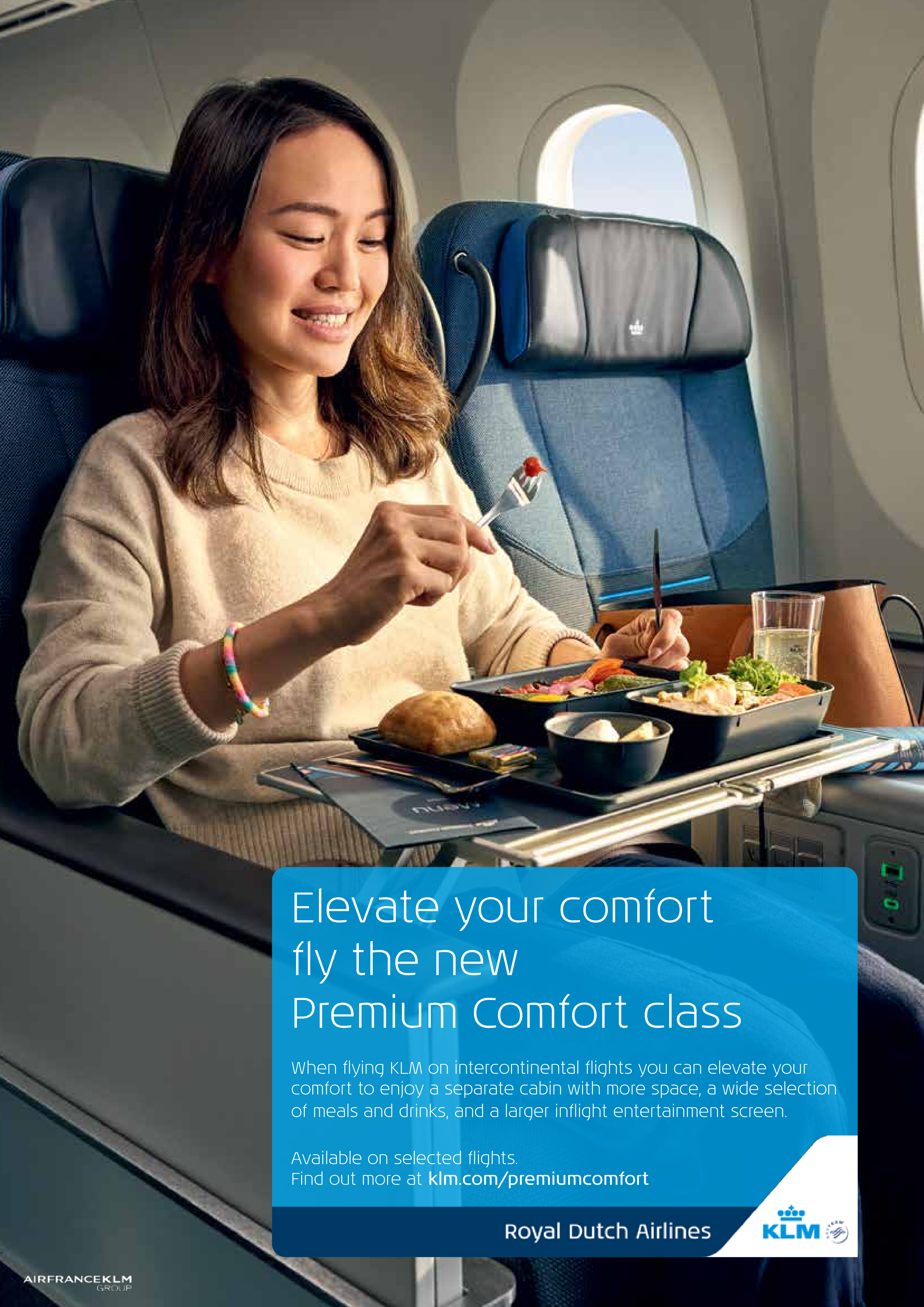
LEONARDO TIMES

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

UNCONVENTIONAL LANDINGS

WHEN TRADITIONAL RUNWAYS ARE NOT AN OPTION

Year 27 | N° 3 | Autumn 2023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ENDINGS AND BEGINNINGS

Dear reader,

You are holding in your hands the first edition of the academic year 2023/2024, which also marks the beginning of my time as Editor-in-Chief. Before you continue reading the rest of the journal, I would like to take a moment and tip my hat off to the exceptional management of my predecessor Topias Pulkkinen, and last year's Final Editor, Naomi Lijesen. Their enthusiasm and commitment are much appreciated by the Editorial team, and they have successfully maintained the impeccable quality of the Leonardo Times over the past year.

This year, the Leonardo Times will be led by three Editors. I as Editor-in-Chief, Lisanne Vermaas as Managing Editor, and Muhammad Arham Elahi as Final Editor. I could not have asked for better people to have at my side, and am looking forward to working with them in the coming year!

The pages of this edition are filled with a rich variety of topics and a wide range of represented industries. Many stories are told; from what it is like to have a taste of working in Formula 1 with Scuderia AlphaTauri's aerodynamics department, to the yet inimitable success of India's south polar region moon landing. Landing somewhere that no one has before can also happen in aviation, as is visible on the cover page, even though in this case it is not usually the desired outcome.

This edition also highlights a plethora of student engagements, featuring several Design Synthesis Excercise projects from the faculty's most recent Bachelor's graduates, and student team Da Vinci Satellite's goal to "elevate education" with a student satellite in orbit. Finally, this edition talks about two different kinds of missions: a recollection of spacecraft moon missions that had the same fate as the second flight of the Caproni Ca.60, and the mission of Dutch Astronaut André Kuipers to enrich the space industry with student creativity. The latter is told in his own words during an interview that four Leonardo Times Editors had the pleasure of conducting. It also includes his thoughts on what it's like to see Earth from Space, the ethics of human presence on other planets, reaching space as a person with physical disabilities, and more.

To close my first editorial note, I would like to bring to your attention a quote by Rebecca West, esteemed journalist and literary critic:

"Writing has nothing to do with communication between person and person, only with communication between different parts of a person's mind."

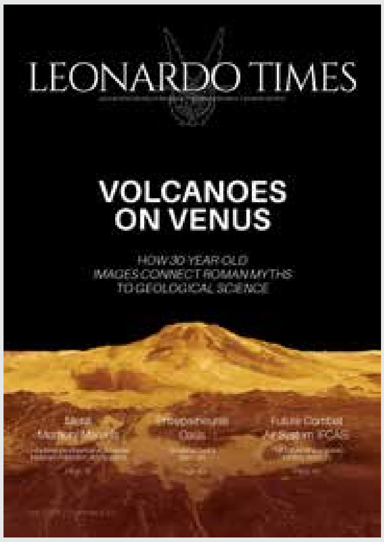
In today's world, where the effect of communication through media cannot be ignored and whose consequences surpass borders, we must never cease to be conscious of the thoughts and reflections that our written words instigate. Because the words that are not said are the ones that form our conscience, and that hold the power to "make the world a better place".

On this note, I would like to thank all the Editors who contributed to this edition of the journal, and I wish you an enjoyable read filled with good thoughts and insightful endings!

Yours truly,

Ruth Euniki Vraka
Editor-in-Chief,
Leonardo Times

Last edition...



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We want to make sure that all the mailed Leonardo Times reach the hands of people who are interested in reading them. So, if for any reason you would like to remove your address from our mailing list, please unsubscribe by using the form in the QR code. We will be sorry to see you go!

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A MESSAGE FROM THE BOARD

Dear reader,

Another fresh academic year has started, and I am genuinely excited to start this year after a well-deserved summer break for everyone. I feel honored to write the foreword of this profound magazine. This magazine is the physical object that shows how connected we are as aerospace engineers. Our passion and interest in the industry is put on paper each and every quarter. And it is due to this passion that this magazine is read by more than two thousand people!

This first edition of the Leonardo Times marks the start of the 79th year of our association. It is the year when important preparations are done for our lustrum next year, extra emphasis is put on sustainability within our association and new opportunities await. This is of course in addition to our legacy VSV activities.

Even before the start of this academic year, more than three hundred people had the chance to enjoy our freshmen weekend. This amazing weekend featured a private airshow from civil aircraft and military helicopters. After this, we continued with one of our largest career events, the career weeks. This event featured workshops and lunch lectures about how to manage your LinkedIn, how to pass a job interview, and several lectures from our partners! We also enjoyed an interesting lunch lecture by Andrew Forrest, working at Fortescue, and one by Brian Moran, working at Boeing, both about how to tackle climate change.

Other events we offered this fall were the consultancy day and Discover Your Space. Again, two very interesting events that connected us students to the versatile industries we are connected with. Similar to this, our diversity department organized the Aerospace Diversity Day. A group of very inspirational students, airline employees, and a commodore from the Air Force shared their experiences from working within the industry. These eye-opening stories taught us a lot about the effect of bias on the work floor.

Several larger events we are really looking forward to this year await us in the coming months already. One of those is our yearly symposium, this year it will be a space-themed symposium. More unique events include our pre-lustrum activities. Examples of these are the theme reveal of our lustrum and the pre-lustrum week taking place in the last quarter! Stay tuned for more updates on these one-of-a-kind events.

I am looking forward to starting this amazing year together! For now, sit back, relax, and enjoy this magazine.

On behalf of the 79th Board
of the VSV 'Leonardo da Vinci',

With winged regards,

Jim Ruysenaars
President of the 79th Board of the
VSV 'Leonardo da Vinci'

EUROPA'S SECRET

The James Webb Space Telescope has discovered CO_2 on Europa in September 2023 with its near-infrared spectrograph. Europa is a Jovian moon (it orbits the gas giant Jupiter) and is the smallest of the four Galilean moons: moons that have a spherical shape due to their self gravitation. Europa most likely has a metallic core, surrounded by a rock and a water ice crust.

The Galileo spacecraft (1997) and the Hubble Space Telescope (2016) have found evidence for water plumes on Europa in one hemisphere and a liquid salty ocean underneath the cold ice crust. As the salty water is conductive, it disrupts Jupiter's magnetic field, which was detected by the Galileo spacecraft. The heat causing this ocean to remain liquid is believed to originate from tidal heating, a result of varying gravitational forces between celestial bodies in time. The water from these potential plumes could cause resurfacing of the moon and therefore explain its smoothness.

The moon is a very attractive scientific object, as it has the potential conditions for life. Next to liquid water, however, carbonous materials would be required for the development of life as we know it. It is exactly this that excited the space community so much after the findings of the James Webb Space Telescope. According to the measurements performed, there is carbon dioxide present on Europa. The most likely theory believes that this CO_2 originates from the liquid ocean beneath the surface rather than from the moon's environment (for example, from asteroids that collided with the surface). This hypothesis is supported by the location of the detected carbonous material: it was found on the Tara Regio, an especially young surface, hinting at a surface that either erodes or expels liquid from below, exposing the carbon dioxide locked inside.

A COSMIC CARE PACKAGE

On September 24, 2023, NASA recovered a special delivery at the Utah desert - a literal time capsule from the early solar system.

The OSIRIS-REx mission, which launched on September 8, 2016, arrived at Bennu, a near-Earth asteroid, on December 3, 2018. A nearly unchanged remnant from the beginning of the solar system, Bennu may hold clues to the origins of life as it is thought that asteroids similar to it brought water and organic molecules to Earth four billions of years ago to jumpstart life. The spacecraft went up-close and personal with the asteroid for five minutes on October 10, 2020, when its sample collection arm made contact with the surface to extract what was intended to be three samples - but the first sample exceeded the 60-gram sample requirement that no further collections were deemed necessary. After departure from Bennu on May 10, 2021, OSIRIS-REx made the journey back home to drop off the sample return capsule.

Two weeks after touchdown and recovery, the sample's constituents from initial analysis was announced to the world; scientists found what they were hoping to find, but this discovery was momentous. The sample contains 5% carbon in mass, which is to date the asteroid sample with the highest amount of carbon ever retrieved. In addition, water-bearing clay minerals were found, supporting the theory of water being brought to Earth by meteorite bombardment.

The samples will undergo further analysis by the mission's science team for the next two years. At least 70% of the samples will be kept at NASA's Johnson Space Center for scientists in the global community to study, with enough for future generations of scientists to analyze. Later this year, a small part of the sample will be on temporary display at the Smithsonian National Air & Space Museum and the University of Arizona.

While the Bennu samples have been successfully returned to Earth, OSIRIS-REx's mission is not over yet. The spacecraft is currently on its way to the asteroid Apophis, with expected arrival in 2029.

2023 FAA NOTAM FAILURE

On the 11th of January, 2023, all flights in the USA were grounded for about 90 minutes. This has not happened in the USA since the 9/11 attacks. But why were aircraft grounded? Was it also a terrorist threat? No, it was an accident.

The NOTAM is a system used to notify pilots of hazards in their route, airport maintenance work, airspace restrictions and special areas, and other relevant information that may have to be taken into consideration by the pilots while en-route.

ALEX WONG

At 7:30 (ET) on the 11th of January the FAA ordered the grounding of all aircraft due to a malfunction of the NOTAM system. There were speculations of a cyberattack, and even though it was shortly disproven, president Joe Biden launched an investigation into the matter. What caused such an important system to fail? Now we know.

On the afternoon of the 10th of January, some servicing work for the NOTAM system was being carried out due to a corrupted file. This was to be done by switching to a backup database. They thought the problem had been fixed but there were still some synchronization errors, so in a second attempt some files were unintentionally deleted, causing the crash of the system at a national level. The problem was fixed relatively fast, but it left 32,578 delayed flights and 409 international flights canceled.

The NOTAM system is technology from the 50s, and many have already been advocating to update to a more resilient and modern system.

ESA OPEN DAY

On the 7th and 8th of October, ESA ESTEC opened its doors to the public. The first of these open days was organized specifically for people with a disability. The importance of this day to ESA was made clear by the statement of the General Director of ESA, Josef Aschbacher, who, during a question session on the 8th of October, highlighted that in space, every astronaut has a disability, and this should not be ignored on Earth either.

The next day, ESTEC was open to everybody who had reserved a spot. Several buildings were open to visit: in the test center, the public was introduced to the HERA mission, which aims at analyzing the literal impact of the DART mission on the asteroid Dimorphos. DART hit the asteroid on the 26th of September 2022, aiming at deflecting its trajectory and explore this concept as a protection mechanism. HERA will be launched in October 2024 and is currently being tested.

In the main corridor at ESTEC, not only several missions were highlighted, but also ESA's charities and sustainability plans were lined up.

On top of all the information about ESA and her missions, there was the NL Space Tent. Here, several companies from the industry had a stand and explained their contributions to missions and their own achievements: TNO elaborated on the instruments they developed, ISISPACE's CEO was present to explain their fields of expertise and the Da Vinci Satellite team aimed at educating and exciting children about spaceflight. Also, NL MOONSHOT '24, a student program running next year, was announced by Andé Kuipers, who will be interviewed about this inspiring initiative this edition of the Leonardo Times.

STUDYTOUR "DAEDALUS"

An overview of the events and activities

Studytour Committee, VSV 'Leonardo da Vinci'

VSV 'LEONARDO DA VINCI'

At the end of last Summer Break, between the 21st of August and the 8th of September, the annual study tour of the VSV 'Leonardo da Vinci' was held. This study tour is a way to connect enthusiastic aerospace engineering students with international players in the industry.

This year's three-week tour was a continental trip, visiting France, Switzerland, Greece and Italy. Our group consisted of 26 persons: 16 participants, 3 AE professors/teachers and 7 members of the organizational Study Tour Committee from the VSV. This article is a small diary of the trip.

Days 1-4, Paris – After an early seven o'clock gathering at Rotterdam Central station, we boarded the Thalys and headed to Paris. For this train journey, we temporarily had another participant: the little mouse under the seats! In the afternoon, we visited the one and only Louvre, the pyramid of which shone under the bright sunny skies.

The next day, Dassault Systèmes was on our company visit list. Most people might know the company for its CAD-software (CATIA). We had a tour, a look at demonstration models of the 3DEXPERIENCE software, Dassault's start-up incubator and ate blood-sugar-threatening amounts of small patisserie during lunch. Back in Paris, the group broke up to once again roam the streets and attractions of Paris.

The next day was a double version of the day before. In the morning, we went to Orly airport to look at the engine maintenance site of Air France Industries. We saw the facility, many large aircraft engines in their overhaul (such as the GE90!), and more.

In the afternoon, we headed to a small village outside Paris to visit Safran, where they assemble LEAP-engines. We had a tour along the brand-new final assembly line, and had extensive opportunities to network with Safran's employees.

The next day started at 05:10 - A time most would be comfortably in bed, but we headed to Toulouse via TVG. The train ride took us through the beautiful French landscape, and along Bordeaux. It wasn't a great day to be there, as we soon found out reading the newspaper headlines: record temperatures that day. And indeed, our weather apps didn't stop at 30 degrees, nor at 35, but at a cozy temperature of 43 degrees Celsius.

Days 5-7, Toulouse – We headed to Toulouse-Blagnac airport to see the final assembly line of the Airbus A350 aircraft. After a

VSV 'LEONARDO DA VINCI'

three-course lunch, we finally got to see the magic: one of the most modern passenger aircraft of this day and age. We closed the day by enjoying the beautiful city of Toulouse.

In the afternoon of the sixth day, we returned to Blagnac airport. This time, we walked over to the other side of the runway, to the aircraft museum "Aeroscopia". As a group of aerospace engineers, we took our time to walk around, amazed by the museum collection (an A380, two Concordes, historic jet fighters, and more). In the spirit of "support-your-local-museum", some of the group went into the gift shop to buy propellor cuff links, flight tags, flight patches, and loads more. In the evening, there was a wine tasting in a wine cellar. Later, in the spirit of "support-your-local-bar", a part of the group went out.

To complete the streak of three, we once again went to the airport in the morning to take a flight to Basel airport. From there, we took a train to the beautiful city of Bern. Our hostel location was between the pristine blue river Aare and the city center.

Days 8-10, Bern – For the first day in Bern, the plan was to hike in the mountains near Grindelwald, a beautiful picturesque village. But that day, the weather was so rainy, cold, and windy that even the birds decided to go on foot. We canceled our original plans and headed out for Luzern by train. The program for the day included free time and the National Transportation Museum.

The day after was a start-up day, with two start-up company visits in Lausanne. We visited Clearspace (a space debris cleaning company) and Rigitech, a start-up making UAVs for small cargo transportation.

Our final day in Bern was a travel day, during which we went by train to Zürich and flew to Athens with a lay-over at Rome. All in all a long travel day. We arrived at three in the morning at our hostel.

Days 11-15, Athens – Our late-night arrival in the hostel was a bit chaotic. The hostel was not in the best neighborhood, and it was undesirable to stay there longer. Luckily, our travel agency found two nice apartments to host us for the rest of our stay.

The next day was a day off, with a private evening tour of the historic National Observatory of Athens.

The following morning was the birthday of one of the participants! An exciting program was on the menu: a bus tour to Tatoi Airbase and to the Hellenic Air Force Museum, and after that, a trip to Tanagra Airbase to witness the first day of the Athens Flying Week. A few days earlier, we could already hear and see the American F35s above Athens, headed for the airbase. But on this day, we could see, hear, and smell them up close. It was a packed afternoon with formation flying, afterburners, tactical displays, and more. The ideal day out for a group of aerospace engineers.

Next up was a day off again. Some of the group wanted to hike in the mountains surrounding Athens, but these were closed off due to forest fire risks.

Days 16-19, Turin – The day after, we headed out for our final destination of Turin, by plane and high-speed train.

In Turin, we visited ThalesAlenia Space, the company that made the dome of the International Space Station. We saw test grounds for Mars rovers, and the production of storage modules for space stations. The day wasn't complete without going to the automobile museum in Turin, where we shifted our attention from the flying things to the driving things.

The following day, we visited Avio Aero, where they produce gearboxes for different engines. Mechanically, it was very interesting to see the testing and production of these complex assemblies.

On the second to last day, we had one of the highlights of this tour. A few days before, we saw an F35 flying. We now went to the final assembly line of this newest military fighter at Leonardo Aerospace, where we could almost touch the fully assembled aircraft and see the assembly of the wing box and its systems installation. Two very welcoming Dutch military liaisons stationed there accompanied us.

Day 19, the final day – All good things must come to an end. The train to Milano and the plane to Schiphol were the conclusion of a long, interesting, inspiring, at times exhausting, but nevertheless more than worthwhile tour. Once again, a wholehearted thank-you to all participants, teachers and companies!

