LEONARDO TIMES
JOURNAL OF THE SOCIETY OF AEROSPACE ENGINEERING STUDENTS 'LEONARDO DA VINCI'

The Flying Dutchmen

How the reputation of Dutch aviation grew during the early 20th century

New Space on the Horizon

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Dear reader,

This quarter we have a very special edition in store for you. As the VSV celebrates its 16th Lustrum, 80 years since its founding in 1945, we wanted to celebrate by writing about the Dutch contribution to the aerospace landscape.

Our journey commences with the early years of Dutch aviation. We take a look at the first four decades of Dutch aviation, from The Real Flying Dutchman passing through Fokker, KLM and the war and interwar period. This leaves us at about the time when TU Delft's aerospace engineering faculty started to become its own entity, and with it, the birth of the VSV. The most veteran readers will also recall that the Leonardo Times used to be written in Dutch. The aerospace engineering classes were also taught in this language. What made them change? How important is the language of education?

Members from the VSV boards of past lustra, boards from 1960 right up until today, share their stories. We get to know about their passions, figures of inspiration, and what was their outlook on the aerospace world while they were celebrating their respective lustra. The story-telling doesn't stop as one of our TU Delft aerospace engineering professors, Dr. Spilios Theodoulis, tells us the fascinating story of robust control. Today, it is a key aspect of aircraft and spacecraft design, but how did it come to be? How were control systems designed in the early years, and what is the direction that we are going towards?

In this edition, we were also invited to visit Airbus' factory in Noordwijk. Here we got to learn about the Netherlands' contribution to Ariane 6. While learning about the giants is always interesting, we were also excited to interview two up-and-coming Dutch start-ups also at Noordwijk: Revolv Space and Aardvark Sensing. These companies are great examples of what the future of aerospace development will be; the so-called "New Space".

And with this message and true sadness, we would like to say goodbye. The journal will be passing into new hands for the upcoming academic year, which will see the 30th anniversary of continued publication! We wish you a very pleasant summer, thank you for continuing supporting the Leonardo Times by receiving us at your doorstep, and we hope you learn something new. Enjoy reading!

Yours truly,

Gerard Mendoza Ferrandis
Editor-in-Chief

James Josep Perry
Editing Director

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Last edition...

If you have remarks or opinions on this issue, please email us at: leotimes-vsv@student.tudelft.nl

We really want to make sure that all the Leonardo Times we send out get into 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, you can unsubscribe by using the form in the QR code. We're sorry to see you leave!

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We are aware that in the last edition the deadline for the Turning Points competition was incorrectly reported as a date in the past, and the email address was misspelled. We apologise for any confusion; the corrected version can be found on page 10.

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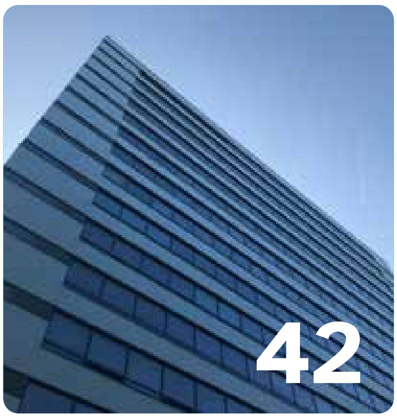

Colophon

Year 29, Number 3, Summer 2025

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IN MEMORIAM

Member of Honour Wakker

February 3 1944 - May 30 2025

It is with great sadness that we learned that one of our Members of Honour, Prof. Ir. Wakker, has passed away.

He was the first full time space professor at the faculty of aerospace engineering and of course of great importance to our society and all of its members.

For all of his efforts, he was installed as a Member of Honour of the VSV 'Leonardo da Vinci' in 1994.

A Message from the Board

Almost without realizing it, the summer break is already upon us. With longer days and rising temperatures, time has flown by, and now, the well-deserved moment of rest has arrived. It's time to unwind, reflect on the past academic year, and recharge before a new one begins. While you're doing so, we invite you to enjoy this brand-new edition of *Leonardo Times*, keeping you connected with both the industry and the VSV.

We at the VSV are also ready for a bit of a break. It's been a fun, hectic, and above all, unforgettable year, filled with highlights that climaxed in our lustrum month, just two months ago.

We kicked off the celebrations with the lustrum night, where we transformed the campus in our lustrum colours and theme. You may have noticed our decorations on the direction signs, bike paths, statues, and TU Delft signs, some of which may still be lingering around.

One of the absolute highlights quickly followed: DeBaCoXL, our own version of *Te Land, Ter Zee en in De Lucht*. In this spectacular event, 12 teams of 8 students each took on the challenge of launching their homemade flying machines off an 8.5-meter-high ramp. With a large crowd of spectators, it became a true flying spectacle and an incredible success.

The excitement continued with two sporty events. First, students had the thrilling opportunity to abseil down the faculty building, alongside our very own Dean! Then, nearly 50 students participated in the Runway Run at Seppe Airport, raising money for cancer research through a unique and meaningful running event.

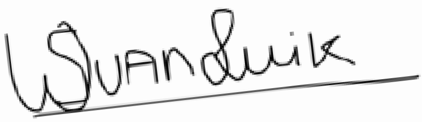
From there, we hosted a variety of smaller activities, ranging from lunch lectures and excursions to a gliding day. Finally, we wrapped up our lustrum celebrations with a grand finale. On the panorama terrace of Schiphol Airport, we proudly unveiled the lustrum monument: three beautifully designed, informative signs created by the lustrum committee and the board. These signs aim to inspire future generations of aerospace students. With this monument, we've commemorated the lustrum and the legacy of the VSV while adding something meaningful to such an iconic place. The evening ended with pizza and a legendary closing party.

As I mentioned earlier, the time has now come to take a step back, relax, and reflect proudly on the year we've had, almost, that is. I'm writing this final message from the balcony of our apartment in northern Paris, where the board is attending the Paris Airshow. We've just returned from our first day at the event, mesmerized and deeply inspired by the beauty of flight. It feels like the perfect ending to this amazing year.

On behalf of the 80th Board of the VSV 'Leonardo da Vinci,' I sincerely hope that you've enjoyed this academic year as much as we did. Thank you for reading our magazine and for being a part of this journey.

On behalf of the 80th Board of the VSV 'Leonardo da Vinci',

With winged regards,



Willemijn van Luik
President of the 80th Board of
the VSV 'Leonardo da Vinci'

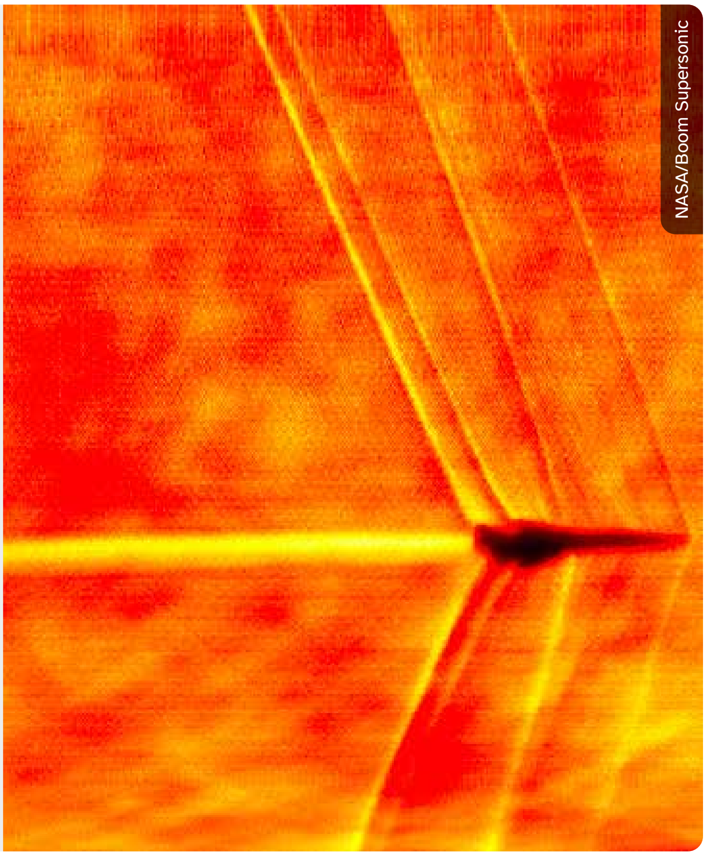
Quarterly Highlights

The Return of Supersonic

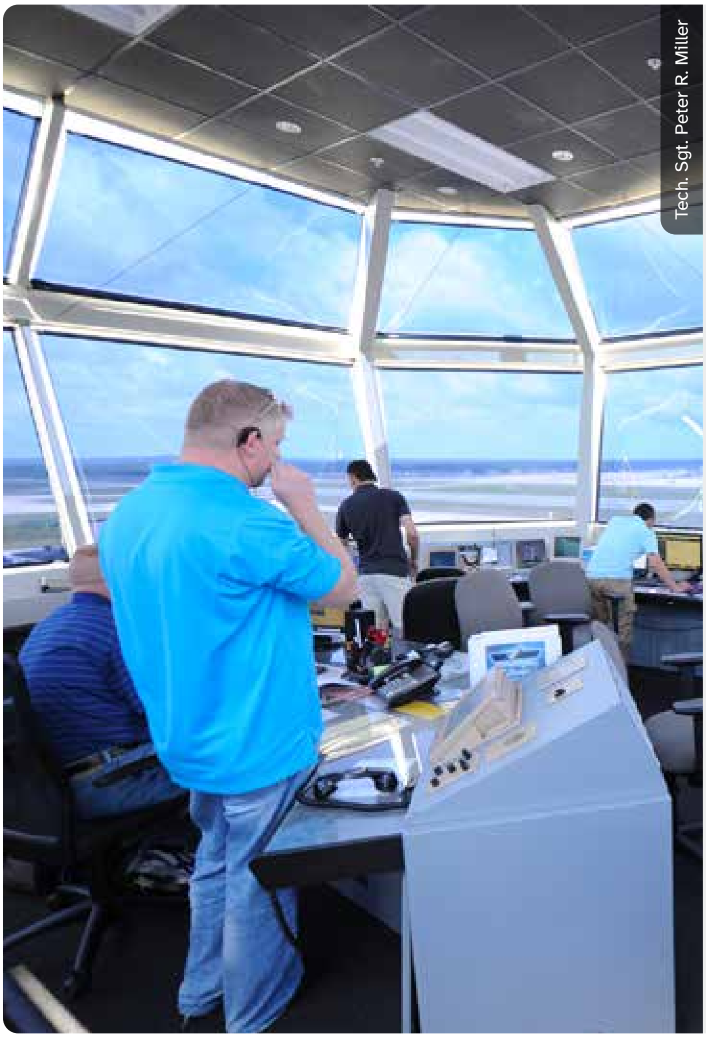
This June, president Donald Trump signed a series of executive orders, one of which lifts the 50-year-old ban on supersonic flights. The ban was placed in 1973 as a response to the nuisance that supersonic aircraft would cause on the population due to their sonic booms. With the lift, Trump aims to establish the US as the leader of high-speed aviation.

This ban lift comes hand-in-hand with NASA's recent accomplishment in supersonic travel. Alongside private company Boom Supersonic, they have managed to develop a "low-boom" supersonic aircraft. The XB-1 flew its first "boomless" supersonic flight in January of 2025.

The executive orders also sought to boost domestic commercial drone development and strengthen U.S. defenses against unauthorized drones. The main purpose of these is to increase public safety in the US for the upcoming 2028 summer olympics in Los Angeles.



NASA/Boom Supersonic



Tech. Sgt. Peter R. Miller

FAA ATC Overhaul Plan

In June of this year, acting FAA Administrator Chris Rocheleau has stated their intention to modernize and overhaul the ATC system in the US. Currently the ATC tech in the US is "stuck in the 20th century", with some towers still running Windows 95, using paper flight strips and even floppy disks. This old infrastructure has caused the aviation industry to form a coalition to lobby for ATC modernisation, called "Modern Skies". The plan is to introduce modernised electronic systems, like electronic flight strips, fiber optic cables, and satellite links.

Transportation Secretary Sean Duffy considers this project one of the most important infrastructure projects in the US in the last few decades, and has set up four years as their desired transition duration.

Recently, US ATC has been in the scope of the media and the general public due to events such as February's nationwide NOTAM blackout, Newark's April and May total blackouts, and Denver's radio silence in May.

Other events such as January's mid-air collision at Reagan National and its 85 near-misses since 2021 highlight the fact that 20 of the 26 most critical US airports are understaffed and overworked. To address this, there is a plan to increase controller pay by 30%, and streamline the hiring process.

ISRO

Shubhanshu Shukla

Shubhanshu Shukla is due to become the first Indian astronaut to travel to the ISS, onboard the Axiom 4 mission. This is a private mission run by Axiom Space, but it is in cooperation with NASA and will be carrying a crew of professional astronauts from space agencies around the world. The launch has been delayed twice, first due to bad weather and then a leak aboard the Falcon 9 booster.

Shukla is an Indian Air Force pilot and astronaut for the Indian Space Research Organisation (ISRO), selected as one of four who will travel to space as part of India's human spaceflight program. This program aims for a first crewed flight in 2026 aboard a HLVM3 rocket, so this will be Shukla's first flight to space. It will make him the second Indian in orbit, after cosmonaut Rakesh Sharma flew aboard a Soviet Soyuz for 7 days in 1984.

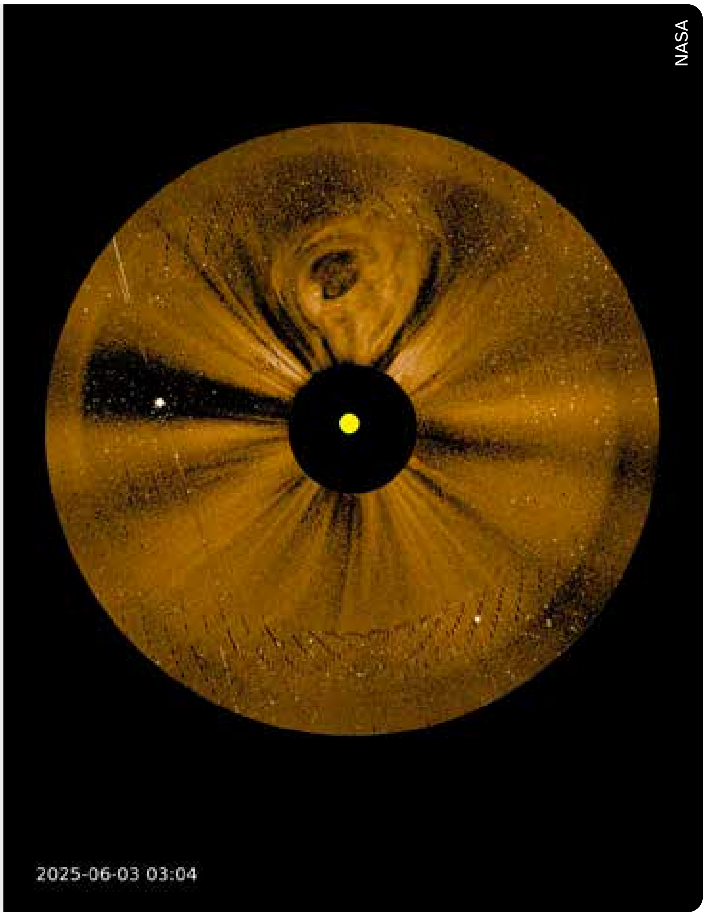
Shukla will bring to space postcards from the Indian Institute of Science, items representing different regions in India, and an object which belonged to Sharma. He will also take a plush swan named "Joy" as a symbol of unity, grace, and cultural heritage. Shukla will also perform various research experiments on behalf of ISRO, including studies on microbial adaptation, muscle atrophy, and crop resilience in microgravity.

First Images of Coronal Mass Ejections

Polarimeter to Unify the Corona and Heliosphere (PUNCH) is a constellation of four satellites in a sun-synchronous low Earth orbit, weighing just 40kg each, launched by NASA in March 2025 aboard a SpaceX Falcon 9. In June, the first results of this mission were presented: high detail images of complete coronal mass ejections (CMEs).

Once the spacecraft reach their final formation, they will be able to continuously observe the Sun's outer atmosphere and the inner solar system in 3D. The images so far were taken using one Narrow Field Imager, a visible-light coronagraph, while the remaining three spacecraft are equipped with side-looking Wide Field Imagers. All the images are taken exclusively of polarised white light, and smaller images are combined to produce a composite over a number of Earth orbits.

The data collected during this mission will enable better understanding and prediction of space weather, which can disrupt communications and endanger satellites. Solar radiation can be damaging for the health of astronauts, so better prediction of the risk is beneficial. CMEs are also responsible for the auroras which are visible on Earth.



NASA

TURNING POINTS

In the next edition you, the reader, can be featured in the Leonardo Times! The idea is simple: we propose a topic, you write, and whichever submission shows the most thought, creativity and meaning gets published. In celebration of the 16th lustrum of the VSV 'Leonardo da Vince', the prompt for this competition is as follows:

What if a major turning-point in the last 80 years of aerospace history had gone differently?

We want you to focus on the repercussions that a different outcome of a major event would have had in the world of air/space travel. But remember, the world of aerospace does not exist in a vacuum! While we don't want you to put excessive focus on non-aerospace topics, the industry has direct interaction with sociopolitics, the economy, and the environment for example. Be creative but describe realistic outcomes, grounded in reality.

Do not choose "an event happening at a different time" nor a "non-event that could have happened". Rather, we ask you to discuss a real moment in time, as if it had led to a different outcome.

Some example topics could be:

- Could we all be flying supersonic if the Concorde crash had not happened?
- What would have been the fate of international space laboratory research if the Apollo-Soyuz handshake had never happened?
- If the USSR had kept developing the Buran, could it have been the most used form of space travel?
- How would the airline industry look today if airlines had remained nationalised?

For your article, we expect the following.

- A minimum of 2,000 words. More words are not penalised, but encouraged if they are meaningful.
- In order to remain factual, cite your sources. It doesn't have to be pure imagination. If the scenario can be backed with real data and studies, even better!
- The Leonardo Times is written in American English, so keep this in mind.
- The article must be handed in as a Word or Google Document before 1st September 2025. Incorrect formats or late entries will not be accepted.
- Add as many figures as you want, but make sure you have permission to use them!
- Send the article to leotimes-vsv@student.tudelft.nl" with the subject "A Different Future - [what your turning point is]"

Happy writing, and good luck!

