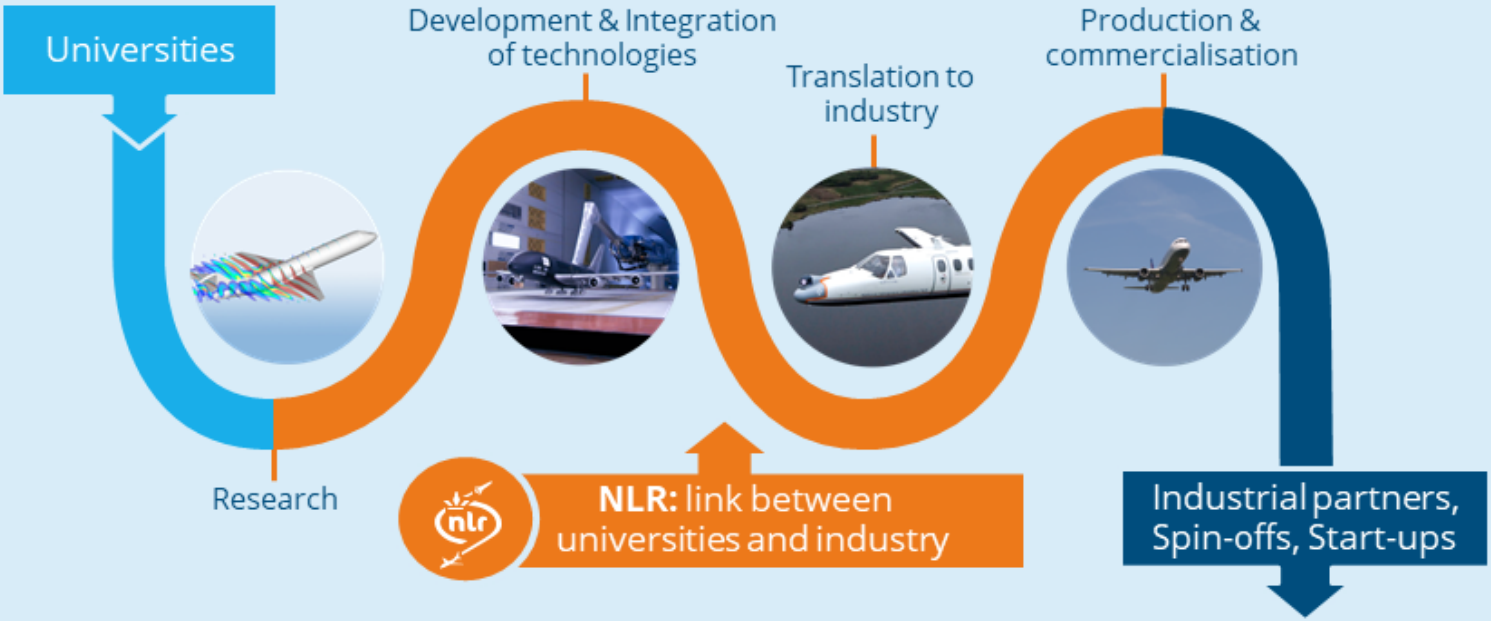
Dedicated to innovation in aerospace

Knowledge powers the future

Royal NLR - Netherlands Aerospace Centre


Universities
Research
Development & Integration of technologies
Translation to industry
Production & commercialisation
NLR: link between universities and industry
Industrial partners, Spin-offs, Start-ups

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 innovating. 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 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 AREAS OF RESEARCH, CAPABILITIES AND RESEARCH INFRASTRUCTURE

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

Aerospace industry

Climate-neutral aviation
Development of air and space vehicles
Operational availability
Unmanned and autonomous

Scaled Flight Demonstrator (SFD)

Scaled test aircraft preparation and qualifications

The SFD is the large scale demonstrator of the European Cleans SKy 2 reearch 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 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 planned for mid-2022. 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.

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

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

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 standard 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:

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

THE SOLUTION

As part of the MFFD development, the STUNNING project will develop, manufacture and deliver 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 will apply advanced design principles, innovative system architecture and advanced materials and processes. Addressed topic are:

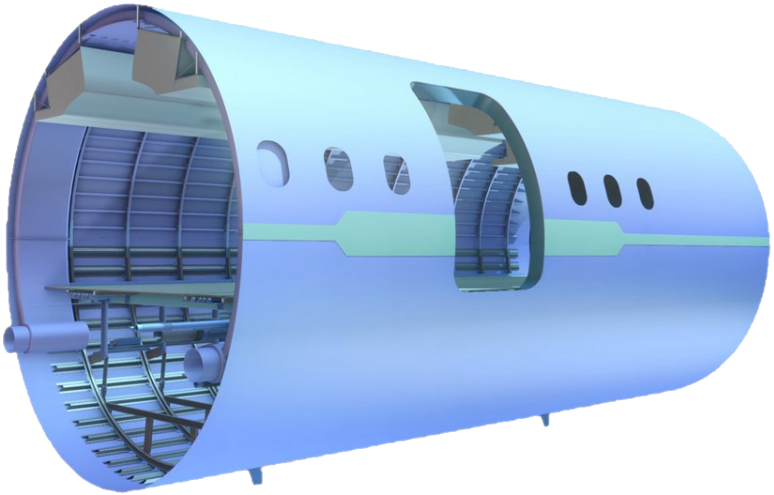
- A 180° full scale multi-functional and integrated TP fuselage shell
- The potential of TP material and its associated manufacturing processes including welding
- The integration of multiple system functionalities
- Industrial Readiness taking in account the requested HRP of 60-100 shipsets per month
- Advanced simulation capabilities

WHAT DID WE DO

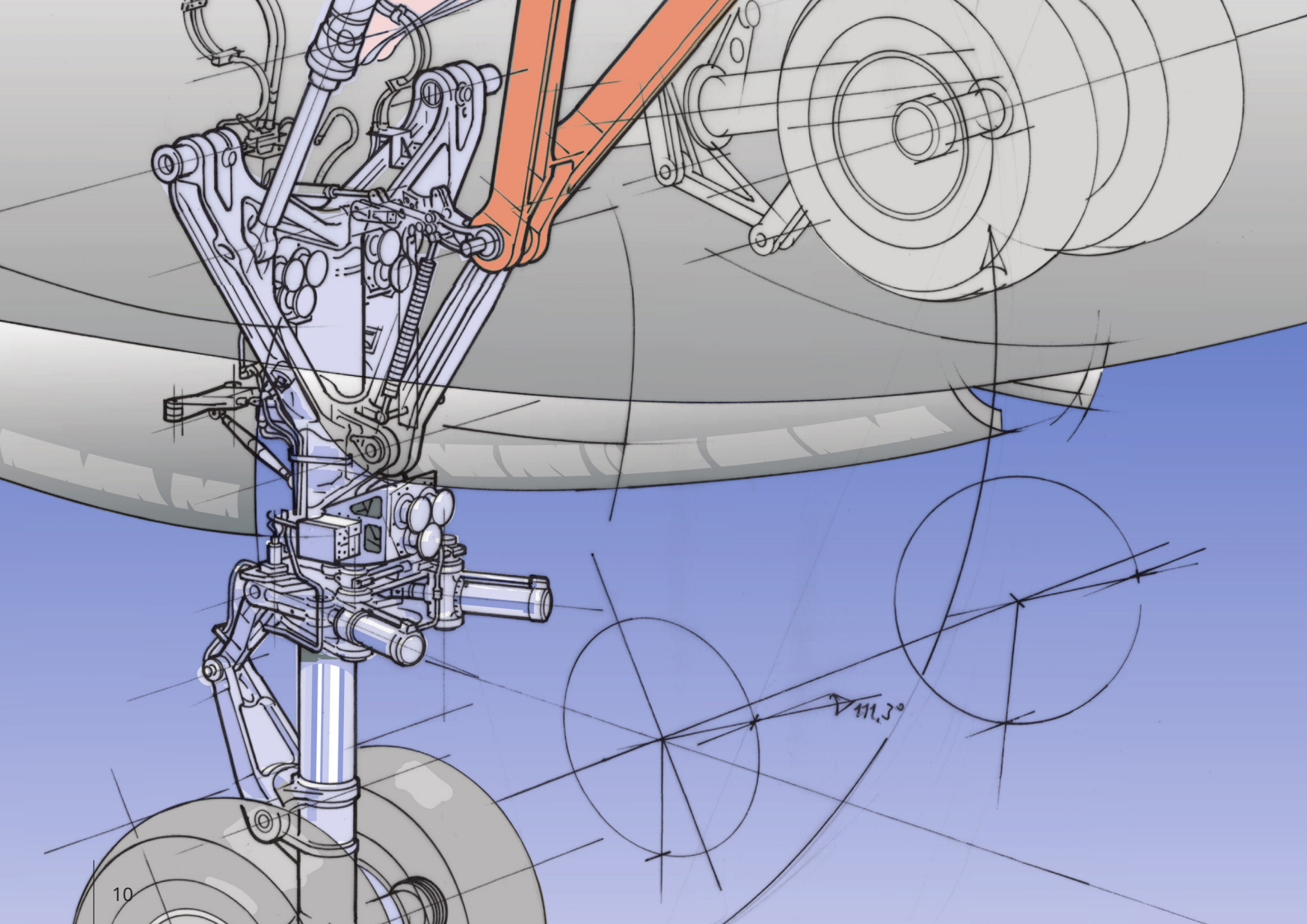
NLR developed and applied a competitive manufacturing process using fast AFP layup of two 90° fuselage segments out of thermoplastic TC1225 PAEK/T700 uni-directional carbon fibre material on a layup tool at room temperature. The part was consolidated by the NLR team in an innovative consolidation mould (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 TRL6.

