
Dedicated to innovation in aerospace
Space R&D for society
Royal NLR - Netherlands Aerospace Centre

# NLR can support you in the following areas

**SPACE APPLICATIONS**

- Satellite navigation
- Earth observation
- Space Situational Awareness

**SATELLITES & LAUNCHERS**

- Concept development
- Space avionics
- Antennas
- Thermal control

**SERVICES & FACILITIES**

- Prototyping
- Research facilities

**ENABLING CAPABILITIES**

- AI on the edge
- Cybersecurity
- AR/VR
- Structures and materials

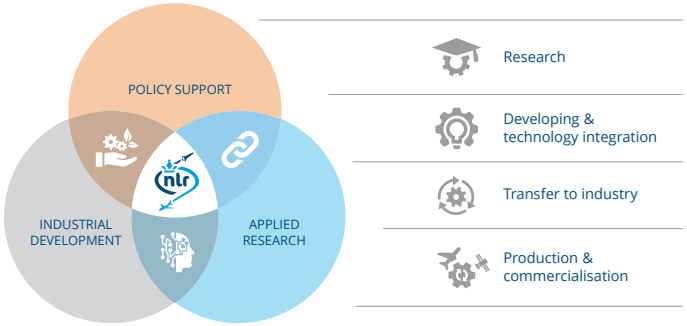
# Space innovations for society

Royal NLR works closely with both industry and government on developing satellites, payloads and launchers systems and subsystems, such as thermal control systems, electronics and antennas. We also 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.

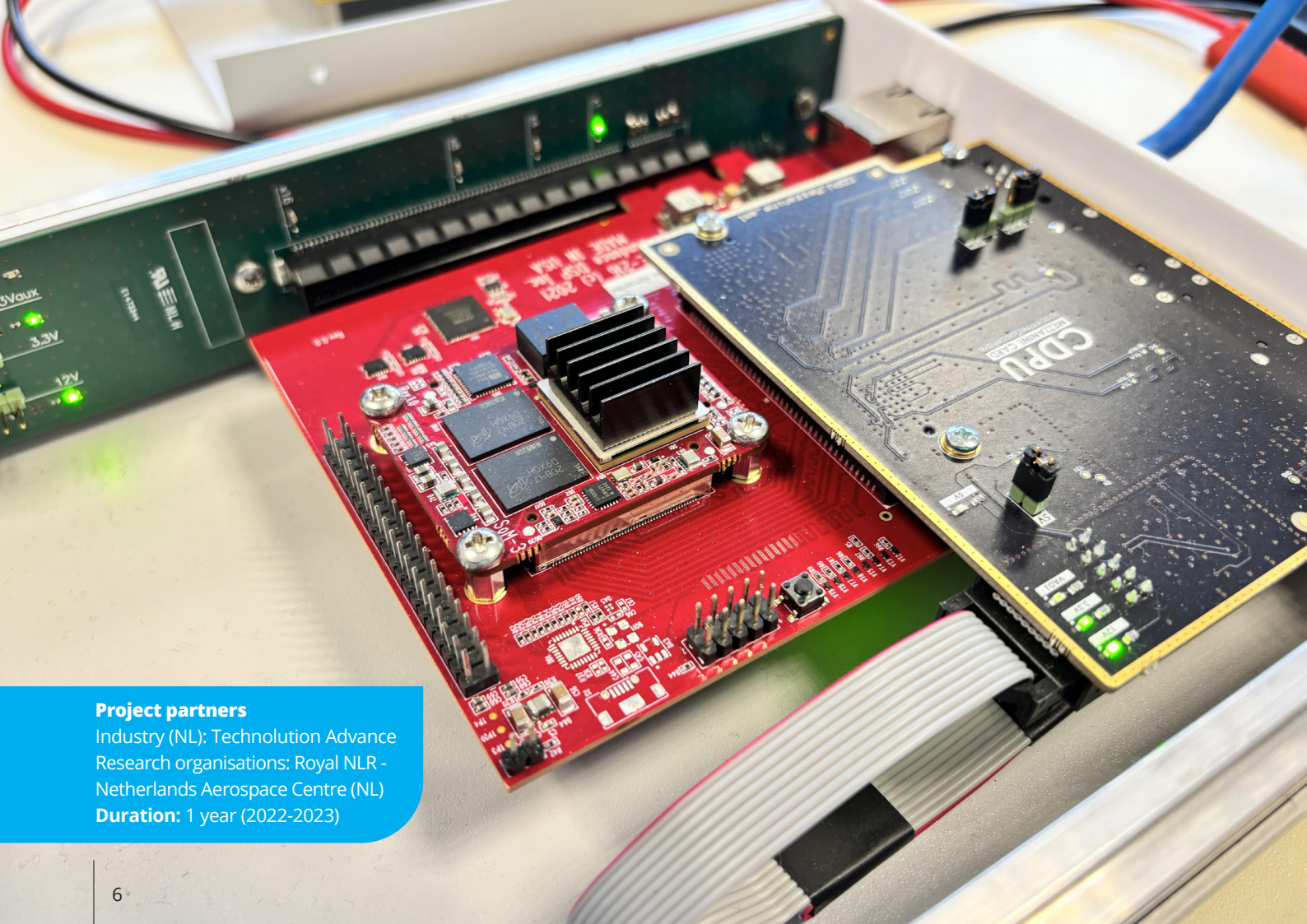
As an independent R&D centre for aerospace we are known for our practical approach and innovative solutions. Based on our expertise combined with facilities we support companies and government in the whole development chain from concept development to prototype and small series production. We develop hardware from sensors to launcher components, up to software and information products derived from multiple source data. For 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 and also wind tunnel testing, up to (zero- and lowgravity) flight testing.

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



# R&D cases




**Project partners**
Industry (NL): Technolution Advance
Research organisations: Royal NLR - Netherlands Aerospace Centre (NL)
**Duration:** 1 year (2022-2023)

# Advanced Payload Control and Onboard Data Processing

## THE CHALLENGE

Current SmallSat avionics are not suitable for commercial SmallSat missions. The challenge is here to get to a solution with a proper balance between size, versatility, reliability, robustness to the space environment and cost effectiveness. A solution using space qualified parts is too expensive and bulky while a solution based on commercially off the shelf (COTS) components will not offer the reliability and quality assurance customers demand.