SPACE

Ariane 6, a (Partly) Dutch Rocket

How Airbus Netherlands helps launch Europe into space

Simon Caron, Leonardo Times Editor


ArianeGroup

Following the historic launch of Ariane 6 last year and my article published in the Autumn edition on the subject, I had the unique opportunity to visit one of the places where Europe's space ambitions take shape, the Airbus Netherlands facility in Leiden. I was invited by Frank Meiboom, director of sales strategy, and VSV Board Member in 1982/83. Together, we walked through the halls where the future of European launchers is being built.

When I arrived at the facility, I was impressed by its "small scale". In my imagination, rocket factories were huge, dungeon-like buildings, like the assembly facilities. But once you enter, it becomes clear that this factory is not like any others; clean, lean, and with high ceilings, it is a sight to behold.

Walking through the surprisingly small number of large manufacturing halls, my guide instructed me about all the advancements made in this very place. Officially known as *Nebula*, it is a factory for the future, purpose-built for Ariane 6. The facility is designed according to *Industry 4.0*, also known as the fourth industrial revolution, where manufacturing and industry are increasingly driven by digital technologies like IoT (Internet of Things), AI, big data, automation, and cyber-physical systems. It's all about creating smart, connected factories that are more efficient, flexible, and data-driven.

At some point, I remarked that there was no paper in sight, no loose open folders, or idly left notebook on the corner of a desk, and indeed, *4.0* also means that the whole production floor has gone *paperless*, which is impressive! Every communication, update, and report happens on company tablets, while tools, parts, and bolts are all neatly arranged, almost to the point of obsessiveness, all in the name of utmost efficiency.

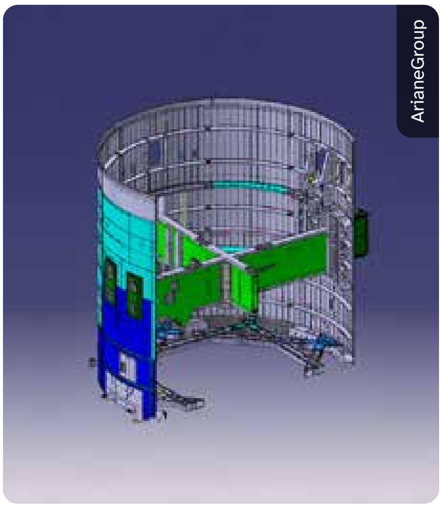
As we made our way into the main area, I was welcomed by enthusiastic workers returning from their ritual mid-morning coffee break. Daunting machinery awaited me as well, rails snaking along the ceiling of the hall, robots, enormous blue supporting structures. All while the main players of the European space program were silently sleeping, at the back of the room. The Vega C interstage lay right next to Ariane 6's Vinci Thrust Frame (ViTF) and Vulcain Aft Bay (VuAB). Efficiency truly takes its meaning when one looks at the infrastructure around those three projects; no more rolling around and pushing, they are simply moved on rails from one step to the next. The whole process felt very Lego-like. Advancements in manufacturing have meant that the assembly became much simpler, requiring fewer parts.

A few sights immediately caught my attention, one of which was an impressive, almost three-meter-tall Kuka robot arm, quietly stationed in a corner like it was waiting for its next assignment. At first glance, it could pass for a standard piece of industrial kit, the kind you would find on an automotive assembly line. But this one is far from ordinary.

Co-developed by Kuka and Airbus Netherlands specifically for the Ariane 6 program, the arm is designed for any fastening operations that demand micrometer-level precision. We're talking about tolerances so tight that even a minor misalignment could compromise structural integrity. The robot helps speed things up, reduces fatigue-based human errors and improves overall safety in areas that are hard to access or involve repetitive strain. It's a perfect example of how automation is being smartly integrated, not just to streamline production, but to match the ever-higher standards of space-grade manufacturing.

One of the most striking parts I saw during the tour was the cross structure, a massive, load-bearing component that connects the Vulcain engine to the rest of the core stage. It's engineered to absorb the full thrust of lift-off while withstanding extreme thermal and mechanical stresses. As Frank Meiboom explained, it's the heaviest load-carrying structure in the rocket, and its precision tolerances are extreme. Built from aluminium alloy, the cross sits at the heart of the Vulcain Aft Bay, acting almost like the backbone of the rocket. Seeing it up close really drove home how much of Ariane 6's strength is forged here, in Leiden.

After seeing the backbone of the rocket, we moved on to a more discreet but equally critical part of the production process. Tucked away in a quiet corner of the facility was a room that looked almost like a sci-fi cleanroom, but with a smell that unmistakably screamed "paint shop". Inside, two alcoves split the tasks: the first one dedicated to applying thermal coatings, and the other specialized in classic aerospace-grade paint.



Computerized design of Vulcain Aft Bay (VuAB)

A render of the Nebula Factory Floor

It's here that parts get their final layers of protection, sometimes with specialized materials like cork-based insulation. And while I can't go into details, let's just say that while I was there, some very intriguing tests were being run, the kind that make you wish your notebook came with a security badge.

As I wrapped up my tour and passed through the external part delivery area, I stepped outside. Mr. Meiboom pointed to the canal and the low bridge just beyond the gates. Once an open-shut bridge, it was sealed permanently after a municipal decision. Suddenly, the entire logistics setup of the factory was at risk. After all, this site was built here because of that canal, meant to move the massive Aft Bays by barge.

But instead of panicking, the team got creative. They simply added more ballast to the barges, lowering them just enough to clear the bridge, and turning a potential showstopper into a great example of how engineering doesn't stop at the rocket. Sometimes, it's about making sure your rocket parts can float under a stubborn bridge.

Innovation at the core

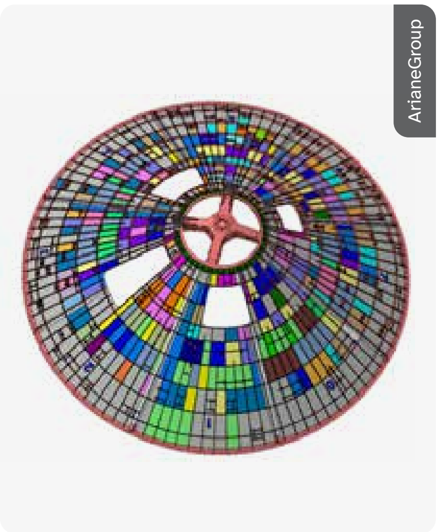
Upstairs, the atmosphere was different: less hum of machinery, more quiet concentration. It's where design decisions are made, challenges untangled, and future upgrades take shape. I met Franklin Annink, Program Manager Launchers for Airbus Netherlands, in a small meeting room overlooking part of the facility. Our conversation was a deep dive into the mindset behind Ariane 6's production, not just what they build, but how and why they build it this way. From cutting-edge simulation techniques to smart redesigns and emerging materials, the conversation revealed how innovation is woven into every bolt and bracket of the launcher's structure.

The one word that came up repeatedly during my visit was iteration. Ariane 6 is far from a frozen design; it's a launcher in motion. Even after its first flight, major upgrades are already underway to boost performance and reduce costs. One example that stands out is the redesign of the VuAB, where Airbus Netherlands managed to trim over 550 kilograms just by rethinking the structure. Thanks to a 1:3 trade-off ratio, that weight saving directly translates into increased payload, a huge win in a world where every kilo counts.

Innovation at Airbus Netherlands isn't only about shedding mass, it's also about reimagining how rockets are developed. Franklin Annink and Frank Meiboom walked me through a shift toward Simulation Driven Product Development (SDPD). SDPD uses high-fidelity simulations to virtually validate components instead of relying solely on expensive, time-consuming physical testing. The approach is so promising that even NASA is watching closely. Remarkably, most of the Ariane 6 structure was qualified with minimal large-scale testing, something almost unimaginable just a few decades ago.

On the factory floor, that same mindset is visible everywhere, from the paperless workflows guiding technicians to the robotic fastening systems co-developed with Kuka. These are more than high-tech add-ons; they cut down on errors, improve precision, and make it easier to adapt to ongoing design changes, a constant in the Ariane 6 program. That push for efficiency is now extending into sustainability. The team is exploring cork-based insulation, a lighter and more environmentally friendly alternative to traditional thermal protection materials.

At Airbus Netherlands, innovation is built into how the entire system operates and not confined to a lab or limited to early design stages. In a program where flexibility,



The design of the Vulcain Trust Frame (ViTF)

precision, and speed are essential, this approach might be considered one of Ariane 6's greatest strengths.

The Dutch Aerospace Edge

Ariane 6 is a European rocket; it is surprising how much of its backbone is built in the Netherlands - both literally and figuratively. Airbus Netherlands, formerly known as Fokker Space, brings over four decades of launcher experience to the table, dating all the way back to Ariane 1. That heritage shows technical expertise, the deep integration between the Dutch teams and the rest of the Ariane industrial base.

During development, engineers from Airbus NL worked side by side with colleagues from ArianeGroup and other European suppliers in a joint design plateau in Les Mureaux. This co-development setup allowed for a high degree of agility, particularly important given the number of design changes Ariane 6 has gone through since its inception. As one engineer put it, "We don't just design our part, we think in terms of what's best for the whole launcher".

That mindset of acting as if they're part of the prime contractor, even when they're not, is what Frank Meiboom refers to as being "virtually vertically integrated". It's a collaborative and flexible way of working, deeply embedded in the DNA of Dutch aerospace. This flexibility extends beyond design to production. From structure to fastener, the Vulcain Aft Bay is an assembly of precisely engineered interfaces, designed to accommodate an evolving launcher. In other words, if the engine changes, the structure adapts. If the mission profile shifts, the structure adapts. It's this seamless capacity for adaptation that has earned the Dutch teams a reputation as reliable partners, not just suppliers.

The Dutch contribution isn't limited to Leiden. In Klundert, the company APP designs and produces the igniters for European launchers- small components with a critical role: ensuring everything ignites when it's supposed to. It's a reminder that Dutch involvement spans from the base of the rocket to the spark that sends it skyward.

Contributions in Numbers

From the moment I stepped into the Nebula facility, it was clear that Ariane 6 was never meant to be handcrafted. This launcher was designed with production in mind, and the factory was built alongside it, not as an afterthought. Everything, from the building layout to the smallest fastening operation, was planned to support serial manufacturing, not one-off craftsmanship.

Rather than pushing structures around the floor, parts are efficiently railed from one workstation to the next. Assemblies that once required thousands of parts have been reduced to a fraction - for example, the Vinci Thrust Frame (ViTG) went from over 1000 individual pieces in Ariane 5 to just 11 in Ariane 6. This isn't optimization for its own sake; it reduces costs, cuts weight, minimizes the chance of errors, and speeds up production.

Airbus Netherlands is responsible for two of Ariane 6's most critical structural elements:

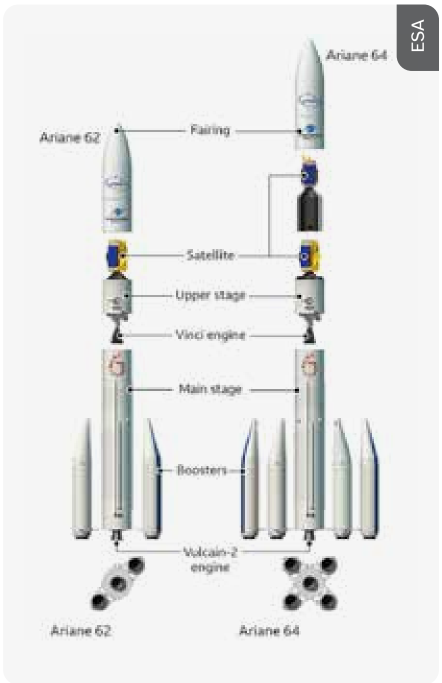
- The ViTF for the upper stage
- The Vulcain Aft Bay (VuAB) for the core stage

The Interstage 1-2 for Vega-C is being produced in parallel with the two. All are built with tight tolerances, complex interfaces, and an eye toward repeatability. Each VuAB, for instance, weighs nearly five tons and has to carry the engine, handle lateral loads from the boosters, and transfer thrust without compromise.

The goal is to ramp up to 12 launchers per year, with Airbus NL already producing five models in 2025 alone. That kind of pace doesn't happen accidentally; it's the result of years of co-engineering between the rocket and the factory, a perfect case of form following function. Even the factory's location was chosen with logistics in mind: the canal just outside provides a direct water route for transporting large parts by barge.

Sustainability isn't Just a Buzzword

In the space industry, sustainability often risks being little more than a marketing tagline, something to check off on a slide rather than a factor shaping real decisions. At Airbus Netherlands, however, the conversation around sustainability is far more



Parts of the Ariane 6

pragmatic, starting with surface treatments and fastener coatings.

As part of Airbus Group, the Leiden site follows strict environmental goals, including reducing its carbon footprint and full compliance with REACH regulations on hazardous chemicals. This has meant rethinking long-established practices: anodizing and chemical coatings, once standard for launcher parts, have been replaced with safer, cleaner alternatives, prioritizing the health of workers as much as the rocket itself.

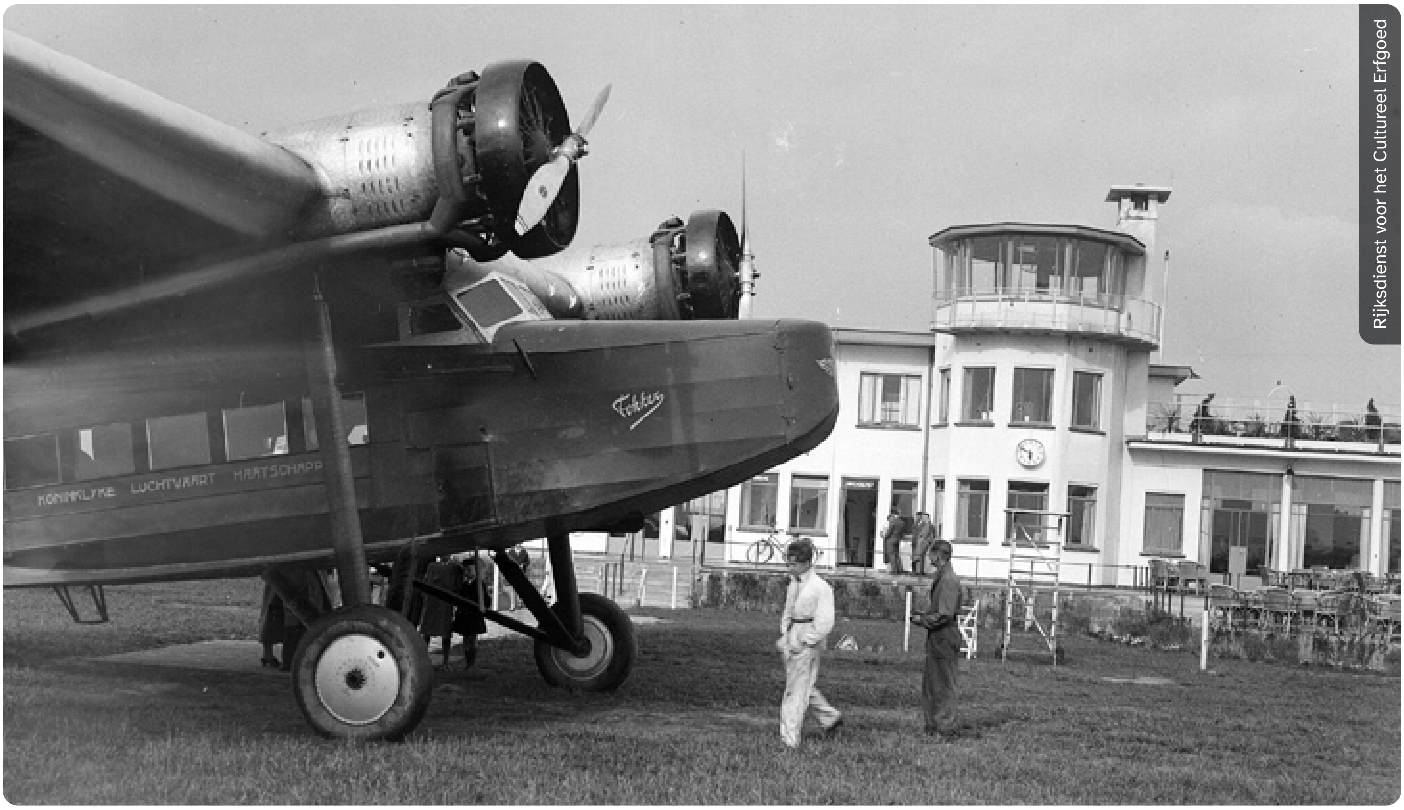
Aluminum machining, which removes up to 90–95% of material, is also tightly controlled: leftover chips aren't waste but reclaimed and reused. The site also participates in Airbus' ASAP program, tracking the environmental footprint of Ariane 6 production, from energy use to emissions.

What I saw at Airbus Netherlands wasn't just rocket parts coming together; it was a whole philosophy in motion. From the spotless, streamlined factory floor to the quiet intensity of the engineering offices, every detail reflected a relentless push for smarter, faster, cleaner spaceflight. In this corner of the Netherlands, innovation is built into every bolt, bracket, and business decision. And as Ariane 6 prepares to redefine Europe's launch capabilities, it's clear that the Dutch aren't just contributing, they're leading.

The Flying Dutchmen

How the Dutch aviation industry and reputation came to be during the early 20th century

Pavel Kelley, Leonardo Times Editor



Rijksdienst voor het Cultureel Erfgoed

Early KLM flight at Eindhoven Airport

1909-1939 was the genesis of the Dutch aviation industry. Many companies and innovators made their name in these early years. For the 80th Lustrum Year, we celebrate Dutch history by taking a look at who was part of these three decades and how the Netherlands navigated through these changing times.

First in Flight

The Netherlands was not the forerunner in very early flight. Due to proximity to France, the country was assisted by French aviators with technical knowledge and experience, a rarity in this early era of flight [4]. Therefore, many of the first Dutch aviators learned to fly in and around France, flying aircraft derived from the original Wright flyer and launched into the air by catapult. The very first Dutch aviator, Gijs Küller, colloquially named *"The Real Flying Dutchman"*, was a mechanical engineer who studied at TU Delft. On the 9th of October 1909, he flew for the first time in France [4]. His career was short-lived; he retired in 1915, already known for his daring flights in heavy wind, hence his nickname.

Following Küller's success, another pilot, Jan Hilgers from Java, took the spotlight. He was the first Dutch pilot to fly on Dutch soil and eventually switched to flying the famous Fokker Spin. As the name might suggest, Hilger went on to work with the now-famous Anthony Fokker, a student at that time, who built the first versions of *De Spin* while studying to become a mechanic [1].

