to be manual and labor-intensive can be outsourced to algorithms that utilize technologies such as acoustic emission to locate potentially damaged locations [7]. This algorithmic fault detection will accompany the increased use of robotic arms in fixing some of the more elementary structural issues. This automation incentivizes as it saves companies considerable labor costs in the long run. That being said, in the medium to short run, the need for mechanics with practical experience will prevail, as robots can only be so adaptive to different types of faults.

One of the less futuristic concepts that will also change the everyday life of employees, namely pilots, is the advancements made in flight computers, civil and military. Like many jobs, pilots too will most likely have a role entailing more system monitoring, meaning pilots will not be redundant for a long time. Human pilots might be able to issue commands to the computer instead of having direct manual control. In the big picture, this continues the trend of the last decades with largely automated flight controls for aircraft like the Airbus A380, which can land, brake and steer (to name a few) autonomously [8]. Regardless of advances in computation, human judgment is still a net benefit in light of recent aviation tragedies, such as the case of the Boeing 737-MAX aircraft.

In 2017, McKinsey Global Institute predicted that intelligent automation could displace between 400 million and 800 million individuals from their jobs by 2030 [9]. Whilst this fact may seem shocking and might cause some readers to frantically reach for ChatGPT, asking what jobs it is yet unable to perform, let us not panic just yet. Other reports conclude that AI bringing on mass unemployment is unlikely and instead, will generate new industries, creating more jobs than are lost [8]. After a period of transition, they express that the most promising utilization of AI will involve people and computers working together rather than the latter replacing the former [10]. Next to this, it is clear that in all aspects of the aerospace industry, our trusty - human - engineering judgment remains necessary.

CONCLUSION

Universities worldwide are starting to ensure that their students attain the right skill set upon graduation. One example is TU Delft's recent introduction of the AI in Aerospace course into the aerospace bachelor curriculum. In the long run, AI's advances will surely change the engineering job description and requirements fundamentally. This said, the world won't end, and there won't be mass unemployment, but instead, we might get work done just that little bit faster.

BOEING'S MANUFACTURING TRANSITION

How one of the world's biggest aircraft manufacturers improves its manufacturing process with automation, robots and artificial intelligence

Lisanne Vermaas, Leonardo Times Editor

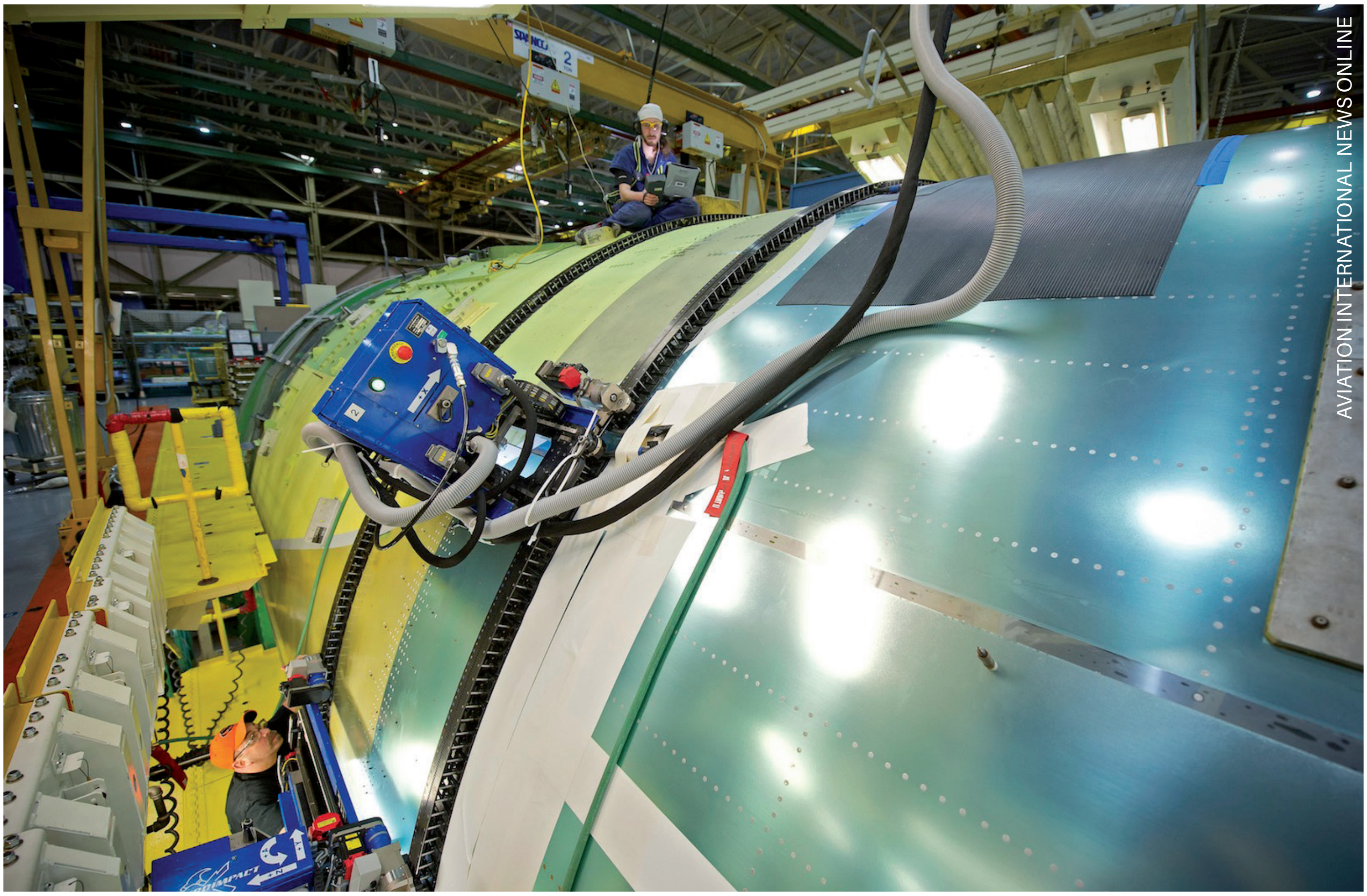


Figure 1: The Flex-Track system, mounted on the fuselage

As the world recovers from the Corona pandemic, the demand for aircraft is increasing again. Before the pandemic, the aviation industry estimated a need for 40,000 new aircraft in the coming 20 years. Experts underline the need for more automation and autonomy in the aircraft manufacturing lines in order to achieve this goal [1].

This article will outline several automation, robotification and autonomization steps taken by Boeing to increase efficiency within their production lines.

FLEX TRACK

Flex-Track is an automated drilling system implemented in the Boeing 777 and 787 Dreamliner production line in 2013. The system is developed by Phantom Works and is used to drill holes in specific patterns for the purpose of assembling large parts such as fuselage sections. The system is attached to the fuselage by means of rails containing suction cups, as seen in Figure 1. The machine then travels along these rails over the fuselage, drilling and countersinking holes. The location of the drilling bit is determined based on reference holes within the part to be drilled, simplifying the positioning of the rails significantly.

Formerly, workers had to move the part to a stationary machine or drill by hand. This was time-consuming and physically demanding. The flex-track system has a mass of only 34kg and is, therefore, easy to move within the factory [2]. Additionally, the drilling is completely automatic. Right after implementing the system, Boeing observed a 93% increase in hole quality. After some time, Boeing managed to increase this number to 98% [3].

FAUB

FAUB stands for fuselage automated upright build, a robotic system developed by Boeing, introduced in 2013 and implemented in 2015. It aimed to overtake the ergonomically intensive task of assembling large 777 fuselage parts, more specifically the forward and aft sections, with 60,000 rivets. The system consisted of four robots collaborating with the factory's mechanics. The mechanics were tasked with holding parts of the fuselage, while the moving robots drilled holes and inserted the fasteners. Two robots were working on the upper half of the fuselage, both on the in-and outside. The robot on the outside of the fuselage drilled the hole and inserted the rivet, while the one on the inside fastened it. The remaining two robots worked on the lower half in a similar fashion. In this way, the fuselage was built from top to bottom (hence the 'upright build' in the name) [4].

However, the robots proved to be a headache for the company, prone to errors and difficult to set up. The result of the project was the exact opposite of its mission: flawed fuselages that required extra work from mechanics and slowed down the production line. A mechanic told the Seattle Times in 2016: "FAUB is a horrible failure". Initially, Boeing kept pushing this technology, convinced these were just startup problems. This: however, was not the case, and Boeing felt the need to drop the project altogether in 2019. For the assembly of its 777, Boeing then started to rely on Flex Track and its mechanics again [4]. Boeing sees the FAUB project as a lesson. "It has taught us how to design for automation", Boeing's vice president Jason Clark said [5].

ASM

ASM is the abbreviation of automatic spray method and, as the name already suggests, is concerned with painting the wings of the Boeing 777. The method - implemented in 2013 - increased the production rate of this aircraft from 84 to 100 per year. The painting task is executed by a robotic system, replacing 35 to 40 painters. The robot has a 19-axes mechanical arm which can reach up to 5.5 meters and is located in a sealed booth, as seen in Figure 2 [3]. The robots travel within this booth over a rail system on both sides of the almost 43m long wings.

The system reduces the time taken to paint the wings by a factor of 10. An additional benefit of this new method is the significant increase in the accuracy of the paint job [6]. Even though the painting job is now executed by robots, "no lay-offs occurred because of the implementation of this new technology", claims Clark. The painters now focus on the programming of the robots and the more difficult painting tasks, such as the aerodynamic finish required for the tails [7].

UR10

Boeing started employing a very new kind of employee in 2017, namely cobots. Cobots are special types of robots, capable of working safely, with humans. Their purpose is to make a human employee more efficient by taking over the easy, repetitive or physically intensive tasks. Universal Robots' UR10s are implemented in the 737 assembly line. Currently, the cobots prepare the aircraft's flap tools (or mandrels) for manufacturing in the tool preparation area. The preparation of the mandrels consists of, among other things, sanding. Sanding the tools is a task easily performed by the cobots, as it is considered a boring task among employees - but crucial in the manufacturing process. Boeing claims that with the implementation of these cobots, they have already saved hundreds of hours in the production process [8][9].

Figure 2: The Automatic Spray Method robots at work

The UR10 is a robotic arm that can autonomously move around in the factory while avoiding people and obstacles - it also provides a warning for its approach. The cobot can work for 10 hours, after which it returns to its charging station [9]. It makes use of a 3D scanner and lasers to determine its location within the factory and avoid any obstacles in its way. Barcodes on tools in the factory give the robot an indication of the flap tool location relative to the robot's arm. After the tool location is determined, it calculates and performs its required movement [9]. The cobot is equipped with software capable of calculating the motion required in any situation and is not pre-programmed [9].

AI

Boeing has also implemented artificial intelligence (AI). In 2017, AI entered the work floor in the German Broetje-automation skin-fastening machines. The skin fastening machines are part of the Boeing 787 assembly line, in the fuselage section assemblies. The machines drill, countersink, apply sealant, insert fasteners, swag collars and feed fasteners. Previously, the machines tuned their fastener feed on and off based on their own judgment. The machine learning models developed by Boeing predict the required fastener feed of the machines. This is done by making use of historical data and clustering the grip length of the fasteners in order to determine when and for how long to turn on the early fastener feed. Boeing claims that this solution saves up to five hours per assembly line [10].

Srini Venkatraman, who, together with his team, has developed the software, sees even greater capabilities in these types of predictive algorithms. He envisions the potential of not only using AI for this purpose, but for many more tasks within the assembly line [10].

OTHER TECHNOLOGIES

In addition to the outlined technologies, Boeing is experimenting with other cutting-edge developments. In 2022, they began providing their workers with a bionic exoskeleton vest. This vest assists in ergonomically heavy tasks such as sanding, sealing and painting the aircraft and protects from injuries [11]. Bluetooth enabled smart wrenches are planned to be handed to the mechanics working in the twin Dreamliner factory, to ensure the correct torque is applied to the nuts. The wrench then signals if the required torque is exceeded [12].

CONCLUSION

In conclusion, aircraft manufacturers are facing an increasing demand for aircraft. They are implementing new technologies to improve the efficiency of their assembly lines. Among these new technologies are robots, AI and cobots. Even though not all implemented changes were successful, the trend of an increase in automation will not change in the near future, as it has proven to improve not only the efficiency of the production line, but also the precision of the product.

ACCELERATING OUTPERFORMANCE

The fourth industrial revolution is taking shape in all sectors of 21st-century society

Topias Pulkkinen and Muhammed Arham Elahi, Leonardo Times Editors

Bram Masselink, the co-founder of Helin

Helin Data Company is a Delft-based firm specialized in edge computing and edge-to-cloud analytics solutions. Edge computing is a novel field where data is processed closer to where it's generated, allowing the processing to occur at greater speeds.