STUNNING IS PART OF THE MULTIFUNCTIONAL FUSELAGE DEMONSTRATOR PROGRAMME HEADED BY AIRBUS



Project partners:
Industry (NL) : Fokker Aerostructures
Industry (EU) : Diehl
Research organisations : NLR
Universities : TUDelft, SAM|XL
Start : September 2017
Duration : 6 years


111,3°

Development of composite drag stay for Airbus A350-1000

Within the CS2 Systems ITD a CFRP drag stay for the A350-1000 has been developed in the Core-Partner project HECOLAG. The goals for the CFRP structure are a weight saving of over 40% at recurring cost similar to the current aluminium drag stay as manufactured by Liebherr-Aerospace. The CFRP drag stay is designed by Fokker Landing Gear (part of GKN Aerospace) in cooperation with NLR, to requirements set by Liebherr Aerospace.

Within the project NLR has focused on automated manufacture of preforms for these types of complex geometries. The present design is optimized for automated preform manufacturing and offers a weight saving of approximately 40%. The tooling for prototype manufacturing is designed and built by Compose Tooling. Functional prototypes are being manufactured by NLR and was tested in 2019 by Fokker Landing Gear.

Project partners
Customer: Liebherr Aerospace
Partners R&D and testing: NLR, Fokker Landing Gear, Compose

Horizon 2020
European Union Funding
for Research & Innovation

Project partners
Royal NLR (coordinator), DLR, VZLU, CIMNE, Fokker Aero-structures, EVEKTOR, Fokker Elmo, IMST, INVENT, TRACKWISE, L-UP

Start: June 2017
Duration: November 2020

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.

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.

WHAT DID WE DO

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.

ACASIAS

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:

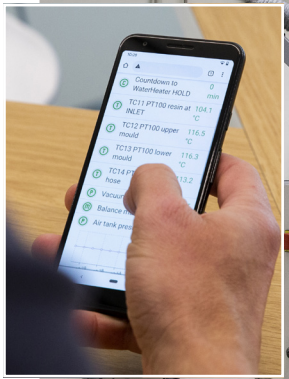
- Design and optimise the production facilities and manufacturing processes
- Optimise maintenance
- Digital threads, digital product passports, and managing data on behalf of certification

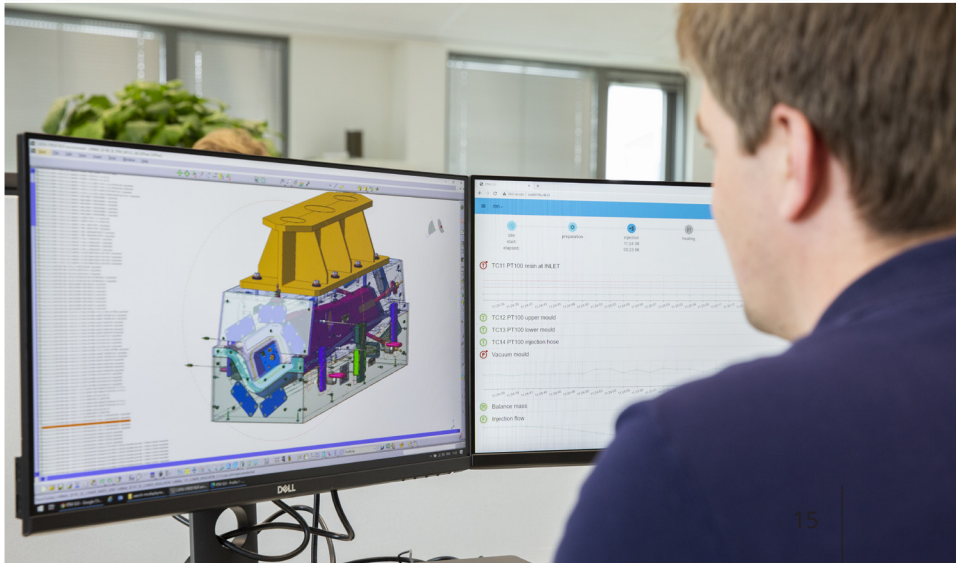
THE SOLUTION

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 DID WE DO

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.





TOPMOST:

Two-phase cooling for aircraft power electronics

THE CHALLENGE

Modern aircraft rely on growing numbers of electronic components, which in turn are increasingly high-powered and compact. Conventional cooling methods have become too large and heavy and have thus become a bottle-neck in aerospace systems. For this reason, a two-phase Mechanically pumped fluid loop is being developed, in which a fluid is circulated which evaporates to absorb the waste heat of the electronics components. This cooling technique, initially developed for space applications, allows for a drastic reduction of thermal constraints, weight and dimensions of high-power electronics modules.

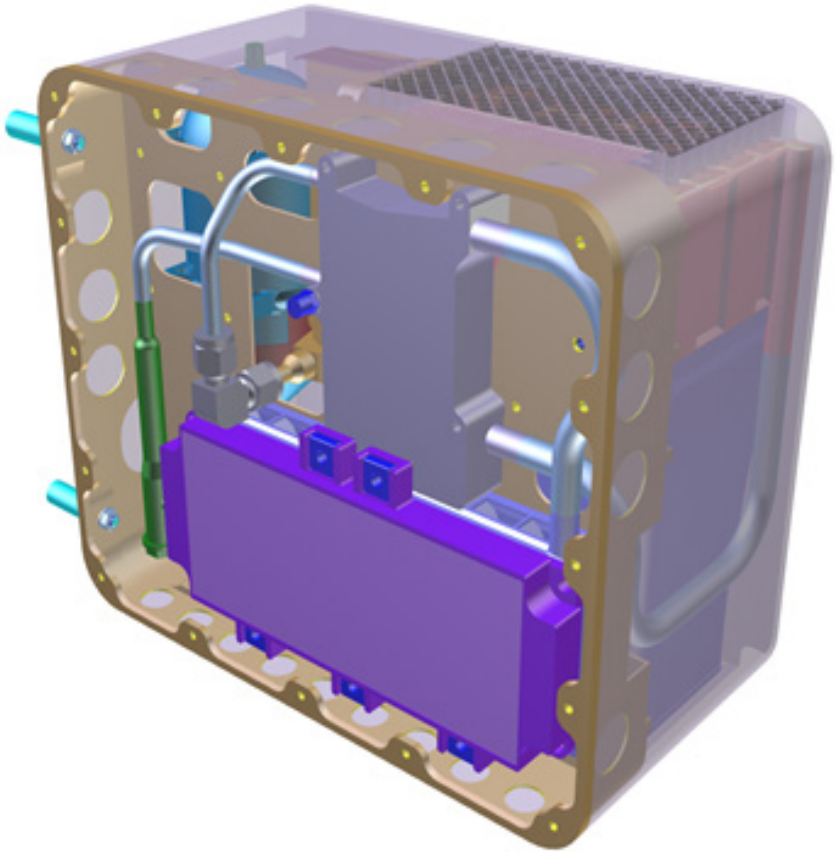
WHAT DID WE DO

Additive manufacturing of three demonstrators of a two-phase pumped cooling system. The demonstrators have a mass of 2.5 kg, and are able to cool a power module that generates 2400W of waste heat. The demonstrators have passed thermal and environmental tests (e.g. vibration and salt spray tests) and have a Technology Readiness Level (TRL) of 5.