Soon, both men became business partners in building, testing, and selling new aircraft designs. In those days, one of the few ways to make money was to sell aircraft to wealthy patrons or hold shows for the public's amusement, as an aviator or an engineer. However, the two roles were often intertwined, as those who built new designs were regularly the only ones who knew how to fly them. These events were good earners for both engineers and aviators, but not a consistent source of income [4].

Anthony Fokker was a student with limited financial resources. The redesigns and purchase of new planes to replace those that often crashed was expensive and required extensive use of his father's credit. However, he succeeded and went on to start a business selling aircraft to both individuals and the German military [1]. Fokker formed a team with Jan Hilgers, Reinhold Platz, one of the first to embrace the new technology of welding, and about 25 engineers and mechanics. Fokker had limited success before the war, when he attempted to sell planes to both the Russian and German forces. However, with the onset of the war in 1914, the aviation industry saw a sharp shift, and Fokker swiftly followed suit.

Flight in the Shadow of War

War time brought many changes to the aviation industry. Aviation navigated from being a show and spectacle for public amusement to a means of observing and attacking enemy forces by air.

The Netherlands intended to maintain its neutrality during this conflict, but Fokker was less inclined; his planes quickly became synonymous with the German air forces. Although the aviation industry quickly evolved in terms of technology, flight was still in its early days. Fokker's creations were plagued with mechanical problems and some of the Fokker triplanes fell apart mid-flight under high-load maneuvers. The German government launched an inquiry into the quality of aircraft produced by Fokker [1]. Fokker's chief of construction, Reinhold Platz, said, "Of the statics probably generally applied in aircraft construction, I understood nothing. Neither did I know the...static break formulas" [1]. It was clear that this was still an era where feeling and blind experience ruled.

The order of business during wartime was to constantly improve designs, and Fokker was certainly fit for the task, repeatedly tinkering and building new aircraft. This may have contributed to the overall rushed nature of their design and construction, resulting in the inquiries and possibly needless loss of life. Despite the shortcomings of his design, Fokker was well known to the pilots who flew his precarious machines, and they were among the last to admit the failings of their planes [1].

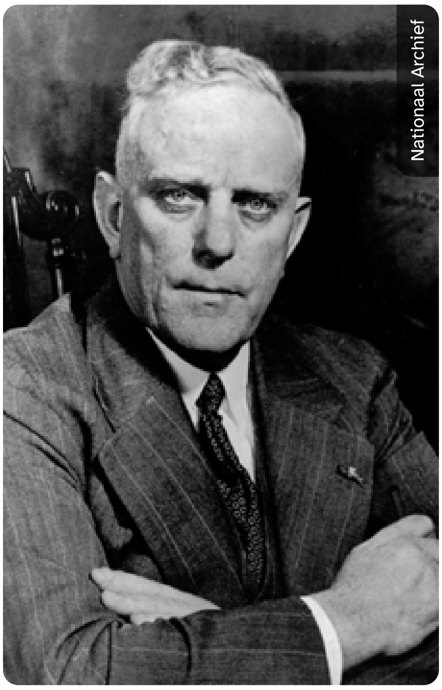
As the war came to an end, Fokker returned to the Netherlands, his business having ended in Germany as quickly as it began. He brought back some of the planes designed and built towards the end of the war; essential stock to restart his company in the aftermath of the First World War [1].

Anthony Fokker in his first aircraft, "De Spin"

Oversight and Overview

At the end of the war, the aviation industry was left in a relatively improved state, with airfields, trained pilots, and factories all over Europe. While early aviators and engineers had struggled to obtain resources, equipment, and aircraft, the now-abundant supply of these resources paved the way for commercial and private aviation sectors to explode in popularity. With that came the founding of two organizations: *Koninklijke Luchtvaart Maatschappij voor Nederland en Kolonien* (KLM) and *De Rijksstudiedienst voor de Luchtvaart* (RSL) in 1919. In the following years, KLM began to serve the Dutch government and public, transporting mail and passengers across the English Channel and the European continent. The RSL, predecessor to the Royal NLR, worked to standardize and expand upon all aerospace knowledge gained in the previous two decades [2].

The RSL was the government agency responsible for supervising airworthiness checks and setting the standard for Dutch aircraft construction. It was also responsible for carrying out aeronautical research using a wind tunnel, which served as the Netherlands' only wind tunnel until the 1940s. For two decades, this research lab performed essential research on topics ranging from "stagnation temperature of an airflow" to "pressure distributions on the fuselage of aircraft". This research was crucial for the development of the aviation industry as new designs and concepts could be tested and evaluated [2].



Alber Plesman, the first director of KLM and the driving force behind the company for the first half of the 20th century

The Fokker F.26 with RSL's Fokker F.II research aircraft

Eventually, the research group would be split into two groups, one for the continuation of research and another for the regulation of the aviation industry. As a consequence, the group was renamed the *Nationaal Luchtvaartlaboratorium* (NLL), and two additional wind tunnels were built around the beginning of WW2. The design work achieved during these crucial decades between the wars slowly took shape, with aircraft design shifting from its original canvas-covered construction to the sleek aerodynamic designs of the mid-twentieth century.

Connections to the Rest of the World

It was time for civil aviation to expand, with growing support from the scientific community and increased resources. During the opening of the *First Air Traffic Exhibition Amsterdam 1919*, the world witnessed the progression of aviation during the war. Albert Plesman, the future chairman of KLM, was one of the event organizers. His tireless efforts to encourage the Netherlands to establish an airline service paid off, with the first services to London and Amsterdam established during the flying season of 1920 [3].

After establishing KLM's air service in Western Europe, KLM went on to partner with Fokker, utilizing the F.II, F.III, and F.VII aircraft during the opening years of operation [5]. In 1924, KLM made a historic first flight to Jakarta with a Fokker Trimotor. In 1929, an air corridor opened linking the Far East with Europe. Although KLM expanded to open more routes during this era, this was the longest Pre-WW2 flight route, spanning almost 15,000 kilometers.

During this time, Fokker expanded his company in America. The international branch of the company was called the *Netherlands Aircraft Manufacturing Company of Amsterdam*, and eventually the *Fokker Aircraft Corporation of America*. With this company, the Dutch aviator-turned-businessman quickly began to influence early American aviation. Many early achievements of American pilots were at the control column of a Fokker aircraft [1].

Steel Birds in the Interwar

Due to the rising demand for high-capacity transport around the world and Fokker's inability to move with this shifting paradigm, KLM soon turned to the Douglas Aircraft Company to supply their new metal-skinned aircraft [5]. This represented a radical shift in aircraft design, moving from wood and canvas-covered aircraft to aircraft held together by aerodynamic metal skin. This new era created a new set of demands from airline operators, with KLM being no exception. Plesmen ordered the new DC-2 and DC-3 aircraft for use on the newly opened routes to Jakarta and other destinations within Europe [3]. This demand was also placed on Fokker, who subsequently developed a four-engine aircraft which could not keep up with the Douglas aircraft. The failure of this design, the Fokker 26, would cause Fokker to lose out on vital business and was subsequently removed from the company in the mid-1930s.

However, Plesman's drive and ability to command brought him and his company, KLM, through this transitory phase [3]. KLM continued to operate and maintain one of the largest aircraft maintenance and manufacturing plants in Europe during this time. Located in Amsterdam, close to Schiphol Airport and bolstered by the new information and research coming from the reformed RSL, now the NLL. It would help to keep KLM operational, maintaining the fleet of aircraft capable of connecting with the far corners of the world. Unfortunately, this era would not last long, and soon Europe plunged into the Second World War. During the war, Plesmen attempted to keep KLM out of the hands of the German military and even tried to intervene on behalf of Britain, one of the main destinations for KLM flights, to negotiate a peace with Germany. Although he met with the chief of the Luftwaffe, Herman Goering, during his attempted negotiations, the meetings didn't go very far [3]. KLM was forced to continue the war in partial operation, as some of the company continued to operate in the Caribbean and the UK [5].

From 1909 to 1939, the first three decades of Dutch Aviation, the country evolved from a late start in aviation to Dutch aircraft and services flying around the globe. Dutch aviation was at the forefront of aircraft development and usage. From one of the world's first air services to another continent to significant contributions to the field of aerodynamics, the Netherlands distinguishes itself as a nation not only capable of developing aircraft but also keeping up with the changing tides of technological advancement in this turbulent era.

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SPACE

New Space on the Horizon

The ongoing transition in the space industry

Vince Lukacsi, Leonardo Times Editor

In early April, the Leonardo Times had the chance to visit the European Space Agency Business Incubation Centre (ESA BIC) in Noordwijk. This was a great opportunity to speak with experienced start-up coach and TU Delft LR alumnus Martin Haselhoff, along with two promising start-ups, about their journeys and the future of the space industry.

In recent years, the space industry has undergone a major transition. The industry, mainly driven by state-funded entities, like NASA and ESA, that poured astronomical budgets into decade-long projects, has slowly shifted into a fast-paced commercialized market, dominated by fast-growing innovative companies. This transition is known as "New Space" and it leaves behind the traditional model, often referred to as "Old Space". New Space is not only a change that determines which sector shapes the space industry, but it is a revolution that completely redefines how this industry is operated. At the core of this transformation are the start-ups that are now being built upon this novel model. These businesses are shaping the industry's future, making it essential to understand how they operate to grasp New Space principles.

The Space Business Innovation Centre, located in Noordwijk, the Netherlands, is the optimal place to meet with such start-ups. This center is responsible for managing ESA BIC Noordwijk, an incubation program for a network of more than 30 centers across Europe. Since 2004, this program has aimed to provide support to start-ups and help them thrive by empowering entrepreneurship [1].

This article features the inspiring journey of two start-ups, Revolv Space and Aardvark Sensing, both of which participated in this program in Noordwijk. Their stories are strong examples of companies based upon New Space principles, and proof of the benefits these companies experience thanks to this novel approach. Their experience sheds light on how New Space is not simply a vague concept, but is a profound change that redefines the concept of the space industry.

What is New Space?

To properly understand the principles upon which Revolv Space and Aardvark Sensing operate, one must examine what New Space is and how it differs from Old Space. Looking back at history, it is clear that the main drive behind the early days of space exploration was political. In the 60s and 70s, during the Cold War between the USA and the USSR, a new form of competition emerged, namely the so-called "Space Race". This race motivated both sides to invest substantial budgets into the nascent space industry through state-funded agencies such as NASA. As this approach led to some major achievements in space exploration, such as the first human in space and the first person on the Moon, it also established the prevailing model of the space industry in the decades that followed. More precisely, the agency would promote certain programs and then fund a large portion of them leaving their execution to designated contractors. Famous examples are the Apollo program and the Soyuz program. Although this approach achieved huge milestones, it mainly focused on fulfilling the needs of the state, while placing market and customer interest at a lower priority. Moreover, high project costs kept the space industry assigned to a few major contractors, limiting access for smaller companies. As Martin explained, *"In the past, agencies translated funding into space programs to develop products they would specify themselves. This was a good way to realize really big projects, but it was not the most efficient way to do things, and it discouraged competition and creativity within the market. This is what we call 'Old Space'".*

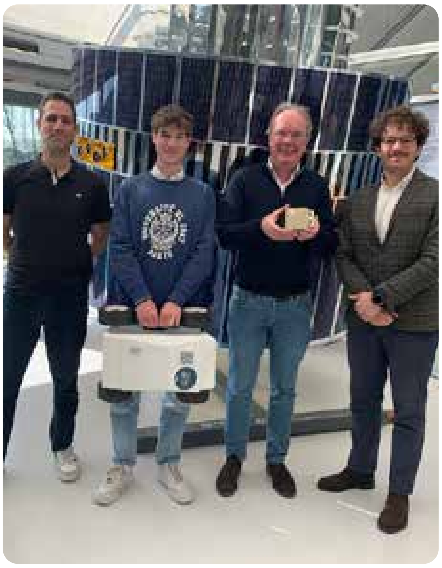
In contrast to the state-driven model, New Space refers to a commercial approach to the space industry. As mentioned earlier, the main difference lies in a transition from political drive to commercial interests. As Martin explained, the easiest way to understand New Space is to compare it to today's IT industry. Nowadays, computers are made by assembling individual components, such as the motherboard and CPU, each designed by a supplier specialized in that specific part. Although this type of approach requires standardization and modularization to ensure that the components are compatible with each other, it also allows companies to focus on a specific field within the IT industry. This avoids each company having to design a complete, one-of-a-kind computer by itself, which would require considerable time and effort. Furthermore, the financial drive encourages collaboration between companies as well as product optimization, making the industry much faster-paced and efficient. Overall, these are the trends within the IT industry that, recently, have also emerged in the space industry and that deviate from the characteristics of Old Space. As Martin put it: *"Thanks to the market standardization, companies focus on making the best components, instead of producing one-of-a-kind parts like they did in the past. This is a huge benefit of New Space"*. Understanding New Space principles sheds light on how Revolv Space and Aardvark Sensing operate and what sets them apart.

Revolv Space

Revolv Space was established in 2022 with a bold goal: to rethink and redefine how small satellites generate energy. It was founded by four TU Delft aerospace engineering master's students while still pursuing their degree. Encouraged by early support, all four founders committed full-time to this venture shortly after their graduation and joined the two-year program at the incubation center in Noordwijk. Upon completion, parts of their operations moved to Turin in Italy. We spoke to one of the co-founders and Chief Commercial Officer at Revolv Space, Filippo Oggionni. He shared insights regarding the start-up, the problems it tries to solve and finally how Revolv Space embraces New Space principles. To understand the innovative solutions that Revolv Space offers, it is first good to appreciate the problem it aims to solve.

Satellite's capabilities are often limited due to their available power. A common solution for generating power is the use of solar panels. However, as modern satellites require increasingly more power due to their increased complexity, it has led to the necessity of more performant panels. To achieve this, one option is to increase the size of the panels, but this is very expensive. An alternative is to make them more efficient, such as by implementing solar arrays capable of rotating instead of fixed in a specific orientation. The extra degree of freedom allows the satellite to continually rotate its panels to maximize the sunlight it receives, even when the satellite's orientation is non-optimal. Thanks to the additional power generated, satellites can house more power-intensive payloads, have higher duty cycles, and generally be more performant. Until recently, only larger satellites, costing several hundred million dollars, were equipped with such mechanisms. As Filippo explained, despite the obvious advantages of this mechanism, it was not common for smaller satellites due to the complexity, cost and time required to build. *"The effort and risk were simply not worth it"*.

The SARA Unit



From the left, Ilan Lewin, editor Vince Lukacsi, Martin Haselhoff, Filippo Oggionni

The launch of Apollo IV

Assembly, Integration and testing at Revolv Space

This changed with Revolv Space and its flagship product, SARA, their Solar Array Drive Assembly. The start-up offers a compact solution to maximize the energy harvested by satellite solar panels under 100kg by using sensors to detect the Sun's relative orientation and rotating the panels accordingly to achieve the maximum exposure possible. The unit can operate in both closed-loop control, by receiving input from the satellite, as well as autonomously using coarse Sun sensors. This added redundancy prevents the risk of a single system failure in the event of any malfunctioning. Overall, the SARA unit is a very elegant answer to the growing demand for power in small satellites.

But what makes SARA truly remarkable, and how does it integrate the principles of New Space? From the first concept in 2022, it took less than three years before the first unit was launched in space in March this year for testing. Filippo gladly shared that, since its launch, SARA had successfully sent nominal telemetry, confirming the unit's health status, as well as the successful deployment of the panels. In an industry where projects historically took decades to complete, this is truly exceptional. As Martin enthusiastically mentioned: *"Maybe it is hard to realize, but this is an amazing performance! It is one of the best examples of the power of New Space"*. This accelerated development was a direct result of the New Space mindset.

One relevant factor was the shift in risk management. As mentioned earlier, the large projects of Old Space, such as the Voyagers, had to be flawless. Any failure would cause millions of euros and decades of hard work to be wasted. On the other hand, because nowadays hardware and access to space are much cheaper, companies can afford to not get everything right on the first try. This shift not only allows start-ups to heavily reduce the time required to develop their products, but also through faster testing and iteration in real-life circumstances, enables them to improve the product quality and brings down the cost of the product. This is key for companies in a commercial market. As Filippo explained: *"The challenge for us is to build something very reliable because [power generation] is a mission-critical subsystem. However, at the same time, we need to keep in mind the budget of the missions. Satellite equipment should cost one or two orders of magnitude lower than the total budget"*. This further emphasizes the benefit of a quicker testing and iteration cycle, made possible by New Space.

However, the advantages do not stop there. By designing a standardized product, instead of building a one-off, bespoke system, Revolv Space's products can be easily integrated into a number of different satellites by only adapting their interface and not the entire product. This feature allows it to access a global market and is not restricted by national boundaries. However, as Filippo carefully noted, *"It is true that the industry now is more global, especially for commercial missions in Europe, but most budgets are still sponsored by the state or military bodies. For defence missions, most countries still like to have their own suppliers. This is just the nature of that industry. Export control laws and regulations also play a role in this scenario, since satellites and their equipment can be considered "dual-use" and therefore each country wants to protect their own sensitive technologies."*. Despite this, the field of operation of start-ups such as Revolv Space is much broader than it used to be in the past, which opens the door for more potential partners and customers.

To conclude, the marks of New Space are evident in how Revolv Space operates. From a quicker development cycle to increased access to the global market, this has allowed the start-up to achieve a very promising start, with its first major accomplishment being the launch of its SARA unit within such a short timeframe.

Aardvark Sensing

A second start-up which perfectly embodies the principles of New Space is Aardvark Sensing. The founder, Ilan Lewin, has a technical background too, having specialized in distributed sensor systems. Although Aardvark Sensing and Revolv Space were neighbors at the incubation center in Noordwijk, the way they profit from the New Space approach differs quite significantly. Whereas Revolv Space brings New Space innovation to the design of space hardware, Aardvark Sensing applies its principles to deliver downstream services based on autonomous robots. Today, Aardvark Sensing aims to build a versatile robot, which can be used in numerous applications such as soil monitoring through a software-defined approach.

At the core of Aardvark is this software-defined approach. This way of engineering involves designing a piece of hardware equipped with several features, such as the ability to move and numerous sensors, but not confined to performing a single, fixed task. By using this hardware as the basic platform, it is then possible to use it for several purposes by implementing the right software. This approach to focus on digitization is another big trend of New Space. As Ilan explained, *"We try to shift as much to the software side and digitization as possible. This is because, thanks to the agility in software, we can first deploy the robot, let it collect data and then see how we want to process it. With this approach you realize you do not need to get everything correct from the first moment,*

The Aardvark Sensing robot

but you can tune your robot with the software after". To illustrate it better, Ilan gave the following example: *"When you want to communicate with a satellite, but do not know how well your radio will perform in a specific bandwidth or frequency, you can use a software-defined radio. You use the same hardware but different software to play around with frequency, bandwidth and modulation to get the best results."* This approach makes the robot so capable and agile in the tasks it can perform.