VSV 'LEONARDO DA VINCI'

TRACKSIDE TALES

An interview with Scuderia AlphaTauri's Aerodynamics interns

Ruth Vraka, Editor-in-Chief, and Syed Muneeb ur Rahman, Leonardo Times Editor

Formula One car of Scuderia AlphaTauri (2023)

Formula One (F1) is a fast-paced, dynamic and competitive environment like no other. It attracts millions of spectators annually, and the stakes are always high. But for many engineering students, the interest is not limited to watching a race. F1 engineering positions are coveted by many, including the aerospace engineering students of our faculty. This article takes you through the internship experiences of Luís Morais and Guido Meindertsma, two aerodynamics students who successfully claimed positions in the French *Scuderia AlphaTauri* F1 team.

Please note that this interview has been edited for length and clarity.

Q: Can you tell us a bit about your educational background and why you chose an internship in motorsport? Was this an industry that interested you when you decided to study aerospace?

Guido: *I am from the Netherlands, specifically Gouda. I decided to do a bachelor's in Applied Physics, not in Delft, but in the east of the Netherlands, at Twente University. But during my bachelor's I discovered that I really liked aerodynamics after completing a minor in aircraft engineering. Later, I applied to do a student solar car project in Twente. That really verified my desire to do aerodynamics. My love for F1 started roughly in 2005 when I began to watch it with my dad and we've watched almost every race together since. The first time I learned about internships at F1 was when I started my Master's. So I immediately applied...*

Luís: *Since I was a kid, I've always had a fondness for engineering and motorsport. When I finished my high school, I considered becoming an air force pilot, but my vision problems had other plans for me. If I could not drive the machine, I could at least help design it. I ultimately decided to pursue aerospace engineering in Instituto Superior Técnico in Lisbon. During my studies, I became increasingly drawn to aerodynamics and how one can manipulate the air in order to fly or, in case of motorsport, to go faster around the track. As I became more involved, I participated in various activities, including a four-year student team. Starting as a trainee, I occupied positions in the aerodynamics department, initially responsible for the structural design of the aero package, followed by Head of Aerodynamics and finally Mechanical Technical Director in my final year. Looking back, my* *childhood memories of watching races with my dad sparked my curiosity about how fast cars can go. This passion for aerodynamics, coupled with the rapid development and innovation in motorsports, made it the pinnacle of the industry for me. Unlike aeronautics, where new ideas take some years to implement due to several safety and performance checks, motorsport offers constant advancements in a short period.*

Q: How was your experience with the Scuderia AlphaTauri internship application process?
Guido & Luis: *Well, first, you write a motivation letter and CV and apply. For Scuderia AlphaTauri, the next stage wasn't an interview but a technical test. You had two hours to complete an exam with eight questions. The second round involved two 45 minute interviews, one more technical and one focused on soft skills. There was also a group assignment in a Teams meeting with other candidates where we worked together to solve a problem. So they could see your working capabilities and decision making in a group. Question example: "You're stranded on an island and the nearest town is this far away. This is in your backpack, one of you has a broken leg. What decision do you make? How do you cope with this situation?" Overall, I really enjoyed the application procedure.*

Q: What parts did you work on specifically?
Guido: *I worked on the rear wing design. It was a new era and there had been no previous time spent on the rear wings when I arrived in July 2021. For all the different racetracks, you have different levels of rear wings. In Monaco, you want as much downforce as possible, and you can always overcome the drag with the power of the motor. So for all the different racetracks, our task was to calculate the maximum and minimum achievable amount of downforce. The season started in Bahrain, in the Middle East. It was a tricky situation I walked into on the first day, but it was also very fun.*

Luis: *I primarily worked on the car floor, which was fortunate because, according to regulations, it's considered one of the most crucial parts. This year, there is a significant focus on ground effects, and it may present some challenges. While I can't provide extensive details, we did work on addressing and resolving floor related issues. As a team, we engaged in discussions, brainstorming sessions, and collaborated to find solutions.*

Q: What is the goal and vision of the Scuderia AlphaTauri team?
Guido: *Officially, Scuderia AlphaTauri's vision is to sell clothes. And that's the funny thing about F1 cars. They're basically just giant billboards driving around the track - it's all marketing. So, the vision is to do as well as possible, of course, and to promote their clothing brand. But I can tell you a little about the vision in the aerodynamics team. I really enjoyed working in Scuderia AlphaTauri because it's such a small team and everyone knows each other. Even as an intern with little or no practical experience, you get assigned to a task that feels quite important. From day one, you get a lot of responsibility and in my opinion, Scuderia AlphaTauri's vision is to include everyone and to take everyone seriously.*

Luis: *Initially, the team was designed as a junior team, focused on nurturing new drivers. When the rebranding to Scuderia AlphaTauri occurred, the team's role changed slightly. The emphasis shifted towards the team independently developing most of the car. While certain components were still sourced from*

GUIDO MEINDERTSMA

Aerodynamics Department Office of Scuderia AlphaTauri in the UK

Red Bull, the majority of the car's development was done by the team itself. Scuderia AlphaTauri's primary focus remains to train drivers but also extends beyond racing. It aims to showcase the brand's exclusive and luxurious fashion line.

Q: What is the division of the team like at Scuderia AlphaTauri?

Guido & Luis: *The team's origin is Italian and based in Faenza. In 2006, they decided to move the aerodynamics department to the UK where the industry has adapted to the needs of F1 teams. Tools and facilities, such as wind tunnels, are more easily accessible. Below the team principal, there is a technical director overseeing several departments such as aerodynamics, vehicle performance, and mechanical design. The aerodynamics department is overseen by the Head of Aerodynamics, Chief of Aerodynamics, Principal Aerodynamicists and Head of Operations. From the different groups, the aerodynamic development group encompasses the design and detailed analysis of new solutions to improve the car's performance. This group is split into different parts of the car, such as the front, rear and middle sections, as well, as the conceptual design for future cars. All these subgroups have a team leader and a deputy team leader. The mechanical groups ensure the mechanical parts of the wind tunnel model of the car are properly secured for testing and develop new tools to improve the wind tunnel testing. The model design group picks up the full size parts to be tested and scales them down to fit the wind tunnel model, ensuring the parts are properly fixed in the process. The surfacing group aids the aero development groups with the design of more complex parts and brings together all new solutions into one single CAD file to ensure the entire department is working with the most recent baseline. The aero systems group (ASG) develops new software tools to improve the wind tunnel testing, the results analysis and the efficiency. The aero performance group (APG) runs simulations to prepare for the following race with the data collected from previous race events. Finally, the logistics, rapid prototyping and model makers groups organize the weekly logistics for the wind tunnel test, print the new parts to be tested and prepare these same parts, respectively.*

Guido Meindertsma in front of the Aerodynamics Department Office in the UK

Q: What is the work-life balance of engineers at Scuderia Scuderia AlphaTauri or in general an F1 team? What keeps engineers motivated at Scuderia Scuderia AlphaTauri?

Guido: *In Solar Twente, I worked on average 60-70 hours and expected the F1 world to be similar. But I found that it was more like a nine-to-five job. But everyone could decide their own working hours. For instance, Luis always worked longer. I would go home at maybe 6:30 PM or 7:00 PM every day and he would stay until 9:00 PM or sometimes 11:00 PM. I would say I left work at an average time. I think Luis was one of the latest to leave the office. I really admire his long hours.*

Luis: *I really enjoyed working with the people there. They were helpful and willing to stop what they were doing just to assist me when I was learning in the beginning. It was incredible to learn about new software and post-processing results. My typical working hours were from 8:30 AM to around 7:30 PM. But there were days when we had to meet deadlines, and that meant working until 2:00 AM or even 3:00 AM. We had to give it our all to ensure all the parts were ready for dispatch, otherwise they wouldn't make it to the race or be included in the initial car.*

Q: What are some of your biggest achievements personally and as a team?

Guido: *The first half year I worked on the rear of the car. I was responsible for all the rear wings that you see on last year's and this year's car. At every race, I'm still very proud to state; "That's my rear wing" at every race.*

When the rear wings were finished, I was transferred to working on the car's floor. I managed to improve the most outboard fence which was upgraded in the French race last year, so that's when I saw another element of the car that I made. For this year's car, the rear wings and also the most outboard fence are my designs. That's my proud achievement.

Luis: *One of my remarkable moments was designing certain parts to be tested in the wind tunnel. Seeing them being tested was an achievement in itself. The biggest accomplishment, though, was when those* *parts made it to the actual car. It was a proud moment for me to look at the car and say, "Hey, Mom, I designed those parts!" It was something special, not only for the initial release of the car but also for the subsequent upgrades that followed.*

Q: How did your previous education and experiences help you in the topics you worked with during your internship?

Guido: *So when I did my bachelor's, I was unsure what I wanted to do and didn't learn much. But then I joined the solar car project and worked with two colleagues who were much more experienced in aerodynamics. When we started drawing solar cars and looking at CFD (Computational Fluid Dynamics) results, I understood what aerodynamics was. I could link everything I read in the books and I saw in the lectures to my experience.*

Luis: *Formula Student has been incredibly helpful to establish a working routine for me. It taught me the importance of teamwork and how to accomplish a lot within tight time constraints. It not only developed my technical skills but also enhanced my interpersonal skills. Whether it's a solar car or an airplane, what matters is the knowledge and experience you gain. Explore as many projects as possible and extract as much knowledge as you can during your bachelor's or master's program because that's what potential employers will be interested in. Engage in extracurricular activities such as seminars. For instance, I attended a vehicle dynamics seminar to expand my knowledge in that area and also developed leadership skills.*

Q: How much of your work as an engineer was limited by factors unique to the industry such as race/care regulations, budgets, etc.?

Guido: *The regulations are very strict and everything comes down to the last millimeter. Even a 10th of a millimeter, especially when you start pushing the designs to the highest downforce ones. If they state a minimum radius of 20 millimeters, and you use a radius of 20.001 millimeters just to be slightly above, it makes even the slightest CAD twitch illegal. The cost cap is also a factor not only behind closed doors that no one really knows about. You have to make decisions regarding what to send to the tunnel. It effects how many geometries you can run, how many rear wings you can make, how many updates you can bring to the car. There are limits to everything.*

Luis: *In Scuderia Scuderia AlphaTauri, similar challenges exist as in F1 teams regarding budget, manpower, and technical resources. While the budget gap is now more leveled, it means less money to operate and develop resources within the team. Established teams like Red Bull, Ferrari, and Mercedes already have the necessary resources and tools in place, so they don't need to invest as much money in that aspect. In terms of personnel, the team size is relatively comparable to others, but they may have some redundancies to ensure smooth operations within the budget cap limitations. It's a balancing act to find the right mix of people without exceeding the cap.*

Q: What are the most challenging parts of your role?

Guido: *It's a nice bridge from what I was saying about pushing everything to the maximum (regarding the cost cap and the regulations). Everything is exactly how you want it in your head, but then not necessarily like that in CAD. Because in CAD, the program can just say no or move outside the tolerance box somewhere. So there was a really stressful period when we worked towards finishing the highest downforce rear wing. We finished everything, but it was hard work, and long hours - a bit stressful. You need the ability to remain calm in a stressful situation.*

Luis: *I think coping with the daily pressures of such a fast-paced environment, working with deadlines is challenging. You want your ideas to be used in the car, so you need to design your parts, ensure they work, and send them to the wind tunnel on time. Sometimes the CFD results don't match the wind tunnel ones and you need to understand why. So there are many details to take into account. But I personally welcome the responsibility and the pressure. But it is also challenging because you need to manage your time. You really want to perform well and to put new ideas in the car to improve the performance.*

Q: What are the skills you had already that were the most valuable in your internship?

Luis: *Participating in projects and gaining relevant experience is crucial to stand out among thousands of applicants. Learning from these experiences, asking insightful questions, and deeply understanding the technical aspects are invaluable. I personally value the TU Delft Aerodynamics Master's degree, as it covered various courses such as flow measurement techniques, experimental measurements, and viscous flow. Moreover, creativity plays a significant role. Thinking outside the box and coming up with innovative ideas is highly appreciated. In summary, pursuing a master's degree in a relevant field, gaining hands-on experience, and demonstrating creativity are key factors for success in the competitive F1 environment.*

Q: What are the most valuable skills you have learned during your internship?

Guido: *You have more aerodynamic knowledge at the end of the year, but I think it was also very valuable to work in a company at the top of motorsport. The fact that it's a company instead of a student team makes it more serious. It also puts things in perspective. The employees also have their lives, their children and other priorities. But at the same time, they work in such a fast-paced environment requiring a lot of time and a lot of effort. Everyone has heart for the team and want to work hard.*

Q: Do you see yourself working in the motorsport industry as an engineer after your studies?

Guido: *I have considered it and I really loved working in F1, and if we had F1 teams here in the Netherlands, I would definitely be the first to join. But since everything is in the UK, I have decided not to pursue it any further. Also, because I think that even though F1 is a wonderful, cool sport to watch and to work in, and I love racing more than anything, I don't really feel I'm adding to the world by making a racing car or a billboard for a fashion brand go just that bit faster.*

Luis: *Yes I actually received the job offer while I was an intern! So I'm planning to go back there after finishing my master's as a* *junior aerodynamicist. I am looking forward to it. To have the opportunity to work on something I am passionate about, and be surrounded by colleagues I enjoy working with. I hope to have a fulfilling experience and enjoy my time there.*

Q: What are the prospects and chances of getting a role having completed an internship at Scuderia AlphaTauri?

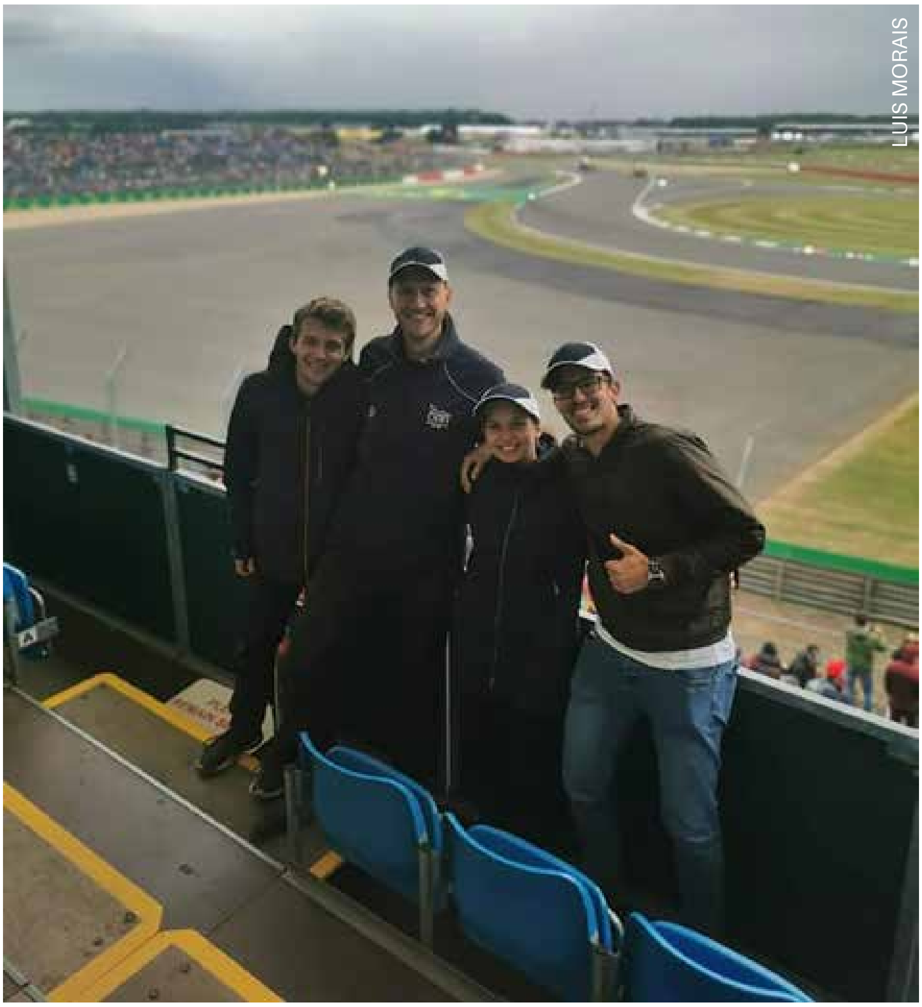
Guido: *They have a certain number of positions and a certain number of people applying. So your chance is X out of Y. But it doesn't really work like that. It depends on your experience, how well you write your letter, and how good your CV is. The key is to get through the first big pile of CVs and motivational letters by standing out. So I added pictures of the solar car project to my motivational letter. It's not considered very professional, but I thought, if I did a professional letter like everyone else, I will never stand out. So you need to think outside the box. Do something that other people will not.*

Luis: *I know many people who did an internship in one F1 team and then applied to another. It's something that really stands out. And even though they may ask similar questions in the interviews, to have that internship experience sets you apart and makes them take a closer look at what you bring to the table. It's definitely a remarkable experience to include in your resume, not just for F1, but also for other companies. F1 is well-known and respected, and people are aware of the work ethic and dedication required in the industry. So, to have that experience can be valuable, and it might make someone think; "Hey, this person could be a good fit for us." So in essence, doing an internship adds a lot of value and makes you stand out.*

Q: What was your most enjoyable moment from your time with Scuderia AlphaTauri?

Guido: *I think towards the end of the internship, the head of aerodynamics invited me into his office and said, "Yeah, you've really done well." and wanted to offer me a contract after my studies. Even though I politely declined, I think that was the most valued moment of the year because it's a reflection of the entire year. I received recognition for my work. But also, as already mentioned, when I first saw the rear wings on track and when I saw my update in France, were both really, really good moments too.*

Luis: *One of the highlights for me was going to Silverstone with the team and being there to cheer them on. Seeing the car up close and personal was incredible, even though I couldn't go to the paddock. I watched from a nice stand, and the atmosphere was unforgettable. Another memorable moment was working until 3:00 AM last year. It involved a group of people working together towards a common goal, pushing through late hours to get the job done. It showcased great teamwork and brainstorming.*



Luis (far right) at the Silverstone Grand Prix

FINAL PARAGRAPH

Guido and Luis have shared their experiences as interns at the Scuderia AlphaTauri Formula One team. They highlighted the rigorous application process, the team's vision, and the division of work within the team. They discussed the work-life balance and the motivation that comes from being part of a small team with a sense of inclusion. They emphasized their personal achievements in designing key car components and the valuable skills they acquired during their internships. Overall, their experiences provided them with a deep understanding of aerodynamics and the fast-paced environment of the motorsport industry.

EMISSIONS IN AVIATION

The state of current zero-emissions technology and greenwashing

Miguel Castro Gracia, Leonardo Times Editor

FPP

Airbus' hydrogen-powered turbofan zero-emissions plane concept

The carbon emissions produced by the commercial aviation industry are a problem that everyone is aware of and that most people try to avoid discussing. The uncomfortable truth is that we do not have a clear path to net zero emissions. So, how is the industry approaching this challenge?

WHAT IS THE PROBLEM?

The technical challenges faced by aviation are incomparable to other industries in many aspects, emission reduction being one. To make a plane fly is considerably more challenging than to make a car move. Excluding all the emissions associated with producing the equipment, the fuel used to power aircraft is difficult to substitute. The biggest culprit is energy density (i.e. energy available per unit mass or unit volume). Kerosene has proven to "just get it right" with a mixture of properties that allow it to operate at the correct temperature range with the equipment all manufacturers are familiar with. But there are other factors making the switch difficult as well. Jet fuel is not very volatile and reasonably easy to handle. It can also operate inside of the temperatures that an aircraft may experience without freezing or evaporating mid flight.

THE "HARD" SOLUTIONS

Hydrocarbon fuel is the main contributor to the commercial aviation emissions [8]. These emissions completely dwarf those that stem from production, so any way of reducing the amount of greenhouse gasses (GHG) produced in the operation of planes has a significantimpact. However, there is huge inertia to keep things as they are in the industry; we've been using combustion engines since we started flying. There are, however, two alternatives which could achieve zero emissions.