THE SOLUTION

The TOPMOST project will deliver a necessary building block for the More Electric Aircraft (MEA) concept that allows for densification and growth of on-board power without overweight or thermal issues.

TOPMOST is a EU funded project. This message doesn't necessarily reflect the views of the EU.



Project partners

Industry (EU)	: Thales Avionics Electrical Systems SAS
Research organisations	: NLR
Start	: February 2017
Duration	: 2 years

Detect And Avoid system ADACORSA

To enable safe airspace integration of unmanned aircraft, a Detect And Avoid (DAA) system is required to evade other (manned) aircraft. One solution is to use a Cooperative Traffic Sensor based on transponder signals. Such a sensor is not yet available with a small form factor suitable for unmanned aircraft. Within the Airborne Data Collection on Resilient System Architectures (ADACORSA) project, such a sensor will be developed and tested in cooperation with the partners.

THE CHALLENGE

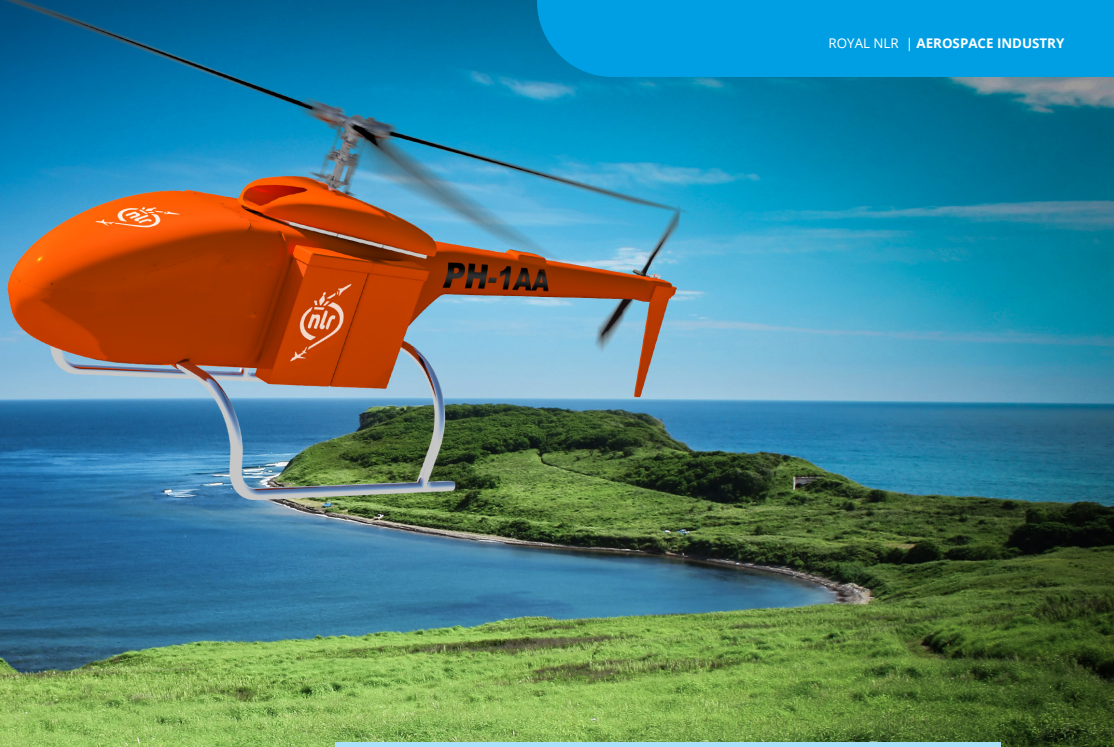
The main challenges of the project are

- The form factor and power requirements of current DAA systems are not suitable for small and mid-sized unmanned aircraft.
- Due to frequency saturation of the manned aircraft transponder frequencies, drones cannot be equipped with ADS-B transponders.
- Manned aircraft with both Mode-S and ADS-B transponders need to be detected.

Project partners
Industry: Anywi, Celestia Technology Group, Embraer, ESC Aerospace, ISEP, etc.
Research organisations: Royal NLR, TUDelft

WHAT DID WE DO

NLR develops a Direction Finder for the Cooperative Traffic Sensor (CTS) and integrates this with a Mode-S interrogator, developed by project partner Celestia Technology Group. The DAA system uses algorithms developed by NLR for semi-automatic avoidance of other aircraft. These algorithms feature both Remain Well Clear (RWC) and Collision Avoidance (CA) functionalities. The RWC functionality takes into account the rules-of-the-air to calculate a new route for the unmanned aircraft. The calculation is performed onboard to be independent of a data link and allows a fully autonomous system in the future. The DAA system will be integrated and flight tested in the DAA Flying Testbed at the NLR Drone Flight Test Centre. Finally, the developed system will be demonstrated in a logistic support use case.



THE SOLUTION

- Miniaturisation of the DAA system suitable to be integrated onboard of small and mid-sized unmanned aircraft
- Sensor suite advancement to include a direction finder to measure the azimuth such that the relative position to the intruders is known
- Information from ADS-B (manned intruder aircraft) will be used to further increase detection of current airspace users

Project partners
Research organisations: Royal NLR
Industry: Avy, CryoWorld
Universities: TUDelft/AeroDelft

HYDRA-2: Hydrogen Drone Research Aircraft

Hydrogen as a fuel is considered to be an important alternative for future sustainable aviation. When produced from green energy sources, hydrogen delivers zero CO_2 emissions – only water vapour. Hydrogen is a light-weight fuel with a 3-4 times higher energy density than kerosene. It can be stored in tanks both in gaseous and liquid form. It can be burned in conventional combustion engines, as well as transferred highly efficiently into electric power with fuel cells, as an alternative to batteries.

THE CHALLENGE

Although the use of hydrogen has been employed widely in other industries for many years, the introduction of hydrogen on board aircraft is a major technical challenge, not to mention the tremendous certification effort that's required. It has a significant impact on the aircraft architecture, powertrain components and operations, as well as on the ground infrastructure.

THE SOLUTION

Drones offer an ideal platform for testing hydrogen technologies safely on a smaller scale and at relatively low cost. Hydrogen also offers an extended flight duration and distances beyond what's possible with batteries. This is highly relevant for commercial applications like transporting medicines or cargo, or for first responders or surveying.

WHAT WE ARE DOING

In cooperation with Dutch industry and universities, NLR obtained first-hand experience in designing, selecting, testing and improving hydrogen components (both gaseous and liquid) suitable for drones, as well as extensive safety analysis and test procedures. The HYDRA projects support the standardisation and certification of hydrogen drones for commercial applications, while also preparing for upscaling for large manned aircraft. The first flight of the liquid hydrogen drone is expected to take place in mid 2022.

Liquid hydrogen composite tank for civil aviation

Hydrogen has been identified by the European Commission (EC) 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 source for civil aviation. This will lower the carbon footprint of air travel and increase and extend the flight range of aircraft fleet by reducing construction weight and cost..

