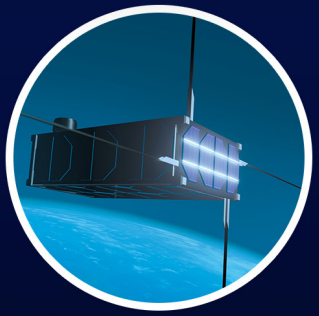
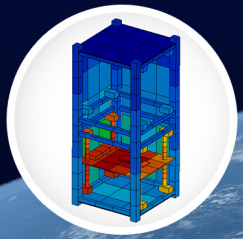
Dedicated to innovation in aerospace

Overview space capabilities





Royal NLR - Netherlands Aerospace Centre

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

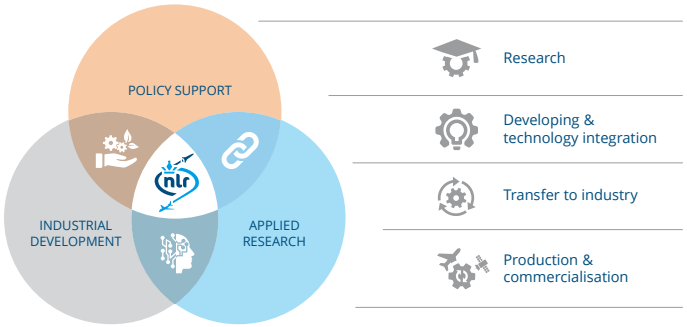
Developing applicable space innovations for society

Royal NLR works closely with both industry and government on developing satellite, payloads an 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.

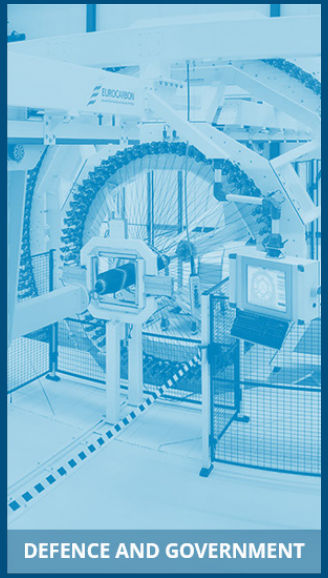
As an independent R&D centre for aerospace we are known for our practical approach and innovative solutions. Based on our expertise combined with facilities we can support companies and government in the whole development chain from concept development to prototype and small series production. We develop 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 low-gravity) 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



NLR, home to many markets



Overview NLR space

SPACE APPLICATIONS
- Satellite navigation
- Earth observation
- Space Situational Awareness

SATELLITES & LAUNCHERS
- Concept development
- Space avionics
- Antennas
- Thermal control

SERVICES
- Prototyping
- Low gravity flights
- Testing & qualification

ENABLING CAPABILITIES
- AI (on-board)
- Cybersecurity
- AR/VR
- Structures and materials

Space applications

NLR supports developments on the effective use of space data and on solutions to generate reliable and robust systems that use these data. We develop methods to automatically convert earth observation data into information products and services for example to detect events, like ship movements. In the area of satellite navigation NLR focuses on the development of robust positioning, navigation and timing (PNT) solutions including mitigation methods for interference for mobility applications such as drones.

As space gets more and more congested the need for a traffic management system for space (STM) is growing and also systems to accurately monitor the space domain and alarm systems to prevent collisions. NLR wants contribute to these solutions as safe use of the space domain is essential for the future. NLR is working on concepts for a SSA tool with an automated alarm system and exploring options for future STM concepts.

Space applications

Satellite navigation
Earth observation
Space Situation Awareness

Satellite navigation

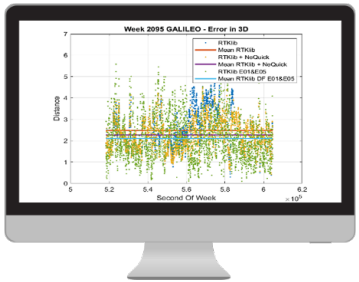
PNT robust to interference

Satellite Navigation is vulnerable to interference. NLR focuses on making it robust by designing new algorithms, antennas and procedures to detect and resist interference. When all else fails, we integrate other sensors to take over when satellite signals cannot be used.

New GNSS signals

Both Galileo and GPS 3 offer new features over the classical GPS signals, such as secure, encrypted signals and high accuracy corrections. NLR researches and tests these new signals to enable customers to use them in an optimal manner. We advise the Netherlands government on the use of new GNSS signals for a safer society.

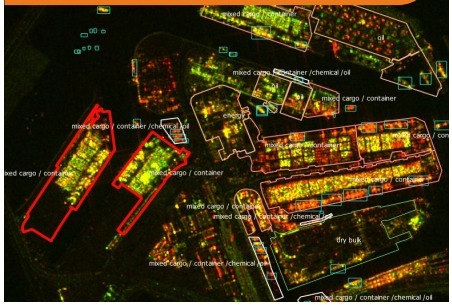
GNSS performance monitoring



NLR monitors the performance of satellite navigation signals and correction signals. This is important for critical applications such as aviation, where small deviations can cause accidents. NLR is expert in GNSS integrity monitoring.

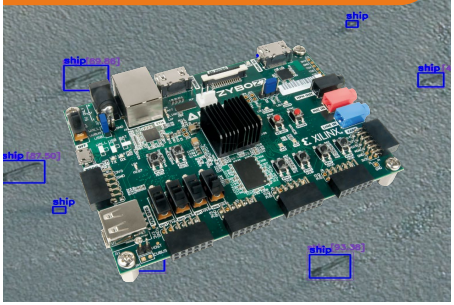
Earth observation

Information extraction



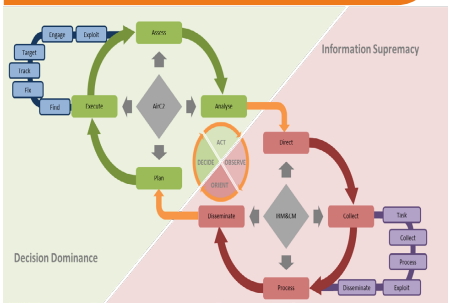
NLR works on the conversion of sensor data to information products and services for intelligence, monitoring and mapping. This involves automatic functions for feature detection, multi-source fusion, spatial-temporal patterns analysis, prediction and decision support. For this NLR uses machine learning, artificial intelligence and big data analytics.

On-board data processing



NLR develops and integrates ruggedized on-board processing electronics with optimized sensor data processing. Besides NLR analysis routines in order to select and reduce data, extract information and such reduce datalink demand, system response times and on-board storage capacity.

ISR process



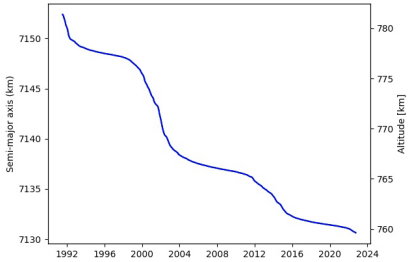
NLR investigates and perfoms experiments to enhance the information requirements management (IRM) and tasking, collection, processing, exploitation and dissemination (TCPED) processes for space and air observations in military, civil and hybrid operations

Space Situational Awareness

Information collection

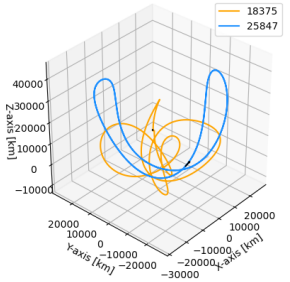
NLR focusses on the understanding of SSA. This starts with accessing the publicly available object tracking data and object information sources to ensure a complete database. By collecting this information on a daily basis, it is possible to investigate trends, procedures and anomalies.

Orbital calculations



With the gathered information in the form of Two Line Elements (TLEs), it is possible to calculate the orbital elements for each tracked object. By doing this, and by propagating the orbits for selected space objects, it is possible to get an insight in behavior and the space environment influences.

Process comprehension



Understanding the outcome of the performed calculations and the limitations of the current propagation techniques allows for a deeper dive into space object characteristics. Trends in operation or deviations from normal procedures can be identified, from which rendezvous and proximity operations can be predicted.