## WHAT DID WE DO

During a one-year Dutch national space innovation programme (SBIR), a proof-of-concept is developed and demonstrated. NLR applied it's experience on high-reliability space avionics and space standards while our industrial partner Technolution Advance applied their efficient, high-quality and secure development approaches. This is a strong collaboration combining the best experiences (i.e. expertise from traditional space processes and agile hardware development techniques) to develop an attractive product.. In addition to the finalised project several R&D activities are being performed on specific product details. One example is the R&D activity on a robust and secure RISC-V processor for harsh environments under an EU Horizon Chips JU (Joint Undertaking) project. In this R&D activity NLR performs characterisation of the radiation hardening solution in radiation environments.

## THE SOLUTION

The solution is using radiation tolerant parts at critical places mixed with well characterised COTS components. Proven and effective processes from traditional space are applied to assure the quality and reliability.

Versatility is offered by the modular approach using a generic central processing module, an Instrument Specific Module offering the interfaces and hardware functions to the payload and the Platform Specific Module offering the interfaces to the satellite platform including a barrier for failure propagation towards the other satellite systems. In order to enable a quick time-to-orbit, early delivery of CDPU lab models allows the customer to perform application software development independently and at an early stage.

# BRIK II, the first Dutch military satellite

**Collection of information is crucial in modern military applications. Especially monitoring the RF spectrum – from space -- is key factor in a number of decisions. NLR has developed the main instrument on the 6U CubeSat called BRIK-II. It detects, analyses and geolocates RF signals of the higher frequency bands, processes it on-board, and sends the relevant information to the ground.Next to this instrument, the BRIK-II has two other instruments: a scintillator, developed by the University of Oslo, and a Store and Forward, developed by squadron 982 of the Dutch MoD. The satellite bus is developed by ISISpace. BRIK-II was successfully launched in June 2021 and is fully operational ever since.**

## THE CHALLENGE

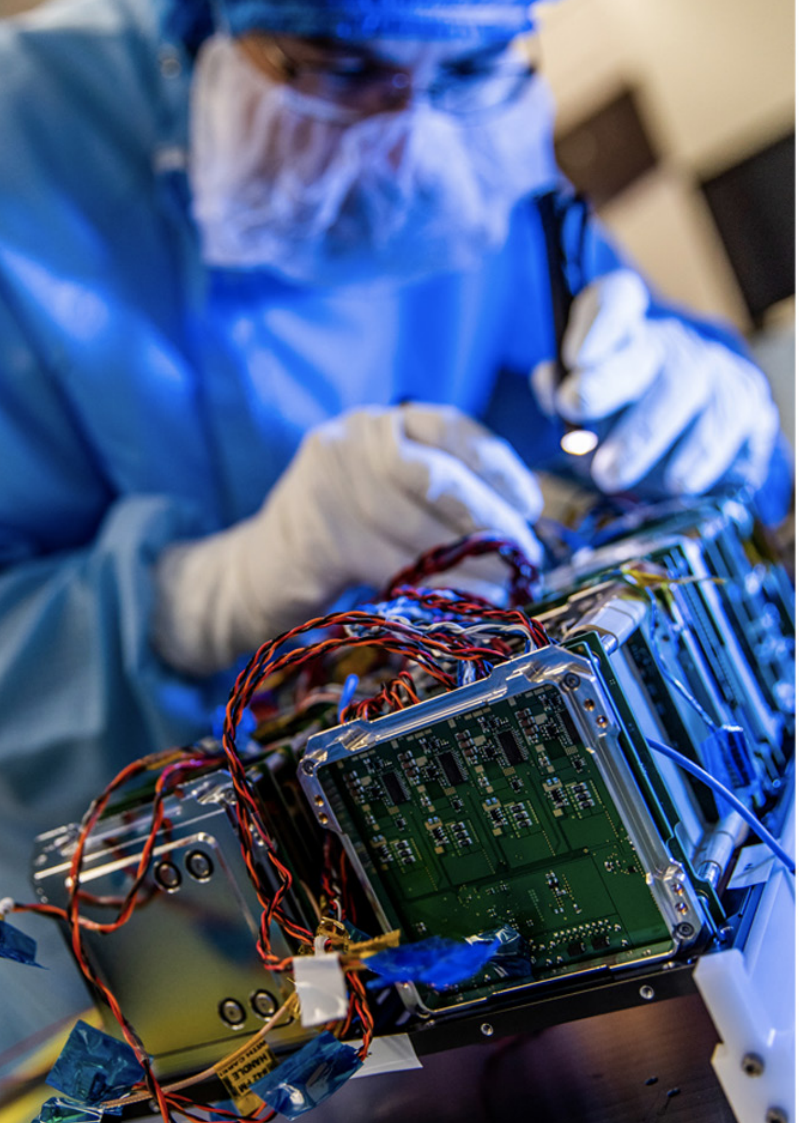
- Demonstrate the potential of nanosatellites for military and civil use
- Development and realisation of a small, yet powerful, instrument that detects, analysis and geolocates RF signals from space
- On-board processing with in-house developed innovative algorithms
- Give a global collection of information on the usage of the RF spectrum