R&D ACTIVITIES:

Material evaluation and testing for application at -253oC
- Thermoset and thermoplastic composites
- Thin ply technology
- Non-metallic Liners

Manufacturing and assembly technology development
- Fibre placement
- Induction welding

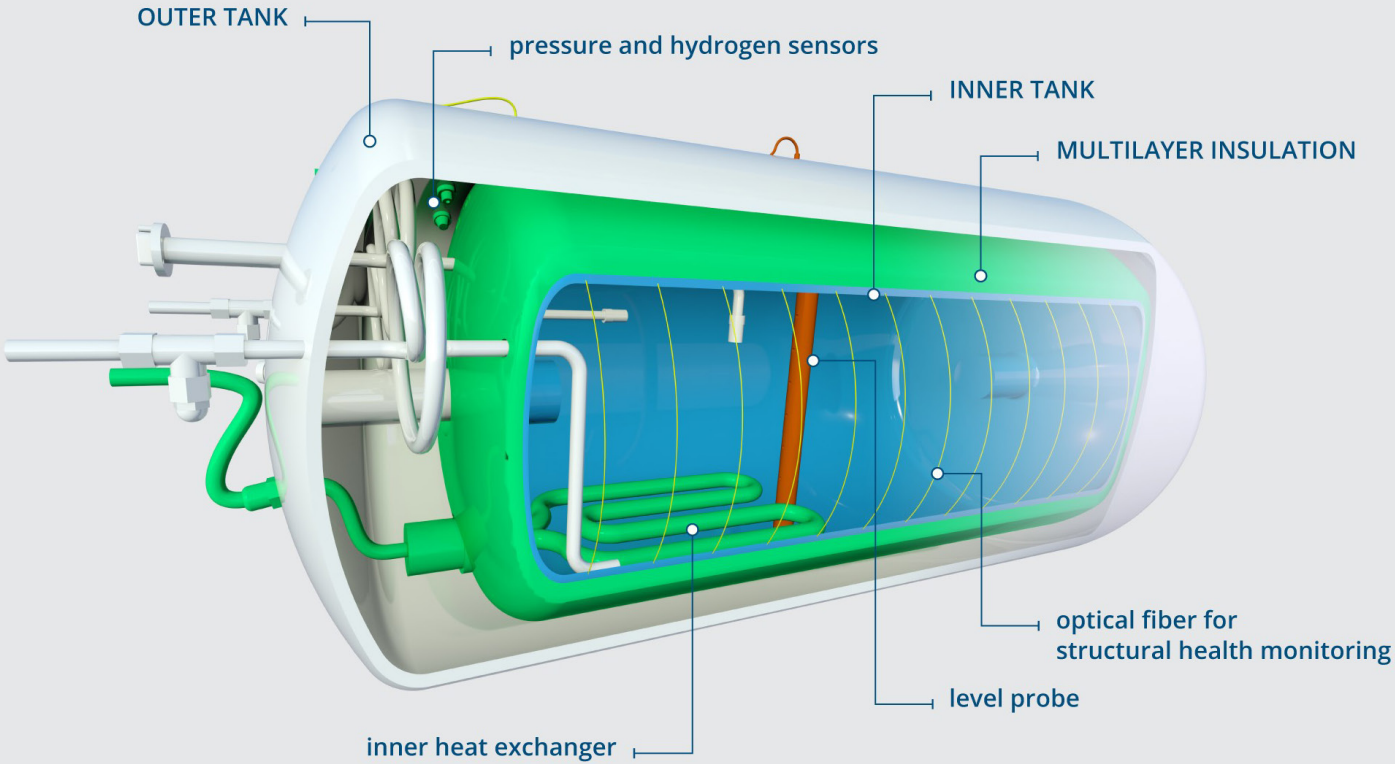
Prototoyping

PLANS AND AMBITIONS:

- Development of non-cylindrical load carrying LH2 tank concepts
- Investigations on LH2 systems integration and refuelling technologies

Project partners
Toray, NLR, ADSE, Airborne, Bold findings, Cryoworld, GKN Aerospace Fokker, IT'S Engineering, KVE Composite Structures, Photonfirst Technologies, SAM-XL, Somni, Taniq, TU Delft
Funding : Mobiliteitsfonds (NL)

LH2 Tank System



Luchtvaart in Transitie (LiT)

Aviation in Transition

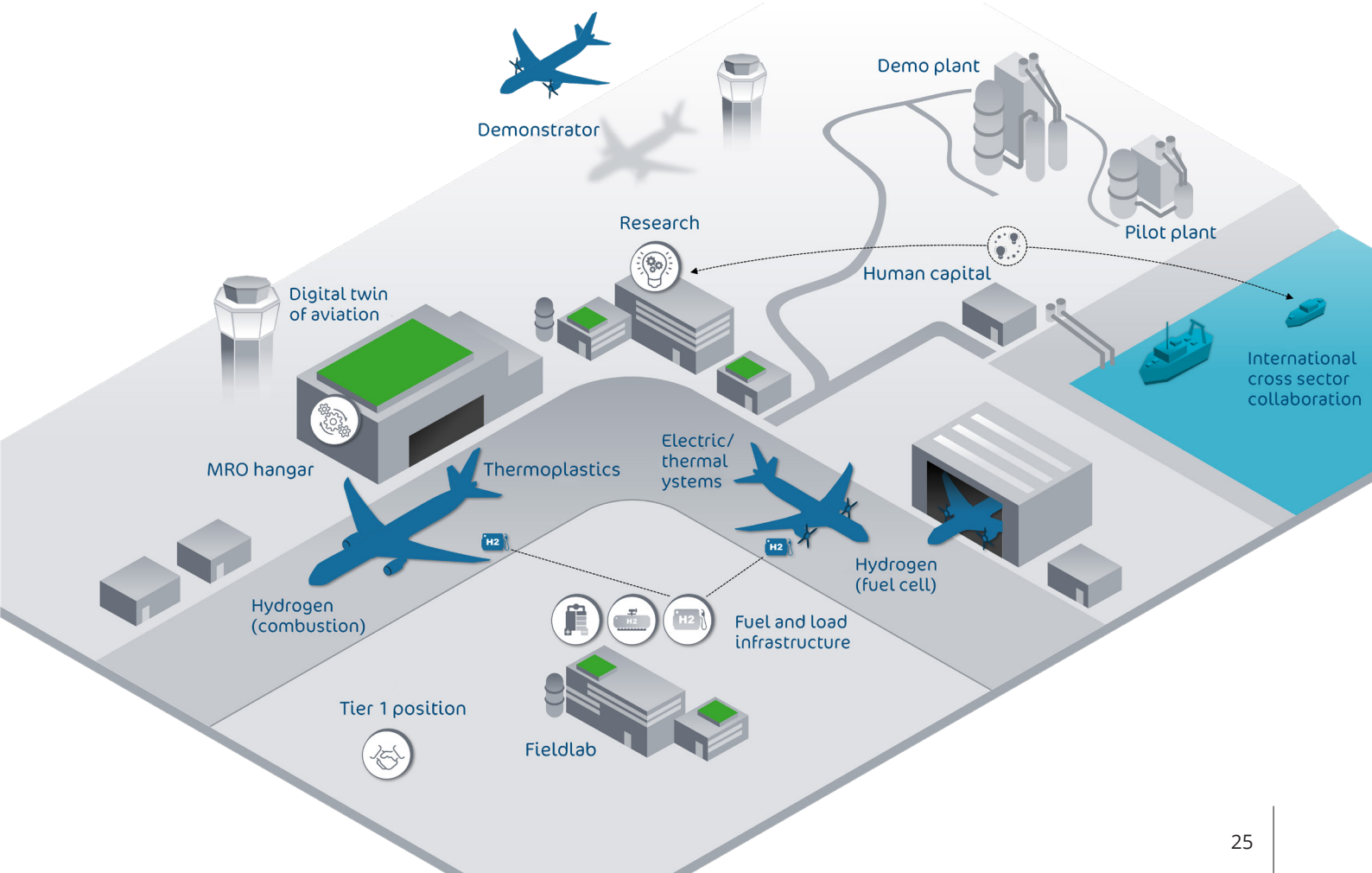
The aviation sector faces an enormous challenge to become climate neutral by 2050. To this end, the Dutch aviation programme **Luchtvaart in Transitie (LiT)**, which translates to 'Aviation in Transition', will develop technology, products and knowledge for which there is an upsurge in demand from the global market. We work together with a broad Dutch consortium and simultaneously reach out to our European and international partners to detect cross-border connections for joint solutions to this global challenge.

WHAT DOES LIT DELIVER?

LiT stands for an integrated approach. The implementation of promising research and innovations is accelerated through the removal of bottlenecks and the creation of a new open innovation infrastructure by means of:

- The development of sustainable ultra-efficient demonstration aircraft with breakthrough technology for hydrogen propulsion, materials and systems
- New and promising research that will continue to feed the innovation infrastructure through vehicles such as Flying Vision and DASAL, the Dutch Aviation Systems Analysis Lab
- Flying Vision, which develops an open innovation platform to provoke break-through and cutting-edge technologies 'coming from the future' by anyone
- DASAL will measure and monitor impact on many themes, such as (CO2)-emissions, noise, policy, climate, economy, logistics etc.