Satellites and Launchers

Concept development
Space avionics
Antennas
Thermal control

Satellites and Launchers

NLR supports developments that help bring small satellites easier, faster and affordable to orbit. We can play a role from the very beginning of a rough idea up to the production of a prototype of a launcher structure or a satellite component or sensor.
With our experience and overall system knowledge of space avionics we invest in small and medium size high end satellites.

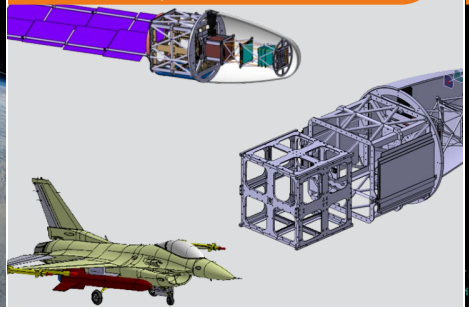
NLR develops phased array antennas or beamsteering antennas for satellite communication and smart satellite navigation antenna's. Phased array antenna's utilise a series of elements that allow the antenna bundle to be controlled electronically instead of mechanically. This makes them less vulnerable and more flexible.
NLR has very broad expertise in developing thermal management systems for space applications and specifically pumped systems. Such systems are interesting in satellites with payloads that generate a lot of heat and need to be cooled in order to function properly.

Concept development

Concept development & experimentation

NLR supports the development of whole concepts including system engineering, constellation design and operational use (BRIKII, MILSPACE...)

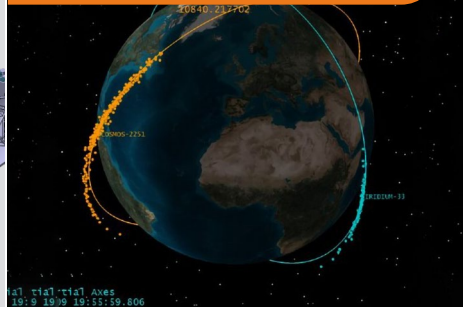
Alternative satellite options VLEO concept



Following from a small-satellite air launch concept, a VLEO satellite concept has been developed in parallel. The concept incorporates:

- Fairing retention in orbit
- Integrated and standardized sub-systems
- Modular payload section
- Standardized mechanical and electrical connections
- Responsive launch capability with a dedicated orbit in VLEO

Space Traffic Management

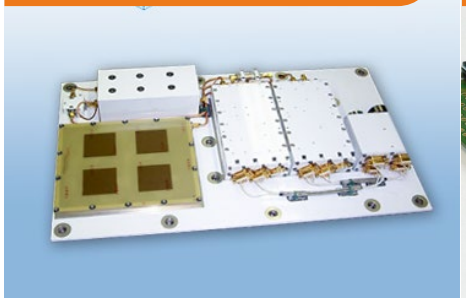


With the increase in number of launches and, subsequently, number of (small) satellites, a management system needs to be put in place as well – with quite some priority. Within STM, NLR has research potential in:

- ATM/ STM integration
- Orbital mechanics (collision avoidance)
- Re-entry procedures
- Material selection for design-for-demise and re-entry
- Technical assistance for regulatory decisions
- In-orbit recycling and refuelling

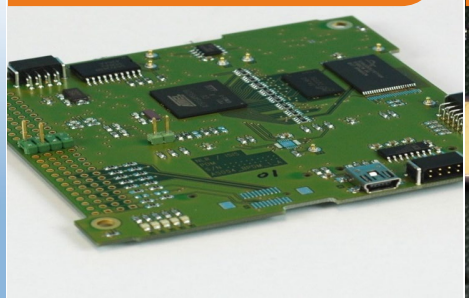
Space avionics

Sensor electronics



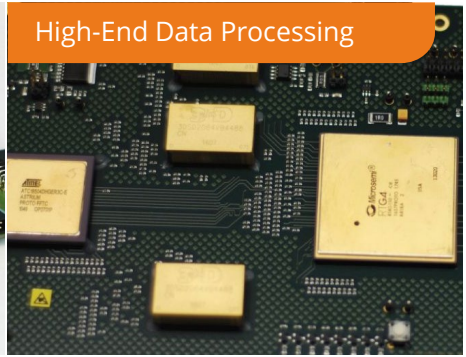
NLR's focus is on high-end space avionics for the small and medium size satellite market. High-end meaning increased reliability w.r.t. current SmallSat standards and space avionics offering very specific payload functions to support Earth Observation, ELINT and SIGINT.

Control units



NLR develops Payload and Subsystem Control Units for COTS-CubeSat to GEO and ISS class applications with a proper balance between size, weight, power, reliability and cost. All covered by a proper level of quality assurance.

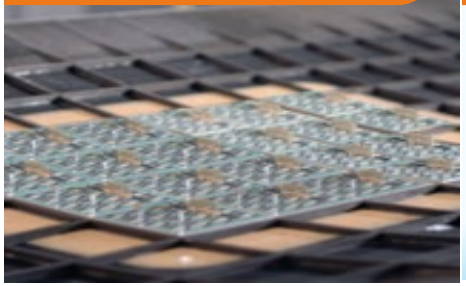
High-End Data Processing



While mission demands become more stringent on low-latency feature detection and data delivery, there is a strong focus on advanced in-orbit data processing functions as edge-AI and algorithms for SIGINT and ELINT using state-of-art hardware and software technologies.

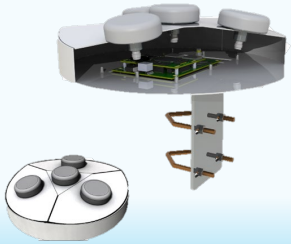
Antennas

Phased-array SATCOM antenna's



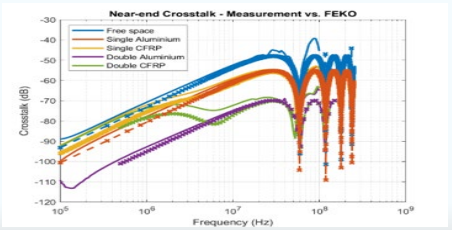
NLR develops phased array (beamsteering) antennas for satellite communication. Such antenna's utilize series of elements that allow the antenna bundle to be controlled electronically. Multibeaming makes it possible to send information to different locations at the same time. NLR is strong in integrating these flat antenna elements in structures.

Smart SATNAV antenna



NLR also develops smart satellite navigation antenna's, such as smart satellite navigation antenna's that are able to compensate for the vibration and deformation and can mitigate interference.

EMC modelling and analysis



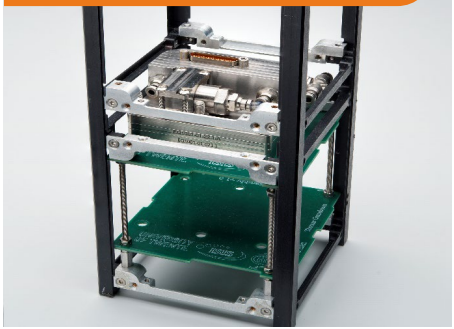
In order to predict the electromagnetic interaction of the antenna with the platform NLR performs modelling of antenna designs (based on SACAMOS software). In the Electro Magnetic Compatibility (EMC) lab NLR can also test the real performance of a system.

Thermal control

Pumped cooling in space

NLR has a broad expertise in thermal management systems for space, specifically pumped systems. With our two-phase systems the temperature of a system can be kept very stable. For the AMS-02 instrument on the ISS for example the heat fluctuations are less than 0.3°C.

Thermal control of Cubesats



NLR has developed a modular cooling system for cubesats or small satellites, a mini pumped loop with a compact design. As cubesats get more powerful and their design is very dense, heat problems are foreseen in next generation cubesats.

Modelling and demonstrators

As the design of two-phase systems is quite complex NLR often builds demonstrators for customers. Besides NLR carries out thermal modelling and also assists customers in setting up realistic thermal models of their designs.

Space Services

Prototyping
Testing & qualification

Space services

NLR has a wide range of test facilities available for testing, verification and validation. This includes environmental and structural testing and also wind tunnel testing, up to (zero- and low-gravity) flight testing.