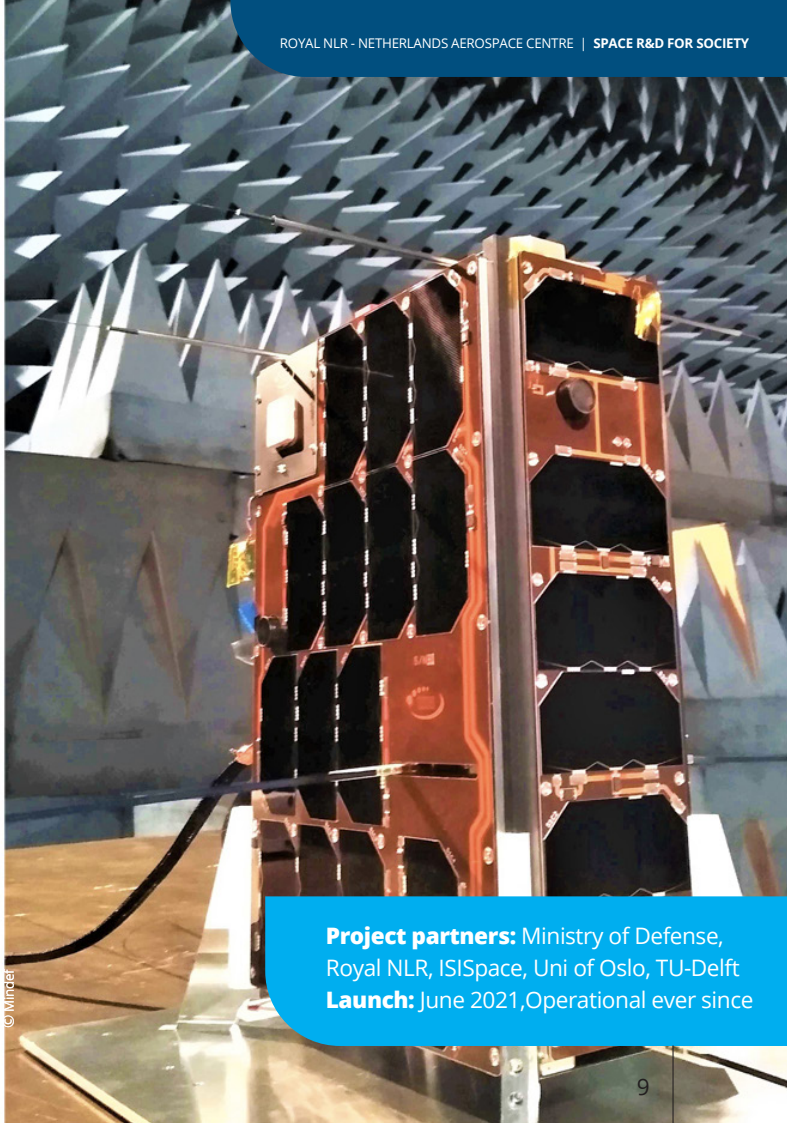
## WHAT DID WE DO

The BRIK-II mission spans the entire development. From prototyping, innovative algorithm development, software development, design, implementation, assembly, test, debugging and verification, including required environmental testing and end-to-end testing and calibration. NLR analyses all incoming data, simulates and improves the filtering and algorithm settings for this current mission, but also as input to future RF missions.

## THE SOLUTION

- BRIK-II CubeSat is small but incorporates three working instruments
- The instrument that detects and analyses the RF spectrum is 10 x 10 x 15cm with a power consumption of approx 15 Watt (depending on the mode)
- Due to on-board processing, the data can be filtered onboard
- Modular design: it can be tuned to different bands for future missions.





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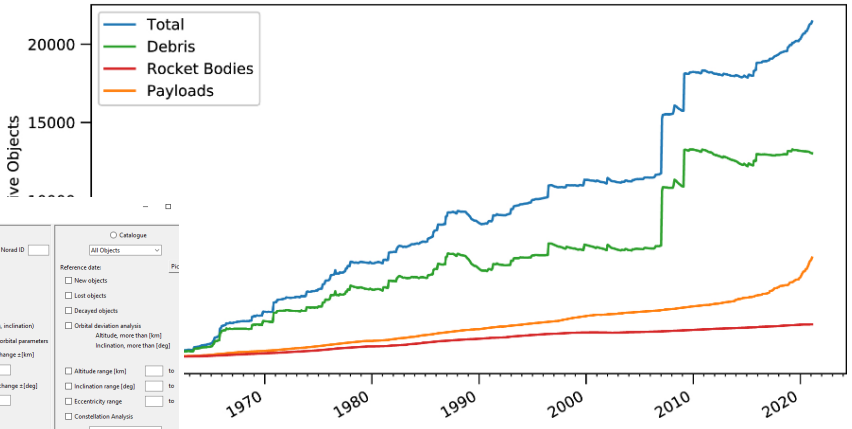
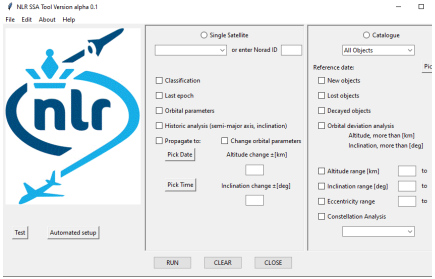
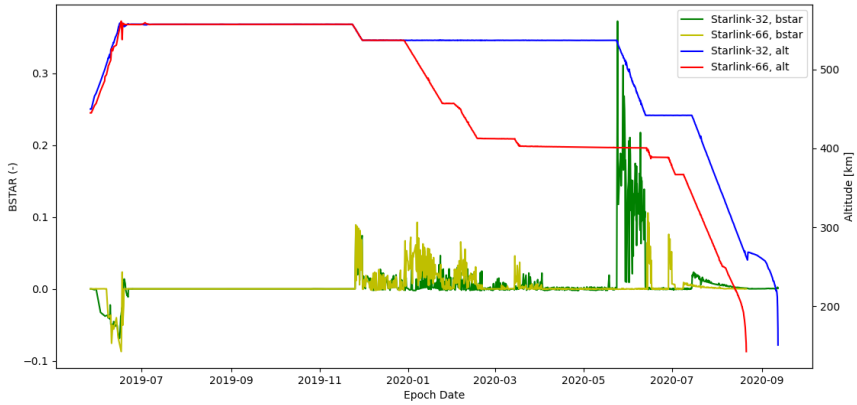
**Project partners:** Ministry of Defense, Royal NLR, ISISpace, Uni of Oslo, TU-Delft
**Launch:** June 2021,Operational ever since

**Project partners**
Dutch Ministry of Defense - Space Contour 2019
**Period:** 2019 - 2023




*NLR is developing the SSA tool "ARGUS". ARGUS can monitor orbital events and will be extended with more advanced functionality such as Space Object Characterisation, Rendezvous- and Proximity Operations, an automated warning system and a 3D output capability*



# 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 DID WE DO

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.

# Advanced Receiver Autonomous Integrity Monitoring - ARAIMFUSE

**Advanced Receiver Autonomous Integrity Monitoring (ARAIM) is an evolution of the currently used aviation focussed GNSS integrity service, Receiver Autonomous Integrity Monitoring (RAIM). Within the precursor of this project, ARAIMTOO, the possibility and advantages of using ARAIM concept for other sectors was shown. Within the ARAIMFUSE project the user algorithm were improved to be more suitable for the UAV application, especially for urban environment.**

## THE CHALLENGE

A typical scenario which is targeted for ARAIM evolutions is that of a UAV flying through a urban canyon. Due to satellite masking, the number of satellites that can be used can be expected to drop significantly in comparison with wopen sky flights. At the same time, the required position accuracy is much more demanding than was the case for general aviation scenario's envisaged for classical RAIM.

## WHAT DID WE DO

To analyse the proposed solution and the effectiveness of this the following steps have been taken.