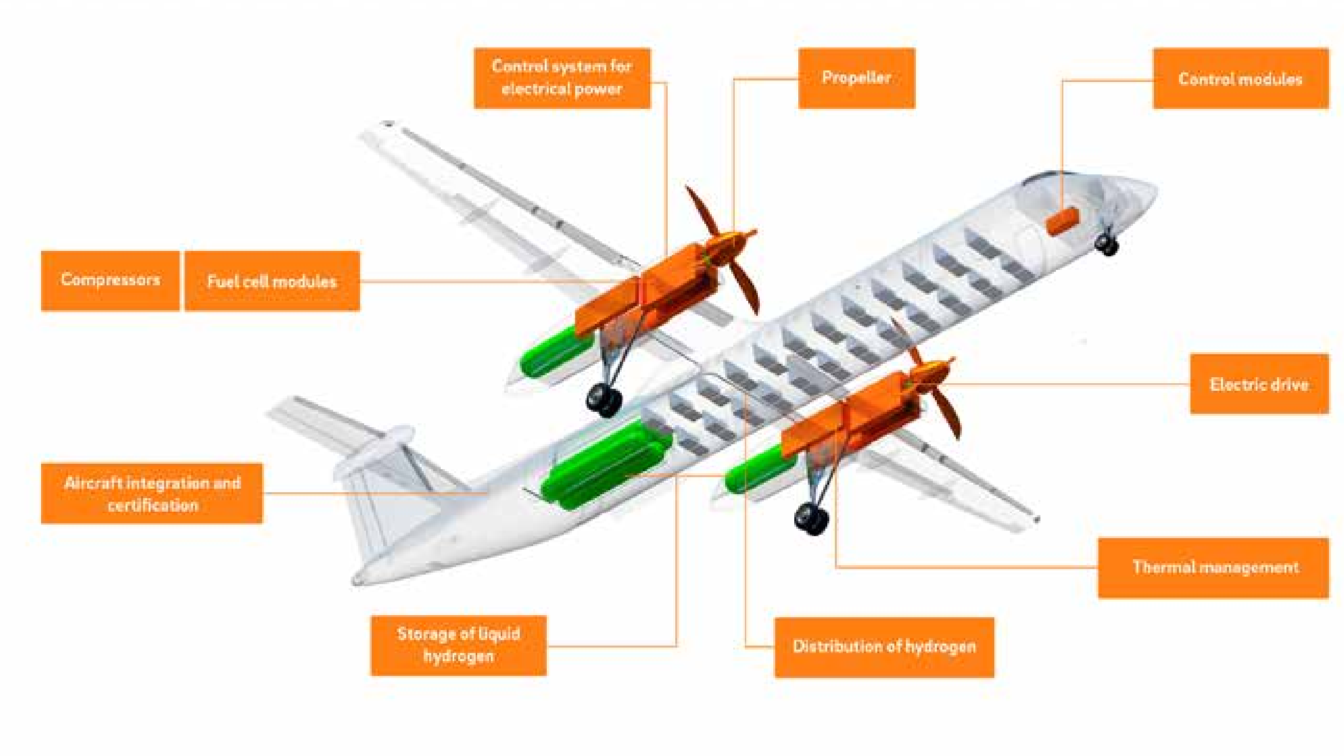
Hydrogen

Hydrogen is a promising fuel that could deliver excellent mass-energy density (almost three times as much as hydrocarbons). However, its volumetric energy density is abysmal (about three times lower than jet fuel in the best-case scenario) [1]. Current tube-and-wing aircraft designs do not have enough space to hold all of this gas, so the hydrogen must be stored at extreme pressures (in the range of 700 Bar), or stored cryogenically as a liquid. These two options represent vital safety risks due to the extreme conditions. Additionally, hydrogen is a small molecule that tends to leak a lot, posing a very high explosion hazard. These risks are manageable for a liquid rocket, but are monumental challenges for an airliner [2].

To add insult to injury, hydrogen production is an energy-expensive process by itself and much more costly than just refining oil. Hydrogen production often requires energy that does not entirely come from renewables. The production of so-called "green hydrogen" is not totally figured out yet. Current production methods often involve fossil fuels, and cost more energy to produce than what's actually extracted from the hydrogen itself. To make it truly sustainable, we would need to compensate with extra capacity from renewable plants or by using alternatives like nuclear energy [16].

Battery power

Batteries have proven themselves as the go-to choice for the automotive industry due to their relative ease of implementation in cars. The fact that there is a lot of research going into them is also a point in their favor, as all the progress in automotive batteries can be applied for aircraft batteries too. However, battery power suffers from very poor mass-energy density [9]. New developments in battery technology may solve this problem, but what's currently available is not feasible for anything beyond short-range flights (less than 200km). This makes the technology seem like it's far away for being implemented in commercial aviation.



Hydrogen Aircraft Powertrain and Storage System (HAPSS) is a hydrogen-powered aircraft being developed entirely in the Netherlands and aims to launch by 2028

THE "EASY SOLUTIONS"

Hydrogen and electric power pose huge implementation challenges, but represent the best solution: a world where the industry can keep growing while considerably reducing its harm towards the planet. However, it seems like the industry is laser-focused on other solutions that promise easier pathways towards decarbonization, and leave these two as side projects.

Biofuels

One such solution is bio-fuels, often referred to in the industry as SAFs (Sustainable Aviation Fuels). These hydrocarbons are not extracted from the ground but produced by processing feedstocks from plants, like palm trees or algae. The main premise for their sustainability is the following: During the lifecycle of fuel production, the feedstocks are supposed to absorb the same or even more carbon dioxide from the atmosphere than is produced by burning the fuel [13]. Reality, however, is not so simple. Often, the processes trying to make these biofuels are not good enough yet to reach the emissions goals. Currently, biofuels are nowhere near being carbon neutral, managing to achieve about a 50-70% reduction in emissions [14]. The performance of biofuels is heavily dependent on the feedstock used. For some types of algae, for instance, the total lifecycle emissions can even be negative, absorbing more carbon than what's produced in combustion [10]. Technologies like these are currently being studied at labs, and would be a fantastic solution that would allow for easy integration into the industry.

Unfortunately, many of these "superstocks" are not ready for mass production. Cultivating algae at a massive scale and then synthesizing the fuel without using too much energy in the first place is not easy. Thus, the overwhelming majority of start-ups currently trying to set up production infrastructure for biofuels are choosing the cheap, easy route: producing fuel from more common feedstock, such as corn or palm trees [4]. Their emissions reduction potential is not as substantial as some of the technologies that are currently being researched, and might be potentially overestimated [11].

The real issue is that, albeit significant, a partial reduction on the emissions is not enough. To focus resources on biofuels allows companies to adhere to regulations in the short to medium term, but will not work in the future, when most industries will be almost completely decarbonized. When emissions per kilometer is the most relevant factor for transport, aviation might shift from being one of the most cutting-edge industries to being the worst-in-class.

Carbon credits

For airlines, the proposed candidate for sustainable air travel is carbon credits. The concept is as follows: An amount of money contributes to "net carbon positive" projects . This means they stop emissions from a given source or directly absorb carbon from the atmosphere [13]. Airlines have adopted carbon credits by allowing their clients to purchase an "offset reduction". Giving passengers the option to actively contribute to offsetting the emissions caused by their flight is certainly nice to have. However, some carbon credit programs have suffered from controversies that have escalated to a point where they directly affect the airlines they collaborate with.

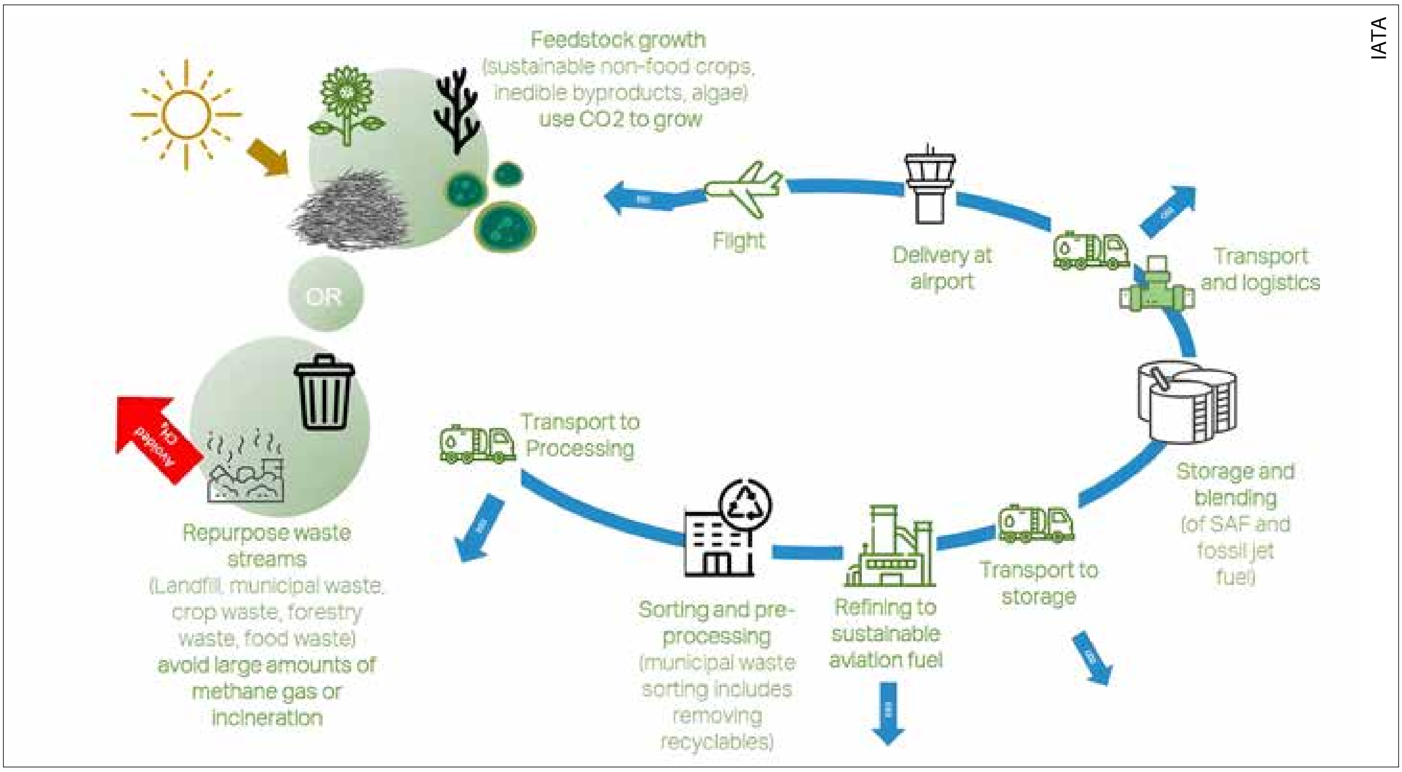
This year, Delta Airlines has received a court order to pay damages to its clients due to its "net zero targets" being considered misleading [6]. More airlines might be susceptible to these types of lawsuits if they keep going in this direction. But what exactly makes carbon credits such a problematic solution to air travel emissions?

Carbon credits usually either support reforestation, direct carbon capture, or the transition to green energy for countries where the energy transition has barely started. By doing so, they assist in bridging the emissions gap between more and less developed economies, as well as allowing the developed economies to continue with their business as usual (albeit with a small additional cost to all polluting operations). The problem with the concept itself is that all credits, not directly capturing carbon, are just a temporary solution. They are functional now, but as the developing economies reach their emission goals, our potential to offset those emissions will reduce.

Certifying authorities and reliability issues

Carbon offset programs are managed by smaller NGOs on the ground, but they rely on external certifying organizations. Their purpose is to audit, verify, and quantify the amount of carbon offset by a project. However, these organizations are not infallible and can often misrepresent the actual impact that offset programs have on the environment.

An example of this in recent times is Verra. Until January of 2023, this company was the biggest carbon credit certifying body. However, an investigation revealed that most of



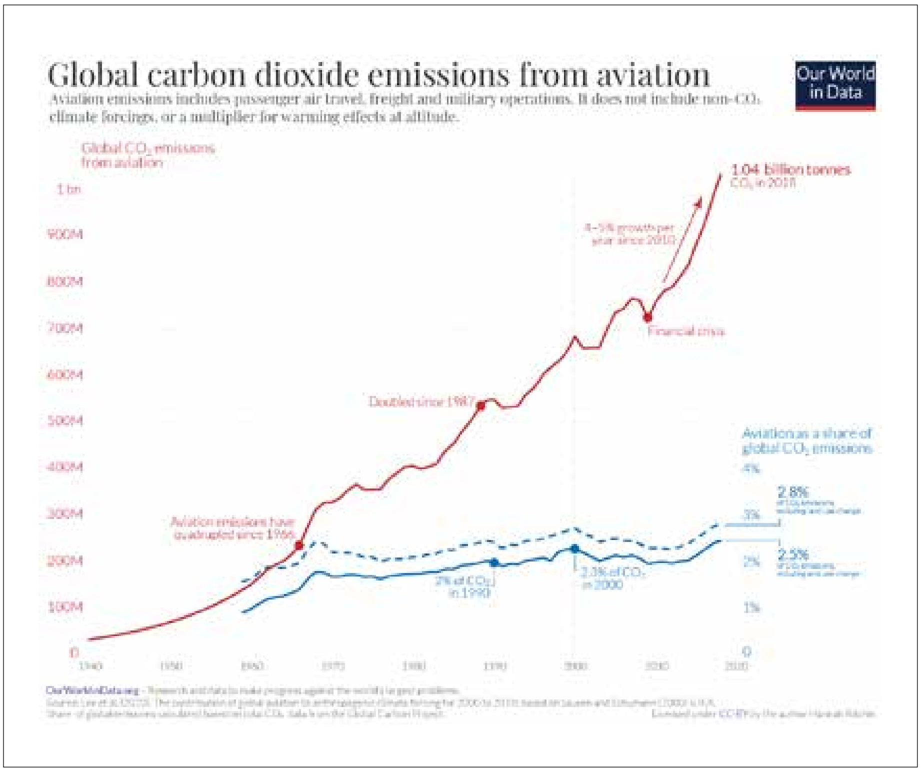
Carbon lifecycle diagram of Sustainable Aviation Fuel (SAF)

the certified carbon credit programs were worthless. They relied on very simplistic calculations to determine their impact on the environment, which often can be grossly inaccurate. Projects trying to avoid deforestation, for instance, sometimes claim to have protected areas that were not endangered in the first place [7]. And, as mentioned before, the unreliability of these credits have trickled down and affected companies using them for marketing.

The biggest problem with offsets, is that all money that goes into carbon offsets is money that does not go into research and development of actual emission reduction technologies, which the industry desperately needs. Many companies make tremendous investments in the technologies that will power the future of air transport, and the rest of the industry will have to keep its focus there.

SO WHAT IS LEFT TO DO?

Aiding ourselves with technologies such as biofuels or carbon offsets is crucial. However, the industry must remember that the goal is to completely eliminate emissions, not partially reduce them. The world is growing rapidly, and partial emission reductions might not be enough to offset this growth. By 2043, the FAA predicts growth in flight hours of 16.6% [15]. So mixing some bioethanol into the regular fuel mix and trying to add a bit more each year will not cut it. The industry cannot afford to keep things like they are. Thus, it is essential that we accomplish radical technological achievements to allow for the new propulsion technologies to develop fully. We must take zero emissions flight from the drawing board to a reality. This must be a combined effort: manufacturers must keep putting money into research and development, and airlines must be open to adopting these technologies when they finally arrive. Additionally, governments should tax carbon emissions to encourage this growth. This is where individual action comes into play: citizens must pressure companies by voting with their wallets and pressure politicians by voting in the ballot box.



Global CO2 emissions by aviation up to 2020

CONCLUSION

The aviation industry is still far away from reaching a long-term solution to the issue of carbon emissions. Hydrogen and electrical power prove promising technologies that need much work to integrate and implement into the industry. Carbon credits and biofuels can be a good way to mitigate current emissions until the completion of greener technologies, but we must keep the challenges and effectiveness in mind. The industry must remember that the goal should be to eliminate emissions, not reduce them. No matter the cost.

TRUE OR FALSE? TEST YOUR KNOWLEDGE ABOUT ASML

1

The name 'ASML' is an acronym.

ASML makes microchips.

2

From chipmaking to EUV and from the number of employees globally to next generation machines, discover the most important facts about our fascinating tech company.

At ASML, we're changemakers! Our growing team of over 37,000 people and 144 nationalities provides leading chipmakers with the hardware, software and services to mass produce patterns on silicon. We're probably part of the device you use to communicate, learn or play games with.

Headquartered in Europe's prolific tech hub, the Brainport Eindhoven region in the Netherlands, we have over 60 locations globally and annual net sales of €18.6 billion in 2021.

Be part of progress.
Visit www.asml.com/students for more information about our events, internships, scholarships or early career opportunities.

3

An ASML machine is all you need to make microchips.

4

ASML is the only company that makes EUV (extreme ultraviolet) lithography technology.

5

ASML is building a new kind of EUV lithography machine.

For any questions about ASML don't hesitate to ask our campus promoter Sara:

Sara Buurman
sara@workingatasml.com
+31640458561

ANSWERS

The name 'ASML' is an acronym.
FALSE. ASML isn't an abbreviation of anything anymore, though it used to stand for 'Advanced Semiconductor Materials Lithography'. ASML was founded in 1984 as a joint venture between Philips and ASM International, so a name was chosen to reflect the partners in the venture. Over time, this name has become simply 'ASML'.

ASML makes microchips.
FALSE. ASML does not make microchips – we make the machines that other companies use to make microchips. We also don't make the silicon wafers that form the cradle of the chip. Customers such as Intel, Samsung and TSMC use ASML's DUV and EUV lithography systems to print tiny patterns on silicon that has been treated with 'photoresist' chemicals. They also rely on our metrology and inspection systems, together with our computational lithography and patterning control software solutions, to achieve the highest yield and best performance in mass production.

An ASML machine is all you need t o make microchips.
FALSE. Making chips is a complex, long and expensive process. Our customers have spent years and invested billions building 'fabs' (fabrication plants), buying equipment and training employees to become experts in the complex field of semiconductor manufacturing. ASML's lithography machines form an important part of a chipmaker's production line, but they are not all that's required to produce microchips. Lithography – printing patterns on silicon wafers – is certainly a critical step in the chipmaking process, but it's just one of many!

ASML is the only company that makes EUV (extreme ultraviolet) lithography technology.
TRUE. Unlike in the DUV (deep ultraviolet) lithography market, where ASML competes with other top-notch suppliers, ASML is currently the only lithography equipment supplier capable of producing EUV technology. Chipmakers use these EUV systems to manufacture the world's most advanced microchips. In fact, if you own a relatively new smartphone, gaming console or smart watch, chances are you've benefited directly from EUV lithography technology. We spent 20 years developing EUV with our partners and suppliers, resulting in a machine that contains around 100,000 parts. To ship just one of these huge machines to customers requires 40 freight containers, three cargo planes and 20 trucks.

ASML is building a new kind of EUV lithography machine.
TRUE. In the semiconductor industry, innovation never stops. That's why we're already developing a next-generation EUV platform that increases the numerical aperture (NA) from 0.33 to 0.55. This means that the optics systems in the new machines will allow light with larger angles of incidence to hit the wafer, giving the system a higher resolution. The EUV 0.55 NA platform, called EXE, is well on its way to production – we're planning the first shipments of these machines to customers for R&D purposes by the end of 2023, and we expect them to be used in high-volume manufacturing by 2025.

DR. ELLEN OCHOA'S ODYSSEY

From La Mesa to NASA Leadership

Aerospace Diversity Department

DR. ELLEN OCHOA

Ellen Ochoa is a retired astronaut, scientist, and engineer who became the first Hispanic woman to go to space in 1993. Ochoa later served as the Director of NASA's Johnson Space Center from 2013 to 2018, becoming the first Hispanic director and second female director of a NASA center.

Ellen Ochoa grew up in La Mesa, California, as the middle child of five to parents who did not have college degrees. After obtaining her PhD at Stanford University, she started as a researcher at the NASA Ames Research Center. In 1993, Ellen made history as the first Hispanic woman to travel to space as a mission specialist aboard the Space Shuttle Discovery. She flew four missions, logging nearly 1000 hours in space.