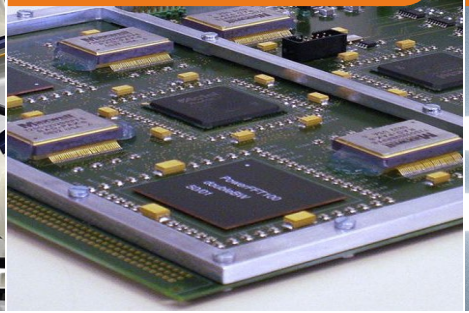
We also offer facilities to support companies to optimize their products and production processes such as composite structures in our Composites Field Lab and metal printed products in our Metal Additive Manufacturing Technolgy Centre (MAMTeC). We can also develop avionics and sensor prototypes in house supported by our ESA-certified personnel. Besides NLR has extensive experience in wind tunnel modelling and production of high precision wind tunnel models.

Prototyping

Composites field lab

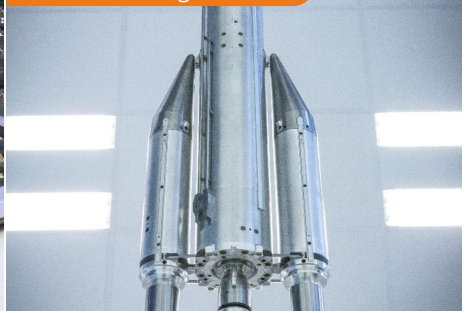
In our composites field lab NLR supports companies in optimizing their products and manufacturing processes: prototypes can be build and even small pilots can be runs. We have several facilities: Automated Fiber Placement (dry, thermoplastics, thermoset), Autoclave and Out-of-Autoclave processing, Press forming, Braiding, Resin infusion, Robotic welding of thermoplastics

Electronics and sensor technology



NLR can perform all steps in the development process of avionics and sensor prototypes. Capabilities include high-speed design, support of many programmable logic brands, PCB assembly including BGA package placement, precise mechanical machining and 3D printing. ESA certified personnel is available for the assembly of flight electronics.

Mechanical design and manufacturing



NLR is specialized in design and manufacture of high quality, high-precision structures such as frames, mirrors and wind tunnel models. Our wind tunnel models can incorporate smart features such as remote controls, advanced instrumentation, balances, rotating systems,....

Testing and qualification: Material and components

Coupon testing

NLR has a wide range of test facilities for mechanical testing, material evaluation and measuring control and calibration.
From material, coupon, component to full-scale level. Under extreme conditions (from -250 and up to 1200 degrees C) and within specific environment (wet, dry, toxic, ...).

Cryogenic component testing

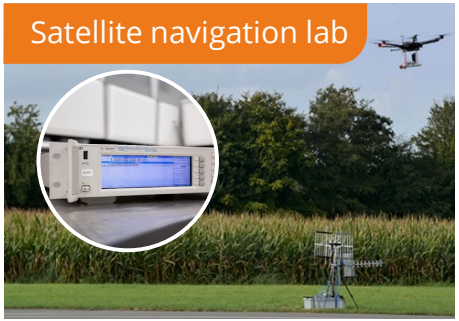
NLR can test all different kinds and sizes of components, even under extreme conditions. Like for example the Ariane 6 component that has been tested under cryogenic conditions (picture)

Inspection

NLR develops and applies appropriate inspection methodologies for all kind of structures including Non-Destructive Inspection (NDI) methods. We offer amongst others visual, ultrasonic, liquid penetrant, acoustics emission, lock in thermography inspection techniques.

Testing and qualification

Satellite navigation lab

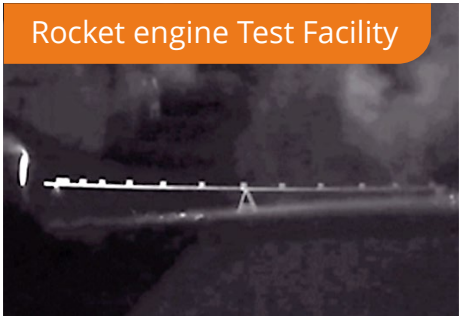


NLR has a number of facilities to test the robustness and reliability of GNSS systems. We have a GNSS various GNSS receivers, software defined radios and antennas available for testing. Besides both of the NLR offices are equipped with permanent GNSS antenna installations that can be connected to indoor test setups. Indoor tests can be performed over the cable or in the available testing halls, for example an EMC chamber or a large indoor hall suitable for indoor drone tests. For outside testing the NLR drone center and digicity support UAV tests in non-RFI conditions on our premises.

Low gravity flight testing

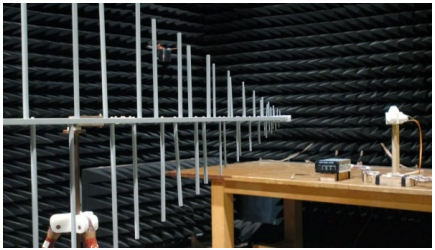
ace2space is the partnership between Royal NLR and Delft University of Technology for performing parabolic flights for testing space equipment before launching it (free fall tower, sounding rocket, space station). You can expose your application to in-flight zero- or low gravity conditions (e.g. moon or Mars), perform a customer-required number of parabolic maneuvers. No implication to take more parabolic maneuvers and associated costs than really needed. Flights are performed with our modified and instrumented Cessna Citation II research aircraft.

Rocket engine Test Facility



The Rocket-engine Test Facility Marknesse (RTFM) has been developed and used several decades ago to test rocket engines. It has recently been reinstated to continue testing and allow for new concepts to be tried. This allows for customers, student teams and NLR-internal projects to test rocket engines in a safe and controlled environment. Various propellant and rocket engine types can be tested at a small scale, within a flexible and low-cost set-up. The facility will be continuously developed to offer more comprehensive and professional support.

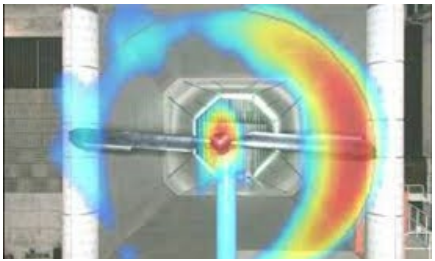
Testing and qualification: Environmental testing



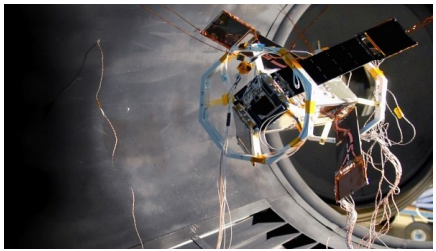
EMC

vibration

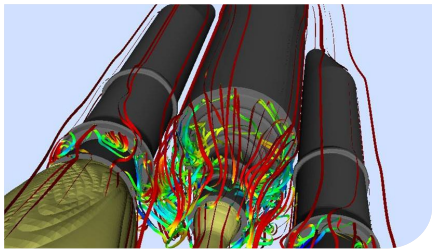
shock



accoustic



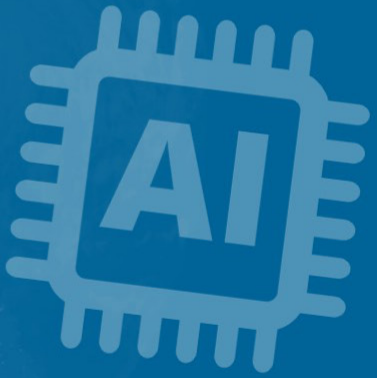
thermal vacuum



aerodynamic / supersonic

Enabling capabilities

AI (on-board)
Cybersecurity
AR/VR
Structures and materials



Enabling technologies

NLR has a wide variety of expertise area's that are relevant for space. Such as our AI expertise, that is relevant for the processing or space data on ground and more and more also for on-board processing. For this we work on the hardware and software side to develop suitable solutions for space.

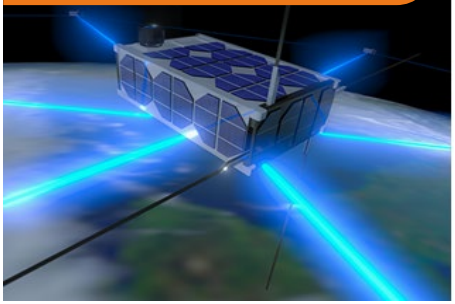
NLR has the ambition to support small satellites integrators and government to design safe and secure space systems. For this we do research on (automated) cyber security solutions for small space systems.