Note: This article has been edited for clarity and length

Topias: Could you provide a brief introduction about your background?
Bram: I am Bram Masselink, I started studying Aerospace Engineering in 2001 and graduated in 2009 with a Master's from the Control and Simulations Department. My graduation research covered the topic of parabolic flight with Max Mulder as my instructor. A funny incident during my master's thesis was a suggestion from Max to complete test flights to test the programs I'd coded for my thesis during my exam period at Erasmus, where I was simultaneously studying for a second degree in economics. That was a busy time.

Topias: In 2005, you founded Lyceo, a company helping Dutch high school students to improve their exam performance. In 2017, you founded Helin, a tech sector company. Can you tell me more about these early entrepreneurial years of yours?
Bram: We were having lunch in the AE Faculty in 2005 and saw leaflets suggesting we go to Leiden to teach high school students science and math. My friend, Joost and I thought we could follow the same concept in Delft but execute it better. We created a business plan and presented it to the Dean of the Faculty. Then we met the University's Executive Board, who thought a university-wide exam training targeting high school students would be an excellent initiative. Hence, we started what was known as TU Delft Exam Training back in its early years. Later on, we realized that we could scale our operations and gave training to people applying to other universities as well, changing the company name to Lyceo. In the end, we trained about 15,000 students in the Netherlands. To us, more than anything, it was an exciting logistical challenge. To interview 2,000 university students with no prior business experience to fill 800 tutor positions was no easy task. Having said this, although I still highly valued education, by 2011, I knew it wasn't my biggest passion, so we initiated talks to sell the company. The paperwork for

this finished in 2012, and afterwards, Joost and I took time off to think about our next move.

Investing in innovation is something I've always found incredibly valuable and interesting, and we agreed we could do this by realizing a technology-based company that could operate at an industrial scale. In 2015, we acquired a company called Rolloos Oil & Gas B.V. working in the turbulent energy and commodities industry. After our first year as the company's owners, we had to do some heavy restructuring, particularly financially, and the previous owners became shareholders again. In the late 2010s, the company sold a large amount of hardware for the oil and gas industry, whereas we wanted to take it into the software field. Then, as we all know, COVID-19 hit the world, forcing us to split the company in two, with hardware staying in the old company structure and the software part breaking off.

Topias: Can you tell us more about the transformation that the coronavirus led to?

Bram: Prior to the corona crisis, oil prices were already low due to geopolitical reasons. As the crisis began, our clients, the drilling contractors, couldn't change their drilling crews due to the pandemic. This led to a complete disruption in the supply chain, resulting in our client's revenue coming to a halt.

Arham: Since you started the company early at university, how did it impact your study, and how did you balance study and work?

Bram: One of the most crucial things is self-discipline. I was doing a second study as well which was an added commitment. Joost and I were eager to learn and didn't mind making mistakes as long as we identified them and learned from them. Luckily, when you are young, you have less to lose. Having a great team and being passionate about what you do was massively helpful.

Topias: How did you enter the renewable energy market, and what are your thoughts on the industry's future?

Bram: By March 2020, when the oil market crashed due to COVID-19, we already had a couple of clients in the green energy market. We knew that going further into the renewable energy market would be a sound business model ethically and financially. Another thing that really inspired us with the renewable energy market was the fact that the market is very complicated with difficult challenges to solve. Distributing energy could be done in a much more optimized fashion and we see great potential here, for example in power-hungry data centers that many tech giants wish to build.

There is a lot of growth in our green energy industry clientele.

Topias: We know you guys have this edge computing platform called Polaris, can you give us an overview of what Polaris is, what it does, and why it is profitable?

Bram: The edge management platform consists of three pillars. The first pillar is data acquisition, for which we use the factory's existing sensors already in place for the operation of the control loop. We create a data pipeline to perform analytics or stream part of it to the cloud. The second pillar is app management, which consists of configuring the edge computers to ingest the correct data and perform some local computations. The local computations can create reports, print alerts, run machine algorithms to detect anomalies, create dashboards to inform the crew of the performance (production and emission) of the factory and much more. The third pillar is the security layer, as the edge computers have direct access to the control network, it is imperative it is secure. Therefore, we developed our own PKI (Public Key Infrastructure) to hand out and administer certificates ensuring safe data communication to renew those certificates. We also have a great deal of security monitoring in place and ensure that the edge computing isn't directly connected to the internet; it goes through a firewall instead. There is still a lot of data going back and forth through the firewall. To keep it secure can be a little bit complicated, which is our added value: we build an infrastructure so that our clients can develop and manage applications.

Topias: What would you say is the most rewarding part of your work, both at an individual and company level?

Bram: At an individual level, it is really satisfying to solve very complex problems. It is one of the main things I learnt from my time in Aerospace Engineering; how to break up a huge puzzle into smaller solvable pieces and then glue the pieces back together to find the solution. It is crucial to have an overview of all the interacting parts and solve the problem in the right order, especially if the problem is difficult. In most cases, I don't come up with the solution, we do it as a team. At a company level, it is about growth, both as individuals and as a team, as well as having a positive impact on our clients. We always want to make sure we help them achieve something impossible without us.

Topias: What is something that no educational background could have trained you for, but you had to learn the hard way?

Bram: During your study, you get all the data to solve all the issues. In reality, it is often not the case, hence you must make decisions based on an incomplete picture. Another thing is that finding a solution yourself is only part of the work. To ensure everyone around you moves and adopts the solution is just as important. That is all about communicating, convincing and inspiring people to follow you. Just saying 'I told you so' has no benefit. You must make sure that the other person understands and implements it. One way we try to ensure we are all on the same page is when we discuss things. The person listening writes it down. This can be double-checked to ensure both people think alike. Lastly, the effort you put into something does not directly translate into results, and results, at the end of the day, are what matters. Preferably we attain those results by taking the path with the least resistance.

Topias: Looking to the future, you mentioned that you wanted to standardize the quality control of the data you acquire. Can you elaborate on that?

Bram: As mentioned before, at university you can assume that all the given data is correct. In reality, when working with real-time systems, there are many errors. They may be due to faulty sensors, which could be uncalibrated or not connected at all. What we would like to offer is a system to process the data, detect these anomalies and send a report to the client about suspected problems. This is integral to ensure this faulty data doesn't get processed further and impact final results, greatly increasing the accuracy of the system.

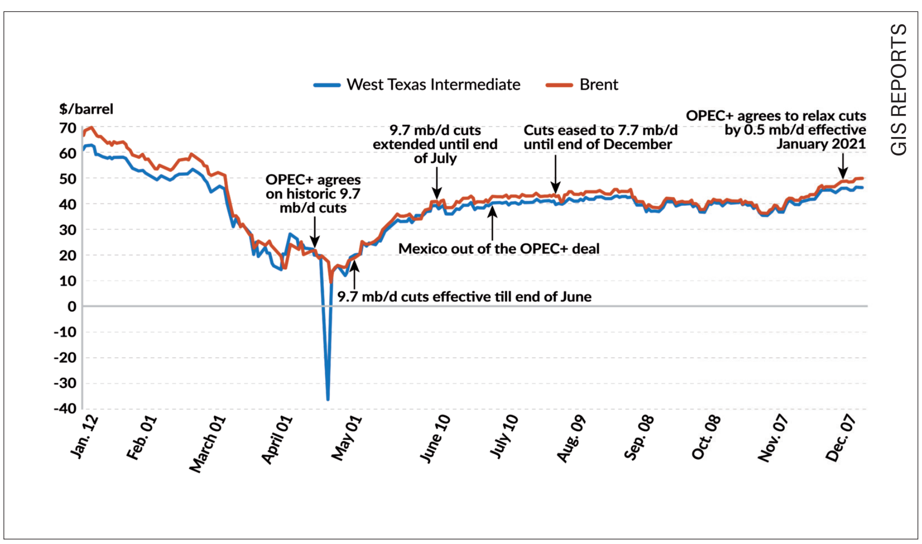


Chart showing oil price shocks due to corona

Helin works with energy companies in a diverse market

Topias: What is the role of machine learning in the company and what future perspectives do you see?
Bram: A machine learning algorithm can be fed data about nominal operation and can detect anomalies. Then we can use the diagnoses people make for those issues to further train the machine learning algorithm and form a feedback loop. In theory, it sounds very simple and effective, however, practically it is quite hard to make it work reliably. I also believe that just finding patterns in data is not the best way to approach the problem, it is always best to combine domain knowledge and engineering principles with the acquired data which will yield way better solutions.

Topias: What advice would you give to entrepreneurs?
Bram: Just do it! Don't be afraid to make mistakes and learn from each one of them, the younger you start, the less you have to lose. It may be hard to leave the comfort of a high-paying job to start a business where you won't earn much, at least in the early stages. Therefore, if you start when you have nothing to lose it is way more comfortable. Don't get attached to material things and dare to take risks, learn from them, and ask a lot of questions. Don't try to protect your idea because it's not about your idea, it's about the execution. Also, we have a lot of competitors who have hundreds of millions in funding, but we can still compete with them because we do things our own way by combining analytics with domain knowledge. We try to understand the business of every client.

Topias: Is there anything you would like to add?
Bram: The edge computing market is a really interesting market because it is essentially a continuation of the whole cloud discussion 20 years ago, but now you find out that in many situations, the cloud doesn't really cut it on its own. That is mainly due to latency issues, especially when you are in a marine sector or when a lot of processing is required. Since there is a lot more data available locally, edge computing is a really fast-growing market; expected to grow by 40% annually over the next 10 years. A lot of large companies also implement edge computing strategies. You might think that there are many things that should have been done already, but it's not the case.

Helin connects different entities

Arham: From what I see on your website, it does seem that you still use the cloud for processed data storage. Do you integrate both these technologies together?
Bram: Yes. For example, in a Tesla, the onboard edge computer processes all the data and video feeds and then sends out the aggregates of the usage to the central cloud. When Tesla initially came to Europe, it had a lot of trouble on highways as it detected bicycles mounted on the back of cars (something not commonly done in the US) and immediately halted to a stop. So to tackle that issue, they sent out a search request to their fleet of Tesla's to send images of bicycles mounted on the back of cars on highways to the cloud. They then used that information to improve their autopilot and update their cars to eliminate these issues. So by using edge computing, you detect anomalies from high-frequency data and send those anomalies to the cloud for further processing to optimize the whole fleet. So it's neither edge nor cloud exclusively but a combination where these are integrated very efficiently.

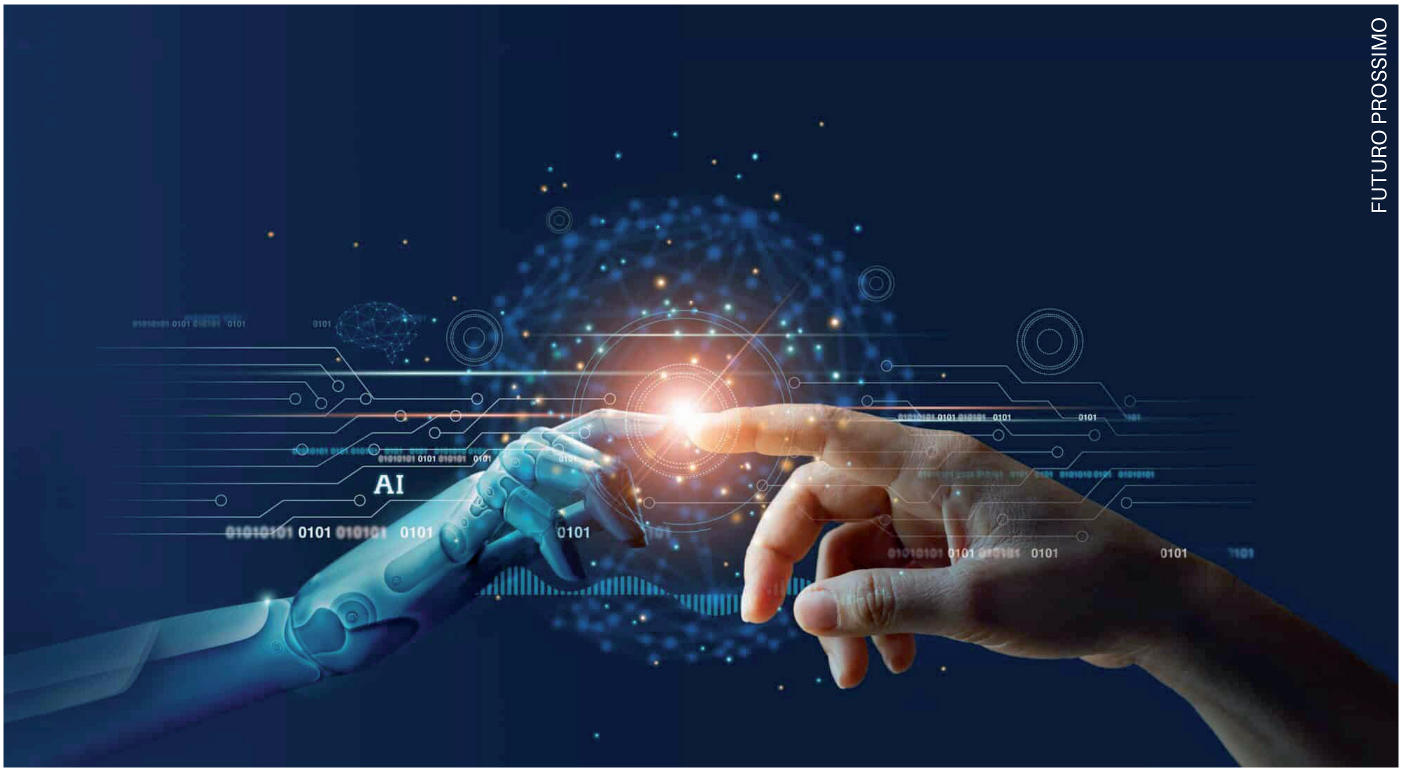
The Leonardo Times would like to thank Helin Data for taking the time to talk to us.