Following retirement from spacecraft operations in 2007, Ochoa took on a leadership role as the Deputy Director of NASA's Johnson Space Center, managing and directing the Astronaut Office and Aircraft Operations. On the 1st of January, 2013, Ochoa became the first Hispanic and second female director of the Johnson Space Center. Beyond her remarkable career in spaceflight, Dr. Ochoa is also a passionate advocate for diversity and inclusion in STEM fields, and has been a champion of outreach and education efforts to inspire the next generation of scientists and engineers. The Aerospace Diversity Department was lucky enough to ask her a few questions about her career and experiences.

How has your background and heritage influenced your perspective on space exploration?

I appreciate that space exploration benefits people of all backgrounds on Earth — it brings new scientific knowledge, technology development applied in many areas, and inspiration for accomplishing difficult things. In some cases, new technology can help underserved communities, such as when water purification technology developed for the International Space Station is deployed in rural areas on Earth. The inspiration aspect is notebaly significant, as I've seen in my own career and outreach.

As the director of the Johnson Space Center, you oversaw the development of ad-

vanced technologies for space exploration, managed scientific research programs, and led an enormous team. Can you discuss your experience in managing such a large and diverse team of professionals and what made your approach successful?

I was fortunate to have a talented, dedicated team, including other leaders who focused on the mission. We all held the same NASA values: safety, excellence, integrity and teamwork. NASA has since added a 5th value, inclusion, which I was happy to see, and it was something NASA in general, and certainly I, had already been focusing on. We need everyone to be fully engaged in our work, which only happens when people feel respected and valued and when we encourage people with different experiences, backgrounds, and perspectives to be involved.

How has the space industry changed since you first became an astronaut, and what do you see as its future?

Certainly the workforce is much more diverse than when I first joined, and there is more attention on ensuring everyone has the opportunity for training, development and promotions. There are also many more opportunities for people to participate in the space industry — not just NASA and the long-time aerospace companies like Lockheed, but also many newer companies. NASA has many public-private partnerships and continues to reach out to industry to support the space economy. It's an exciting time for the space industry!

What do you hope to see for future diversity and inclusion efforts in the aerospace industry, and what can we do to work towards this vision?

I hope — and expect — for the workforce to continue to diversify, especially the one in the U.S., it would be more reflective of the population in general. We need to continue efforts to get underrepresented groups into the STEM fields. Progress has definitely been made, but there's a long way to go. I also hope the trend for NASA (and companies) to work internationally continues. It's exciting to see that 24 countries have signed on to the Artemis Accords, for example, to see that the Artemis II crew includes Canadian astronaut Jeremy Hansen and to see two UAE astronauts as part of the Axiom-2 crew that launched on the 21st of May 2023. It's, again, a big step for us all.


DR. ELLEN OCHOA

LOOKING BACK AT AEROSPACE DIVERSITY DAY: KICKING BIAS

In the fast-paced world of aerospace, where innovation and precision are paramount, the Aerospace Diversity Department of VSV 'Leonardo da Vinci' orchestrated a remarkable event on the 17th of October. The vision was clear: to tackle the prevailing issues of diversity and inclusion within the aerospace industry head-on. Under the theme "Kicking Bias: How Unconscious Bias Affects the Work Floor and How to Unlearn it," the Aerospace Diversity Day set out to create ripples of change in the sector.

The day began with the insights of Philip Jordanov, a cognitive neuropsychologist, unraveling the intricacies of unconscious bias. Air Commodore Siemensma from the Netherlands Royal Air Force followed, sharing experiences and insights into bias in leadership and hierarchical culture. The symposium not only pinpointed problems, but also presented solutions, encouraging individuals to reflect and act.

The panel discussion, featuring KLM, TNO, Transavia, and TU Delft's True-U, provided practical insights into overcoming unconscious bias. The audience, engaged through thought-provoking questions, left with a deeper understanding of their individual roles in fostering diversity and inclusion.

The symposium was a melting pot of industries, drawing speakers and panelists from diverse backgrounds. The networking drink that followed, accompanied by live music from JUNE, was the cherry on the top where students and professionals continued the discussions from the program, fostering connections extending beyond the symposium.

While all speakers contributed to the successful event, Rahel de Vriend, the Chair of the Day, emerged as a standout figure. Her adept orchestration and ability to guide discussions left a lasting impression on all attendees.

CONCLUSION

In retrospect, Aerospace Diversity Day not only addressed unconscious bias but catalyzed a collective drive towards change within the aerospace industry. The symposium was not just a one-day event - but a new start for dialogue and action in the journey toward a more inclusive and innovative future.

CRATER MAKERS

Recent Moon missions shed light on the race to success and the shadows of failure

Muhammad Arham Elahi, Final Editor, and Naomi Lijesen, Leonardo Times Editor

AI-generated image of the Hakuto-R lander crashing on the lunar surface

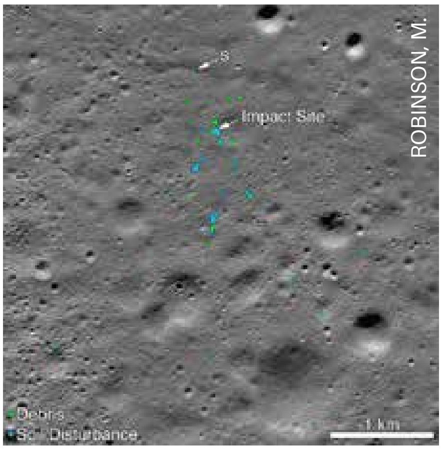
In 1959, the Soviet's Luna-2 became the first man-made object to impact the surface of the Moon. Since then, almost 30 missions have impacted on or landed on the Lunar surface. Yet lunar exploration is an endeavor fraught with challenges, and there have been almost as many failures as successes. So why go? In the early days, the justification was: "because we can". However, by the 1970s, perhaps the attraction wore off, and through the 80s, the Moon was abandoned, afollowed by a meager combined total of six (surface) missions in the 90s and 2010s [1]. But in recent years, motivation has returned. The discovery of ice in the poles promises an opportunity to re-understand the barren surface we first assumed it to be. In the last five years there have been several efforts from various parties to return and explore. While triumphs such as India's recent Chandrayaan-3 mission are outstanding, failures from other parties remind us of the lunar commute's complexity. It prompts the question: is the pursuit of lunar exploration and the opportunity to establish a permanent presence on the Moon justified despite the substantial (literal) cost incurred by our numerous failures? The following article examines a number of failed Moon landing missions from recent years and what they each mean for the new Moon race that is undeniably underway.

CHANDRAYAAN 2

The Indian Space Research Organization (ISRO) initiated its space program in 2008 with the launch of Chandrayaan 1, a lunar orbiter and impactor, which achieved considerable success. Chandrayaan 1 played a pivotal role in establishing the presence of water molecules in lunar soil and producing a comprehensive map of the Moon's chemical composition. Despite falling short of its targeted 2-year lifespan, the mission successfully fulfilled most of its objectives. Building on this accomplishment, Chandrayaan 2 aimed for an even more ambitious goal – landing a rover on the Moon's South Pole [2][3].

Chandrayaan 2 comprised three critical components: an orbiter, a lander, and a rover. Initially, India was responsible for the orbiter, rover, and launch, while Russia provided the lander. However, significant delays arose following the failure of the Russian mission to Phobos, one of Mars' moons, which shared technological similarities with the lunar lander. Consequently, Russia needed to reevaluate its lander design, leading to changes that increased the lander's mass. To accommodate this change, India had to reduce the rover's mass, potentially affecting its reliability. Eventually, India decided to build the lander independently. Further delays occurred during vehicle testing, causing the gross lift-off mass to escalate from 3250 kg to 3850 kg. Consequently, the launch vehicle had to be upgraded from an uprated GSLV Mk II to the more capable LVM3 [2][3].

The original launch date was July 14, 2019. However, a technical glitch necessitated a postponement to July 22. The orbiter's launch proceeded smoothly, marking a successful start to the mission. Nevertheless, as the lander and rover descended towards the lunar surface, they began to deviate from their assigned trajectory at an altitude of 2.1 km. At this critical moment, the lander lost contact with the ground station, coinciding with the expected landing time. ISRO subsequently confirmed these initial reports, with the chairman remarking, "It must have been a hard landing." The cause of the crash was determined to be a software glitch, which began with the engines' thrust being higher than the nominal level. As a result, the lander decelerated more than intended during that phase. Due to the strict time and location constraints imposed during the landing procedure, the lander attempted to compensate for lost time. Consequently, just before impact, the lander had a horizontal velocity of 48 m/s and a total velocity of 50 m/s, significantly higher than the ideal 2 m/s for that stage of the landing [2].



Crash site of Chandrayaan 2

Despite the unfortunate crash of the rover, the Chandrayaan 2 orbiter remains operational and continues to excel. With a lifespan already exceeding four years, it is expected to stay in lunar orbit for at least three more years. During this extended mission duration, the orbiter will continue to collect valuable data, contributing significantly to lunar research and furthering our understanding of Earth's nearest celestial neighbor. Additionally, Chandrayaan 2's successor, Chandrayaan 3, was recently launched and successfully landed on the South Pole of the Moon and was able to obtain data about the composition of the Moon. See further details of this immense achievement on Page 32 [2].

HAKUTO-R MISSION 1

Hakuto-R was a privately funded lunar landing mission developed by ispace, with the initial motivation to compete for the Google Lunar X Prize. The total prize value was $30 million, with $20 million allocated for the first-place team. The challenge entailed landing a lunar rover on the Moon, covering a distance of 500 meters, and transmitting high-definition video and images back to Earth. Engineer Andrew Barton founded White Label Space in 2008 with the goal of winning this prize. ispace, established by Takeshi Hakamada in 2010, served as the Japanese arm of White Label Space. Originally, the Lunar X Prize deadline was 2014, but it was extended to 2018 due to the lack of progress from the participating teams. In 2013, many professionals abandoned the project, with the exception of some Japanese members, and the project was rebranded as Hakuto, named after the Japanese mythological white rabbit. By 2017, Hakuto had secured $90 million in funding, and despite missing the 2018 Lunar X Prize deadline, they decided to continue with their plans for a lunar mission [4][5].

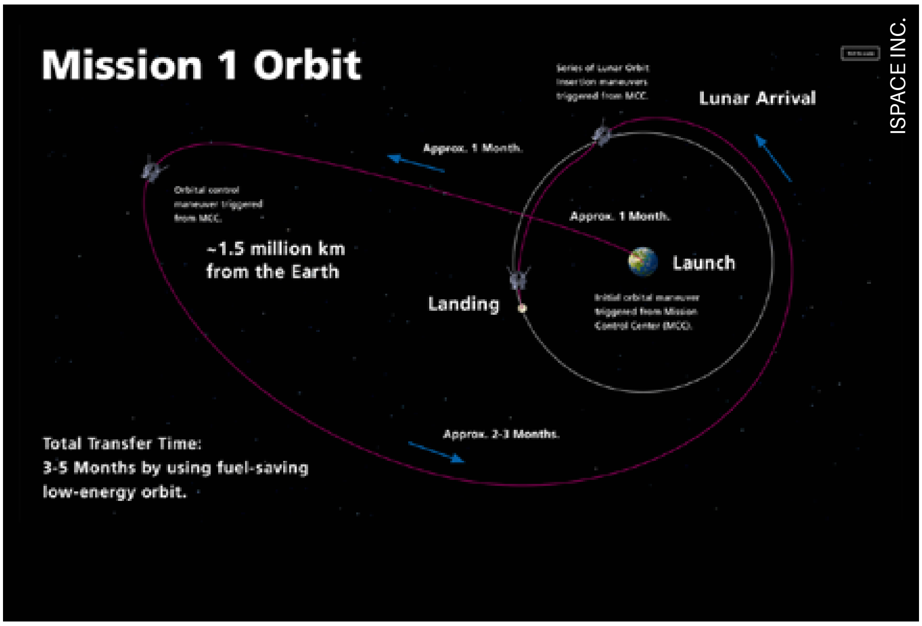
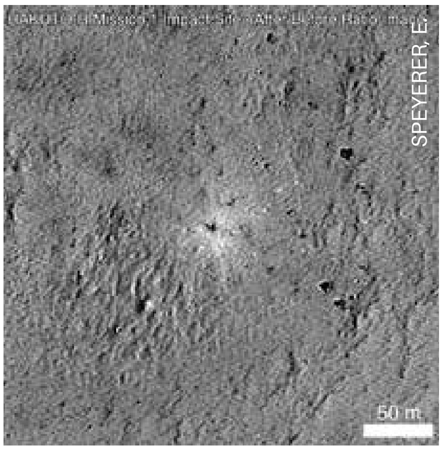


Figure 1: Hakuto R Mission Profile

The Hakuto-R lander had an approximate weight of 1000 kg, and its payload included the Emirates Lunar Mission, which marked the UAE's first foray into space exploration. The Emirates lunar mission was equipped with a high-resolution microscopic and thermal imaging camera and aimed to investigate the adhesive properties of lunar dust. A longer route to the Moon was selected to conserve fuel, extending the journey to nearly 6 months, as depicted in Figure 1. The initial stages of the mission were successful, with the launch and initial manoeuvres proceeding smoothly. However, during the approach phase, contact with the lander was lost [4].

Subsequent investigation revealed that the cause of the crash was a combination of faulty sensors providing erroneous data to the onboard computer and the computer's inability to distinguish between correct and faulty data. The telemetry data sent by the rover incorrectly identified its location as the Lacus Somniorum crater instead of the Atlas crater. The flight computer misinterpreted the radar altimeter data as erroneous and disregarded it, resulting in the lander hovering 5 km above the Moon's surface until it exhausted its fuel. Despite the mission's failure, Hakuto-R travelled almost 1.4 million kilometres, marking a significant achievement as the furthest distance covered by a privately funded spacecraft to date. Furthermore, Hakuto-R Mission 2 and Mission 3 are already well underway in their design and planning to land on the Moon in 2024 and 2025 respectively. They aim to validate the lander's design and technology and perform resource exploration to develop the cislunar ecosystem [4].



Crash site of Hakuto-R

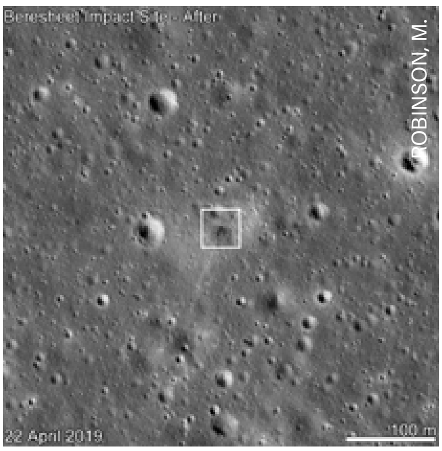
BERESHEET

Beresheet, a privately funded lunar mission co-developed by SpaceIL and the Israel Aerospace Industries (IAI), received significant backing from Israeli billionaire entrepreneur Morris Kahn. The project also participated in the Google Lunar X Prize competition. Its primary goal was to kindle interest in space exploration among young people, inspiring them to pursue careers in STEM (Science, Technology, Engineering, and Mathematics) fields. The project's total budget reached approximately 100 million USD [6][7].

The lander's payload included a magnetometer, a time capsule, and a laser retroreflector. The time capsule held an impressive assortment of data, including over 30 million pages of information, a complete copy of the English-language Wikipedia, the wearable Rosetta disk, the Panlex database, the Torah, children's drawings, memoirs from a Holocaust survivor, and the Israeli flag and anthem. As the project neared its conclusion, genetic samples and tardigrades (water bears) were also included in the payload [6][7].

On February 22, 2019, the spacecraft was launched as a secondary payload aboard a Falcon 9 rocket. The main engine was employed four times to establish a circular orbit around the Moon. Its expected operational lifespan was limited to just two days due to the spacecraft's lack of thermal control and susceptibility to overheating. During the descent phase, as the lander began to slow down for a soft landing, an IMU gyroscope suddenly failed. Ground control was unable to reset it in time, resulting in the lander failing to decelerate sufficiently and impacting the Moon's surface at a speed of 500 km/h [6].

Despite this unexpected outcome, Beresheet marked a significant milestone in privately funded lunar exploration efforts. It demonstrated the potential for non-governmental organizations and private individuals to engage in lunar missions, despite not achieving all the mission's objectives. Moreover, the project



Crash site of Beresheet

succeeded in its broader goal of sparking interest in space and science among the younger generation, leaving a lasting legacy in space education and outreach. Moreover, Beresheet 2 aims to be the first-ever dual-lander deployment mission and will have two separate landers touch down on separate locations on the moon. It also will contain the lightest landers to ever soft-land on the Moon. It is targeted to launch in 2025 [6].

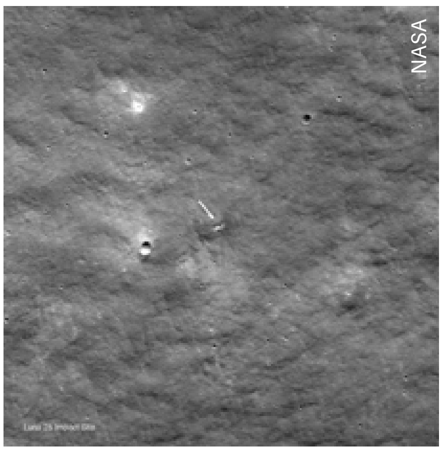
LUNA-25

Perhaps the most high-profile and recent lunar mission failure was Luna-25. As its first moon mission in nearly 50 years, Roscosmos (Russia's Federal Space Agency) attempted to reignite the Luna program to explore the Boguslawsky crater in the lunar south pole in August 2023.

The foundations of the mission began in the 1990s and plans made for an orbiter and lander, and at some point during development, discussions included a small rover – an idea abandoned to reduce weight [8]. Its completed design consisted of a lander only, whose two primary scientific objectives were: to study the components of the surface layer at the lunar poles and investigate the elements of the atmosphere there, including dust and charged particles [9]. If successful, it would have been the first lander in history to investigate the treacherous craters at the poles for ice and other precious elements – commodities that would make creating a permanent base on the Moon conceivable and invaluable.

It is no surprise that the toolkit of the 800 kg lander was impressively well-equipped to tackle this daunting task. Propped up on a four-legged base were the landing rockets and propellant, solar panels, communication equipment, computers, heaters and the eight scientific instruments. Namely, ADRON-LR, a gamma-ray and neutron spectrometer to study the surface regolith; ARIES-L, which detects charged particles and neutrals in the polar exosphere; the PML detector to study dust in the polar exosphere; and LIS-TV-RPM, an infra-red spectrometer that measures surface water (to mention a few) [9]. As you would expect, there is also a panoramic and local imaging system, named STS-L, to chart and study the unfamiliar terrain. Furthermore, the significant task of collecting samples of lunar regolith, demanded the need for a lunar robotic arm (LRA). This 1.6-meter-long arm, capable of four degrees-of-freedom/rotations, could remove and collect lunar surface material up to depths of 30cm. This impressive array of instruments underscores the substantial research prowess of the Luna-25, which was reportedly something of a pet project for Russia' President, Vladimir Putin [12].