Furthermore, in our NLR X-Lab we develop applications with immersive technologies such as AR/ VR for customers in order to improve communication on designs or missions, to support engineering processes or make remote handling possible.

In the field of structures we focus on the development of light-weight structures based on composites and additive metal printing (AM). For composites NLR focuses on optimal design and use of composites in combination with automatisation of production processes to realise space structures for attractive costs. NLR has extensive knowledge of Metal-AM design rules, build preparations, production process and post-treatments, as well as certification and qualification processes.

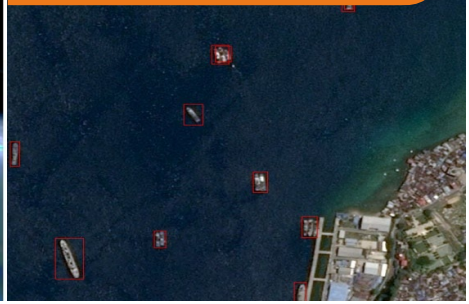
AI on-board processing

Smart on-board



With the increase in the number of small satellites, and the increased performance on-board as well, there is a necessity to ensure the availability of all collected information back on Earth. With the limited downlink capacities, one solution is to perform AI-supported evaluations on-board.

Ship detection



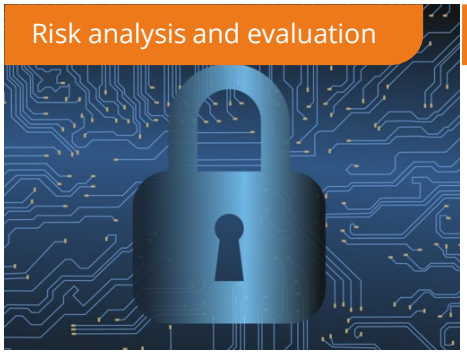
As a first use case, an NSO/ESA supported project together with AAC/Hyperion is ongoing for the development of a dedicated hardware unit with a ship detection task in mind. As the focus is on small satellites, the processing performance and required electrical power are taken into account when selecting the appropriate AI model.

AI Training framework

The bigger picture is to develop a training pipeline which allows for various types of datasets to be used for different use cases. With this, it will be faster to train an AI model for any sensor type with optimization for selected hardware to ensure optimal performance.

Cyber for safe and secure operations

Risk analysis and evaluation



As NLR we have the ambition to support the design of safe and secure space systems. Up to now our research focus has been on aerial platforms and operations like drones and will now be extended to satellites. One of the 3 cyber activity lines is 'Risk analysis and evaluation' of aerial systems and small satellites at platform as well as fleet level.

Secure Command & Control

A second activity line is 'Secure command and control' of air and space based systems This research line is also part of the MILSPACE project in Netherlands cooperates with Norway. NLR research focuses on security standards for space systems and the tailoring of these to small satellites.

Automated cyber assessment

Future resilient space systems will have automated cyber assessment on board. Through continuous monitoring the safety and security state of the systems anomalies can be detected and the platform can response to safety and security events. NLR focusses on sophisticated threats resulting from the inside threat (malicious code/operator) and the application of AI.

Augmented and Virtual Reality (AR/VR) technologies

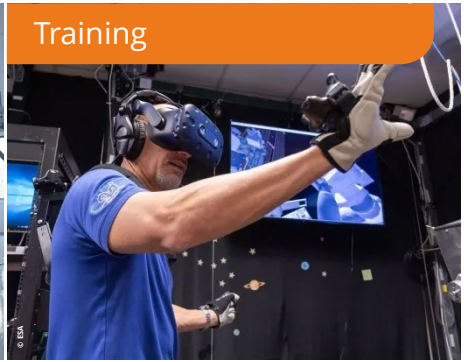
Immersive technologies

Information transfer is no longer confined to mouse, keyboard and screens. Immersive technologies like AR / VR make it possible to interact with information and be part of it. They are an added value for:
– Engineering process (MBE)
– Communication on designs, missions etc.
– Training
– Remote handling

Engineering Process

AR/VR can support the engineering process in various ways. It enables f.e. engineers to observe and evaluate hardware components or systems collaboratively in a more interactive and immersive manner than traditional tools. This can help to foresee problems and possible challenges in an earlier stage and save time in the development process.

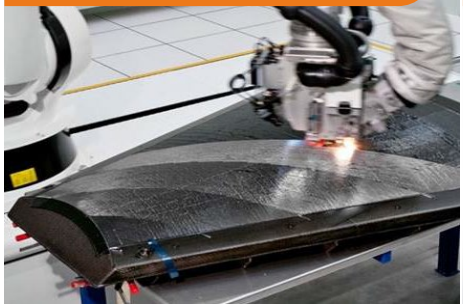
Training



AR/VR can be used to train engineers or astronauts. Immersive technologies can make training very realistic and effective and is affordable compared to a lot of current training means, such as high-end simulators or real-life training.

Structures and materials

Carbon fibre placement

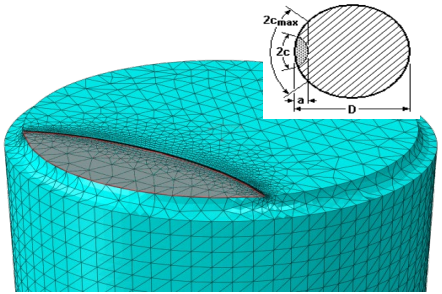


NLR has extensive experience with, and knowledge of, polymer based composite materials, including manufacturing processes. NLR focuses on optimal design and use of composites in combination with automatization of production processes to realize space structures for attractive costs. NLR works with dry fibers, thermoplastics and thermoharders.

Additive manufacturing

NLR has extensive knowledge of Metal-AM design rules, build preparation, production process and post-treatments, as well as certification and qualification processes. We work with deposition and powder bed fusion techniques and focus on printing with titanium, nickel, aluminium and magnesium alloys and combinations of materials.

Crack growth solution developments



For ESA we continuously improve crack growth analyses of the ESACRACK software package. We do this through the analyses of different types of crack growth solutions. The input is integrated into the software package Nasgro due to the cooperation between ESA and NASA.

R&D cases

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.

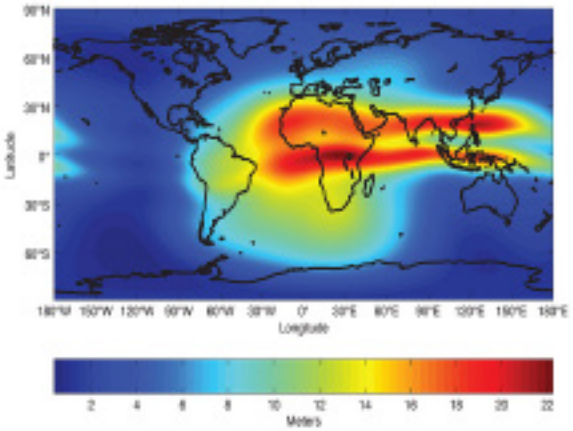
WHAT WE DO

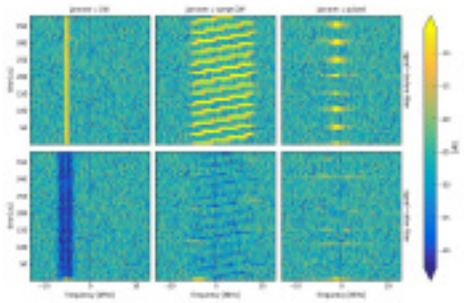
- Design and implementation of RF Interference Detection and Mitigation (IDM) module (interference filtering in time and frequency domain)
- Design and implementation of an anti-jamming antenna (interference filtering in the spatial domain)
- Design and implementation of a ionospheric correction module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