LiT is funded by the Netherlands National Growth Fund (Groeifonds) with which the government is investing in projects that will ensure long-term economic growth. New and promising research will continue to feed the innovation infrastructure.
The National Growth Fund is an initiative of the Dutch Ministries of Economic Affairs and Climate Change and of Finance.


Demonstrator
Demo plant
Pilot plant
Research
Human capital
Digital twin
of aviation
International
cross sector
collaboration
MRO hangar
Thermoplastics
Electric/
thermal
ystems
Hydrogen
(fuel cell)
Hydrogen
(combustion)
Fuel and load
infrastructure
Tier 1 position
Fieldlab

NLR works closely with both industry and government on developing satellite, payload and launcher systems and subsystems, like thermal control systems, electronics or antennas. We offer unique capabilities in the area of aerospace qualified light-weight composite structures and multi-metal additive manufacturing, and on the effective use of earth observation and satellite navigation data for both **civil** and **military** use.

As an independent R&D centre for aerospace we are known for our practical approach and innovative solutions. Due to our expertise combined with facilities we can support companies and government in the whole development chain from concept development to prototype and even small series production. We develop hardware from sensors to launcher components, up to software and information products derived from multiple source data. For all these developments NLR has a wide range of test facilities available with which we can test, verify and validate products. This includes environmental and structural testing, but also wind tunnel testing up to (zero-gravity) flight testing.

SPACE APPLICATIONS

- Satellite navigation
- Earth observation
- Cyber security assessment
- Space Situational Awareness

SATELLITES & LAUNCHERS

- Concept development
- Space avionics
- Antennas
- Thermal control
- Structures and materials

SERVICES

- AR / VR expertise
- Electromagnetic compatibility expertise
- Prototyping
- Low gravity flights
- Testing & qualification

Space

Development of air and space vehicles
Information-driven operations
Future Air & Space Power
Unmanned and autonomous

Project partners

Industry (NL)	: ArianeGroup
Research organisations	: NLR, DNW, ONERA
Start	: 2014
Duration	: 6 years

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.

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.

IMPACTA:

An innovative cooling system for satellite electronics

THE CHALLENGE

The Objective of IMPACTA is to create an innovative thermal control solution for Active Antennas that are a building block of next generation telecom satellites in Europe. This will as a consequence, solve the thermal control needs of future space missions of telecommunication. The developed technology will be transferrable other satellite payloads.

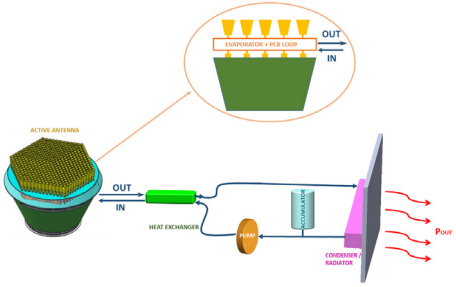
WHAT DID WE DO

A consortium of 6 leading partners in the space and thermal industry are collaborating on this project. At NLR-side the cooling system will be modelled in NLR's in-house two-phase cooling system model. Therein, a quantitative analysis of applicable refrigerant fluids will be done, to ultimately select the most optimal working fluid. Once a fluid is selected, the entire design of the two-phase cooling system is determined. This involves the selection of a pump, heaters, compatible materials, and the design of the evaporator.

Once the design is finalized, the necessary components fabricated and assembled. This involves the usage of Additive Manufacturing for production of the evaporator section. The finalized system is then tested to assess the correct working in various situations, including a test campaign in NLR's environmental test facilities.

THE SOLUTION

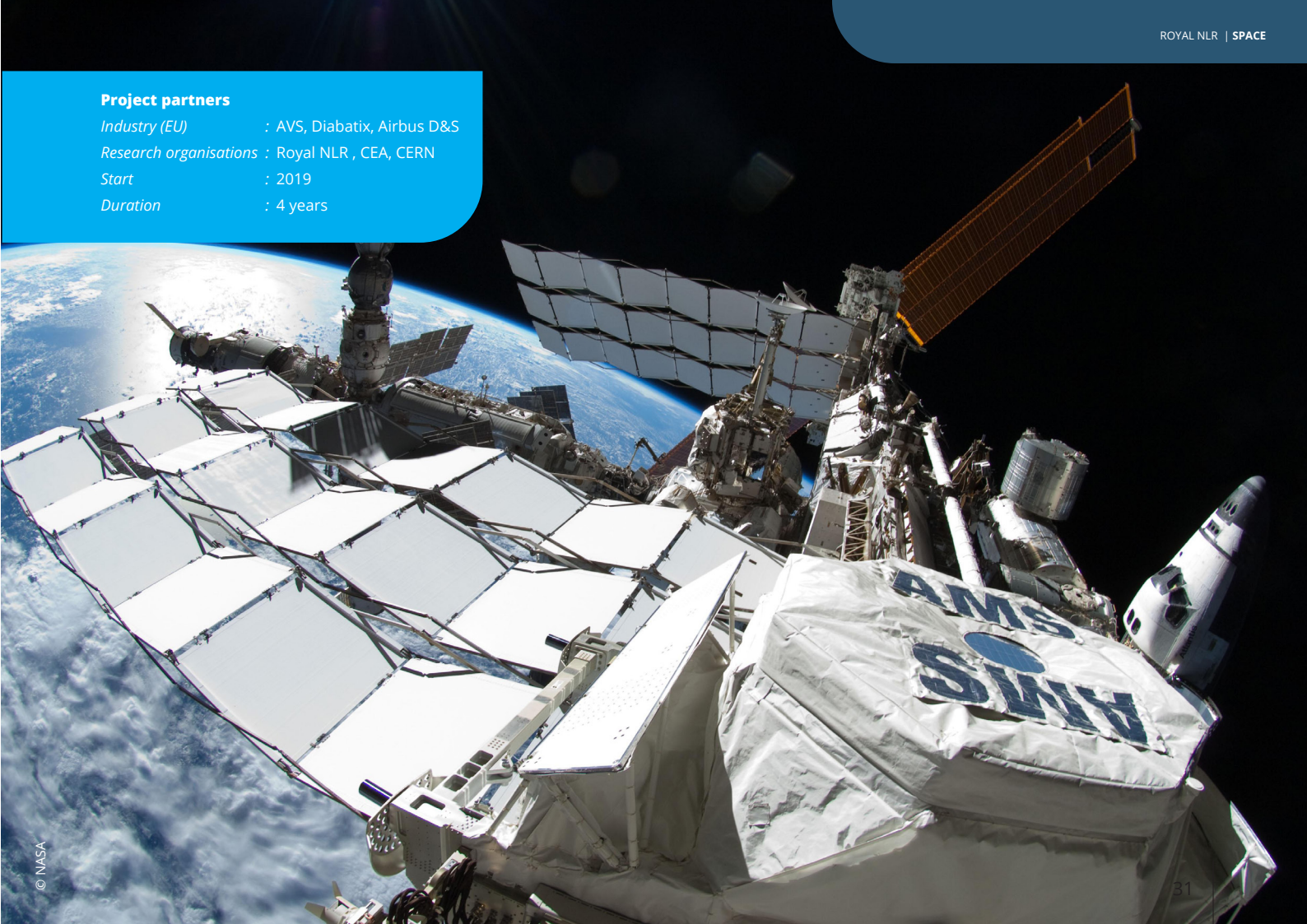
The expertise that is built during this EU-project, will be applicable in cooling needs for the next generation of satellites. This will enable the usage of electronics with a higher power density than currently used. Furthermore, the project has improved the TRL of two-phase cooling systems aboard satellites.