Alas it was not to be. Luna-25 was launched into Earth Orbit from Vostochny Cosmodrome in a Soyuz-2 Fregat on August 10th. The upper stage was fired into a lunar transfer orbit, and after six days, the spacecraft reached the Moon [9]. However, after firing the engines to enter its pre-landing orbit on August 19th at 11:57, UT communications were lost [9]. The orbital maneuver went wrong after the



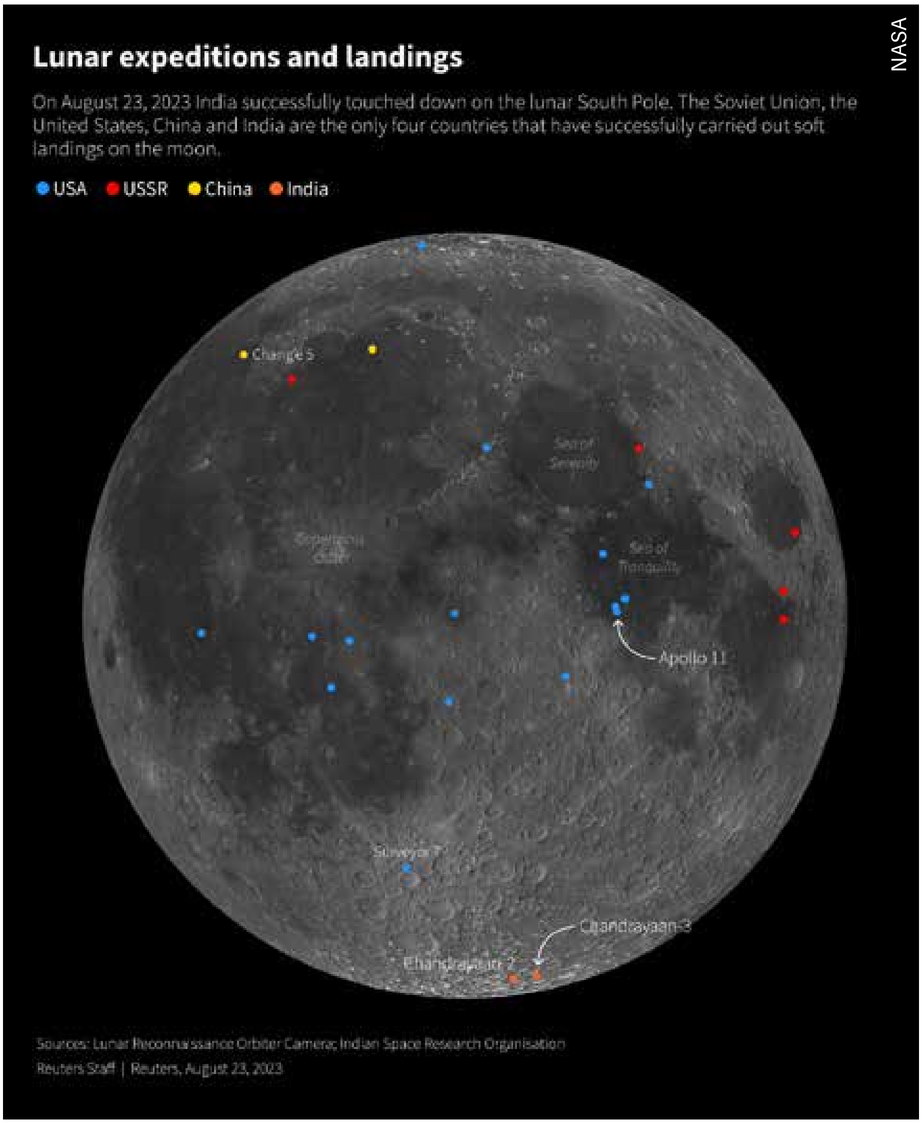
The impact crater made by Luna-25's crash landing on the Moon, as captured by NASA's Lunar Reconnaissance Orbiter.

thrusters failed to stop firing, continuing for 127 seconds instead of the planned 84 seconds, causing the spacecraft to crash-land into the Moon surface [13]. This created a crater that has now been identified by NASA's Lunar Reconnaissance Orbiter, confirming Luna-25's unplanned hard-landing [9].

Speculation abounds regarding the factors that may have contributed to the disaster. Roscosmos' Director General Yury Borisov blamed the crash on the 47-year interruption between lunar exploration [8][13]. Noting that "the priceless experience that our predecessors earned in the 1960-70s was effectively lost" and "the link between generations has been cut" [13]. Some have noted the possibility of Russia rushing to the finish line to prevent the Indians from getting to the Moon first – after all, Chandrayaan-3 arrived less than three days after Luna-25's scheduled landing [13]. It is also impossible to overlook the impacts of Russia's invasion of Ukraine. Funding has reportedly been redirected to military efforts, and Western sanctions will undoubtedly have exasperated the state-controlled space company [10][13]. One such restriction came after ESA announced it would discontinue co-operative activities with Russia on all Luna projects, even requesting that they return a navigation camera known as Pilot-D [11].

So, what does it mean for Russia's space program? While specifics of what went wrong are not yet released, undoubtedly, there will be extensive investigations. For Russia, the crash is a blow to their credibility and their status as a space trailblazer has been diminished. As the vanguard of what was planned to be a multitude of new missions to the Moon, Luna-25's failure means that, with the new invaluable currency of lunar (pole) data and experience, Russia will be poorer off than many countries – including the United States, China and now also India. Prior to the launch, Roscosmos described how they wanted to show that Russia "is a state capable of delivering a payload to the moon" to "ensure Russia's guaranteed access to the moon's surface" [12]. But like a child bringing a dish to the big parents' table of lunar exploration, Russia has stumbled on its first step, missing the chance to impress. It stands on starkly uneven footing with other states, for example China, which now has three successful moon landings [12].

Roscosmos is undeterred by this setback and will move ahead with previously outlined plans for the following three Luna missions, firmly committed to re-joining the ongoing Moon race. As somewhat of a sister to the recent lander, the upcoming mission, Luna-26, is for an orbiter set to launch in 2027 [14]. Originally planned to launch in tandem with the Luna-25 lander, the unusual decision was made to send the orbiter afterward. Its objective is to locate and quantify natural lunar resources and focus on studying the lunar surface and its environment, including cosmic rays and solar wind [14]. Initial plans were that onboard instruments were to be supplied by NASA and other private companies, but these may face potential changes due to the ongoing Invasion of Ukraine. Facing even more uncertainty than the Luna-26, is the ambitious lunar lander mission of Luna-27, scheduled to launch the following year. As a joint effort between Roscosmos and ESA, it was also supposed to utilize ESA's Pilot-D instrument designed specifically for lunar landings. It boasts an impressive fifteen instruments – almost double that of its unsuccessful predecessor – twelve of which are being developed solely or in collaboration with IKI (Russia's scientific institute for conducting space related research) [15]. Its main objective will be to study the soil composition near the lunar South Pole to prospect for minerals, volatiles and lunar ice. But it will also analyze plasma in the exosphere, lunar dust and seismic activity [15]. As the logical next step up from this, Luna-28 will be a sample return mission consisting of a stationary lunar lander and a rover with a launch recently set to be no earlier than 2030 [14]. So, while we will have to wait and see what becomes of these missions, the future Roscosmos looks promising.



Graphic showing previous successful moon landing locations. The right most red dot being Luna-24

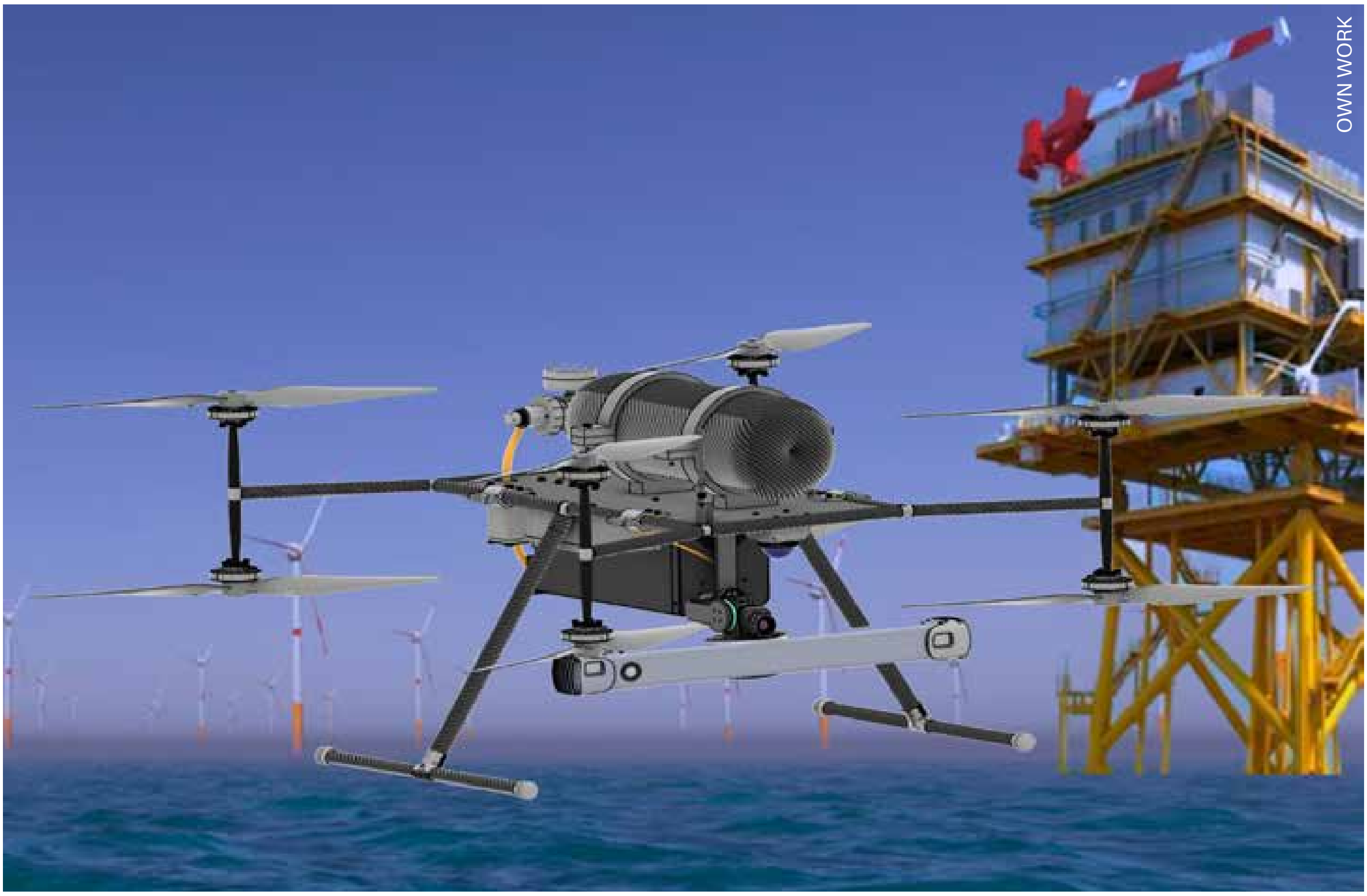
CONCLUSION

Despite their setbacks and challenges, these recent lunar missions, have at least succeeded in reigniting a collective interest in space exploration, particularly when it comes to our Moon. While past failures are disheartening – each mission has its successors armed with the experience of their predecessors, enhancing the likelihood of success. With NASA confirming their plans to send humans to the Moon once more and create a permanent base on the Moon in the form of the Artemis mission and China's Chang'e missions reconfirming the presence of lunar water ice, we stand on the verge of another highly thrilling era of lunar discovery.

DSE 2023

Some highlighted projects of the Design Synthesis Exercise 2023, the final project of the Aerospace Engineering bachelor at the Delft University of Technology.

Lisanne Vermaas, Managing Editor, Muhammad Arham Elahi, Final Editor, Naomi Lijesen, Leonardo Times Editor, Maxime Bielders, External Editor



OWN WORK

TU DELFT AEROSPACE ENGINEERING

The 1st place winners of the DSE Symposium of 2023, for the project titled "Multi-Rotor Turbine Block Design (MR-TBD)" tutored by Prof. Carlos Simao Ferreira and coached by Dr. Morgan and Ing. Stratos

DSE, or Design Synthesis Exercises, is an immersive program that ignites creativity and problem-solving skills. It challenges participants to tackle real-world issues through innovative design thinking. Here, we explore some of these imaginative solutions and how they may drive meaningful change in their respective domains.

The DSE comprises groups of 9 or 10 students working full-time for 10 weeks, with each project supervised by a professor and two coaches, typically PhD students. It often involves collaborations with industry and implementing some projects into real-life products. The DSE culminates with the Symposium, where each group presents their work to a panel of industry experts for evaluation.

SSETI EXPRESS RESCUE MISSION

Alec Sterckx
Jasmijn Tromp
Jeroen van Daelen
Jokubas Mickus
Lisanne Vermaas
Łukasz Gałecki
Marte Medina León
Martijn den Hoed
Maurits de Matos Lourenco Kuipers
Willemijn van Luik

In 2005, ESA launched SSETI Express, part of their Student Space Exploration and Technology Initiative program. The spacecraft was designed and built by students from all over Europe. It carried three CubeSats (satellites of 10x10x10cm, weighing 1kg) to be deployed in orbit and was also tasked to take pictures of the Earth. However, only a few hours into its flight, all contact with the satellite was lost and could not be recovered. Group 24 of the 2023 summer DSE was tasked to design a satellite capable of rescuing SSETI Express, and deorbit it at the end of its operational lifetime while ensuring no space debris creation.

The preliminary design of this rescue satellite was called SERUM (SSETI Express RescUe Mission) and was the end product of 10 weeks of full-time work by 10 Aerospace Engineering students, seen in Figure 1. The satellite will be launched by SpaceX's Falcon 9. Via a sequence of orbital maneuvers, it will approach SSETI Express. When in close proximity, a robotic arm will grab the failed satellite, initiating a docking procedure. The arm has an extension mechanism which will be inserted in one of the picosat deploy cavities (called T-POD). In this way, a first connection between the two satellites is obtained. The robotic arm will then move SSETI Express towards the docking side panel of SERUM. After this, SERUM will enclose one side of SSETI Express, as seen in Figure 2 and a more sturdy connection is achieved: a zond (linear actuator with circularly extending pins at the end) is inserted in SSETI Express and will press it against SERUM.

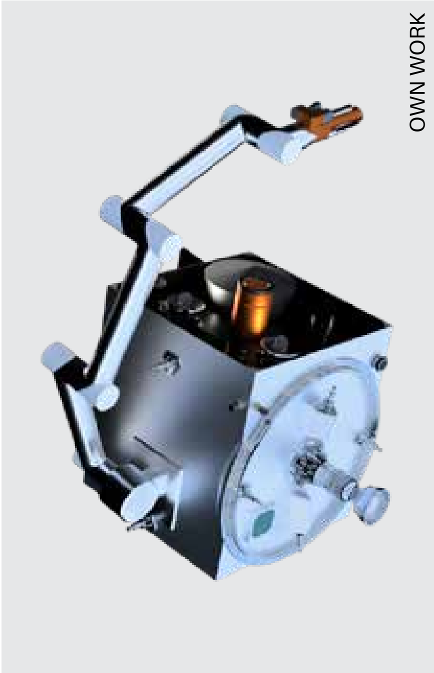


Figure 1: SERUM

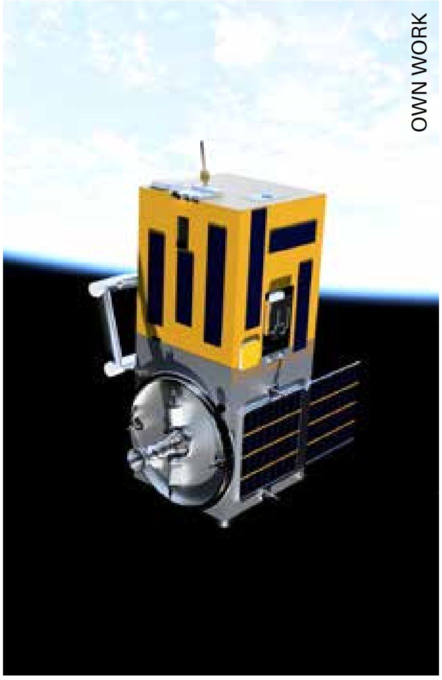


Figure 2: SERUM Docked to SSETI Express

The preliminary design of the rescue satellite has two payloads dedicated to repairing the malfunctioning satellite, the first of which is predominantly launched as a technology demonstrator: it consists of a piercing mechanism with internal endoscope Figure 3.

The enclosed side panel of SSETI Express will be punctured, to create a hole through which the endoscope can enter the insides of SSETI Express. The students have performed a test in which a similar panel was punctured with a metal spike, demonstrating that such a maneuver does not create debris (Figure 4). The instrument will then maneuver itself to the location of the failure, analyzed to be a MOSFET (electrical component). The pliers on the endoscope will intercept the wires to this component, and reroute the current to the spacecraft bus, and repair the system. The secondary repair method uses the power plug located on the outside of the satellite, which does not route the current through the failed MOSFET. After repair, SSETI Express will continue its mission for the intended two months, after which it, guided by SERUM, will perform a controlled deorbit.

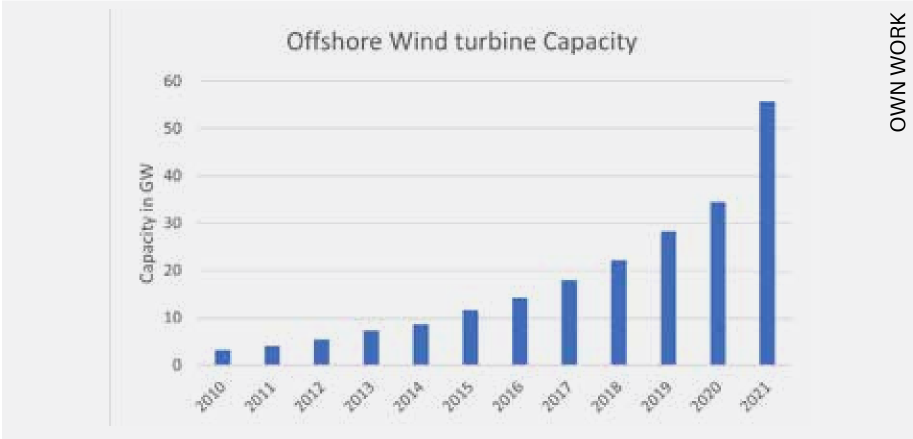
This mission provides a serum for SSETI Express, but more importantly, demonstrates in-orbit satellite repair while not producing any debris and cleaning up the orbit after its mission lifetime.

Figure 3: The endoscope out of the piercing tool, intercepting the wire

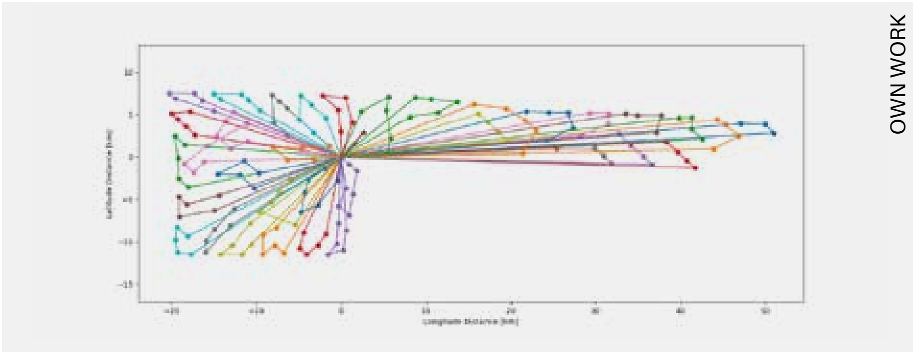
Figure 4: The test which was performed to investigate debris creation when piercing the panel

WIND TURBINE MAINTENANCE DRONE

Muhammad Arham Elahi
Nachiket Dighe
Tomás Machado
Enes Berkay Koca
Michael van Breukelen
Anton Hendrickx
Jip van Sommeren
Louis van Tienhoven
Mike Timmerman
Radu C. Serşeniu



The evolution of the Offshore Wind Energy Market



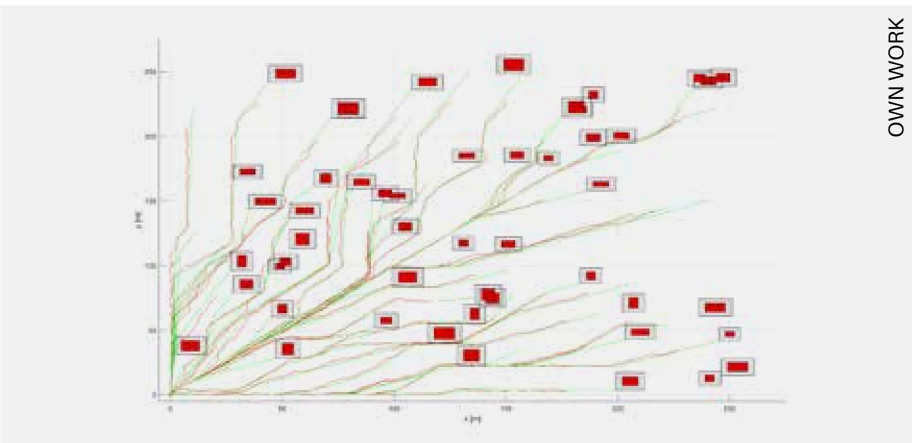
The automatically generated route for the drone to follow to cover all the turbines in a large wind farm

In the ongoing pursuit of sustainable energy solutions, wind power has emerged as a promising source of clean and renewable electricity. Wind turbines, towering on the horizon, harness the wind's energy to power countless homes and businesses worldwide. However, meticulous maintenance is essential to ensure the longevity and performance of these elegant giants,. Doing this manually would require extremely skilled and brave workers hanging off rope harnesses and tapping the turbine with a hammer to check for defects. However, innovation over the last decade in the world of wind energy has led to the use of wind turbine maintenance drones. Group 2 of the 2023 Summer DSE had the challenging task of designing an Autonomous Drone for Wind Turbine Maintenance Inspections.