C&O

THE ROAD TO CERTIFICATION

Long and winding but flying by

Juan Avila Paez and James Perry, Leonardo Times Editors



AI can make mistakes. With such a high focus placed on safety within the civil aviation industry, how can regulatory bodies ever be satisfied? To find an answer, we must understand the causes of these mistakes and obstacles encountered on the journey of an AI system to certification for commercial use.

THE DOWNFALLS OF AI

The fundamental premise of a machine learning system often referred to as AI is that computer software develops its own neural network by responding to test data. If it responds correctly, the program will strengthen the process by which it arrived at that answer until the vast majority of answers given are suitable. In contrast to more standard software, no human writes instructions for an AI to follow, the result being we usually do not know how they reach their provided answer [1]. The direct consequence is that we can't check if this process is correct, or even if it makes any sense. However, assuming the answer is regularly good, we are generally satisfied. It works well for programs like art generators, where the consequence of a bad outcome isn't too severe. A certain number of mistakes are acceptable, and often occur, but have no significant consequence. For example, Microsoft's AI search engine, Bing, has been reported to call users delusional, express emotions such as sadness and provide scary responses such as, "I'm tired of being stuck in this chat box" [2]. The companies providing these websites may take measures to avoid such mishaps, such as the since-imposed five-message limit on Bing chats, but even then it is not always successful. Even when first released to the public, ChatGPT included safeguards to prevent the AI from making inappropriate comments. However, at the time of writing, it is possible to overcome these restrictions by asking the program to pretend that it was a different AI, to which the safeguards do not apply [3]! Similar failings and loopholes would surely not be appropriate for the aerospace industry, where lives may depend on the safe operation of an AI system.

One of the causes of this particular problem is that ChatGPT is a language model. It produces paragraphs aimed at mimicking what the user may expect in response based on the data it was trained on, not necessarily what they should be told or what the correct information actually is [1]. Although arguably unfortunate, this is by design – the software is simply making a trade-off between capability; the ability to respond effectively to a wide variety of tasks, and alignment; the optimization to perform a particular task well [1]. It often leads to a lack of helpfulness, biased outputs, and "hallucinations" (convinced incorrect responses). To minimize these problems, human feedback is included at many points in the training process. "Supervised fine-tuning" is the first step where the initial dataset used for training is created by human labelers, which is followed by human voting on the model's outputs to provide feedback. This creates comparison data, mapping input to the most favorable output, on which a new "reward model" is trained. This model is then used to provide feedback to the original model as it iterates on a dataset far larger than humans could reasonably supervise [1]. In this way, humans provide the foundation for the machine learning process, their judgment and biases are, to some extent, reflected in the final software.

There is hope that these issues may be eliminated entirely. IBM has several programs aimed at improving the trustworthiness of AI, often geared towards the use of "foundation models" – general-purpose models smaller businesses can build on. For example, these models can contain biases embedded in the data they were trained on, so may struggle to label a phrase such as "Islam means peace" as non-toxic if it is found during training that toxic phrases more commonly contained references to Islam than other religions [4]. The FairReprogram technique involves giving the model a small set of new prompts to teach it to avoid biases, the phrasing of which may seem unnatural to humans – "paul long course parish body" could be used to correct the previously described error [4]. In New York, researchers developed a framework called "TED", which enables machine learning models to explain their increasingly complex techniques, by including explanations of decisions in the original training data alongside each prompt and response. It is also hoped that such a system would allow biases to be more easily detected and was shown to improve the accuracy of simple decision-making such as playing tic-tac-toe [5].

CERTIFICATION IN AEROSPACE APPLICATIONS

The European Aviation Safety Agency (EASA) follows a four-step procedure to certify new aircraft. Firstly, the project is presented and the regulatory body then decides on the standards. The manufacturer then demonstrates compliance before finally receiving approval [7]. In this way, the EASA tailors the criteria to be tested to the individual case, making it difficult to predict exactly what approach will be taken. The current generation of autopilot software uses traditional algorithms, which differs significantly from AI as just discussed. It means its operation is reliable and predictable, except for hardware malfunctions or software errors from its human programming. AI has the potential to fix both of these issues, with its ability to deduce solutions to problems never previously encountered, but possibly at the expense of the total predictability currently enjoyed. Since the advent of autopilot, it has been possible to map out the system operation, identify logic errors and provide fixes as required. It is currently not something which can be done with AI, as the precise methods used by a trained system are currently always unknown.

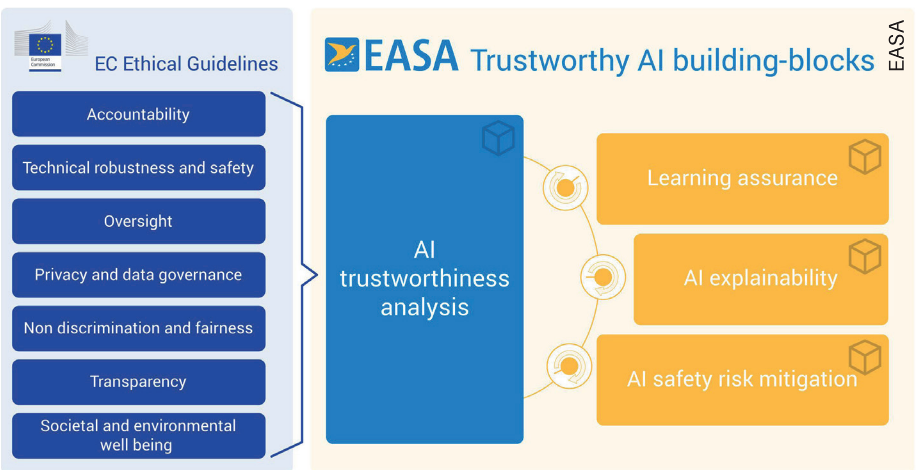
One application of AI which has come into use in a safety-critical environment is the "autopilot" function on some cars manufactured by Tesla. This is a machine learning system but has been certified in the USA for use as if it were any other lane-keeping software. Mark Roboff, chairman of SAE's AI in Aviation Committee, makes a comparison to how human pilots are certified, through check rides in which various flight situations are simulated and their reactions tested. It is not the examiner's concern exactly how the pilot's brain functions, only that they react quickly and safely to the situation at hand [6]. For software, this is called black-box testing – used in conjunction with white-box testing in which the flow of data through the program is also reviewed. As the latter stage is currently impossible for humans and is simply not carried out, why should it be of concern for AI?

There is also an argument to the contrary: of fatal commercial aviation accidents caused by human error, 20% were due to pilot fatigue [8], a problem from which an AI system should not suffer. This improvement almost goes without saying; it is simply expected from automation. The performance of AI systems is compared to current computer systems, not humans, and so requires more rigorous testing to be certified. With the eventual implementation of AI software, current levels of safety should not only be maintained but improved upon.

Ultimately, the nature of the aerospace industry means that we always strive for safety improvements. Approximately half of commercial aviation accidents have been attributed somehow to human error [8], but software is increasingly in the spotlight, as pilot interaction with automated systems in the flight deck is of growing importance. The infamous 737 MAX 8 crashes of Lion Airlines in 2018 and Ethiopian Airlines the next year were the culmination of many errors and oversights which could have been prevented if not for the poor interaction between the erroneous MCAS software and pilots [9]. No matter the difficulties, AI must be integrated to allow for safe interaction with the aircraft's human pilots.

EASA ROADMAP FOR AI

AI faces huge challenges in terms of certification for use in aviation, especially if our understanding of how trained models create outputs does not significantly improve. Therefore, the dream of something



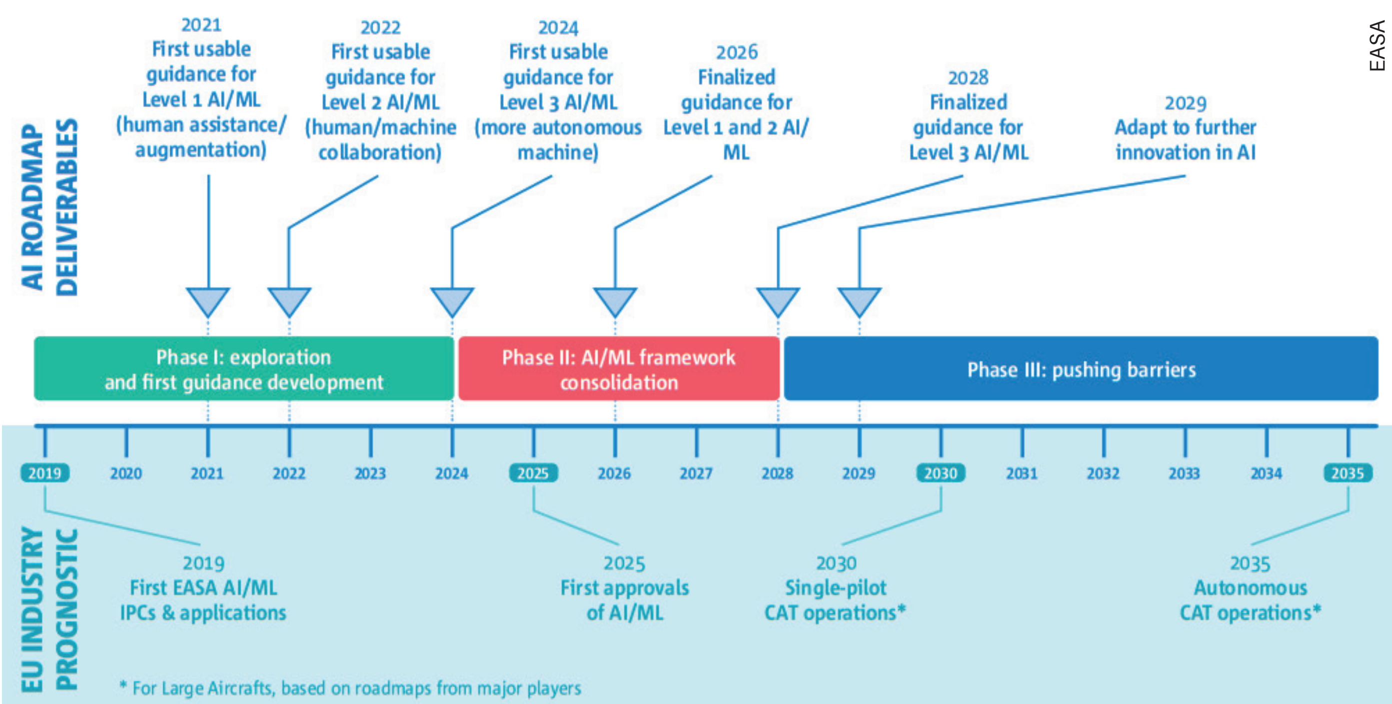
The EASA's AI building blocks themselves build off the European Commission's ethical guidelines like an autonomous flight on a large scale is still very distant. After all, we cannot trust a model with human lives if we do not fully comprehend how it would handle critical situations. Nonetheless, within the entire aviation industry, there are other areas in which AI would not be critical to safe operation, and we could start using it much earlier. In fact, we already do. To gain insight as to where and when AI could commence use in the aviation industry, one can look at EASA's "Artificial Intelligence Roadmap".

EASA released this report in February 2020, pointing out interesting areas of AI impact in aviation and the timeframe they expect implementation in commercial flight. To dissect this report, we start in one area already disrupted by the use of machine learning: aircraft production and maintenance. For the manufacturing side, machine learning algorithms process data from factories and optimize production for time and energy efficiency. As for maintenance, these algorithms are used for a task called "predictive maintenance". With the data provided by sensors on different aircraft components, computers can predict likely points of failure to deal with them pre-emptively [10]. These tasks are supervised by humans. Therefore, if the AI makes a mistake, human inspection could address it before it led to an unsafe situation during aircraft operations.

