Accelerating the future of aerospace

Impact Report 2024

TURNING KNOWLEDGE INTO VALUE

Royal NLR - Netherlands Aerospace Centre

Reference to Dutch government policy

- IKIA for Climate and Energy (mission/MMIP number)
- Aviation Research Agenda (research topic)
- Defence Vision 2035 (design principle)
- Long-term Space Agenda (mission)
- Key Technologies (category number)
- KIA for Digitalisation (digital and information technologies)

NLR Impact Report 2024

As an applied research organisation in the field of aerospace, NLR holds a central position in the valorisation process of converting knowledge into value. Our goal is for our research to result in impactful applications for society and the economy.

NLR is committed to shaping promising ideas into concrete applications. We are not in this alone, however. With the support of the government, universities, knowledge and research institutions, as well as technology companies all form a vital link in converting applicable innovations into added value for the Dutch economy contributing to a sustainable society.

In this light, NLR was regularly mentioned in the media in 2024, culminating in around 200 online publications. In the Dutch (regional) news media, the focus was often on issues related to striking a healthy balance between prosperity and well-being, and on mitigating environmental impacts. There were also frequent discussions about current geopolitical tensions, with an increasingly prominent role for drones and space travel. In trade media, topics were covered that will take longer to have an impact on our daily lives, such as the development of lighter materials, alternative fuels to kerosene, and electrification, all aimed at making aviation more sustainable in the future.

This impact report showcases important developments that contribute to sustainability and a safe society in addition to the media coverage. It features a range of articles that provide insight into our most notable research projects from 2024. Additionally, we examine the connection with the business sector, where startups and scale-ups play a vital role in driving economic growth. Their entrepreneurial spirit and ability to create high-quality jobs reinforce the Netherlands' position as a knowledge hub.

By working together closely and leveraging our expertise and facilities to their fullest potential, we are able to provide swift and effective solutions for the challenges that society is facing.

Pleasant reading,
Michel Peters, Managing Director

Michel Peters
Michel Peters, Managing Director

STRATEGIC THEMES

SUSTAINABLE AVIATION

If climate neutral aviation is to become a reality, we need to commit to the development of radical innovations.

[read more...]

COMPETITIVE AEROSPACE

New products and markets are emerging to address issues such as the living environment, accessibility and sustainable air transport.

[read more...]

SAFE AND SECURE SOCIETY

A technologically advanced military is vitally important.

[read more...]

"The Netherlands helps shape the future of the sector through active participation"

International standards serve as a compass for sustainable aviation transformation

Sustainable aviation is not a distant future dream, but a necessity that the sector must address today. Within Europe, the European Organisation for Civil Aviation Equipment (EUROCAE) plays a crucial role in developing standards that will enable this transition. 250 experts, entrepreneurs, policymakers, and researchers from Europe, America, Japan, and Korea are working together in Working Group 80 to develop standards for the storage of gaseous and liquid hydrogen, as well as the application of fuel cells for aircraft propulsion. The outcomes of this work will largely determine how hydrogen can contribute to the sustainability of global aviation.

Working Group 80 (WG80) is collaborating with SAE International – the US counterpart to EUROCAE –, international aviation authorities (EASA, FAA, CAA), private companies and research institutions from Europe, America, Japan and Korea on three standards to enable the application of hydrogen in aviation. The success of this initiative will be crucial in determining the potential of hydrogen to reduce greenhouse gas emissions in the aviation industry.

Roel van Benthem is a senior R&D engineer at NLR involved with WG80. "We are developing standards for a hydrogen-based powertrain for passenger aircraft, which entails everything from hydrogen storage to delivering electrical energy to the motors. These standards will form the basis for certification and regulation and are essential for the certification and implementation of new technologies." Through active participation, the Netherlands remains at the forefront of the latest developments and helps shape the future of the sector. This enables knowledge institutions and companies to take the lead in the development of hydrogen technologies.

NLR plays a key role in this working group, with multiple researchers providing substantive contributions in areas such as airport infrastructure, hydrogen design requirements, safety, and aircraft maintenance. Van Benthem also leads the development of a guideline for fuel cell applications, which convert hydrogen directly into electrical energy.

INTERVIEW FROM NLR PEOPLE

We'll be flying in hydrogen-powered aircraft ten years from now

When his classmates were giving presentations about seals or their pet guinea pigs, a twelve-year-old Roel van Benthem chose nuclear energy as his topic. "For as long as I can remember, I've wanted to know how things work. I've always been keen on technology."

So it was hardly a surprise when he moved from Lelystad to Enschede to study applied physics, completing his studies at the University of Twente in low-temperature physics in the 80's. After studying, Roel started to work in the space flight department of the aircraft manufacturer Fokker, where he carried out research into thermal control systems for single-phase and two-phase cooling – or in other words, how to control the heat balance on a spacecraft in the extreme conditions prevailing in space.

read more →

The working group's (ambitious) goal is to publish a comprehensive review of fuel cell applications by 2026. This milestone is not only crucial for the international aviation industry but also for the Netherlands' position as an innovative and competitive aviation country.

Hydrogen in Aviation: Opportunities and Challenges

Green hydrogen is widely regarded as a promising sustainable energy source for aviation worldwide. It offers a way to fly aircraft emission-free, provided it can be applied just as safely and efficiently as current-generation kerosene-powered aircraft. "We're focusing on answering questions like: How can we safely store hydrogen on aircraft? What materials are suitable, given hydrogen's small molecular structure and the risks of material degradation due to extreme conditions such as extremely low temperatures or high pressures? And: what test procedures are needed to ensure the safety and reliability of hydrogen systems?", explains Van Benthem.

Much of this discussion revolves around balance: how to set requirements that are stringent enough for safety, yet leave room for innovation? "We want standards that are generic enough to enable different solutions, without impeding manufacturers' product development," the project leader explains.

Participating in this type of working group plays a crucial role in bridging the gap between fundamental research and commercial application. Many promising technologies often stagnate in this phase because the requirements are not clearly defined beforehand. By working on guidelines, NLR enables companies to enter this new market more quickly and efficiently.

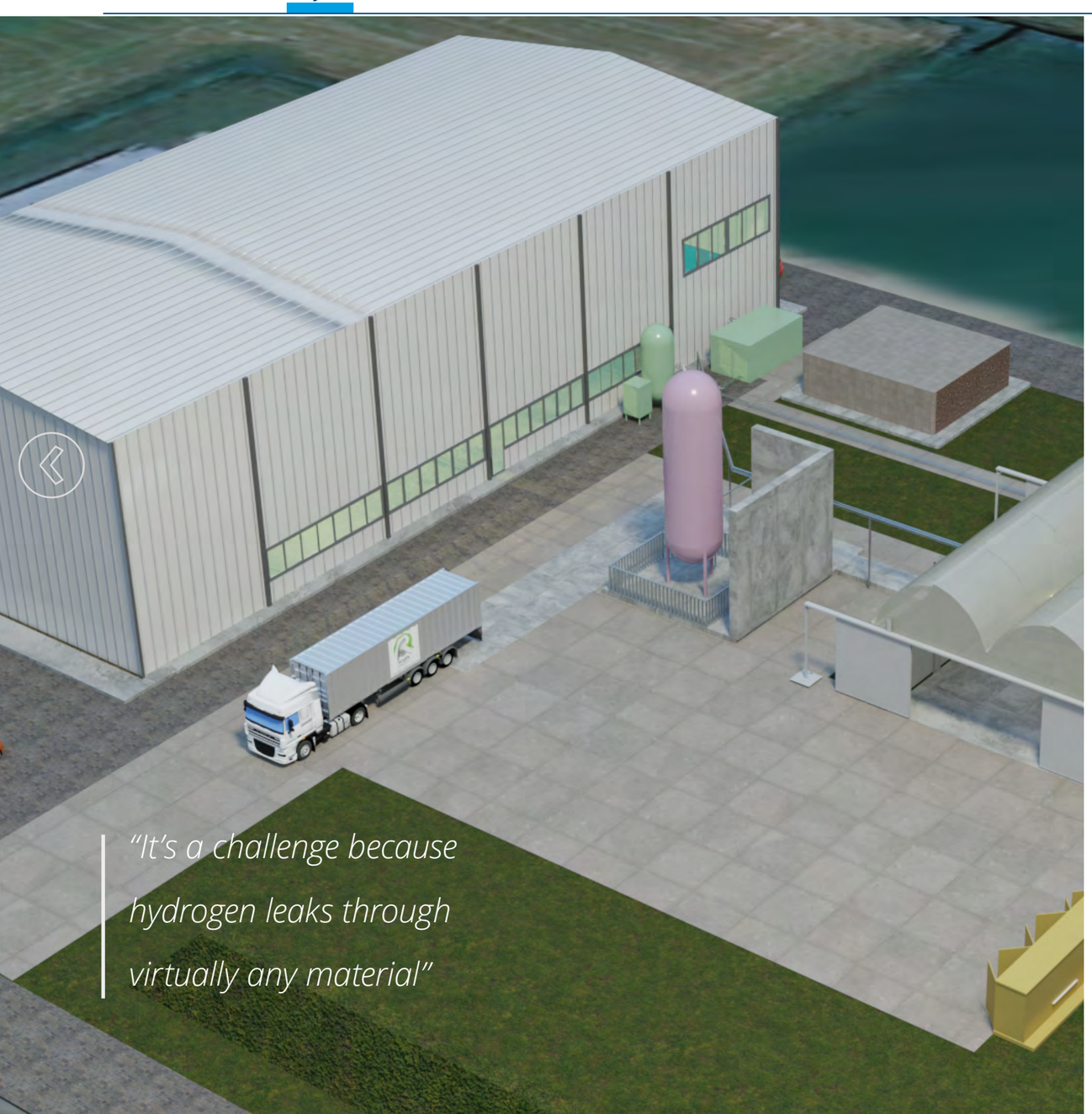
"If we weren't involved, the Netherlands would simply not know what's going on in this field," says Van Benthem. "We can help companies participate effectively and bring their innovations to market faster."

The Next Steps: Testing and Certification

In addition to standardisation, NLR also plays a role in the next steps: testing and certification. New technologies must be proven to be safe not just in theory, but also in practice. NLR has testing facilities and is developing new infrastructures to enable thorough testing of hydrogen systems. Van Benthem: "Globally, there is a shortage of suitable testing facilities for hydrogen in aviation. Our involvement in WG80 means we are aware of the requirements that will be imposed, so we can prepare for them accordingly."

The senior engineer has joined the working group to drive change. "By doing so, I can make a tangible contribution to sustainable aviation. Although the standardisation process can be frustratingly slow, as it requires consensus on every point, the end goal is a powerful motivator. I'm encouraged to see that, step by step, we're moving closer to a more sustainable aviation industry."

PERIOD
Ongoing
PROJECT
EUROCAE WG80 (participation in standardisation working group)
STRATEGIC THEME
Sustainable aviation
NLR KNOWLEDGE PROGRAMME
Climate-neutral aviation
GOVERNMENT POLICY
Aviation Research Agenda (7,9); IKIA for Climate and Energy (D+9)



The foundation for carbon-neutral flying by 2050

As we explore alternative energy sources to fossil fuels, numerous concepts emerge. For large aircraft that cover long distances, one crucial question is: what does hydrogen-powered flight entail? "There's no shortage of ideas," says Paul Arendsen, leader of NLR's Structures Testing and Evaluation department. "However, we must be able to turn those ideas into reality."

Early testing of a concept is paramount. The same holds true for flying with hydrogen. In order to address this need and because such a test facility currently does not exist, NLR launched the construction of an Energy to Propulsion Test Facility (EPTF) in 2023. This will make NLR one of the world's first organisations to facilitate large-scale testing of hydrogen-powered flight using (liquid) hydrogen.

"We are investigating the potential of hydrogen as a future energy source for aviation from multiple perspectives", Arendsen explains. "This is motivated by our commitment to sustainability, but we also aim to support the Dutch aviation industry in staying competitive in the economic development of this technology."

Showstoppers

Hydrogen-powered flight presents several challenges, including energy management. "When an aircraft is powered by a hydrogen-electric propulsion system, it requires fuel cells for propulsion, which in turn generate heat. For every megawatt of propulsion power, one megawatt of heat is produced. It's essential to dissipate this heat from the aircraft, but the question is how? In traditional gas turbine engines, the heat is released through the exhaust, but in fuel cells, it remains within the aircraft."

A second major challenge, Arendsen mentions, is transporting the hydrogen itself. "The only viable option appears to be flying with liquid hydrogen." Hydrogen liquefies at a temperature of -253°C. However, this poses new challenges, Arendsen explains: "Cooling it to near absolute zero raises a lot of questions, such as what happens when the aircraft is exposed to warm temperatures, for instance when it's left standing in the sun?"

Another important question is: what material should be used to manufacture the tank that contains the liquid

substance? “The tank material must be both lightweight and thin, while also being able to withstand extreme temperatures. Hydrogen molecules are extremely small, however, and can leak through virtually any material, making this a significant challenge.”

Testing the entire powertrain

All components of the system together, with its mechanical parts and other elements, is what we call a powertrain. Every single part, from the cold liquid hydrogen in the tank to the warm gas that fuels the fuel cell, which in turn powers the electric motor, needs to be tested thoroughly.

Merely carrying out calculations and making predictions is not enough, Arendsen says. “What if an aircraft suddenly enters a dive, resulting in a vertical instead of a horizontal flight position? Will there still be sufficient power? And what happens if the tank starts to shake? The EPTF is intended to test these kinds of scenarios. It’s primarily about investigating what happens when we connect all the components together.”

The world’s first

Setting up the test facility is a complex undertaking. “NLR is one of the first organisations in the world to build such a facility, so there’s no established blueprint to follow. We have to work closely with authorities, such as the Regional Environment Agency North Sea Canal Area, to find our way.”