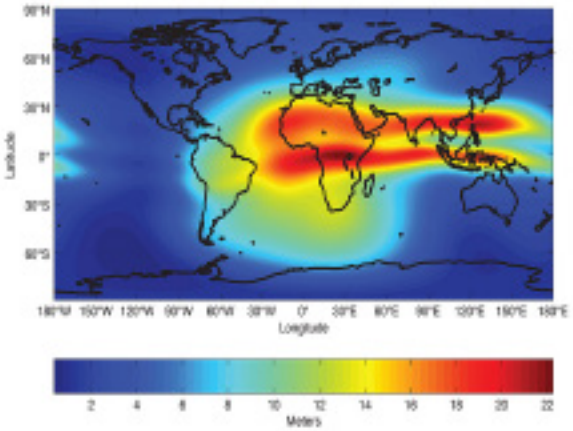
- Update of the algorithm architecture with respect to the ARAIMTOO project proposed solution
- Perform flights to collect data for local error characterisation
- Analysing the proposed PNT concept by a dedicated experimentation using software implementations.

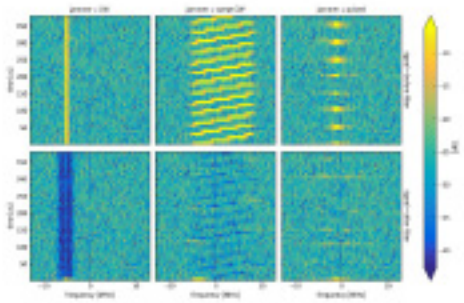
## THE SOLUTION

The research showed that the use of all four available GNSS constellation in combination with Precise Point Positioning (PPP) techniques with an adaption of ARAIM plus the hybridisation with IMU could allow to cope with harsh environments typical of urban areas and the stringent accuracy and integrity requirements of UAVs in urban environments. The new Galileo High Accuracy Service (HAS) could be used to provide the user with PPP corrections for Galileo and GPS.

*ARAIMFUSE is a European Commission funded project*

**Client:** DEFIS (Directorate-General for Defence Industry and Space)
**Partners:** GMV, VVA and NLR
**Period:** 2023 -2024



**Research organisations :** Royal NLR, NLS-FGI (Finland) Industry/SME: Orolia (France) (lead), FDC (France), NavCert (Germany) .
**Period:** 2019 - 2022

# GalilEo Authenticated Robust timing System - GEARS

**Precise time is crucial to a great variety of economic activities around the world. Communication systems, electric power grids, and financial networks all rely on accurate and reliable timing for synchronisation and operational efficiency. The timing services supplied by GNSS (Global Navigation Satellite System) are an increasingly important part of modern infrastructure. The EU strives to improve and increase the robustness of critical infrastructures by increasing the resistance and resilience of timing and synchronisation (T&S) services. In particular, Galileo is the first GNSS that will provide an authentication function to civil users through the Open Service Navigation Message Authentication (OS-NMA) that will come into operation soon. The GEARS project aims at providing a Galileo-based timing receiver with increased robustness for Critical Infrastructures.**

## THE CHALLENGE

- The key objectives of the GEARS project:
- Improve performance and resilience of a Galileo and GNSS timing receiver
- Develop and demonstrate the effectiveness of unique Galileo services to operators
- Strengthen market adoption through standardisation activities.

## WHAT WE DO

- Design and implementation of RF Interference Detection and Mitigation (IDM) module (interference filtering in time and frequency domain)
- Design and implementation of an anti-jamming antenna (interference filtering in the spatial domain)
- Design and implementation of a ionospheric correction module (including NeQuick G algorithm)

## THE SOLUTION

The main focus of the project was the on the implementation of a range of technologies (Multi-Frequency, Multi-Constellation, OS-NMA, RF interference detection and mitigation, T-RAIM, etc.) for improving the accuracy, reliability and robustness of the GEARS timing receiver.

*The GEARS project is funded by the European Union Agency for the Space Programme (EUSPA).*

# Compliance of GNSS receivers used in military aircraft - COMSTAC

**Performance-based navigation (PBN) is being introduced in Europe. Military Aircraft must be compliant to be allowed to fly in civil PBN airspace. However, most military GPS-PPS receivers are not certified for this use. An methodology is defined to qualify and certify military GPS PPS receivers.**

## THE CHALLENGE

Define an alternative method to show that GPS-PPS receivers can provide navigation data compliant with PBN requirements.

The method must allow states to approve and certify military aircraft to comply with PBN requirements, safeguarding civil-military interoperability.

## WHAT DID WE DO

The methodology was defined based on:

- Determination of technical requirements
- Gap analysis between requirements and GPS PPS receiver
- Definition of a new compliance method based on black box testing
- Example demonstration on the Eurofighter Typhoon aircraft

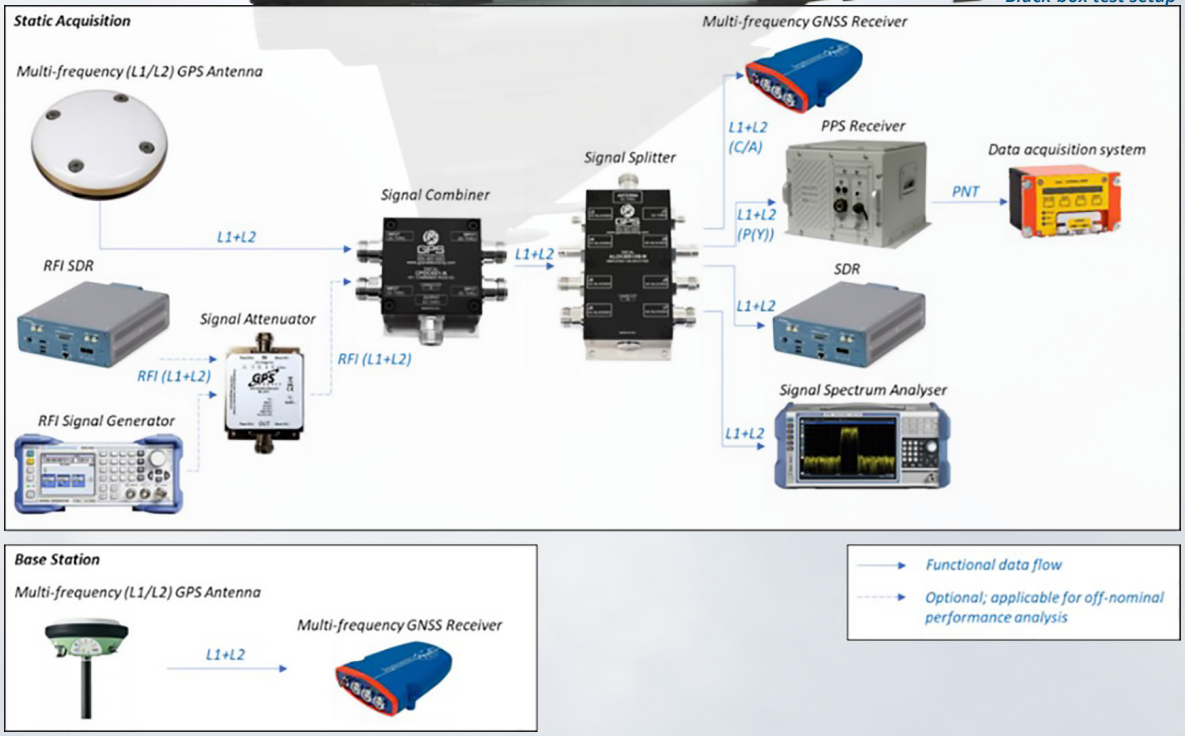
## THE SOLUTION

A new methodology is demonstrated based on extreme value theory and black-box testing.