Applying machine learning to aircraft production and maintenance is fairly straightforward, provided checks are in place so that humans can inspect and judge the outputs of the models. However, EASA points to another area in which AI could become a future necessity: drones and urban air mobility. It is definitely a step up from the previously discussed areas as AI would be responsible for controlling manned flying vehicles. Even in unmanned drones, using AI could cause dangerous situations in urban environments with dense populations and, presumably, an increasingly higher amount of air traffic in the future. But, if we want cities where air transport for people and cargo is commonplace, machine learning may be the only solution. With such a high number of flying vehicles in a relatively small area during any given time, conventional air traffic control (ATC) is likely unfeasible. Therefore, even disregarding the issue of urban air mobility vehicles and drones flying autonomously, AI will almost inevitably be needed to control these urban air spaces [10].

Finally, we get to perhaps the most exciting application of AI in aviation as highlighted by EASA: automated commercial flights and ATC. It would truly be the apex of AI in aviation, essentially putting the lives of the millions of people who fly around the world each day at the mercy of a computer algorithm. Even then, a transition from our current systems to complete automation is extremely unlikely. Over the years, we will see a gradual transition to fully automated systems, in which increasingly more tasks will be delegated to machines, with humans taking a step back. EASA lays out this timeline in detail, dividing the transition into three main phases: Exploration and first guidance development (Phase I), AI/ML framework consolidation (Phase II), and pushing barriers (Phase III) [10].

At the time of writing this article, we find ourselves at a late stage of Phase I (2019-2024). In this phase, AI reaches an experimental level of application in which it can either perform functions under human supervision or supervise the functions humans perform



The EASA's roadmap for AI certification

during aircraft operation [10]. It is called "Level 2" by EASA. In Phase II (2024-2028), the first AI implementations for autonomous operations are created, reaching "Level 3", and the previous levels of AI applications are refined for certification. Finally, in Phase III (2028-2035), level 3 AI applications are ready for certification, expected to allow for single-pilot commercial flights in 2030 and fully-autonomous commercial air transport (CAT) operations by 2035.

BEYOND CERTIFICATION

When examining possible AI introduction into aviation, we must think about the human component of the problem. That is, even though all the technology may be certified for use, resistance from pilots, air traffic controllers, and, most significantly, passengers could be a significant obstacle to introducing this technology to commercial air transport.

In this sector, airline companies are likely to desire the transition to autonomous flight as soon as it is safely possible to do so. The introduction of AI into commercial aircraft operations will gradually reduce the salary costs for these stakeholders, as it requires fewer personnel (especially pilots). Aircraft manufacturers will also relish this transition as soon as possible, given that AI will likely unlock a new level of performance enhancements for their aircraft. However, as this would come at the expense of human pilots, resistance from pilot unions is likely [11]. And, even though airline companies might not need them in the future, pilots still hold leverage over them, slowing down the AI implementation in commercial aviation.

Furthermore, passenger concern about the decreasingly important job of humans in the cockpit is anticipated. Despite aviation's safety track record, ensuring any AI technology introduced to an aircraft system is redundantly safe, passengers might be hesitant to fly on these aircraft. We do not need to look any further than the previous example of the 737 MAX, an aircraft which many travelers are still wary of boarding, despite its recertification by all major aviation safety agencies [12]. When polled if they would board an autonomous commercial flight, most travelers said no [11]. Therefore, although AI will replace humans in the cockpit at some point in the future, it will definitely not be a smooth transition.

CONCLUSION

All in all, AI will likely revolutionize aviation in terms of efficiency, sustainability, and convenience. It will also allow for greater adoption of air vehicles in novel areas such as using drones for cargo transport and urban air mobility. Nonetheless, we must keep the limitations of our AI knowledge in mind; no performance improvements should come at the cost of safety, and regulators should always be guided by this principle. With that in mind, there is still a long road ahead for this technology, but with each coming year we will get closer to unlocking its full potential.

AUTONOMOUS DRONE RACING

Unleashing the Power of Autonomy: The Revolutionary Technology Behind Autonomous Drone Racing

Muhammad Arham Elahi, Leonardo Times Editor

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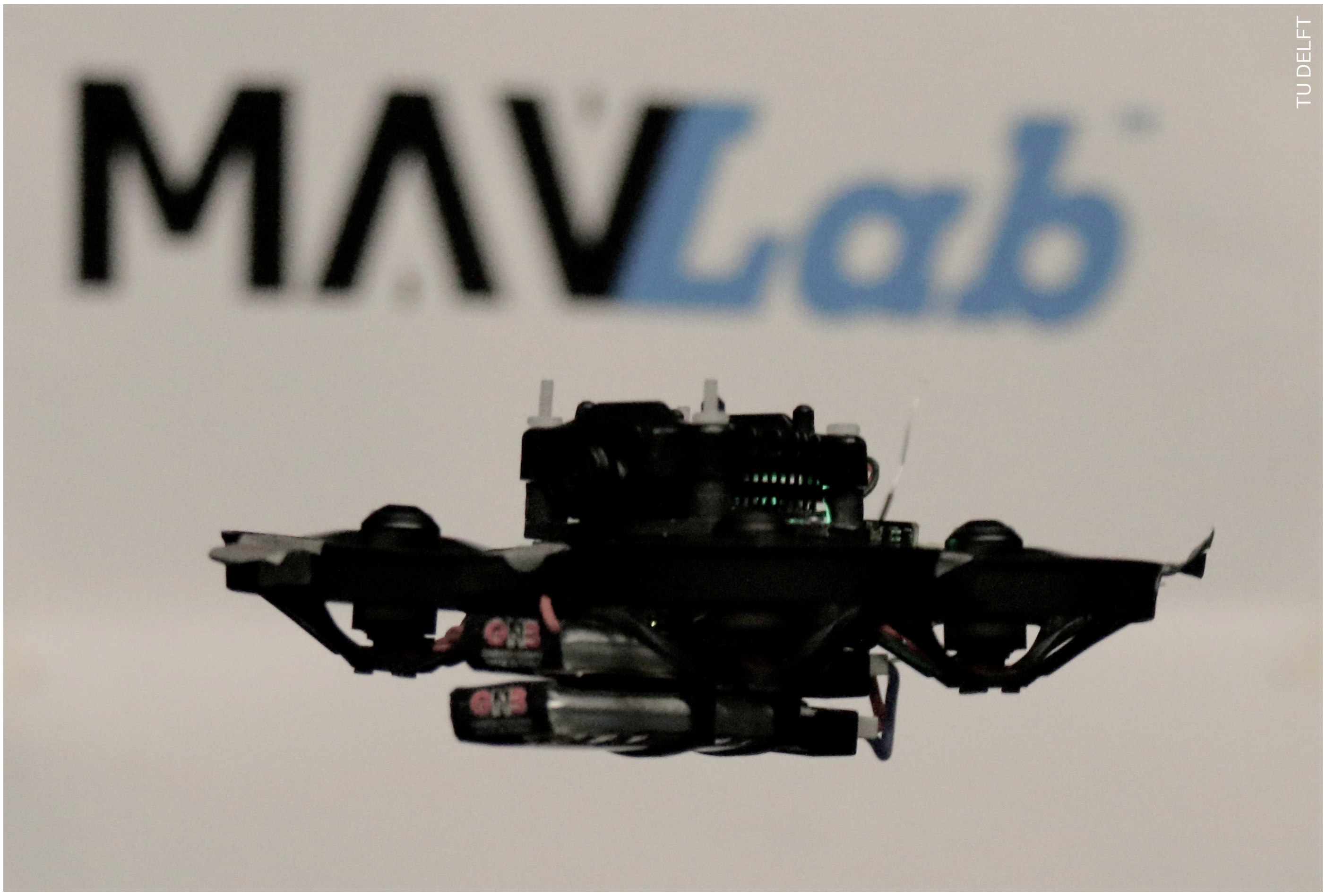


TU DELFT

Autonomous drone racing is an emerging sport combining the thrill of high-speed racing with cutting-edge technology. In this exciting new field, drones equipped with AI algorithms compete against each other in complex obstacle courses, showcasing the latest autonomous flight technology abilities.

BACKGROUND

With the rise of modern technology, several new sports have emerged, including drone racing. It started in Germany around 2011 and has gained significant traction since, with the Drone Racing League (DRL) raising more than 30 million dollars in funding [1]. The sport involves human pilots using a First Person View (FPV) to navigate the drone through obstacle courses as quickly as possible. The FPV is obtained from cameras installed in the drone which are coupled to head-mounted displays for the pilots. The drones used in these races are built for speed and agility, in contrast to photography drones that are built for hovering and stability. A typical photography drone consists of 4 propellers equally spaced apart and arranged in an X pattern. Racing drones, on the other hand, prefer the propellers in an H pattern, allowing them to thrust forward instead of upward. Typically, they have shorter, faster-spinning blades for quick maneuverability. Recently, the sport has taken on a new shape - autonomous drone racing, which combines the thrill of high-speed racing with state-of-the-art deep learning models to an impressive effect.

The significance of autonomous drone racing is not just competition; in fact, that is a minor part of the overall picture. It can gauge the accurate autonomous agile flight progress by micro air vehicles. This research extends to applications worldwide, as autonomous drones are already used in many industries for inspection as well as for executing menial tasks. However, the lack of endurance and mobility is the biggest limiting factor for further application and increasing efficiency. [2]

Several competitions with over a million dollars of prize money have been set up to offer incentives to researchers and entrepreneurs. These include DARPA's Fast Lightweight Autonomy (FLA), European Research Council's AgileFlight, and Lockheed Martin's AlphaPilot challenge. These competitions allowed for the comparison and testing of several methodologies and initiated a wave of tremendous progress in the sector. This can be visualized in Figure 1.

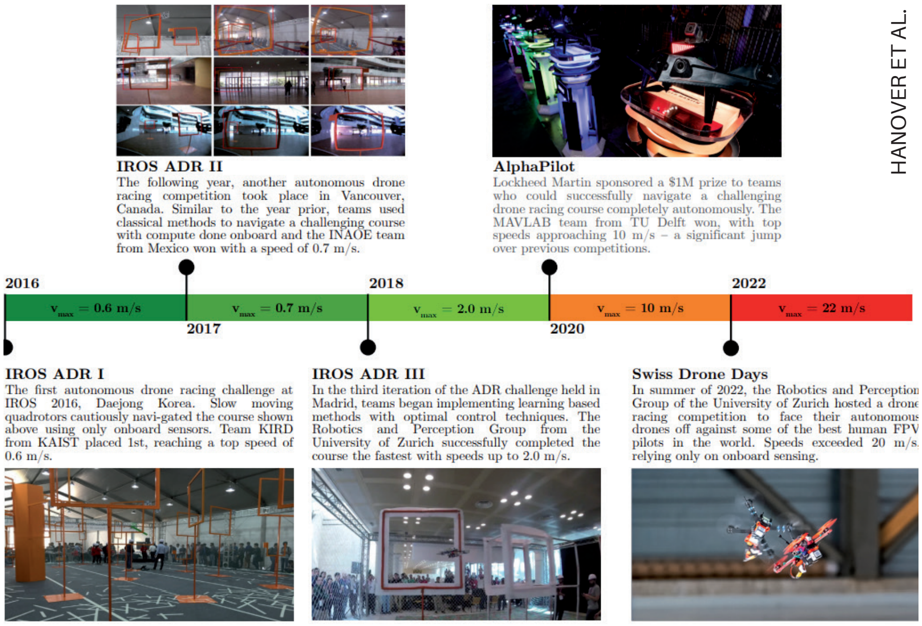


figure 1: The progress of autonomous drone racing over the last decade

HISTORY

In 2016, 11 teams participated in the Autonomous Drone Racing (ADR) competition held at the IROS conference. They had to navigate a series of gates. Most teams took a very cautious approach, the winning team KAIST making it through 10 of the 26-gate course in 1 minute 26 seconds. The next year, a similar competition took place, the winning team, INAOE taking over 3 minutes to make it through the 13-gate course. In 2019, The Lockheed Martin Alphapilot AI Drone Racing Innovation Challenge took place, where the winner MAVLAB took 11 seconds to complete the track, in 2nd place University of Zurich's Robots and Perception Group (UZHRPG) took 15 seconds. For reference, a human pilot could complete the track in 6 seconds. In 2022, the Swiss Drone Days event in Zurich, Switzerland pitted three of the best human pilots against autonomous drones. This event demonstrated that drones keep up with human pilots, and with an offboard motion capture system, they can even beat them handily. With the motion capture system, the drone could reach speeds of over 100 kph, while without it, it could still go up to 80 kph. Over the three-lap race, the drone outraced the fastest human by 0.5 seconds, the first time drones have beaten humans. [2][3]