The test centre will ultimately be 60 by 60 metres in size, with a built-up area of 17 by 17 metres, and can be fully opened for ventilation during tests. In addition to liquid hydrogen and a sufficiently powerful (bi-directional) electrical connection, tests will be supported by hydraulic, pneumatic, liquid and gaseous nitrogen, and gaseous hydrogen systems. A sound barrier will protect against noise pollution and provide privacy for the often commercially sensitive systems being tested.

Eagerly anticipated

Arendsen notes that there’s a great deal of anticipation surrounding the opening of the facility, which he expects to happen by the end of 2025. “We’re involved in several European projects, such as HYPOTRADE and COCOLIH2T, and the EPTF has already been booked for a number of National Growth Fund projects.” Moreover, the first significant test has already taken place. “It was as part of the HYPOTRADE project where a 110-kilowatt fuel cell was subjected to a series of tests.” Arendsen and his team will also be testing a composite hydrogen tank for liquid hydrogen coming September.

“We’re venturing into uncharted territory and designing tests that have never been possible before. For instance, testing materials at -253°C. That’s truly unique. All in all, it’s an exciting journey. With the EPTF, we are laying the groundwork for sustainable aviation by 2050.”

PERIOD
2023 - end 2025
PROJECT PARTNERS NL
Internal funding
STRATEGIC THEME
Sustainable aviation
NLR KNOWLEDGE PROGRAMME
Climate-neutral aviation
GOVERNMENT POLICY
IKIA for Climate and Energy (D+9)

PERIOD
2023 - 2026
PROJECT PARTNERS NL
TNO, Dawn Aerospace
PROJECT PARTNERS EU
https://www.giance-project.eu/consortium/ (DAWN, Boeing are WP partners)
STRATEGIC THEME
Sustainable aviation
NLR KNOWLEDGE PROGRAMME
Emerging technologies
GOVERNMENT POLICY
Key Technologies (1. Advanced materials)

"Graphene is incredibly small and thinner than a human hair"

Graphene: The Silver Bullet for Aerospace

Pioneering a highly promising new technological development, "that's exactly what NLR is doing with graphene", according to Ronald Klomp, R&D engineer at NLR. As part of the European GIANCE project, NLR is collaborating with companies like Dawn Aerospace, a Dutch-New Zealand space transport firm, and a Turkish division of Boeing to develop high-performance composites for the aerospace industry.

Klomp's team has successfully added graphene to the resin used for composites, and expectations are running high. The combination of graphene and resin is expected to result in aircraft parts that are incredibly strong, ultra-thin, extremely heat-resistant, and lightweight. "We're investigating whether it is indeed the silver bullet for making aerospace more sustainable,"

A pencil-thin layer

Graphene is the world's first two-dimensional material, composed of a single layer of carbon atoms arranged in a honeycomb structure. This unique structure makes graphene incredibly thin, stiff yet flexible, transparent, and remarkably strong.

Graphene was first discovered in 1947, but it wasn't until 2004 that physicists Andre Geim and Konstantin Novoselov from Manchester University successfully produced a small quantity of it. The duo was awarded the Nobel Prize in 2010 for their research.

The tip of a pencil is actually made of graphene. It is incredibly strong, comprised of layers of carbon. Physicists have managed to extract a thin layer of graphene from a pencil using sticky tape. Klomp comments: "While this breakthrough didn't immediately yield commercial products, it was clear that it had huge potential."

That is why the European Union launched the Graphene Flagship research initiative in 2013, with the aim of taking graphene from the lab to commercial applications. "Over the years, various parties have developed their own methods for producing graphene, resulting in hundreds of different varieties." As a result, graphene is now used in coatings, paints, kitchen worktops, and batteries, among others. The material's properties make it an attractive resource for the automotive and energy sector, particularly in relation to hydrogen storage, as well as for applications in aerospace, due to its ability to withstand extreme conditions.

Uniform resin

In 2023, the European Union took research to the next level with the GIANCE project: Graphene Alliance for Sustainable Multifunctional Materials to Tackle Environmental Challenges. Within GIANCE, NLR is working on a resin modified with graphene. The material will soon be tested on a test component based on Dawn Aerospace's unmanned vehicles. "This shuttle-like vehicle launches satellites into orbit around the earth. It takes off, flies above the atmosphere, deploys the satellite, and then returns", Klomp explains. "This business case is subject to extreme heat."

Klomp and his team developed a processing method for the resin that needs to make the leading edges of wings and engine components heat-resistant. "Graphene is incredibly small and thinner than a human hair. It's difficult to handle and tricky to process as a dry powder, so it's supplied in a solution, which we mix with the resin." With so many different types of graphene having been developed over the years, finding the optimal resin-graphene ratio is a daunting task, according to Klomp. "Furthermore, it's a challenge to add exactly the right percentage of graphene. It can't be too viscous. Rather, it needs to have a uniform consistency. We've managed to achieve that. The next step is to test it in realistic scenarios."

Graphene also appears to be an excellent conductor of heat and electricity, which would be a game-changer for lightning protection. Together with Nanoprom, an Italian company that produces graphene-modified coatings, NLR is developing a component for Boeing Turkey that will be fitted to the rear of the wing. "We know how to process thermoplastic composites and manufacture parts from them. With help of a German partner, we can test these coated thermoplastic composite plates for lightning strikes."

National attention

In addition to expanding its in-depth technical knowledge of graphene, NLR is building a solid network of graphene suppliers through GIANCE. "We know what's happening in Europe. If there's a query from Dutch industry about what advantages graphene holds for them, we can assist them with our expertise." The development of graphene is receiving significant attention at national level, according to Klomp. He and his colleagues have regularly met with key stakeholders from Dutch industry to keep them informed about NLR's work on this subject and learn about their needs and questions.

While practical applications of graphene are still on the horizon, Klomp and his team are paving an exciting path forward. "There's still so much to discover. Only time will tell if graphene really is the silver bullet for aviation, but our expectations are high."

Determining the environmental impact of fossil fuel alternatives

A plane that runs on hydrogen doesn't emit CO_2. But what other environmental effects come into play? What's the impact of manufacturing such a new type of aircraft? What are the implications for the raw materials needed, for example, to build a hydrogen tank? And how easily can the materials be recycled at the end of the plane's life cycle? A life cycle assessment (LCA) provides the answers to these questions. Worldwide, industries like construction, food production, chemicals, and energy are already adopting this approach on a large scale.

Until about ten years ago, this was hardly a research topic in aviation. “It wasn’t particularly interesting to conduct an LCA on planes that run on kerosene,” Daniël Kan, an LCA specialist at NLR, says. “The vast majority of the impact occurs during the flight itself. Compared to the huge amount of kerosene burned, the environmental effects of producing the aircraft are negligible. That’s even more true given that these planes have a lifespan of over 25 years.”

Developing an LCA Guideline

An LCA is valuable for aircraft that run on batteries, hydrogen, biofuel, or synthetic fuel, for example, Kan posits. That is why it’s being applied ever more frequently nowadays. When conducting a standalone LCA, the person commissioning the study can choose the software, calculation methods, and background data themselves. While there are international quality standards for LCAs, also known as ISO norms, these give LCA researchers a great deal of flexibility, Kan explains. For instance, a researcher trying to assess water scarcity can choose from three or four different impact assessment methods. Kan notes: “This has the advantage of providing an in-depth answer to the question at hand, but it makes it impossible to compare the results with other studies.”

For this reason, NLR is working together with the German Aerospace Centre (DLR) to develop a guideline for LCAs of the entire air transport system; this includes the aircraft itself, as well as fuel production and airports. “It’s not a standard that prescribes system choices, but rather provides guidance on those choices. It complements the existing ISO norms.”

State of the Art & In-House Research

In collaboration with his DLR colleagues, Kan is gathering prime examples from existing literature, as well as drawing on their own experience and using optimal working methods. For instance, Kan conducted an LCA with consulting firm Roland Berger for an aircraft such as a Boeing 787-800 or an Airbus A320neo that runs on hydrogen, synthetic fuel, or continues to fly on kerosene but removes the CO_2 from the air.

His NLR colleagues from Collaborative Engineering calculated the consequences of design adjustments to the aircraft for this LCA. “Flying on hydrogen means you need to carry two hydrogen tanks on board during flight. If placed at the rear of the plane, you need to extend the frame, which makes the aircraft heavier and slightly unbalanced. How does this affect fuel consumption? We investigated the direct emissions during flight and the indirect emissions, as well as the resource usage of the airport, aircraft construction, and energy generation. We did this for all three fossil fuel alternatives.”

An LCA also considers a broader range of environmental issues, according to Kan. “We’re not just looking at climate impact, but also take into account problems such as water scarcity, particulate matter emissions, and landscape transformation. By doing so, we want to avoid solving one environmental problem only to create another. This is what happened with first generation biofuels, for example, which required large areas of land to produce biomass, leading to deforestation, among others.”

Significant reduction

The life cycle assessment for fuel alternatives in a narrow-body aircraft such as the Airbus A320neo yields positive results in terms of climate impact. New technologies can significantly reduce greenhouse gas emissions, Kan states. “These three technologies have the potential to reduce climate impact by 50 to 75%, but their use also has a greater impact on some other environmental issues. Therefore, it’s not enough to focus on technological solutions. The need to reduce air travel remains a relevant issue.”

Informed Insight

Kan’s research contributes to the development of LCA guidelines for aviation systems. “By combining knowledge from various fields, we are creating novel approaches that can be applied in aerospace. Given the need to significantly reduce the climate impact of next-generation aircraft, it’s essential that we provide companies and policymakers with informed insight.”

PERIOD

2024 - 2025

PROJECT PARTNER EU

DLR

STRATEGIC THEME

Sustainable aviation

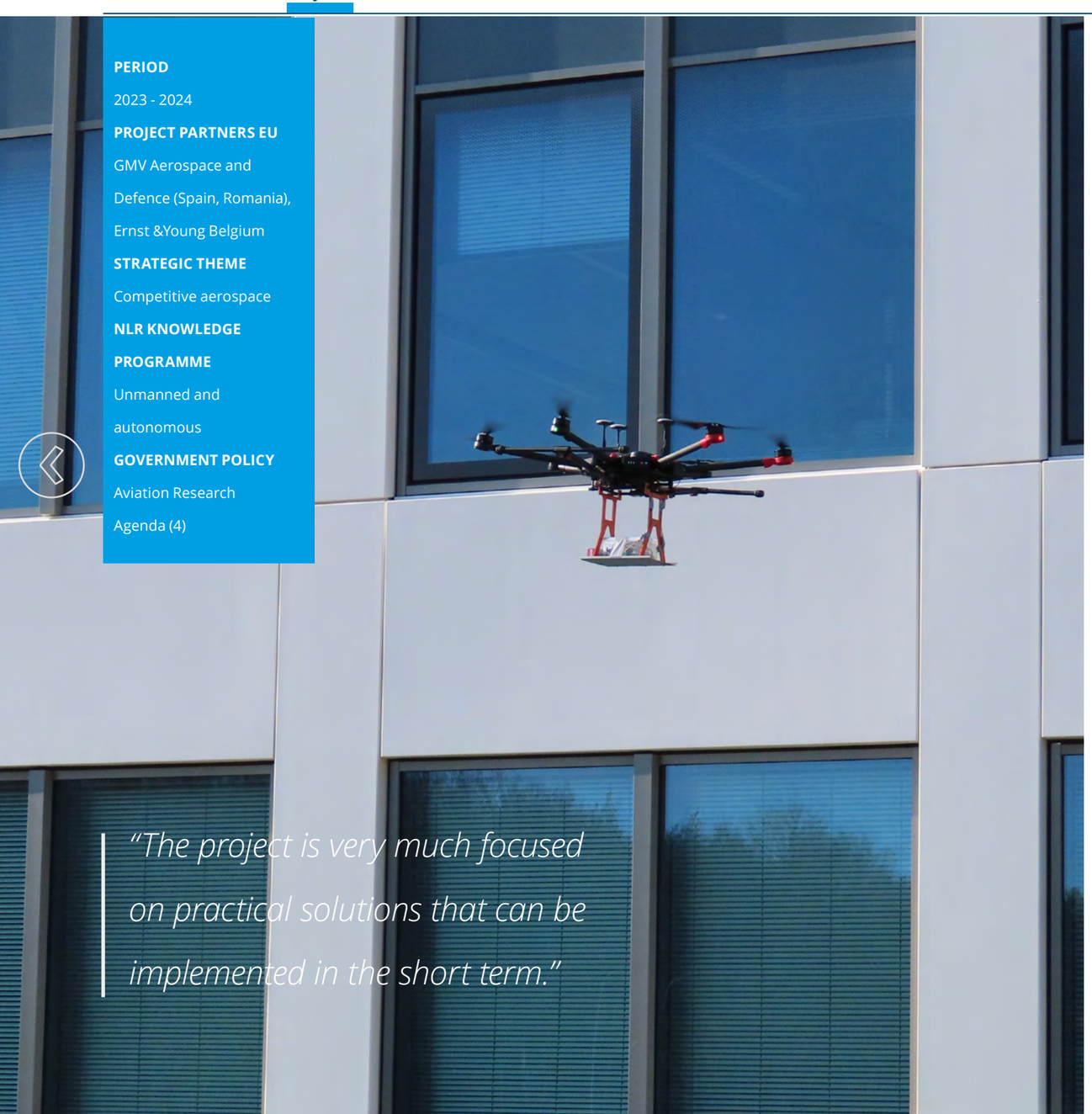
NLR KNOWLEDGE PROGRAMME

Climate-neutral aviation

GOVERNMENT POLICY

IKIA for Climate and Energy (D+9)

12 RESPONSIBLE CONSUMPTION AND PRODUCTION



PERIOD

2023 - 2024

PROJECT PARTNERS EU

GMV Aerospace and Defence (Spain, Romania), Ernst &Young Belgium

STRATEGIC THEME

Competitive aerospace

NLR KNOWLEDGE PROGRAMME

Unmanned and autonomous

GOVERNMENT POLICY

Aviation Research Agenda (4)

"The project is very much focused on practical solutions that can be implemented in the short term."

