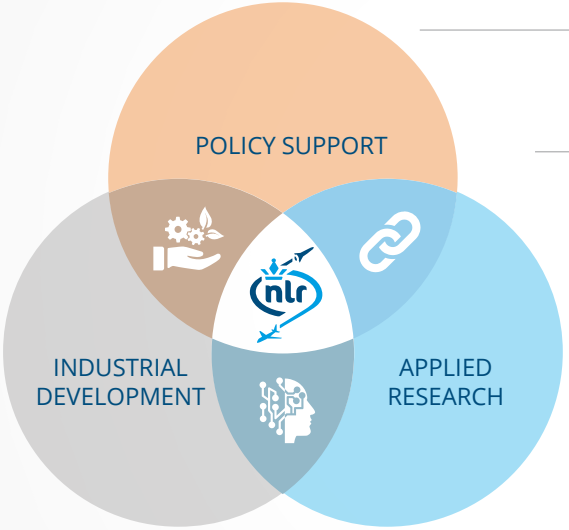
Dedicated to innovation in aerospace

Applied research for aerospace industry, space and defence

Royal NLR - Netherlands Aerospace Centre



Research

Developing & technology integration

Transfer to industry

Production & commercialisation

Making applied research work for society and economy

The Royal Netherlands Aerospace Centre – Royal NLR - has been an ambitious, knowledge-based organisation for over a century, with a deep-seated desire to keep innovati ng. Royal NLR has over 100 years of experience in aerospace. Our knowledge and expertise have made us one of the driving forces in the aerospace sector, both in our own country and abroad.

Royal NLR operates as a non-profit, objective and independent research centre, working with its partners towards a better world tomorrow. As part of that, NLR offers innovative solutions and technical expertise, with the aim of making aerospace more sustainable, safer, more efficient and effective.

We are the connection between scientific research, policy-based support and industrial development. There are various areas where our knowledge and technology are at a world-class level. We use our state-of-the-art research infrastructure, which was given new accommodation during the past period, to experimentally assess the effects of new technology and check the feasibility of new concepts.

This booklet gives an overview of the broad spectrum of the knowledge, capabilities and facilities that Royal NLR is applying in the research projects and programs in the Netherlands and worldwide. We hope you will enjoy reading about our research and welcome you to contact us for more information.

Michel Peters, CEO
Royal Netherlands Aerospace Centre

NLR, home to many markets

NLR supports the civil, space and military aerospace industry in all phases of development of systems and subsystems with innovative solutions, whether it be aircraft manufacturers, Tier 1, 2 or ++ suppliers, scale-ups and SMEs.

NLR research, capabilities, concepts and high tech facilities contribute to scientifically proven and practical developments and solutions that provides impact and will support your organisation in reducing production costs, increase adaptability, and increase sustainability throughout the lifecycle.

This can be achieved by reducing the costs of design and production, certification and testing and automating the production and maintenance process. In the aim of making aviation climate-neutral, NLR works on the use of new materials, effective new production methods, novel solutions for propulsion and operation, and revolutionary aircraft designs. This is relevant not just for traditional aircraft manufacturers but also for new players working with UAM and drones (RPAS) concepts, both in Europe and beyond

NLR STRATEGIC THEMES AND PROGRAMMES

SUSTAINABLE AVIATION

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

COMPETITIVE AEROSPACE

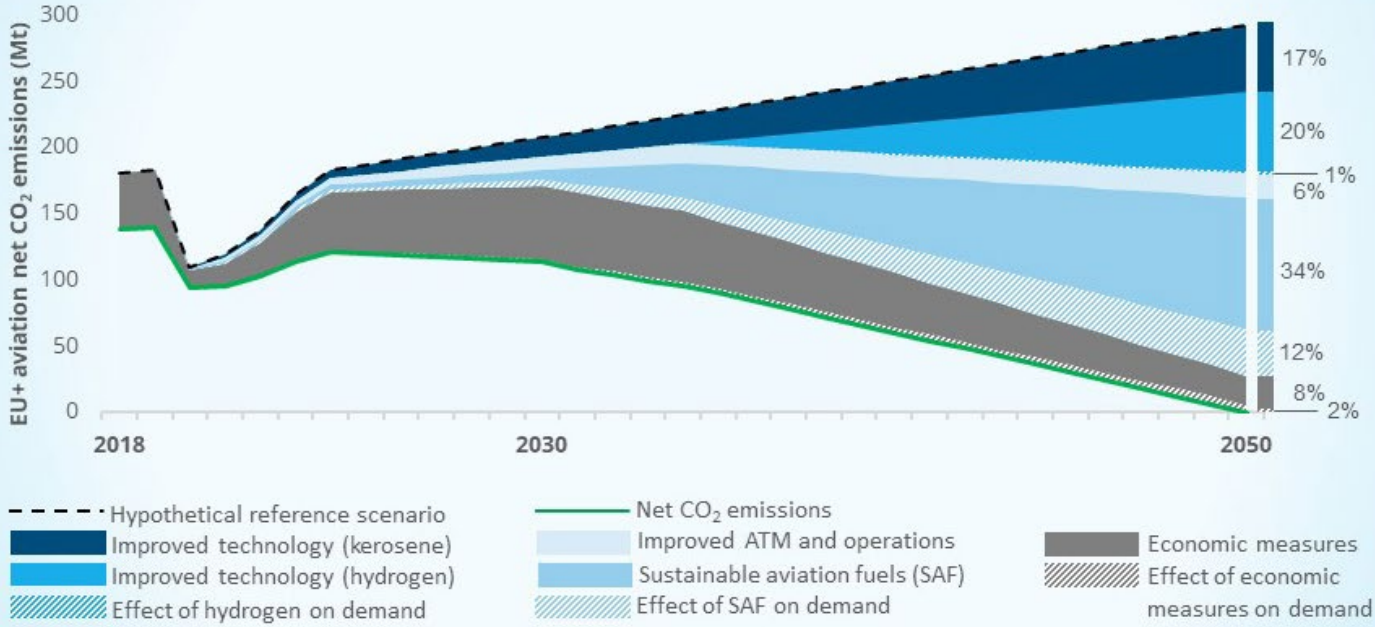
New products and markets are emerging to address issues such as the living environment, accessibility and sustainable air transport.

SAFE AND SECURE SOCIETY

A technologically advanced military is vitally important.

Decarbonisation Roadmap for European Aviation

All flights in scope



Destination 2050

A Route to Net Zero European Aviation

THE CHALLENGE

Aviation must continue to reduce its climate impact. But how? In what ways can the aviation industry mitigate emissions, while ensuring development possibilities within the domain?

1. What can we expect from technology, operations, fuels and economic measures contribute between now and 2050?
2. What do industry and policymakers need to do to capture these benefits?
3. What targets can we set for 2030 and 2050?

WHAT WE DID

Royal NLR and SEO Amsterdam Economics identified decarbonisation measures in a hybrid bottom-up and top-down approach. An ambition level was determined that is both consistent with realistic expectations of future developments and (international) climate and sustainability policymaking. Next, the impact of these measures was modelled to plot the course to sustainable aviation in Europe.

Clients : A4E, ACI-EUROPE, ASD, CANSO, ERA
Research organisations: Royal NLR, SEO Amsterdam Economics
Period: 2021

During the project we worked with airlines, airports, air navigation service providers, aircraft manufacturers and many others. We then used our state-of-the-art knowledge on aviation research and innovation to combine stakeholder views. Together with economic data and insights from SEO we showed how a push toward sustainability is both possible and beneficial.

THE SOLUTION

The research showed net zero CO_2 emissions from all flights within and departing from the EU can be achieved by 2050 through joint, coordinated and decisive industry and government efforts. Destination 2050 shows a possible pathway that combines new technologies, improved operations, sustainable aviation fuels and economic measures. Absolute emissions are reduced by 92%, while the remaining 8% is removed from the atmosphere.

Scaled Flight Demonstrator (SFD)

Scaled test aircraft preparation and qualifications

The SFD is the large scale demonstrator of the European Cleans Sky 2 research programme for future large passenger aicraft. The aim is to validate scaled flight testing as a viable means for de-risking disruptive aircraft technologies and aircraft configurations to a high technology readiness level. The NLR activities involve 'Test Aircraft Preparation and Qualification'.

THE CHALLENGE

The goal is to develop a highly representative scaled aircraft of an actual aircraft, equipped with very accurate flight test instrumentation to perform measurements during the tests. This will introduce a very cost-effective approach to developing radical new aircraft, as needed for more sustainable aviation.

THE SOLUTION

The project has developed a 4-meter wing span Scaled Flight Demonstrator (SFD) of a scaled reference aircraft (A320, scale 1:8,5), which is representative for the full-scale aircraft at Mach 0.4. SFD flight test data is measured to show that scaled flight-testing can be used for obtaining flight-mechanics characteristics that are representative of the full-scale aircraft.

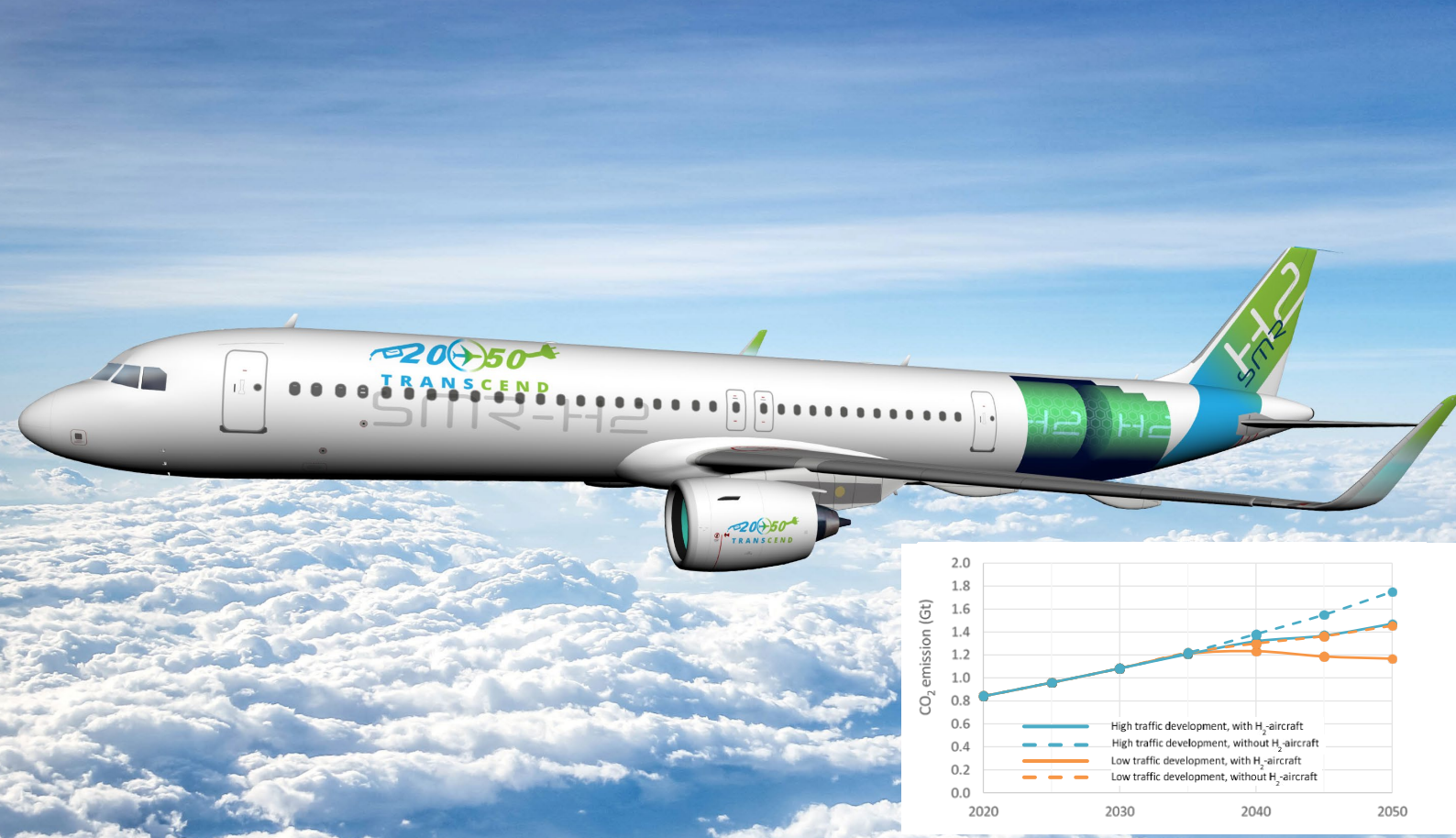
WHAT WE ARE DOING

The work included avionics subsystem design & manufacturing & test, SFD airframe (wing & fuselage) design & manufacturing & assembly & integration (with Orange Aircraft), integration of Flight Test Instrumentation (developed by NLR), development of and integration with the Ground Control System (with CIRA), SFD system integration and test, wind tunnel tests at DNW LLF (April 2021), qualification of an operational concept to obtain an authorisation to fly, and training of the flight crew. High-speed taxi tests were performed at Deelen, the Netherlands, in November 2021. A Flight Readiness Review has been conducted successfully, with Airbus as an important reviewer.