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

Start: July 2019
Duration: 2.5 years

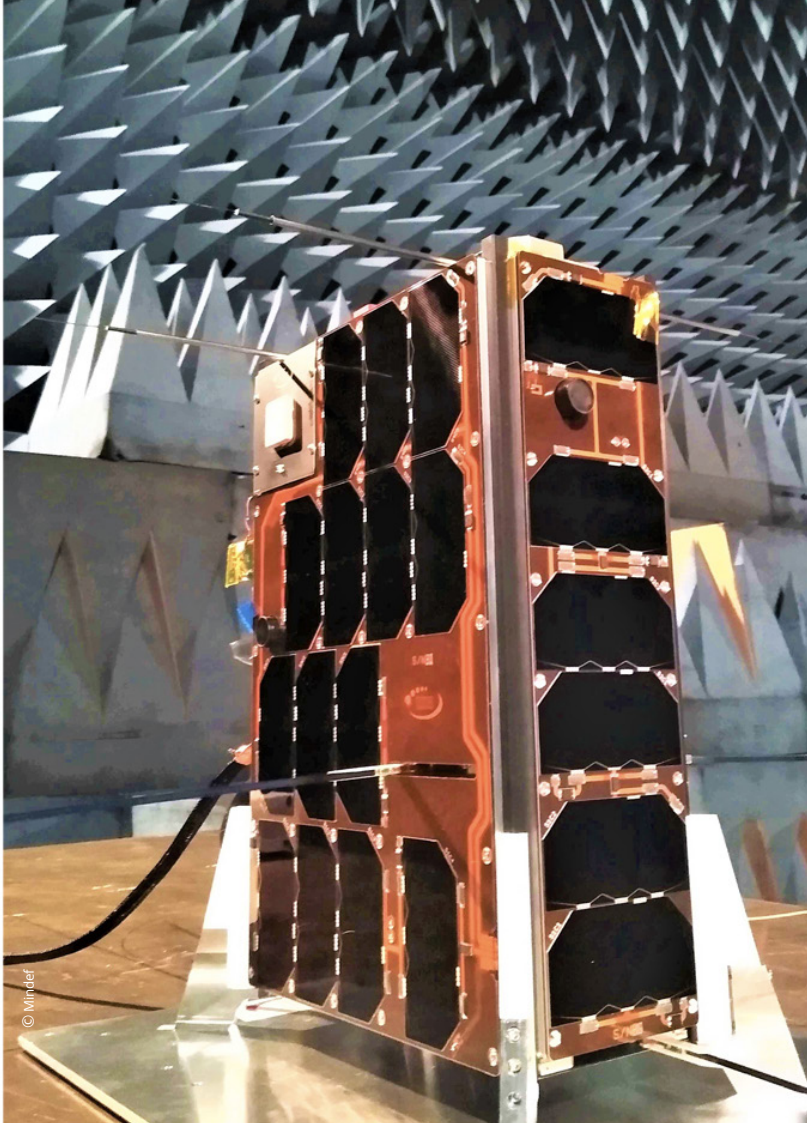
RF Sensor for CubeSats

With a more and more crowded RF spectrum, especially in the satellite communication domain, collection of information on the usage of the RF Spectrum becomes more and more important. NLR has developed a RF sensor for cubesats, called Phino. It detects and analyzes RF signals on-board of a cubeSats, it selects and filters these signals and sends the relevant information to the ground for further processing.

In Phino, the detection of signals is based on in-house developed innovative algorithms with an optimal trade-off between accuracy on one hand and low power consumption on the other hand.

KEY PARAMETERS PHINO

Mass: ca. 2.0 kg (depending on configuration)
Volume: ca. 1½ U (10x10x15 cm)
Power consumption : ca. 15 Watt (depending on the mode)
Operational modes: Raw mode or processed mode
Operating frequency: currently designed for X-band, but the design can be tuned to different bands according custom needs
Temperature range: -30 to +60 degC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BRIK II, the first Dutch military satellite

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

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

COOPERATION

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

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

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

Start: March 2018
Duration: 3 years

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.

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.

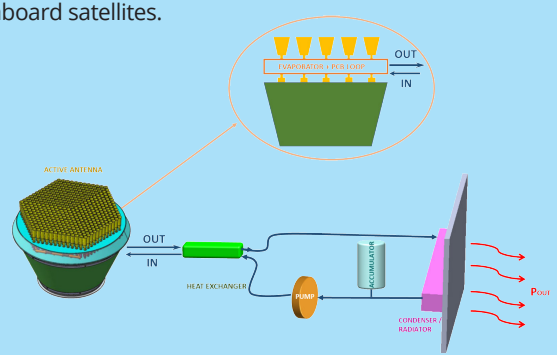
WHAT DID WE DO

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

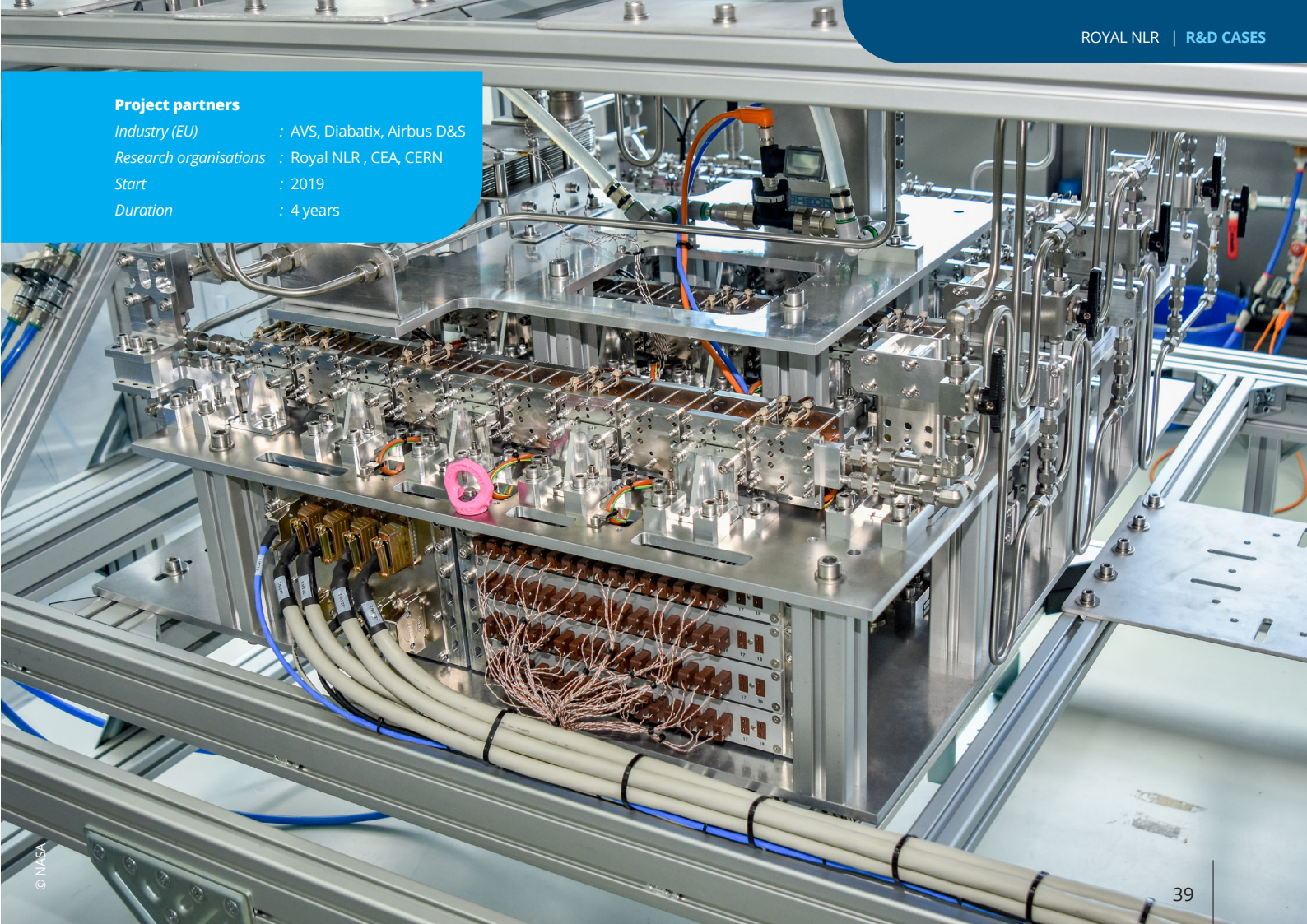
The expertise that has been developed during this EU-project, will be applicable in cooling needs for the next generation of satellites. This will enable the usage of electronics with a higher power density than currently used. Furthermore, the project has improved the TRL of two-phase cooling systems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