Reliable navigation systems: essential for autonomous drones

The potential applications of Unmanned Aerial Vehicles (UAVs), better known as drones, are endless. Autonomous drones are set to play a significant role in society. "Drones can perform tasks that are hazardous or mundane for humans, and their deployment can also provide various efficient logistical solutions," explains Heiko Engwerda, a navigation engineer at NLR.

One of the key prerequisites for autonomous flight – flying completely independently, without pilot intervention – is accurate and reliable navigation. An autonomous drone must have precise knowledge of its location and what's happening in its surroundings. In urban areas, this challenge is exacerbated by factors such as tall buildings that can block or disrupt satellite signals. "We need to be able to rely on a particular navigation solution and timely alerts to any issues," says Engwerda.

NLR took a significant step forward in the development of safe and reliable autonomous drones by participating in the European ARAIMFUSE project. This project focused on the application of Advanced Receiver Autonomous Integrity Monitoring (ARAIM). ARAIM is an advanced technique that assesses the reliability of satellite navigation signals (such as Galileo and GPS) on aircraft. The technology helps navigation systems detect and correct errors from satellites, enabling more accurate and safer positioning.

ARAIM was developed for aircraft, specifically for the most critical phase: landings, where a plane must stay within the runway, requiring an accuracy of around 20 metres. For drones, which often take off, fly and land in densely populated areas, this level of precision is not sufficient. "So, we couldn't simply adopt the concept wholesale for the UAV sector," Engwerda says.

Applying aviation systems to other sectors

Other precision navigation technologies need to be added to ARAIM to make the technology suitable for use in autonomous drones. Engwerda explains: "For the ARAIMFUSE project, we worked with the consortium to

explore how aviation systems can be applied beyond traditional aviation. NLR's focus was specifically on applying ARAIM technology to enable autonomous drones to fly as safely as possible."

Examples of these supplementary technologies include Inertial Measurement Units (IMUs), empirical error models that analyse and correct uncertainties in position, velocity, and direction measurements, and enhanced accuracy of satellite navigation signals using the Galileo High Accuracy Service.

By combining these data with the ARAIM algorithm, a more robust and accurate navigation system is created, which is better equipped to withstand interference. This allows autonomous drones to fly within the expected integrity requirements for specific operational scenarios. "Without this kind of technology, that's not possible," Engwerda states.

A wide range of applications

The study covers a broad range of applications where navigation plays a key role. For example, GMV (Spain) explored applications in the rail and maritime sectors, while the Belgian VVA examined the financial impact of ARAIM on industry. In the rail sector, this included the European train control system (ERTMS), door control in trains, and tracking hazardous cargo. For the maritime sector, the study looked at applying ARAIM to autonomous ships and employing ARAIM in scientific ocean research.

Impact on the Dutch drone industry

The findings of the ARAIMFUSE project have direct implications for the Dutch drone industry. By anticipating future regulations and meeting stringent safety requirements, Dutch companies can gain a competitive edge. The project helps identify technical opportunities and challenges, enabling the industry to align their products and services with expected standards and norms.

"ARAIMFUSE is a practical impact study commissioned by the European Commission, so it's very much focused on practical solutions. We have looked at solutions that can be implemented in the short term using existing technology, and that can ensure the integrity of UAVs," Engwerda explains.

The European Commission is also the body responsible for drafting safety regulations. "As such, our work not only contributes to a stronger position for Dutch companies, but also lays the foundation for new regulations that will allow autonomous drones to fly safely."

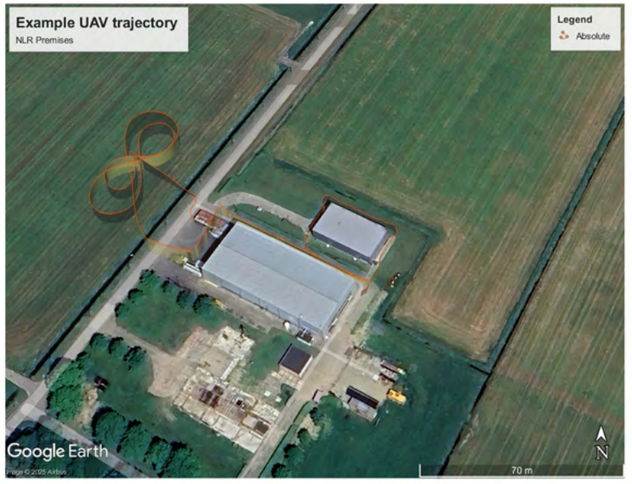
Future prospects

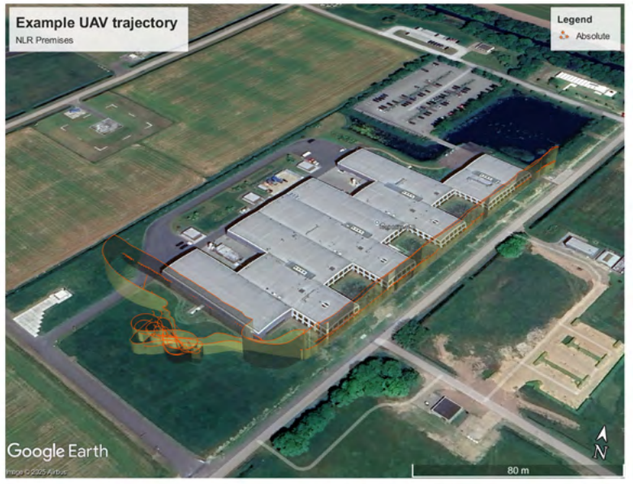
Although ARAIMFUSE has yielded promising results, there are still significant steps to be taken. Further software development and data modelling are needed, as well as more extensive testing and additional flight hours to demonstrate reliability and effectiveness.

The project serves as a technological demonstrator, but this does not automatically mean it will be applied in practice immediately. The demonstrator is intended to show various stakeholders that this technology works, providing regulatory entities with insight into what is possible and what further developments are required.

According to Engwerda: "The operational aspect also plays a major role: who will be responsible for implementing and enforcing regulations? A governing authority is needed to oversee this."

Through projects like ARAIMFUSE, NLR showcases its leading role in the evolution of aerospace technologies. By developing innovative solutions and collaborating with industry and government, NLR contributes to a future where autonomous drones can safely and reliably navigate complex environments.





PERIOD

2021 - 2024

PROJECT PARTNERS NL

Eindhoven University of Technology, GKN Fokker ELMO, Synano, ADSE

PROJECT PARTNERS EU

Collins aerospace Ireland, Evektor, plc-tec, ECMS

STRATEGIC THEME

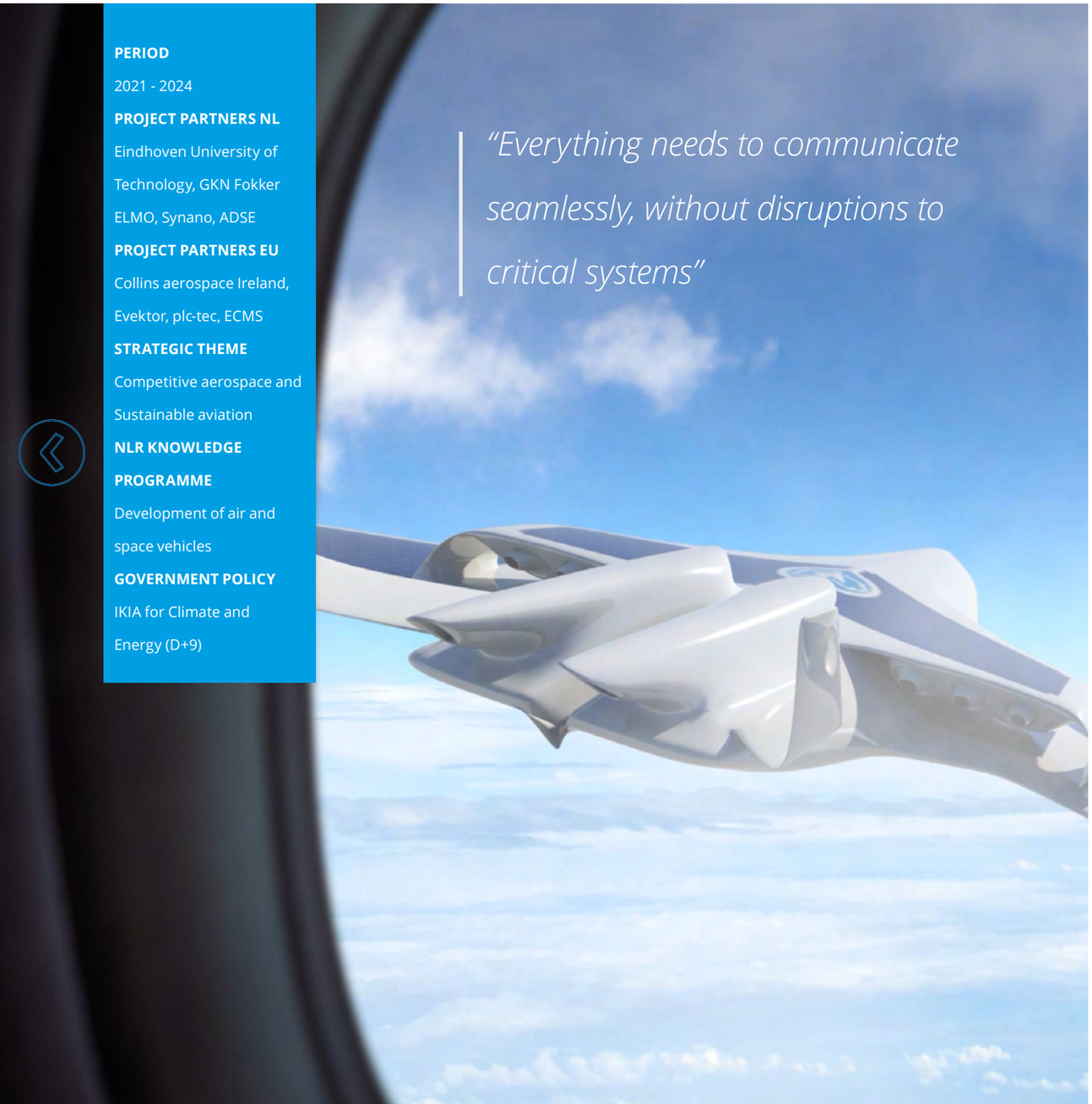
Competitive aerospace and Sustainable aviation

NLR KNOWLEDGE PROGRAMME

Development of air and space vehicles

GOVERNMENT POLICY

IKIA for Climate and Energy (D+9)



An energy-efficient and lightweight communication system as a prerequisite for future-proof aircraft

Sensors, wing ice protection, and passenger video screens: aircraft are equipped with an increasing number of electrical systems that are predominantly connected by cables. A medium-sized aircraft, such as an Airbus A220, can easily have around 700 kilograms of cabling on board. As the demand for sustainable solutions grows, so does the number of electrical systems - and with it, the complexity of the power and data network. Furthermore, the additional cabling adds weight, which in turn leads to higher CO_2 emissions.

“A more efficient and less complex power and data network doesn’t directly lead to carbon-neutral aviation, but it’s definitely a prerequisite,” says Jesper Lansink Rotgerink, R&D engineer in Electromagnetic Technology and Antennas at NLR.

Reliable and safe

Lansink Rotgerink is NLR’s project leader for the European project ADENEAS, which stands for Advanced Data and Power Electrical NEtwork Architectures and Systems. His team is exploring the possibilities of a hybrid data network within aircraft, where cabling is supplemented with other forms of communication, such as wireless connectivity. NLR is working on this project in partnership with Eindhoven University of Technology (TU/e) and GKN Fokker Elmo, a specialist in the design and production of wiring harnesses for the aerospace industry.

The electrical components require power and need to be able to communicate with other components, Lansink Rotgerink explains. “For example, the flaps on the rear of the wing, which are used to enable flight at lower speeds. They are in contact with an altimeter, which determines the aircraft’s height above ground during the final phase of landing, and the flaps respond accordingly. Everything needs to communicate seamlessly without interference, especially in critical systems such as these.”

Wireless

One alternative to cables is a hybrid network where components communicate wirelessly. The challenge is to make this network just as reliable as a wired system.

Lansink Rotgerink's team, together with researchers from TU/e, conducted laboratory tests. "For instance, we tested how wireless communication waves behave within a metal object. When two antennas are positioned facing each other in free space, communication is relatively straightforward. However, as more metal is introduced, reflections off metal surfaces increase, making the situation more complex. We also investigated the impact of wireless communication on a radar altimeter, which gave us insight into the use of so-called Shielded passenger windows as a form of electromagnetic shielding. These windows allow for higher power levels to be used within the aircraft without affecting passengers' visibility. This enhances the practical feasibility of a wireless network."

Powerline communication

In addition to wireless communication, Powerline communication is another possible alternative, where communication and power are transmitted through a single cable instead of two, reducing the amount of cabling required by half.

NLR worked with the Swiss company plc-tec, which develops powerline communication technology, to investigate how to make communication via a power cable more robust in the face of the electromagnetic environment on an aircraft. "There's a lot of sensitive equipment on board an aircraft, such as radio equipment for communicating with the ground and landing systems. This communication must not be disrupted. The equipment is designed to withstand certain levels of interference, and it's crucial that other systems don't generate noise that exceeds those levels." To address this, Lansink Rotgerink tested powerline communication in NLR's Electro Magnetic Compatibility (EMC) test laboratory. A second version was also tested in a small electric aircraft, the Evektor Sportstar EPOS+. "We developed a demonstrator to show that no interference occurs."