- Black box testing with only 3 month of data collection
- Changes to the aircraft under test are not required
- Technical performance requirements are derived from the PBN regulations
- The safety levels for compliance are equal to or better than the PBN safety requirements
- Alternative compliance allows optimal use of airspace, strategic de-confliction of flight paths and reduction of ATC intervention

**Project partners:** Eurocontrol
**Period:** 2021 - 2022

*Black-box test setup*




**Project partners**
Customer: European Space Agency
SME (EU): Orange Aircraft (NL) and Barnard Microsystems Ltd. (UK)
Research organisations: Royal NLR - Netherlands Aerospace Centre (NL)
**Period:** 2018 - 2021

# Integrated Steerable Antenna for Beyond Line-of-sight L-band data Exchange-ISABELLE

**The market for satellite communications for Unmanned Aerial Vehicles (UAV) is expected to grow considerably in the next years. The growth of the UAV sector follows from the diversity of potential applications. Among the earliest applications of UAVs for civil use are the so-called dull, dirty or dangerous tasks (e.g. performing oil and gas exploration surveys). In order to routinely operate a UAV Beyond Visual Line Of Sight (BVLOS), one needs a SATCOM link between the UAV and the Remote Pilot Station (RPS).**

## THE CHALLENGE

A recurring obstacle is the accommodation of any satellite antenna into small sized UAVs. Geometrical dimensions of a single antenna are an obvious consideration for interfacing with the UAV. In the project an integrated satcom array antenna has been developed.

## WHAT DID WE DO

Available surfaces such as the wing and tail can be used to integrate antenna arrays. The objective of the ISABELLE project was to demonstrate by design, manufacture and testing the viability of an embedded antenna array with real time adaptive beam forming where the antenna is integrated in the wing structure of the UAV

## THE SOLUTION

The work carried out in this project comprised:

- Providing an overview of the available satellite services and antennas for satellite communication.
- Selection of applications that benefit most of the use of the integration of antennas in the mechanical structure of the UAV.
- Defining an antenna concept, antenna architecture and antenna requirements.
- Making a preliminary design of an array antenna integrated in the wing of a UAV.
- Design, manufacturing and test of a number of critical components of the antenna system.
- Manufacturing of the antenna arrays (receive and transmit), the beamformers (receive and transmit) and the antenna control.
- Measurements to characterise the manufactured components.
- Ground and flight tests.
- Writing a detailed design, development and manufacturing plan to bring the UAV antenna to production level.

# Development of AM-propellant tanks for use in satellites

**This research project aimed to develop additively manufactured propellant tanks using non-standard metals for use in ESPA and ESPA Grande-class satellites. The propulsion systems of Dawn Aerospace use self-pressurizing propellants, eliminating the need for helium pressurants and propellant management devices. This allows for flexible, custom tank designs without additional systems, making Dawn's propulsion systems simpler, faster to manufacture, and more cost-effective. This flexibility enables Dawn to accommodate various customer needs. The project contributes to the objectives of the Dutch space policy in the NSO roadmap for satellite systems and aligns with ESA's goals.**

## THE CHALLENGE

The goal of this project was to develop titanium propellant tanks for medium-sized satellites using metal Additive Manufacturing (AM). This development is important to prepare for a potential ban on hydrazine. Therefore, the project focused on using industrially available fuels with low toxicity. An additional goal is weight reduction.

## WHAT DID WE DO

The compatibility with propellants was investigated through various tests on additively manufactured samples. Tensile testing was conducted to establish design values. The material's performance was evaluated in different directions and after immersion in the propellant. Leak before burst testing was carried out on flat samples with printed surface cracks. The material had to show pressure relieving leakage rather than unstable crack growth.

Pressure testing, including proof pressure, cyclic pressure, and burst pressure testing, was also carried out. Qualification testing on a shaker with sinusoidal and random vibrations was performed on pressurised tanks to assess their performance under operating conditions, ensuring reliable operation.

## THE SOLUTION

Test specimen and titantium qualification tanks were produced. These test articles have been tested to qualification levels for representative pressures and vibration loads. All test results showed no anomaly. Furthermore, no compatibility issues with the propellants were found.

*Funded by the Netherlands Space Office (NSO): Small Business Innovation Research' (SBIR)*

**Project partners:** Dawn Aerospace (lead), Royal NLR, TNO– Energetic Materials
**Period:** 2021 - 2023

**Project partners**
**Industry (EU):** ArianeGroup
**Research organisations:** NLR, DNW, ONERA
**Period:** 2014 - 2020

# 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 DID WE DO

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.

The Ariane 6 was successfully launched on 9 July 2024.

# CFRP Vinci Thrust Frame

## Optimising the engine thrust frame of the Ariane 6 launcher

**The Ariane 6 Launcher will enter a very competitive commercial launcher market. New entrants to this market have reduced the launch price per unit mass payload by half (50%). Compared to Ariane 5 the production costs of the Ariane 6 launcher should be reduced by at least 50%.**