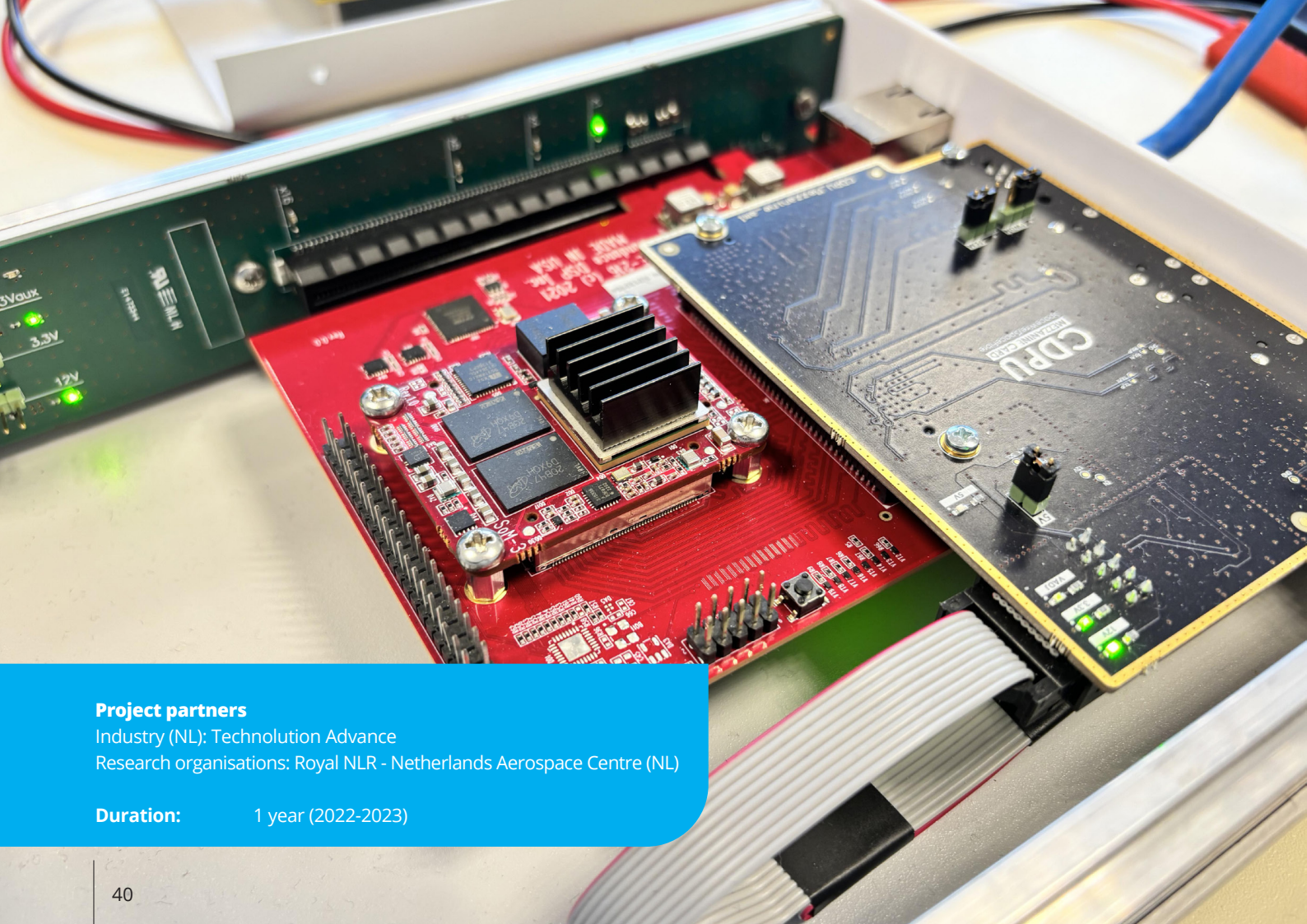


IMPACTA is co-funded by the European Union.
This message doesn't necessarily reflect the views of the EU

Project partners

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





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 and 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. The project contained two focus areas; 1) a technology development part aiming for optimised architecture and key parts selections, and 2) a business case refinement part with extensive consultation with potential stakeholders including ESA. In addition to the finalised project several R&D activities are being performed on specific product details. One example is the R&D on a robust and secure RISC-V processor for harsh environments under an EU Horizon KDT-JU (Key Digital Technologies Joint Undertaking) project.

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.

On-board Advanced Payload Data Processing

Satellites become more and more complex. Sensors have a growing demand in bandwidth, resolution, sensitivity and accuracy. This results in higher data volumes generated by these sensors. The downlink capabilities also increase, but not in the same pace which makes the downlink often the bottleneck for the mission utilisation and yield.

THE CHALLENGE

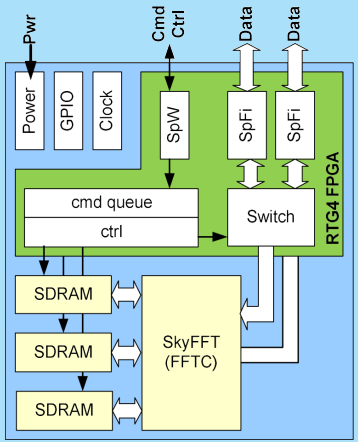
The challenge is to realise data compression or other advanced on-board data processing with the objective of downlinking less data or allowing more observations per orbit. This will optimise the utilisation and yield from space assets, and be an enabler for new mission capabilities.