Two-phase cooling system

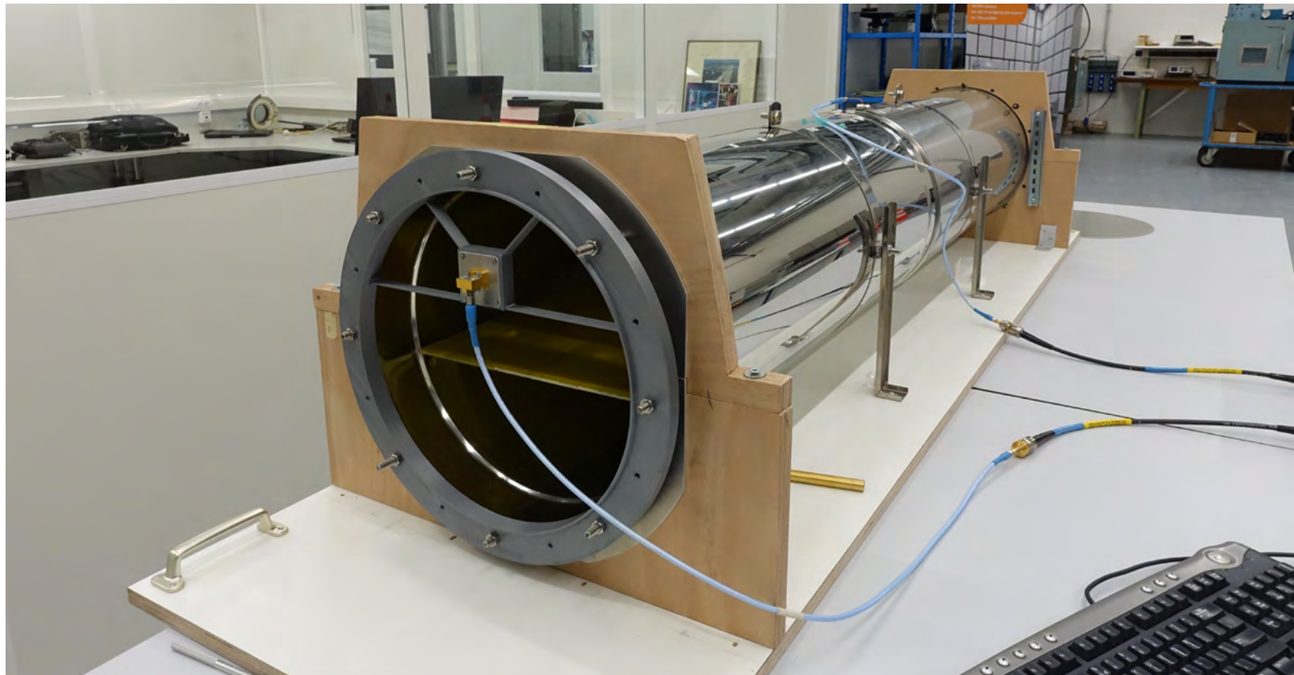
The increased number of electrical systems on board also leads to greater heat dissipation, or energy loss, which generates extra heat. NLR's thermal research group has expertise in two-phase cooling systems, which work by evaporating liquids in a loop, Lansink Rotgerink explains. "It transports excess heat that builds up in certain areas to another location within the aircraft, where it can be used for other purposes, such as heating something up or dissipating it."

The numbers

The project was completed by the end of 2024, achieving a weight reduction of 456 kilograms for a 120-seat aircraft. "This weight saving is due to the combination of wireless communication, powerline communication, two-phase cooling, and modular power electronics, with the Irish company Collins making a significant contribution to the latter. The combined effect of these measures also leads to a reduction of 334 kilograms of CO_2 per 4,000-kilometre flight. However, further research is still needed to enable aircraft with hybrid data and communication networks to take to the skies. "According to our estimates, this is unlikely to happen before 2031."

Future-Proof

The project not only indirectly contributes to more climate-neutral aviation, but also strengthens the market position of industrial partners, including Fokker Elmo as a manufacturer of wiring harnesses. Lansink Rotgerink states: "Cabling alone is not a future-proof product. It needs to be complemented with other communication media, such as wireless communication or powerline communication. This project helps make Fokker Elmo's product future-proof, safeguarding its competitiveness. The same holds true for us, as we are building our knowledge and expertise in these areas."



"Quieter drones are also valuable for defence purposes"

Flying in urban areas: what's the noise impact and how bothersome is it?

Air traffic in future cities is on the rise, with electric drones delivering medicines and packages to doorsteps, and air taxis ferrying people through the skies. As this development is driven by a desire for sustainability, it also brings new challenges.

As drones and air taxis become more prevalent in cities, what will be the impact on noise levels? And how will residents perceive these new forms of air traffic? These are the key questions being addressed by NLR's DOGGIES project, which was launched in 2023 with internal funding.

"We want to accelerate the development of new electric flight concepts," Remco Habing, senior R&D engineer at NLR, says. Habing and his team have developed a simulation tool that helps policymakers set noise standards, limiting noise pollution in urban areas. It also enables aircraft manufacturers to take noise reduction into account during the design phase. That's the civilian side of the project, Habing states. "Quieter drones are also valuable for defence purposes, however."

Broadband noise

Helicopters or traditional propeller aircraft produce a 'tonal' sound, characterised by a constant low-frequency hum. In contrast, flying with one or more rotors, such as drones and air taxis, also generates high-frequency sound, according to Habing. "We call this broadband noise. It's a different sound source that can suddenly stand out above the background noise."

In addition to the difference in sound type, there are other factors that determine the acoustics. "A rotor has a different blade profile and rotates at a much lower speed than a propeller," Habing continues. "As a result, the sound radiation is fundamentally different. The flight path is also different; take-off and landing are vertical, for example. And what about vertiports, a kind of futuristic airport in the city? How many air taxis and

drones can take off and descend simultaneously? But also: how much noise disturbance will people living and working nearby experience? All these factors define the applications of DOGGIES."

Rapid calculations

From public domain sources and literature, hundreds of so-called eVTOL (electric vertical take-off and landing) concepts - including both manned and unmanned aircraft and objects - were screened. This revealed a number of common characteristics that Habing's team worked with. "All calculations are based on the simulation model, using a drone as a representative example. With our tool, we can predict how much noise future configurations will produce, regardless of the number of rotors or flight path."

Additionally, a sound propagation model was implemented in an urban environment. "This is the second building block of our prediction tool," Habing explains. "This model simulates the sound emitted from the source model, such as a drone, and shows how it radiates through and around urban environments. Factors such as atmospheric damping, reflection, and diffraction of sound waves all play a role. The city is essentially a kind of grid with Lego bricks representing buildings. We can also import maps of Dutch cities into this model."

As the final component of the tool, the NLR team enhanced its Virtual Community Noise Simulator. "In this Virtual Reality environment, we investigate how sound is perceived between buildings and what the noise impact is."

The overall prediction tool is primarily designed to provide quick insights, Habing continues. "Companies and municipalities don't have to wait months for highly detailed calculations. Using semi-empirical relationships (assumptions intended to simplify calculations) and fast methods, we can make predictions in no time and calculate multiple configurations and flight routes. This allows startups to immediately determine whether their design will generate too much noise."

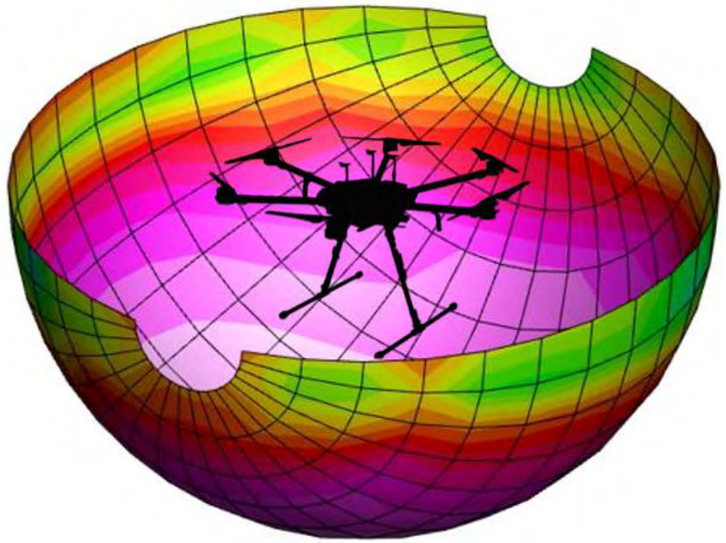
The research also had a fundamental component: a graduate from the University of Twente investigated the effect of the boundary layer flow. "The millimetre-scale area where the flow velocity adapts to the rotation speed of a rotor," Habing explains. "The study validated a widely used semi-empirical model for aircraft wing noise for specific rotor applications. It was a nice addition and fun to supervise."

A useful starting point

Habing states: "Our goal from the outset was to develop something with real-world applications. How good it ultimately is will depend on further research." The tool is currently being tested outdoors with a multi-copter drone at various flight speeds. This will enable NLR to provide more effective advice on the noise effects of drones and air taxis in urban environments. "We can use this tool to advise the government, as a design tool for industry, and for mission planning for Defence."

Last summer, Habing presented an NLR paper at the European Rotorcraft Forum. "It is essential that research is conducted on the impact of noise of future Urban Air Mobility applications. This issue is far from resolved. With DOGGIES, we're taking an important first step to demonstrating what's already possible."

PERIOD
2024
PROJECT PARTNERS NL
Internal funding
STRATEGIC THEME
Competitive aerospace
NLR KNOWLEDGE PROGRAMME
Impact on people and society
GOVERNMENT POLICY
Aviation Research Agenda (10,11)



The hunt for promising hybrid-electric aviation solutions

Climate-neutral aviation requires new aircraft, but which concept is promising enough to develop further? Hybrid-electric propulsion is one of the technologies that can help reduce CO_2 emissions. As part of the European project IMOTHEP (Investigation and Maturation of Technologies for Hybrid Electric Propulsion), NLR explored the application of this technology in small and medium-sized aircraft.

"You can compare it to the Toyota Prius of aviation," Jaap van Muijden, researcher at NLR and coordinator of NLR's contribution to IMOTHEP, says. "An aircraft with a hybrid-electric powertrain draws energy partly from kerosene and partly from batteries or fuel cells."

Blended wing body

The aviation industry can take the concept of hybrid-electric propulsion in many different directions. To focus its efforts, the project narrowed its scope to two types of aircraft: a regional jet and a Short to Medium Range (SMR) aircraft, such as an A320. Researchers explored conventional and radically new concepts for both variants, moving away from traditional twin-engine propulsion and fuselage-with-wings designs

Van Muijden explains: "For example, a regional jet was reimagined with a disruptive concept featuring multiple propellers and engines. For the SMR, designs emerged such as a blended wing body (BWB), where the wing merges with the fuselage, creating a wider, more integrated shape. Passengers wouldn't be seated in traditional rows of four or six, but instead, the seating arrangement would become progressively wider towards the rear, with multiple aisles. Within IMOTHEP, NLR acted as configuration manager for the radical SMR design."

"More disruptive solutions may be needed to significantly reduce aircraft emissions."

PERIOD

2020 - 2024

PROJECT PARTNERS EU

ONERA, AIRBUS, CIRA, DLR, Leonardo, Safran, Avio Aero, AIT, GKN, Chalmers, ILOT, INCAS, ITP, MTU, BHL, UL, ISAE, KIT, USTRATH, POLIBA, UNOTT, Eurocontrol, CNRC, UT, EASA

STRATEGIC THEME

Competitive aerospace and Sustainable aviation

NLR KNOWLEDGE PROGRAMME

Development of air and space vehicles

GOVERNMENT POLICY

IKIA for Climate and Energy (D+9); Aviation Research Agenda (7)

9 INDUSTRY,INNOVATION AND INSTRASTUCTURE

Flying with and without a gas turbine

For hybrid-electric propulsion systems, the focus is on turbo-electric propulsion, where the kerosene-powered gas turbine on board is used to generate electricity, which then powers the propulsion components. The goal is to use kerosene primarily to run the gas turbine as efficiently as possible, at an optimal speed. As a result, the gas turbine can be smaller and lighter than those used in conventional propulsion systems.

When an aircraft doesn't have a gas turbine, electric motors and additional cabling must be added. This extra cabling is necessary to distribute the required electricity throughout the aircraft and control the electric motor. A drivetrain comprising generators, rectifiers, busbars, cables, and converters enables the actual control. The electric motors ultimately drive the propellers within the motor housing. NLR investigated the effect of positioning the propulsion system above or below a wing for both SMR concepts, examining questions such as: What are the aerodynamic implications? How do these configurations affect drag and power output?

Additional components on board also generate extra heat. "We're talking about high powers flowing through the electrical components. That is why we not only have to look at the drivetrain's efficiency, but also at a sensible way to cool it." Van Muijden and his team worked on thermal management. Cooling the entire propulsion system, with all its new components, also affects the aircraft's weight and performance. This altered weight distribution, in turn, requires changes to the aircraft design.

Next steps in development

IMOTHEP was largely a theoretical study, Van Muijden says. "We conducted numerous simulations, but didn't develop any demonstrators or carry out laboratory measurements." The project has provided parties like Airbus with insight into which concepts are most promising. Launched in 2020, IMOTHEP initially explored whether expectations for hybrid-electric propulsion could be met within the aviation industry. By the end of the project, it became clear that a regional aircraft powered by batteries and supplemented with a gas turbine for propulsion could be a potential contender.

Van Muijden continues: "Further research is needed for the other configurations, for example by integrating innovations in drag reduction and propulsion to achieve at least 10% fuel savings. This could mean that manufacturers of larger aircraft, such as Airbus, may need more disruptive solutions than hybrid-electric propulsion to significantly reduce emissions."