TECHNOLOGY

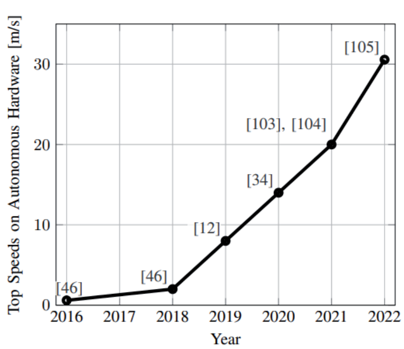
The drones use monocular or stereo cameras combined with inertial measurement units (IMUs), ideal due to their low cost and weight combined with their mechanical robustness. The velocity is calculated using the relative readings between different sensors to estimate the drone's motion as well as any moving objects alongside it. These sensors must be calibrated before operation due to the large amount of noise generated, hindering accurate measurements. The noise source can be attributed to high-frequency vibrations induced by the propellers. In addition to skewing the IMUs, this can blur the camera image, causing difficulties for the neural network to identify targets. Therefore, a suitable damping mechanism is required to mitigate the vibration effects Another issue to consider is that the ondboard cameras have a limited field of view, and drones often have to estimate the position and keep track of objects not directly visible.[2]

Another method to track objects in space is to use an offboard motion capture system, allowing a computer at a nearby desk to send real-time high-resolution images to the drone. Thus, the drone knows its precise position, the position of any obstacles, and the exact targets during the entire flight, to plan an optimal trajectory at maximal speed. It skyrockets the drone performance to over 30 meters per second. This is a truly outstanding figure, however, the test condition is very impractical: ideally, a drone should operate solely with its onboard computer since a motion capture significantly limits the drone operation and as increases its cost.

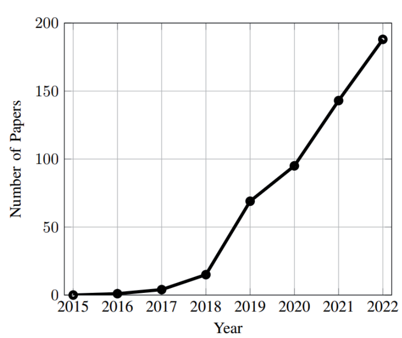
FUTURE

The interest in research for autonomous drones is only increasing and numerous areas still require further research. The drones still struggle to keep track of their surroundings when used at high speeds. This is due to a combination of errors from motion blur, low texture, and high dynamic range that accumulate to cause significant localization errors. They also need a large influx of data for control, using only visual cues for control (like humans do) will likely significantly decrease the power requirements and manufacturing cost. Current perception algorithms are incapable of solely controlling the drone, but the rate AI technology is advancing, it might not be long before it becomes a possible reality. Drones cannot predict a foreign object's movement (for e.g. another drone) like a human can, a huge pitfall when drones operate in high density for industrial purposes. They need to learn to maneuver out of any potential impact. [2]

Although autonomous drone racing is an eye-catching spectacle, it is important to remember that it is a benchmark, not the end goal. There are several real-world applications that would greatly benefit from autonomous drones. Search and rescue, inspection, agriculture, videography, delivery, passenger air vehicles, law enforcement, and defense, to name a few. To make them applicable for these purposes, work is required to make drones more reliable and safer to comply with certification standards. The drones also need to operate in any general environment rather than a controlled lab. Racing algorithms also take too long to find an optimal route, making them unsuitable for emergency deployment. Therefore, research is necessary to make more practical algorithms suited towards particular niches.



Autonomous Drone Racing: A Survey



Autonomous Drone Racing: A Survey

CONCLUSION

In conclusion, autonomous drone research is in its infancy, yet has made massive strides. There are still multiple areas of improvement, but with the rising interest in its development and potential for its application in numerous fields, it's only a matter of time before autonomous drones integrate with core aspects of society.

EVERYONE CALLS SHOTGUN!

An overview of the past, present, and future of autonomous vehicles

Chaitanya Dongre and Tuomas Simula, Leonardo Times Editors

DLLU

A decade ago, major car manufacturers started to announce plans to launch autonomous vehicles. Many tech companies emerged with promising applications such as autonomous shuttles, delivery vehicles, and "robotaxis." In 2023, there are still no truly autonomous cars available for consumers. In this article, we look into the recent history of self-driving cars, and their future.

HISTORY OF AUTONOMOUS CARS

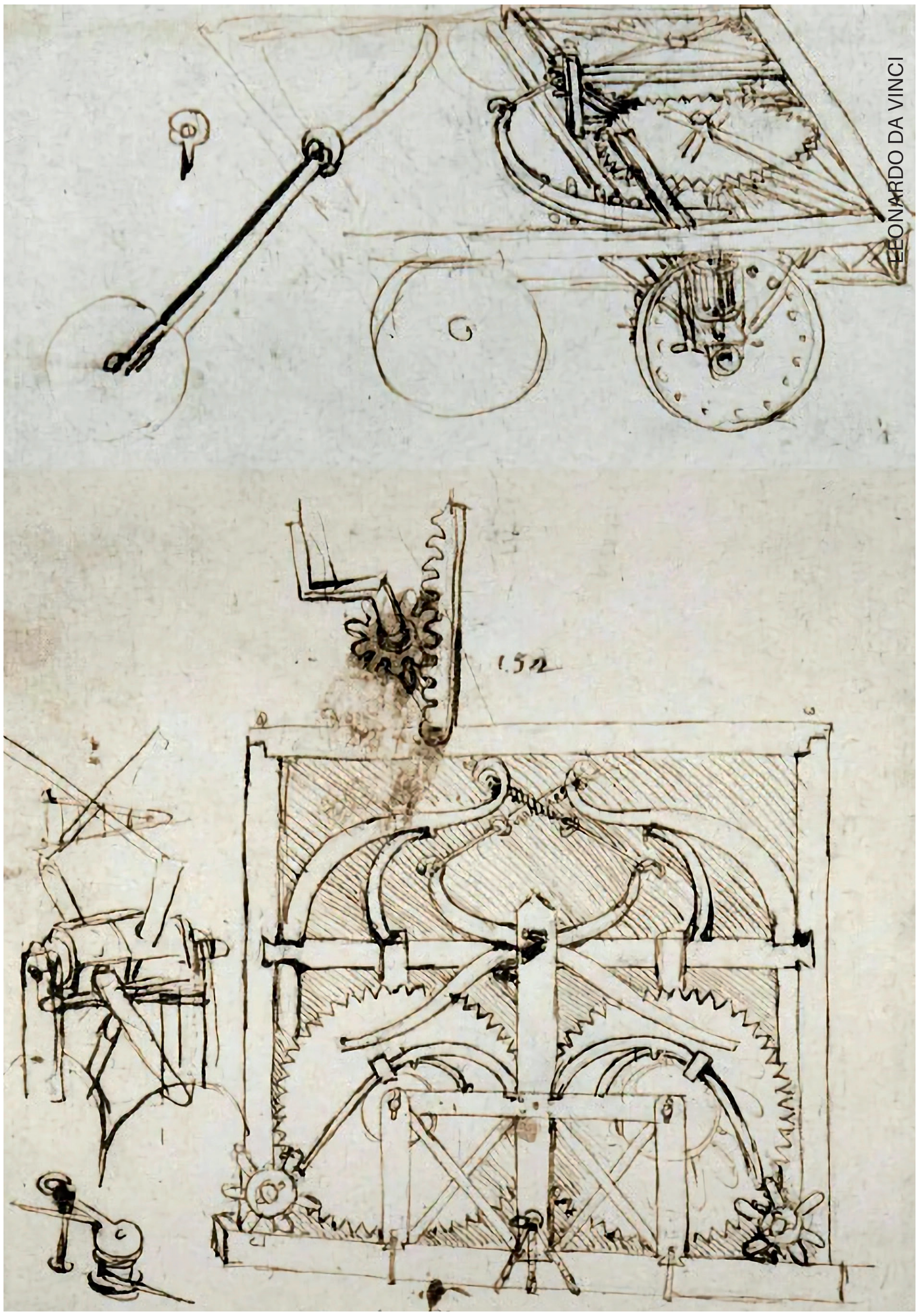
Autonomy in automobiles has been long sought after and will continue to capture the public imagination until it becomes reality and autonomous vehicles are commercially available. There has been a long-standing race amongst big automotive companies and research institutions, all competing to be forerunners of the potential to change societal views and uses of transportation. It is interesting to see the progress in innovation relating to this once seemingly impossible quest.

The first idea for an autonomous car came way before the first car itself; a puzzling fact. In the late 1400s, Leonardo da Vinci designed a cart that could move without being pushed or pulled. He could do so by using springs under high tension to provide power, while the steering was set in advance so the cart could move along the predetermined path. This, in addition to a mechanical knight that could sit, stand, and independently maneuver its arms, was famously called Leonardo's robot.

In the 1900s, electrical engineer Francis Houdina developed a radio-operated automobile. He demonstrated this in the streets of Manhattan. The car could start the engine, shift gears, and blow the horn independently. This vision of the future of autonomy was short-lived as the operator lost control of the car and crashed into another vehicle. However, this did not deter the industry from continuing to work towards the possibility of self-driving cars.

At the 1939 World's Fair in New York, General Motors exhibited an early depiction of automated guided vehicles. This car was radio-controlled and propelled by electromagnetic fields formed by circuits embedded in the roadway. This became a reality in 1958. At the peak of the space race in 1961, researchers looked into ways to land vehicles on the moon. Consequently, James Adams created the Stanford Cart, fitted with cameras and programmed to autonomously detect and follow a line on the ground. It was the first use of cameras for autonomy and is a vital element in such cars today.

The next improvement came from the Japanese, who improved on this idea with a camera system that sent data to a com-



Leonardo da Vinci's drawing of his self-driving cart

puter and processed images of the road. It, in turn, led to the testing of the world's first self-driving car which could reach speeds of up to 32 kilometers per hour. By the 1990s, Carnegie Mellon University began building self-driving cars. They integrated neural networks into image processing and steering controls. In 1995, their car, NavLab 5, completed a 4500 kilometers ride from Pittsburgh to San Diego. Their only two controls were speed and brakes, the rest of the car was autonomous.

By the 2000s, the self-driving car industry was booming. In 2004, the Defense Advanced Research Projects Agency (DARPA) of the US Department of Defense hosted the DARPA Grand Challenge for autonomous vehicles. The vehicles had to self-navigate 240 kilometers on desert roads. However, no cars completed the route. Later in 2007, the amended challenge simulated a 96- kilometer-long urban environment - four cars completed this route [1].

Meanwhile, the first-ever driverless vehicle to transport the general public was introduced in none other than the Netherlands in 1999. The ParkShuttle, an electrically-driven autonomous shuttle, runs between Kralingse Zoom metro station in Rotterdam to Rivium business park in Capelle aan den IJssel. It is owned by the Rotterdam-The Hague Metropolitan area(MRDH) and operated by the bus company Connexxion. The system is a hybrid between a personal rapid transit and an automated people mover. The shuttle works like a horizontal elevator and can be manually called at the stop. The vehicles are fully autonomous and their positions are checked based on artificial reference points in the form of small magnets on the road surface.

There have been three generations of the shuttle service, the first two being unidirectional with front-wheel steering and reverse direction at turning loops at both ends of the route. As of 2018, ParkShuttle was the only operational automated road vehicle in Europe that provided a permanent revenue-generating service. It was also trialed at Brussels Airport and at Nanyang Technological University in Singapore in 2019. In November 2022, the new third generation of shuttles was introduced and made operational. There are currently six shuttles in service covering a route of 1.8 kilometers. These third-generation shuttles are lighter, can drive bidirectionally, and have air conditioning. There is a charging station at the Kralingse Zoom metro station where the shuttles are charged daily [2].

SAE LEVELS OF SELF-DRIVING

SAE International is a global association founded in 1905. It was formerly known as the Society of Automotive Engineers and is at the forefront of connecting and educating mobility professionals to enable safer, cleaner and more accessible mobility solutions [3]. To understand the levels of automation, it is imperative to understand what the SAE levels of automation mean. The SAE classification is a system with six levels ranging from manual to fully automated systems. This classification, published in 2014, is based on the degree of driver intervention and attentiveness required. There is less focus on the vehicle's capabilities even though the two interrelate. This standard has certain limitations but is still widely used and accepted. In SAE's levels, the driving mode defines a driving scenario with a characteristic dynamic driving task requirement. There are six levels, namely:

- Level 0 - The automated system issues warnings and may intervene momentarily but has no sustained control over the vehicle.