IMPACTA is co-funded by the European Union.
This message doesn't necessarily reflect the views of the EU

Project partners

Industry (EU)	:	AVS, Diabatix, Airbus D&S
Research organisations	:	Royal NLR , CEA, CERN
Start	:	2019
Duration	:	4 years



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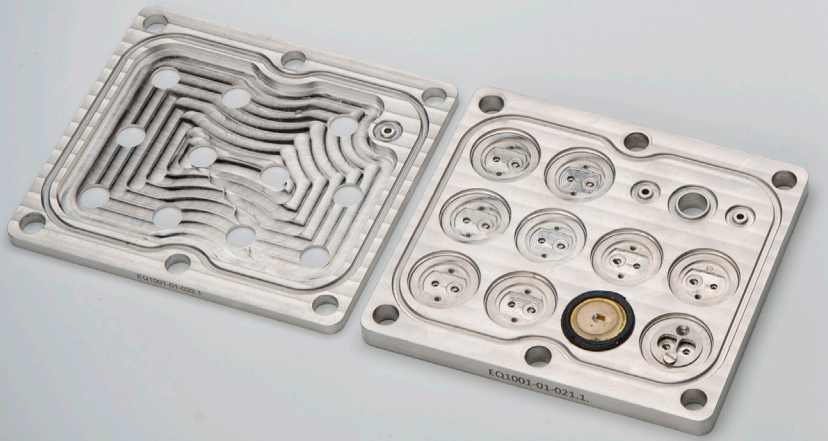
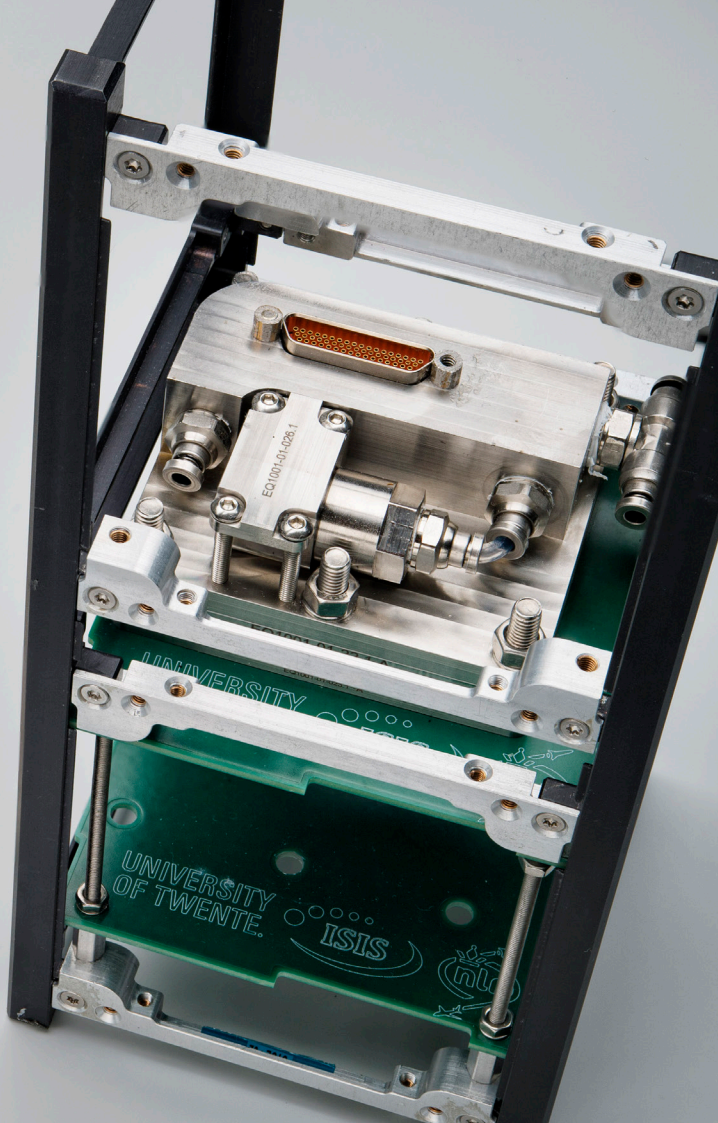
Project partners

Industry (EU)	:	Demcon Kryoz, ISISpace
Research organisations	:	Royal NLR, ESA
Start	:	2021
Duration	:	2 years





Mini Multi Parallel Micro Pump development

THE CHALLENGE

Development, production and launch costs for CubeSats are very low compared to conventional satellites. This has sparked interests from industry to develop their own CubeSats. The drive for volume and mass optimisation from the industry has led to miniaturisation of electronics in CubeSats. To keep costs down, commercially available electronics (COTS) are used which are very cost effective but have a small operational temperature range. The relatively high power density of CubeSats means that more power is being transferred into heat in the same volume, causing a faster warm-up of components. The thermal problems are aggravated by the introduction of propulsion modules for CubeSats which themselves produce a large amount of heat. Without adequate heat removal the CubeSat components can quickly overheat.

WHAT DID WE DO

Conventional methods like heat pipes to remove this heat are no longer suitable, and mechanically pumped loops are a feasible solution to remove this heat as they are more efficient. However, these loops are usually expensive and need much smaller mass flows compared to the larger satellites. To create a smaller mechanically pumped loop, a smaller, flexible pump is needed which is the goal of the MPMP. A consortium of Demcon Kryoz, ISISpace and Royal NLR, with support of the European Space Agency (ESA) aims to develop the MPMP for use in small satellites.

THE SOLUTION

The Multi Parallel Micro Pump consists of a stack of several micro pumps, which consists each of a piezo membrane and a valve to direct the flow. The prime functionality lies in the flexibility the current solution offers: if a higher flow is needed, more pumps can be added to be able to deliver that flow; which also helps in the robustness. For typical space applications expensive pumps are used, and due to redundancy reasons, added with a second back up. With for instance 20 micropumps placed in one stack, the loss of one single pump will not result in loss of functionality of the loop, but will lower the flow with 5%.

We currently have a full scale MPMP prototype which has demonstrated a mass flow of 500 mg/s which is sufficient to transport at least 20 watts of heat. The consortium aims to improve upon the design to transport at least 100 watts of heat away from a heat source, such as a CubeSat propulsion module, to a heat sink elsewhere in the satellite.

This project was funded by ESA.

Royal NLR has over 100 years of experience in the defence industry and is supporting the Royal Netherlands Air Force in daily operations, lifecycle management and (virtual) training. In addition, Royal NLR is supporting Netherlands' Defence Technological & Industrial Base (NLDTIB) with research on new materials and optimization of various manufacturing techniques.

Royal NLR is proud to be a partner in several military programs starting from the early development phase and is committed to continue to support the Warfighter with Dutch excellence and innovations.

NLR expertise for Life Cycle of military applications

Smart Manufacturing Processes
Focus Today on the Technologies of Tomorrow

Factory of the Future
Making Industry 4.0 Business as Usual

Hangar of The Future
Contributing to Technology Innovation with State of the Art Facilities & Tools

Durable Sustainment & Repairs
Providing Durable and Affordable Sustainment Solutions

Multi-Domain Operation
Continuous Operational Improvement through Multi-Domain Integration

Operational Support & Training
Evaluating Concepts of Operations and Training for Excellence

Society
Perceiving the Sound of Freedom

Defence

Information-driven operations
Future air and space power
Operational availability
F-35 entreprise

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)

Project customers:
Royal Netherlands Air Force (RNLAF)
Defence Equipment Organisation (DMO)
Research organisations: Royal NLR
Netherlands Organisation for Applied Scientific Research (TNO)

Start: February 2000
Duration: ongoing

F-35 Acquisition & Operational Readiness Preparation

THE CHALLENGE

NLR helped the RNLAF with the F-35 acquisition and operational readiness by focussing on transforming the Defence Equipment Organisation (DMO) into a smart buyer and by assisting the Air Force with a smooth transition from F-16 to F-35. Within this programme, multiple training & education projects have been carried out to design and improve training for pilots, maintenance staff, and mission support crew.

WHAT DID WE DO

Several training methods, tools and activities conducted by NLR throughout the F-35 programme include:

- Training Needs Analysis (TNA) for pilot maintenance staff, and mission-support roles
- Design of a F-35 Pilot Competency Profile, initial and recurrent training course content
- Training Media Selection Analysis (TMA
- Business case for a Maintainer Training Centre (MTC)
- Multi Spectrale DataBase (MSDB)
- Continuation Training including Performance Based Training (PBT)

THE SOLUTION

The activities mentioned helped to develop a variety of products and services, including:

- Initial and recurrent training course content for pilots and maintenance staff
- Design and execution of an Operational Test & Evaluation plan for Continuation Training
- Design and construction of a WLT (Weapons Loader Trainer) including Augmented Reality applications.