### THE CHALLENGE

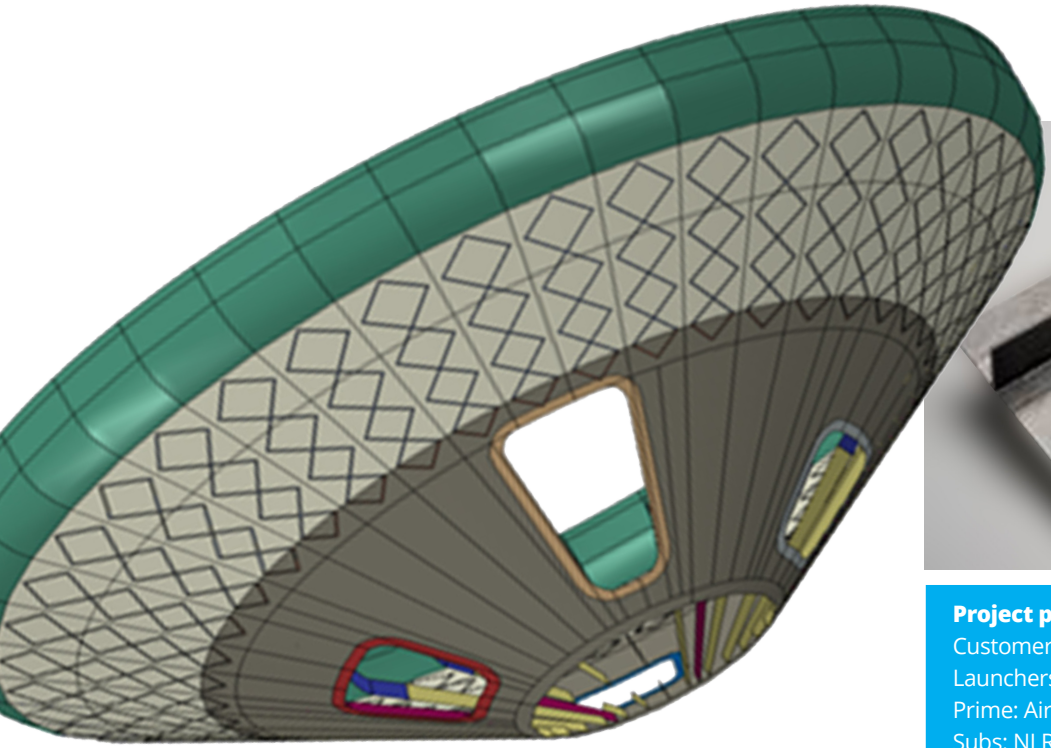
A key requirement for the development of the Ariane 6 is reduced recurring production costs and increased performance. Cost reductions and performance increase (both stiffness and mass) is to be realised in proposed materials, manufacturing technologies, processes, procedures and optimisation of the industrial organisation.

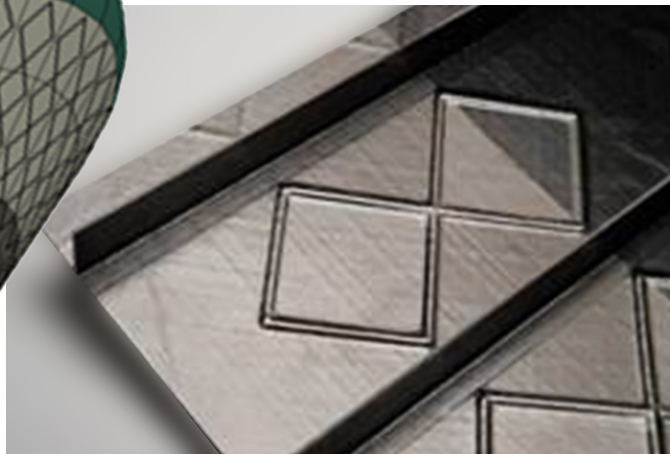
### WHAT DID WE DO

Currently, engine thrust frames for launchers are made from metal. Previous programs showed that cost and weight can significantly be reduced by application of carbon fibre reinforced polymers (CFRP) in tailored ply architectures, processed by the automated fibre placement technology. Based on a reference finite element model provided by Airbus DS NL, NLR developed optimisation to reduce the amount of manufacturing steps and tooling and to create vector fields for the steered plies. This innovative design in combination with the automated fibre placement technology will lower knock-down factors, reduce weight and minimize scrap material, resulting in reduction of material and energy consumption, processing time and increased payload.

### THE SOLUTION

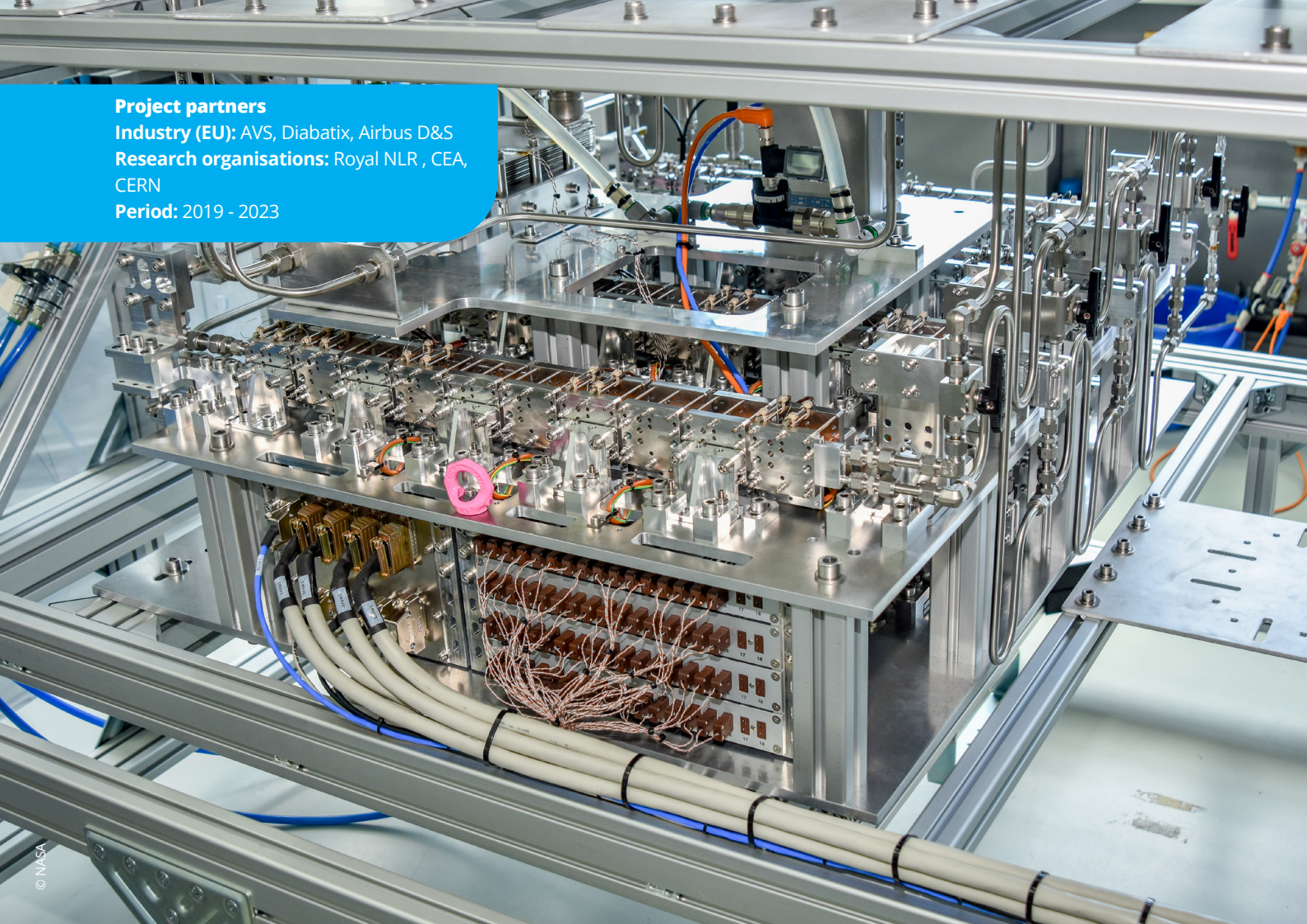
NLR developed optimisation to reduce the amount of manufacturing steps and tooling and to create vector fields for the steered plies. Dedicated local reinforcements are composed by smart overlapping in order to improve the buckling behaviour between the reduced amount of blade stiffeners. This innovative optimisation method is combined with the automated fibre placement technology. In addition, fibre detection methods are integrated by Infactory Solutions into the automated fibre placement technology. Possible material defects like gaps, overlaps or twists are detected, analysed and written to a database. Corrections are applied in order to support first time right production for further cost reductions.