- Level 1 (hands-on) - The driver and the vehicle both have control. There's a combination of the controls in how this works. The driver controls the steering and the automated system controls the cruise speed by maintaining engine power or brake power. The driver must be ready to take control of the vehicle at any point. Automatic emergency braking alerting the driver before a potential crash, permitting total braking capacity is also a level one feature.

- Level 2 (hands-off) - The automated system takes total control of the vehicle including accelerating, braking, and steering. The driver needs to monitor the driving and be ready to intervene at any time if the automated systems fail to respond effectively. The contact between hand and wheel is often mandatory during the SAE 2 level as the system needs confirmation that the driver is ready to intervene. The actual hands-off driving is considered level 2.5, though there are no official half-levels. A camera may monitor the driver's eyes to ensure attentiveness towards traffic. An example is adaptive cruise control which also uses lane-keeping assist technology.

- Level 3 (eyes off) - The driver can turn their attention away from the driving tasks and can follow activities like watching a movie and messaging. The vehicle will handle immediate responses such as emergency braking. The driver must remain on standby and when alerted by the car, intervene within a specific time determined by the manufacturer. An example of this level is a traffic jam chauffeur, a car satisfying the international Automated Lane Keeping Systems (ALKS) regulations.

- Level 4 (mind off) - This is the same as level 3. But here, no driver intervention is required and the driver may go to sleep or leave the driver's seat. However, this is only supported in limited areas with geo-fencing or under special circumstances. Outside these areas, the vehicle must be capable of safely aborting the trip. It includes slowing down and parking the car if the driver does not retake control. Automated valet parking is an example of this level.

- Level 5 (steering wheel optional) - There is no human intervention required. An example is a robotic vehicle that works on all kinds of surfaces, in all different conditions all year round.

The limitations of SAE levels are that it does not account for the changes necessary in infrastructure and driving behavior. They have been criticized for their sole focus on technology and for suggesting that automation increases linearly and more automation means a better system, which is not always the case [4].

CURRENT DEVELOPMENTS

In the first half of the last decade, interest in autonomous cars rose sharply. In 2014, Tesla announced its plans to develop an "autopilot" for their cars within three years, and soon most big players in the automotive industry followed suit. It was certainly not the first time major car manufacturers looked into the possibility of autonomous cars, but it was the first time they presented concrete estimates of when they estimated to bring such products onto the market.

Of course, these estimates were extremely optimistic. It seemed quite unlikely that Tesla, a company that had barely sold its first mass-produced vehicle, would in three years produce something that most of the industry wasn't seriously even considering at the time. But, they'd already introduced something the big companies hadn't yet seen: a mass-produced fully electric vehicle. And they were selling as many as they could manufacture.

Thus, the big players in the industry started working on their ambitious goals. In 2015, Toyota, previously very skeptical of autonomous technology, announced a billion-dollar investment in research into AI and robotics. The investment goal was to have products based on the experimental Highway Teammate platform ready by the Tokyo Olympics in 2020, but the announcement was ambiguous about the expected level of autonomy. Meanwhile, Honda also made big promises for the Olympics: partnering with Waymo, a company originating from a Google project, to produce cars capable of driving autonomously on highways by 2020 [5].

European and American manufacturers were close at hand to their Japanese competitors. There were many collaborative projects between large car manufacturers and modern tech companies, with hundreds of millions or billions of dollars invested into the joint ventures. Renault partnered with Microsoft and Volvo with Uber. Perhaps the most ambitiouproject was in 2017, when Daimler partnered with Bosch with the goal to bring level 5 cars to cities

The ParkShuttle autonomous bus transports people between a few stops in the east of Rotterdam

A Google driverless car prototype on a test course

"by the beginning of the next decade." Also in 2017, Ford invested a billion dollars into Argo AI, and in 2020 Volkswagen joined with an even larger investment of 2.6 billion. Two years later, the company was disbanded and its property and employees split between the two major investors.

For a while, it seemed like the 2020s could be the decade of the driverless car. At the time of writing this article, there are barely any cars capable of autonomy beyond Level 1. Some manufacturers offer "autopilot" as an expensive optional feature. Practically, all of these, including the misleadingly named Tesla Full Self-Driving, are Level 2 at best, and many of them only work on select roads such as highways. There are also some Level 3 cars available, but they are extremely limited by legislation and only work in very specific conditions. For example, in 2021, Honda produced a limited run of 100 cars of its Legend model with the Level 3 Sensing Elite technology, only available for lease in Japan. With the system enabled, Honda claims that the driver could watch TV while stuck in slow traffic, which is the only situation where the system can be activated [6]. Two years earlier, Audi sold the A8 model with a similar Traffic Jam Pilot system fully equipped but not activated. But in 2020 the conclusion was that the system would remain deactivated, as even such a simple system was legally too difficult [7]. In January 2023, Mercedes-Bentz started offering its Drive Pilot on some 2024 models in the state of Nevada, becoming the first legal Level 3 system in the United States. This system too, is only usable in congested traffic on highways [8].

Besides the limited Level 2 and 3 models currently available, there actually are some Level 4 autonomous cars being tested in traffic. However, they are all experimental one-off models, such as the prototypes of British company Oxbotica, only permitted to operate in very specific areas under strict conditions. No true level 5 vehicles exist on public roads at the time of writing this article.

FUTURE OF AUTONOMOUS CARS

In 2022, research conducted by the safety charity Lloyd's Register Foundation found that only a meager 27% of the world's population would feel safe in self-driving cars. However, a brief analysis of the crashes involving these cars shows that most accidents occur by another driver being distracted, a strong case for the benefit of self-driving cars. The increasingly important issue is the regulation of self-driving cars. It includes multiple concerns such as car liabilities, and regulations concerning the approval of these cars, along with international conventions. In 2020, an international regulation was established, specifically outlining level 3 automated driving making approval of such a level of a self-driving car very difficult.

It will be a while before we achieve full automation levels, and developing the technology and infrastructure will take time. It is likely that the vehicles will have increasing levels of automation. Currently, Tesla vehicles contain hardware that claims to allow fully self-driving capability in the future. This full self-driving is still only level 2 on the SAE scale. In late 2022, Honda announced that it would enhance its level 3 technology to function at speeds below legal limits on highways by 2029. In January 2023, Holon, a new brand from the Benteler Group, revealed its self-driving shuttle during the Consumer Electronics Show in Las Vegas. They claim their vehicle is the world's first Level 4 shuttle built to an automotive standard. U.S. Production of this car is due to start at the end of 2025. These are only a few of the multitude of claims made by companies worldwide.

Even after facing setbacks postponing autonomous vehicle launches and delayed customer adoption, the mobility community still broadly agrees that autonomous driving has the potential to transform transportation and society as a whole. It could make driving safer, more enjoyable, and more convenient. The growing adoption of advanced driver-assistance systems (ADAS) in Europe could reduce the number of accidents by 30%. It could also improve mobility for senior citizens, providing them with an option going beyond public transport. Growing demands for driverless control have the prospects of generating billions of Euros in revenue. Customers buying self-driving cars would avoid paying high insurance premiums, as autonomy would mean they are no longer liable for accidents [9].

CONCLUSION

With the costs for sensors and high-performance computers decreasing, newer regulations advocating for advanced driver assistance capabilities, and the increasing societal trust for newer technologies, the future of self-driving cars looks promising!

NAVIGATING THE SKIES

The Benefits and Challenges of Automation in Air Traffic Control

Marcos Talocchi, Leonardo Times Editor


BULOVAK

Automation, AI and machine learning are all hot topics right now: they are being talked about everywhere you look. But how do those themes fare in one of the most conservative and stubborn-to-change industries in the world, the aviation sector?

Since the advent of commercial aviation in the last century, air traffic volume has considerably increased worldwide and continues to do so. The growing number of aircraft flying demands an increasing number of Air Traffic Control (ATC) operations to be performed. However, a barrier is presented to operation centers all around the world: training new Air Traffic Controllers (ATCOs) is slow and currently the global demand is not satisfied. Annually, approximately 6,740 air traffic controllers are trained globally, while the demand for new controllers stands at 8,700 per year [1]. Therefore, more than ever, automation and more effective management techniques are necessary for safe and efficient operations in the upcoming years.

CURRENT AUTOMATION LEVEL

As of today, the automation level of ATC greatly varies between different centers around the globe. The current technologies involve weather conditions mapping, advanced collision detection and increased visibility for ATC towers in airports. The latter is implemented for example in the UK's London City Airport through remote digital towers that provide automated collision alerts for the operators when combined with the conventional radar systems [2]. The system works by independently reconstructing the runway and the planes on it through the towers' cameras and microphones, aiding the ATCOs when faced with harsh weather conditions.

Another use of automation in airports is the implementation of time-based separation techniques instead of space-based ones. This is done through the automated radar system performing a time integration of different aircraft based on their speed vectors, and thus more effectively calculating the clearance required. In 2015, London Heathrow Airport, one of the busiest in the world, implemented the technology and increased the number of landings per hour, particularly during high headwind situations. Next to the reduction of waiting times for passengers and fewer delays, this implementation has environmental (and economical) benefits. Aircraft can spend less time waiting with their engines on, because the controllers are able to make more accurate predictions on when a runway will be clear [2].

Outside airports, the Extended Computer Display System (ECDS) in the UK offers a way for controllers to automatically move the aircraft between airspaces in the digital environment, where all the aircraft's information is readily stored. The process previously required operators to make phone calls, but now this burden is eased, reducing their workload and stress, resulting in a more efficient system.

In the United States, similar systems are being implemented as well, such as Standard Terminal Automation and Replacement System (STARS) and En Route Automation Modernization (ERAM). STARS tracks all air traffic within a certain area of airspace while ERAM uses incoming flight and surveillance data to generate display data to the ATCO. Through the use of 4D trajectory predictions, the systems remind operators of the outcomes and reduce their workload by performing the difficult and intense task of trajectory calculation. Therefore, it's not a fully automated system, but rather a guiding tool that still leaves the human with the final decision and responsibility [3].

NEED FOR AUTOMATION

Over the next two decades, ATC operations are expected to grow 1.9% a year, resulting in an increase in workload and stress in the sector that could be detrimental to traffic safety [4]. Combined with expected staff shortages in the near future, the need for new and elaborated automation technologies is evident to ensure that traffic stays smooth and safe.

Furthermore, with an ever-increasing importance being placed on mitigating climate change and emission of greenhouse gasses, the aviation industry is viewed as one of the main antagonists in the global scenario. The automotive industry makes a push for development of electric vehicles and the energy sector diversifies the clean energy options, yet hydrogen or electric powered aircraft still seem distant. Thus, the only current alternative lies in increasing efficiency of the already existing fossil fuel ones. Good news is, one approach can already be implemented without the need of refitting existing models or completely reinventing the plane.

Although not as fancy as a hydrogen powered plane or as cool looking as the Flying V, highly-developed algorithms for optimal pathing can still lead to huge CO_2 emission savings in the long term. In the UK, the three-dimensional insight, or 3Di, is a metric used to determine the performance of an aircraft's flight profile compared to its most efficient one in terms of fuel savings. The 3D comes from its uniqueness in measuring both horizontal and vertical performance alike. In the past decade, it has enabled 6.86 metric tons of CO_2 savings in the United Kingdom, and the metric has been available to aviation stakeholders around the world for free since 2021 [5].

Lifting the burden from humans in the future is also a reason for automation in ATC. The field is notorious for the high stress situations it puts workers in, with the safety of thousands of people lying in their hands. Workloads and fatigue rates are high, and so any aid for ATCOs is welcome and justifies implementing automation solutions in the sector.

CHALLENGES WITH AUTOMATION

However promising all the new technologies may look, there are still challenges that must be overcome. Balancing trust between the human and the machine is one of them. Too much trust from the operator can lead to complacency and lack of discipline, more colloquially the out-of-the-loop (OOTL) phenomena, potentially leading to conflicts in case the machine doesn't perform as intended. On the other hand, under-trusting the automation is also counterproductive: it results in the controller having a heavier workload due to double-checking the operations, measurements and calculations made by the computer since they don't trust them to be correct. A healthy middle ground where the human trusts the algorithm to be accurate while also being attentive to a potential malfunction is the ideal scenario, where both sides work together to complement one another.

Another potential issue is the existence of out-of-the-loop (OOTL) phenomena with controllers. These may arise when overtrust is held by the human in regards to the system, making them lose concentration in their job and have little situational awareness of the environment. By not performing the menial tasks they are used to and thinking the automation is flawless, conflicts may arise when failure occurs and the controller is unable to reassess and recover the scenario because they were, simply put, alienated from their job [6].