The first SFD flight as part of a qualification campaign at Deelen was performed in March. The mission flight campaign in Italy is will take place in May-June 2024. The maiden flight was carried out on 2 May 2024. All results will be used by ONERA to compile a final report and validate the concept of scaled flight testing as a viable means for future aircraft development.

Project partners
Airbus, ONERA, Royal NLR, CIRA, TU Delft and Orange Aerospace B.V.

This project has received funding from the Clean Sky 2 Joint Co-funded by the European Union



Co-funded by the European Union.
GA no. 864089

Project partners: NLR, Delft University of Technology
Period: 2019 - 2022

TRANSCEND

Technology Review of Alternative and Novel Sources of Clean Energy with Next-generation Drivetrains

The Clean Sky 2 Coordination and Support Action TRANSCEND identifies what alternative energy sources for aviation and novel aircraft propulsion methods can help mitigate climate change and achieve the environmental goals for 2050. Additionally, as we progress towards 2050 roadmaps and strategic recommendations for alternative energy sources and novel propulsion techniques have been developed to ensure that the potential contributions become reality.

THE CHALLENGE

Global air travel is expected to increase significantly in the coming decades. At the same time, becoming climate-neutral by 2050 is a key objective that aviation will have to play its part in. Reducing greenhouse gas emissions is therefore one of the main challenges when developing future commercial aircraft. One of the research objectives of TRANSCEND is to estimate the effect of introducing hydrogen (H2) powered aircraft on global greenhouse gas emissions by 2050.

WHAT WE DID/WHAT WE ARE DOING

The potential of H2-based aircraft propulsion was studied at both the aircraft level and the fleet level. H2-powered configurations (with future entry into service) were conceptually dimensioned and assessed in terms of mission energy consumption and emissions for three different ICAO seat classes in the 20 to 300-seat range: a regional turboprop configuration, a single-aisle turbofan configuration and a twin-aisle turbofan configuration.

The aircraft modelling results were applied in a global fleet-level analysis (for the period 2020–2050) with varying traffic development scenarios (differing primarily in terms of traffic growth, designated low and high).

THE SOLUTION

In our simulations, the relative number of flights with H2-powered aircraft increases from 2035 to 2050: by up to 38% in the low traffic scenario and up to 35% in the high traffic scenario. This leads to fleet level reductions of 20% (low traffic scenario) and 16% (high traffic scenario) in global gross CO2 emissions by 2050 compared to the case in which no H2-powered aircraft are introduced. On the other hand, global gross energy consumption and NOx emissions increased slightly and H2O emissions increased significantly.

Pipistrel Range Extender

Hydrogen powered aircraft is one of the most promising novel aircraft technologies to contribute to a sustainable future for aviation. NLR is involved in various areas related to hydrogen knowledge- and capability development, ranging from tanks to engine and from design to testing and certification. As part of a roadmap and build-up approach, for NLR's electrical research aircraft, the Pipistrel Velis Electro, a hydrogen based range extender will be developed and demonstrated in flight.

THE CHALLENGE

As hydrogen propulsion is a new technology in aerospace, the following questions need to be answered:

- Is it possible to develop a cost- and aircraft performance efficient solution for a hydrogen powertrain?
- Can compliance demonstration of a hydrogen powertrain with the – yet to be defined – safety requirements be achieved?
- How does the hydrogen powertrain compete with other conventional- and novel technologies?

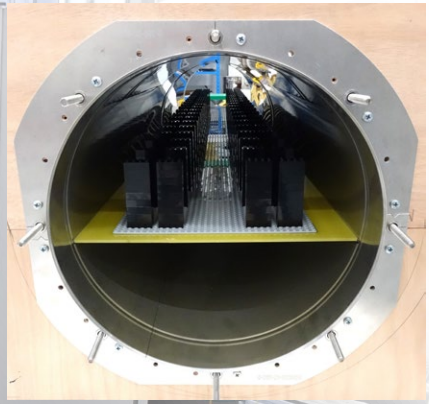
WHAT WE ARE DOING

Currently in the requirements capture- and conceptual design phase, trade offs are being assessed to realise a demonstration flight in 2026. Regarding the hydrogen powertrain the existing market and technologies are being explored. In addition the aircraft modification- and integration aspects are being assessed.

THE SOLUTION

The Pipistrel Velis Electro will be retrofitted with a liquid hydrogen tank and a belly fairing to accommodate the hydrogen powertrain, which will interface with the existing electrical system. Thereby independence can be maximised and risk can be mitigated as a first step towards fully hydrogen based solutions. Following a design period and extensive ground testing, the flight demonstration will be a significant next step in realising the goals.

Research organisation : NLR
Period : 2023 - 2026



Industry (NL): GKN Fokker Elmo (project lead)
Industry (EU): Collins Aerospace Ireland, Evektor, plc-tec ADSE, Synano
Research organisation : NLR
Universities: Eindhoven University of Technology
Period: 2021 - 2024

ADENEAS

Advanced Data and power Electrical NEtwork Architectures and Systems

The More Electric and Connected Aircraft (MECA) concept is one of the most promising enablers for achieving the goals of Flightpath 2050. However, MECA implies more electrical systems exchanging more data – that can be safety-critical – and higher electrical power consumption, leading to higher thermal dissipation.

THE CHALLENGE

For the on-board power and data network, the increased number of electrical systems implies higher complexity, weight and risk to intended or unintended electromagnetic interference. To mitigate these challenges, new communication, power distribution and cooling technologies are required for optimising the power and data networks in future aircraft. ADENEAS is developing these new technologies and paving the way for a safe, lightweight, self-configuring, autonomous and modular power and data distribution network that is scalable to all aircraft sizes.

WHAT WE DID

NLR analysed the propagation of wireless communication inside the aircraft environment, as well as the risk wireless signals may pose through interference with other aircraft systems, in particular the radio altimeter. Samples of shielded windows were tested to analyse their effectiveness in protecting this critical system. NLR has also performed electromagnetic compatibility tests to evaluate the robustness of powerline communication and modelled crosstalk between PLC modems. NLR's thermal team has designed an optimised two-phase cooling system to deal with thermal management of on-board power electronics, and demonstrated the flexibility and modularity of such a system. Taken together, the ADENEAS technologies that enable an optimised power and data network can yield a 456 kg weight reduction, leading to a 334 kg reduction in CO_2 emissions for a single flight of about 4,000km.

THE SOLUTION

ADENEAS developed enablers for a hybrid data network in which parts of the conventional wiring can be replaced by powerline communication or wireless communication. Modular power electronics were developed for decentralised power network design, targeting dynamic power delivery to consumers. Moreover, a two-phase cooling system for the thermal management of power electronics was developed. Nanofeatures were investigated for further improvement of the system's heat transfer. Finally, supporting architectures, design optimisation and standardisation have all been integral parts of ADENEAS.

Co-funded by the European Union. GA no 101006728

HyPoTraDe

Hydrogen Fuel Cell Power Train Demonstrator

The HyPoTraDe objective is to deliver a validated digital twin model based on testing a powertrain demonstrator of a 500 kW fuel cell battery hybrid powertrain that can be scaled up to future MW class aircraft. It explores utilising the fuel cell's waste heat to enhance system efficiency and tests the powertrain under flight-relevant conditions. The outcome of the project contributes to fulfilling the ambitious goals for regional and short-range hydrogen-powered aircraft with Entry Into Service in 2035 to meet EU's climate neutrality targets by 2050.

THE CHALLENGE

The key impact of HyPoTraDe is a fast-track optimisation of fuel cell powertrain electrical and thermal architectures based on state-off-the-art industrial components. It provides for a comprehensive understanding of the operational characteristics of modular, fuel cell - battery hybrid-electric, distributed electric propulsion powertrain configurations for future aircraft. While safety is paramount in aviation, potential failure modes are analysed and identified mitigation measures are evaluated during the powertrain demonstrator test campaign.

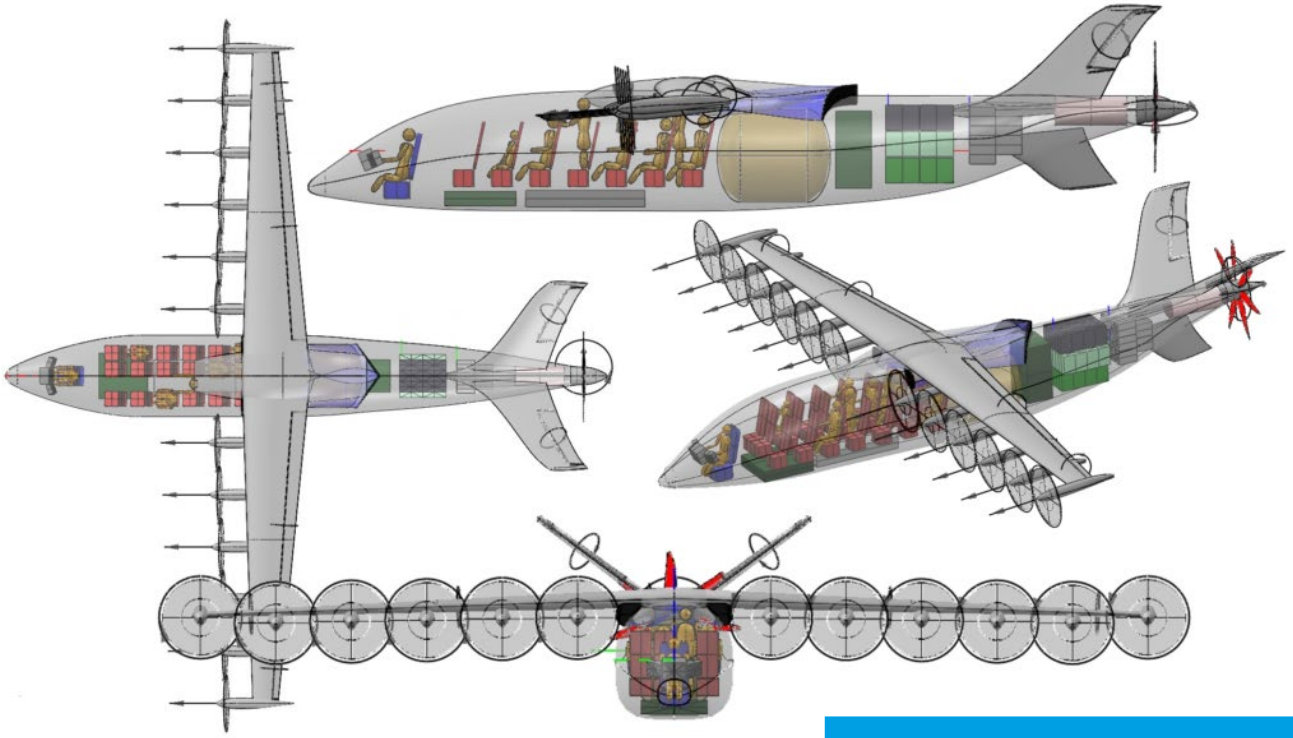
WHAT WE DID/WHAT WE ARE DOING

NLR is responsible for:

- Coordination of the failure modes studies
- Design of the powertrain demonstrator Thermal Management System design
- Design, modelling and testing of the (liquid) hydrogen distribution system including a liquid hydrogen heat exchanger and a two-phase heat transfer loop utilising fuel cell waste heat
- Creation of ground level test environment at NLR Marknesse for flight representative testing of the 500kW powertrain demonstrator
- Coordination of the subsystems integration and the powertrain demonstrator test activities
- Delivery of a dataset for Digital Twin validation