Since the software was discussed, it is also interesting to mention the hardware, which also aligns with New Space principles. What makes the robot special is that the outer part and the wheels are entirely 3D printed. This allows for relatively cheap production and easy iteration of the design. Furthermore, the electronics inside the robot follow the trends of standardization. As Ilan mentioned, *"The battery used is similar to the one found in a drill, and the robot is controlled by a Raspberry Pi computer."* Thus, instead of producing its own electronics, Aardvark focuses on using commercial off-the-shelf components, making the production faster and cheaper and the components easily replaceable.

The first idea which emerged from the start-up was to create a platform capable of precise soil sensing. By using sensors, it would be possible for the robot to collect relevant data at given locations and then later process it using software. Ilan realized the potential behind such a robot in numerous applications. He explained that the current focus is on the healthy grass golf courses. Because the green area close to the hole must be in perfect condition, it is critical to monitor the biometrics of the grass around it. Ilan highlighted that, thanks to the sensors on the robot, it could give an individual score for each centimeter-square of grass, and thus locate any areas of damage. Regarding the coming years of the start-up, Ilan noted, *"On one hand, it is good to be versatile in the long term but on the other, a start-up needs to solve a very specific problem, at least in the beginning."* Martin added, *"Golf courses are what we refer to as a beachhead market, the first market in which you want to be successful. Then later you can focus on accessing different markets as well."* This approach of solving a clear and immediate problem, while designing a multi-function, software-defined product, is another powerful example of New Space. Through the standardization of the hardware, the components can be easily replaced and the design iterated.

> *"Maybe it is hard to realize but this is an amazing performance! It is one the best examples of the power of New Space"*
>
> **Martin Haselhoff**

Conclusion

The stories of Revolv Space and Aardvark Sensing offer more than examples of technological development; they are proof of a transforming industry. Whether designing an affordable mechanism to rotate solar panels or a software-defined ground robot, New Space principles are applicable in any engineering context. The two very different issues Revolv and Aardvark aim to address prove that New Space is not limited by market or location, but is truly a shift in approach.

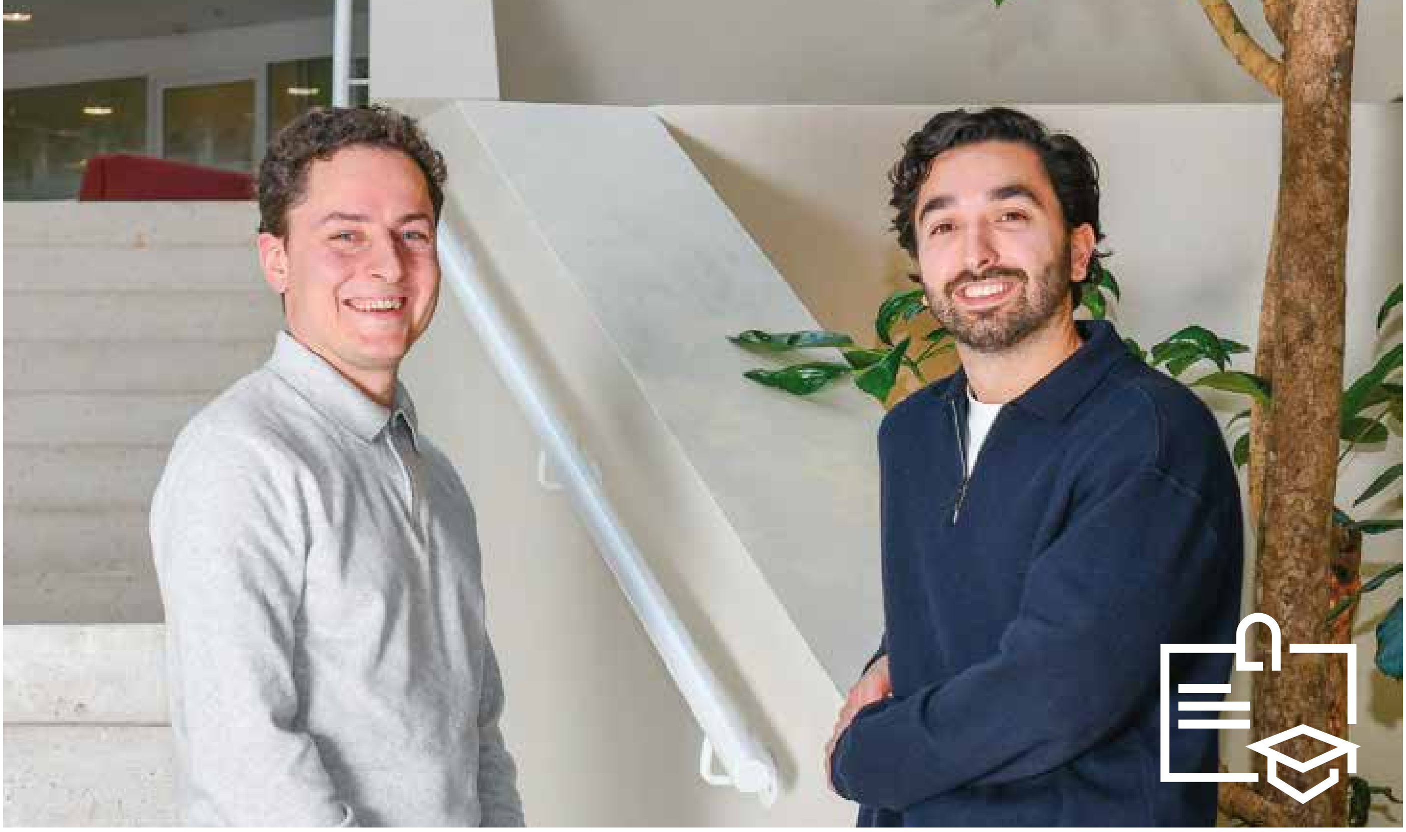
A major trend found in both start-ups is a shift in risk management. Where traditional developing cycles took decades and massive budgets, today's market is characterized by much shorter and cheaper cycles and the idea that not everything needs to be right on the first try. This allows start-ups to iterate their products faster, improve them more rapidly, and thus commercialize them more efficiently.

Furthermore, using standardized products instead of making everything bespoke is another trend in the New Space approach. This allows companies to focus on a few products only, instead of producing everything one of a kind. This not only encourages collaboration between companies, but is what truly sets the foundation for a commercial market driven by financial interest.

However, New Space is ultimately not just about commercialization, but is about building an efficient, versatile and profitable space industry in which smaller companies can make a big impact. As these start-ups continue to grow, they stand as strong examples of how the New Space model is not only viable but essential for the future of the space industry.

Live demo of the Aardvark sensing robot at the Smart City expo in Barcelona

The Leonardo Times would like to thank again Martin Haselhoff, Filippo Oggionni and Ilan Lewin for taking the time for the interview, as well as sharing their inspiring stories.



Ward Dijkman and Swen Sekha

Making an impact in a world of possibilities

"ASML has so much to offer, there's always something that fits your profile," says Swen Sekha. Swen and his colleague Ward Dijkman are two new graduates who recently joined ASML's management traineeship in Veldhoven. Besides working on technological challenges, Swen and Ward experience first-hand how the company also takes social responsibility and cares for its employees.

Ward obtained his master's degree in High Tech Engineering, with a specialization in Micro & Nano Science. Swen graduated in Applied Physics, with a specialization in Renewable Energy.

Ward: "I wanted to work in the high-tech industry, there was no doubt about that. But I didn't want to have to choose a single area of specialization right from the start. I heard about traineeships as a way of getting to know companies and discovering what possibilities are available for me. With its management traineeship, ASML offered a terrific opportunity in this context."

You've both been at ASML for a few months now. How have you found it so far?

Ward: "It's a big company, which can feel a bit overwhelming at first. But you soon settle in. Everyone is willing to help you, and there are lots of tools to support your success in your role. For example, there is a buddy system: someone who answers all your on-boarding questions and who is always there to lend an ear."

Swen: "It has struck me how the 'three Cs' – which stand for 'Challenge', 'Collaborate' and 'Care' – are embedded into everyone's behavior within ASML. You have various mentors to help you out at the technical level. And in terms of 'Challenge', just as we learned to do during our studies, we challenge each other to see our work through fresh eyes."

‘Challenge’ is indeed very important within ASML. So are you also made responsible for challenging yourself and taking new steps?

Ward: “My first traineeship assignment is related to the supply chain. My buddy tasked me with making sure that the warehouses don’t stock too many parts, and I am held to account on that. I was given the necessary responsibility and trust quite quickly, even though you’re supposed to have more experience and training for this task. So I feel like a fully-fledged employee rather than a trainee.”

Swen: “Proactiveness is highly appreciated. During my first assignment I started to look for additional challenges. Now I am part of multiple projects, which shows just how much they reward proactiveness here. People are comfortable with giving you responsibility, and I like getting that responsibility. We have to arrange our next assignments ourselves too.”

How do you notice in practice that ASML makes it a point to take social responsibility?

Swen: “One of my projects relates to eliminating plastic bags from one of our plants. We’re working on reusable packaging to increase sustainability and reduce costs, which is a sizable challenge for ASML.”

Ward: “There are various social impact initiatives. For example, every employee is allowed to spend one working day per year volunteering.”

Swen: “Diversity and inclusion is an important theme within the company. At ASML, people from many different nationalities work together. To make sure we feel at home, there are many communities for different groups. Education efforts ensure that as many employees as possible come into contact with these communities and learn what they stand for, so they can join them when they feel like it.”

Ward: “Even in my own team of 14 people, we have seven different nationalities. One nice thing about diversity is that some people want to be free at Christmas and others prefer to take time off for Ramadan or Chinese New Year. That’s useful in departments that have to be staffed all the time.”

Have you already discovered first-hand that you can make a real impact with your projects?

Swen: “Yes, thanks to being given responsibility, you can also make an impact. At ASML, it is not so unusual to be able to make a mark within such a short space of time. Colleagues in the factory have told me they’re happy that we’re working to reduce the number

of plastic bags we use. Moreover, the new solution is more pleasant for those employees to work with. It’s very nice to hear feedback like that.”

Ward: “Not all projects make it easy to see your personal impact, but for my current project, I see my weekly improvements reflected in the data. It feels very good to see that we really are reducing stock levels.”

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LUSTRUM

Voices of Lustra Past

The stories of VSV board members throughout history

Gerard Mendoza Ferrandis, Editor-in-Chief, and James Perry, Editing Director

In order to celebrate the VSV Leonardo da Vinci's 16th lustrum, the Leonardo Times reached out to several past board members. The aim was to appreciate the changes in the aerospace engineering landscape throughout the years, as viewed through the eyes of several board members from past lustra. We asked about their studies, their affinities, their view on aerospace progress, and their inspirations.

Here we tell the stories of Karel Ledeboer (1960), Paul Th. L. M. van Woerkom (1965), Teun Ros (1970), Sander van den Berg (1995), Jan Wouter Kruyt (2005), Leanne van Dam (2020), and Willemijn van Luik (2025). Their lustrum years were key moments in aerospace history, and their stories represent a wide range of interests with undisputed enthusiasm.

Karel Ledeboer (1960)

Karel Ledeboer was part of the VSV board between 1959 and 1960, a member of the 15th board, celebrating the VSV's 3rd lustrum! During the lustrum celebrations, a gift was presented to Ledeboer and the rest of the board by Koo Siu Ling. She is first female aeronautical engineering student of the Netherlands!

Unveiling of the memorial in the garden of the Noordeinde Palace in Den Haag by the 15th VSV board

Ledeboer studied Aerospace and Flight Control in TU Delft. Back then, the Aerospace Engineering faculty was not independent, so aeronautical engineering was taught as part of the "Mechanical Engineering and Shipbuilding" faculty's program. After earning his degree in 1962, he began working at KLM for 33 years. In 1994, he joined IATA as Senior Director, and in 2002, he was appointed Chief Operating Officer at the newly founded SWISS. Currently, he is 88 and retired. He has been awarded two of the most prestigious honours in the Netherlands: Fellow of the Royal Aeronautical Society (RAeS) and Knight in the Order of the Netherlands Lion.

Koo Siu Ling giving a present to members of the 15th VSV board Herry Schoevers, Bert Michon and Karel Ledeboer

"I am a plane person. When I was 12 years old, I made a flight over Amsterdam in the DeHavilland Rapide, and then I knew I was going to be an Aeronautical Engineer. But I also have an interest in space matters."

One has to look no further than Ledeboer's track record in the aeronautical sector to prove he's not lying about being a "planes person". It is interesting to know about the DeHavilland Rapide, which inspired Ledeboer to become an aerospace engineer. This aircraft was first produced in 1934. This was just 30 years since the first flight took off, and the world waited 4 more years for the first pressurized aircraft cabin! Manufacturing of the DeHavilland Rapide halted in 1946, with 727 being built all around the world. After the war, many re-entered service as civil aviation aircraft.

"I definitely saw the world of aerospace evolve. From piston engines, turboprops, straight jets, to fan jets. From multi-engined aircraft to two-engined aircraft. From a reduction in the cockpit, no radio operator, navigator and even flight engineer. From mechanical control to fly-by-wire."


Arpingstone

A De Havilland DH-89 Dragon Rapide aircraft that was repurposed for contemporary use

Karel Ledeboer visits Boeing's 747 assembly line in 2018

Ledeboer was greatly inspired by Prof. H.J. van der Maas, the first professor of aerospace engineering at TU Delft. Born in 1899 in Amsterdam, he graduated from TU Delft in 1923 as a maritime engineer and completed a doctoral thesis on aircraft stability and control in 1929 at the *Rijksstudiedienst voor de Luchtvaart* (RSL). In 1939, he became the first professor of aerospace engineering at TU Delft, but the Second World War prevented the launch of the degree program. Van der Maas went into hiding in 1944 after refusing to declare loyalty to the occupying Nazi forces. Following the end of the war and the beginning of aerospace engineering courses, he became the Rector Magnificus of the university, and chaired what would later become the Royal Netherlands Aerospace Center (NLR) for 23 years, until 1971.

Prof. van der Maas died at age 87, having made a lasting impression on the students of TU Delft. He was elected to the Royal Netherlands Academy of Arts and Sciences just the year before Ledeboer's lustrum year, and so was at the height of his career during the VSV's third lustrum.

Prof. Van der Maas greets Karel Ledeboer and his parents after graduation

Van Woerkom studied theoretical aerodynamics under prof. J. A. Steketee in TU Delft, while simultaneously studying aerospace and mechanical sciences at Princeton. He graduated in 1969, and finished his PhD in astrodynamics at Princeton in 1972. This year, he started working at NLR's space division. In 1994, he joined the newly-founded Faculty of Aerospace Engineering as a part-time staff member, and after leaving NLR in 1997, became a full-time professor in the Faculty of Mechanical, Maritime and Materials Engineering (3ME, now just ME).

Paul Th. L. M. van Woerkom (1965)

Paul van Woerkom was a member of the 1964-1965 board, belonging to the 4th lustrum of the VSV. In fact, during the celebrations of this lustrum, Prince Bernhard of the Netherlands was installed as Honorary VSV President during the celebrations!

"There's no place like space!"

Do not be fooled by van Woerkom's studies in theoretical aerodynamics. You need to get through the atmosphere to get to space! As stated earlier, van Woerkom specialised in space in his PhD, trading the 'aero-' for the 'astro-'.

Prince Bernhard receives the Honorary Member title from then VSV president Paul van Woerkom

"My interest was mainly in astrodynamics, re-entry dynamics, spacecraft dynamics and control. Developments in micro- and nano-electronics, in system modelling, in system optimization and in computing power must be a continuing surprise and delight for anyone."

Prof. Arie van der Neut gives his diploma to Paul van Woerkom

The 1960s saw the height of the space race between the USA and the Soviet Union. It was just twelve years between the first satellite, Sputnik 1, in 1957 and the first man on the moon in 1969 - the same year van Woerkom graduated. Both Concorde and the Boeing 747 would make their first flights that year as well. This lustrum year took place in the heat of this race; the same year saw three Saturn I launches.

"Some events from my lustrum were: Advances in supersonic and hypersonic aerodynamics, development of the supersonic airliner Concorde, spacecraft technology, and space applications (surveillance from space in particular)."

Van Woerkom was also inspired by Prof. van der Maas, who he describes as an "unsurpassed visionaire". He also mentioned Prof. S. F. Erdmann, pioneer in supersonic aerodynamics. Erdmann worked for the NLR to develop the first wind tunnel in Europe capable of reaching six times the speed of sound. Finally, he gave credit to Prof. J. M. Kooy, who studied at Delft and went on to research astrodynamics and rocket propulsion at the Royal Military Academy in Breda.

"I remember vividly the International Air Show at the Rotterdam airport. Aircraft from more than 5 countries. Many problems to solve, but finally successful execution! Demonstrating the growing international world. My international activities have been very inspired by this event."

Teun Ros (1970)

Teun Ros was part of the 5th lustrum of the VSV from 1965 to 1970. During his lustrum celebrations, he helped organise an airshow at Rotterdam's Zestienhoven airport, which included participants like the Red Arrows and the Patrouille de France. KLM's executive vice-president J. Luymes was also appointed as Honorary Member of the VSV this year.

Ros studied aerospace engineering at TU Delft, specialising in computer-aided design and production engineering of aircraft, and graduating in 1973. He was one of the pioneers in the use of Computer-Aided Design (CAD) technology for engineering. He spent 16 years in a leading CAD/CAM software company: EDS Matra Datavision. In 2003, he began working for Dassault Systèmes, where he stayed as Sales Director for six years.

"I remained an aircraft as well as a CAD/CAM oriented person. Have been active in aircraft design, mechanical design / manufacturing industries and CAD/CAM companies. This included a very international technical scope."

Although Ros is more fond of aviation than space, his real passion is CAD. In his time, CAD was still an emerging tool. He was one of the first pioneers to integrate CAD into the design pipeline. CAD/CAM was born in the 60s, with its birth being attributed to French engineer Pierre Bézier. Before CAD, most aircraft and spacecraft were designed by hand, using paper blueprints, pencil, and a lot of patience. This includes the Saturn V rocket and Concorde!