Last but not least, no computer is flawless and there is always the possibility that it will fail. Be it a bug, an instrumental error or network crash, if the lives of thousands of people are to be trusted to automated computers, a form of backup or supervision is necessary. Even a fully automated operations center will need humans supervising at the top level, ready to take control if a malfunction occurs, as safety can never be prioritized enough in the aviation industry.


NATS - UK AIR TRAFFIC CONTROL

London Heathrow Air Traffic Control Tower.

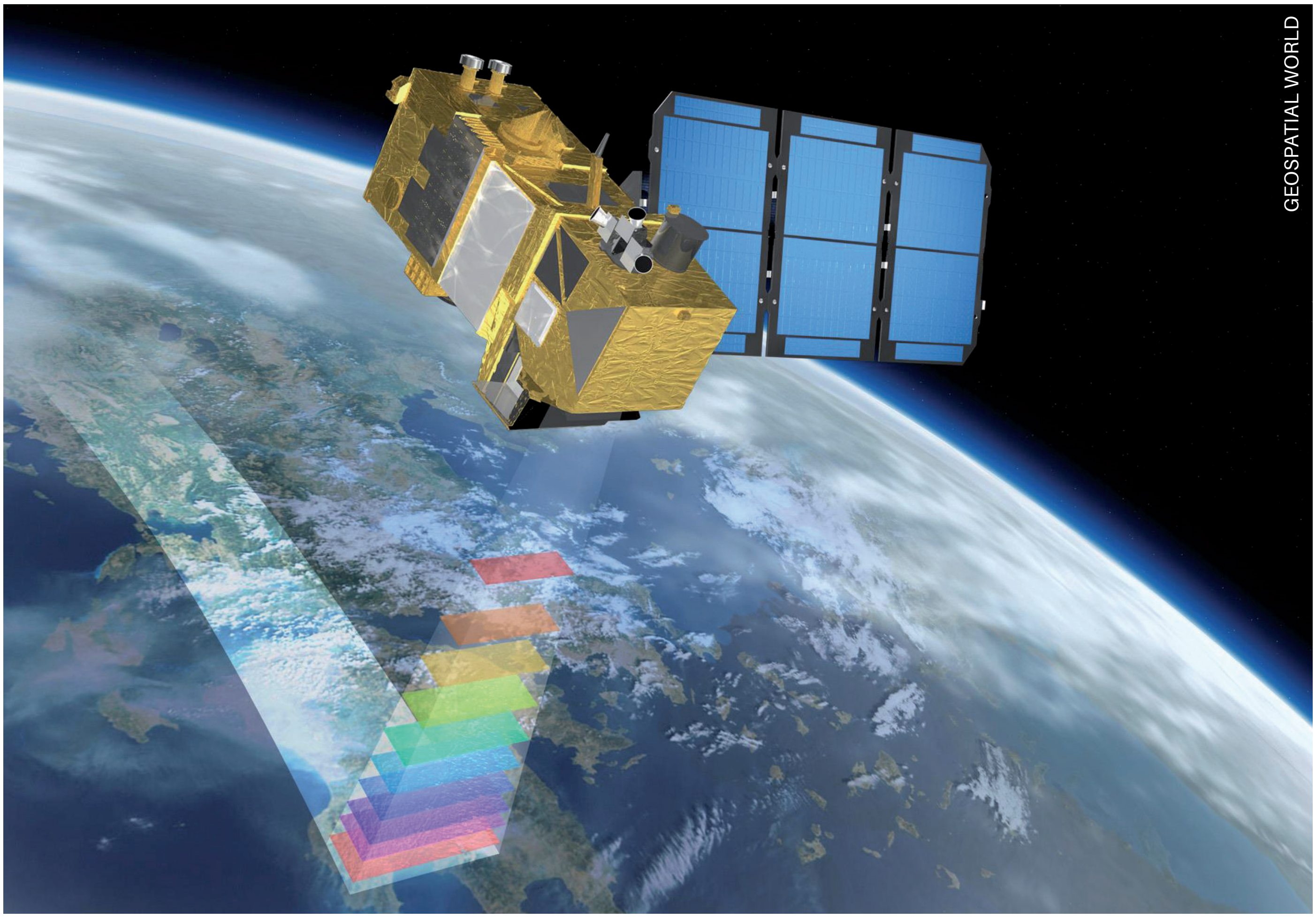
CONCLUSION

The future of AI and further implementation in ATC has come knocking at the door. The construction of more advanced sensor towers and radars will lead to more accurate data, and the increasing data flow will lead to better optimization algorithms. The systems will be more fuel efficient, the wait times for flights will be shorter, the ATC sector will be more organized and flying will be safer. Once the challenges regarding human-machine integration and the safety standards are overcome, air traffic management will be at its most powerful ever.

AI IN THE SKY

How remote sensing and artificial intelligence are helping uncover hidden details of our planet, allowing us to see the unseen

Varun Gottumukkala, Leonardo Times Editor


GEOSPATIAL WORLD

The Earth is dynamic. Sea levels rise, forests disappear, and ground surfaces rupture. Many of these phenomena significantly impact our lives. Gaining a better understanding of these processes can help us tackle important challenges. Data collected by remote-sensing satellites play an increasingly important role in understanding the natural and artificial dynamics of our ever-changing planet.

The first satellite launched into orbit around the Earth, Sputnik 1, was used to gather data about the density of the upper atmosphere. Now, there are nearly a thousand satellites orbiting around the Earth, collecting various kinds of data. Before a satellite can collect data over a specific region of the Earth, it must first find itself over that region. Earth-observation satellite orbits are precisely determined based on the mission - the kind of data gathered, the geographical location and the frequency of the satellite's passes. Satellites in polar orbits, for example, orbit from pole to pole while the Earth rotates underneath, enabling them to collect data over the entire globe. Satellites orbit at several angles and altitudes, moving at varying speeds relative to the Earth's surface. Satellite orbits are also designed to take advantage of natural phenomena, such as Earth's gravitational field, to obtain specific orbits without refuelling, but that is a topic for another time [1] [3] [9].

Satellites beam down about 150 terabytes of data daily, a number which is certain to grow in the future. It is extremely time-consuming, and sometimes impossible for humans to sift through this data and identify details and patterns. That is where artificial intelligence can lend a hand. Machine learning algorithms can efficiently analyse and interpret data collected by sensors on remote sensing satellites. But first, what is remote sensing [6]?

OBSERVING FROM A DISTANCE

Before looking into how we can apply machine learning to satellite data, it is important to understand what the data is and how it is collected. To measure the physical properties of any object in nature, we must be close to it. However, remote sensing satellites measure these properties from a distance. This is particularly advantageous when observing a large number of objects that would be impossible to do on the ground. Satellites have the advantage of a periodic view of vast portions of the Earth. Photons are constantly being emitted from Earth into space at the speed of light, carrying information about their source. To detect these photons and the information they carry, we need sensors. The two main types of sensors used for remote sensing are Optical and Synthetic Aperture Radar (SAR) [2].

The more intuitive of the two is the optical sensor, which detects photons whose wavelengths lie within the visible spectrum. Each pixel represents an RGB value, which, when combined with other pixels, represents an optical image. Optical sensors are passive sensors, which only detect electromagnetic pulses emitted or reflected from external sources. Active sensors, however, send out their own signals and measure the nature of the reflected signals [2].

SAR is a form of active sensing that works by emitting microwave pulses and measuring the amount of energy reflected back, also called the backscatter. The method is 'synthetic' because it simulates the effect of long radar antennas since it is impractical to have a single antenna long enough to achieve desirable image resolutions. Different objects absorb and reflect different amounts of microwaves, allowing us to identify the nature of the objects. By understanding how the properties of substances affect the penetration and backscatter of microwaves, it is possible to characterise the objects that the microwaves interact with. One of the biggest advantages of SAR is that it works irrespective of solar illumination or cloud cover; this is because the wavelengths used can penetrate clouds to a much greater extent than visible light, which is mostly reflected. Of course, our eyes cannot detect any images formed using wavelengths outside the visible spectrum, so we colourize images based on the amount of energy in each pixel [3] [5].

We measure the quality of data gathered by satellites across four kinds of resolution: spatial, temporal, spectral, and radiometric. The spatial resolution refers to the size of each pixel in an image. The best spatial resolution available today by commercial satellite sensors is 30 centimetres, allowing for the detection of objects such as buildings and cars. The temporal resolution refers to how frequently it obtains images over a specific location. This depends on the orbit of the satellite, the sensor characteristics and the swath width, which is the width of the portion of Earth being imaged. Spectral resolution is the ability of a sensor to identify narrower bands of wavelengths. This means that fine distinctions are made in images which contain objects that interact with several wavelengths. Radiometric resolution refers to the amount of information contained in each pixel. Each pixel contains a certain number of bits of information. An 8-bit resolution indicates the sensor has 2^8, or 256 potential values to store information in each pixel. A high radiometric resolution is useful when minor differences in energy need to be measured[3] [7] [8].

Why not create a sensor that has a high spatial, temporal, spectral and radiometric resolution? It is difficult to combine all resolutions into one sensor because certain trade-offs must be made. For example, a high spatial resolution would require a sensor to have a small swath width, which requires more time before that narrower region is observed again, resulting in a lower temporal resolution. It is therefore important to understand the nature of the data observed - the weather, for example, is highly dynamic and time-sensitive, indicating that a high temporal resolution is a priority [3].

A Landsat image of Reykjavik, illustrating the difference in pixel resolution

REFINING THE DATA

Data does not arrive as neatly ordered images - it is a wealth of raw, binary information, and it is crucial that scientists know what they are looking for and what the data represents. As pre-processing steps, several corrections are made to the raw data to improve its usability. For optical data sets, we perform atmospheric correction. Due to the dynamic mixture of gases in the atmosphere, reflected light undergoes refraction, making prediction difficult. However, we can use atmospheric correction to correct this refraction by using current models of the expected atmospheric conditions [2] [13].

To maximise their coverage, satellites often collect data at off-nadir angles - the nadir always points directly below a particular location. Since it is not practical to have satellites orbit directly above every point on Earth, satellites take images of objects at an angle. However, in applications such as maps, it is necessary to have images from a nadir point. Therefore, a correction known as orthorectification makes objects measured at off-nadir appear like they are imaged from directly above. Another correction, known as registration, is used to accurately assign geolocations to images since navigation systems used to locate satellites are always corrupted by the non-homogenous nature of the Earth's atmosphere and gravity field [2] [14].

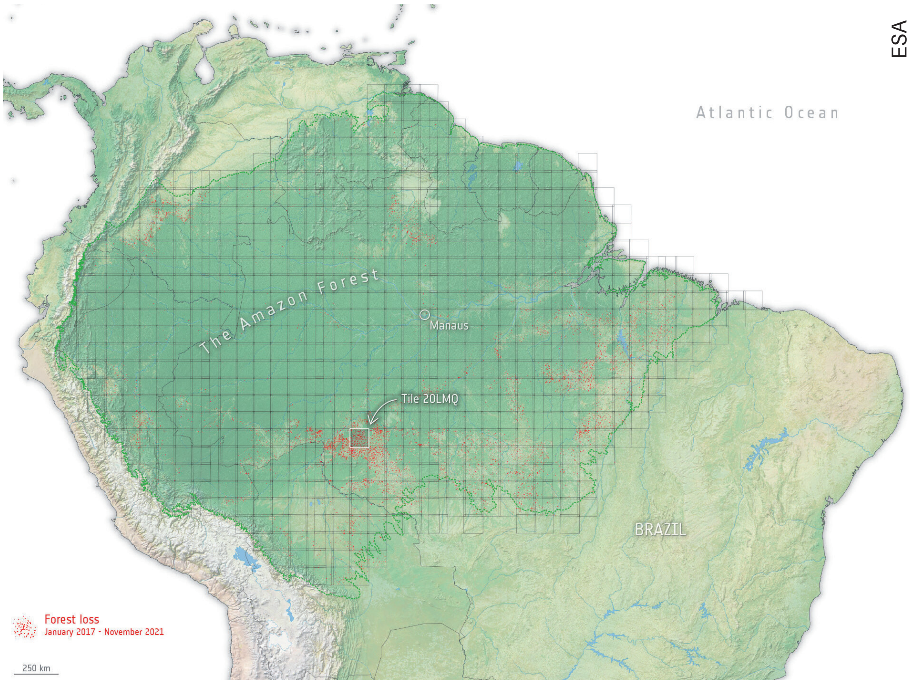
Deep learning has given rise to algorithms that can enhance the spatial resolution of satellite images, known as super-resolution.

These algorithms can obtain over 4x zoom, allowing for extremely sharp images. However, it is not all good news, as there are always trade-offs. If the data collected is at a specific spatial resolution, increasing that resolution by over 4 times requires the addition of imaginary data. Sharpened images assume that the colour of a pixel in a low-resolution image applies to its counterpart in the sharpened image. This is however an incorrect assumption, as each pixel mixes colours from different objects. While machine learning algorithms seemingly provide us with endless possibilities to enrich existing datasets, their limitations should always be taken into account and identifying those limitations relies on a thorough understanding of how the sensors collect data [2].