THE SOLUTION

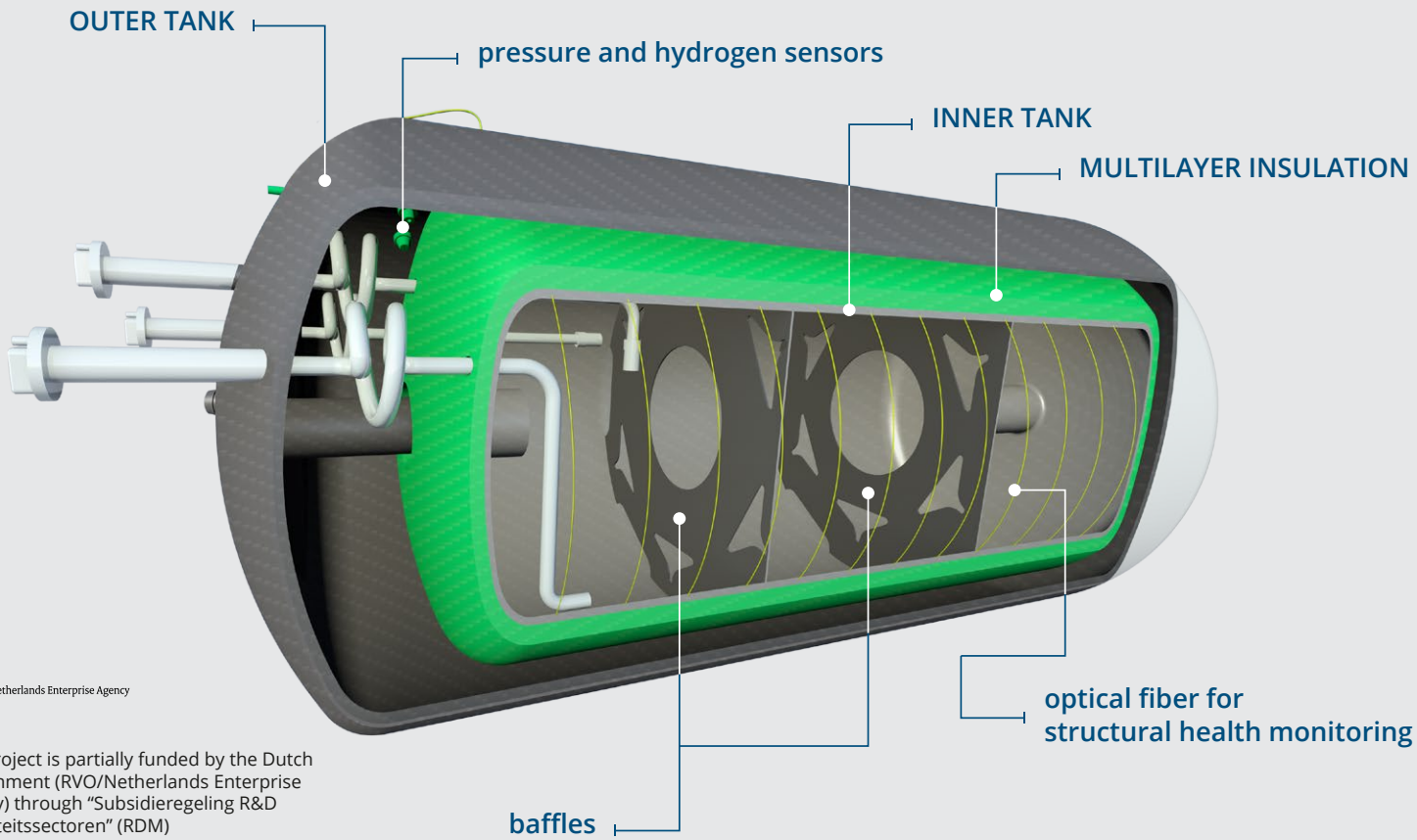
The project provides for a ground level test environment for testing of a 500 kW hydrogen-electric powertrain demonstrator with the aim to validate the Digital Twin model. Flight representative mission profiles are being tested and evaluated. The powertrain demonstrator includes fuel cells, batteries, power distribution system, controls, convertors, TMS, hydrogen distribution, liquid hydrogen heat exchanger, propulsor units, non-propulsive load emulation and a large liquid hydrogen storage tank. The validated Digital Twin will enable accurate performance predictions for scaled-up hydrogen-electric powertrains for future aircraft.



CLEAN AVIATION

Co-funded by the European Union. GA no. 101101998

Industry: Pipistrel (project lead), Honeywell
Research organisations: Fraunhofer, NLR
Universities: Universtity of Stuttgart, Delft University of Technology
Period: 2023 - 2025



Netherlands Enterprise Agency

This project is partially funded by the Dutch Government (RVO/Netherlands Enterprise Agency) through “Subsidieregeling R&D Mobiliteitssectoren” (RDM)

Liquid hydrogen composite tanks for civil aviation

Hydrogen has been identified as a key priority to achieve the European Green Deal for a sustainable economy. By converting the construction of the hydrogen tank from existing metallic solutions to composites, the liquid hydrogen (LH2) composite tank will achieve weight savings that enable the advancement of liquid hydrogen as a sustainable fuel for civil aviation. This will lower the carbon footprint of air travel and extend the flight range of aircraft by reducing construction weight and cost.

THE CHALLENGE

For single-aisle commercial aircraft, the energy density of compressed hydrogen gas is not sufficient to provide the necessary range; this can only be achieved with liquid hydrogen, stored at 20 Kelvin/-253 °C. The project aims to develop a linerless long-life lightweight composite tank that can withstand the low temperature of liquid hydrogen and related thermal stress.

THE SOLUTION

The project will focus on the application of microcrack-resistant composite materials with sufficiently low permeability for hydrogen. In order to comply with boil-off and dormancy requirements without adding significant weight and/or volume, a vacuum/MLI insulated tank will be developed with contributions of all consortium members. The tank will be equipped with fluid level sensors and sensors for safety systems. During the design phase, digital design strategies will be used to minimise thermal stress and optimise utilisation of automated manufacturing technologies.

WHAT WE ARE DOING

NLR has developed additional facilities for testing composite materials at 20 Kelvin. Several thermoset and semi-crystalline thermoplastic composites (Toray) have been screened regarding their properties at this very low temperature.The materials are also characterised regarding their permeability properties and resistance against thermal cycling down to 20 Kelvin. Together with project partners, a suitable thermoplastic composite material is selected for the inner tank and characterised regarding engineering properties at 20 Kelvin. For the outer tank a thermoset composite material is selected. With these materials a composite tank will be designed, manufactured and tested. The health and safety of the tank will be monitored with various fibre optic sensors, having no electrical signals and minimal heat ingress, that monitor the temperature, pressure, LH2 fuel level, acceleration and leak detection.

Industry (NL): Toray, ADSE, Airborne, Bold Findings, Cryoworld, Fokker Aerostructures, IT'S Engineering, KVE, PhotonFirst, Somni Solutions, Taniq
Research organisations : NLR, SAM XL
Period: 2022 - 2026

Aviation in Transition

Luchtvaart in transitie

In 2050, aviation must be climate-neutral. Through Aviation in Transition, the Netherlands strengthens its position as an innovative and resilient leader in aviation. Between 2023 and 2030, a range of projects will be undertaken to develop technologies, build sustainable knowledge, and strengthen the aviation ecosystem. As a result, we will have enough trained individuals for the transition to a new aviation system, and we can secure a stronger market position within the global chain. Within Aviation in Transition, various stakeholders, ranging from universities, knowledge organisations, and SMEs to large enterprises, are united. In close collaboration, they work on the accelerated development of breakthrough technologies that make crucial systems, and consequently, future aircraft ultra-efficient and free of CO2 emissions. The Dutch government contributes to this mission with essential support from the National Growth Fund, as well as supportive policies to facilitate the introduction of "sustainable flying."

Aviation in Transition (Luchtvaart in Transitie) is a groundbreaking eight-year program where the Dutch government and the aviation sector join forces. The goal: to initiate a revolution by accelerating sustainability, with climate-neutral flying from 2050 as the guiding principle. Participating partners in Aviation in Transition aim to achieve this by developing energy-efficient solutions, lighter materials and systems, and even carbon-neutral propulsion systems using hydrogen as a fuel. To achieve this, the Aviation in Transition program will financially invest in and collaborate with over 60 partners to boost the Dutch aerospace sector and, consequently, the economy. The National Growth Fund (Nationaal Groeifonds) supports this programme.

Aviation in Transition will result in:

- Development of three flying demonstration airplanes
- Technology development for a new generation of ultra-efficient aircraft
- Sustainable knowledge development and preservation
- Reinforcement aeronautical networks

LUCHTVAART
in transitie

The Aviation in Transition programme consists out of twelve projects. NLR is partner in most of the twelve LiT projects, including the following industry led projects

NLR is furthermore partner in the following projects:

Advanced Electric Wiring
Project lead: Fokker I GKN Aerospace

Project aim: to develop advanced high-power wiring systems for increased electrical power in hybrid-electric aircraft and hydrogen fuel cell systems

Hydrogen Aircarft Powertrain and Storage Systems (HAPSS)
Project lead: Conscious Aerospace

Project aim: by 2027, to have a flying HAPSS zero-emission hydrogen-based demonstrator turboprop aircraft (>36 seats) derived from a large regional turboprop airplane. And to develop products for the other two hydrogen demonstrator aircraft.

Hydrogen Conversion Turbofan (HOT)
Project lead: Fokker NextGen

Project aim: to develop a retrofit modification, enabling existing jet aircraft to be suitable for hydrogen combustion in a hybrid solution. This can still involve the use of kerosene or a greener variant thereof (bio or synthetic).

Lightweight composites and structures
Project lead: Fokker I GKN Aerospace

Project aim: the development of innovative production technologies for complex thermoplastic composite parts and integrated structures. The activities cover the entire spectrum from material development and product design to production, certifiability, repairability, reuse, and sustainability evaluation of thermoplastic composite products.

THE SOLUTION

As part of the MFFD development, the STUNNING project developed, manufactured and delivered the 180° full scale lower half of the multi-functional integrated thermoplastic fuselage, including cabin and cargo floor structure and relevant main interior and system elements. The STUNNING team applied advanced design principles, innovative system architecture and advanced materials and processes.

Watch the making of the thermoplasic fuselage

Clean Sky 2

This project has received funding from the Clean Sky 2 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme EU

STUNNING

the world's largest known thermoplastic aircraft structures

The Clean Sky 2 Multifunctional Fuselage Demonstrator (MFFD) with its 8.5 meter long composite-made fuselage section with an approx. 4 meter diameter gives a glimpse of what a next-generation aircraft could be. This typical section of a single aisle aircraft fuselage is completely produced from thermoplastic. Now, Royal NLR's STUNNING project is turning heads as the MFFD's largest component, the 8.5 meter long lower fuselage skin, has been manufactured and delivered to the project partners.

THE CHALLENGE

As part of the EU's Clean Sky 2 initiative, the aerospace industry is looking for flight path to sustainability. To deliver a double-digit fuel burn reduction for the Large Passenger Aircraft (LPA) segment next generation fuselage structure concepts are needed in which cabin, cargo and physical system elements are integrated. Its three main and for STUNNING overarching objectives for future Single Aisle Aircraft fuselages compared to the state of the art are:

- Reduce weight
- Reduce recurring cost
- Enable a High Rate Production (HRP) of 60-100 shipsets per month

Industry (NL) : Fokker Aerostructures
Industry (EU) : Diehl
Research organisations : NLR
Universities : TUDelft, SAM|XL
Period: 2020-2024

WHAT WE DID

NLR developed and applied a competitive manufacturing process using fast AFP layup of two 90° fuselage segments out of thermoplastic Cetex® TC1225 LMPAEK/T700 uni-directional carbon fibre material on a layup tool at room temperature. The part was consolidated by the NLR team in an innovative consolidation mould (EMOTION CfP) using the research autoclave at the German Aerospace Centre (DLR) in Stade, Germany. The consolidated 180° fuselage skin was inspected at NLR using Thermography and delivered to the STUNNING partners for the integration of structures, interior and systems installation.

A significant weight reduction resulting from this integrated approach, based on advanced thermoplastic assembly principles like welding, will contribute to the environmental goals. Manufacturing costs and assembly times will be reduced and high production rates can be realized. To achieve the overall goals, 'beyond state of the art' technologies are developed and verified in dedicated tests up to TRL5.

Digital Twins

Mastering and optimising highly automated composites manufacturing processes

The aerospace manufacturing and production industries are increasingly challenged to be more competitive, and do more with less. To be able to comply with higher production rates, affordability and constant quality, high levels of automation are required for current-day manufacturing processes. This results in more parts meaning more process data to control and keep track of while the number of operators at the production floor has not grown.