Examining the market, it became evident that drones had become commonplace in the wind energy sector. However, the majority of them still required human operators for management and deployment. It significantly increased the operating costs, encompassing not only employee salaries but also transportation and logistics expenses. Another issue that surfaced were the stringent regulations surrounding autonomous drones when operating on land where people and animals might be present; these regulations still necessitated a human supervisor at all times. Furthermore, the market was highly competitive, with all wind turbine manufacturers tied up in agreements with their respective maintenance service providers. Therefore, the team needed to explore opportunities elsewhere.

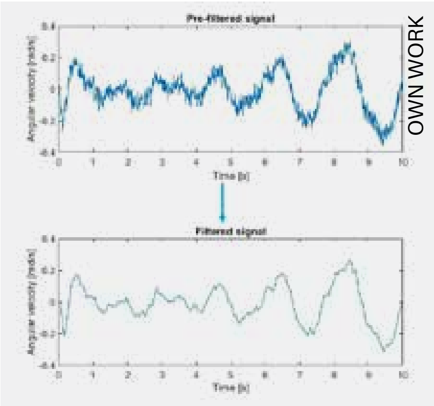
Offshore wind farms represent an emerging market that is experiencing exponential growth. The offshore turbines are notably larger, more structured, and densely positioned, leading to enhanced energy production efficiency. The consistent and high-speed offshore winds, unobstructed by natural or man-made structures are primary drivers behind the increased performance. However, the significant distance of these turbines from the shore presents various challenges. These include; the costly transportation of parts to the offshore location, installation of cables and their incurred energy losses, and the highly complex maintenance in this offshore environment. Commercial off-the-shelf drones powered by batteries have a limited flight time of only 20 minutes when carrying a payload. Consequently, these drones can only inspect one wind turbine at a time and must be transported to the base of each turbine for inspection. Transporting the drone to and from the offshore location requires a boat rental, significantly adding to the service's overall cost (approximately 10,000 euros per day!).

This is where the team identified a significant opportunity to reduce transportation costs and minimize the need for constant human supervision during drone operations. To achieve this, the drone would be stationed at the wind farm substation, serving as its operational base. They resolved the primary challenge of limited drone endurance by switching from batteries to hydrogen power, which dramatically increased the flight time from around 20 minutes to over three hours. With this remarkable performance improvement, the drone could inspect multiple turbines on a single trip, up to six at a time, without needing a boat. However, this innovation raises the question of refueling the hydrogen tank. Fortunately, this issue can

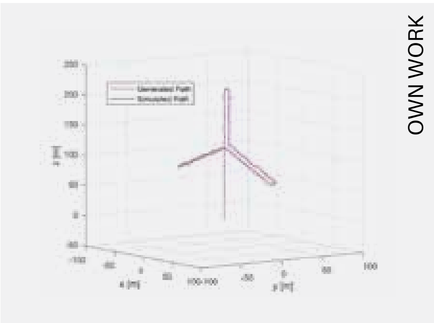


Navigation Model allows drone to travel from point A to point B while avoiding all obstacles (50 randomly start and end points in the image)

AI Model implementation which recognizes damage with a level of certainity



Input Signal Filtering to ensure smooth operation



Guidance Model allows the drone to track a preset path (in this case along the edge of a turbine)

be easily addressed by either transporting a hydrogen tank to the substation (requiring a maximum of 3kg of hydrogen even for the largest wind farms in the world) or by utilizing a hydrogen generator. Hydrogen generators are not typically found on substations, but this could change due to the energy loss observed in cables. Beyond a certain distance from the shore, it becomes more energy-efficient to use electricity to convert water into hydrogen and transport the hydrogen back to shore. There, it can either be used directly as fuel or converted back into electricity.

In addition, the drone has a Control Guidance and Navigation system that can autonomously map out its route with just the coordinates of its destination. Its onboard LIDAR sensor enables it to react instantly to any approaching and unforeseen obstacles. Furthermore, it has a visual camera (typically the sole inspection tool in conventional maintenance), a thermal camera and a 3D scanner to enhance imaging resolution and cover a more extensive range of potential failure modes. This advanced technology is complemented by an AI model trained on thousands of labeled images of wind turbines, enabling accurate assessment of the turbine condition.

In conclusion, an autonomous drone has been designed with the capability to not only fulfill the role of commercially available manually piloted drones but also surpass their performance in almost every aspect. These alterations prove especially valuable for offshore wind farms, for which conventional methods are not particularly tailored.

WINGS FOR AID

Torben L. R. Aalbers,
Maxime J. M. Bielders,
Tim N. A. den Blanken,
Theo P. R. Huegens,
Ties H. Leniger,
Linda Mahajna,
Jarno J. Platenburg,
Bram A. A. Staps,
Jan Vonken,
Jan T. Wiącek

Wings for Aid is a company on a mission to tackle the "last mile" hurdle in humanitarian aid distribution. This challenge involves delivering essential aid to isolated communities affected by natural or man-made disasters. The approach to solving this problem utilizes pinpoint accuracy air dropping of standardized boxes that contain up to twenty kilograms of humanitarian aid each. Driven by a cost-efficient strategy, they aim to achieve delivery rates two to four times lower than traditional truck transport. Furthermore, The aircraft must fit into a standard 40-foot ISO container to enhance logistics.

The objective of Group 18's DSE project was to design an aircraft capable of air-dropping ten to twelve aid boxes across a 250 kilometers range. The target price-tag of such an aircraft was aimed at €25,000 or lower, ensuring the cost per kilogram of payload delivered stays below €0.96. But that's not all. The project takes its cues from customer demands, emulating the payload delivery capacity of a C130 Hercules aircraft. Meaning a squadron of 20 to 30 aircraft shall be deployed every operation. Therefore, the mission objective, also entails the design of an operation with multiple of these aircraft. This includes everything from the deployment decision and on-site assembly to the end of the mission, disassembly and storage.

The first step in the design process consisted of meticulous project organization and planning, laying the foundations for the project, generating the design options. While making crucial trade-offs, it became apparent that certain subsystems options were limited. For example, a high, braced wing tractor configuration was necessary due to loading and terrain constraints. Also, the empennage is mounted on a boom and full moving horizontal tailplanes are utilized. A render of the concept can be seen in the figure. The aircraft boasts a truss structure which better facilitates the dropping of the boxes, and it operates on about 60 liters of fuel per sortie (where the sortie time for a range of 250 kilometers is around three hours, with a cruising speed of 100 to 110 knots). During an operation, 20 to 30 aircraft are assembled on site by mounting the wings and the horizontal tailplanes. Boxes are loaded via hatches that cover the side of the aircraft. A human operator performs the in-flight dropping of the boxes with to ensure a safe drop zone to the aircraft. The boxes are dropped using gravity and have self-deploying flaps that stabilize and slow the box, guaranteeing an impact within limits.

In conclusion, Wings for Aid successfully delivered a fully realized aircraft design, accomplishing the critical mission of transporting 10-12 aid boxes across a 250 km range. While cost-efficiency remained principal throughout design, the initial targets were exceeded somewhat, with the average unit cost at €41,300 and the payload delivery cost at around €1.50/kg. This group was exceptionally fortunate in its seamless collaboration, with each member effectively playing to their strengths and preferences. As the culmination of the project approached, they dedicated themselves to preparing for the DSE symposium, where Wings for Aid achieved a commendable 3rd place overall. This achievement is a testament to the group's diligence and the project success.

CONCLUSION

A spectacular sendoff is just the beginning for JUICE and it still has a long voyage to go. It will be less than a decade before it can bring us a fresh taste of the mysteries of the Jupiter system, but it will, without a doubt, quench our thirst for knowledge about our own Solar System and worlds beyond.

A rendering of the designed aircraft, in the process of a humanitarian aid box-drop

SPACE

THE DARK SIDE OF THE MOON

How India sent a rover to the south pole of the moon

Chaitanya Dongre, Leonardo Times editor


ISRO

Days after Russia's Luna 25 failed to perform a soft landing, India successfully landed its rover on the south pole of the Moon, making it the first nation to achieve this monumental goal. Let's dive into this ambitious mission and discover what it means for Moon exploration.

WHAT IS "CHANDRAYAAN"?

Chandrayaan, Sanskrit for "Moon Craft", is the Indian Space Research Organisation's (ISRO) program for research and exploration of the Moon. Its first edition, Chandrayaan-I, was a lunar orbiter and impactor launched in 2008 with the main goals of searching for surface and subsurface lunar water ice at lunar poles. It aimed at obtaining high-resolution chemical and mineralogical images of the permanently shadowed North and South polar regions. Even though contact was lost with the spacecraft halfway through the mission, 95% of its primary objectives were complete. The mission confirmed the Magma Ocean hypothesis of the Moon and enabled scientists to study the interaction between solar winds and a planetary body without a magnetic field. It also detected ice on the Moon and helped confirm the presence of water ice on its surface [1].

However, the subsequent Moon missions did not go forward without setbacks. In September 2019, the Vikram Lander of the second edition of the Chandrayaan mission crashed on the surface of the Moon. The mission aimed at examining the south pole of the Moon and the exosphere, the surface, and the sub-surface of the Moon [2]. It consisted of an orbiter, a rover, and a lander. The lander Vikram was named after Vikram Sarabhai, founder of the cradle of space sciences or the Physical Research Laboratory (PRL) in India [3]. Unfortunately, the lander's trajectory drifted from its original intended path above the Moon's surface and caused a catastrophic crash. The lander managed to impact near the site of landing. However, the remains of the spacecraft were scattered around various locations in an area spanning kilometers. The crash investigation revealed that it occurred due to a software glitch. This crash was immensely disheartening for the scientists at ISRO, who pride themselves on fueling their missions with passion, and operate on a highly cost-efficient budget. Even so, the orbiter from the mission continues to be operational and is conducting its seven-year mission to examine the Moon [4].

LEARNING FROM FAILURE

In November 2019, ISRO announced the follow-on mission to Chandrayaan-II. This mission would be their second attempt to demonstrate an end-to-end capability in a soft landing and roving on the southern lunar surface. The mission would then conduct in-situ experiments on the materials available on the surface of the Moon to better understand its composition. This highly ambitious mission was estimated to cost around US$90 million. The low cost was attributed to local sourcing of equipment and design elements [5]. Chandrayaan-III, consisting of the lander Vikram and the rover Pragyan, was launched on 14 July 2023. Vikram made a touchdown on 23 August 2023, making India the first country to perform a soft landing on the south pole of the Moon. Subsequently, Pragyaan also rolled out.

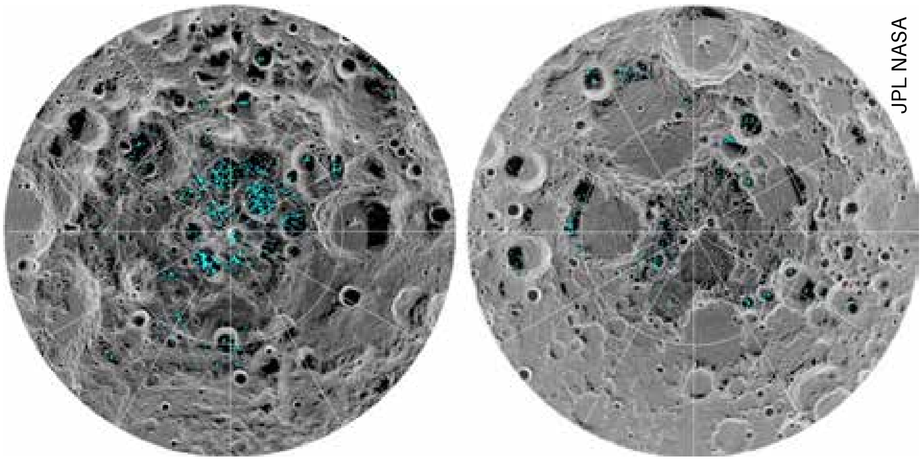


Figure 1: The distribution of surface ice at Moon's south (left) and north (right) poles, detected by NASA's Moon Mineralogy Mapper (M3) instrument aboard Chandrayaan-I

CHANDRAYAAN-III

The current edition of India's Moon mission consists of an indigenous lander module (LM), a propulsion module (PM), and a rover. The lander module weighs 1752 kg, which includes the weight of the 26 kg rover. In total, the propulsion and lander modules weigh 3900 kg. The rover is similar to the rover on Chandrayaan-II, with certain improvements to ensure a safe landing. The propulsion module is a box-like structure with a solar panel mounted on the side and a large cylinder on top. The nominal power generated by the side-mounted solar panel is 738 Watts. The communication transmits via an S-band. The attitude sensors consist of a star sensor, a sun sensor, an inertial reference unit, and an Accelerometer Package (IRAP). The lander is also box-shaped with dimensions of 200x200x116.6 cm and has four landing legs and thrusters. It has several sensors, such as altimeters, accelerometers, touchdown sensors, inclinometers, and cameras to avoid hazards and to provide positional knowledge, as shown in Figure 2 [6].

The lander and the rover come equipped with scientific payloads. These instruments have specific functions to accomplish and particular phenomena to collect data on. The propulsion module will remain in orbit around the Moon and act as a communications relay satellite. Its payload has the Spectropolarimetry of HAbitable Planet Earth (SHAPE). SHAPE aims to discover minor planets in reflected light to allow us to probe into exoplanets qualified for habitability in the future. It can also detect the presence of life. The rover has a rectangular chassis of 91.7 x 75.0 x 39.7 cm. It is mounted on a six-wheeled rocker bogie and includes a Laser-Induced Breakdown Spectroscope (LIBS) for the qualitative and quantitative elemental analysis. It also seeks to derive the chemical and mineralogical composition of the Moon's surface. Along with LIBS, the rover Pragyaan is equipped with an Alpha Particle X-ray Spectrometer (APXS) to determine the elemental composition of the Lunar soil and rocks around the landing site. It also has navigation cameras and a solar panel capable of generating 50 Watts of power [5][6].

The lander comes equipped with Radio Anatomy of Moon Bound Hypersensitive Ionosphere and Atmosphere (RAMBHA) to measure the surface plasma density and the deviations with time. It also consists of Chandra's Surface Thermophysical Experiment (ChaSTE), which serves to carry out measurements of the thermal properties of the lunar surface near the polar region. The Instrument for Lunar Seismic Activity (ILSA) will examine seismic activity near the landing site and delineate the lunar crust and mantle. Lastly, the dynamics of the Moon system are set to be understood by the LASER retroreflector Array (LRA). The lander's propulsion system is a bi-propellant (MMH+MON3) with throttle-controlled engines capable of providing 800N of force each. The lander also consists of the lander legs, the rover ramps, and the rover itself. It uses an X-band antenna for communication, while the rover can only communicate with the lander [5].

MISSION PROFILE

Chandrayaan-III's lander and rover have a mission life of one lunar daylight period or

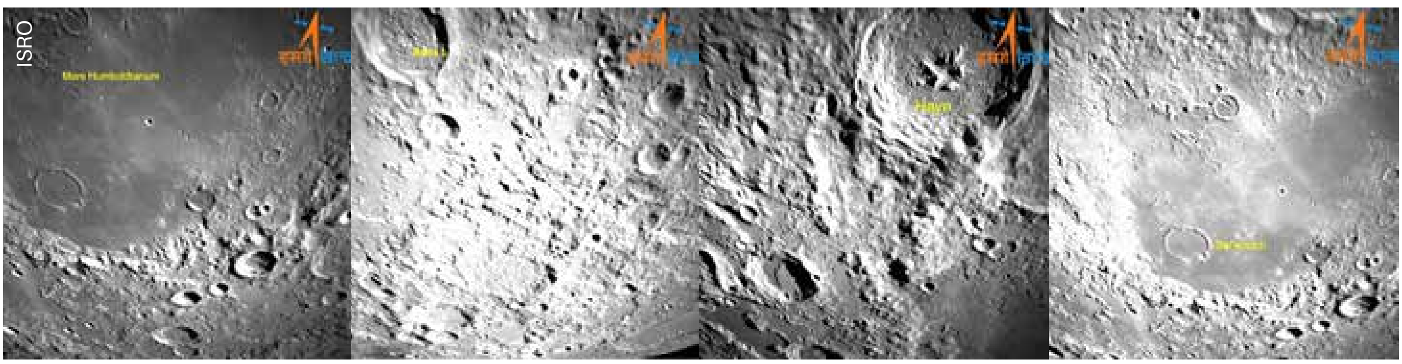


Figure 2 : Lunar far side area imaged by Lander Hazard Detection and Avoidance Camera (LHDAC)

fourteen Earth days. On the 5th of August 2023, Chandrayaan-III entered lunar orbit. The orbit attained was 164 km x 18074 km as planned. The spacecraft then underwent multiple maneuvers to decrease its altitude. On the 17th of August, the lander module separated from the propulsion module. After that, deboosting was performed and the lander began its powered descent towards the surface. Upon its touchdown on the 23rd of August, the rover emerged from the lander and drove down a ramp to start its exploration of the lunar environment.

The lander and the rover spent two weeks gathering data and conducting experiments on the Moon. Chandra's Surface Thermophysical Experiment (ChaSTE) provided data for the first profile of temperature variations of the lunar surface or near-surface at various depths at the lunar south pole. ChaSTE's controlled penetration mechanism can reach a depth of 10cm beneath the surface. The probe also has 10 individual temperature sensors [7]. Later, The Laser-Induced Breakdown Spectroscopy (LIBS) made in-situ measurements on the surface and confirmed the presence of Sulphur in the region. This was not previously possible using the instruments onboard the orbiters. LIBS exposes materials to intense laser pulses and analyzes their composition by focusing it onto the material's surface. The laser pulse generates an extremely hot plasma. This plasma light is spectrally resolved and detected by charged coupled devices. The particular wavelengths emitted help in identifying the elemental composition of the material [8].

The Radio Anatomy of Moon Bound Hypersensitive Ionosphere and Atmosphere - Langmuir Probe (RAMBHA-LP) onboard the lander conducted measurements of the surface-bound Lunar plasma environment. Langmuir probe is a device used for characterizing a plasma. It has a 5 cm metallic spherical probe mounted on a 1-meter boom attached to the lander's upper deck. The extended boom length ensures the operation of the probe in an undisturbed plasma environment isolated from the lander's body. The system is capable of detecting minute return currents. Upon applying a sweeping bias potential ranging from -12 to +12 V in increments of 0.1 V to the Langmuir probe, the system can accurately determine ion and electron densities and their energies based on the measured return current.

The initial evaluation indicated that the plasma encompassing the lunar surface is relatively sparse, characterized by a numerical density ranging from approximately 5 to 30 million electrons per cubic meter. This evaluation is specific to the early stages of the lunar daytime. These observations have significant implications for understanding the charging process within the lunar near-surface region, particularly in response to the fluctuations in solar space weather conditions [9].

The Instrument for Lunar Seismic Activity (ILSA) recorded vibrations occurring due to the payloads and the Rover movements. It has a cluster of six high-sensitivity accelerometers fabricated using the silicon micromachining process. It recorded vibrations during the rover's movement. The most significant was a natural seismic event that lasted for about 4 seconds. The cause of this event is still under investigation [10]. Additionally, the rover could safely navigate around craters (seen in Figure 3 and Figure 4), which indicates environmental awareness and good communication with the command center. The primary goals of the mission were completed. On the 4th of September, upon the onset of lunar night, the lander and the rover were sent into sleep mode. Although not designed for the freezing conditions during the lunar night, ISRO wants to try and wake them up.

CONCLUSION

Even though the lander and the rover have not woken up yet (as of November 2023), Chandrayaan-III perfectly showcases the grit and capabilities of the Indian Space Research Organisation. Turning adversity in their favor to complete their mission and performing this complex feat is certainly a thing to be very proud of.