INTERPRETING THE DATA

Once each pixel in the processed image is assigned a specific value, how do we make sense of the image? How do we define these combinations of pixels to derive information for use in the real world? One way to classify these images is through supervised learning. A machine learning algorithm is trained using datasets known to be accurate - these datasets are called the ground truth. This is data provided by subject matter experts. The ground truth acts as a basis against which machine learning models can be trained. It contains annotations that the supervised algorithm learns to identify in new datasets. A major limitation of supervised learning models is the heavy reliance on accurate ground truth, which is not always available [2] [4].

There are several models in which explicit supervision is relaxed. One promising approach to unsupervised learning is self-supervised learning, where we alter a dataset of images, and train the altered set to return to the original set. Certain changes include - removing pixels, removing wavelength bands, reducing spatial resolution, or removing the last revisit from a time series. The goal is to guess the missing parts of the image and 'repair' the altered image to its original. There is no need for ground truth here, as the original set plays this role now. However, it is still important to have subject-matter expertise to help design the tasks. There is no point in training an algorithm to reconstruct an image with a removed spectral band when the main purpose of the algorithm is to identify temporal change - in this case it would make more sense to alter the time-series data instead of spending computational effort on making changes that train the algorithm for the wrong purpose [2].



Identified deforestation across the Amazon, using Sentinel-1 data

An example to illustrate the use of remote sensing and how machine learning comes into play is the European Space Agency's mission to use their satellite data to monitor deforestation in the Amazon: Sentinel-1 for Science Amazonas. The Sentinel-1 Mission, launched in 2014, consists of a constellation of two polar-orbiting satellites that image the Earth in the C-band SAR at a frequency of 4-8 GHz, or a wavelength of 7.5-3.8 centimetres. These wavelengths can penetrate the thick cloud cover usually present over tropical regions like the Amazon. The Sentinel-1 satellites have a relatively high temporal resolution, with a 12-day repeat cycle. This allows for effective early-warning systems that can help prevent deforestation. A Multitemporal Change Detection algorithm is used on the collected SAR data. Change detection is the method of analysing several images of the same geolocation over a certain period of time to identify how the images have changed. In this case, the change detection algorithm works by analysing the backscatter time series from the Sentinel-1, identifying breaks in the usual pixel-level trajectory and marking those pixels as potential candidates for forest loss. The data goes through several pre-processing steps to correct for effects such as seasonality and rainfall [10] [11] [12] [15].

CONCLUSION

More data streams down from satellites than ever before. It is important that this data is quickly analysed and turned into meaningful information. Implementing machine learning models in data processing has proven to be a great asset, but it is vital to consider their limitations, refer to subject matter experts. As our world becomes increasingly data-driven, extracting impactful information from data without compromising accuracy is crucial. AI is always ready to process incoming data, but advancements in remote sensing technology and satellite data transmission are equally important. To answer questions about the Earth, we have turned to space for answers, and it is proving to be very helpful.

RESAERCH #4

Prof. Dr. Guido de Croon

Juan Avila Paez, Leonardo Times Editor

C&O

GUIDO DE CROON

For the fourth edition of ResAErch, Leonardo Times interviewed Prof. Dr. Guido de Croon, Full Professor in Control and Simulation (C&O) and the Micro Air Vehicle Lab (MAVLab).

Note: This interview has been edited for length and clarity.

Q: Could you introduce yourself?
I'm a professor at the Micro Air Vehicle Lab (MAVLab) in the Control and Operations department. My background is in AI, which I studied at the University of Maastricht. My interest in the field originated from computer games; the artificial opponents in the first games released were very easy to beat, and I wanted to make them better. However, when I started studying, I became interested in a more natural form of AI. Natural intelligence is more efficient in terms of computation, and investigating it led me to robotics. I did a stay at EPFL in Switzerland as a PhD researcher, where I came into contact with drones for the first time. At first, drones seemed very fascinating because they must carry a lot of hardware, like sensors and processors, but also, they must be very lightweight. I realized that that would be the ideal demonstration of the capabilities of natural intelligence. Eventually, I became interested in neural network controllers for robots and evolving them to see the surprising solutions, which often resemble what we see in small animals like insects. I currently work on autonomous drones and mainly focus on small, lightweight drones, as they're the safest, while still capable of doing a great variety of tasks. In fact, by looking at examples in biology like flying insects, even with tiny flying vehicles, we can achieve impressive results.

Q: How much untapped potential is there still in drone technology?
I think drones, even small ones, are capable of much more than they are now, but one of the main additional features needed is their autonomy. For a task like navigating a city, you have to go from A to B, avoid obstacles, avoid air traffic, and so on, which is hugely challenging. Endurance is also another area with a lot of potential for improvement. We've worked on developing flapping-wing drones that can, in principle, stay in flight longer, although they're more suited for indoor applications. Outdoors, we focus on vehicles able to exploit updrafts like birds to prolong their flight. With this, you can imagine drones being able to stay in the air for considerable amounts of time with minimal power usage, mainly for propulsion. If drones can fly autonomously and for longer, I think there are many applications, both indoors and outdoors, yet to be tapped into.

Q: How can we ensure the safe operation of these drones?
At the MAVLab we do this in multiple ways. We see it as multiple safety nets that all need improvement. To make the system more robust, an obvious way would be to add more sensors or add more processing for redundancy. However, I don't think this is a good idea for drones since it makes them heavier. So, if something goes wrong, the drone is more dangerous because of its extra weight. We choose the other way, which is to keep them very lightweight. With flapping drones, the wings are very soft, so they can't hurt anybody even if they hit them. For a fixed wing, body design is important as well. For example, using foam bodies considerably reduces their impact and, hence, improves safety. If you go to even larger drones, weighing up to 3-5 kilograms, if they fall on someone, it could cause a fatality. Therefore, besides a smart body design, we think about having features like obstacle avoidance, communication with other drones, or air traffic control communication, even on small systems. There are many safety nets in work, which include both software components for active safety and design to minimize risk in the case of an accident. If you combine them, the chance of accidents happening is minimal.

Q: What's the biggest challenge that you have encountered in your research?

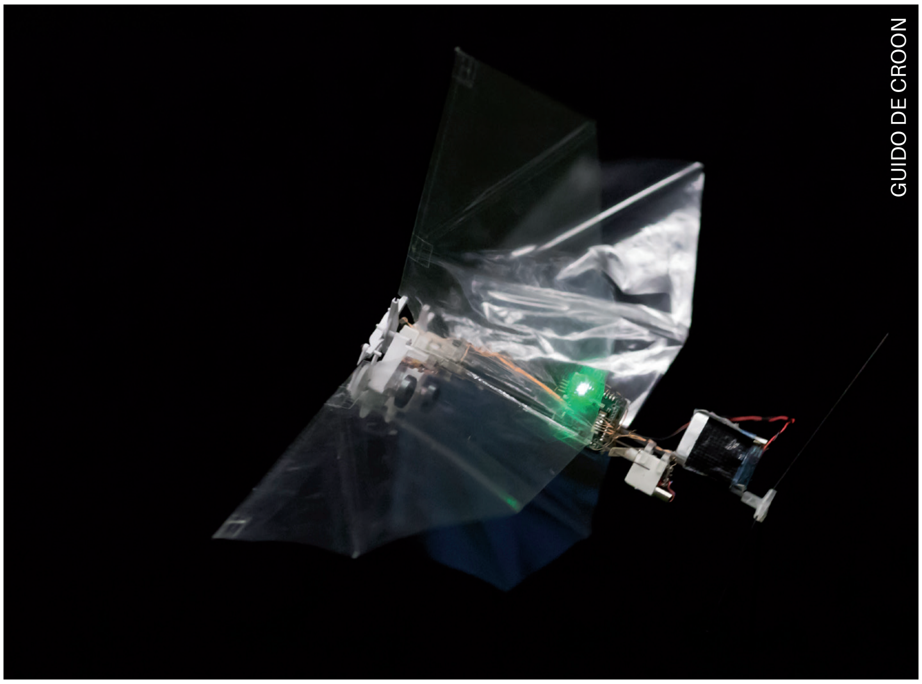
In my opinion, hardware. I chose to work on drones because they're challenging due to the constrained resources, and it used to be extremely hard to get onboard processing. When I came to Delft in 2008, we flew with the DelFly. It had a camera, but it transmitted images to a computer. The computer would process the images and send commands back. This issue has since been solved, but we're still struggling with hardware like battery technology, more efficient sensors, and processors that can run deep neural networks. To solve some of these problems, we take inspiration from biology, and observe how, for example, insects can do tasks like navigation. So, we know something about the ingredients of how they achieve this, but are still unable to put them together in many cases, which is a big challenge.

Q: Is hardware, in general, what hinders drones from becoming more widely adopted?

I think hardware plays a role, but autonomous flight is the main obstacle. Autonomous flight is comparable to self-driving cars in the way that, 10 years ago, everyone thought we would be using self-driving cars in 2020. Nonetheless, full autonomy is a challenge even for these heavy self-driving cars, just because some situations are difficult to predict. It needs more research. Even if it works in 99% of cases, that's still not good enough in terms of safety. As people, we have a low tolerance for autonomous flight accidents. Therefore, regulations for drones are harsh. This is good because we want to avoid accidents, but it is a big hurdle in technology development. It is very hard to obtain permits for research and testing of autonomous drones in environments we are interested in, such as urban areas. So, technology is a limiting factor, but regulations also must be more accommodating for experimentation, while maintaining the same safety standards.

Q: Since your research is based on bio-inspiration, has there been anything striking about nature that you've learned?

I started out working on optical flow sensing when I worked at ESA because it's a simple strategy followed by, for example, honey bees. They keep optical flow constant to guide their landing. For landing systems, we typically need heavy distance sensors that measure the distance to the landing surface. Of course, bees can do this with their brains that weigh just milligrams, so there was the promise of that. However, with the optical flow, you don't receive information about distance, only the ratio between your distance to the surface and your velocity. When we started experimenting with drones, we established they could never land. Once they got close to the ground, they would start to oscillate. We figured out the reason for this; as the distance approached zero, the ratio between velocity and distance became very large and gave large inputs to the thrust commands. This was very disappointing, as the goal was to avoid measuring the distance with the heavy sensors, but it seemed like we had no choice. Then I realized the possibility that insects could detect these oscillations, and I could show theoretically that these oscillations always took place at the same height. When I looked back at honeybees, I saw that the same occurred: they would always start to hover at a certain height, which had been a mystery until then. Even though they can't sense distance, they can detect these oscillations and hover 7 cm over a surface. So, by trying to imitate the the visual perception of honeybees in drones, I discovered how they could do that.



The DelFly during one of its flights

Q: On the same topic of nature, is there a lot of use for micro air vehicles to solve key environmental solutions in the future?

I had a big project related to greenhouse food production to monitor crops. Drones would gather images around the greenhouse and upload them. We see that agriculture is moving towards precision agriculture, for which you need a lot of data. And drones are the ideal vehicle for this. Moreover, I also know of colleagues working on drones applied directly to ecological monitoring, so they will definitely be important for these issues.

Q: Is there an ethical concern about drones replacing living organisms for these applications?

This occupied my mind some years ago when we did the article on the DelFly, and we got many requests from journalists about pollination. I must say at the time I didn't jump at it, because I didn't think it would be a good idea to give the impression that we can replace natural pollinators with artificial ones. Of course, first, I think we should save natural pollinators. We are still years away from the ability to replace them. So, we shouldn't create an environment toxic to every living being except for ourselves. I think this is most important. But, there are some niche cases, like greenhouses, that now use honeybees for pollination, in which switching to drones could be the ethical choice. This also happens in pest control, where drones could be a biologically friendly alternative to pesticides. Therefore, we should protect living organisms and their roles in ecosystems, but for some specific applications, drones might be the better choice.

Q: What's the next notable development that will accelerate drone research into a new stage?

I think neuromorphic AI will be this development. Neuromorphic AI means event-based vision, in which vision sensors register brightness changes in an asynchronous way, and then process them through spiking neural networks. This kind of hardware is very lightweight and is orders of magnitude more energy efficient. So, this really brings deep neural networks within reach of drones. Some embedded processors are already available for this, but they make the drone much heavier. If I think back to our 30 g DelFly, they're not an option. I think it would be able to do far more complex tasks if we succeed in the endeavor towards neuromorphic AI.

CONCLUSION

Leonardo Times would like to thank Prof. Dr Guido de Croon for his time and cooperation in this interview. It provided valuable and interesting information about research done in aerospace on AI.

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