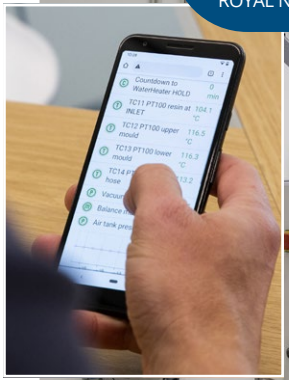
THE CHALLENGE

The challenge is to be able to maintain overview of individual process steps, part quality and status of equipment. Advanced monitoring and inspection of automated processes by a Digital Twin (DT) of the physical manufacturing environment could help an operator to filter all the available data supporting timely detection of production flaws, first-time right production, product quality, and delivery reliability. Additionally, all the collected data can be used for many more purposes:

- Design and optimise the production facilities and manufacturing processes
- Optimise maintenance
- Digital threads, digital product passports, and managing data on behalf of certification

THE SOLUTION

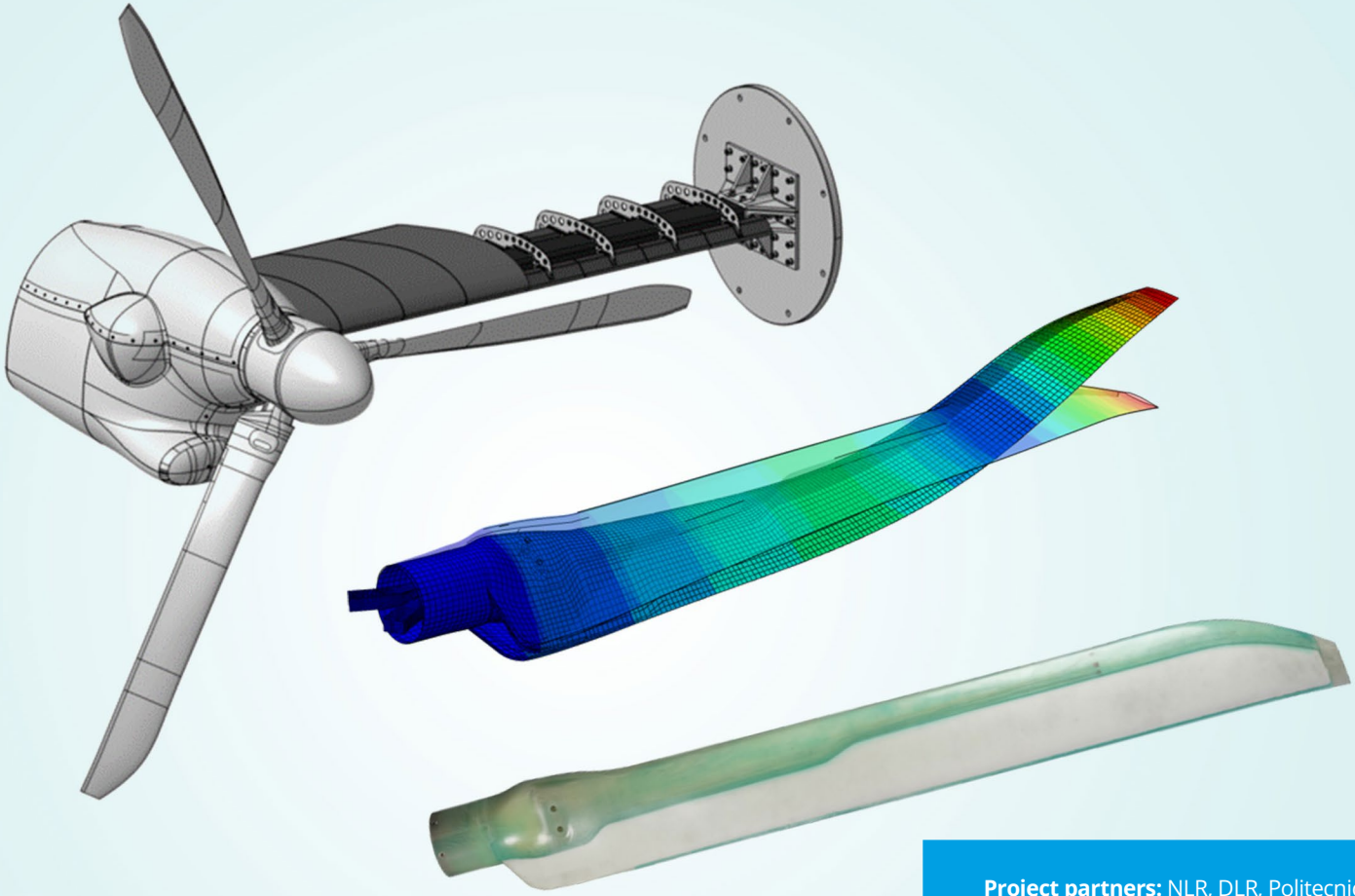
The Digital Twin compares the actual situation, going-on real-time process and product information of the physical manufacturing environment, against the expected and simulated behaviour and properties, thereby signalling deviations beyond thresholds. The DT raises situational awareness through dedicated dashboards and advanced interactive visualisation technology (e.g., VR, AR via handhelds, information projection on PT), enabling and supporting operator and mechanics to monitor, understand, inspect, adjust and repair. A DT can collect and organise data and statistics from processes, detect trends, and analyses data across process runs, to support process optimisation and condition-based predictive maintenance. The Digital Twin facilitates digitals threads and passports of the products and machinery.



WHAT WE DID

NLR developed a Digital Twin ecosystem and implemented this as test case on our Resin Transfer Moulding RTM manufacturing environment for validating and testing. By connecting actual live data from the industrial OT/IT technology and machine communication protocols, and a tailored integrated mix of IT technologies (e.g. AI/machine learning, data analytics, big data, cloud, etc.) and data sets, a digital replica (DT) of the physical RTM manufacturing environment was realised. The Graphical User Interface (GUI) of the DT and added handhelds/ tablets to the work environment that advises the operator not only when on the production floor but also when the operator is taking a coffee break, have created a powerful “smart assistant”. Besides, the Digital Twin is available in any place over the world remotely, in (near) real-time. It only visualises the relevant data in each phase of the manufacturing process and issues alarms or warnings which are triggered based on defined thresholds and predictions by the Digital Twin.

Research organisation : NLR



Project partners: NLR, DLR, Politecnico Milan, DNW, PhotonFirst
Period: 2019-2023

Co-funded by the European Union. GA no 831969.

ATTILA

Advanced Testbed for Tiltrotor Aeroelastics

THE CHALLENGE

Rotor blade designs have to be sufficiently strong for wind tunnel testing and must have dynamic characteristics that resemble the full-scale behaviour. This implies that the blade design should have a closely matching stiffness and mass distribution along its entire span in comparison with the target properties of the aeroelastically scaled blades.

- Stiffness properties along the blade span:
  - Axial, flap and lead-lag bending, and torsion stiffness
  - Location of the neutral axis and shear centre
- Mass properties along the blade span:
  - Mass and mass moments of inertia
  - Centre of gravity position

In addition, the blades have to be instrumented for monitoring the loads and dynamic behaviour of the blades during the wind tunnel test.

WHAT WE DID

Aeroelastically scaled blades were designed and manufactured. The design encompassed everything from conceptual design to detailed stress analysis of the final blade structure. The final blade design has closely matching stiffness and mass distributions, while still satisfying all wind tunnel strength/safety requirements.

The blades have been instrumented with embedded strain gauges and optic fibres to monitor the flap bending, lead-lag bending and torsion loads at three different cross-sections, and at the same time to monitor the dynamic behaviour of the blades during the wind-tunnel test.

THE SOLUTION

The blade design consists of a load-carrying D-spar and separate (thin) trailing edge. Both are constructed from glass fibre-reinforced laminates supported by an internal foam core. In addition, the D-spar has tungsten bars of varying lengths and diameters; these non-structural masses are used for tuning the mass distribution and CoG position along the span of the blade.

The final design of the blade is based on detailed FEM analyses to determine the cross-sectional stiffness properties along the blade span. These properties were tuned to the required values by varying the lay-up in the different segments (nose, top/bottom skin, web, trailing edge) for each blade cross-section.

It turned out that the blade needs to be very flexible towards the tip. The low required stiffness properties necessitate the application of ultra-thin glass fibre fabric plies (47 gsm). These thin plies also allow accurate tuning of all the different stiffness properties in the rest of the blade.

Project partners
Royal NLR (project lead), DLR, VZLU, CIMNE, Fokker Aero-structures, EVEKTOR, Fokker Elmo, IMST, INVENT, TRACKWISE, L-UP
Period: 2017-2022

ACASIAS

Advanced Concepts for Aero-Structures with Integrated Antennas and Sensors

THE CHALLENGE

Aircraft drag reduction is an important issue for cleaner air transport. Up to now, satellite antennas are positioned on top of the aircraft in large protruding radomes. Within the European ACASIAS project, Royal NLR is investigating the possibilities to integrate antennas in the structure to create smoother outer surfaces.

WHAT WE DID

The complete panel is cured on a female mould in an autoclave at a higher temperature and pressure. To support the stiffeners during this process no labour intensive tools were used. Instead of the common used high number of supporting blocks a silicon bag is developed. The silicon bag has the same pattern as the final panel with stiffeners. In this way, an affordable panel was made with integrated stiffeners. No man-hours are required for cleaning of tool blocks, bonding of stiffeners or the installation of fasteners to connect stiffeners.

THE SOLUTION

As part of the programme, NLR and the ACASIAS partners have developed new beam forming Ku-band antennas, but also new composite structures with integrated Antennas. The ACASIAS fuselage panel is made with a fibre placement machine, using carbon fibre prepreg. Fibre placement machines are often used for large surfaces with local patches. NLR has now optimised the process for the manufacturing of thin stiffeners. In the crossings of the lattice structure, half of the tapes are cut in one direction and half of the tapes are cut in the opposite direction, so no thickness build up occurs. In the middle of the panel, glass fibre prepreg is used to create a transparent skin for the internal antennas.

By doing so, antennas can be placed on the inside instead of on the top of an aircraft, reducing the total drag of the aircraft.

Co-funded by the European Union. GA no 723167.

ACASIAS

MANTA

MovAbles for Next generaTion Aircraft

THE CHALLENGE

The objective was to manufacture three Ti-6Al-4V flaperon ribs by Direct Energy Deposition (DED). With conventional manufacturing processes, it can be very costly or even impossible to produce components with such complex shapes. However, DED is also challenging due to various features inherent in the design: bulky thin parts, asymmetric geometry, overhanging features etc. The main challenge was manufacturing all the structures with the minimum distortion and highest accuracy.

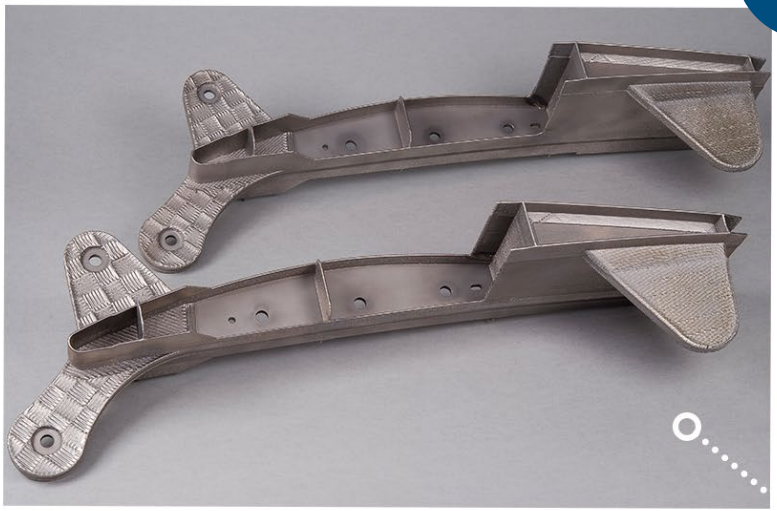
WHAT WE DID

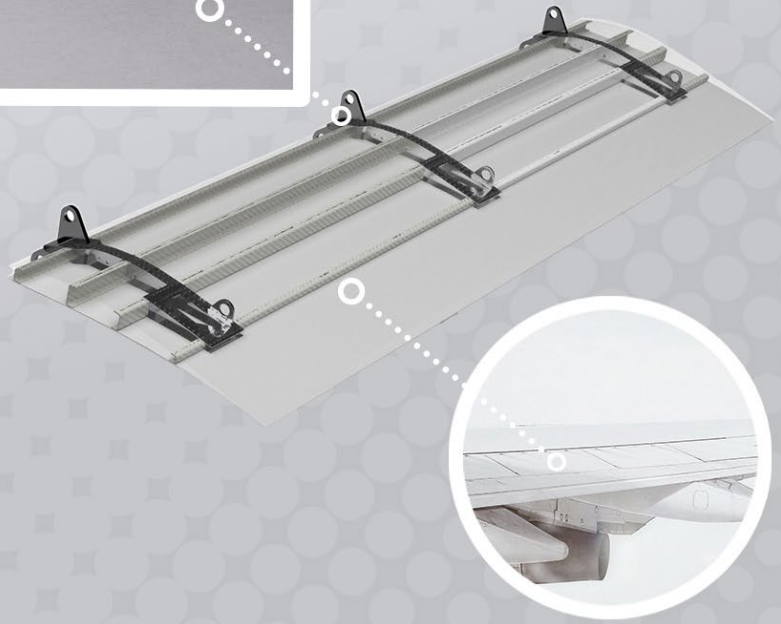
First, all the characteristic features of the flaperon rib were identified. An experimental design was then produced to evaluate and optimise the production of those features. All the critical structures such as the overthickness, wall-intersection overlaps or horizontal web welding were therefore optimised before manufacturing the ribs. The design guidelines for critical features for Ti-6Al-4V were developed through this work.

THE SOLUTION

Three full-scale Ti-6Al-4V ribs were successfully produced by laser powder DED. To reduce the baseplate distortions, a symmetrical build-up was chosen. This strategy helped minimise substrate deformations. For the 15 mm lugs, checkboard deposition with an outside-in strategy was chosen to avoid distortions. In addition, a horizontal plate was welded with DED to create an offset shear web. Thanks to DED, manufacturing the ribs by DED reduced the buy-to-fly ratio from 40 (starting from a titanium block) to 3.

Clean Sky 2 *Co-funded by the European Union.*





Project partners:
Asco, Royal NLR, DLR, TU Delft, Fokker Technologies Holding

Project partner
Boeing
Project lead: Royal NLR
Period: 2014-2021

Magnesium LPBF to manufacture light-weight components for vertical lift applications

The objective of this research project was to demonstrate the capability to produce high-quality magnesium products for vertical lift applications by Laser Powder Bed Fusion (LPBF). Magnesium has become the preferred material for vertical lift transmission casings due to the combination of low density and high specific strength. Magnesium LPBF therefore offers a great deal of potential for vertical lift applications. Internal channels for lubrication and/or cooling can be optimised and substantial additional weight reductions can be achieved compared to cast products.