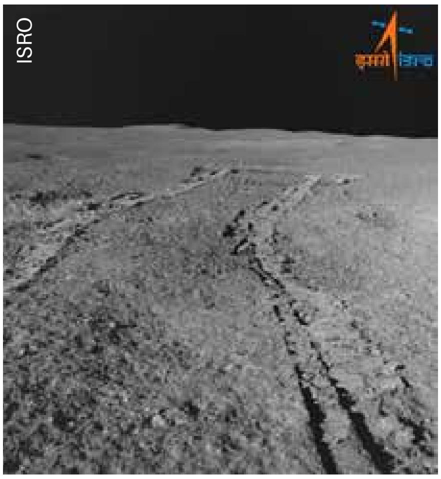


Figure 3 : Path retraced by Pragyaan, away from the crater

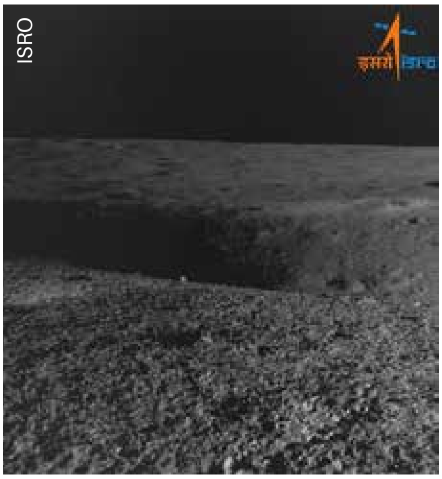


Figure 4 : Crater imaged by the navigation camera onboard the Pragyaan rover

Figure 5: Vikram lander on the Moon

UNCONVENTIONAL LANDINGS

When traditional runways are not an option

Gerard Mendoza Ferrandis, Leonardo Times Editor

C&O

A Boeing C-17 Globemaster III taking-off at Antarctica. The markers make the end of the ice runway more visible

While it is routine for all pilots, it is without question that landing is probably the most significant and complex phase of flight. However, the complexity of landing is much greater when performed where no runways exist.

THE MOST CRUCIAL PHASE OF FLIGHT

Approximately one-third of all aviation accidents in the past decade occur during approach and landing [1]. Certain airports make this even more difficult. Some have extremely short runways, such as Lukla Airport in Nepal, while others demand intricate maneuvers through rugged, mountainous terrain, such as Paro Airport in Bhutan, necessitating specially-trained pilots.

Nevertheless, as hard as these landings can be, they still perform a conventional landing, on a runway specially adapted and tailored to the needs of the aircraft and the airport. However, another breed of pilots exists whose entire training involves landing in places where no runways are available. This may be due to lack of infrastructure or in the event of an emergency, making their expertise in such unconventional landings invaluable.

ICE LANDINGS

The reader might be curious about what makes an ice landing truly unconventional, as many planes land at airports where snow or ice covers the runway. The crucial difference is the level of risk involved. Airports where snow conditions are the norm are usually equipped with the necessary machinery and personnel that can swiftly address the conditions to aid the safe landing of aircraft: they have the means to de-ice runways, quickly respond to emergencies, and can divert landings if icing conditions become too severe.

On the other hand, genuine ice landings occur on runways that are essentially frozen slabs, where the very surface beneath the aircraft is made of ice. Think of landing on glaciers, in the Arctic Circle, or in Antarctica, where icing conditions are unavoidable. This section will focus on Antarctica, the most extreme example of ice landings. So, how do pilots land on the white continent?

THE CHALLENGES OF ANTARCTICA

Flights to Antarctica are restricted and strictly timed and scheduled, so there are about 70-80 flights in a season [2][3]. There are about 50 runways in Antarctica, each with different capabilities, but the main aeronautical hub is located in the Ross Ice Shelf. It is located in close proximity to the McMurdo and Scott Bases thanks to a vast ice expanse that can be readily converted into runways.

In order to make an ice landing in Antarctica, you must undergo special training, including survival training, should things go wrong [2][4]. Consider that for six months most of Antarctica is in a perpetual night. Not only that, but due to the changing weather conditions, there may be no runway lighting or a light-out, so pilots must learn how to land on the ice while blind [5]. Conversely, when sunlight is abundant, the whiteness of the surroundings presents its own challenges. Snow and ice can create blinding reflec-

Picture of the first Airbus A340 landing in Antarctica. The grooves made on the ice to increase the grip are visible

tions, making it difficult for pilots to transition from instrument monitoring to visual flight. To combat this, pilots wear special eyewear, but there are some inconveniences that can only be overcome through experience. For example, there is often no discernible reference point when coming in to land, as the white runway seamlessly blends into the Antarctic desert, making it challenging to gauge your approach height without relying on instrumentation [5].

Flying an aircraft so far south also requires special equipment. For example, fuel that will not freeze under extremely low temperatures, and sometimes even ski-fittings (runways for ski-landings are called "skiways") in the landing gear to facilitate the touchdown and rollout [4]. Furthermore, replacement parts for the landing aircraft are sent in advance and equipment such as refueling stations are periodically checked to prevent the aircraft from being stranded for long periods of time if maintenance is required [2][3]. Before the landing, special snow groomers create a freshly-grooved surface that facilitates the grip between the wheels and the ice [5]. However, due to the low friction coefficient, most of the braking when landing in Antarctica is performed using reverse thrust [4].

Planes that land in Antarctica are usually retrofitted military, heavy-duty, or small planes, but recently, more and more firsts are being made in the world of Antarctic aviation, such as the first Airbus 340 and the first Boeing 737 MAX [2][5].

WATER LANDINGS

Water landings are a more frequent occurrence in comparison to the pure ice landings in Antarctica. However, while landing on ice has many additional difficulties, it essentially involves touching down on a flat, expansive surface, similar to a typical landing. On the other hand, water landing is a whole new realm of complexity. Aquatic landings are more common in remote regions where constructing conventional runways would prove problematic due to geographical constraints, local wildlife, or protected environmental status. They are performed at "water airports" tailored for water landings, also referred to as "seaplane bases" or "water aerodromes", and can be located on the coast or in rivers, but are typically placed in lakes due to their natural reduction in wave intensity and currents.

There are two main types of seaplanes: flying boats and floatplanes. The difference lies in how they land. Flying boats land on

Amphibious flying boat performing a water landing. Despite landing on its fuselage, it also has floaters on its high wing in case of rough waters

US Airways Flight 1549 after ditching into the Hudson River. All of the passengers and crew safely evacuated the aircraft

their fuselage, which is designed as a boat's hull, while float planes land on fixed landing gear fitted with floaters. The latter is the most prevalent, especially in general aviation, as many small commercially-available airplanes can be retrofitted with pontoons, enabling them to function as seaplanes. Many even keep their conventional undercarriage as well and become amphibious! [6]

LANDING IN THE WAVES

When landing these planes, the procedure is similar to conventional landings: a low-speed approach, followed by a gentle flare and a touchdown. However, there are several critical considerations to bear in mind. Firstly, water exerts significantly more resistance than rolling landing gear on solid ground, resulting in a more pronounced deceleration [6]. This drag will induce a nose-down attitude on touchdown, which can be counteracted by maintaining a higher nose attitude during the landing approach. Secondly, the dynamic nature of water environments introduces an element of unpredictability, therefore hazardous objects may float or surface into the designated landing area, necessitating a precautionary fly-by or orbit around the intended landing zone to assess the risks. Thirdly, viewing water from elevated altitudes may lead to optical illusions, such as creating a false impression of calmness, potentially leading to missed approaches if the conditions are misjudged. Conversely, excessively-calm water can be perilous, as it often signifies shallow depths in the vicinity, which can lead to the aircraft becoming lodged. Once the aircraft is situated on the water, a water rudder deploys to assist with taxiing operations, which can also get stuck if the shallowness is misjudged. [7]

While the suitability of water landings often falls under the pilot's discretion, in the cases of very rough waters, the pilot should follow some standard recommendations. It is usually recommended to land facing the wind, making the approach as smooth and low as possible to take advantage of ground effect. Furthermore, while a high-pitch attitude is recommended, to mitigate the risk of bouncing off high waves, it is advisable to land and taxi perpendicular to the waves. In addition, the wave pitch and height must be assessed as some pitch-height combinations could lead to the aircraft capsizing. [8]

DITCHING: THE UNSCHEDULED WATER LANDING

It's important to highlight that, in the event of an emergency, airline pilots are trained to perform water landings following a similar protocol as described for seaplanes. The additional challenge when landing a commercial airliner on water is the positioning of the engines, which can rapidly dig into the waves, leading to significant accelerations and an abrupt nose-down motion, much like when the pontoons of a floatplane dig into the waves. This is the most critical point during ditching attempts. However, despite ditchings being a highly unlikely event, in order to enhance post-crash survivability, some aircraft such as the Airbus A320, A330 and A340 have incorporated a "ditching switch". This attempts to minimize the influx of water into the plane by closing all ports and holes in the plane hull [9].

In the last 100 years, there have been more than 40 ditchings of aircraft, with the leading cause of death being the inappropriate use of life-jackets. The most famous one was performed by Captain Chesley B. "Sully" Sullenberger, landing a full Airbus A320 on the Hudson river, skillfully saving the lives of all 155 on board.

CONCLUSION

The world is a very diverse place and, since the inception of aviation, we have fought hard to reach its most inaccessible places by airplane. Unconventional landings play a key role as, due to their intrinsic geography or protected biodiversity, it is impossible to place a runway in some of the most inhospitable places on Earth.

Places like Antarctica have vast expanses of flatness where infrastructure is impossible to construct, leaving ice landings as our only alternative. Places surrounded by mountains or dense forests but with the presence of a lake or a river make a water landing an attractive option.

These landings are undeniably challenging, but they expand the scope of scientific research, facilitate humanitarian aid missions, and establish crucial resources and infrastructure in the most remote corners of our planet. By conquering these challenges, these skilled pilots contribute to the broader mission of human exploration and development, reminding us of the indomitable spirit of aviation in overcoming nature's barriers.

DA VINCI SATELLITE

From inception to orbit: How a satellite project run entirely by students plans on inspiring young minds about space

Deborah Cardoso, External Relations Manager, and External Relations Team, Da Vinci Satellite

At the start of 2020, the education team went by the International Primary School in Delft, which is still one of the closest partners for the development of the education modules

In the field of Aerospace Engineering, education and innovation often come together to pave the way for groundbreaking projects. The journey of Da Vinci Satellite, from its conceptualization to its current state of development, is a testament to the fusion of student passion and the pursuit of inspiring future generations. Originating within the Aerospace Engineering faculty at TU Delft, what began as a preliminary design for a CubeSat evolved into an ambitious goal to launch a satellite that not only explores space but also serves as a unique educational monument.

THE INCEPTION OF DA VINCI SATELLITE: FROM CONCEPT TO REALITY

In the BSc Aerospace Engineering course at TU Delft, students must go through the Design Synthesis Exercise (DSE) in their final year in order to obtain their diplomas. During this activity, groups of students are put together to collaborate on a ten-week project to make a design in the aerospace field . In the academic year of 2018-2019, one of these groups worked on a preliminary design of a CubeSat, supervised by Dr. Ir. Chris Verhoeven, subsequently presented to a group of experts from the Dutch space industry.

Around that time, the 75th anniversary of the VSV 'Leonardo da Vinci' was approaching. For this occasion, a special monument was requested - a spot occupied by this CubeSat. As a student association, it was in their interests to launch an education-focused project. Therefore, to launch a satellite with the primary purpose of educating and inspiring children about the field provided them with this unique, impactful monument. It was then decided: a new team formed to work out the preliminary design in detail and bring the idea to life, and thus, the Da Vinci Satellite project as we know it now started taking form in 2020. Together with it, its mission statement also took shape: inspire and enthuse the youth of the Netherlands for technology and space travel while emphasizing the impact of space travel on our society.

The plans, milestones, and goals set for a project can look very different when executed in real life. For such a substantial project, setbacks can be expected in various areas, not only when it comes to technical components but also due to funding, lack of manpower, and so on. Since its start, Da Vinci Satellite has had to learn how to keep running in the face of adversity, and its members have seen their fair share of ups and downs. Despite that, these obstacles have provided the students with essential skills: teamwork, problem-solving, and - perhaps most importantly - determination.

In order to cope with the changes and challenges, the team has gone through different phases. New roles have been created, subteams expanded, and goals modified or formulated. Today, the Da Vinci Satellite team looks very different from its original format, but thanks to these changes, the team has accomplished what it has so far.

UNVEILING DA VINCI SATELLITE TODAY: A CLOSER LOOK

The current project is divided into four main teams, each with their respective sub-teams, all overseen by the Team Manager. The technical team, divided into smaller groups focusing on software, electrical, systems, and so on, was charged with the design and construction of the satellite itself. To cater for the differing interests of both primary and secondary school students, the team developed two distinct payloads.

The payload designed for primary school was inspired by the students, who requested the ability to play a game in space. The team decided to replicate a unique dice game housed within a transparent compartment of the satellite, developed with the help of the Leidse Instrumentmakers School (LIS). This design captures images of the dice against the backdrop of our planet Earth. These images are then sent back to the students in their classrooms.

Meanwhile, the payload tailored for secondary students delves into how the space environment influences a digitally stored image. Once students dispatch an image to the satellite, the payload engages in a process known as "bit flipping". Cosmic radiation, temperature fluctuations, and power variances cause alterations of individual bits stored in an electronic device, switching 0s to 1s and vice-versa. Since an image in its electronic format comprises of 0s and 1s,

In 2021, the payload team went on their first zero-gravity flight test in order to test the functionality of the dice payload in a zero-gravity environment

this phenomenon makes the colors and shapes slightly distorted. Therefore, the activity teaches students the practical applications of mathematical probability, and also bit representation in computer systems.

The Da Vinci Satellite project embarked on an ambitious journey from its start, dedicated to the design and construction of a satellite destined to launch into space. Nevertheless, the primary project objective extends beyond reaching orbit; it centers around the remarkable educational opportunities that it will offer after the launch. The main goal of the project lies within its educational aspect: becoming the only educational CubeSat in the world. Therefore, the Education team of the project has the essential task of paving the way to make the project successful.

The Education team comprises two subteams, one dedicated to primary school groups and the other to secondary school ones. They are developing multiple educational modules which will become accessible without any associated costs. These modules encompass elements such as lesson plans and masterclasses, which go hand-in-hand with the satellite's payloads, and demand minimal supplementary tools, rendering them truly accessible. The primary school sub-team has collaborated with international primary schools to develop lesson plans, and the secondary school subteam has focused on crafting masterclasses touching topics such as interplanetary travel to black holes. Furthermore, these educational modules focus on nurturing student understanding of Computer Science.

While the Education and Technical teams are the two pillar components of the project, the Da Vinci Satellite project receives vital support from various auxiliary teams -the Business team, divided into External Relations and Finance, and the Public Relations team. Together, they take care of funding efforts, expanding the project's outreach, gaining partnerships, and other multifaceted responsibilities necessary to keep the project running. Thanks to these efforts in particular, the project has gained partnerships with big names such as Airbus and NLR (Royal Netherlands Aerospace Centre); and enable the team’s participation in prestigious events like the ESA Open Day at Katwijk.

BEYOND ORBIT: DA VINCI SATELLITE'S VISION FOR THE FUTURE

Despite having an unwavering focus on the essential day-to-day tasks, the Da Vinci Satellite team is already starting to look up to the sky. The satellite underwent many alterations, and the project members are working tirelessly to reach its final version. Testing plays a vital role in the everyday routine of the technical teams, and its results are detrimental to setting the final launch date.

While half of the team works hard to launch the satellite into space, the other half is already investigating collaboration with schools and organizations to accomplish the final mission: to reach the classrooms. Hand-in-hand with this goal, is developing a new website. The ultimate aim is to form an interactive environment to accomplish three issues: Firstly, a platform where students can access educational material, images of the payload and upload pictures to the satellite. Secondly, a platform for teachers and guardians containing teaching packages and customer support. Finally, the website is an E-learning environment for younger students who can access online games and interact with the satellite itself to continuously learn about space-related topics.

CONCLUSION

While the team still has to account for big challenges before the launch date, its current and past members can look back with pride at the progress made so far. As the final steps that lead up to the stars are slow, but sure, climbed one by one, the Da Vinci Satellite team is menjoying the ride while they can. After the launch, the project will continue "elevating education", and inspiring the upcoming generations about the wonders of space.

In 2022, students of the International Primary School in Delft got the opportunity to pose questions they wanted to ask the stars and later categorized and created presentations surrounding these questions

A recent picture of some of the members of the team

THE SPACEFARING AIRLINER

Why the Space Shuttle Cockpit looks so familiar

James Perry, Leonardo Times editor

C&O


NASA

The Space Shuttle was the height of aerospace technology, but its cockpit bears a remarkable resemblance to commercial airliners. To find out why invites a deep dive into the history of both.

When STS-1, the first Space Shuttle mission, launched in 1981, the world had never seen anything like it. An orbiter which could be piloted to the ground to land like a glider and then reused sounded like fantasy in a world where spacecraft up to that point had looked more or less the same. The technological leaps in the development programme are unparalleled, and yet the cockpit looks strikingly familiar. In fact, during its lifetime, the Space Shuttle has had two slightly different instrument panels, when the Multi-function Electronic Display System (MEDS) replaced the original Cathode-Ray Tubes (CRTs) around the turn of the century [1]. And yet both resemble airline cockpits of different eras, the original, more traditional analogue cockpits and the upgraded version more similar to the glass cockpit of modern airliners. The systems of the Space Shuttle are remarkably different to any aircraft, at the time or since, so how did this come about?

THE SIX PACK

Perhaps the best place to start is the beginning, over 100 years ago at the Wright brothers' very first flight. They had very few flight instruments: a stopwatch, a tachometer showing engine RPM and an anemometer (wind meter), and in fact, no cockpit at all as the pilot lay on the wing [2]. Navigation wasn't a problem because they didn't fly far or high, and as they only dared to fly in perfect weather conditions, it was always possible to fly the aircraft by eye [3]. As aircraft became more complicated, specific instruments became necessary to allow for navigation and avoid accidental stalls. Pilot comfort became a consideration, and so the first cockpits were developed. When the age of airlines came along, there became a need to fly in poor visibility and at night. In 1929, General James H. Doolittle (most famous for the Doolittle raids of WW2) carried out the first flight only using instruments, from take-off to landing [4]. We still use these basic flight instruments today, in addition to variants of the same radio navigation aids, as the aircraft was guided on its approach by radio beacons on the ground.

There are six basic flight instruments, common to practically every powered aircraft, often referred to as the "six pack" due to their standardized arrangement, see Figure 1. On the top row, from left to right, there is the airspeed indicator, the artificial horizon to indicate pitch and bank angle, and the altimeter to show altitude. Beneath these, the turn and slip indicator (or the turn coordinator, a modern variant) allows the pilot to judge rate of turn and keep the aircraft coordinated. This is followed by a direction indicator, or horizontal situation indicator (HSI), to show aircraft heading, and the vertical speed indicator, to report the rate of change in altitude. Other instruments depict signals received from radio navigation aids, and the state of the engine(s), but these vary between aircraft.

While these instruments were initially mechanical, the hundreds of dials soon cluttered the cockpits of larger aircraft and were difficult to read. In the 1970s, NASA began researching what new, improved displays would be possible with emerging digital technology [3]. The result was to combine all six instruments into a single, easy-to-read 'Primary Flight Display', also shown in Figure 1, in approximately the same configuration as pilots were familiar with.

DESIGNING A SPACE SHUTTLE

Unlike conventional aircraft, there had been nothing like the Space Shuttle before. There was little to inform its cockpit design, as all previous space capsules had simply landed under parachute, so engineers were left to develop it from scratch. The 2,214 switches controlled flight through the atmosphere, orbital maneuvering and countless subsystemsl [5]. Despite appearances, the details of the Space Shuttle flight deck are vastly different from airliners, primarily because they were required to serve a different purpose.

Some essential spaceflight instruments were already in existance and could be borrowed from other NASA programmes. For example, the Flight Direction/Attitude Indicator (FDAI), which indicates roll, bank and pitch through 360 degrees, was present in both the Apollo and Gemini capsules. Before this, the Mercury control panel used six dials to indicate pitch, roll, yaw and rate of change in each of these axes. While easier to construct from an engineering perspective, it was much harder to interpret, and the astronauts, many of them ex-military pilots, requested the subsequent adaptation of the artificial horizon found in aircraft [6].