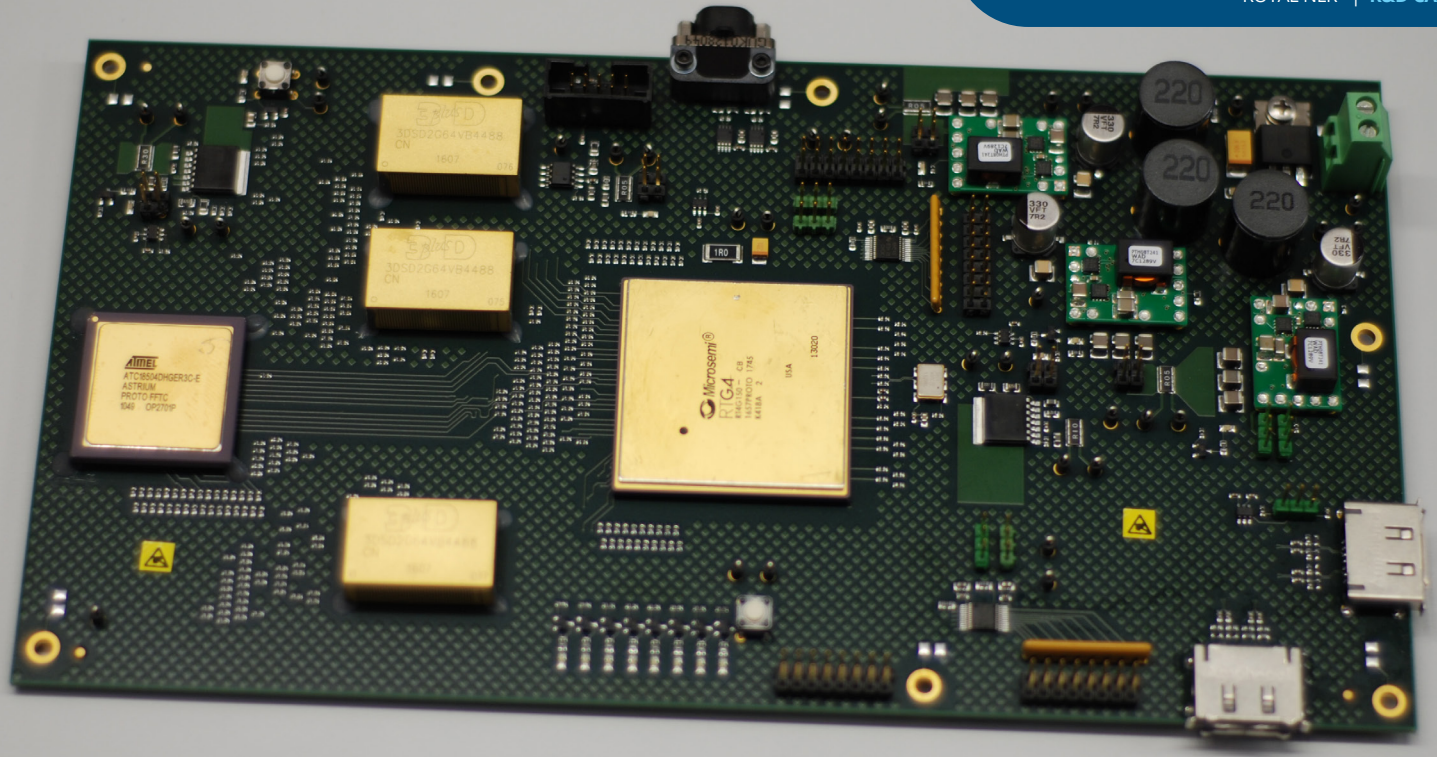
WHAT DID WE DO

NLR applied it's broad experience with dedicated processors for processing of artificial intelligence algorithms and Fast Fourier Transform operations. In this project the SkyFFT (Fast Fourier Transform Co-processor – FFTC), a space qualified ASIC that can perform all kinds of FFT operations, is applied. An RTG4 FPGA is used as core controller and included SpaceFibre interfaces capable to transfer payload data up to 2 Gbit/s net. A SpaceWire interface with a data rate up to 200 Mbit/s is implemented for TM/TC. The overall result is a hi-end and hi-reliable payload data processor board with a competitive form factor.

THE SOLUTION

Small and lower cost missions allow the use novel and high performance COTS components, but for larger missions (radar, SigInt and ComInt). the quality aspect becomes increasingly important. With the SkyFTT we developed a compact solution for efficient onboard data processing using Fast Fourier Transform operations. The overall result is a hi-end and hi-reliable payload data processor board with a competitive form factor.

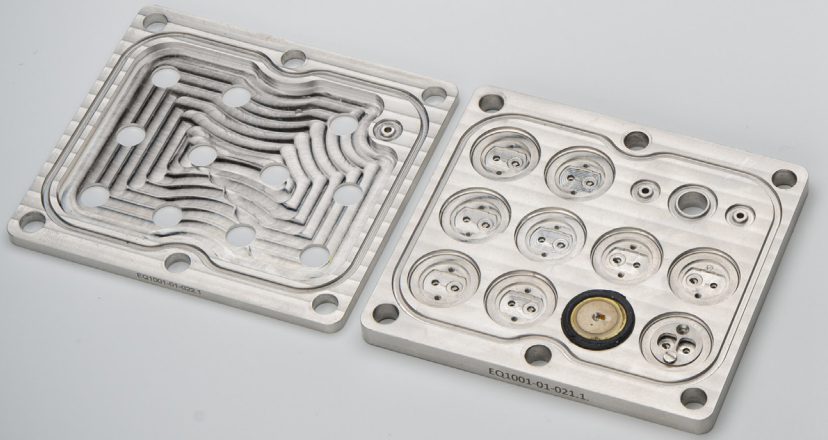


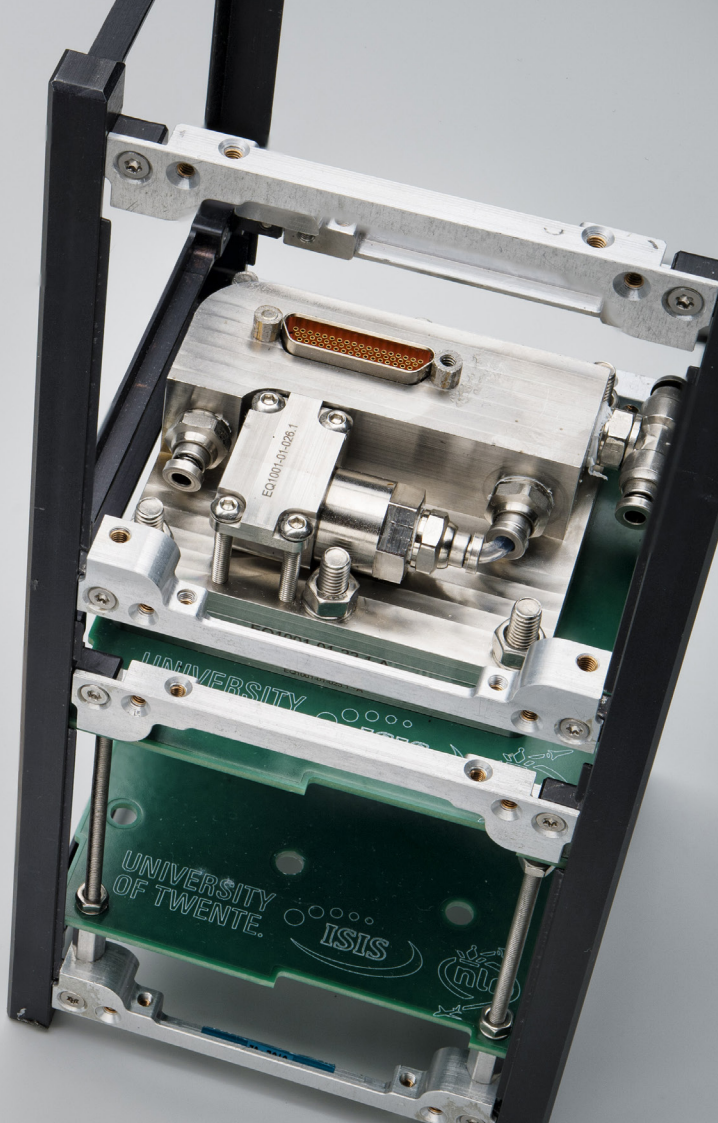


Partners
ESA GSTP Project executed by NLR and SSBV (now C-STS)
Project: finalised in 2018

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.

This project was funded by ESA.

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.

CFRP Vinci Thrust Frame

THE CHALLENGE

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%). As a consequence a key requirement for the development of the Ariane 6 is reduced recurring production costs and increased performance. Compared to Ariane 5 the production costs should be reduced by at least 50%. Cost reductions and performance increase (both stiffness and mass) shall be realized in proposed materials, manufacturing technologies, processes, procedures and optimization of the industrial organization.