This illustration depicts the geometry of the BWB SMILE aircraft, which is based on an ONERA conceptual study and forms the basis of the SMR-0HEP configuration. The image shows the 3D shape with two CFM-LEAP-1A engines mounted on the rear centre fuselage (left) and provides a comparison of the approximate planform (orange outline) with that of the A320neo (blue outline).

The research provides valuable insights for component suppliers like Safran from France or Honeywell from the US. "When aircraft components are electrified, companies need to know how to design and manufacture them."

IMOTHEP's outcomes also help startups, as demonstrated during the project. Van Muijden presented the thermal research findings at the EUCASS 2022 Conference in Lille, France. Soon after, a startup approached NLR with questions on thermal management of their electric drivetrain concept. "We ran some calculations for them, which enabled them to move forward with development."

"It's an exciting journey of discovery, but we are still a long way off. As we aim for climate-neutral aviation by 2050, societal interest in innovative flight concepts is growing. It's essential to gain early and informed insights into the viability of electric flight. NLR plays a crucial role in this process through projects like IMOTHEP," Van Muijden concludes.

"Artificial intelligence enables inspectors to identify defective components more quickly"

Innovative inspection techniques for enhanced aircraft production

The production of large composite parts is becoming increasingly crucial in the aerospace industry, offering advantages such as reduced assembly work, weight savings, and improved performance. However, ensuring the quality of these components without disrupting the production process is a challenge. Over the past 4.5 years, NLR collaborated with 30 European partners in the PENELOPE project to develop new methods for improving efficiency and precision in large-part production by integrating advanced manufacturing technologies into a digital feedback loop (closed-loop digital pipeline).

"Inspectors currently check the production quality of aircraft parts using ultrasonic inspection. This technique uses high-frequency sound waves to analyse the internal structure of a component", Johan Kos explains. He serves as project leader for PENELOPE in his capacity as a principal R&D engineer at NLR. The project focused on optimising inspection technologies, such as alternative, faster simulation models and artificial intelligence (AI), to speed up the interpretation of inspection data.

Smart inspection using robots and AI

The conventional ultrasonic method is time-consuming and labour-intensive. "The major advantage of composites is that manufacturers can produce large components. It is therefore paramount to be quickly aware of any potential defects." NLR has collaborated with industrial and academic partners within PENELOPE to develop a more efficient approach. At the heart of this innovation lies thermography, which uses thermal imaging to detect defects in materials.

In a previous project, thermography had already been applied manually to aircraft fuselages, Kos says. "In PENELOPE, we've taken this technique to the next level by automating it: a robot moves a heat source and camera along the surface, scanning large sections in a single pass, allowing inspectors to quickly identify defective components and adjust production as needed."

By automating thermography and integrating it with a digital feedback loop, we can detect defects up to ten

A mathematician's search for sustainable aviation solutions

He's a mathematician, a chess player and the father of three children: meet Johan Kos, a principal R&D engineer principal with NLR, the Netherlands Aerospace Centre. Close on thirty years ago, he made the switch from the academic world to the aerospace sector. Since then, Johan has been working behind the scenes on new technologies for making aviation more sustainable.

One example of that is the European Clean Sky 2 project TRANSCEND, for which Johan took the initiative and had the role of project leader. The project, which NLR carried out together with TU Delft, looked at how alternative aviation fuels and new aircraft propulsion techniques – including propulsion using liquid hydrogen – could help reduce the environmental impact of aviation.

read more →

times faster than with the current ultrasonic method. This not only accelerates the process but also boosts production line efficiency and minimises waste, as defects are flagged earlier and less material is scrapped. According to Kos, PENELOPE's unique strength lay in its broad focus, which extended beyond aerospace to production technologies in other industries. "This enabled us to tap into a wider network of organisations and experts, gaining valuable insights from outside the aerospace sector. By sharing knowledge and experiences, we were able to evaluate various non-destructive inspection (NDI) methods and identify best practices."

Simulations are key to improving defect detection

A major challenge in AI-powered inspection is gathering enough training data, as real-world defects are relatively scarce. To overcome this, NLR has developed virtual simulations of defects, Kos explains. "By using software to accurately model digital composite panels with various defects, we can train AI algorithms more effectively, improving the accuracy of inspection results and further optimising the technology."

Relevance for the Netherlands and NLR

PENELOPE has significant implications for the Netherlands. By investing in advanced manufacturing technologies, Dutch companies such as GKN Fokker, Airborne, and KVE can maintain a competitive edge in the global market. Kos states: "This inspection method facilitates the aerospace sector in its transition to more sustainable and efficient production processes. By collaborating closely with industry partners and other knowledge institutions, we can drive innovation forward and mitigate the risks associated with adopting new technologies and materials."

Future prospects

Now that PENELOPE has been completed, its findings are being used to inform new research. The results show that intelligent inspection, automation, AI, and simulation can revolutionise aerospace manufacturing. With these innovations, the Netherlands is well-placed to play a pioneering role in the aerospace industry of tomorrow - a goal that NLR is passionate about driving forward.

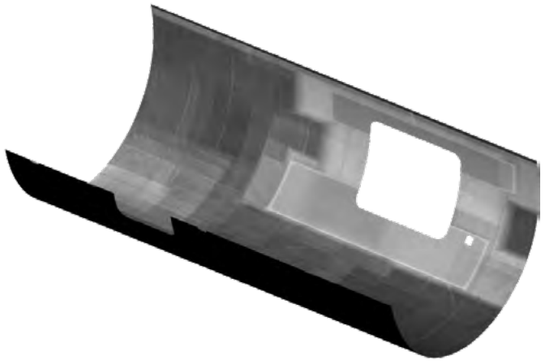
PERIOD
2020 - 2025

PROJECT PARTNERS
https://penelope-project.eu/consortium/

STRATEGIC THEME
Competitive aerospace

NLR KNOWLEDGE PROGRAMME
Development of air and space vehicles

GOVERNMENT POLICY
Key Technologies
(8 Engineering and fabrication technologies)



Thermographic scan of the lower half skin of the thermoplastic Multifunctional Fuselage Demonstrator made with manual scans, preceding PENELOPE

PERIOD

2023 - 2025

PROJECT PARTNERS EU

T27, among others: Netherlands Institute for Radio Astronomy (Astron), Land Registry and Mapping Agency, national space agencies, and several European universities

STRATEGIC THEME

Competitive aerospace and Sustainable aviation

NLR KNOWLEDGE PROGRAMME

Unmanned and autonomous

GOVERNMENT POLICY

Aviation Research Agenda (4); Long-term Space Agenda (1)

"It's more crucial than ever that Europe becomes less reliant on services like GPS"

Robust faith in European Galileo satellite system

Millions of people unknowingly rely on satellite signals every day - whether it's our smartwatch tracking our runs or helping us navigate from A to B. While the US's GPS system is perhaps the most well-known, the European Galileo system has an impressive 4 billion daily users.

Juliette Casals Sadlier, an R&D engineer at NLR, finds it astonishing how much faith we put in satellite systems. "Especially at a time when signal disruptions are likely to become more frequent", she notes. As part of the European GEMOP project, Casals Sadlier investigated the performance of Galileo's satellite services for Unmanned Aerial Vehicles (UAVs), or drones, in urban areas. She conducted tests at NLR's testing facility in Marknesse and in the Austrian Alps, where she simulated signal disruptions in open-air environments.

The European space agency responsible for maintaining Galileo, EUSPA, launched a two-year project in 2023: Galileo and EGNOS Monitoring of Performances (GEMOP). A consortium of 27 universities, research organisations, and space agencies, led by the French space agency CNES, is carrying out the research. The aim is to assess the services provided by Galileo, such as positioning, navigation, timing, and high-precision services. The project team will report back to EUSPA on whether these services are performing as they should, identifying any errors or deviations.

Autonomous flight

There are four global navigation satellite systems worldwide. In addition to the US's GPS and Europe's Galileo, these include China's Beidou satellite system and Russia's Glonass. According to Casals Sadlier, "Galileo currently outperforms other satellite services, as research by EUSPA has shown. It offers high accuracy and availability of data. Furthermore, it's an independent European system, which means that European users and industry can access its services free of charge. Given the current geopolitical climate, it's more crucial than ever that Europe becomes less reliant on foreign services, such as the US's GPS or Russia's Glonass."

"GEMOP gives us a deeper understanding of how Galileo services can benefit industry," Casals Sadlier says. "This allows businesses to design their own receivers, which can be used for different applications - including smartphones, wearables, autonomous vehicles or drones - in various sectors, ranging from consumer electronics and healthcare to transportation. Within NLR, our focus for GEMOP is on drone flight."

Robust signals

"Our focus is on obtaining a robust position, navigation, and timing (PNT) signal", Casals Sadlier continues. "We're examining the integrity and safety of the positioning solution calculated from satellite signals. Here's how it works: satellites broadcast an encoded signal that allows receivers on the ground or in the air to pinpoint the satellite's location and the time the signal was transmitted. The receiver then uses this signal to calculate its own position, velocity, and time. Built-in algorithms within a specific user receiver refine the PNT calculation's accuracy by verifying the reliability of the signal and data. By combining these data with other sensors, we can improve this calculated solution."

Flight and static testing

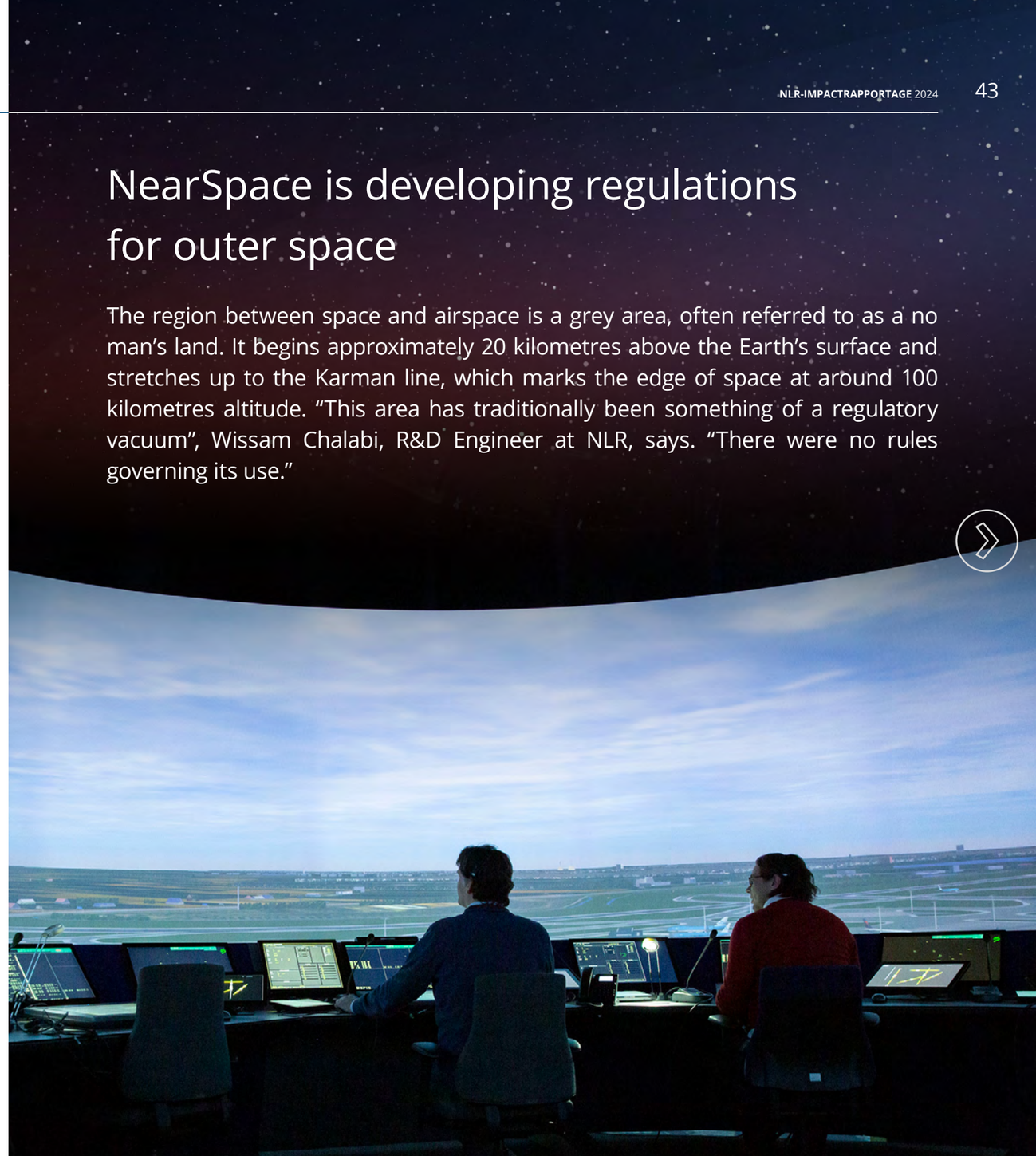
Casals Sadlier and her team use two test scenarios to gather data. The first involves flying a drone at the Marknesse test facility. "We've fitted the drone with a receiver that works in tandem with other sensors," she explains. "As the drone flies, we collect satellite data, which we then run through our algorithms to assess the system's accuracy, speed, and reliability."

As well as flight testing, the team also conducts static tests to assess how receivers respond to satellite signal interference, including spoofing and jamming. "This involves transmitting fake signals that are stronger than the genuine ones. Our tests reveal how accurate positioning is and how disruptions can be identified and mitigated", Casals Sadlier elaborates.

By gathering and analysing this data, NLR enhances its understanding of satellite signal applications. "This allows us to pursue our own research initiatives, such as for autonomous drone flight or its implementation", she states. "The insights gained can be used by organisations like the Ministry of Defence when making decisions, or by companies developing autonomous systems that require precise navigation."