J. Luymes honorary member of 'Leonardo da Vinci'

In Delft on the occasion of the 25th anniversary of the Aircraft Engineering Society 'Leonardo da Vinci' KLM's executive vice-president J. Luymes was appointed an honorary member of the Society on Thursday September 24, last. President T. Ros of 'Leonardo da Vinci' handed Mr. Luymes a document confirming the appointment.

Extract of the news about KLM's vice-president J. Luymes being installed as a Honorary Member of the VSV

"The aircraft industry has concentrated on a few very big companies with a wide range of participating suppliers. Evolution seems to me very related to changing international technical and political situations."

One of the first versions of CATIA being used for aircraft design

Sander van den Berg (1995)

Sander van den Berg was a member of the 50th board of the VSV, a milestone year for the VSV. In fact during his lustrum celebrations, the VSV broke the world record for the furthest large paper airplane flight, flying 35 meters! He studied Aircraft Design and Performance at TU Delft, and would later graduate and start working for BAE systems. Later in his career, van den Berg joined Airbus, where he has been working since. Currently, he is the Technical Contracts Director at Airbus Africa and Middle East, based in Dubai.

"I prefer planes! But I still have a great interest in all things space as well."

It is difficult not to believe van den Berg when he says he prefers planes. He has dedicated his whole life, from his work at BAE systems to his current position at Airbus, to the A3XX family of aircraft. Particularly the A380 in his early years, and later the A350.

"Aerospace in the 20s is hopefully about more than just COVID-recovery! Before the decade is over, I expect the launch of new aircraft types with further step-change efficiency improvements and (near-) carbon neutrality for smaller aircraft types."

Van den Berg reflects on the progress that has been made throughout the years in the aerospace world. He recalls decade-by-decade what aerospace engineering was all about. The 90s and CAD, the 00s and the desire for new, bigger and bolder aircraft, and the 10s and the push for digitalization and increased efficiency. Now, van den Berg expects an aircraft revolution towards greener and more sustainable aircraft.

"I recall the unfortunate bankruptcy of Fokker during my lustrum."

Following a period of financial difficulties, Dutch aircraft manufacturer Fokker declared bankruptcy on March 15, 1996. The company was founded by Dutch aviator Anthony Fokker in 1912, and was a pioneer not only of Dutch aircraft, but aviation worldwide.

"Professor Wakker was an excellent professor."

His main source of inspiration during his studies was professor Wakker. Van den Berg recalls him being the Rector Magnificus of the university during his board year. Professor Wakker was so inspiring and involved with the faculty that van den Berg's board added him to the list of Members of Honour of the VSV. Today we mourn his loss, but we see he still lives in the minds of those whom he inspired.

Many airlines, like KLM, still use Fokker aircraft

Jan Wouter Kruyt (2005)

Jan Wouter Kruyt was the president of the 60th VSV board. He did both his bachelor's and his master's in aerospace engineering at TU Delft, specialising in airplane design and aerodynamics. He also did his MSc research at Wageningen University, collaborating with Wageningen's Experimental Zoology department to develop the RoboSwift morphing wing drone. A passionate fan of drones, he became Director of Business Development at Propeller Aero.

"I moved from being inspired by space flight to loving all of aerospace, including small-scale flight in animals and drones"

While some find their love for aerospace in space, and some others in aviation, there is still a small percentage of aerospace engineers that go back to where it all started: birds. The idea of aerospace design is now mostly divorced from nature, but we must remember that we started flying by imitating birds. To date, we are still learning a lot of tricks from them that are applied to new aircraft designs.

"During my studies I felt also inspired by David Lentink, who introduced me to bird flight & experimental research."

Kruyt stated that under Lentik's guidance he spent several years researching hummingbird flight performance. This included working with live birds in wind tunnels and measurement setups, something not many aerospace engineers have done in their lives.

"Except for the rise of unmanned aircraft in military and civil applications, I'm not sure I've seen aerospace evolve too much since my time in Delft. I'm looking forward to having better options for climate-friendly air travel someday."

This might be an impression many people currently get from aviation. During the early 90s, aviation was changing shape at an almost exponential rate. There were aircraft of all kinds being used, each with their own unique quirks. However, in the last few decades, aircraft evolution has been more discrete. We have found a general shape that works, and we are working on optimising it, as Sander van den Berg pointed out.

However, as Kruyt noted, drones have started playing a key role both in the civil and military landscape. This might be one of the flashiest evolutions we have seen lately in the world of aerospace engineering, and it is probably only the beginning, as applications for drones just keep growing.

"Someone had to go and pick up KLM's the first Airbus A330-200 from Toulouse, and I got lucky and was invited by KLM's CEO Peter Hartman"

From his lustrum year in 2005, Kruyt recalls when he was invited to go with the KLM board to pick-up the brand-new A330-200. He recalls how they got a tour of the A330 assembly line, flew over to Amsterdam, and saw the shiny blue aerospace faculty from above. When arriving at Schiphol Oost, fire trucks blew welcome fountains. A truly once-in-a-lifetime experience!

Leanne van Dam (2020)

Leanne van Dam was part of the 75th VSV board during the 2019-2020 lustrum year; an eventful one for obvious reasons. She was also the first female president of the VSV! It was also during her board year that the VSV launched the Da Vinci Satellite project, helping to support and fund the project. She graduated after completing her aerospace engineering master in Control & Simulation with honors. In 2021, she was awarded the International Aviation Women's Association (IAWA).

She is currently an R&D Engineer in the Climate and Emissions division at NLR. Her work focuses on analyzing and mitigating the climate impact of aviation, which includes studying greenhouse gas emissions from aircraft operations and exploring strategies to meet stringent climate objectives set by the Netherlands and the EU.

"I'm not an aircraft or space person, I'm a helicopter person! These machines still fascinate me, and I cannot resist looking up at them whenever I see one. I love that they can fly pretty much anywhere and can reach such cool spots, like mountain ridges and whatnot!"

When people are usually asked if they are a "planes or space" person around our faculty, the last thing one would expect is this answer! Helicopters are often overlooked in the aerospace world. However, as van Dam explains, they are one of the most technically advanced, flexible, and fascinating machines to emerge from our industry. The first helicopter ideas date back to ancient China! However, the first detailed conceptualisations date to the 1480s with Leonardo da Vinci's aerial screw. Today, helicopters play a crucial role in society due to their aforementioned flexibility, helping bring provisions to remote areas, providing invaluable time to people during emergencies, assisting in search and rescue, enabling aerial surveying, etc.

Van Dam's thoughts on the progress of technology relate very much to the present day. Her perspective contrasts with that of the previous board members, showing how the focus has shifted from larger and faster aircraft to those that are more efficient and sustainable. This is the biggest challenge aviation currently faces, and will surely be the significance of this decade in aviation history.

"I wonder how far the innovations concerning alternative fuels have come in the next Lustrum, and if the first people are actually traveling on, for example, hydrogen aircraft across the globe. I look forward to seeing how aerospace evolves."

In 2020, the world was rocked by the coronavirus pandemic. At the height of the response, air traffic was reduced by over 80% worldwide, with the busy hub of Schiphol airport seeing just 30% of its usual passenger numbers over all of 2020.

This was an unprecedented decline in the otherwise consistently increasing popularity of air travel, which took two years to recover.

"COVID-19 happened during our Lustrumyear. It was very weird to have silent skies and a silent Delft in the period that we'd planned the Lustrum activities."

From the 13th March 2020, students were not allowed into buildings on the TU Delft campus, and learning moved online. At first, this was due to last just two weeks, but five days later, the university advised international students to return home, and laboratories were closed a week later. Online learning was extended until 1st June, and any communal lustrum celebrations were out of the question. Instead, the VSV hosted a number of online workshops and produced videos celebrating the VSV. An art piece was produced with the faces of the faculty on green tiles, which can still be seen in the building's entrance hall.

Van Dam was especially inspired by Lt. Gen. E. Boekholt-O'Sullivan, the commandant of the Defence Cyber Command and Deputy Commander of Air Operations in the Royal Netherlands Air Force.

"She was one of the speakers at the Aerospace Women's Day, and amazed me with her calm leadership style. She is the highest ranked woman in the Royal Dutch Air Force, and I was inspired by how she got to where she was at the time by focusing on her strengths instead of complying with the male standards."

Among other endeavours, Boekholt served in Afghanistan in 2007, leading a project to rebuild civil aviation in the country. In 2016, she became the first female Commandant of an air force base, taking charge of Eindhoven's military airfield. After being appointed commandant of the Defence Cyber Command in 2022, she became the first woman to reach the rank of three-star Lieutenant-General.

Willemijn van Luik speaks at the extraordinary general members assembly

Willemijn van Luik (2025)

Finally, we arrive at the present day; the 80th board of the VSV. The current president is Willemijn van Luik. Van Luik began her aerospace engineering studies in 2020, and went on to pursue a master's degree in flight performance. However, she paused her studies to preside over the current VSV board and dedicate herself full-time to the 16th lustrum. She has been a member of the VSV since she started her studies, working on the yearbook, and being part of the MediaCo and PreLuCie committees.

"The lustrum monument reveal on the Schiphol panorama terrace was unforgettable"

One of the activities that van Luik has taken part of as president of the lustrum is the reveal of the lustrum monument. This year it consisted of a series of information signs created by students from the aerospace engineering faculty, which invite visitors to explore the history of aviation, the principles of flight, and the journey an aircraft takes from gate to runway.

"I used to be a space person. I started studying aerospace because I wanted to become an astronaut. During the bachelor, however, this completely switched to aviation, which led to me choosing Flight Performance for my master."

This shift in perspective is common in the world of aerospace engineering. Many of us, like van Luik, have dreamt of being an astronaut. However, many are also later captivated by the world of aviation. To an extent, space exploration can be considered to have been born from aviation, but many aerospace engineering student's love for aviation is born thanks to space exploration.

"In the coming lustrum, I see even greater achievements in green propulsion, AI-driven design, and the overlap between aviation and space. It's an exciting, transformative time for the industry."

Van Luik, like van Dam and Kruyt is also wishful for big achievements in sustainable aviation. She outlines how fast the aerospace world has been evolving, especially in automation and sustainability efforts.

"The people I find most inspiring in the faculty are all the professors that teach their courses with so much passion and enthusiasm, as well as the members of honour of the VSV."

TU Delft's aerospace engineering faculty can be a very inspiring place thanks to the works of all of our professors. They manage to project their passion onto students who, as we have seen throughout this article have reached great places, with many more to come.

Render of one of Airbus' ZEROe hydrogen aircraft, which might be the future of aviation

Ledeboer, van Woerkom, Ros, van den Berg, Kruyt, van Dam and van Luik represent a snapshot of the VSV throughout some of the most important moments in its history. Leonardo Times would like to thank them for taking the time to share their stories.

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Green Skies Ahead

Exploring the vision, technology, and economics of the E9X

Shourya Bhandari, Leonardo Times Editor

Elysian Aircraft

The Elysian team: L-R, Daniel Rosen Jacobson, Rob Wolleswinkel, and Reynard de Vries

Founded in 2023, Elysian Aircraft is a Delft-based startup on a mission to redefine the future of air travel with the first large-scale battery-electric aircraft. Its flagship concept, the E9X, is a 90-seat aircraft designed to fly roughly 800 km on a single charge. In this interview, Rob Wolleswinkel and Dr. Reynard de Vries discuss how they arrived at this bold concept, the technical challenges involved, and what it means for the aviation industry and aspiring aerospace entrepreneurs.

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

Founding Vision and Background

Q: Could you introduce yourselves and describe your roles at Elysian? How did your backgrounds lead to founding this company?

RdV: I'm Reynard de Vries, co-founder and Director of Design and Engineering. I lead technical development, overseeing the aircraft's design and systems integration. My background includes a bachelor's in aerospace engineering in Madrid, a master's in flight performance and propulsion at TU Delft, and a PhD focusing on hybrid-electric aircraft design and aerodynamics, especially distributed-propulsion systems. I've been studying electric aviation concepts for years, and teaming up with Rob in 2023 felt like the right moment to turn theory into reality.

RW: I'm Rob Wolleswinkel, co-founder, co-CEO, and CTO. I graduated in aerospace engineering in 1993, worked at Fokker Aircraft, then the Royal Netherlands Air Force, and later became a senior partner at Boston Consulting Group. In 2020, I switched careers to become a commercial pilot for a small Dutch airline, which gave me practical operational insight. In 2023, Reynard and I founded Elysian. I bring technical expertise, piloting experience, and strategic know-how from consulting.

Q: You're tackling a concept that many before you dismissed as unfeasible. What was the "lightbulb moment" that made you think, maybe the conventional wisdom is wrong?

RW: The breakthrough came when we realized that everyone dismissed battery-electric aviation by using existing turboprops as references. Their process was: take a turboprop design, swap in batteries, and then find it can't meet range requirements, so they conclude battery-electric airliners are impossible. But that logic is too narrow-minded. Instead, we needed to explore the entire design space from first principles. Research by Professors Torenbeek and Obert at TU Delft showed why long-range jets have high fuel fractions due to specific design choices, which encouraged us to rethink everything. Once we stopped copying existing aircraft and started fresh, it became clear that a battery-electric 90-seater could be viable.

Q: I've been referring to your company as Elysian Aircraft, but back in 2021,

Maeve Aerospace, a key competitor to Elysian, is advancing hybrid-electric aviation with an aircraft featuring advanced aerodynamics

Professor Emeritus Egbert Torenbeek - author of the world-famous book "Synthesis of Subsonic Airplane Design"

you probably hadn't even settled on the name. What's the story behind it?
RdV: This is a fun one! Initially, our main investor owned the Fokker brand, so we informally called the project "Fokker9X." But that got confusing; multiple Fokker entities exist, and we needed a distinct identity. We held a naming session: everyone pitched ideas, and we even used ChatGPT for suggestions (this was right when it first launched). We gathered about twenty names, some human, some AI-generated, and voted. "Elysian", from Greek mythology's Elysian Fields, symbolized eternal peace and clarity, which resonated with our vision for sustainable flight. You'll see that optimism reflected in our logo and branding.

Q: What specific problem in aviation are you aiming to solve, and how did that need to catalyze the founding of Elysian Aircraft?
RdV: The core problem is emissions. Aviation generates substantial CO_2, both directly from jet engines and indirectly through supply chains, and industry growth is outpacing sustainability improvements. While efforts to make current aircraft more efficient help, they won't suffice to offset the climate impact. We studied alternatives, hydrogen, Sustainable Aviation Fuels (SAF), and battery-electric propulsion, and concluded that battery-electric systems offer the most realistic path to decarbonizing short-range aviation in the near term. That realization shaped every high-level decision: from passenger capacity to propulsion layout. To make a real dent in emissions, an aircraft must serve the mainstream market, be CS-25 certifiable, and compete economically with existing jets. The E9X isn't a green-demo platform; it's engineered to be a commercially viable airplane for airlines from day one.

Q: Where does Elysian Aircraft currently stand in its development journey? Are you still in the conceptual design phase, or have you moved into preliminary or detailed design? And what major milestones have you reached so far?
RW: We're in the conceptual design phase, and intentionally so. Because our concept is fundamentally new, we've allowed ourselves time to explore deeply. Our first conceptual iteration wrapped up in early 2022. During that process, we identified our "10 hot potatoes", the ten most critical technical challenges to resolve before advancing. These included questions such as achieving a high lift-to-drag ratio, designing an effective thermal management system, and ensuring acceptable noise levels from eight distributed propellers. We've now worked through nearly all ten, with only two or three under final review.

We kicked off a second iteration of conceptual design this winter, building on those studies. We expect to finish that iteration by summer 2025. We're not rushing: decisions in this phase define the aircraft's ultimate architecture. Once in preliminary or detailed design, changes become exponentially harder and costlier. We're effectively in a three-year "tinkering" period, and I'm proud of that rigor. By the time we enter preliminary design, we'll have clarity on key systems like thermal management, so we won't be scrambling in later phases. From concept to entry-into-service typically takes eight to nine years; our timeline aligns with that.

Q: Who do you consider your main competitors, and how does Elysian's approach stand out when it comes to the challenges of achieving climate-neutral aviation?

RW: There are different segments to consider. In the small aircraft and eVTOL space, there are companies like Joby Aviation or Vaeridion, which are developing a nine-seat electric aircraft. They're further along in some regulatory and prototype aspects, which is good for the industry, but they're not competing with us; we operate under CS-25 for large commercial transports. In that domain, you could say our competitors are Airbus, Boeing, and Embraer in terms of certification regime, but technologically, most major manufacturers are pursuing SAFs, hydrogen, or mild hybrids. Examples include Heart Aerospace and Maeve Aerospace, which are focusing on 20% electrification. These give incremental improvements but won't transform short-range aviation.

Our approach includes a small hybrid system only for diversion or emergencies, but normally we fly fully battery-electric. It is a Prius in hardware but a Tesla in operation. That choice drastically changes both the economics and the climate impact. It places us in a niche: on one hand, we have few direct competitors in heavy electrification; on the other, we must constantly demonstrate feasibility to skeptics. However, trends increasingly shift in our favor. Airbus recently delayed its hydrogen program; hybrid projects like ATR Evo have been postponed. A recent German Aerospace Center (DLR) report singled out heavy hybrid concepts similar to ours as the most fuel-efficient and climate-friendly solutions for short-range aviation. We're starting to see momentum build around our technology pathway.

Q: One of the most technically distinctive aspects of the E9X is the integration of battery packs directly into the wing structure. Could you explain your approach here and what trade-offs you've had to navigate in terms of structure, weight, and accessibility?
RdV: Embedding batteries in the wing is both advantageous and challenging. Structurally, aligning battery mass with lifting surfaces improves overall efficiency compared to placing them in the fuselage. But it introduces complex requirements: safety, maintainability, and structural in-

tegrity. Safety-wise, you must design robust containment and fire-suppression systems, whether batteries are in the wing or fuselage; we can't compromise on that. Maintainability is key: batteries degrade and most likely need replacing every 9–12 months. The wing must enable quick access via removable panels or hatches without compromising structural integrity.

Openings in a load-bearing wing affect stiffness, load paths, and fatigue. Each design decision, from battery placement to structural reinforcement, cascades into aerodynamic and thermal considerations. For example, battery size and weight influence wing thickness and chord length, altering lift characteristics. We've explored everything from traditional wing-box configurations with internal racks to advanced modular approaches. There's no off-the-shelf solution; we're creating a new design paradigm that integrates structure, electrical, thermal, and aerodynamic requirements.

Fokker Services Group - a key partner to Elysian specializing in Type Certification of Aircraft

Q: Considering the added weight of batteries, how have you adapted the aerodynamic design of the E9X to maintain efficiency? Are you exploring any unique aerodynamic technologies for future versions?