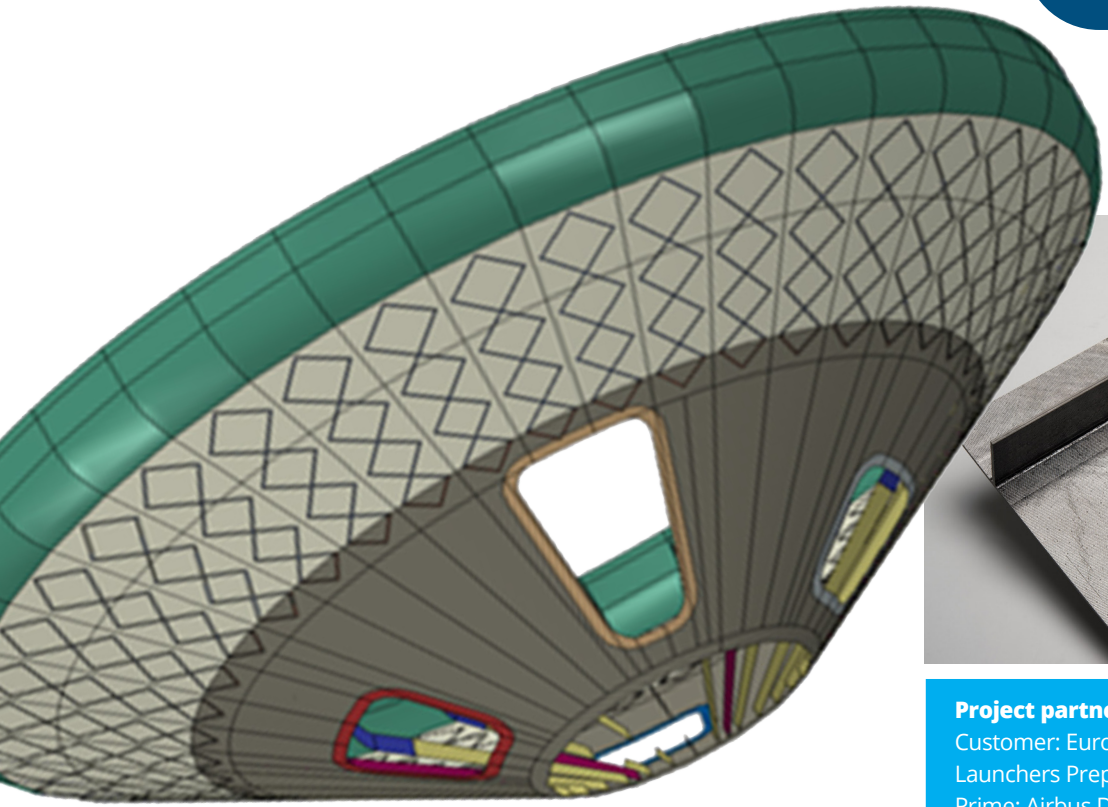
WHAT DID WE DO

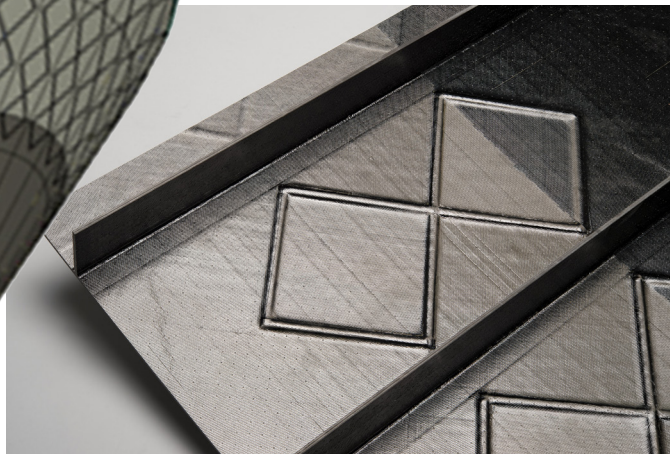
This innovative design in combination with the automated fibre placement technology will lower knock-down factors, reduce weight and minimize scrap material, resulting in reduction of material and energy consumption, processing time and increased payload. Together with application of smart tooling, a snowball effect is created to reduce. A detailed track record of each component will be available in a manufacturing database, containing as-built information.

THE SOLUTION

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 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.

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 in combination with the automated fibre placement technology will lower knock-down factors, reduce weight and minimize scrap material, resulting in reduction of material consumption and processing time in order to save manufacturing costs and increase the payload. 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

Project research infra:
GMV, NLR, FGI, Axentec, GMV NSL, Enaire

Aviation resilience to GNSS frequency jamming and cyber threats - AIRING

The AIRING project has investigated the increased risk of interference and spoofing for aviation, and the technical ways it can be detected or mitigated. A concept was proposed to combine technology and operational procedures, in such a way that GNSS interference can be detected and dealt with in an effective and safe way.

THE CHALLENGE

The increasing use of GNSS in civil aviation (Performance Based Navigation) also increases the risk of flights being affected by GNSS interference. When moving toward GNSS-based navigation solutions, detection and mitigation of such interference becomes critical. The project aims to present a set of technologies to be applied, as well as a roadmap how to integrate them into current rules and operational standards.

WHAT DID WE DO

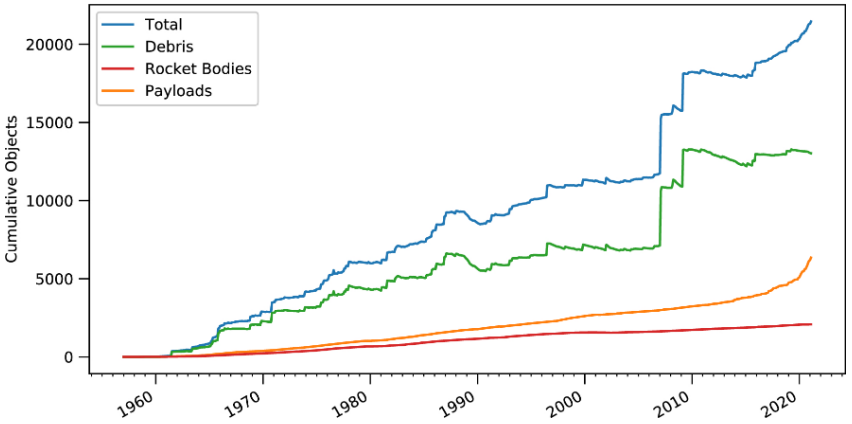
NLR has investigated the use of a controlled radiation pattern antenna for civil aviation. The complex, multi-element antenna enables both detection and mitigation of GNSS interference and spoofing. The impact of AIRING technologies on ATC operations was investigated in an operational demo with the tower (NARSIM) and cockpit (APERO) simulators, to show that the concept can reduce the operator workload and increase safety

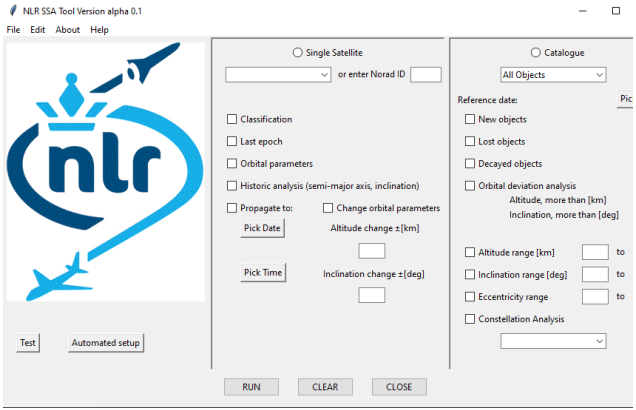
THE SOLUTION

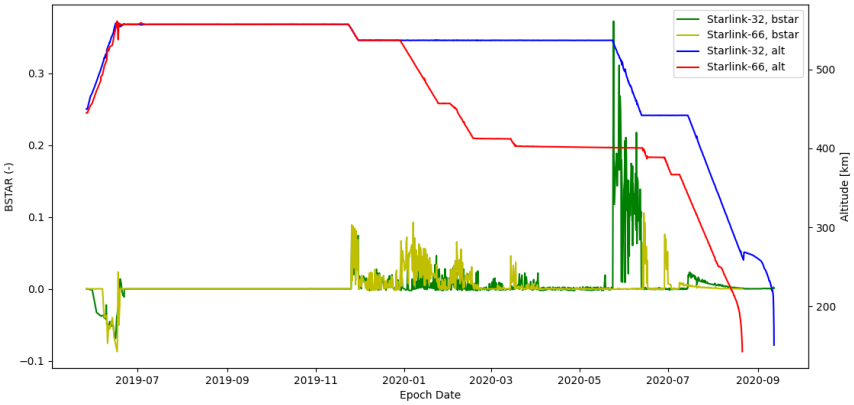
A wide range of technological solutions for interference detection and mitigation was investigated, ranging from simple and readily available filtering techniques to complex, new antennas that cannot (yet) be applied on civil aircraft. The technologies are integrated in a detection and reporting concept. An operational concept is proposed to integrate the solution into current ATC practice.

Project partners
Dutch Ministry of Defense -
Space Contour 2019

Start: 2019
Duration: 4 years







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.

As an independent R&D centre for aerospace, NLR- Royal Netherlands Aerospace Centre is known for its practical approach and innovative solutions to the complex challenges of the aerospace sector. Our mission is to make air and space transport safer, more efficient, more effective and more sustainable. 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.

Examples of our expertise fields:

- AI enabled on-board data processing
- phased array antenna's
- active thermal control
- Metal additive manufacturing and composites.
- Space-based Intelligence Surveillance and Reconnaissance (ISR).
- Space Situational Awareness (SSA) and Understanding
- Space based early warning

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