NearSpace is developing regulations for outer space

The region between space and airspace is a grey area, often referred to as a no man's land. It begins approximately 20 kilometres above the Earth's surface and stretches up to the Karman line, which marks the edge of space at around 100 kilometres altitude. "This area has traditionally been something of a regulatory vacuum", Wissam Chalabi, R&D Engineer at NLR, says. "There were no rules governing its use."



Growing congestion

Commercial aircraft typically cruise at altitudes between 9 and 12 kilometres, with some occasional higher excursions. Beyond 100 kilometres, the realm of other vehicles and objects such as space shuttles, satellites, and rockets begins. Air traffic control, air and space surveillance, and segmentation into multiple sectors ensure safe flying and facilitate efficient traffic flow. However, Chalabi observes that the area in between is becoming increasingly congested. This prompted NLR to launch its internal NearSpace project in 2024. “Our goal is to make flying in this region just as safe by selecting optimal flight routes.”

Superfast aircraft

Aside from the growing congestion in the intermediate region near space, startups are also developing superfast aircraft that operate just above the atmosphere, Chalabi continues. This would allow for incredibly short journey times - for example, from Amsterdam to Sydney in just three hours. “Supersonic and hypersonic aircraft cruise at altitudes of around 18 to 40 kilometres, which reduces air resistance and fuel consumption. Additionally, this region has less air traffic, making it safer to fly.”

Finally, there is a growing number of objects in this region for safety or environmental reasons, Chalabi says. “This includes High Altitude Platform Systems (HAPS) and unmanned balloons that monitor the Earth and detect unusual activities, such as wildfires or other natural disasters. These platforms, which can stay aloft for weeks or even months, slowly navigate through and above existing air traffic. This requires careful coordination to ensure seamless integration with faster-moving aircraft.”

A safe intermediate space

Currently, no single authority is responsible for overseeing this intermediate region. Chalabi explains: “With NearSpace, we aim to advise European authorities on how to keep the intermediate space safe.” NLR has a proven track record in Air Traffic Management (ATM), Chalabi states. “Our simulator NARSIM allows us to replicate new traffic scenarios and train air traffic controllers.” Furthermore, NLR has in-depth knowledge of how objects in space relate to each other. “We call this Space Situational Awareness (SSA). For instance, satellites need to be able to determine the location, trajectory and velocity of other objects to prevent collisions.”

An uncontrolled falling object

As part of NearSpace, Chalabi and his team are working on an operational concept to tackle the scenario of an object falling uncontrolled through the intermediate region. “This is a very real possibility. As the number of objects in space increases, so does the likelihood of one of them breaking apart and shedding debris. We want to prevent an uncontrolled object from colliding with an aircraft or causing significant damage if it lands on Earth. By the end of this year, we will be able to simulate an uncontrolled object entering the intermediate region. Using data on the object and our calculations, air traffic control can alert pilots of nearby aircraft.”

> *“We want to prevent objects from colliding with aircraft or crashing to Earth”*

Call to action

The research findings are relevant to authorities such as the Ministry of Defence or the Ministry of Infrastructure and Water Management, according to Chalabi. “They provide a foundation for developing procedures for the intermediate region.” Startups that are developing spaceplanes or rocket-powered aircraft will also find the results useful. “We’ve been in touch with several of these startups, and they’re looking for clarity on the rules and regulations that apply to this part of the airspace.”

The project is essentially a call to action, Chalabi remarks. “The fact is that near-space is becoming increasingly busy, which increases the risk of objects falling from the sky. At the same time, there is a lack of standardised protocols for dealing with these situations. The sector needs to be aware of the risks and work together to coordinate our activities in this space. That is how we can ensure the space remains safe.”

PERIOD
2024 - 2025
PROJECT PARTNERS NL
Internal funding
STRATEGIC THEME
Competitive aerospace
NLR KNOWLEDGE PROGRAMME
Safe and competitive operations
GOVERNMENT POLICY
Long-term Space Agenda (1)

PERIOD

2020 - 2024

PROJECT PARTNERS NL

TU Delft, DTC (part of Collins Aerospace), AELS

PROJECT PARTNERS EU

AIT-LKR, DLR, JR, JKU, INO, INVENT, RTDS

STRATEGIC THEME

Competitive aerospace and Sustainable aviation

NLR KNOWLEDGE PROGRAMME

Development of air and space vehicles

GOVERNMENT POLICY

IKIA for Climate and Energy (D+9)

Lightweight materials and recycling are key to achieving sustainable aviation

The aviation industry needs to become more sustainable, and the materials used in aircraft are crucial to achieving this goal. By reducing an aircraft's weight, fuel consumption is lowered, resulting in fewer harmful emissions. "Composites, which combine plastic with reinforcing fibres like carbon or glass, are a highly promising material for aviation," Ruben Nahuis, project manager at NLR, says. "They offer a strong yet lightweight alternative to conventional metals." Alongside the adoption of new, lightweight materials, aircraft manufacturers can also take steps to recycle materials as much as possible.

NLR plays a key role in the application of new materials and the optimisation of material usage in aviation. Over the past four years, it has been closely involved in the SUSTAINair project. This project, which brought together knowledge institutions and companies from across Europe, focused on two main themes. The first theme explored ways to make aircraft structures lighter, while the second theme concentrated on increasing the aerodynamic efficiency of aircraft. "Within NLR, we zoomed in on three subtopics within the first theme, with a strong focus on composites. Other partners looked at developments in the field of metals."

Recycled composites

Composites, and thermoplastics in particular, are a major research area in the Netherlands, Nahuis points out. Thermoplastics are a type of plastic that becomes pliable when heated, allowing them to be reshaped. They are being explored for various uses in the aviation industry. As part of the SUSTAINair project, NLR and its Dutch partners have been investigating the recyclability of the material and its suitability for welding. "We've taken existing thermoplastic carbon fibre composite components, shredded them, and then reprocessed them, applying a new layer of material to the recycled core", he says.

Welding composites

The outer layer of new thermoplastic carbon fibre composite is crucial for the second topic: welding composite materials using an induction welding process. By locally heating two components using a magnetic field, the materials melt at the point of connection. Once the components have cooled under pressure, a bond is formed. To join components together, it's essential that the carbon fibres in the material can effectively conduct the induced current throughout the component. This is more challenging with shredded, recycled material. "That is why the new outer layer is so important", Nahuis notes.

Moreover, the fibre direction is critical in determining the material's strength and stiffness. "In some cases, it's not possible to work solely with recycled material."

Lighter aircraft through welding

Welding composites contributes to making aviation more sustainable, the project manager explains. "Currently, metal rivets are often used to join components together, which adds extra weight. Welding, on the other hand, eliminates the need for these rivets."

The research also focused on optimising the welding process because, if the material is heated to the wrong temperature, the joint can lose strength. "This can lead to products being rejected and scrapped. But by carefully controlling the welding process and maintaining the optimal temperature, we can minimise waste and reduce the number of rejected products", Nahuis elaborates.

Recycling metal

As part of SUSTAINair, NLR has also been investigating the recycling of metal components. In this endeavour, NLR has been working with AELS, a Twente-based company that specialises in aircraft dismantling. The project involved developing technology to automatically identify and remove rivets from aircraft fuselages. This allows for the recovery of loose metal alloys of different quality grades, each with its own unique properties, which can be reused in various industries.

From desert scrapheap to high-grade product

"Some retired aircraft end up in desert scrapheaps. That should change", the project manager states. "At present, when aircraft are recycled, large metal parts are shredded and the resulting mixture is used to make low-grade products like cola cans. That may sound like recycling, but it's actually downcycling, as the end products are of increasingly poor quality. If we can dismantle components in a cost-effective way, separate alloys cleanly, and then reuse them in high-grade products like aircraft or cars, that's a much more appealing proposition. It means we can avoid downcycling altogether", Nahuis adds.

Effecting change through collaboration

Most of the findings from the project cannot be applied in practice in the short term, as further research is needed. However, the parties involved are looking to the future with confidence. "NLR bridges the gap between science and industry, helping to drive innovation forward. With regard to recycled composites, TU Delft has conducted fundamental research into the material's properties, while DTC Collins, a commercial company, has used its facilities to create prototype products. As NLR, we understand both worlds, allowing us to connect different stakeholders and potentially paving the way for DTC Collins to commercialise the technology in future. That's how we effect change together", Nahuis concludes.

Life Cycle Analysis

As part of its work to drive the transition to more sustainable aviation, NLR is developing guidelines for Life Cycle Assessment (LCA). An LCA is a systematic approach for evaluating the environmental impacts of a product, process, or system throughout its entire lifecycle, from raw material extraction to end-of-life. This allows NLR to assess whether new technologies offer a more sustainable alternative to current standards. Nahuis states: "We're laying the groundwork now by developing the guidelines, so that when the technology is ready, we can quickly conduct the necessary analyses to understand its impact."

"Welding composites helps to make aviation more sustainable"

PERIOD

Ongoing

STRATEGIC THEME

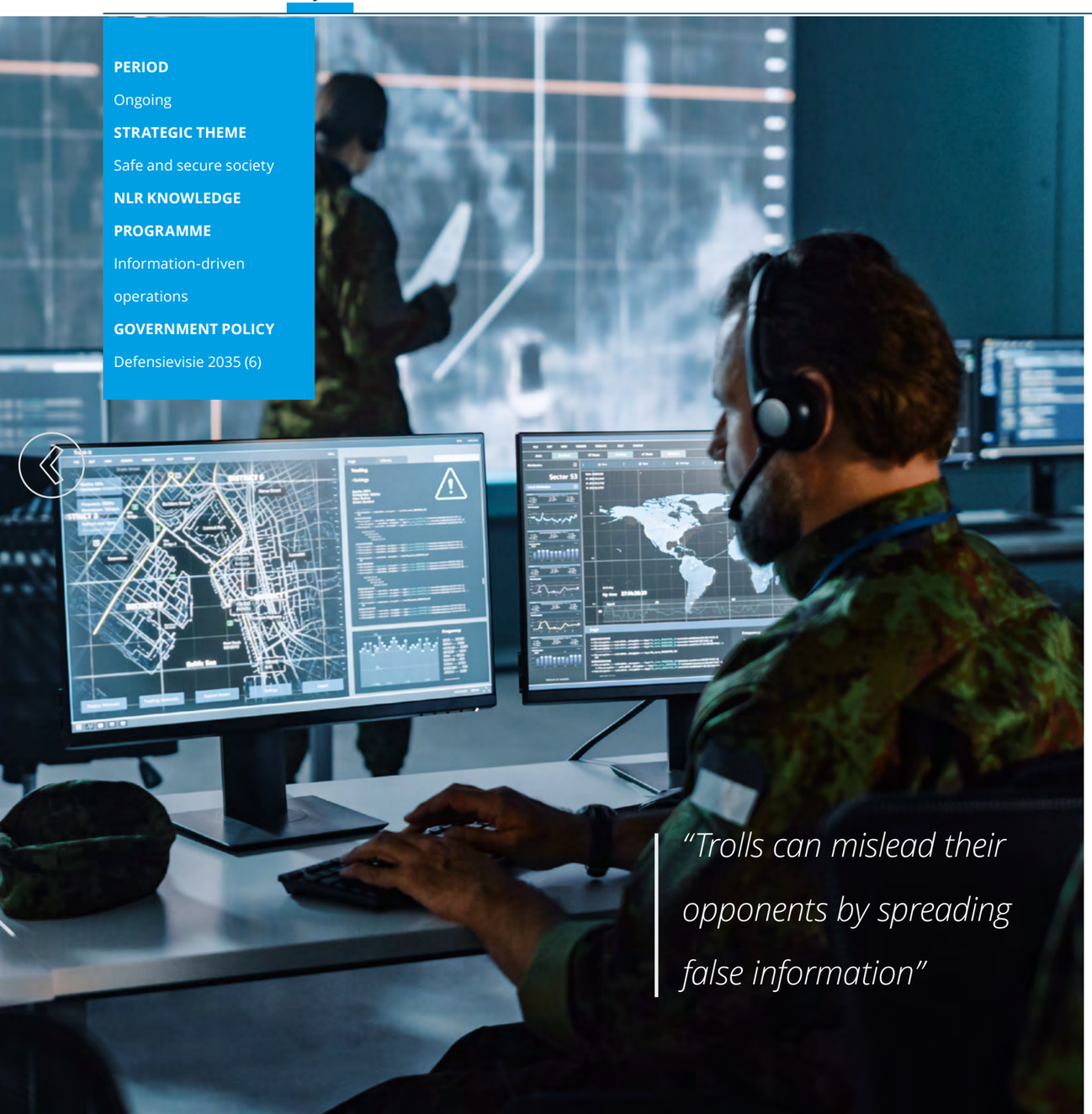
Safe and secure society

NLR KNOWLEDGE PROGRAMME

Information-driven operations

GOVERNMENT POLICY

Defensievisie 2035 (6)



"Trolls can mislead their opponents by spreading false information"

Beyond Kinetics: NLR develops virtual training ground for modern warfare

Cyberattacks, disrupted GPS signals of aircraft, and social media manipulation: the nature of conflict is changing. Modern conflicts are no longer fought solely on physical battlefields, but also increasingly extend into the virtual world. This non-physical aspect of conflict is also referred to as the "non-kinetic" domain by experts, Antoine de Reus, programme leader for Information-Driven Operations at NLR, explains.

The deployment of rockets or other types of weapon systems that physically attack targets are examples of kinetic activities. "NLR has in-depth knowledge of kinetic activities and their simulation", De Reus says. "In addition, we have years of experience and extensive expertise in cyber and cognitive sciences." With Beyond Kinetics, NLR is leveraging this expertise and experience to enhance resilience and effectiveness in both aspects of the non-kinetic domain.