**Project partners**
Customer: European Space Agency – Future Launchers Preparatory Programme (FLPP)
Prime: Airbus Defence and Space Netherlands
Subs: NLR, Infactory Solutions
**Period:** 2018 - 2020

**Project partners**
**Industry (EU):** AVS, Diabatix, Airbus D&S
**Research organisations:** Royal NLR , CEA, CERN
**Period:** 2019 - 2023



# 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.

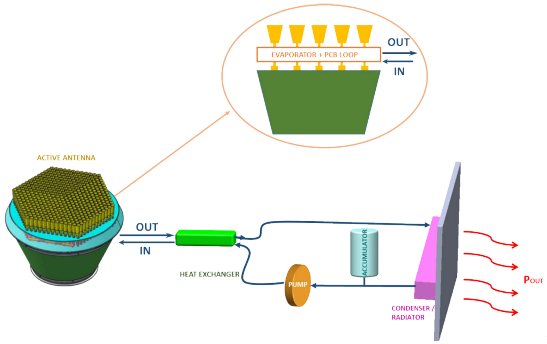
### WHAT DID WE DO

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

With the complete design, the necessary components were fabricated and assembled. This involved the usage of Additive Manufacturing for production of the evaporator section. The finalised system is currently tested to assess the correct working in various situations, including a test campaign in NLR's environmental test facilities.

### THE SOLUTION

The expertise that has been developed 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*

# 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 warmup 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.

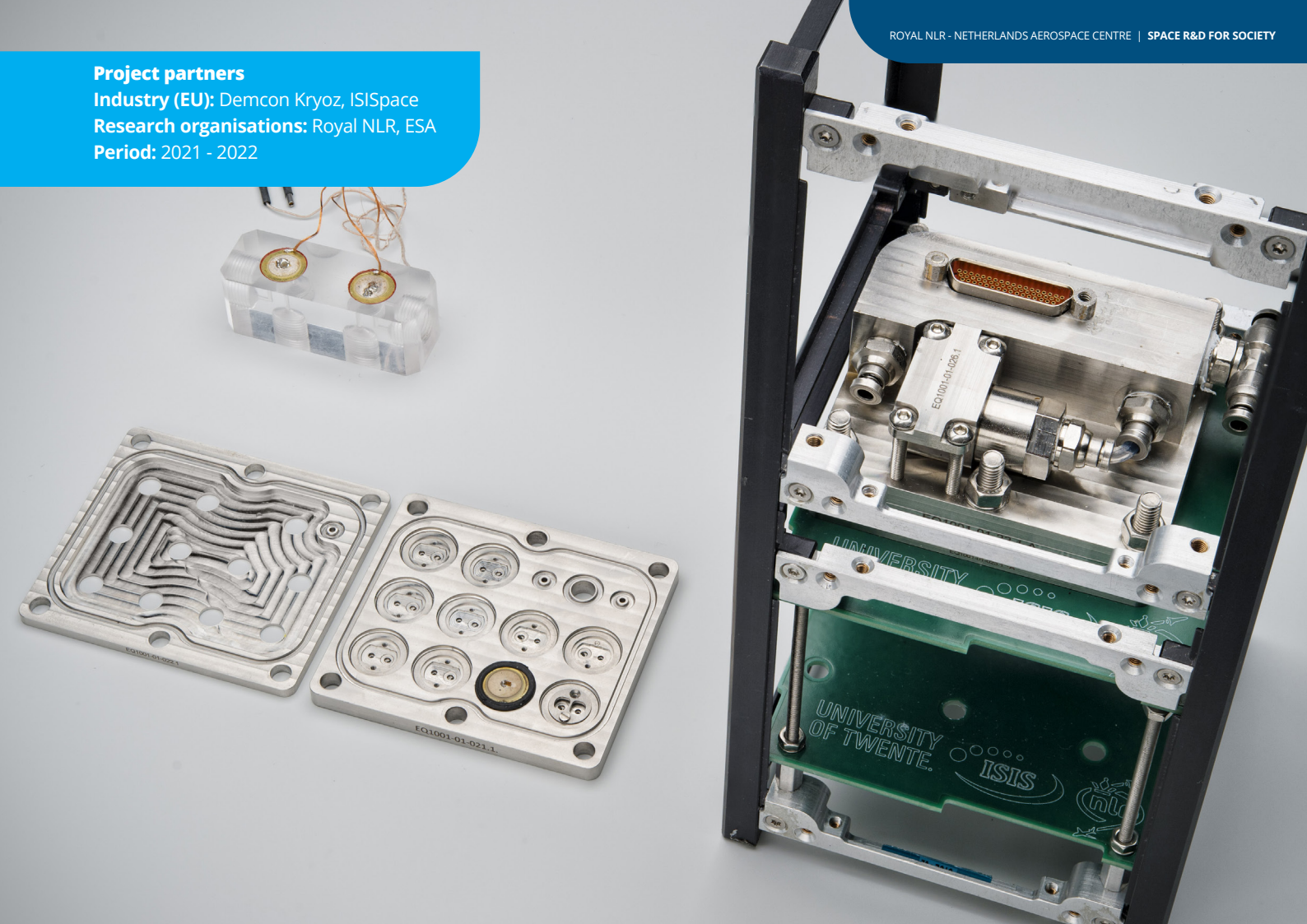
## THE SOLUTION

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%.

