Dedicated to innovation in aerospace

Adding value to what protects us

Royal Netherlands Aerospace Centre

100 YEARS

Dedicated to innovation in aerospace

Milestones


1983

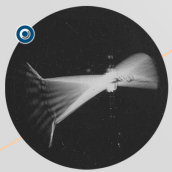

1921


1926


1919


1982


1955


1923

100 YEARS


2012


2011


2006


2006


2001


2070


1987


2016

	First air brakes **1921**
1919 **Establishment NLR**	
	First Dutch helicopter **1926**
1923 Flutter research	
	Flight data stored digitally **1962**
1955 New propulsion helicopter	
	New wing shapes **1970**
1966 Supercritical wing profiles	
	Safer & quieter flying **1982**
1980 Accurate position determination	
	Air Traffic Control Simulator **1987**
1983 First astronomical satellite	
	Lynx service life extension **2001**
1987 Vegetation monitoring Africa	
	Fighter pilots training simulations **2006**
2006 Detect-and-avoid-system	
	Antimatter detector cooling **2011**
2009 Hover trial simulation	
	Cleaner, quieter landing **2016**
2012 Tiltrotor wind tunnel model	
2019 **NLR 100 years!**	

A century of knowledge and innovation in aerospace

Wanting to progress is human nature. We dream about the unknown. We're curious about what we may find beyond the horizon and want to get to the bottom of things we don't understand. NLR has been an ambitious, knowledge-based organization for a hundred years now, with a deep-seated desire to keep innovating. We are very proud that we have received the royal predicate and that we are now the **Royal Netherlands Aerospace Centre**. Our knowledge and expertise have made us one of the driving forces in the aerospace sector, both in our own country and abroad. Our staff search tirelessly for new technology and have the courage to think outside the box, translating trends and developments into actual solutions for the market. That drive is helping us make the world of transport safer, greener, more efficient and more effective.

Above all, we keep looking ahead – because we have to keep setting ourselves tougher challenges if aerospace is to become more sustainable in the long term. How can we make sure that the environmental impact is minimized? How can we guarantee aviation safety despite its exponential growth? In short, how can we use airspace more efficiently? How can we make the best possible use of satellites and satellite data? The future looks highly demanding yet fascinating and it will require even faster innovation and closer cooperation, with the right driving forces behind it. We are devoting our knowledge and expertise to that future, with an eye on the interests of the commercial sector, the general public and the environment at all times.

Together with our partners, we can help shape the fascinating world of tomorrow. We are on the threshold of innovations that will really break the mould. But plans and ideas only really get moving if they are nourished with the right kind of energy – and the amazing thing is that the source of that energy is still exactly the same as it was when we started a hundred years ago. That driving force is NLR's knowledge.

Knowledge powers the future

Royal NLR

One-stop-shop for Defence

The research and activities of Royal NLR comprise working in a challenging and fast-changing field of research every day, assisting a wide range of clients. NLR has available a wide range of test facilities with which we can test, verify and validate products. Royal NLR can support anyone in need of technical and operational support for the safe and effective deployment of air defence platforms such as

- technical support for the acquisition of new weapon systems and their subsequent modifications
- support for the life cycle management of aerospace-related weapon systems
- support in determining and implementing military aviation standards
- research into the environmental aspects pertaining to military aviation and advising the Defence department in the formation of its policy in this area
- the implementation or design of effective training programmes for pilots, onboard personnel, ground-station and maintenance personnel of aviation systems
- technical support for the interoperability of aviation weapon systems or support for the Ministry of Defence's general policy.

We have selected some of the projects, research and capabilities that we have developed ourselves and together with partners, for you to get to know more about NLR and our activities.

We hope you enjoy reading and discovering more about Royal NLR.


Requirements
Life cycle support
Improvements
LC SUPPORT
SYSTEM
OPERATIONS
OT&E
Flight safety
Operations

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

Start: February 2000
Duration: ongoing

F-35 Acquisition & Operational Readiness Preparation

WHY?

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

HOW?

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

- Training Needs Analysis for pilot maintenance staff, and mission-support roles
- Design of a F-35 Pilot Competency Profile, initial and recurrent training course content
- Training Media Selection Analysis
- Business case for a Maintainer Training Centre (MTC)

WHAT?