Physical, virtual and cognitive

Non-kinetic attacks operate outside the physical battlefield and take place in the cognitive and virtual dimensions. A fictional example of an attack in the cognitive dimension is influencing a helicopter mission where defence secretly extracts a person from enemy territory. "If people spot the helicopter, they can post photos of it on social media", De Reus explains. "If the opponent reads such a post, the element of surprise is lost. Another example is the visibility of world leaders, which has increased significantly through social media. Their messages now have a much broader reach and greater impact."

De Reus mentions disruption of an aircraft's GPS signals or cyberattacks as examples of offensive effects in the cognitive and virtual dimensions. "More specifically, trolls or fake profiles can be used to deliberately mislead an opponent. This stream of false information can impede decision-making."

Virtual training ground

To effectively defend against these types of attacks or prevent them from happening, it's crucial to understand their impact, according to De Reus. "That is why we need to experiment with and train for them. However, within

our current ethical and legal frameworks, Defence is not permitted to launch simulated cyberattacks." As part of Beyond Kinetics, NLR is developing a 'virtual training ground', a term coined by military lawyer and professor of Cyber Warfare at the Netherlands Defence Academy, Paul Ducheine. This virtual training ground would allow the Dutch armed forces to prepare for potential conflicts or try to prevent them.

A team effort

The project combines four existing projects within NLR that are part of the strategic programme Information-Driven Operations. De Reus sees this amalgamation as a key strength of Beyond Kinetics. "It's a true team effort", he says. "Each project addresses a different aspect, from modelling to understanding the cognitive effects in military operations. Just as the physical, virtual, and cognitive dimensions are intertwined, these four projects are too. In order to create a highly realistic training environment, we need to work together on this." Beyond Kinetics is an NLR initiative, but with a clear demand from the Ministry of Defence to facilitate non-kinetic simulations. "Defence must be able to operate effectively in modern conflicts", De Reus states. "That requires integrated information across all three dimensions." Beyond Kinetics focuses primarily on knowledge development. NLR already has extensive know-how on mission simulations for manned and unmanned aircraft, as well as simulating operations on a larger scale in its battle lab Cerebro. With its knowledge and expertise in artificial intelligence, electronic warfare, cyber modelling and simulation, and cognitive psychology, NLR is now adding simulations with non-kinetic effects to its arsenal. "Imagine a physical command post with a commander receiving misleading information and consequently losing trust in the system", De Reus continues. "How will that affect the ability to make decisions?"

Applied research to enhance the Netherlands' safety

Beyond Kinetics is rooted in applied research, De Reus notes. "We're building on what we already know. We are already experimenting with simulating cyber and electromagnetic effects. When it comes to simulating cognitive effects, however, we are still in the early stages. In our research on cognitive effects, we're not investigating how fatigue impacts decision-making, but rather working off the assumption that it does."

De Reus stresses that the project is still in its conceptual phase. "Ultimately, the virtual training ground will make a tangible contribution to the Netherlands' safety. It's a real privilege to play a part in that."

"Hypersonic missiles are harder to detect with conventional air defence systems"

New missiles demand a more advanced air defence system

Hypersonic missiles are on the rise. These relatively new missiles are five times faster than the speed of sound. Moreover, they are more unpredictable than traditional ballistic missiles because they can easily change course mid-air. "That poses significant challenges for air defence," notes the NLR team leader involved in the project. Over the past year, he and his team have been researching the development of new sensors to detect hypersonic missiles.

Radar and infrared systems can detect aircraft, missiles, and other objects in the air. “This enables us to monitor what’s happening in the air from the ground,” the senior R&D engineer and team leader* explains. If an object is identified as a threat, it allows time for a response, such as intercepting it mid-air or evacuating people in time.

Faster and more manoeuvrable

“With current air defence systems, you can see aircraft and ballistic missiles coming from miles away; they follow predictable trajectories. A ballistic missile, for example, typically flies in an arc towards its target. Hypersonic missiles, on the other hand, fly faster, closer to the ground, and are more manoeuvrable. This makes them less visible to traditional air defence systems.” For this reason, NLR is researching sensors that can detect hypersonic missiles.

The advanced research is part of the Integrated Air and Missile Defence (IAMD) programme, a collaborative effort between NLR, TNO, and the Ministry of Defence. The programme comprises various research projects focused on air and missile defence from land, sea, and air. According to the team leader, the rise of hypersonic missiles currently poses one of the biggest challenges in the IAMD domain. “If we cannot intercept a missile mid-air, it is essential to have sufficient warning time between missile detection and impact. This enables people to be alerted and seek shelter in time, which is crucial for national defence.”

Study and Compare

The team leader continues: “Within the Ministry of Defence, there’s a pressing question about how we can best defend ourselves against these new missiles. That is why NLR has been conducting research into the performance of hypersonic missiles, sensors for detection, and measures to neutralise them for years. To this end, NLR carries out a wide range of tests in both laboratory and field settings (i.e. a less controlled environment outdoors).”

To characterise the performance of these systems, engineers at NLR develop sophisticated aerodynamic and plasma models grounded in fundamental physics. At extremely high speeds, temperatures, and pressures, gases in the atmosphere can change state and form plasma, which affects detectability. The models can predict the formation of these plasmas.

NLR recently conducted a review for the Ministry of Defence, evaluating the advantages and disadvantages of various sensors - including radar, visual, and acoustic systems. The engineering team simulated the impact of each technology on ground-based warning times, providing a comprehensive overview to inform the Ministry’s decisions on acquiring systems to counter the emerging hypersonic threat.

From theory to practice

NLR plays a vital role as a knowledge partner for the Ministry of Defence, providing expert advice and supporting the practical application of the scientific insights gained. “For instance, we also consider the long-term maintenance of systems and the personnel required to do so, offering a comprehensive solution.”

The team leader notes that the Ministry of Defence is taking action and implementing changes based on NLR’s research: “In light of developments in the political landscape, our work has become increasingly relevant over time.”

PERIOD

2023 - 2026

PROJECT PARTNER NL

TNO

STRATEGIC THEME

Safe and secure society

NLR KNOWLEDGE PROGRAMME

Future Air & Space Power

GOVERNMENT POLICY

Defence Vision 2035 (3)

**The name of the interviewee has been withheld for security and privacy reasons.*

PERIOD

2023 - 2026

PROJECT PARTNERS NL

TNO, MARIN

STRATEGIC THEME

Safe and secure society

NLR KNOWLEDGE PROGRAMME

Climate-neutral aviation

GOVERNMENT POLICY

Defensievisie 2035 (2,10)

"With the current high threat level, the Ministry of Defence's energy requirements are expected to keep rising."

Sustainable Defence operations: a win-win for society and military capability

Military aviation must become more sustainable, from both a societal and strategic perspective. "Sustainability can strengthen the air force's position," Elisabeth van der Sman, senior consultant and team leader for sustainable aviation at NLR, states. We rely on other countries for fossil fuels, which are necessary for producing kerosene and diesel. Reducing this dependence is paramount in the energy transition.

As part of the 'Energy Transition of Operational Equipment' programme, NLR is exploring ways to enhance the energy security and independence of the Ministry of Defence through sustainability measures. "Given current developments, it's essential that the Ministry of Defence becomes more autonomous - and thereby less vulnerable", Van der Sman says. "At the same time, we want the air force to reduce its emissions and contribute to the wider sustainability efforts of society. It's a win-win situation."

Energy demand set to increase

Within the programme, NLR has assessed the Ministry of Defence's long-term energy requirements up to 2050. The aim is to understand the amount of energy consumed, how it can be monitored, and which technologies can help optimise energy use. According to Van der Sman, "Given the high threat level, energy demand is likely to increase significantly in coming years." For instance, the Ministry of Defence will need to conduct more training exercises and fly more missions in order to be better prepared. This means more energy will be required in future.

Simulations offer savings

Various technologies can help optimise energy use. One approach is to replace certain aspects of training with simulations. "For a fighter jet pilot, actual flight time is essential for training," Van der Sman explains. "But the enemy they engage with during training doesn't have to be real - we can use simulations instead."

Sustainable jet fuel: a short-term solution

It's also possible to make flying more sustainable, even in the short term. Using sustainable fuels reduces emissions compared to traditional fossil-based kerosene. That is why NLR has investigated the use of Sustainable Aviation Fuel (SAF) - kerosene made from sustainable waste streams - within the Ministry of Defence. Van der Sman notes that "one of the benefits of SAF is that it can be used in existing aircraft without requiring any modifications."

SAF can help the Ministry of Defence take a significant step towards sustainability in the short term. According to current fuel standards, it's already possible to blend SAF with traditional fossil fuels up to 50%. "We have already seen promising results from pilots run with SAF at the Leeuwarden airbase", Van der Sman points out.

Looking ahead, NLR aims to explore whether it's feasible to use an even higher percentage of SAF. This would involve re-testing engines and other systems to see how they perform with higher concentrations of SAF.

Hybrid-electric or hydrogen-powered

The programme also involves researching ways to enhance the performance and sustainability of next-generation aircraft. This includes exploring opportunities to optimise the engine of the F-35. For smaller aircraft and helicopters, NLR is investigating innovative propulsion systems that use electricity or hydrogen. These often involve hybrid solutions. Conversely, Van der Sman expects traditional kerosene to remain the primary fuel source for larger aircraft, which means that sustainable fuel alternatives will be crucial in reducing their environmental impact.

Electric transport at the Ministry of Defence: a prototype military hybrid quad. Photo: Paul Tolenaar-Leusden, 2 September 2019

The Hybrid tugboat Noordzee in the port of Den Helder. Den Helder, 1 March 2016

The entire armed forces

The programme centres on acquiring knowledge and is a collaborative effort between NLR, TNO, and MARIN. The first phase involved investigating different technologies, while the second phase concentrates on putting these technologies into practice. Ultimately, the researchers will compile their findings into a joint report for the Ministry of Defence, encompassing all branches of the armed forces.

"It's vital to take a holistic approach and consider all aspects of the armed forces", Van der Sman posits. She uses fuel as an example, pointing out that a facility producing fuel for aircraft often also produces diesel for land-based vehicles. As hydrogen technology advances, it could potentially be used across different branches of the military. "In that case, it is important to consider the overall impact and ensure that everything works together seamlessly from a logistical perspective. Our goal is to make the entire military more sustainable and less reliant on fossil fuels."

There's a lot more to sustainable aviation than CO_2 emissions

At coffee machines in offices, in parliament buildings and at the European Commission in Brussels, climate change and aviation's part in it have increasingly become topics of conversation. Yet although science has provided abundant evidence that climate change is going to have consequences for our planet, doubt is sometimes cast upon that fact in the debate within society.

Elisabeth van der Sman works as a consultant and team leader for sustainable aviation at Royal NLR, the Netherlands Aerospace Centre (NLR). Among other things, she specialises in research on the impact of sustainable aviation fuels and new energy carriers, such as hydrogen, on sustainable aviation. She makes sure that the dialogues, discussions and debates are conducted...

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"Fatigue is the primary cause of structural problems in aircraft"

Knowledge development is key to enhancing the Ministry of Defence's operational readiness

"Should the Royal Netherlands Air Force be needed on the eastern flank of NATO territory, it is crucial that aircraft and helicopters are readily available and can be deployed for extended periods", John Dominicus, senior research and development engineer at NLR, says. Having the necessary knowledge is paramount in safeguarding operational readiness of equipment.

NLR is utilising the knowledge development programme for Maintenance of Military Aircraft (IML – *Instandhouding Militaire Luchtvaartuigen*) to help ensure the operational readiness of the Royal Netherlands Air Force. "Our goal is to make certain that the Ministry of Defence can always deploy aircraft and helicopters when and where they are needed. As such, we are also focused on making maintenance more cost-effective and efficient, while leveraging the latest technologies", Dominicus explains.

The Ministry of Defence defines its key research questions every four years. In collaboration with NLR, they determine the focus areas, considering current political and social trends. On an annual basis, NLR and the Ministry of Defence then review the concrete activities planned for that year. "By doing so, we maintain flexibility in our research programme and can easily respond to new developments and emerging issues", Dominicus notes. Although some research projects may run for the full four-year period.

Sensors for monitoring aircraft condition

To boost the deployability of military aircraft, several elements are critical. These include monitoring an aircraft's condition, rapid turnaround for repairs, predictability of maintenance requirements, and development of new materials - all of which are important areas of focus within IML. First and foremost, it is essential to assess the condition of an aircraft or its components. "Imagine a pilot wanting to take

off tomorrow - it's vital to know the aircraft's status", Dominicus elaborates. He compares it to preparing a bicycle for a long ride. "You check your tyres, brakes, and lights, using your own senses to do so. Similarly, sensors can provide useful insights into an aircraft's condition."
NLR is researching the types of sensors needed to assess the quality and durability of certain components. In addition to the sensor technology itself, other factors are also being considered. These include determining the optimal location of the sensor on the aircraft as well as developing effective methods to process and analyse the collected data to obtain an accurate and comprehensive picture.

Detecting fatigue

"Fatigue is the primary cause of structural problems in aircraft", Dominicus states. Fatigue occurs when material is subjected to repeated (low) stress loads - which may not cause immediate failure in and of itself - but leads to failure in the long run. This can result in cracks, dents or other forms of damage over time. By using sensors to detect fatigue, the Ministry of Defence can optimise its maintenance scheduling and maximise the availability of its aircraft.

Efficient repair

Aside from detecting potential issues like fatigue, rapid repair is also essential for maintaining high operational availability when a component fails. To achieve this, researchers are exploring ways to automate the inspection of helicopter rotor blades. Currently, this process is done manually - someone uses a hammer to tap on the blade, listening for changes in sound that indicate a loose attachment.