NLR Battle lab Cerebro

Testing environment for military study, demonstration, and research purposes

NLR provides a battle lab capability by integrating high fidelity platform simulators with additional proof of concept demonstrators and extension to other battle labs. Cerebro can ultimately also be coupled with live systems when connected to e.g. a Link-16, DIS or HLA gateway.

Cerebro can be used for both small and larger projects that require multiple simulators to work in an integrated environment. The extensive use of platform simulators and computer generated forces will reduce the costs while enabling testing of new functionalities concepts in a safe and classified environment.

BROAD RANGE OF RESEARCH AND TESTING

TECHNICAL SPECIFICATIONS – SIMULATION SET-UP

The steps for concept development in Cerebro are cyclical, as is usual in CD&E and DT&E processes. Before starting development, relevant background information is collected, experiment questions are formulated and ultimately conclusions are drawn and a report is written.

BATTLE LAB BASED ON VIRTUALISATION

The Cerebro infrastructure is fully based on a virtualisation solution, enabling rapid configuration and deployment of exercises with various tools, services, and simulators:

- Quick configuration of simulation tooling and scenarios
- Rapid deployment of simulation exercises to end-users
- Core services readily integrated, i.e. terrain databases, scenarios, chat, simulation backbone
- Promotes quick and agile development of simulation experiments

CONTROL/OBSERVE:

- SCENARIO CONTROL
- OBSERVERS
- RECORDING
- ANALYSIS
- DEBRIEF

BACKBONE:

- CORE SERVICES: GEODATABASE, SIMULATION SUPPORT, ...
- CONNECTIVITY: DIS/HLA, EXTERNAL BATTLELABS
- LIVE ASSETS CONNECTIONS (LVC)

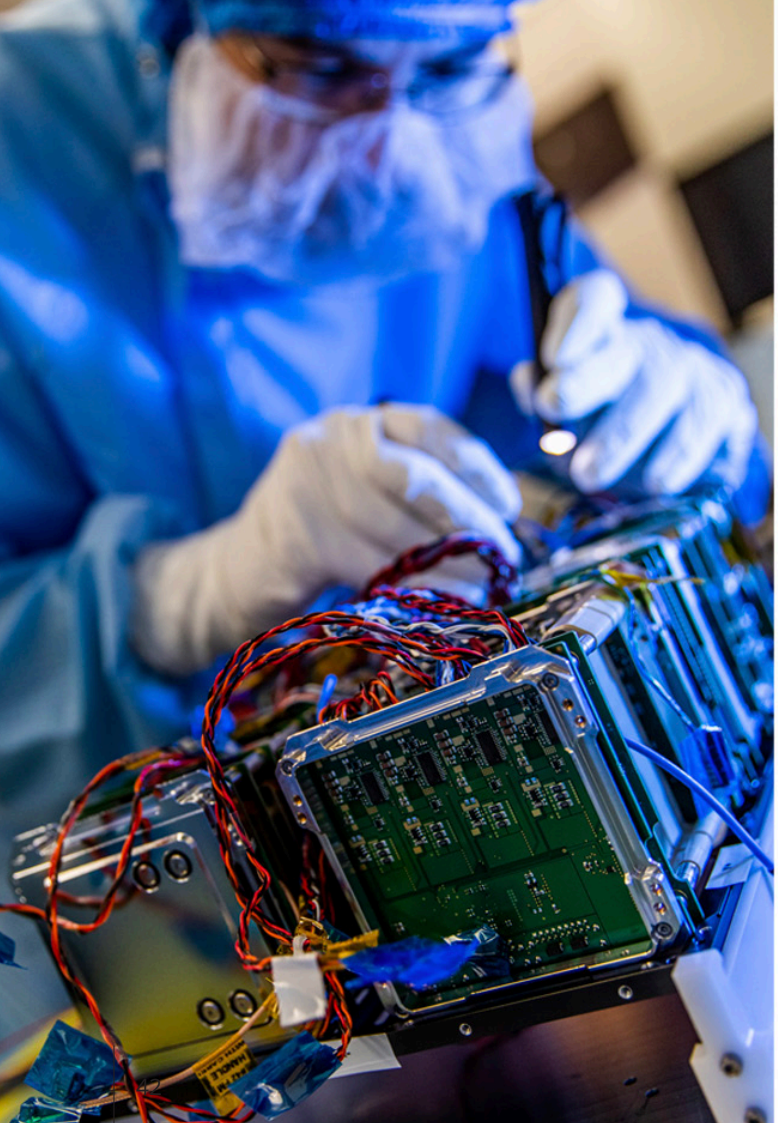
TACTICAL LEVEL:

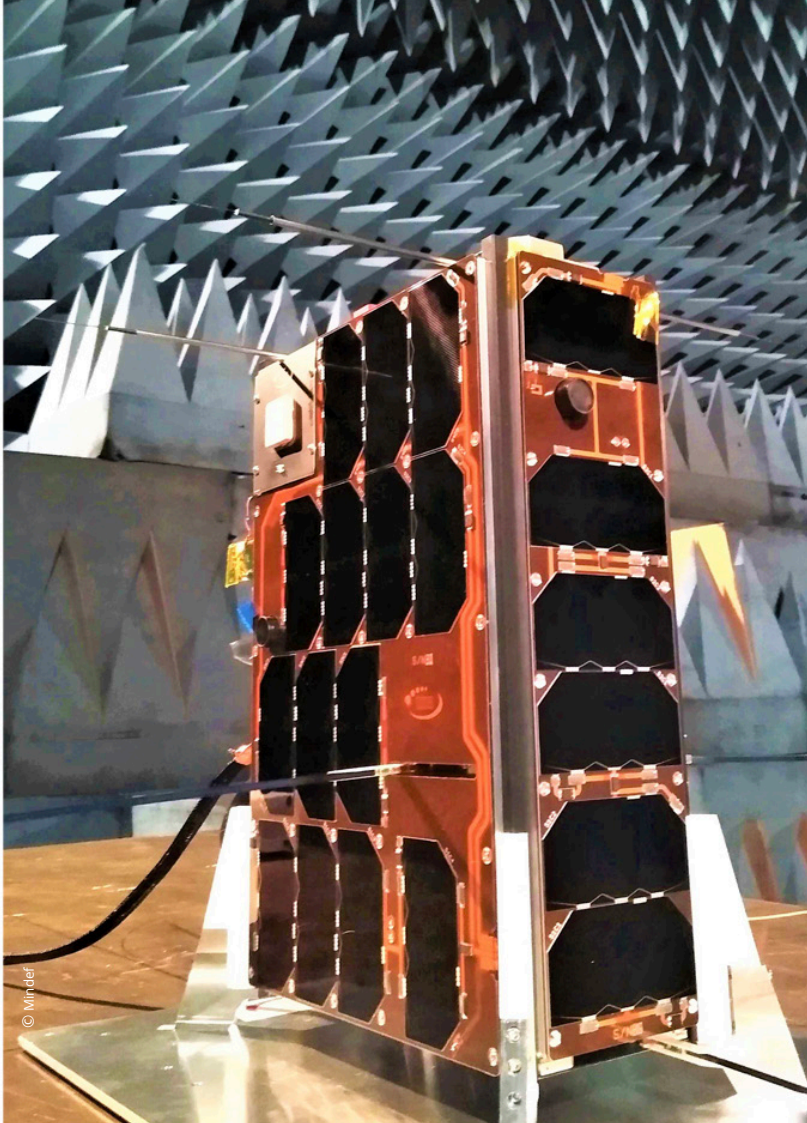
- FIGHTERS: F-16 &-F-35
- HELICOPTERS: AH-64, CH-47, NH90
- TRANSPORT & TANKERS:C-130, KDC-10
- UAV'S: MQ-9, SCAN EAGLE
- SPACE ASSETS: SPACE SA, BRIK-II
- WEST
- TACTICAL REFERENCE MANUAL
- SMART BANDITS
- F35 CDEF

OPERATIONAL LEVEL:

- AOC: MASE, SCOTT
- ISRD: INFORMATION FUSION & SHARED SU DASHBOARD
- AIR C2: RESOURCE MANAGEMENT, PLANNING & MONITORING/CONTROL
- SMART MISSION PLANNING & DEBRIEF

The NLR Battle lab Cerebro will be operation mid-2023





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.