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

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

Royal NLR contribution to the F-35 Lighting II of the Royal Netherlands Air Force

- ET Simulator/ET Demo
- SJE Wind Tunnel Testing
- Low Speed Inlet Test
- IOT&E Participation
- Gun Pod
- Embedded Training

ISR: Lead by Information with Innovation

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

WHAT YOU NEED

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

WHAT WE DELIVER

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

OUR CAPABILITIES

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


SOUTH
MM
MB
NB
NM
MA
NL
ML

CEREBRO:

The NLR Air & Space Operations Battlelab

WHY?

The increasing complexity of modern warfare, with its various forms ranging from very asymmetric counterterrorism operations to full scale peer conflicts, requires research on new tactical and operational systems and concepts. These, usually joined and combined, operation concepts need to be tested in a secure environment which can be safely connected to similar secure battelabs located at national and international partners. New generation platforms, new command and control concepts and the increased adoption of "information governed operations" in combination with the quick rise of big data analysis and artificial intelligence capabilities pose new operational challenges for the RNLAF.

HOW?

NLR provides a battlelab capability by integrating high fidelity platform simulators with additional proof of concept demonstrators and extension to other battlelabs. The platforms include Fighters (F-16 and F-35), Helicopters (AH-64, CH47, NH-90), UAV's (MQ-9, ScanEagle) while the concept demonstrators include e.g. (Air-) C2 and ISR related systems. Cerebro can ultimately also be coupled with live systems when connected to e.g. a Link-16 or a DIS gateway.
The extensive use of platform simulators and computer generated forces will reduce the costs while enabling testing of new functionalities concepts in a safe environment and freeing operational flying hours for other purposes.

NLR has a long history in Military Operations research which has produced a number of operational tools that will be integrated in Cerebro. These include a threat reference manual, mission planning tools with AI support and very advanced and accurate weapon system models. The dedicated NLR developments are combined with products developed by industry and other research institutes to create a state of the art battlelab environment allowing CD&E sessions of different scales without the need to (re)build the test environment first. New systems will be added to Cerebro over time when developed in separate programs and these will then be maintained for use in new programs that will run on the Cerebro environment.

WEST: Weapon Engagement Simulation Tool

Thanks to WEST (Weapon Engagement Simulation Tool), NLR has a validated simulation environment available for detailed modelling and simulation of weapons systems. Air-to-air, air-to-surface and surface-to-air systems, sensors and weapons are all covered. WEST has its own interface for defining scenarios and engagements and for visualising and analysing the results. In addition, both single engagements and batch runs or scenarios with multiple entities can be handled. The models in WEST are however also available to use separately. This has already been done in the F4S environment, where the missile fly-outs are generated by WEST and the DLZ (dynamic launch zone) in the HUD (heads-up display) is also directly linked to the WEST missile models. Embedded training (ET) also utilises models from WEST.

STK: Satellite/Systems Tool Kit

NLR has STK (Satellite/Systems Tool Kit) as a simulation environment for operational space scenarios. This allows both single satellite systems and constellations for the military use of space to be modelled, including the sensors. In addition to models of the space domain, STK is integrated with objects specific to the land-based, maritime and airborne domains for purposes of observation (of the Earth), communication and navigation. Operational issues relating to line-of-sight calculations, overfly times and communications links can then be calculated and visualised.

A user-friendly MMI lets the user set up operational scenarios rapidly using the objects from the various domains.

MUST: Multi-UAS Supervision Testbed

MUST is NLR's testbed for operating unmanned systems. It provides a workplace for an RPAS crew that can be used for controlling multiple RPAS craft at the same time. MUST offers standard functionalities, while additionally being fully customisable as required. The architecture of MUST supports control of operational and simulated RPAS; this has also been demonstrated in practice. One aspect that makes this possible is the STANAG 4586 compatibility.

MUST is an integrated component of NLR's Airpower Simulation, in which all the NLR simulators can be linked flexibly as required for a variety of missions. For example, MUST has connections to Fighter 4-Ship (F4S), Helicopter Pilot Station (HPS) and Virtual Battlespace (VBS). This makes manned-unmanned teaming (MUM-T) concepts possible, for instance.