RdV: Electric aircraft like the E9X are heavy, primarily because of the batteries. That requires a large wing to support the weight, which usually means more drag. But range depends on the lift-to-drag ratio (L/D), not absolute drag. With a big wing and a slender fuselage (since we only need 90 seats instead of 180), we naturally get a high L/D. The fuselage's drag contribution in coefficient terms is relatively small, making the overall configuration resemble a flying wing's performance-wise, even if it looks conventional. This "free gift" of geometry gives us about three extra L/D points without exotic features like morphing wings or boundary-layer control. We purposely avoid chasing marginal aerodynamic improvements; our focus is on leveraging physics and proportions. That configuration alone helps us meet range targets with present-day battery energy densities.

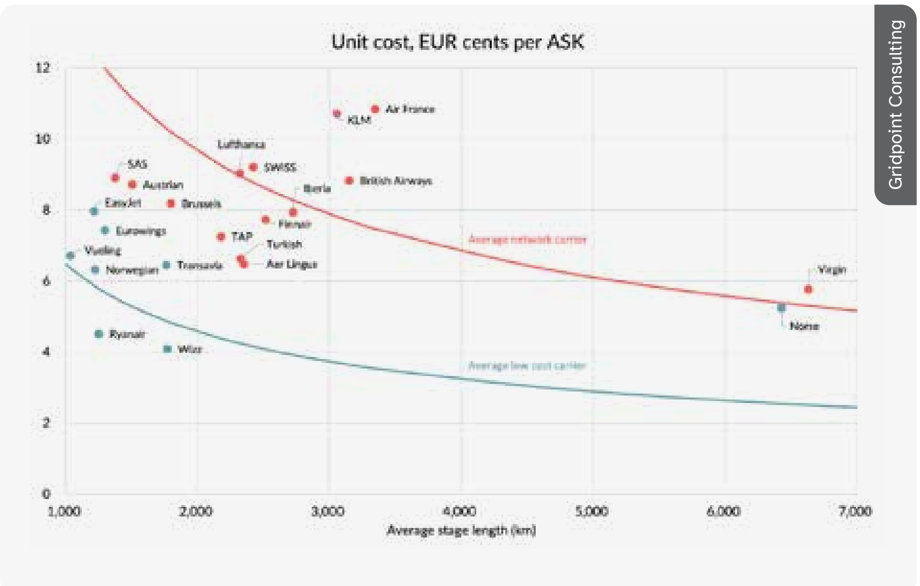
Q: Managing the powertrain in battery-intensive systems presents serious challenges, particularly with regards to thermal regulation and electrical power distribution. What solutions are you considering?

RdV: Power distribution and thermal management are among the most complex issues, especially when balancing weight and safety. From the outset, we design to meet CS-25 safety standards: catastrophic failure probability below 10^9 flight hours, and no single-point failure can cause total loss of aircraft. That means every component choice, including batteries, wiring, and heat exchangers, must follow these principles. We're exploring synergies where a component serves multiple functions to reduce redundancy. These synergies save weight without sacrificing safety. Lessons from other industries influence our approach, but the aviation context has unique constraints of certification, extreme redundancy, and mass sensitivity.

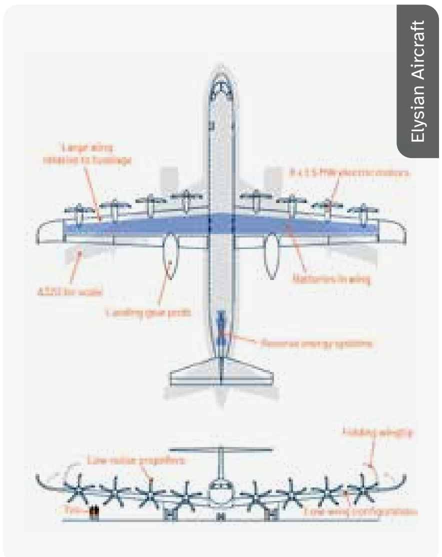
After extensive modeling and testing, we believe the problems are tough but solvable. It's largely an engineering grind: detailed thermal-fluid simulations, rigorous failure-mode analysis, and iterative prototyping. We've had bigger "unknown unknowns" elsewhere, but powertrain and thermal systems now feel within reach.

Q: Battery replacement is a central part of the electric aircraft operational model. How is the E9X being designed to facilitate quick and safe battery swaps?

RdV: Battery degradation is a performance



CASK (Cost per Available Seat Kilometer) figures of various airlines, which Elysian hopes to be competitive against



Engineering highlights of the E9X, with a reduced fuselage cross-section and an expanded wing span relative to the A320 *issue, not a safety issue; as batteries age, energy density drops, limiting range. Operators must swap packs roughly every 9–12 months, depending on usage. For airlines, aircraft are revenue assets that need to spend as much time in the air as possible. We're targeting a 12–24 hour turnaround for a full pack replacement, ideally during overnight maintenance or in parallel with routine checks. That means handling large, integrated battery packs, not shoebox-sized modules, so that crews can swap entire units in one operation. We're developing patented concepts to standardize pack geometry, electrical interfaces, and thermal insulation so swaps become easy.*

Q: What role has AI played in the design of the E9X? (Aside from helping name the company!)
RdV: AI's role in our process has been surprisingly limited so far. Most AI today is statistical and relies on historical data. In our case, there's no existing dataset for integrating large battery packs into commercial wing structures or designing an electric propulsion system at CS-25 scale. You can't ask a neural network to invent something that doesn't exist. For instance, if you'd asked ChatGPT two years ago whether a 90-seat electric aircraft was feasible, it would have confidently said no, mirroring prevailing consensus. If we'd let AI lead, we'd have never started this project. Instead, we rely on deep domain expertise, first-principles thinking, and detailed modeling. When it comes to core design decisions, airfoil selection, structural sizing, and system architectures, it's human engineers doing physics-based analysis. As AI tools improve, we'll integrate them more for optimization and parametric studies, but they won't replace engineering judgment.

RW: To illustrate, I just asked ChatGPT, "Why do aircraft fly at high altitude?" It said, "Because the air is thinner, reducing resistance and improving fuel efficiency." That's an oversimplified textbook answer. In reality, the total energy required to fly a given mission is nearly the same at any altitude; what changes is engine efficiency at lower temperatures. That nuance matters, and AI models often miss it because they regurgitate common phrases rather than reasoning. Until they truly understand physics, we'll use AI as a tool, not a designer.

Q: Many aerospace startups struggle with certification and regulatory hurdles. How do you plan to tackle these challenges?
RW: No one certifies an aircraft alone. Whether you're Airbus or a startup, you depend on partners, suppliers, and authorities. Our first strategic pillar is partnerships. From day one, we connected with experienced engineering houses and certification bodies. One of our investors owns Fokker Services, which still holds active type certificates for legacy airplanes and has a full in-house engineering team. That resource is invaluable.

Second, aerospace rewards experience. We're hiring brilliant young engineers, but we complement them with seasoned professionals who've been through certification cycles. This blend ensures we understand both novel concepts and certification pitfalls. Third, we've built an advisory board including stakeholders from KLM, NLR (Netherlands Aerospace Centre), TU Delft, and Tesla. These advisors are more than names on a slide; they actively contribute through design reviews, risk assessments, and connections to regulatory authorities. It's not David versus Goliath; we're David with a strong support network and a clear understanding of the battlefield.

Q: How does the operational cost of the E9X compare with current commercial aircraft?
RdV: Many people assume short-range flights use turboprops or regional jets, but in practice, about 80% of flights under 1,000 km operate on larger aircraft like A320s or 737s because of their per-seat efficiency. That's our benchmark. If we can approach, or beat, the cost per available seat-kilometer of an A320 or 737 on a 90-seat platform, we'd already be more efficient than Embraer ERJs, CRJs, or A220s.

Electric propulsion systems have far lower maintenance requirements than turbines, and electricity, especially from renewables, is only going to get cheaper than jet fuel. In a future with SAF mandates, fuel costs for jet operators will rise, and our energy advantage will widen. Additionally, we're lobbying for fee structures that don't penalize smaller zero-emission aircraft. Consider landing charges or airspace fees that favor clean operations. When those factors combine, we see a path to genuine cost competitiveness.

Q: If I wanted to fly from Amsterdam to Prague today, it might cost around €150. What would that same ticket cost on an E9X?
RdV: Initially, it would likely be 20–25% more expensive, because fossil-fuel aviation today benefits from unpaid climate externalities: no carbon taxes or emissions surcharges. That keeps ticket prices artificially low. As environmental regulations tighten and SAF prices rise, conventional tickets will become pricier. In that case, E9X fares could match or even undercut fossil-fuel options on a fully cost-accounted basis. Furthermore, zero-emission flights could receive discounted landing fees or priority slots, making our prices more attractive. So while an E9X ticket might start higher, policy shifts and carbon pricing will narrow and eventually invert that gap.

Q: What key lessons have you learned, and what advice would you give to students hoping to follow in your footsteps?
RW: First, don't be naïve. Aerospace isn't the app economy; you can't drop a few bright minds into a garage and expect to revolutionize aviation overnight. It requires deep domain knowledge, decades of experience, and a rigorous understanding of certification. That said, young talent is vital. The best outcomes arise from combining fresh curiosity with seasoned wisdom. Second, collaborate relentlessly. From day one, we've sought partners: TU Delft for aerodynamic expertise, Fokker Services for structural experience, and KLM advisors for operational insights. No one innovates in isolation. Third, embrace realism with optimism. Know the regulatory, financial, and technical hurdles but believe that clever engineering and dedicated execution can overcome them.

RdV: And fourth: challenge everything. Don't accept textbook assumptions, even your own models. Scrutinize every result. Question your frame of reference, verify your boundary conditions, and always ask, "Is this physically plausible?" That mindset led us to question prevailing wisdom about electric aircraft and design a 90-seater that many thought impossible. The mindset to be critical, sceptical, and curious is what drives real innovation.

From their complementary expertise to their pioneering spirit, Wolleswinkel and Dr. de Vries have shed light on Elysian Aircraft's visionary journey, crafting a 90-seat electric airliner that could redefine short-haul travel. Their candid discussion of engineering decisions, economic prospects, and the future of sustainable flight was both insightful and inspiring. The Leonardo Times would like to thank Rob and Reynard for taking the time to conduct this interview.

C&O

A Story of Robust Control

Through the eyes of Prof. Theodoulis

Spilios Theodoulis, Associate Professor TU Delft Aerospace Engineering

Prof. Spilios Theodoulis, an Associate Professor in the Control & Simulation section at TU Delft, and founder of the AEROCON group, shares a story shaped by curiosity, coincidence, and control theory. Taking us on a journey from the early struggles and challenges of conventional control theory to the groundbreaking innovation of $\mathcal{H}_\infty$ control (a specific method of robust control), he reflects on the evolution of robust flight control and why it still matters today both to the industry and to himself.

Q: Can you introduce yourself?

ST: I am an Associate Professor in the Control & Simulation section of the Faculty of Aerospace Engineering at Delft University of Technology. In September 2022, I founded the AEROCON research group (AErospace dynamics and RObust CONtrol) within the Guidance, Navigation & Control (GNC) cluster of our department. My academic background is rooted in systems and control: I hold a PhD in the field from Université Paris XI, as well as an MSc from Université Paul Sabatier in France. My original engineering diploma, however, is in Electrical Engineering, which also included a second MSc in control systems—so, yes, a lot of control theory! Before joining TU Delft, I spent nearly 14 years as a researcher at the French-German Research Institute of Saint-Louis (ISL), where I co-founded and helped lead the institute's GNC department.

Q: How did you get into the fascinating world of robust control?

ST: This is a story shaped entirely by coincidence and a bit of serendipity. My very first encounter with $\mathcal{H}_\infty$ control happened in the fourth year of my Electrical Engineering studies. Unfortunately, it was... underwhelming. I didn't yet have the mathematical maturity to grasp the concepts, and it felt like I was trying to decode alien technology. The whole thing left me more confused than inspired. But just a couple of years later, my path crossed with one of the towering figures of robust control: Dr. Jacques Bernussou, at the renowned LAAS-CNRS research institute in Toulouse. I consider myself incredibly lucky to have been one of his students. I remember him vividly, around 65 years old at the time, with a calm intensity, sitting with me and explaining, by hand, across several A4 pages, the intricacies of robust control. His clarity and patience made a lasting impression. There's a funny story here that still makes me smile. While Jacques was talking me through the (now legendary) "1994 LMI solution" to $\mathcal{H}_\infty$ control, a landmark paper co-authored by Pierre Apkarian, one of the most influential minds in the field, I noticed Pierre's photo on the last page of the journal article. Suddenly, I had a flashback. A month earlier, during the robust control course at SUPAERO (which I was taking as a requirement), I had unknowingly pestered a, what I thought then, "just another postdoc", with many questions. It turned out that this "postdoc" was Pierre Apkarian himself! Not only was he no ordinary researcher, but in 2006, the very next year, he revolutionized the field again with his groundbreaking work on *nonsmooth optimization, which led to the development of HINFSTRUCT and later SYSTUNE in MATLAB.*

Q: If you could have contributed to the FCS of any aircraft in the world, which one would you have chosen?
ST: There are, of course, so many remarkable aircraft. If I let my inner geek speak for a moment, I can list more than few: the F-14 Tomcat, with its variable-geometry wings and pioneering use of a microprocessor-based flight control system; the Dassault Rafale, with its aerodynamically complex and highly integrated airframe; the F-22 Raptor, featuring thrust vectoring and unmatched stealth-performance balance; the Sukhoi Flanker series, including the forward-swept-wing Su-47; and NASA's daringly unstable X-29A, the list goes on and on. But if I had to pick just one, the aircraft that truly captured my imagination from a very young age, it would have to be the F-16 Fighting Falcon. As a boy, I remember watching the Viper perform high-g manoeuvres from the roof of my house, streaking out of the Vouraikos canyon in Diakopto, Greece. It was breathtaking. Beyond its striking design and aggressive flight characteristics, the F-16 was the first operational aircraft to rely entirely on fly-by-wire technology, analog in its early versions, with no mechanical backup. That was nothing short of revolutionary. Its flight control system (FCS) was a masterpiece of engineering, enabling levels of agility and responsiveness that were simply unheard of at the time.

> *"Beyond its striking design and aggressive flight characteristics, the F-16 was the first operational aircraft to rely entirely on fly-by-wire technology"*
>
> **Prof. Spilios Theodoulis**

Q: Robust control is now a fundamental part of aerospace design. What were the standard practices before its inception?
ST: The control techniques for stability augmentation systems in first and second-generation fighter aircraft of the 1950s and '60s were constrained by the theoretical tools available. Design methods were mostly single-input, single-output (SISO) or followed a loop-at-a-time philosophy. Engineers relied heavily on classical techniques such as root locus, Bode plots, and Nyquist diagrams, often combined with hand-tuned PID controllers and lead-lag compensators. These systems were designed using a blend of analytical tools, engineering intuition, and, quite frankly, a good amount of courage. Without today's computational resources or multivariable design frameworks, achieving stable and responsive flight control required deep experience, sharp judgment, and much trial and error.

Q: But then, why was there a need for new control methods?
ST: These classical methods were adequate for the aircraft of their era in the 1950s and '60s, but their limitations soon became annoying. As aircraft grew more manoeuvrable, aerodynamically unstable, and began pushing the boundaries of performance, especially with the introduction of fly-by-wire technology, traditional control tools quickly showed their age. They were unsuited for multivariable systems, essential to managing the complex, tightly coupled feedback loops present in modern aircraft. Nor could they effectively handle uncertainties in critical parameters such as mass properties, aerodynamic coefficients, and varying operating conditions. Most importantly, these classical approaches offered no formal guarantees of stability or performance across changing scenarios. For engineers at the time, demonstrating or even simply hoping for safety and reliability in such control systems must have been an intimidating task. The rapid technological advances of the 1960s, fueled by the space race and accelerating aerospace innovation, created an urgent need for a new, more rigorous theoretical framework – and fast.

An F-16C Block 52+ belonging to the Hellenic Air Force, aircraft which Spilios finds a revolutionary masterpiece of engineering

Q: How was this fixed? How did the industry and the research community react?
ST: Rudolf Kalman's groundbreaking work in the early 1960s fundamentally changed the landscape of control theory. The introduction of state-space theory, the Kalman filter, and the development of the Linear Quadratic Regulator (LQR) and, when the last two were shaken-and-stirred together, the Linear Quadratic Gaussian (LQG) controller, offered an elegant and (seemingly) powerful new framework. For the first time, it became possible to systematically handle multi-variable systems, incorporate disturbances and noise, and optimize system performance based on mathematically defined cost functions.

However, the reception wasn't universally enthusiastic, at least not at first. There was a significant gap between academia and industry. The aerospace industry, trained in classical control lore that was well-understood and flight-validated, viewed these new state-space techniques as a mathematician's illusions. Yet over time, some of this elegant theory was indeed put to good use, particularly in the space program for filtering and navigation.

Q: This sounds awesome! Why doesn't the story end here?

ST: Because the same person who "destroyed" LQG came to its rescue 3 years later. John Doyle and Gunter Stein (another important figure in robust control during the 80s and 90s) published another paper, again in IEEE Transactions on Automatic Control, in which they proposed the concept of Loop Transfer Recovery, and literally brought LQG back from the underworld. The idea was simple: through a so-called recovery parameter, we can redesign the (optimal Kalman) estimator of the controller to try and recover the excellent robustness margins of the LQR controller at the plant input. These works were further refined by Stein in 1987 and by researchers from Boeing a bit more recently (in 2012) in a heroic attempt that made the LQG/LTR a quite solid approach to control design, even though controversy still exists today.

Q: This sounds like our final stop, right?

ST: Well, not exactly... While Doyle, in this very 'compassionate' move, saved LQG in the early 80s, the "damage" was kind of already done. In 1981, George Zames, in the very next volume of the same journal as John Doyle, opened a completely new way of seeing things, the $\mathcal{H}_\infty$ landslide. He and John Doyle later considered the control problem as minimizing the worst-case gain from external disturbances to performance outputs, but across all permissible system uncertainties. This was a radically different, frequency-based mindset than LQG control, which is essentially a time-domain technique. But posing the problem was one thing; actually solving it was a totally different beast. Following the words of Doyle himself, the $\mathcal{H}_\infty$ problem was, in its mathematical sense, first solved in 1984. This was an "on-paper" massive breakthrough and was achieved through a so-called Youla parameterization of all stabilizing controllers, the use of Hankel-Toeplitz operators, and the solution of "Nehari-type" problems.