Dominicus adds: "The technical maintenance sector is also facing a shortage of skilled personnel. That is why we are investing heavily in research aimed at optimising and automating certain tasks, enabling us to achieve greater productivity with fewer people. One example of this is a demonstrator we've developed, where a collaborative robot - or cobot - works alongside a human in a shared workspace on a single object." This approach can potentially deliver savings of up to 50 per cent.

Materials

Another important aspect of the programme is its focus on materials. Metamaterials, for example, show great promise. These are materials with properties that don't occur naturally. They can be used to create components or structures with unique characteristics. In future, metamaterials could potentially be used to make aircraft undetectable by radar systems from other countries. "That would be a major breakthrough in military aviation."

Introducing a new material also presents new challenges. "To address these challenges, we need to gain a thorough understanding of the material's properties first", according to Dominicus. "Only then can we assess what impact it will have on our inspection and repair methods, among other things. It will also have implications for personnel working with these materials." By developing expertise in these areas through IML, we're ultimately providing the Ministry of Defence with practical knowledge they can apply.

Paving the way for improvement

Innovation is rooted in knowledge. Fundamental research conducted by universities often lays the foundation for knowledge development. "To turn this knowledge into practical applications, it is vital to build on this foundation by devising more concrete solutions. NLR fulfils a crucial role in this process by bridging the gap between academia and industry." The outcomes of our applied research at NLR enable the Ministry of Defence to implement the necessary changes and improvements.

PERIOD
2022 - 2025
PROJECT PARTNERS NL
Ministry of Defence, NLDA, Technical Universities and Universities of Applied Sciences
PROJECT PARTNERS EU
Foreign research institutes (AFRL, DST, AvMC/SRD, ATRI,..)
STRATEGIC THEME
Safe and secure society
NLR KNOWLEDGE PROGRAMME
Operational availability
GOVERNMENT POLICY
Defence Vision 2035 (1,2)

SAR-CASM: Radar satellites for conflict monitoring

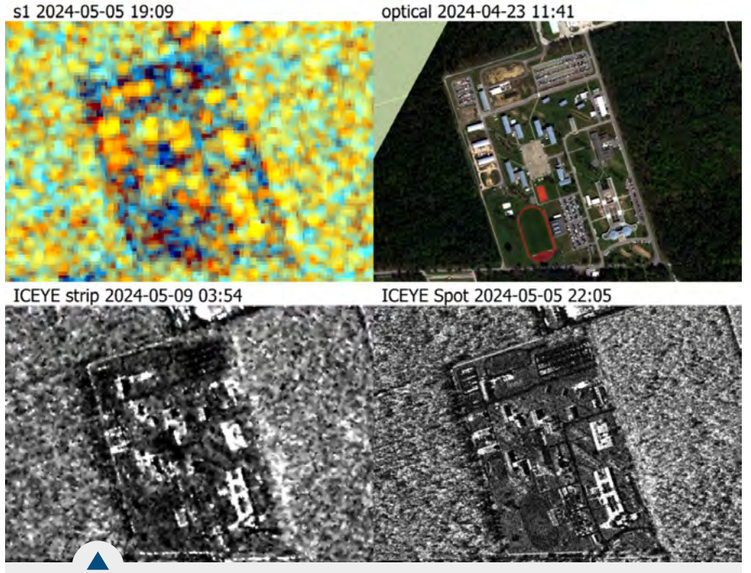
The European Space Agency (ESA) has launched radar satellites (SAR) into space as part of the Copernicus programme. These satellites capture images of the Earth's surface every two to three days. All the images produced by these radar systems are open data. "In the lead-up to a conflict, there's often already a significant amount of unrest in and around the conflict zone, with various preparations underway. Can we gain better insight into these developments by harnessing radar data more effectively? This question prompted the SAR-CASM project", the NLR project lead explains.

SAR (synthetic aperture radar) is an advanced radar technique that can observe the Earth in detail, regardless of weather conditions or time of day. Radar sensors actively transmit radar signals and receive the reflections back from the Earth. Unlike optical satellite imagery, SAR is not impeded by cloud cover or darkness. This makes it a powerful tool for conflict monitoring and security analysis.

The SAR-CASM project (Space-based SAR for Conflict and Security Monitoring) investigated the potential of open SAR data to enhance situational awareness in conflict zones. In partnership with the Ministry of Defence and the Dutch satellite data analysis firm S[&]T, NLR compiled a variety of datasets, including areas of preparatory military activity and Dutch military training exercises.

SAR: an advanced radar technique

The project entails a temporal analysis of satellite imagery. By tracking changes in images over time, researchers can identify subtle indicators of military activity. "We examined a frontline region and observed the emergence of defensive structures over a period of 12 months. We also monitored several military bases, where a sudden change in the number of vehicles present can be a telling sign. Additionally, we analysed changes in logistical activity at a port", the project leader* continues. Until recently, the use of SAR data was limited "due to its low resolution and unique characteristics, which require specialised training to interpret. The valuable information isn't contained in a single image, but in the patterns and trends that emerge when you analyse a series of images over time."



Images captured by the Sentinel-1 satellite showing a clear expansion of logistics. Source: https://magazines.defensie.nl/specials/2024/01/03_space

> *"The valuable information isn't contained in a single image"*

Lower-resolution images (with pixels of up 10 to 20 m) are suitable for tracking large-scale trends and expansive areas, such as urban development or the movement of large military convoys. During the project, the team also explored the potential of next-generation commercial satellites with much higher resolution capabilities (up to 25 cm in detail). These images are more precise, but cover a smaller area. "It's like looking through a straw", the project lead notes. "Combining both types of data is therefore essential: low-resolution images to map broad developments, and high-resolution images to analyse specific situations."

PERIODE
Jan 2023 - June 2024

PROJECT PARTNERS NL
Ministry of Defence, S[&]T

STRATEGIC THEME
Safe and secure society

NLR KNOWLEDGE PROGRAMME
Information-driven operations

GOVERNMENT POLICY
Defence Vision 2035 (5); Long-term Space Agenda (1)

**The name of the interviewee has been withheld for security and privacy reasons.*

Collaboration with the Ministry of Defence and industry

The SAR-CASM initiative was born out of a close partnership between NLR and the Ministry of Defence. The Ministry of Defence sought to gain a deeper understanding of the capabilities of SAR technology and its potential operational and tactical value. Leveraging its expertise in space applications, NLR took the lead in developing analytical methods and test cases. An important partner in this project was S[&]T, a Dutch company specialised in satellite data analysis. Through their involvement, the project has yielded not only theoretical insights but also tangible progress towards the operational use of SAR data in military decision-making. This outcome aligns with NLR's strategic objective of translating innovative technologies into practical applications for governments and companies.

Implications for The Netherlands and NLR

"SAR-CASM has provided the Ministry of Defence with a clearer understanding of how to utilise open SAR data and the potential of high-resolution SAR satellites. This will inform their decisions on future investments in space technology", the project leader says. The findings gained from this project contribute to international security and humanitarian aid efforts. For example, SAR data can be used to support peacekeeping missions or disaster relief efforts.

From project to practice

Although the SAR-CASM project has been completed, it lays the groundwork for further developments. A roadmap has been drawn up for future implementation, enabling the refinement and automation of the methodology. This will involve harnessing the power of AI and machine learning to enhance reliability and response times, allowing the Ministry of Defence and other agencies to respond more quickly and efficiently to changes in conflict or disaster zones. "The SAR-CASM project has showcased how our expertise in space technology can contribute to a safer society. By strengthening our capabilities in satellite data analysis and conflict monitoring, we are not only supporting the Ministry of Defence but also helping to advance the broader Dutch security sector", the project leader concludes.

INTERVIEW FROM NLR PEOPLE

Without our work, no plane can take to the air

As a Mechanical Design Engineer at the Royal Netherlands Aerospace Centre (NLR), Shafeeq Kasiemkhan works with planes, helicopters and rockets that the rest of the world only sees when they finally take to the air years later.

The testing and validation of new aircraft with wind tunnel models is indispensable for the aviation of tomorrow. The models are used to develop new aircraft types and research innovative technology. They enable aircraft manufacturers to determine the optimal aerodynamic properties before a prototype has even been built. Added to that, the simulations save time and money and improve safety because any problems can be identified and resolved before the new aircraft actually takes to the air.

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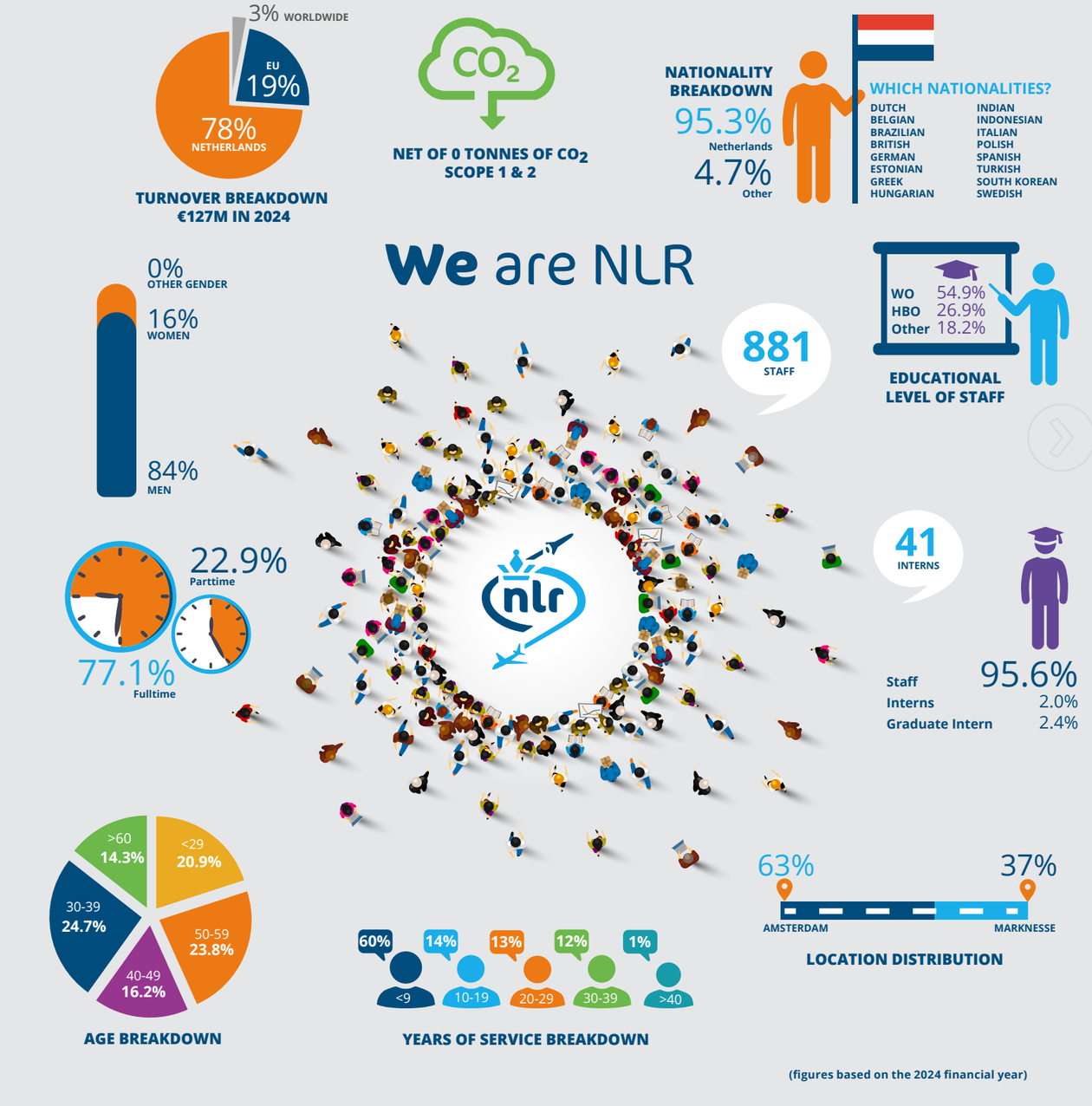
About Royal NLR

For over 100 years, NLR has been an ambitious applied research organisation, driven to keep innovating for the benefit of making aerospace more sustainable, safer, efficient and effective. Objectively and independently, we are now laying the foundation for a future meaningful, societal impact.

In a rapidly changing world, mobility and stability needs are constantly evolving. Aware of the social urgency, NLR helps pave the way for promising concepts to quickly see the light of day and transform into disruptive solutions or incremental improvements. We do this by combining a deep understanding of customer needs, multidisciplinary expertise and the use of our leading research facilities. In doing so, NLR plays a pivotal role between science, industry and government at home and abroad, bridging the gap between fundamental research and practical applications.

NLR is taking a leading role to achieve Dutch and European objectives. Together with our partners, we are working hard on a resilient and sustainable mobility system, and we support Dutch Defence in all military domains, with space and cyberspace playing an increasingly prominent role. From its headquarters in Amsterdam and Marknesse and our two satellite sites and in this way, NLR contributes to a safer and more sustainable society, strengthening the competitive position of Dutch industry.

For more information, go to www.nlr.org.



CREDITS

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Several projects have received funding from the European Commission, including ARAIMFUSE (page 21), ADENEAS (page 25), IMOTHEP (page 32), PENELOPE (page 37) and SUSTAINair (page 47) from the European Union's Horizon 2020 research and innovation programme, and GEMOP (page 41) from the European Union Agency for the Space Programme (EUSPA). GIANCE (page 15) has received funding from Horizon Europe and UK Research and Innovation (UKRI).

NLR Amsterdam

Anthony Fokkerweg 2

1059 CM Amsterdam

t) +31 88 511 31 13

NLR Marknesse

Voorsterweg 31

8316 PR Marknesse

t) +31 88 511 44 44

e) info@nlr.nl i) www.nlr.org

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