THE CHALLENGE

Magnesium is a challenging material to process in LPBF due to its low boiling point and high reactivity with oxygen. Considerably more fumes are generated during LPBF processing of magnesium alloys than with other alloys. These fumes can absorb or deflect the laser beam, resulting in an unstable process.

THE SOLUTION

NLR-MAMTeC analysed and improved the inert gas flow configuration so that the extraction of fumes was made more effective. This improvement was found to be an important step in making LPBF processing of magnesium possible.

WHAT WE DID

An efficient optimisation approach was applied for selecting the process parameters. Benchmark parts were produced for evaluating design rules for printing magnesium parts. Demonstrator parts were successfully produced based on a representative lightweight component for a vertical lift application. A fine homogeneous microstructure was found at the melt-pool and grain scale.

Fast Contactless Multidomain Non-Destructive Inspection

Currently, not a single NDI technique is able to find all defects considered inside of a part. By combining multiple NDI techniques into a single platform, defects are better found and classified. By using non-contact techniques with a large Field Of View (FOV) scanning can be done rapidly. The NDI techniques provide a data set that enables, a complete digital twin of the inspected part.

THE CHALLENGE

The challenge for most hardware maintainers is that data from inspection can be quite fragmented and not easy to find. For example: The technical status of rotor blades are not easy to be found inside current systems. By using non-contact NDI methods this data can be extracted from the part itself. The NDI methods must be able to capture the geometry of the part, defects and be able to identify and locate previous repairs.

THE SOLUTION

The solution consist of scanning rotor blades with multiple NDI techniques. First, the external geometry of the part is captured using photogrammetry and 3D structural light scanning. This enables the detection of geometrical defects like dents, holes and scratches. Additionally, the surface mesh is used as a template to map the NDI inspections on. Thermography and Shearography can locate defects and repairs in the subsurface of the part.

WHAT WE DID

Royal NLR has developed a method to combine multiple NDI data streams on top of a single surface mesh. This allows for easy comparison of defects in different NDI data, leading to better defect classification. Additionally, since the data is stored on top of the 3d surface mesh, a complete digital representation of the part is achieved. This allows the user to go back to every scan interval looking for changes inside of the product during in-service. Additionally, this can also be used to view the results using augmented reality.

Industry NL: DCMC, Defence NL
Research organisation: Royal NLR

Industry (NL) : ArianeGroup
Research organisations: NLR, DNW, ONERA
Period: 2014-2020

Artist impression : SkywalkerPL

ARIANE 6

Europe's development of the sixth generation launcher

THE CHALLENGE

The overall objective of the development of the Ariane 6 launcher is to create a reliable, flexible and competitive European launch system. Flexibility comes in the form of a launch configuration adjustable for smaller or larger payload or lower or higher delivery orbits. The competitiveness comes from the fact that Ariane 6, compared to Ariane 5, can be launched more often per year and cheaper.

WHAT WE DID

In the entire development of the Ariane 6 launcher, NLR plays various roles. Most effort of NLR up to now has been devoted to providing ArianeGroup with wind tunnel models for various stages in the development:

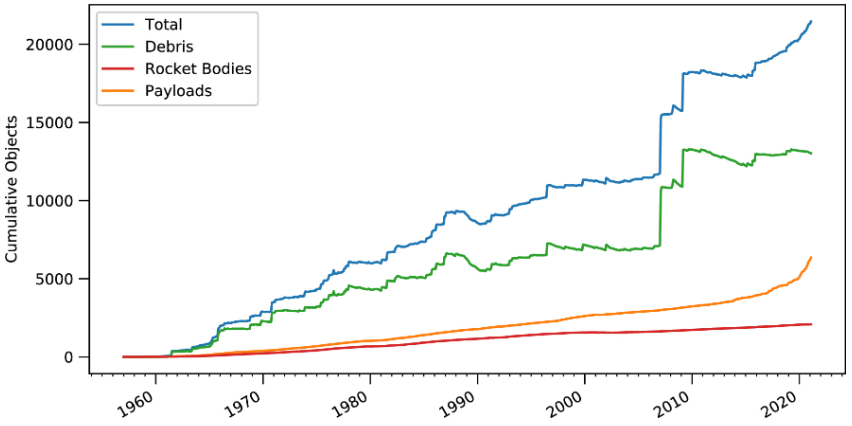
- Aerodynamic characteristics of basic lay-out
- Buffeting and acoustic characteristics of detailed aerodynamic shape
- Aerodynamic characteristics of detailed aerodynamic shape

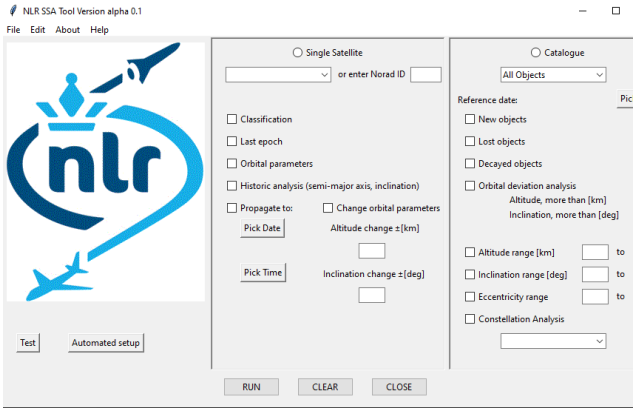
THE SOLUTION

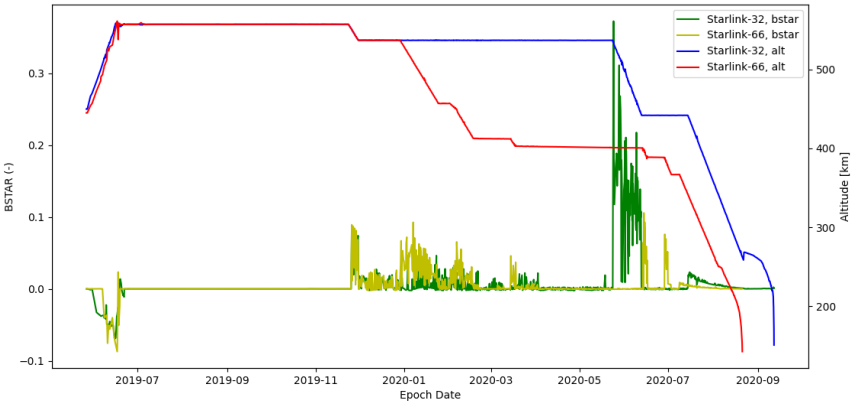
Results from wind tunnel tests performed on the models provided by NLR have delivered the design teams of ArianeGroup valuable data to be able to advance the design. This contributes to realizing the goals of the Ariane 6 project: a reliable, flexible and competitive launcher.

NLR has used its expertise to equip the three models with a significant amount of sensors, be it static or reference dynamic pressure sensors. The available space in the models was minimal which forced the design and instrumentation of the models to be optimized. Modularity of instrumented boosters added complexity but surely also functionality for ArianeGroup.

Project partners
Dutch Ministry of Defense - Space Contour 2019, NLR
Period: 2019-2024







Space Situational Awareness for safe and sustainable use of space

Currently, approximately 27,000 objects are being tracked to allow predictions to avoid collisions between satellites and debris. Forecasts indicate this number will increase exponentially over the next few years. To ensure a safe and sustainable space environment, it is vital to understand the orbital mechanics and growth in space usage and orbit selections to facilitate continued operations. In this way, by performing characterisations and trend analyses, it is possible to continue space exploration and utilise space as a nation.

THE CHALLENGE

To get an overview of the space objects orbiting the Earth and their characteristics and behaviour, the following questions need to be answered:

1. Which sources of data are available for this overview?
2. What kind of data is available in these sources?
3. What kind of characteristics can be deduced from this data?
4. Is it possible to identify capabilities?
5. Is there a trend analysis possible to obtain more insight?

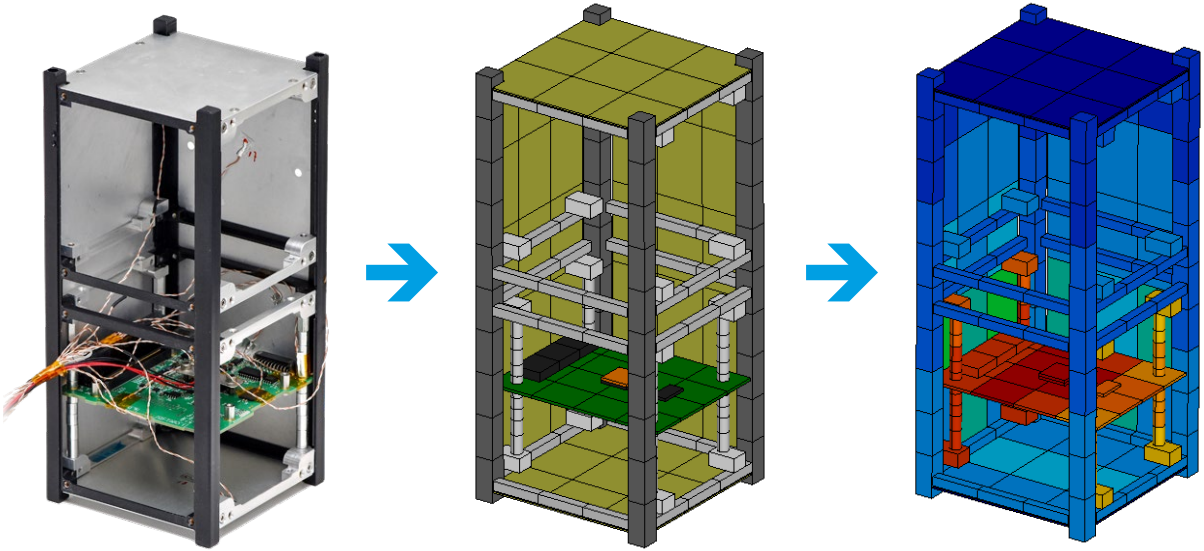
WHAT WE DID

To address these questions, NLR is developing a Space Situational Awareness (SSA) tool. This tool is set up in such a way that databases and other sources of information can be combined and verified. With this data, details concerning the space objects such as last observation and number of new or decayed objects will be available. With this tool, a user is able to specify the required information and monitor specific space objects either on request or scheduled. This allows a more detailed insight in satellite (recurring) activities and influences on the orbital tracks, which could have an operational impact. This information can be included in future Space Traffic Management developments as well, with SSA being an essential enabler.

THE SOLUTION

By combining databases and reviewing the available information, it is possible to gather the required parameters to be able to perform the analysis. Furthermore, the gained insight can be used to look into space objects behavior such as orbit corrections and functional applications. By adding various data sources, a verification can also be performed. This will help in obtaining a better understanding of the situation and the potential threats to Dutch space assets and possible mitigation actions available.

Project partners: ISIS
Research organisation: Royal NLR
Period: 2019 - present



CubeSat Thermal Modelling

Applying ESATAN-TMS for the CubeSat industry

THE CHALLENGE

With the increase in power density, thermal control measures are needed for CubeSats. This requires low-cost hardware and software solutions, which are currently hardly available. Miniaturisation and application of thermal control systems is being worked on, however evaluating design iterations is hindered by the lack of thermal analysis imposing large uncertainties in the thermal design of CubeSats. ISIS - Innovative Solutions in Space and Royal NLR have worked together on an innovative modular approach for CubeSat thermal analyses in ESATAN-TMS. Key of this approach is the interchangeability and scalability of validated thermal submodels allowing for fast and more accurate analysis for LEO missions.

THE SOLUTION

A library of validated thermal sub-models will be created in ESATAN-TMS, allowing for fast and accurate orbital analysis, which results in improved thermal designs of CubeSats. CubeSat manufacturers and integrators can use the thermally verified submodels in ESATAN-TMS and decrease their development time of the design of a CubeSat by implementing the thermal modelling in an early stage of the design cycle.

WHAT WE DID

NLR's expertise with ESATAN-TMS is applied in this project to set up a modular approach of thermal modelling of CubeSats. Thermally relevant submodels are built for commercially available subblocks, like the ISIS TXS-module, and general building blocks of a CubeSat frame. This is built in such a way, that it can be easily adapted and assembled into an entire CubeSat system. The correct modelling of interfaces between sub-models is herein critical for the thermal maturity of the model. Hence a lot of attention is given to this minor detail in the assembly. In the next stage of the project, the thermal submodules were correlated with the results of thermal vacuum tests. This correlation will ultimately result in a verified thermal model of the submodules.

Flex-XR

Taking AR and VR to the moon

ESA and DLR are developing an analogue lunar facility to train astronauts for future lunar missions. Part of the facility is a simulated lunar base (FLEXHab) in which scientific experiments can be conducted. Utilisation of such a facility is expensive and the cost could be lower by reducing time spent in de FLEXHab, especially during the familiarisation phase and experiment preparation and design.