In addition, MUST can be coupled to NLR's Video Exploitation System (VES), allowing MUST to be utilised as an element of an actual or simulated data-to-decision chain. Moreover, for carrying out tests for the integration of RPAS craft in controlled airspace, MUST is also linked to NARSIM. NARSIM is NLR's simulation environment for radar and ATC towers. This connection offers options for testing new concepts with RPAS, from the perspectives of both the ATC (e.g. in a tower) and the RPAS crew.

Air Operations as a Team

The Air Operations as a Team uses Virtual Battlespace 3 (VBS3) as a simulation environment for executing tactically relevant helicopter scenarios. The project was typically CD&E in nature and involved the end users closely. In three experiments, up to 21 participants at the same time (AH and TH pilots, load masters and commando troop staff) carried out simulated missions. This determined the added value of mutual data exchange, both of live remotely-piloted aircraft systems (RPAS) during operations and for being able to control the RPAS (sensor and flight path) from the helicopter.

Fighter 4-Ship for Tactical Intercepts (TI)

For a variety of reasons, it can be useful to provide elements of BVR (beyond visual range) aerial combat in a simulated environment. Firstly, it often turns out to be difficult in practice to get enough aircraft into the air to handle more complex setups (such as 4 versus 4). In addition, aspects that are not possible in reality can be approximated in a simulator. The performance and behaviour of enemy aircraft and the associated systems such as radar and IRST can for instance be modelled realistically. Using computer-generated forces (CGF) eliminates the dependency on scarce human and other resources for generating opponents. It is also possible to insert fly-outs of missiles – both friendly fire and from the opponents – into the scenarios. Integrating fighter controllers into the simulation creates an environment in which not only pilots but also combat leaders are involved, for instance through joint debriefing.

Integrating Fighter 4-Ship (F4S), with other simulators creates an environment in which tactical actions can be evaluated effectively. This environment can for instance be used for experimenting with various presentations and for modifying tactics.

Detect and Avoid development

2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

AIRPASS
Feasibility study of required (on-board) equipment for integration in u-space

B-VLOS
BVLOS flights planned to gather experience, support rule-making in the Netherlands and develop the market potential.

DAA Miniaturization

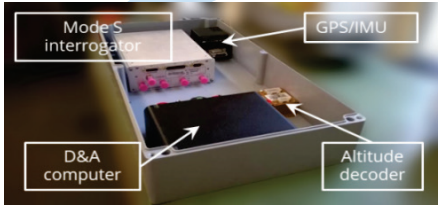
AIRICA
Interface design with RPAS BVLOS without visual observers Flown with manned aircraft to evaluate Detect And Avoid measures

PODIUM
Demonstrate U-space services with today's technology in 'unexpected' situations (incl. BVLOS flights)

Fuel cell Drone

VUTURA
Validation of U-Space by Tests in Urban and Rural Areas. Combination of different U-Space systems

Explorer
System Development & Testing



AIRICA:

ATM Innovative RPAS Integration for Coastguard Applications

WHY?

The purpose of this SESAR 'Demonstration Activities' project was to perform a Beyond Visual Line Of Sight operation for a realistic application, demonstrating Detect And Avoid functionality, aiming at:

- demonstrating how to integrate RPAS into non-segregated airspace in a multi-aircraft and manned flight environment;
- focusing on concrete results filling the operational and technical gaps identified for RPAS integration into non-segregated airspace; and
- capitalising on the SESAR delivery approach by providing synergies, risk and opportunities.

HOW?

NLR had already developed the AirScout Detect And Avoid (DAA) system to fulfil the essential function for the integration of RPAS in in non-segregated airspace. The AirScout system is a cooperative DAA system based on Mode-S Transponder interrogation and ADS-B reception combined with algorithms that assess the risk of conflicts and devise a realistic solution if necessary. In teamwork with Schiebel the AirScout system was integrated in the S-100 CAMCOPTER®.

Together with the Netherlands Coastguard and the Royal Netherlands Air Force a flight test campaign has been performed at the Netherlands RPAS Test Centre. The final validation flight campaign has been successfully performed at De Kooy Den Helder Airport using both Coastguard and RNLAF aircraft as manned intruders.

WHAT?