SCOTT
Tactic A
Tactic B
Tactic C
BAND BOX

SCOTT: Smart Controller Training Tool

Fighter Controllers are essential for the safety and effectivity of fighter pilots. They provide the pilots with a complete and correct air picture. Fighter Controllers must be well trained to observe, assess and communicate in rapidly evolving situations. This includes training scenarios that are diverse and have realistic fidelity and scale in terms of involved platforms and their behavior.

THE CHALLENGE

The training and education of Fighter Controllers is often highly labour-intensive due to the fact that well designed and user-friendly tools to simulate air engagements are not readily available. Frequent training with live assets in the air is inhibitively costly in terms of logistics, coordination and required number of platforms (blue and red) to be involved. Generating realistic behaviours of constructive platforms is typically not available without human inputs. The challenge is to create the desired level of realism in an environment where the minimal required human involvement is low.

THE SOLUTION

Royal NLR designed and developed SCOTT as an easy to use tool for instructors and pseudo-pilots for Fighter Controller training. SCOTT is a tool that can create realistic tactical simulation exercises using Artificial Intelligence (AI), consisting of both Blue and Red air platforms. SCOTT can run autonomously Air-to-Air combat scenarios, but a human can intervene in the tactical decisions of the constructed air platforms. Since the scenarios are easier to control, larger tactically relevant scenarios can be implemented. SCOTT presents these scenarios via DIS to the operational system for Fighter Controllers. Interoperability between SCOTT and other simulator systems are also possible, e.g. for LVC or MTDS exercises.

WHAT DID WE DO

NLR developed the SCOTT tool to allow the design and execution of Air-to-Air combat scenarios and contain (semi-) autonomous tactical constructive entities. NLR added realistic tactics and missile performance which can be specified to national performances. These are based on in-house developed tools Smart Bandits (AI behaviours) and WEST (missile performance). This resulted in a low effort tool to easily control the scenario and adjust to the desired learning objectives.

Royal NLR in brief

One-stop-shop	Global player with Dutch roots	100+ Since 1919	Amsterdam, Noordwijk Marknesse, Rotterdam, Volkel
Innovative, engaged and practical	For industry and government	For fixed and rotary wing	690 employees
€ 91 M turnover	73% Dutch, 23% EU and 4% international	Active in 30 countries	Extremely high client 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.

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.

Knowledge and technological developments

Royal NLR plays a leading role in the field of aerospace in the Netherlands, as the connecting link between science, business, society and government. As a knowledge organisation for applied research, we occupy a central position in the valorisation process, transforming knowledge into value. Our goal is for the result of our research to have a societal and economic impact through the development of practical applications.

We make this possible through sustainable innovation, by developing knowledge about clean solutions and safety and security in the aerospace domain, and making this accessible to the aerospace industry, both civil and defence. In this way, we help to maintain a prosperous society and make a meaningful contribution towards a clean, safe and better future world.

STRATEGIC THEMES AND PROGRAMMES

There are three main themes in which NLR wants to make a lasting, long-term impact. To accomplish this, we have set ourselves concrete, ambitious programmes and goals for the forthcoming period.

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.

Our programmes

The NLR programmes,together with our knowledge basis, contribute towards our objectives within the three strategic themes.

CLIMATE NEUTRAL AVIATION

CLIMATE NEUTRAL AVIATION

To contribute towards climate neutrality of the aviation sector in 2050, this programme sets up research projects in collaboration with universities, other knowledge institutions and industry. The focus lies on (components of) propulsion technologies, sustainable fuels, testing facilities, innovative aircraft architecture, circular production and maintenance techniques, aircraft operations, regulation, certification, governmental policy and climate research.

IMPACT ON PEOPLE AND SOCIETY

IMPACT ON PEOPLE AND SOCIETY

Aviation and aviation technology have a huge impact on people and society. NLR supports in dealing with the use and acceptance of (existing and) new technological developments. To make the impact of aviation more transparent, we are investigating new ways of measuring air quality and noise nuisance caused by aircraft, of determining the influence of routes on nuisance and of identifying nuisance-reducing measures. With this, we want to make a positive contribution to the quality of life of those living near airports, and to provide optimum advice to governments. This also includes societal acceptance of drones and Urban Air Mobility (UAM).

CLIMATE NEUTRAL AVIATION

SAFE AND COMPETITIVE OPERATIONS

NLR helps governmental authorities, the aviation sector and society to ensure aviation operations remain competitive, now and in the future, and to make civil and military aviation, and society, safer. We offer insight into changes in new technologies, for safety and security for instance, and into operational concepts, organisation, regulation and safety oversight in the aerospace industry. We also propose solutions for reducing costs in aviation operations, for expanding airspace capacity and for maximising the reliability and resilience of aviation operations, within societally acceptable limits.

DEVELOPMENT OF AIR AND SPACE VERHICLES

DEVELOPMENT OF AIR AND SPACE VEHICLES

With our knowledge, we want to enable the aerospace industry to have a competitive share in the development and production of the next generation low emission aircraft, in programmes for the next generation helicopters, in new small satellites, launchers and space applications, and in new flight concepts. The focus is on the development of innovative and advanced avionics, systems, materials and constructions and accompanying manufacturing processes, modelling, simulation, data analytics and AI methods. The goal is a short time-to-market at optimum costs and smart reconfigurable systems.

OPERATIONAL AVAILABILITY

OPERATIONAL AVAILABILITY

NLR supports Defence, the aviation industry, MRO and maintenance companies and airlines in the development and application of innovative, sustainable solutions for maintenance, inspection and repair. In this way, NLR wants to contribute to the optimisation of the material availability and the cost effective use of aircraft, helicopters, drones, wind turbines and other complex systems. Areas of work include developing accepted techniques and procedures for composite repairs, inspection techniques, maintenance concepts for electric flying, AI-based maintenance optimisation and autonomous visual aircraft inspection.

INFORMATION-DRIVEN OPERATIONS

INFORMATION-DRIVEN OPERATIONS

NLR supports the Dutch government in accelerating the transformation of its operational concepts and systems into information-driven operations for Defence. The focus lies on the tactical and operational processes within the aerospace domain. The goal is to speed up these processes, on the basis of better informed decisions.

FUTURE AIR & SPACE POWER

FUTURE AIR & SPACE POWER

NLR works on solutions that contribute to a safer society. These solutions can help in the effective performance of tasks, and can increase the combat readiness of troops and the resilience against new threats in the air and in space. The focus lies on knowledge of threat systems and technology, the corresponding countermeasures, and education and training. In this programme, NLR is building a leading knowledge position in the field of training and simulation, making aerospace part of information-driven, multidomain and integrated operations. We do this together with our national and international (EU, NATO) partners

UNMANNED AND AUTONOMOUS

UNMANNED AND AUTONOMOUS

Drones are a key enabler for innovative solutions to tackle rapidly changing societal, economic and security challenges. It is necessary to create innovative drone solutions, platforms and systems in a safe, sustainable and cost-effective way, and to integrate these within the airspace. NLR offers support in the development, implementation and societal acceptance of unmanned and autonomous aviation, taking into account safety and minimal nuisance. We help with the realisation of safe, sustainable and affordable drone systems and the harnessing of commercial opportunities, and we support the rise of manufacturers in the area of drones and Urban Air Mobility (UAM).

EMERGING TECHNOLOGIES

EMERGING TECHNOLOGIES

This programme is the breeding ground for new technologies and ideas within Royal NLR. NLR invests in technologies of the future that are widely deployable for NLR and that could have a huge impact on the way that we live, learn, work and produce. Consider, for instance, virtualisation, digitisation, automation, AR/VR, (explainable) artificial intelligence (AI) including machine learning and deep learning, distributed ledger technology such as blockchain, and advanced data analytics. We identify emerging technologies and predict how these will develop. We then link these with topics and programmes that are relevant for NLR and our stakeholders and partners.

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.

Royal NLR makes aerospace more sustainable, safer, more efficient and more effective. The innovative solutions and practical advice strengthen the competitiveness of the business community and contribute to solutions for social issues. NLR works in an objective manner, for and with the (inter) national business community and government agencies.

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