THE CHALLENGE

NLR developed a user-centered VR-concept that supports users to get familiar with the environment, design and review their experiment set-up before ever physically entering the facility. This saves time and money during the development phase of the experiment. For such an application to be useful several functionalities, like a database instrument model and their interaction with the environment, needed to be developed.

WHAT WE DID

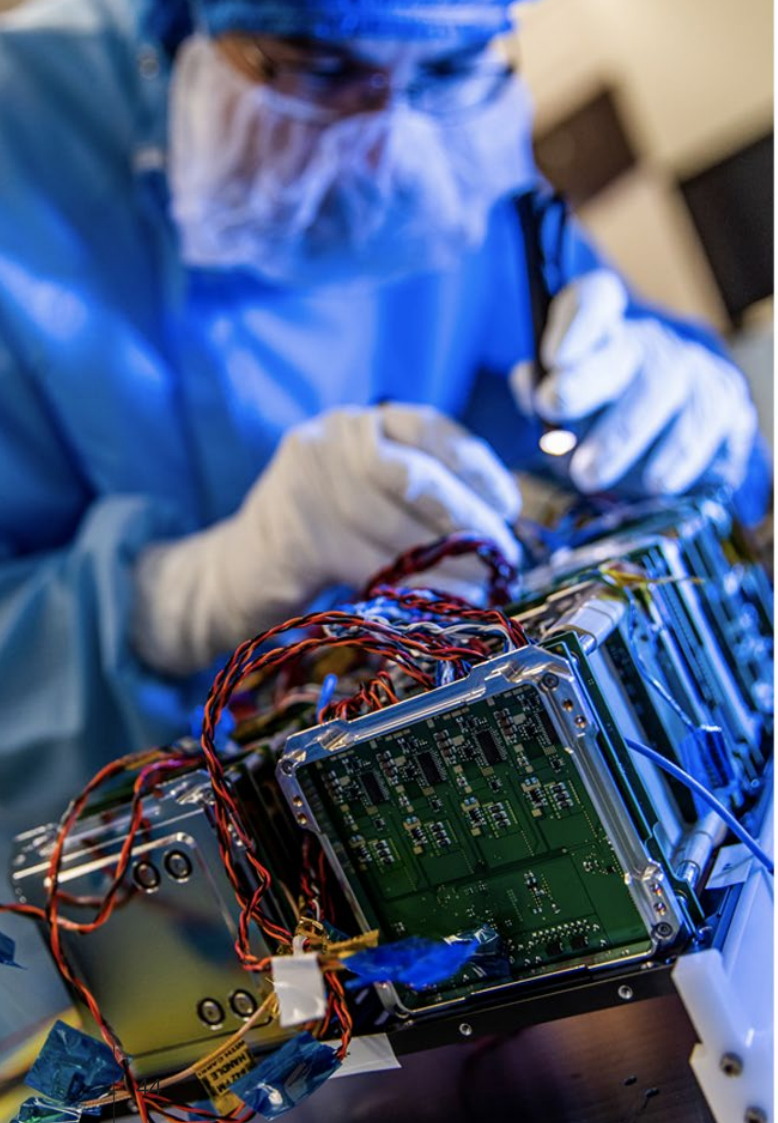
NLR developed a VR application that can recommend instrumentation based on the specific research domain that users are designing an experiment for. Moreover, it assists users to configure their experiment set-up as well as verify and validate constraints and assumptions concerning their experiment design. The application is promising to be a useful tool. User tests are now required to validate whether the developed VR application indeed results in more efficient experiment designs. The next steps would include complementing digital twin with AR technology, to seamlessly merge the virtual and real environments, enhancing collaboration between users and ground segment personnel in the actual FLEXHab and eventually soon on the moon.

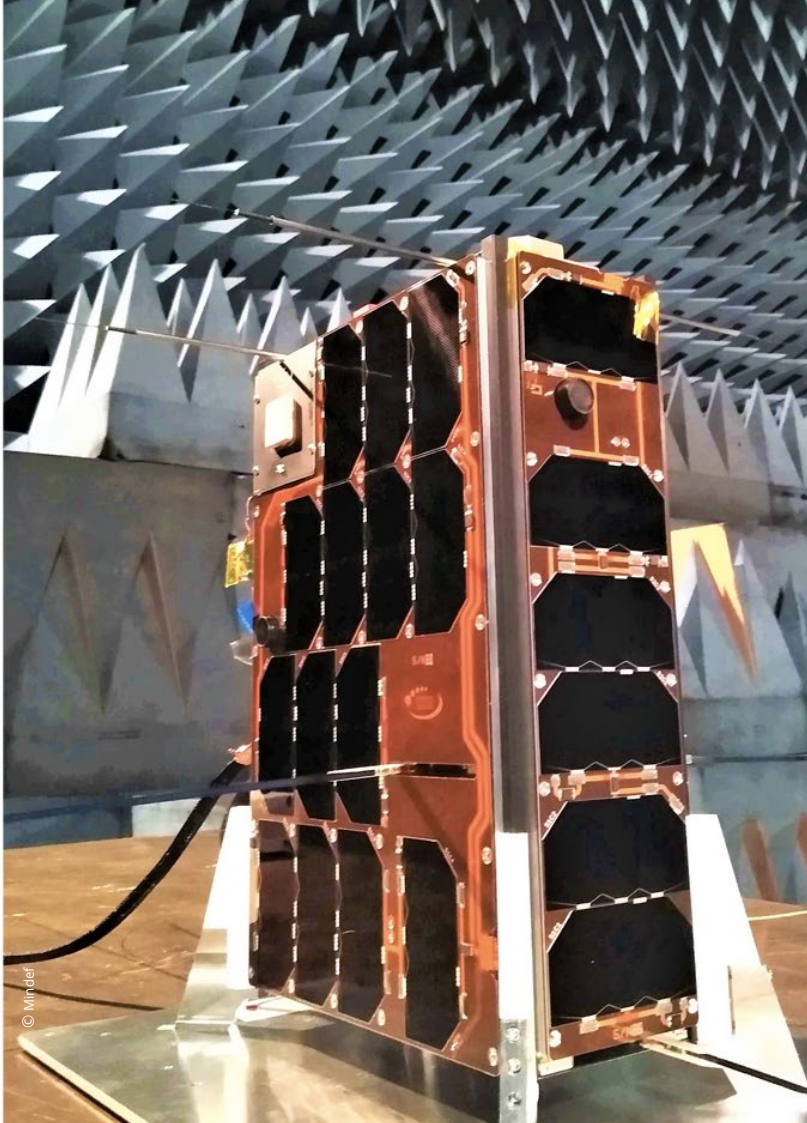
THE SOLUTION

A digital twin to:

- Enter and explore the FLEXHab environment
- Select a research domain for which they would like to design an experiment and configure instrumentation
- Access a catalogue with recommended instruments based on the selected research domain
- Place and configure the instrumentation in the FLEXHab and FLEXracks
- Work collaboratively in the virtual environment. Users do not have to be in the same physical location to cooperate

Project Partners: ESA, DLR & Royal NLR
Period: 2021

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BRIK II, the first Dutch military satellite

The first Dutch military satellite was successfully launched in June 2021. The BRIK II nanosatellite is an experimental project of the Royal Netherlands Air Force. On 30 June, the Virgin Orbit company launched the "LauncherOne" rocket, with BRIK II as one of its payloads from Mojave in the United States.

The launch is a first test for Defence to demonstrate the potential of nanosatellites for military and civil use. The Dutch Defence Vision 2035 states that space has become a necessary link for information-driven action by the armed forces. Defence is highly dependent on satellites. For example, consider the use of navigation and communication systems. In order to keep the development scalable and affordable, Defence works together with Dutch industry and knowledge institutes. BRIK II emerged from this.

COOPERATION

The construction of BRIK-II underlines the innovative abilities the Dutch industry and knowledge institutes are capable of in developing relevant military and/or dual use capacities. Innovative Solutions in Space (ISISPACE) located in Delft is the designer and integrator of the nanosatellite. Royal NLR has developed new technologies that will be put into practice on the BRIK-II: with a miniaturized payload, in the field of signal intelligence, the satellite can detect radio signals from space and locate the location of the source on the earth's surface. Furthermore there is a collaboration with the Delft University of Technology (TU Delft) and an international collaboration with the University of Oslo.

The name of the satellite is a reference to the first aircraft for the Aviation Department in Soesterberg. This aircraft from 1913 was called 'De Brik' and was used by the Dutch armed forces to discover the aviation domain.

ISR: Lead by Information with Innovation

Superior information position calls for the right information in the right place at the right time. Increasing complexity and hybrid nature of current conflicts call upon a proper intel position within the military context. Data is gathered from a variety of sources and contains varying types of information. These different types of data are fused in order to increase the situational awareness.

THE CHALLENGE

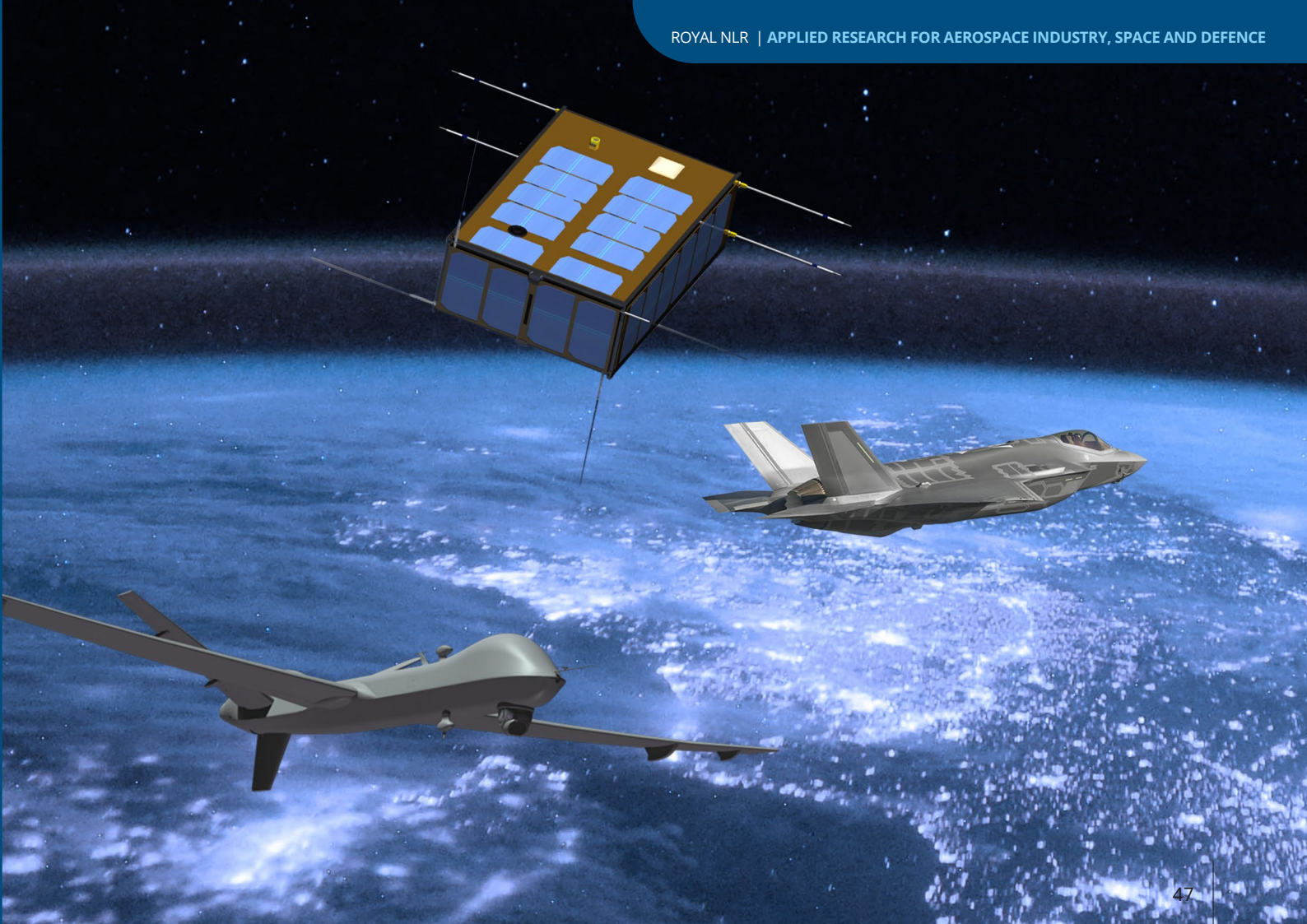
- Right information in the right place at the right time to support the right decision making of commanders and operational units in the field in order to generate the right military effects
- Looping through the Observe-Oriënt-Decide-Act OODA cycle faster than the adversary in order to achieve and maintain a lead with respect to the adversary

WHAT WE DO

- NLR is a one-stop-shop for end-to-end complete chain-based ISR solutions by means of innovative sensor, processing, analytics and presentation techniques
- NLR supports, analyses and advises for ISR procurement, exercises and operations for the continuous improvement of Information Governed Operations (IGO)

OUR CAPABILITIES

- NLRs capabilities comprise of
- Innovative sensors for Air- & Spaceborne platforms for i.e. geolocation & identification
- Federated Processing Exploitation and Dissemination (FPED) processes
- ISR information analytics by Artificial Intelligence and Big Data techniques
- Effective decision support for operators
- Presentation of ISR information for operators using Virtual and Augmented Reality
- Protection against cyberattacks
- Support Information Governed Operations by Concept Development & Experimentation
- Provide tactical and operational support for Information Governed Operations
- Provide products and services to enhance Situational Awareness and Understanding
- Enhance Processing Exploitation & Dissemination cycle
- Expertise in reconnaissance pods
- Real-time Access to Airborne ISR (RAAISR)
- Apache Data Video Intelligence SystEm (ADVISE)



Research infrastructure

NLR's research infrastructure exists of a wide variety of facilities and equipment which constitutes the backbone for NLR's applied research. The research infrastructure is accessible to other research institutes, companies, universities and agencies.