Q: This sounds big. Is this $\mathcal{H}_\infty$ control in its final form?

ST: Far from it, actually. While the so-called 1984 solution was groundbreaking in its own right, it was perhaps impractical for widespread engineering use. While a more compact solution was lurking behind the scenes, it was not until 1989 when John Doyle, together with K. Glover, P. Khargonekar and B. Francis, provoked a sort of "nuclear detonation" in robust control when he published the celebrated DGKF (from the first letter of the authors' surnames) paper. This paper (with more than 5000 citations) gave a simple state-space solution via two algebraic Riccati equations, while proving that the resulting controller can be put in a state observer/feedback form, much like (but in a fundamentally different way) as an LQG controller. This paved the way for software tools to support robust control design. The problem was that the "1989 solution" lacked flexibility and generality, until the "bulldozer", called LMI's (Linear Matrix Inequalities), arrived in the early 90s. In a stroke of genius, P. Gahinet and Pierre Apkarian (mentioned earlier) managed the impossible: in another classical 27-page journal paper in 1994, they invented a particular mathematical projection literally out of thin air that managed to convexify the $\mathcal{H}_\infty$ problem, making it solvable using LMI's. Still, this was not the end of our "suffering"... This 1994 solution had the same shortcomings as the 1989 solution: industry did not seem to like it because it yielded controllers of high complexity, unlike any of our venerated PIDs... We had to wait for more than 10 years until they nailed the problem. In 2006, Apkarian and D. Noll finally "solved" the $\mathcal{H}_\infty$ problem for one last time by using non-smooth optimization techniques. This permitted the design of robust controllers in an $\mathcal{H}_\infty$ setting and any desired convexity (aka PIDs, lead/lag, etc). This is what the industry wanted.

Laurent Lessard

The authors of the famous DGKF paper. From left to right: J. Doyle, K. Glover, P. Khargonekar and B. Francis

Dr. Theodoulis (center) with test pilots Hans Mulder (left) and Alexander in 't Veld (right) in front of TU Delft's flying laboratory PH-LAB. The aircraft is used for advanced flight control law research at TU Delft

Q: How do we currently practically achieve $\mathcal{H}_\infty$ tuning?

ST: After decades of theory, breakthroughs, and setbacks, robust control is now accessible to practising engineers, thanks largely to tools like MATLAB, though open-source alternatives also exist. An early implementation of these algorithms appeared around 2010 with the introduction of the HINFSTRUCT function. However, it was not until 2012 with the release of the function SYSTUNE in MATLAB's Robust Control Toolbox that the full power of robust control could be unleashed.

This was a true game changer. Instead of using Riccati equations or solving large LMIs, engineers could now optimize (not tune!) controller parameters to satisfy a wide range of design objectives such as $\mathcal{H}_\infty$ or $\mathcal{H}_2$ (akin to LQG), pole placement, multi-model and gain-scheduled setups, and many others. However, this innovation may come with a trap. Tools like SYSTUNE can obscure the underlying principles of robust control, leading some engineers and students to use them without a deep insight and understanding of what automatic control really is. The risk is that one might assume *a design is robust simply because the tool is advertised as robust when, in fact, if the control problem wasn't set up properly, robustness may not have been achieved at all… This is where education becomes critical, and that, in my opinion, may have even deeper implications for how we teach and practice control engineering.*

Q: What is the big challenge being faced by academia and industry today?

ST: The challenges facing automatic control today are greater than ever before. With a growing global population, dwindling natural resources, geopolitical instabilities, and an unrelenting demand for "faster and more," the need for advanced automation is becoming increasingly urgent. In aerospace in particular, we need to develop aircraft that consume less fuel, carry more passengers, and do so with ever-higher levels of safety. But as always, there is no free lunch. Achieving these goals requires lighter structures, lower-drag aerodynamic designs, more efficient engines, and carefully optimized flight trajectories. Meeting all these demands simultaneously is only possible through the use of sophisticated flight control systems that can maintain safety and performance even under degraded or uncertain conditions. Concepts such as reconfigurable flight control, cooperative multi-agent systems, learning-based algorithms, and adaptive structures are all at the forefront of this paradigm change. Yet, this rapid advancement brings with it a risk: the loss of foundational knowledge. In our pursuit of constant evolution, we risk forgetting the hard-earned insights of previous generations, lessons often learned through painful experience, or as we say in aviation, "written in blood". One easy example: how many engineers graduating with a Bachelor's or even a Master's degree today can confidently tune a simple PID controller? It's an important question and a reminder that innovation must go hand in hand with education, critical thinking, and respect for the fundamentals. Food for thought for all of us…

Q: AI is the buzzword of these last few years. Is there a place for AI in robust control?

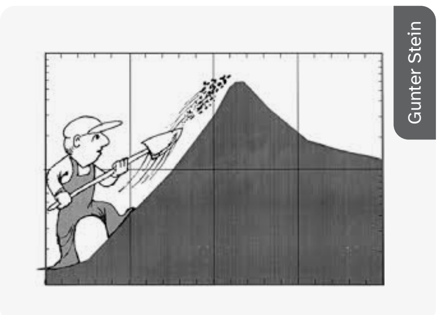
ST: That's a very good question, and I might offer a somewhat heretical *answer. Robust control has long attracted some of the brightest minds in control theory, going back to the 1960s and 70s. But with that intellectual rigor sometimes came a tendency to focus on elegant mathematics and theoretical purity rather than on real-world relevance. As Gunter Stein, a major figure in control and someone whose motto,* "Respect the Unstable", *has deeply influenced me, once pointed out, we occasionally hide behind mathematical complexity, distancing ourselves from the actual needs of industry and society. The truth is, no single theory can solve every problem. While I don't believe we should be putting AI "even in our soup," we* do *need to embrace its strengths, especially for addressing problems that are naturally suited to data-driven approaches, rather than to purely model-based or deterministic formulations. Let me give you a few examples. Imagine what a triumph it would be for automatic control if, in the event of a catastrophic failure, an aircraft could reconfigure its flight control system on-the-fly to land safely, saving all its passengers. Or consider a scenario where a pilot loses consciousness due to G-LOC (G-force induced Loss of Consciousness): how remarkable would it be if a control system* *could recognize this autonomously, take over, and guide the aircraft back to a safe trajectory? These aren't just engineering dreams; they're very real possibilities at the intersection of robust control, autonomy, and intelligent systems. But to reach them, we must combine the best of both worlds, not as replacements for one another, but as complementary tools in service of safety, performance, and resilience.*

Q: What research are you currently involved in, and what are you most excited to see in the coming years?

ST: Before answering this question, I would like to first express my deepest gratitude to all of my students, both MSc and PhD, for their relentless pursuit of knowledge, their curiosity, their collaborative spirit, and the many intellectually stimulating exchanges we've had over the years. I also extend heartfelt thanks to my colleagues, both in academia and industry alike, from across the globe, who have honored me with their trust and support. Above all, I am especially grateful to my colleagues at the Control and Simulation (C&S) section of our faculty: Erik-Jan van Kampen, Max Mulder, Marilena Pavel, Marija Popovic, Ewoud Smeur, Olaf Stroosma, Coen de Visser, and Xuerui Wang. Each of them has, in their own way, fueled my passion for research and education during these three inspiring years within this dynamic ecosystem.

Now, returning to your question: my core research focus lies, of course, in robust control and its deep interconnections with flight dynamics and GNC (Guidance, Navigation, and Control) systems. This foundational work is linked to a wide range of aerospace applications, including civil and fighter aircraft (such as our own Flying-V concept), space launchers, helicopters, sounding rockets, drones, and last but not least, defense platforms. Within my AEROCON group, we are committed to advancing knowledge on aircraft handling qualities, designing resilient flight control laws to mitigate actuator or sensor saturation, to alleviate gust loads, and to guarantee robustness and performance of aerospace systems under adverse or uncertain conditions. One area we are currently investing heavily in is the unification of (potentially nonlinear) inversion-based control laws with robust control theory; a paradigm that could significantly enhance the capabilities and ease of design of future flight control systems. We are also exploring adaptive augmentation of robust controllers and integration of data-driven approaches into the design and analysis of robust flight control laws. But allow me to add something I consider essential: none of this would be possible without a deep and systematic commitment to education. Through our MSc course on Robust Flight Control, as well as the Bachelor-level control course taught in close collaboration (and primarily by) with my colleagues Coen de Visser and Rene van Paassen, we aim to build a strong foundation for students in control theory. Initiatives such as our soon-to-be-established Flight Controls Lab, alongside our SIMONA Research Flight Simulator and our experimental fly-by-wire aircraft, the PH-LAB, are all designed to immerse students in hands-on, meaningful learning experiences. Only by strengthening this foundation can they go on to deliver cutting-edge research and push the boundaries of what once seemed impossible to achievable.

NASA's infamous X-29A with its forward-swept wing



A caricature present in Gunter Stein's famous 2003 "Respect the Unstable" *paper*

Q: Final question. Looking back, what's been your favorite project or moment that made you think, "This is why I got into control"?

ST: Thank you for this question, since it allows me to pay tribute to three individuals who have played a pivotal role in shaping my professional journey: Professors Antony Tzes, George Bitsoris, and Gilles Duc. Much like a dynamical system evolves based on its initial conditions, I believe the same holds true for a person's intellectual path. These three remarkable mentors helped set my own "initial conditions", and for that, I am grateful. Rather than highlighting a single project or defining moment, I believe it's the people and their stories that leave the most lasting impact. Professor Antony Tzes was the first to open my eyes, and those of many fellow students from the 2001 Systems & Control track, to the power and versatility of automatic control. Under his charismatic supervision, I worked on a magnetic levitation system for my thesis, a project that still resonates with me to this day. He showed us how control engineering can bring any technical dream to life. Professor George Bitsoris taught me that quality outweighs quantity and that becoming a true control engineer or scientist requires a deep mastery of the fundamentals. His MSc course on dynamical systems and control theory was an unbelievable formative experience; it lives in my memory even more than 25 years later. His emphasis on conceptual depth has profoundly shaped the way I think about engineering and education. Last, but not least, Professor Gilles Duc, my PhD supervisor, not only introduced me to the field of robust control but also, perhaps more importantly, tried (with some success!) to instil in me a sense of scientific rigor and intellectual discipline. His influence helped balance out my otherwise more "Mediterranean" character, and continues to guide the way I approach research and education. In hindsight, each and every one of them not only introduced me to the field of automatic control but also kept me in it.

Leonardo Times would like to thank Prof. Spilios Theodoulis for taking the time for this interview, and for continuously sharing his passion for the field with the students of the faculty.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Tariff Turbulence

The Trump administration's impact on European aerospace

Shourya Bhandari, Leonardo Times Editor

The aerospace industry must brace for all eventualities as transatlantic trade turbulence arises. With President Trump's revived "America First" tariffs threatening to purge decades of duty-free aerospace commerce, the EU's looming countermeasures could spark a trade war. This article unpacks the far-reaching consequences for European aviation.

Trump's 2025 "America First Trade Policy" threatens to inflate annual aerospace and automotive import costs from roughly $8 billion to $109 billion, a near-13-fold jump that would upend four decades of duty-free transatlantic trade under the 1979 General Agreement on Tariffs and Trade (GATT) Aircraft Agreement [1]. In response, Brussels drafted a €100 billion retaliation package, including levies on Boeing jets, jeopardizing aircraft deliveries and further straining an industry that is already experiencing delivery delays [2].

The Netherlands, though exporting only 4–5% of its goods to the US, exports 43% of its machinery and transport equipment there, including aerospace components, making Dutch GDP growth vulnerable. Models forecast up to a 1pp drag by 2026 and a 5–6% contraction in aerospace output if steel tariffs continue [3, 4]. Dutch manufacturers and enterprises are considering alternatives: rewiring supply chains, investing in digital twins, and lobbying for a carve-out. In the meantime, policymakers prepare the WTO challenges, targeted subsidies, and new trade agreements to diversify export markets.

The EU's Response

The U.S.–EU aerospace relationship was reinforced by the 1979 GATT which, effective January 1st 1980, eliminated tariffs on civil airplanes, engines, simulators, and parts among 33 signatory countries [5]. This plurilateral accord enabled Airbus's rise and allowed Boeing to import European components tariff-free, fostering deeply integrated transatlantic supply chains and supporting over €106.9 billion in EU Exports concerning the Civil Sector [6]. For nearly forty years, this framework provided stability and predictability, making current U.S. tariffs all the more disruptive to an ecosystem built on tariff-free exchange.

On January 20th, 2025, President Trump signed an executive order reviving the "America First Trade Policy", tasking the U.S. Trade Representative with probing "unfair" trade barriers in all sectors [7]. By February 13th, the administration unveiled its "Fair and Reciprocal Plan", proposing reciprocal tariffs on countries imposing higher VAT or other "non-tariff barriers", initially targeting the EU, India, and Japan [8]. PwC, a British consulting firm, conducted an analysis which projected that, without countermeasures, these levies could raise combined automotive and aerospace import costs from $8 billion to $109 billion annually, since $306 billion of the $481 billion in trade currently enters duty-free [1].

The EU argues that the Trump administration's 2025 reciprocal tariffs are "unjustified and damaging" [9]. Possible legal implications could arise from a possible breach of core WTO commitments, particularly the "Most Favoured Nation" principle under Article I of the GATT 1994, which prohibits discriminatory treatment between WTO members [5]. Trade experts, including those at the Peterson Institute for International Economics, have argued that the U.S. justification has no legal grounding unless proven in WTO dispute proceedings [10]. This legal ambiguity leaves the aerospace sector especially vulnerable as Brussels prepares countermeasures, while the institutional framework of global trade continues to erode. In response to Trump's tariffs, in May 2025, the European Commission unveiled a €100 billion retaliation package targeting U.S. imports, including civilian aircraft, initially set at 20%. This was later reduced to 10% for a 90-day negotiation window [2]. If talks fail by mid-July, Brussels is poised to reimpose tariffs on Boeing aircraft.

Thales delivers advanced Multi-Mission Radar to the Dutch Army for 4D air and ground defense

Unlike Airbus, which assembles aircraft in Alabama, Florida, and Mississippi, Boeing lacks production facilities within the EU and would be hit on both sides, paying U.S. import tariffs on European parts and EU tariffs on transatlantic aircraft exports [11]. Analysts at the Financial Times estimate that Boeing's margin per aircraft could fall by up to 15%, while airline executives warn that 50–70 deliveries could be deferred over the next two years due to rising costs [2]. The move not only disrupts supply chains but also risks shifting market share toward Airbus. Wouter Dewulf, an air transport economist at the University of Antwerp, noted that Boeing will likely have to absorb the added material costs, significantly increasing production expenses and squeezing per-aircraft profit margins [11].

Since 2015, Airbus' site in Mobile, Alabama, has assembled A220 and A320 jets, fueling aerospace growth in the U.S.

Airbus, by contrast, signalled greater flexibility in navigating the tariff landscape. In February, CEO Guillaume Faury stated that the company may prioritize deliveries to non-U.S. customers if tariffs disrupt transatlantic trade [11]. An Airbus spokesperson added that the firm "continuously assesses how to best allocate production and deliveries in response to changing market conditions", as part of its standard risk management strategy.

Impact on Dutch Aerospace

Due to the Netherlands' deep integration in global value chains, even limited direct exposure can trigger outsized ripple effects. De Nederlandsche Bank projects aerospace output could contract by 5–6% by 2026 under a 10% U.S. tariff regime, especially when coupled with the ongoing 25% levy on steel imports [4].

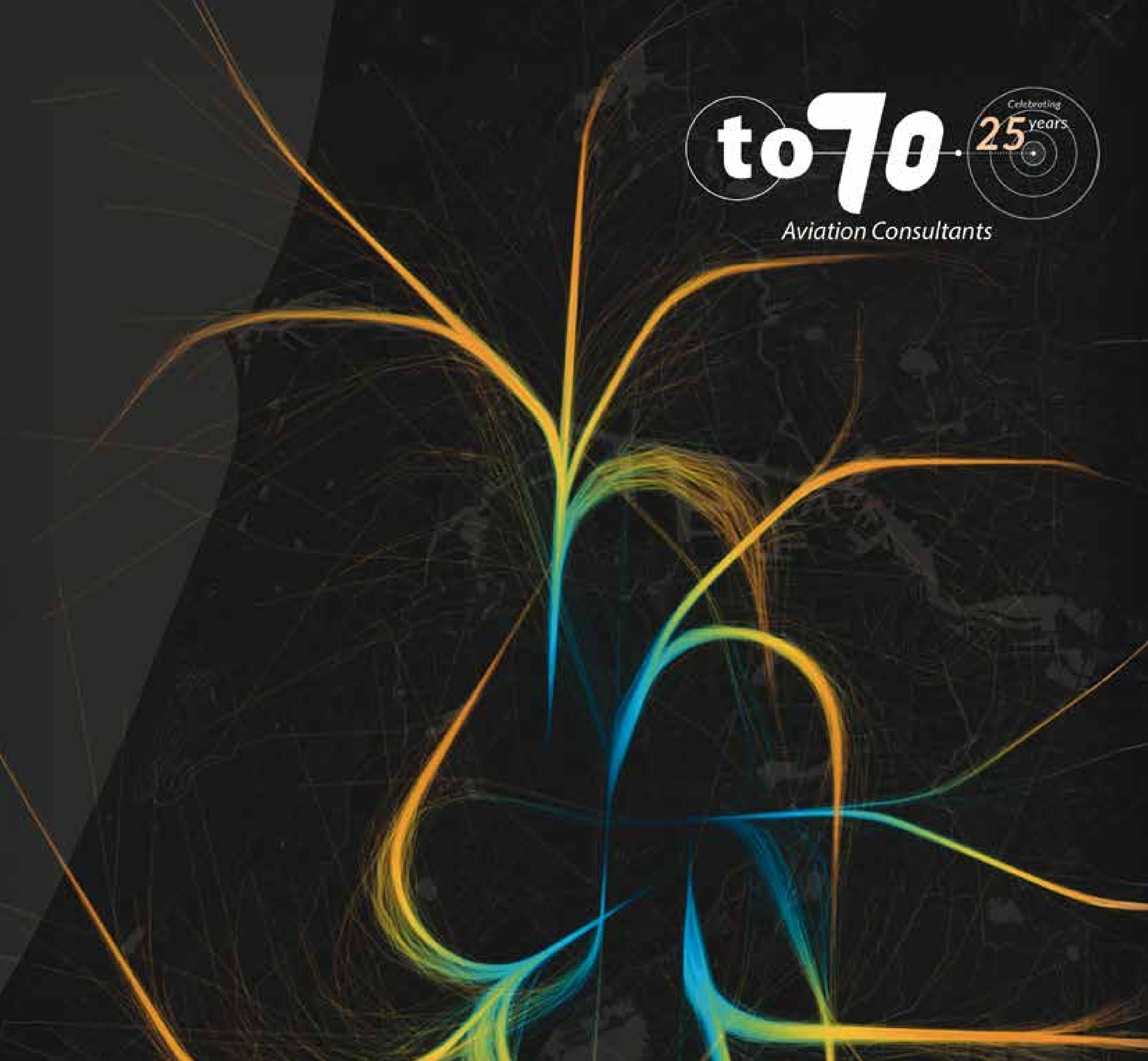
In response, companies like GKN Aerospace are exploring various strategies, including altering shipping routes for components and parts to navigate the new trade restrictions [12]. Similarly, Thales is implementing several mitigation measures in response to these regulations. These include: utilizing specific customs programs like duty drawback and temporary importation under bonds, redirecting certain production flows, adjusting transfer pricing, optimizing the supply chain through alternate sourcing, and applying customer surcharges [13]. Additionally, Thales Netherlands has ramped up lobbying efforts with Dutch and EU authorities to secure sector-specific exemptions, emphasizing the national security importance of avionics and defence components [3, 13].