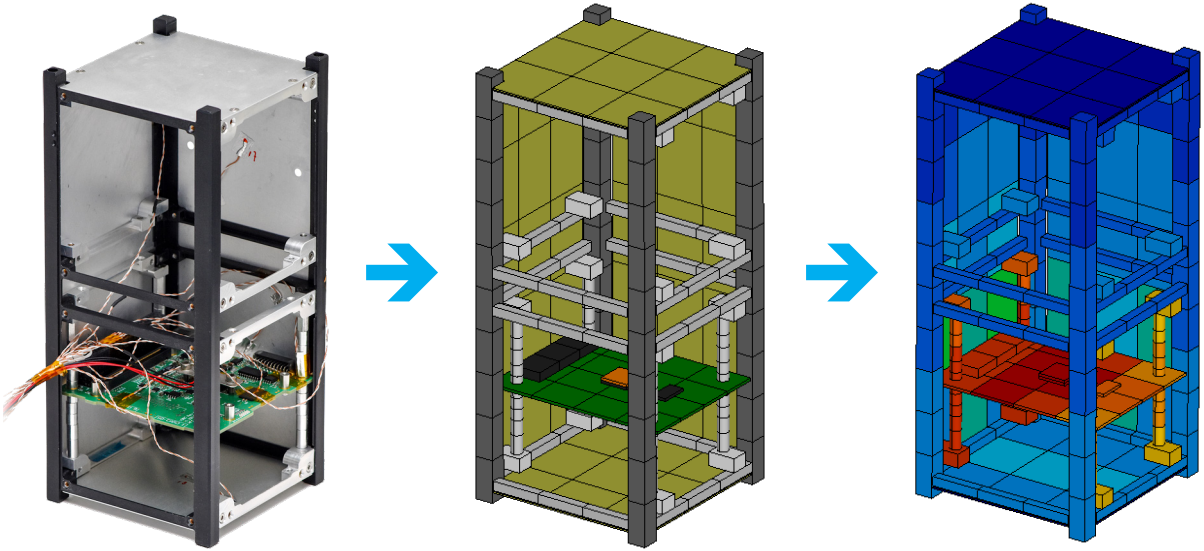
We currently have a full scale MPMP prototype including drive electronics which has demonstrated a mass flow of 500 mg/s which is sufficient to transport at least 20 watts of heat. The consortium aims to improve upon the design to transport at least 100 watts of heat away from a heat source, such as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

*This project was funded by ESA.*

**Project partners**
**Industry (EU):** Demcon Kryoz, ISISpace
**Research organisations:** Royal NLR, ESA
**Period:** 2021 - 2022



**Project partners**
**Industry (EU):** ISIS
**Research organisations:** Royal NLR
**Start:** 2019



# 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.

### WHAT DID WE DO

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.

### THE SOLUTION

Creating a library of validated thermal sub-models in ESATAN-TMS, which allows for fast and accurate orbital analysis, with improved thermal designs of Cubesats as the end result. 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.

# Virtual Reality AIT Trainer - ICARUS

**The assembly and integration of small satellites require a high level of precision and security. Aspiring satellite builders, such as university project groups, need to develop a comprehensive understanding of satellite construction and space awareness. Consequently, satellite companies like ISISPACE are seeking effective educational and training solutions to enhance the learning process for these future professionals.**

## THE CHALLENGE

The increasing demand for small satellites has led to a growing need for skilled professionals in the field of satellite assembly and integration. However, the traditional training methods for these complex processes are often time-consuming, costly, and limited in their ability to simulate real-world scenarios. As a result, aspiring satellite builders face significant challenges in acquiring the necessary skills and knowledge to succeed in this field.

The objective: to create a (VR) training tool that enables customers to efficiently train employees on the standard procedures for mechanically assembling and integrating satellites in a clean room environment.

## WHAT DID WE DO

The project yielded satisfactory results, as the VR tool was successfully developed en validated by experts. The tool is available for selection and training purposes, enabling knowledge transfer and skills development among (aspirant) professionals. The VR tool allows users to gain a realistic understanding of the work involved in satellite assembly and integration, thereby enhancing training and recruitment.

NLR focused on analysing the training needs, designing the training program, and validating its effectiveness. ATG developed the VR training tool and its environment, while ISISPACE contributed operational expertise.

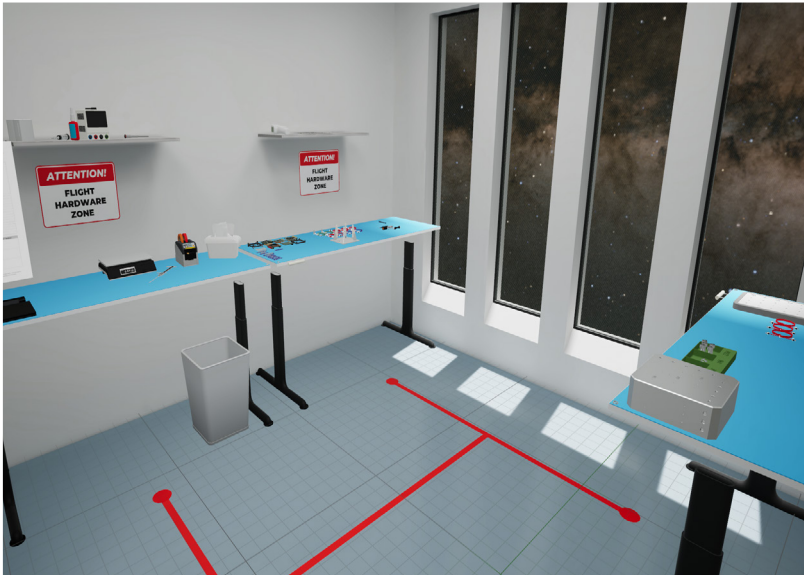
## THE SOLUTION

Virtual Reality offers a valid and efficient solution for training engineers in satellite construction, providing an immersive and interactive learning experience that simulates real-world scenarios, reduces costs, and enhances knowledge retention. The project partners developed a VR-training that provides a comprehensive overview of the entire assembly and integration process for a 1U satellite, fostering a responsible attitude and awareness of space-related concerns.

*This project was co-funded by the Dutch National Space Office (NSO)*

**Project partners:** ATG Europe (lead), ISISpace, Royal NLR
**Client:** ESA
**Period:** 2023 - 2024





# 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

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.

As an independent R&D centre for aerospace, NLR- Royal Netherlands Aerospace Centre is known for its practical approach and innovative solutions. NLR is the connecting link between science, industry and government. Based on our expertise combined with facilities we can support companies and government in the whole development chain from concept development to prototype and small series production.

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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