MEMMERT
EUROCARBON

Automated composites manufacturing

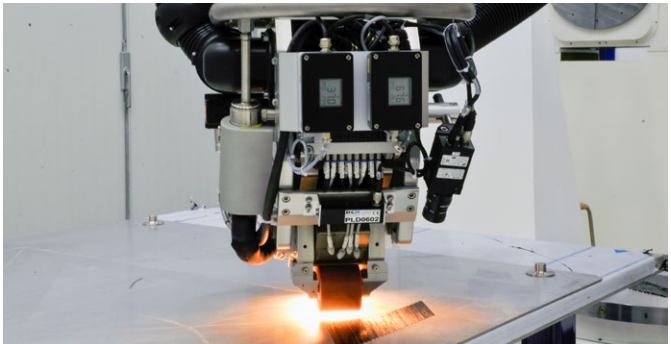
The Automated Composite Manufacturing Technology Centre (ACM-TC) and the Automated Composite Manufacturing Pilot Plant (ACM-PP) were established at NLR in the Netherlands to prepare the way towards automated manufacturing of advanced composite structures, largely in support of the 'composites' industry, but also of enterprises, which are new to this material. The centre brings together the complementary research capabilities of research centres, universities and specialised small enterprises and industries. ACM-TC operates at Technology Readiness levels TRL 3 - TRL 6 where the ACM-PP operates at TRL 6 - TRL 8.
The vision of the ACM is 'to pioneer innovative fabrication technologies for composites with potential for automation' and thereby 'to enhance the competitiveness of its members', by conducting applied research and carry out development programmes up to the level of full scale prototypes.

OUR CAPABILITIES

- Design concepts in composite
- Detailed finite element calculations for composite designs
- Trade studies to evaluate different design concepts
- Cost modelling
- A second opinion on composite designs
- Composite manufacturing
- Full scale prototyping
- Mould design and manufacturing
- Automated Fibre Placement
- Resin Transfer Moulding
- Vacuum assisted Resin transfer moulding
- Automated Composite Manufacturing (e.g. Pick & Place)
- Press forming
- Braiding
- Induction welding

WHAT WE DELIVER

Extensive experience with, and knowledge of, Polymer Based Composite Materials, manufacturing processes, the mechanical behaviour of composite materials and the structural response of composite structures. We perform activities for the 'High Tech-High Spec' community like aerospace, automotive, maritime, rail, transport and medical.



NLR Metal Additive Manufacturing Centre: MAMTeC

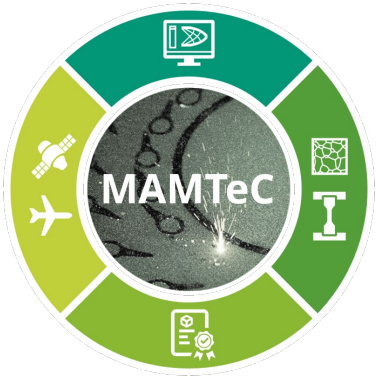
MAMTeC is the Metal Additive Manufacturing Technology Centre in the Netherlands. More than 45 years of materials experience in aerospace applications is applied to define optimised process parameters and post-processing methods. We support development processes up to the certification qualification of the metal–AM products. The development of Metal-AM materials and components is supported by making use of advanced inspections, analysis techniques and testing facilities.

TECHNOLOGIES AND MATERIALS

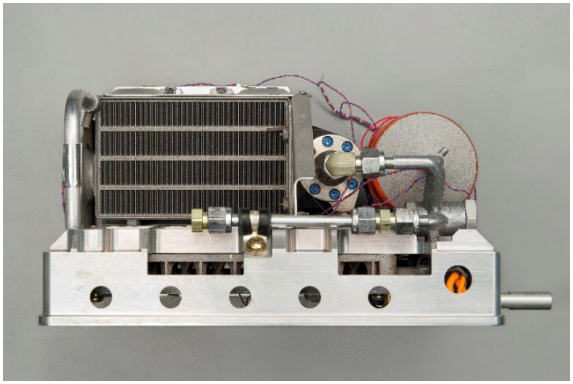
- Laser Powder Bed Fusion
- Blown Powder Directed Energy Deposition (manufacturing & repairs)
- Sinter-based Fused Filament Fabrication
- High Performance Alloys (e.g. aluminium, titanium, nickel based super alloys, magnesium)
- Multimaterial AM
- Materials laboratories and testing facilities

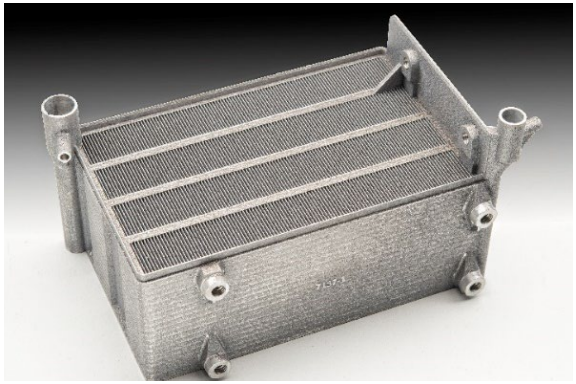
SPACE APPLICATIONS

NLR has developed and produced various heat-exchangers for space applications in cooperation with our thermal management experts. Complex internal geometries were realised for optimum performance, high efficiency and low weight. The combination of design optimisation capabilities, extensive AM material performance knowledge and qualification expertise enabled NLR to support with the development of structural and propulsion space applications.




TIMO





Hydrogen energy transition infrastructure
NLR research & test facilities (NL)

ENERGY SOURCE
- **Sunspace Solar park**
- High voltage grid connection

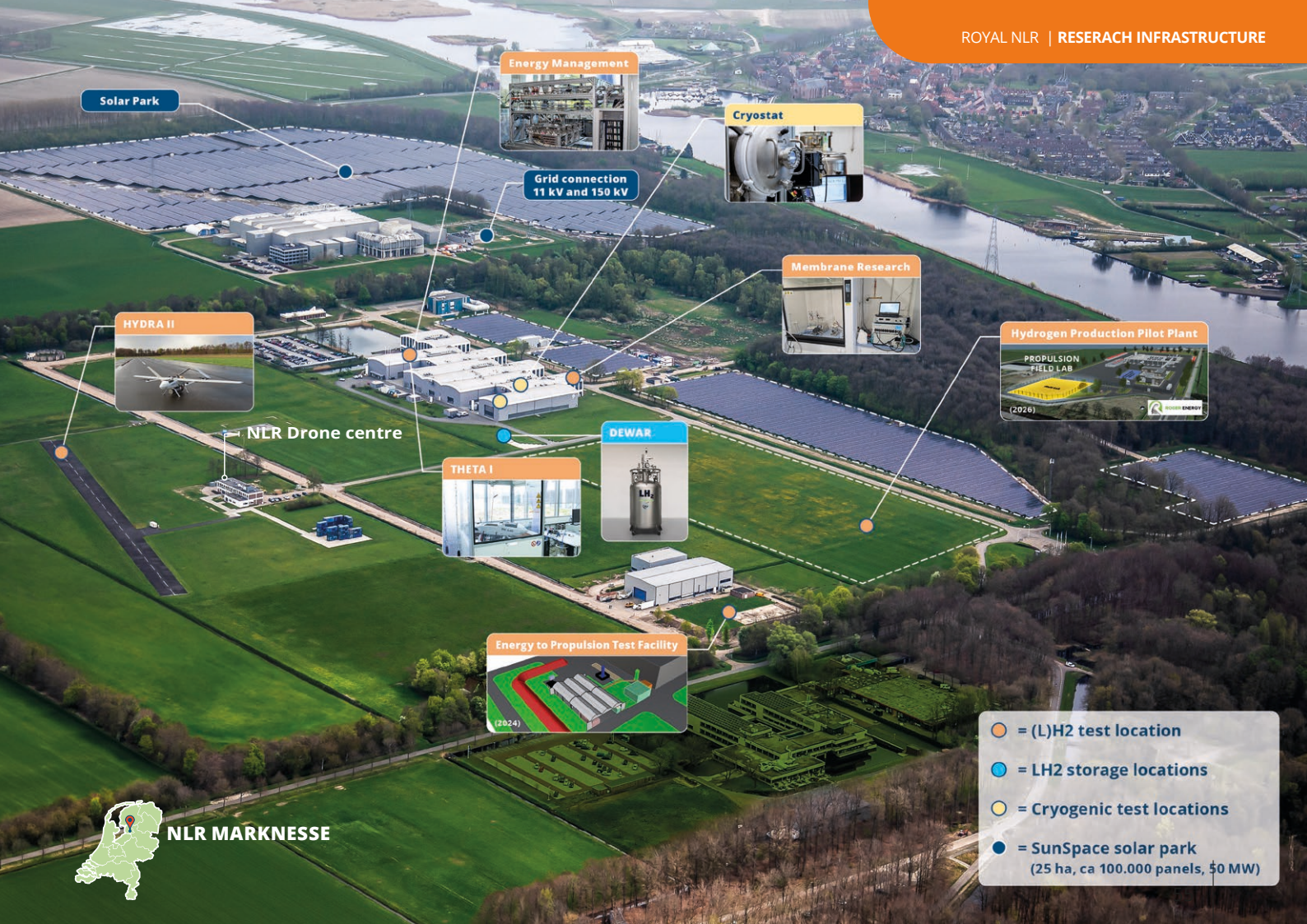
ENERGY CONVERSION E > H2
- **Hydrogen Production Pilot Plant** (a cooperation with Roger Energy), providing a local supply of (green) gaseous hydrogen, liquid hydrogen and methanol and high TRL validation capabilities.

H2 STORAGE AND (RE)FUELLING
- Commercial storage tank of 40m3 liquid hydrogen (at the Energy to Propulsion Test Facility)
- Co-designed/manufactured local LH2 storage ground vessel: **DEWAR**

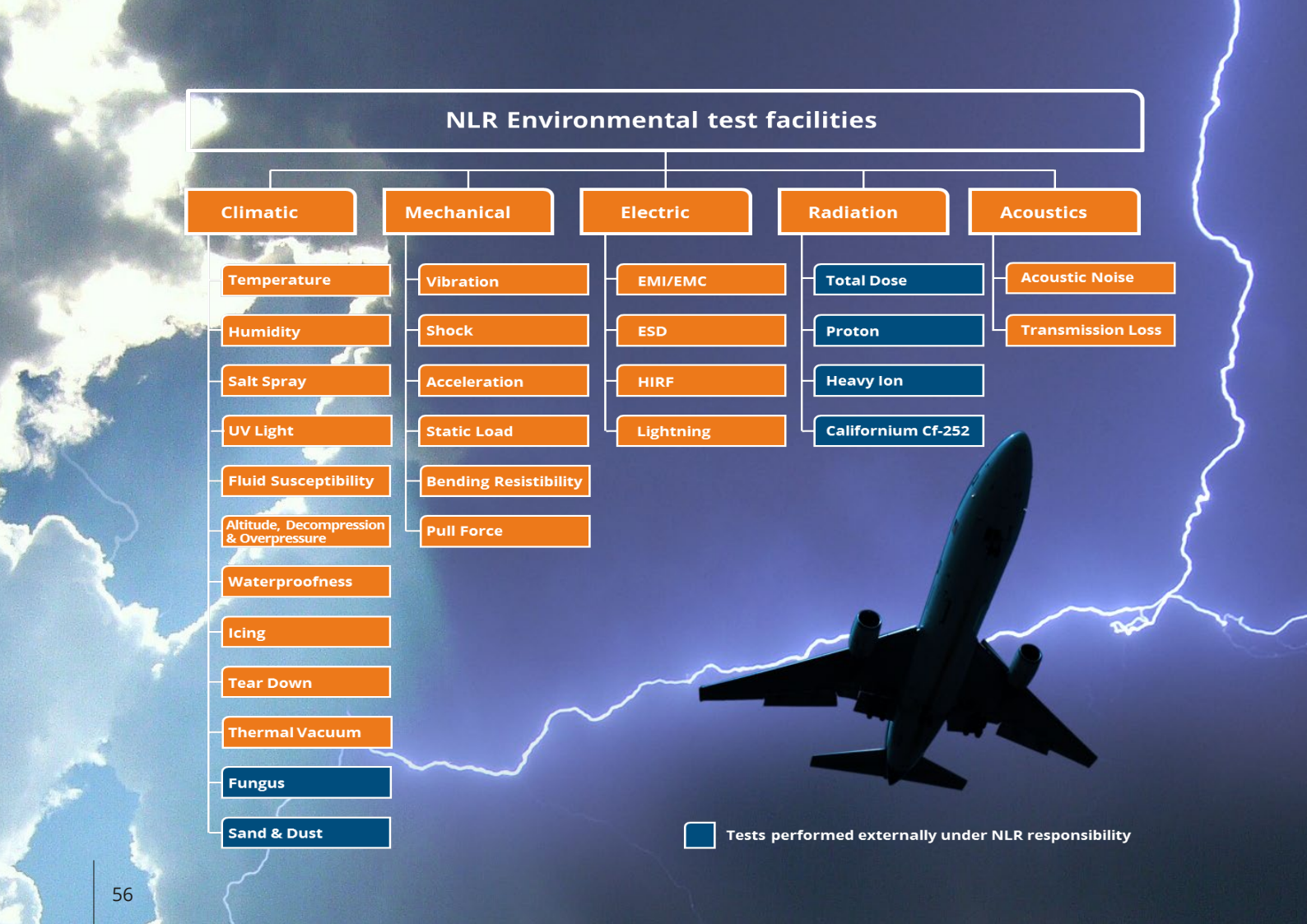
ON-BOARD FUEL TANK
- Design, manufacturing and testing of composite LH2 storage solutions for aircraft applications
- Deep cryogenic (20K) material and structures testing: **Cryostat**
- Co-designed/manufactured local LH2 storage flying tank (in the HYDRA II drone)