Air France–KLM has taken a cautious but firm stance in response to potential tariff-related cost increases. CEO Benjamin Smith emphasized that the group would "aggressively" challenge any suppliers attempting to pass on tariff-related price hikes for parts and materials used in its maintenance operations [14]. While it remains uncertain whether aviation tariffs will persist, Smith noted that the group's predominantly Airbus-based order book reduces exposure to U.S.-specific measures. Even for Boeing aircraft, he highlighted that many components are produced in Europe, further mitigating risk. Although current contracts typically do not contain exceptions for import tariffs, the airline is closely monitoring developments. Meanwhile, Air France KLM Engineering & Maintenance continues to perform strongly, posting a €65 million profit in Q1 2025, despite ongoing supply chain challenges in its component business [15].

R&D research programs at NLR and TU Delft focus on hydrogen propulsion, advanced composites, and sustainable aviation requires stable, multi-year funding commitments. Tariff-driven revenue uncertainty could risk deferring development campaigns and scaling back any partnerships with U.S. organizations.

Brazil becomes the latest member to accede to the Agreement on Trade in Civil Aircraft

The Trump administration's 2025 tariffs have upended a long era of tariff-free transatlantic aerospace trade, forcing OEMs, suppliers, and airlines to absorb higher costs, recalibrate global supply chains, and pursue new markets. For the Dutch aerospace sector, deeply embedded in global value chains, the risks to GDP growth, sectoral employment, and R&D competitiveness are significant. Sustaining Europe's leadership in aerospace will require corporate agility, robust legal challenges, and targeted public support to navigate this unprecedented trade turbulence.



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Language of Instruction

A history and debate

James Perry, Editing Director

The only aerospace engineering degree in the Netherlands is taught in English. This has implications for the university, the country, students and industry across the globe. But it has not always been this way, and may not continue to be in future. Language goes far beyond words on a page.

Students at the Faculty of Aerospace Engineering may have noticed the collection of old Leonardo Times covers framed above the stairway to the VSV floor. They illustrate the pride and history of our journal, which celebrates its 30th anniversary next year. The covers also show that at some point there was a change in language, with older editions of the Leonardo Times printed in Dutch. One of the most famous of these is titled "Glare gaat groot!" (Glare goes big!), an article about the use of the faculty's composite material "glare" in the Airbus A380. This is an alliteration which wouldn't work in English. If the title were written today, it wouldn't carry the same weight or have quite the same impact. The Leonardo Times has editors from around the world, only one of whom at the moment is fluent in Dutch. This article first examines the importance and influence of language, then discusses its role in this faculty, and concludes with key insights.

Words Matter

The importance of the language used by a university consists of three major parts. Most obviously, the language of lectures, assignments, and exams affects which nationalities choose to enroll. Dutch is the eighth most common spoken language in the European Union, with over 25 million speakers, mostly from the Netherlands and Belgium [1]. Bachelor-level courses given in Dutch are generally expected to only be accessible to students from these countries, as it is rare that Dutch is learnt to a sufficient level as a foreign language by that age. By contrast, English has roughly 1.53 billion speakers, making it the most spoken language in the world by number of native and non-native speakers [1]. Mandarin Chinese comes third at 1.18 billion, followed by Hindi, Spanish and standard Arabic. English is often seen as the professional language of the Western and wider world for international business, so it is often learnt to a high proficiency as a foreign language in school. This means teaching in English enables students from around the world to study at a university, as can be seen in our faculty. While it might be expected that English-speaking countries would be overrepresented, this is not the case.

Secondly, the language we speak influences the way we think. This is not true in a broad sweeping sense as is often claimed, as we possess the ability to understand concepts we have no word for. It is often claimed that there is no English word for "gezellig", which is translated as a mix of sociable, cosy and just generally nice – but that does not mean non-Dutch speakers cannot understand the concept. On the other hand, the language we speak has been shown to impact the way we do even non-linguistic tasks. For example, some languages exclusively use an absolute cardinal-type direction system to refer to objects, as either North, South, East or West of each other. Such languages include Tzeltal, spoken in regions of Mexico, and Arrernte, spoken in regions of Australia [2]. This is opposed to English or Dutch, where we would usually use the relative directions of left, right, in front of and behind. If an English speaker is shown a table with an arrow on top pointing left, and then taken around to the other side of the table and asked to recreate the situation, they will usually place another arrow pointing to their new left. A Tzeltal speaker usually places the arrow pointing to their right, see Figure 1, as it preserves the original cardinal orientation, even though no relevant language is used in this experiment [2]. Similarly, speakers of languages with absolute direction keep track of which way is North far more effectively than speakers of other languages can.

This is an extreme example, but similar phenomena occur in languages with far more speakers. For instance, English distinguishes between actions like "put in" versus "put on", emphasizing containment or attachment. On the other hand, Korean allows speakers to express the *tightness* of

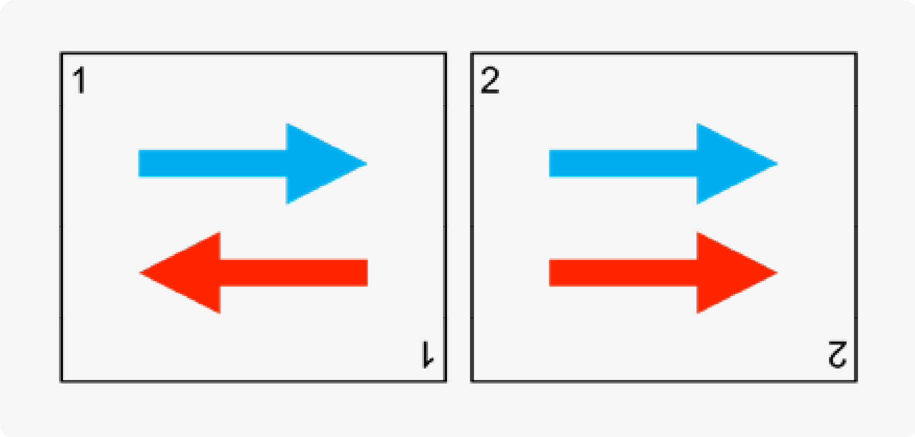


Figure 1: Lie the page flat, and consider the direction of the blue arrow. Look at the page from the other side, and consider the red arrow. In box 1, it is oriented the same in relative direction, while in box 2, it is oriented the same in absolute direction

fit. The verb "kkita", for example, means to put something in or on with a snug, firm fit. Until around two years old, the human brain is flexible enough to easily understand both concepts [3]. However, past that age, special categories become fixed, and children no longer understand concepts other than those present in their own language. Dutch and English are relatively similar languages, and as such semantic differences are few. One such difference is how the English preposition "on" breaks down into "op", for resting on top of, and "aan", for being attached to the side of something, see Figure 2. Could this different perspective influence engineering design?

Finally, and most relevant to our university, language is intertwined with culture. When all Dutch aerospace engineers must study in English, they are all well equipped to leave the Netherlands to make careers abroad, should they choose to do so. International students are less motivated to remain in the Netherlands because they never integrate into Dutch culture. Extremely high English proficiency means that it is quite possible to live and work in the Netherlands without understanding a word of Dutch. As international students never have to invest any effort into learning the language, they make no commitment to the country. As a result, TU Delft does not provide aerospace engineers for the Netherlands, but for the world, to mixed reviews [4]. This reduces direct return on investment for the Dutch government, but makes the faculty a major player on the global stage.

The government is keen for students educated in the Netherlands to stay in the Netherlands and contribute to society and the Dutch economy, something only a third of international students do currently [5]. The university receives funding from Dutch taxes, so it seems unfair to some that numerus fixus programs, such as aerospace engineering, should be full of non-EU international students who won't give back financially.

History Repeating

Aerospace engineering first began as an independent degree program in 1945, after the faculty's founding in 1940 and a few false starts during the Second World War [6]. At the time, it was a five-year Dutch-language integrated master's degree, which evolved with time and was eventually split into separate bachelor's and master's degrees in the early 2000s. From 1999, it was one of the first faculties to hold an English-language program alongside the original Dutch one [7].

When new programs were launched in 2009, a significant number of students (eventually up to 20%) did not continue to the master's program [5]. As this number grew, so did the number of incoming external students. In 2014, following "very insistent" advice from the review committee [7], the Dutch language track was discontinued, and the program began to be taught only in English. According to the faculty's eighty-year publication [5], it was the influx of students from other universities, including internationally, to the master's phase, which saw the first rise in international students at the faculty. Dutch students were leaving voluntarily and being replaced by international applicants. By 2018, approximately half of all new aerospace engineering students were from outside the Netherlands, a third of whom came from outside the EEA (European Economic Area).

So, where are we currently? At the start of 2025 [8], 26.2% of all students at TU Delft are international, and 22.0% of permanent staff. Interestingly, last year 32% of diplomas were awarded to international students, which suggests a lower drop-out rate. International students have made a greater social and financial commitment to their studies abroad, so they may be more reluctant to change heading. Internationals comprise 18.5% of bachelor students, 35.2% of master students, and 66% of PhD candidates, of which Chinese students comprised nearly a quarter in 2021. Four of the sixteen bachelor's programs are taught entirely in English [9], and none are taught entirely in Dutch [7]. All master's programs are in English [9].

In February 2024, the Dutch parliament's Tweede Kamer (House of Representatives) passed a motion, 106 votes to 44, to take action to reduce the number of English-language degree programs in the country [10].

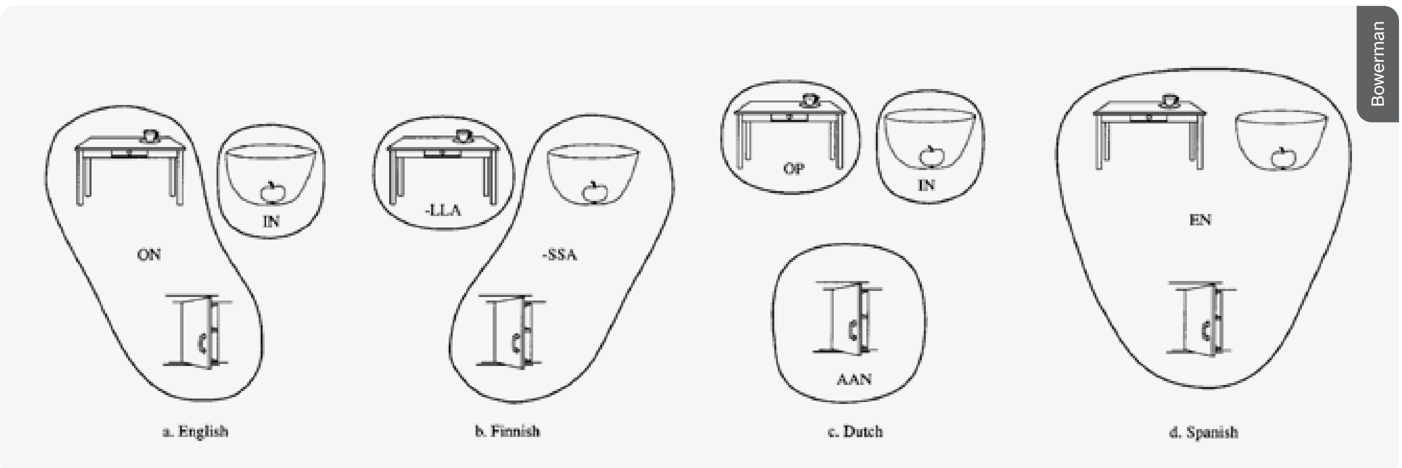
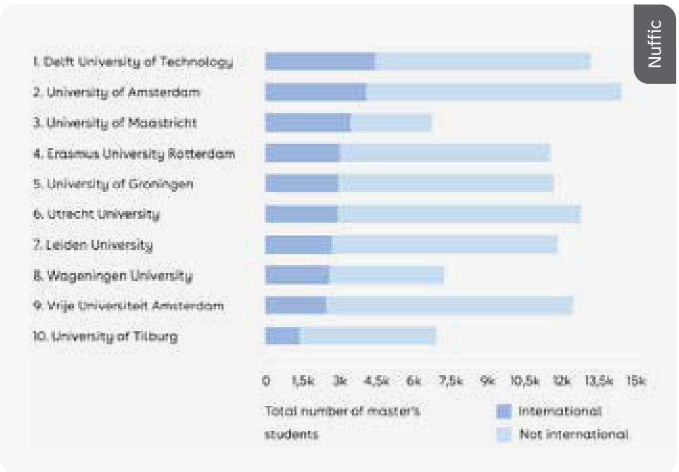
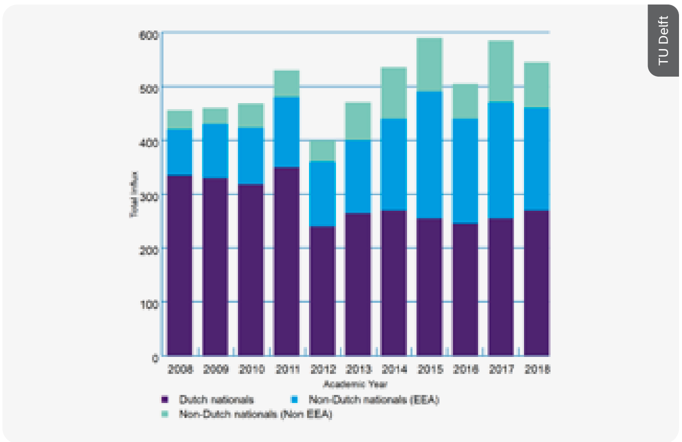


Figure 2: Words in different European languages with overlapping meaning to describe relative locations



Statistics on the number of international master's students in the Netherlands as of 2022. TU Delft ranks the highest, with approximately 4,300 international MSc students [8]



The total number of new aerospace engineering students at TU Delft annually, from 2008 to 2018. There has been a decrease in new Dutch nationals, and an increase in both EEA and non-EEA international students

The reasons formally given were that previous legislation identified Dutch as the primary language of higher education, and that proficiency should be promoted. The Dutch universities responded [5], committing to teaching all major bachelor's degree programs in part or entirely in Dutch. It was unclear exactly what was meant by this, or when these changes would take place. TU Delta reported that then-Vice-Rector Robert Mudde suggested the faculty of aerospace engineering would return to having degree tracks in two languages [7]. Faculty director of education Joris Melkert called the article "premature", continuing that their "preference is to stick to English, as this is a particularly international working environment" [11].

A year later, the Inspectie van het Onderwijs (Inspectorate of Education) released a report detailing five case studies into the use of the English language for degree programs [12]. All five cases found compelling reasons why the degree should continue to be taught in English, from an international job market to a lack of Dutch-speaking staff. There have been no changes announced to the language of instruction of aerospace engineering at TU Delft at the time of writing.

Tough Decisions

The choice of language for a degree program has wide-ranging impacts, and arguments on the topic are often incomplete. Whatever the goal behind the reasoning for one language or another, there are almost always alternative methods of achieving a similar result. Sometimes the target is reasonable, but altering the language of degree programs could shift the course of events in either direction.

Dutch universities announced they are committed to providing Dutch language courses for international students [5]. This measure alone is insufficient without an accompanying drive, a culture or a need to understand the language. Doing more business in Dutch may accomplish this, but it could also scare away international students altogether. The university's offering, while broad, is simply impractical for most bachelor students. The intensive courses last half a quarter, nearly full-time. The less intensive workload is 10 hours a week [14]. At face value, this is not an enticing offer for all but the most dedicated. Learning Dutch is something one must go out of their way to do, even if the opportunity is there.

If a third of the roughly 120,000 international students remain in the Netherlands [15], that number is still double the number of Dutch students, even studying, let alone remaining abroad [13]. This means internationalism in education is still a net positive to the Dutch workforce, and so decreasing the number of international students will only serve to decrease the number of graduate job seekers. Dutch students who are not admitted to their preferred degree programs appear to, in most cases, simply go elsewhere within the Netherlands.

However, this does mean that the number of international students plays a part in contributing to the housing crisis. In Delft, the average time waiting to receive student housing from the provider Duwo is over 5 years [16]! Finding a place to stay is incredibly challenging, and reducing the number of international students would ease this problem. Building more student housing would also be a solution! A solution which is more difficult, more expensive, less convincing, and therefore unlikely to happen in earnest. Even if the number of international students is to be reduced, this could be done through a quota, rather than through language. Changing the language has far-reaching impacts and may not even be as effective as intended. Now that TU Delft is one of the best names in aerospace, how many students would learn Dutch if it were their only way in?

What's the Problem?

It is unclear whether language or internationalization is the issue for the politicians and the public. While the two are linked, the implications of each are different, and they are by no means the same. In order to draw the very best academic staff from around the globe, some of the teaching must take place in English. In order to draw the best researchers, the working language must often be English too. The university currently draws the best students under the same policy, but this may not last forever.

It is impossible to reconcile being an international university in an outward-facing country with a desire for complete nationalism and internalism. There is a need for compromise, to find the balance between the two, but with so many opinions and complications, the way forward is unclear. What everyone does seem to agree on, however, is that language matters. It shapes how we think, how we connect, and sometimes even the entire course of our lives.

> The use of English in degree programs at the Faculty of Aerospace Engineering opened the university up to international students to receive education at one of the best places worldwide. The side effects have been immense: increased student numbers, international employees and a majority of international graduates leaving the country. Some say it solidified the place of Dutch education on the world stage.

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