Here lies the first cause of similarity between the Space Shuttle cockpit and those of aircraft – it was designed to be flown by pilots, and so it made sense for it to feel familiar to them. The original Space Shuttle instruments were positioned in approximately the same arrangement as the Six Pack found in almost every aircraft. After millions of flight hours, it was also proven as a sensible, easily intelligible arrangement. This is most clearly visible in the later-developed soviet Buran spacecraft, which had much in common with the Space Shuttle but only made one orbital flight in 1988 [7]. It was, however, the only Spacecraft made with a cockpit similar to the shuttle, perhaps because by that time it was a proven concept. The Space Shuttle worked.

Figure 2: The view from the Commander's seat of the Apollo 11 Command Module Columbia

GOING DIGITAL

After a while, aircraft manufacturers pushed for more advanced technology – to increase safety but primarily to sell more airplanes. New astronauts found themselves familiar with modern "glass cockpits", rather than the mechanical instruments of the Space Shuttle [6]. Additionally, some of the Space Shuttle dials were stock parts from aircraft manufacturers, who had subsequently ceased their manufacture. This meant repairing the instruments was time-consuming and expensive, and NASA began seeking an alternative [1].

In 1998, Space Shuttle Atlantis was the first to receive the new glass cockpit. By this point, the technology had proven reliable in commercial aviation, having been first implemented in an airliner the year after the Space Shuttle first launched. The displays installed in the Space Shuttle were manufactured on the same production line as those for the Boeing 777, out of the same glass, although more redundant avionics processors were used [8]. A major benefit of digital displays is that different data can be selected and displayed on the same screen, removing the need for simultaneous physical displays of every individual system.

There was also a need for familiarity with the previous Space Shuttle instruments. Therefore, when all the displays were redesigned in color, the CRTs were simply swapped out [8]. However, additional Primary Flight Displays replaced the mechanical FDAIs and HSIs, which required the development of a 2D representation of each of them. Airliners already had this and, although slightly different information is displayed, the panel layout remained similar to those on the previous Space Shuttle, newer airliners and, by extension of both, most of aviation history.


Figure 1: The same information shown on a Primary Flight Display (left) and analogue six-pack (right)

The commander's seat in the replica Space Shuttle Independence, with the original analogue instruments

The upgraded glass cockpit. Note that this is a composite image from before the cockpit flew, as the seats have been removed!

THE HYPERSONIC GLIDER

The Space Shuttle wasn't the first spacecraft to have some instruments similar to that of aircraft, but it was the first to use them in the same manner. Its unique glide approach to land, following re-entry, had never been attempted before, and consequently all previous spacecraft had not required the same field of view from the capsule windows. Apollo for instance, had only four small windows, and Figure 2 shows how the control panel was instead placed directly in front of the three astronauts, filling their line of sight. By contrast, the final approach to land of the Space Shuttle was hand-flown by the pilots, who required good visibility to see the runway despite the high pitch angle. It resulted in six huge forward-facing windows, and the crucial necessity to locate the flight instruments to keep them easily visible without obstructing the windows.

Additionally, due to the reliance on human flying, it was decided that there should be two Space Shuttle pilots, equally capable of landing the orbiter should the other be in an unfit state to do so [9]. To ensure both pilots had equal visibility, and to enable clear communication, they sat side by side. It's not hard to make the link between the requirements of the space shuttle and those for aircraft design, and it makes sense that the engineers would come to the same solution: place duplicate displays below the window in front of each pilot, with a center console and an overhead panel.

Current spacecraft, such as Crew Dragon, Orion and Starliner, display flight instruments and information on digital panels, as pioneered by the Space Shuttle. However, none of their control panels share the same similarity to aircraft cockpits as the Space Shuttle did. They lack the previously mentioned glide flight phase and large windows, instead descending under parachute, and so have returned to a more modern version of original capsule designs. Perhaps the human rated version of the Dream Chaser spaceplane will see a revival of a similar cockpit, but with ever-increasing automation this is by no means guaranteed.

WHAT'S IN A NAME?

When it was first envisioned, the intention of the Space Shuttle was a regular shuttle to space and back, rapidly reusable, making spaceflight available to the masses. In publications from the 1970s, NASA boasted the ability of its future shuttle to land at any commercial airport, require about as much refurbishment as an airliner and carry out over a hundred flights in each orbiter's lifetime [9]. Figure 3 shows the hope that one day spaceplanes might be handled at airports like any other aircraft. There was also consideration for the possibility of including conventional jet engines for easier flight in the lower atmosphere without the severe restrictions of gliding. Consequently, from the start, the Space Shuttle had been designed to behave like an airliner, inside and out.

In reality, six orbiters only made 135 flights in the thirty years the programme ran [7]. But there was a vision for a brighter future, where Star-Trek fantasies of everyday space travel seemed not so far-fetched. After all, man had just walked on the moon, so nothing was impossible.

CONCLUSION

There were many reasons that both generations of the Space Shuttle cockpit look similar to airliners of the time, despite its increased complexity. Many astronauts were previously pilots, and so a familiar cockpit made it easier to interpret the instruments. Additionally, the glide phase of approach and original intention for airline-like operations imposed requirements on the design which were most easily met by copying and modifying existing aircraft technology. A reversion to capsule design means no comparable cockpits have been developed since, but the Space Shuttle still serves as a shining example of the best of human factors engineering.

Figure 3: A concept artist's impression of a fully reusable space shuttle at an airport

Sally Ride, the first American woman in space, admiring the view from the cockpit. This was her second space shuttle mission, STS-41-G aboard Space Shuttle Challenger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A COSMIC PERSPECTIVE

An interview with astronaut André Kuipers about his new mission on Earth

Ruth Euniki Vraka, Editor-in-Chief, Muhammend Arham Elahi, Final Editor, Lisanne Vermaas, Managing Editor, Naomi Lijesen, Leonardo Times Editor

JAIME KORBEE

How does it feel to see Earth from space? What might happen if humans live on Mars? Can a disabled person go to space? Why does the space industry need crazy ideas, and how can students contribute? All these questions, and more, are discussed in an interview with André Kuipers in light of the NL MOONSHOTS '24 program.

Please note that this interview has been edited for length and clarity.

Let's get straight to the point: you are working on a new mission. Can you tell us more about that? Are you going back into space?

When you talk about a mission, this does, indeed, naturally come to mind. I would be open to going to space again. But this mission takes place on Spaceship Earth. The project is called NL MOONSHOTS '24, which I announced in a press conference on Sunday, October 8. We would ideally like to have one hundred teams of students at all levels (MBO, HBO and WO). They have to come up with really crazy ideas or 'moonshots'. Just think of Kennedy's speech in 1962, when he announced that he wanted to be on the moon before the end of the decade. They had eight years to make that happen! A crazy idea, but it worked. That is also the thinking behind this.

What awaits the students who participate?

You have one year to develop your crazy idea with your team. During this period, you will be linked to specialists from science and business, you will follow workshops and attend presentations. Your team will also be linked to an astronaut, so to me or one of my 99 colleagues who will help you with his or her expertise, experience, and Overview Effect experience. You may even be able to pitch your idea at the ASE conference. Wonderful!

Who can participate in NL MOONSHOTS '24?

Students from the entire educational range, i.e. MBO, HBO and WO, are invited to participate. Providing you are registered at a Dutch educational institution. We are seeking students from different fields, so not just technology, but also other sciences, medicine, space law, hairdressing schools, you name it. We have different categories under which your crazy idea can fall: Earth, Human, Technology, Data, Artificial Intelligence, and another Extraordinary category for out-of-the-box ideas. We are very curious about all the ideas students come up with and how they will develop. I am very much looking forward to it.

What was the reason for doing the NL MOONSHOTS '24 project?
The reason was the association meeting of astronauts, the Association of Space Explorers (ASE). About a hundred members come together for an annual conference, and next year will be twenty years after my first flight, so that's a major reason to do it in the Netherlands. It will take place partly at ESTEC (Noordwijk), and partly in Amsterdam for the cultural program. An important aspect is outreach. That is also one of ASEs tasks: to show people what we do with space travel and to inspire youth. There is also always a Community Day, during which the astronauts travel into the country. Next year, we will also have the NL MOONSHOTS '24 program. Students have a year to develop their idea, and present it at the ASE conference.

Can you tell us more about the ASE?
It is an international group of astronauts founded during the Cold War, completely independent of politics and agencies. The Soviets and Americans wanted to form a club of astronauts, because together, they did useful things for Earth and were friends up there. This is still the case. The space station is international and the only place we still work with the Russians. The ASE is an independent club, of which about four hundred astronauts are members.

The MOONSHOTS program is about crazy ideas. Some ideas might be invaluable and inspiring, but some might just be too crazy. So, how far would you advise student to go with their ideas?
Of course, the laws of physics still apply. You cannot say: "let's go to the Moon in our swimming trousers". You have to be realistic in that sense. But the main point is to think in different ways. Even geniuses like Einstein couldn't imagine that you could get energy out of atoms. Edison was a great engineer, but he thought indirect current didn't work. Kelvin thought that you could not fly something heavier than air. It's very difficult to predict the future, so the crazy ideas should come from people who don't think within borders yet. My whole life, I learned how to think in a certain way, so you now need the young people who think out of the box.

The MOONSHOTS program is very interdisciplinary, and health is a crucial aspect. John McFall recently became the world's first disabled astronaut. What are your thoughts on this development about overcoming these obstacles considering your medical background?
That's an interesting question. I know John pretty well. In fact, I was on stage with him on Sunday and have even done parabolic flights with him. ESA has had four astronaut selection groups, I was in the second selection group. For the fourth, ESA decided: why not include people with a disability? Because you don't need your legs much in space. So you enter a fantastic pool of great people who can also do the job. Of course, we have to work together with NASA because we don't have our own spacecraft. You must deal with companies like Axiom or SpaceX to see what's feasible. So, whether it

JAIME KORBEE

be a missing leg, uneven legs or even someone under 130cm, we must find solutions for everybody with a disability.

Of course, there are exceptions. For example, accommodating blind people can be a bit difficult. So, you have to be realistic about addressing the safety concerns that might arise, for instance, if the astronaut needs to escape quickly. But I was wearing glasses when I got selected; nobody's perfect. Disabilities come in all kinds of levels. It could be a good topic for a moonshot, to get people with a disability into space. Stephen Hawking, wheelchair-bound, made a parabolic flight, and he has been weightless. One of my colleagues, Samantha Cristoforetti, stated, in space, we all have a disability. Because all of a sudden, you cannot walk and instead float; you lose control very easily. Getting used to the environment in space takes a while because we are not made for that. We are made for 1 atm, 1 g, 25°C, and even if we travel five kilometers per hour on the sea, we already get seasick. We are actually already limited, but we have the knowledge to adapt. We're not birds. We're not fish. But we can fly, and we can go underwater. Space is the next step.

So, I think it's a great step for ESA to take, and I'm pretty sure that John will fly and they will find solutions for the safety issues. And that's a good example of finding solutions instead of rigidly sticking to a rule.

In the space industry, it is often discussed that human presence will eventually establish on other planets. What is your opinion on the ethical aspects, and how can we avoid having the same "colonization" attitude that people historically have towards Earth?

That's a very philosophical question. Humans are a plague for the planet. We grow and grow like locusts, eat everything until it's finished, and they die. It's biological, primitive feature of living creatures. Humans will go to other planets. The question is then, of course, what do we bring? Assume that we don't have life on Mars and we cannot destroy another culture like we did on Earth. So far, there's no nature on Mars. But we must be very careful because we want to know if there is life underground on Mars. So from a scientific point of view, you don't want humans on Mars until you're totally sure that Mars is dead. You don't want to find life, which turns out to be your own bacteria that you brought several years before.

And then it's also a philosophical question: "can we invade another heavenly body and then claim that it is ours"? And, maybe there is life, and we destroy it unknowingly. The other way around also, imagine that astronauts go to Mars bring some stuff back, and it turns out that there are microbes in there that kill the whole world. After the first astronauts that came back with Apollo 11 and Apollo 12, they had isolation suits on and were in a big container immediately after landing for 19 days to see if they would get sick or not.

And then, the legal question: "who owns it"? There are six US flags on the Moon, but it doesn't mean that the Moon belongs to the United States. But, imagine that we find invaluable minerals there, and possibilities for other exotic ideas. You might have a moon war, and the resources become very important. So I really hope that with MOONSHOTS we also get proposals from the legal point of view, for example. Who owns the Moon? Who owns an asteroid? We have the oceans here on Earth, and we have that scientist (Hugo de Groot) who invented the sea laws. The ocean is everybody's, but if you take something out, it's yours. Antarctica is an interesting example, you can do research there, limited tourism, but no military, no mining, etc. And with the Moon, we have the same discussions; who owns what and how much can you claim?

Since you entered the space industry two or three decades ago, it has evolved substantially. If you were to graduate right now as a student, would you be interested in staying in the medical field, or would you still go into being an astronaut?

First of all, there is no astronaut school; every astronaut has a different background. You need to have another career first. There are astronauts who were once scientists, engineers, pilots, or medical doctors. So, I would probably start off in medicine again because I like the field. Also, I didn't study medicine for fun or just because I thought it was interesting. I thought it gave a good combination of skills. Of course, when I started off, I was realistic; I wasn't certain I would become an astronaut. The odds are stacked against you, but I at least wanted to work in the space business. I wanted to be part of the future of humanity, and you can do that in all kinds of fields. My interest in space mainly evolved from wanting to work on a human mission to Mars. That was 40 years ago, and we still don't have humans on Mars. That always seems to be in the far future. So, if I would enter the field today, I would still actually have the same dream; I would still want to work on a human mission to Mars. The main problem with spaceflight is that there are continuous postponements and delays. Because right now, I believe there will be people on Mars in 25 years. But I said that 25 years ago as well. One day it will happen, and I hope to live to see people on Mars.

Suppose you were still a medical student participating in NL MOONSHOTS '24. What would your moonshot be?

Maybe something to mitigate the serious, long-term threat of radiation. I would like to come up with a construction where, for example, the water tanks are placed on the outside of the spaceship and can rotate. A crazy idea to best protect people against radiation when traveling to Mars.

Looking at Earth from the International Space Station must have been a beautiful image. How did you experience the Overview Effect commonly experienced among astronauts?

Yes, that was special. I know that I live on a globe and how everything works. But when you look outside, the Earth seems flat, the sky is infinite, and the Sun seems to revolve around you. So, I can imagine that people used to think that too, until, of course, they discovered that it was all a bit different. When you enter orbit, you suddenly feel what you know. You fly around the Earth, the moon rising, the planets, and so many stars that it is difficult to identify constellations.

How did that make you feel?

I felt two things: First of all, I felt claustrophobia. Not for myself, but for the planet. I could see a very large part of the planet at a quick glance and orbited around it in an hour and a half. The *universe felt like a menacing black blanket of cold, emptiness and radiation. I saw the Earth as a kind of living cell that could break any moment. A bit like a baby: very beautiful, but also very vulnerable. When looking into the universe, I experienced another special feeling. A believer would call it a religious feeling. I call it more of a cosmic feeling. We know the world around us is small. What you see is your world. When you walk outside, you see trees everywhere in the distance, and maybe some clouds, but from the ISS you see that we are part of a solar system. You can see the Earth, a large sphere, but also the Moon and the Sun. You realize that you are part of something much bigger, of an entire universe. We are all stardust.*

Since Apollo 8, we could look at that little Earth from a distance for the first time. On Earth, everything seems infinite, but in space you realize the limitations of our planet. Suddenly, you see that everything belongs together - all people, all animals, all plants - as one living being.

You've talked extensively about your vision of a brighter future for humanity. And space is an experience that's foreign to most people. What part of that experience would you like to share with others?

Well, there have been a few moments in my life where I realized that I was part of something much larger - part of the universe and our solar system. One of those moments was during my spaceflight. When you orbit the Earth and see the Moon and Mars on the horizon, and even fly under the Moon, it's a profound experience. During our flight, we even had a comet sighting just before the sun rose over Australia. Because you're constantly moving in space, you truly feel like a part of something bigger. But on Earth, you can also have similar experiences. Take a total solar eclipse, for example. It's an incredible moment when you suddenly feel connected to the solar system in your everyday life. You see the Moon as a black disk surrounded by the flames of the sun. Another example is the Aurora. It happens at altitudes of 100 to 400 kilometers, with lights dancing in the sky. It's another moment where you feel the vastness of our world. Lastly, I attended a solar eclipse in Libya. The night before, with the new moon, it was incredibly dark, and all I could see were stars. I was in the Libyan desert, and I couldn't even see my own feet. The entire sky was filled with stars, and it felt like the universe was drawing me in. So, even here on Earth, you can experience that cosmic, spiritual feeling. It takes some effort, but it's possible, and I want to share that sensation as much as possible. We can also leverage technology like virtual reality trips and IMAX movies to show how beautiful our planet can be.

CONCLUSION

Leonardo Times would like to thank André Kuipers for taking the time to talk to us and NL MOONSHOTS '24 for the invitation and facilitation.

JAIME KORBEE


Als meisje worden wat je wil
Wij zijn enorm trots op onze vrouwen in de cabine, de cockpit en de rest van de organisatie.
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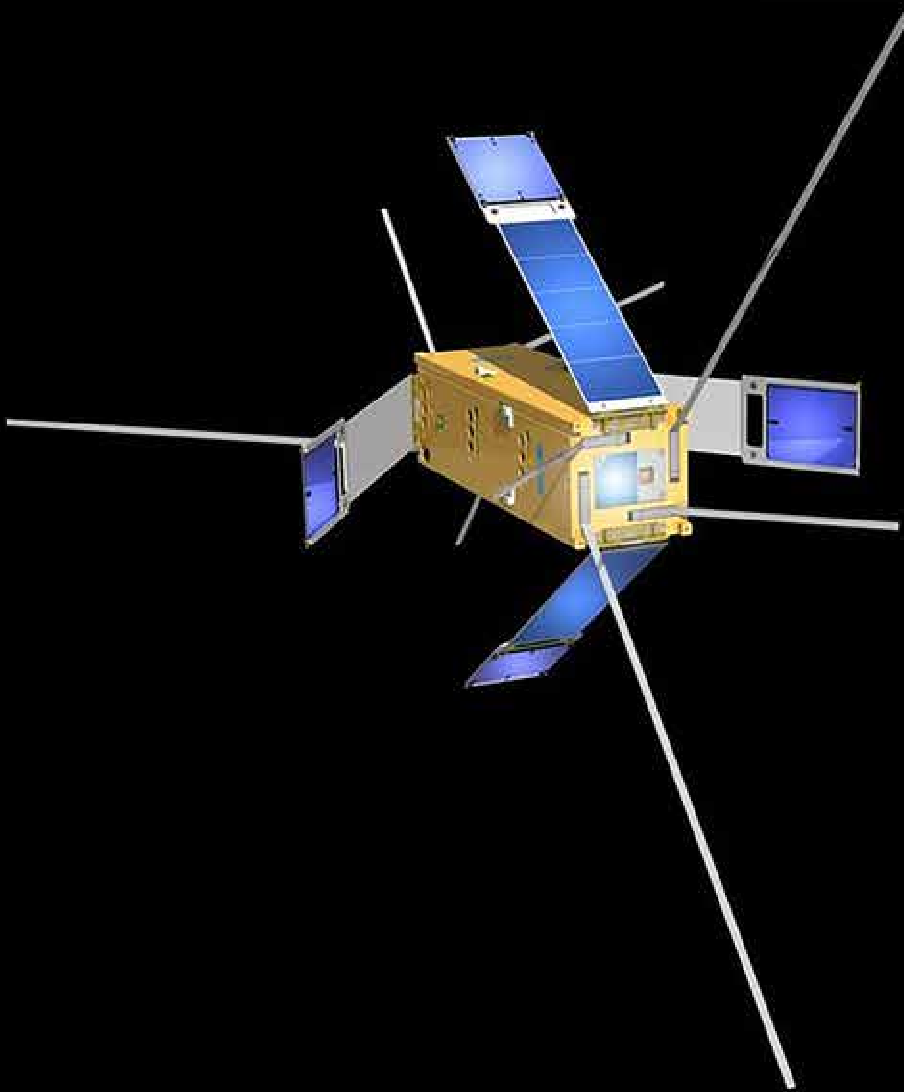

A TRIBUTE TO DELFI-C3

On the 13th of November, the pioneering nanosatellite Delfi-C3 burned up in the Earth's atmosphere. Built in 2006, it orbited Earth more than 85,000 times covering 3.7 billion kilometers. Its mission lifetime greatly surpassed the three months it was designed for, providing valuable insights for scientists at TU Delft.

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