ENERGY CONVERSION H2 > E
- Advanced power electronics and wiring infrastructure
- Best of class thermal control and cooling solutions: E**nergy management**
- Membrane health monitoring and maintenance research: **Membrane Research**
- Fuel cell testing in controlled environment: **THETA I**

AIRCRAFT PROPULSION SYSTEM
- Dedicated airfield and airspace with facilities for operation and testing of GH2/LH2 powered drones: NLR Drone Centre and HYDRA II
- **Energy to Propulsion Test Facility** (EPTF)
  - Power train ground testing, currently up to 2MW
    - Electric, hydrogen-electric
    - Battery, gaseous/liquid hydrogen and e-methanol energy storage solutions
    - Functional component and full system performance testing
    - Ground testing and moving platform testing of full systems
  - Mechanical testing of liquid hydrogen tanks
    - In situ LH2
    - Dynamic loads
    - Slosh testing


Solar Park
Energy Management
Cryostat
Grid connection
11 kV and 150 kV
Membrane Research
HYDRA II
Hydrogen Production Pilot Plant
PROPULSION
FIELD LAB
(2026)
NLR Drone centre
DEWAR
THETA I
Energy to Propulsion Test Facility
(2024)
= (L)H2 test location
= LH2 storage locations
= Cryogenic test locations
= SunSpace solar park
(25 ha, ca 100.000 panels, 50 MW)
NLR MARKNESSE

NLR Environmental test facilities



- **Climatic**
  - Temperature
  - Humidity
  - Salt Spray
  - UV Light
  - Fluid Susceptibility
  - Altitude, Decompression & Overpressure
  - Waterproofness
  - Icing
  - Tear Down
  - Thermal Vacuum
  - Fungus
  - Sand & Dust
- **Mechanical**
  - Vibration
  - Shock
  - Acceleration
  - Static Load
  - Bending Resistibility
  - Pull Force
- **Electric**
  - EMI/EMC
  - ESD
  - HIRF
  - Lightning
- **Radiation**
  - Total Dose
  - Proton
  - Heavy Ion
  - Californium Cf-252
- **Acoustics**
  - Acoustic Noise
  - Transmission Loss

Tests performed externally under NLR responsibility

Environmental test facilities

With our wide range of test facilities we can simulate your environmental testing requirements for your spacecraft or aircraft equipment, meeting international, military, aircraft and commercial standards. Regardless of the environment that has to be simulated, NLR is the 'one stop shop' for all your testing needs.

We conduct environmental tests for climatic, thermal vacuum, mechanical, electric, radiation and acoustics properties using our specialised knowledge, experience and over 20 different facilities for environmental testing.

We can advise and support you throughout the entire testing process from establishing test requirements and test definition, to test set-up and execution. We can also assist you in validating your own models of your test subject.

ace2space

Zero-G Flight Testing Capability

THE CHALLENGE

- Test space equipment before launching it (free fall tower, sounding rocket, space station)
- Expose your application to in-flight zero- or low gravity conditions (e.g. moon or Mars)
- Save on your experiment cost by obtaining a favorable cost-per-parabola ratio
- To only perform a customer-required number of parabolic maneuvers. No implication to take more parabolic maneuvers and associated costs than really needed.
- Use of a low gravity flight test facility that is solely dedicated to your project, allowing for a customer oriented and confidential project environment
- To be able to return to base whenever your application is not properly functioning, thereby saving valuable flight test time

ace2space is the partnership between Royal NLR and Delft University of Technology for performing parabolic flights

HOW CAN WE SUPPORT YOU

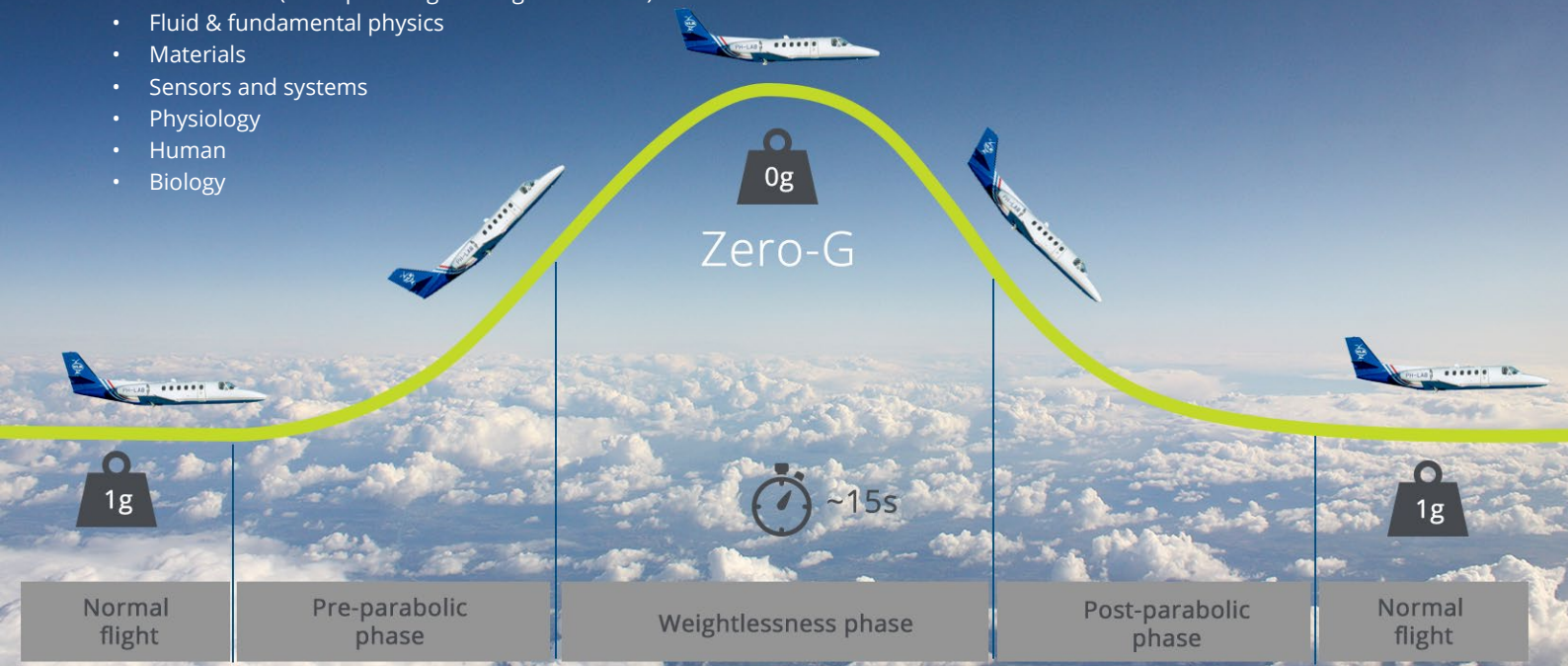
- A modified and instrumented Cessna Citation II research aircraft capable of performing zero or partial gravity flight maneuvers
- A relatively small aircraft which allows for favorable cost, yet provides enough cabin space for many low gravity applications
- Multiple certified cabin configurations are available which can host almost all required experiments
- Part 21 based design organization to support installation of your application onboard our aircraft
- A flexible and affordable flight test facility representing more than one century of experience

Flight operations that are dedicated to a single customer or project, which allows for:

- performing of only those parabolic maneuvers that are required by the customer > saving time and cost
- aborting a flight whenever your application requires so > saving flight time
- confidentiality and protection of intellectual property rights

Low / 0-g gravity flight testing in the field of (among other):

- Demonstrations, Training of Pilot Flying Skills and Instructions (Aerospace Engineering Curriculum)
- Fluid & fundamental physics
- Materials
- Sensors and systems
- Physiology
- Human
- Biology




NLR Marknesse
NLR Drone DigiCity
NLR Drone centre
Runway 320 M

NLR Drone centre

NLR set up the NLR Drone Centre in 2015. Here, tests and evaluations of (prototype) RPAS and sensor applications are conducted, demonstrations are facilitated, flight inspections are carried out and drone practical training and technical examinations are given.

The NLR Drone Centre has its own restricted airspace with the necessary authorisations and exemptions to facilitate these activities. It offers developers, manufacturers and business users, both civil and military, the opportunity to carry out test flights needed to take advantage of the economic opportunities offered by RPAS developments. The NLR Drone Centre is located at NLR's premises in Flevoland, and complies with all government requirements.

RESTRICTED AIRSPACE

Only aircraft and pilots who fulfil all the statutory requirements may fly in Dutch airspace. The NLR Drone Centre has more extensive dispensation: for example, it is permitted to fly prototypes that do not yet meet all the requirements. The airspace above the NLR Drone Centre is closed to other users, and the territory is also a restricted and closed area. Herewith fulfilling a significant need for drone development and the technology it requires, such as detect-and-avoid sensors that prevent drones from coming too close to other air traffic. In this way the centre supports the development and use of drones and integrating drones safely into civil airspace, and acts as a 'one-stop shop' for the drone sector. With its drone expertise, NLR builds on its integrated knowledge of the entire aerospace chain, using its extensive test and research facilities for this purpose.

Royal NLR in brief

One-stop-shop

Global player with Dutch roots

100+

Since 1919

Amsterdam, Marknesse
Rotterdam, Noordwijk, Brussel

Innovative, involved and practical

For industry and governmental

For civil and defence

800+
staff

€ 110 M turnover

74% Dutch, 23% EU
and 3% worldwide

Active in 26 countries

Extremely high customer satisfaction

About NLR

Royal Netherlands Aerospace Centre

NLR is a leading international research centre for aerospace. Its mission is to make air transport safer, more efficient, more effective and more sustainable. Bolstered by its multidisciplinary expertise and unrivalled research facilities, NLR provides innovative and comprehensive solutions to the complex challenges of the aerospace sector.

NLR's activities span the full spectrum of Research, Development, Testing & Evaluation (RDT & E). Given NLR's specialist knowledge and state-of-the-art facilities, companies turn to NLR for validation, verification, qualification, simulation and evaluation. They also turn to NLR because of its deep engagement with the challenges facing our clients. In this way, NLR bridges the gap between research and practical applications, while working for both government and industry at home and abroad.

Royal NLR stands for practical and innovative solutions, technical expertise and a long-term design vision, regarding their fixed wing aircraft, helicopter, drones and space exploration projects. This allows NLR’s cutting-edge technology to find its way also into successful aerospace programmes of OEMs like Airbus, Boeing and Embraer.

Royal NLR - Netherlands Aerospace Centre

The challenges in aviation are always greater than the possibilities of today. Only the continuous connection of an in-depth understanding of customer needs with leading knowledge and research facilities enables rapid innovation. NLR is the connecting link between science, industry and government. The innovative solutions and practical advice strengthen the competitiveness of the business community and contribute to solu-tions for social issues. NLR works in an objective manner, for and with the (inter) national business commu-nity and government agencies.

NLR AREAS OF RESEARCH, CAPABILITIES AND RESEARCH INFRASTRUCTURE

- Scaled flights tests
- The use of alternative propulsion methods
- Multi-modal Supply Chain optimisation
- Requirements & specifications
- Concept development
- Prototyping & manufacturing
- Design & analysis
- Test & verification
- Qualification & certification
- MRO optimisation

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