The AirScout system contains all necessary sensors for its functioning and is only dependent on the RPA for its power supply, the location of the antennas and the use of a data link (channel). The system was set-up with qualified Commercial Of The Shelf (COTS) hardware and in-house developed NLR software. During the demonstration preparations, 14 test flights have been performed with a total of 26.5 flight hours and over 50 intruder encounters to verify the system's correct functioning. The Detect And Avoid functionality has been successfully demonstrated during the execution of a Coastguard SAR mission. During the preparation and execution of the demonstration a lot of experience has been gained on several different subjects such as: regulations, organization, ATC interaction, airport involvement, and technical issues.

Project partners
Government (NL): Netherlands Coastguard
Research organisation (NL): NLR
Industry (AT): Schiebel
Defence (NL): Royal Netherlands Air Force

Start: October 2013
Duration: 2½ years

Maintenance Engineering, Management and Technology (MRO)

AIRPOWER is dependent on the number of fighters, helicopters and transporters you can deploy at any time, also on short notice. It requires top-notch availability, even in peace time, because conflicts can escalate quicker than you can push aircraft in maintenance out of the hangar. If your fleet spends too much time in maintenance and if you are seeking higher availability, talk to Royal NLR with its proven track record in military aircraft Maintenance Repair and Overhaul (MRO).

NLR delivers, based on unique and high-quality knowledge, practical solutions for excellence in maintenance operations, and innovative maintenance technologies to improve availability and affordability with standard and tailored solutions for maintenance organizations, airlines and OEMs in civil and military domain. So, what can NLR do for your availability?

MAINTENANCE ENGINEERING – NLR can help you improve the effectiveness of your maintenance activities. We can help you to (i) set up reliability programs to measure your performance, and (ii) assess the effectiveness of your Aircraft Maintenance Programs. And we can help you to improve your availability by adjusting maintenance task intervals. Or we can help you improve your system reliability. NLR offers Root Cause Analyses to (i) expose the root cause, and (ii) develop practical measures to eliminate root causes. NLR performs RCAs for the RNLAF and we are successful with quick wins, constantly improving the annual availability and affordability of the RNLAF fleet.

MAINTENANCE MANAGEMENT – NLR offers you practical solutions for excellence in maintenance operations. We can help you with your regulatory processes, such as the implementation of the European Military Airworthiness Regulations or EMARs. You benefit from our civil and military expertise, opening the door to efficient and effective regulatory processes in military operations. If you want insight in the cost-effectiveness of your operations, you can evaluate your operations with our Aircraft Availability and Resource Estimator, a decision support system to evaluate your budget and resources against your on-time performance. Or if you want to maximise your availability and affordability, we can optimise your maintenance schedule by repackaging your maintenance tasks and your planning using our state-of-the-art optimisation tool FlexPlan. NLR helps the RNLAF with the implementation of EMARs and planning optimisation using FlexPlan.

MAINTENANCE TECHNOLOGY – NLR develops innovative maintenance technologies to improve availability and affordability. NLR offers a tool to determine the failure modes of components about to fail. This helps you troubleshooting problems at the line and in the backshops. Our tool Failure Diagnoses using eXplainable Artificial Intelligence or FD XAI also offers predictive capabilities, giving you indications about the remaining life of components. NLR also develops robot technologies to overcome manpower shortages. We develop robots to perform maintenance inspections, focussing on sensors and platforms for inspection purposes. For example, we currently work on a helicopter main rotor blade inspection robot. We minimise the workload of blade inspections and improve the track and balance of the blades.

Competency based maintenance training

WHY?

The development of the European Military Aviation Regulations (EMAR) resulted in changes in the Dutch military aviation regulations. The content and levels of the maintenance type training for the F-16, AH-64D, CH-47D/F and the NH-90NFH therefore needed to be updated. Besides, the training did not fully meet the needs of the (novice) maintenance mechanic and the training did not always represent the actual work of mechanic accurately. The focus of the training was merely on theory. Practice was not offered in an integrated manner.

HOW?

In cooperation with maintenance mechanics and instructors, the different steps in an instructional design process have been carried out. To analyse the training needs, several workshops where held with both experienced and inexperienced maintenance mechanics. Throughout the process, different presentations and discussions were held to explain and define the desired training concept. Working sessions with the instructors and developers were subsequently held, in order to develop a training in accordance with this concept.

WHAT?

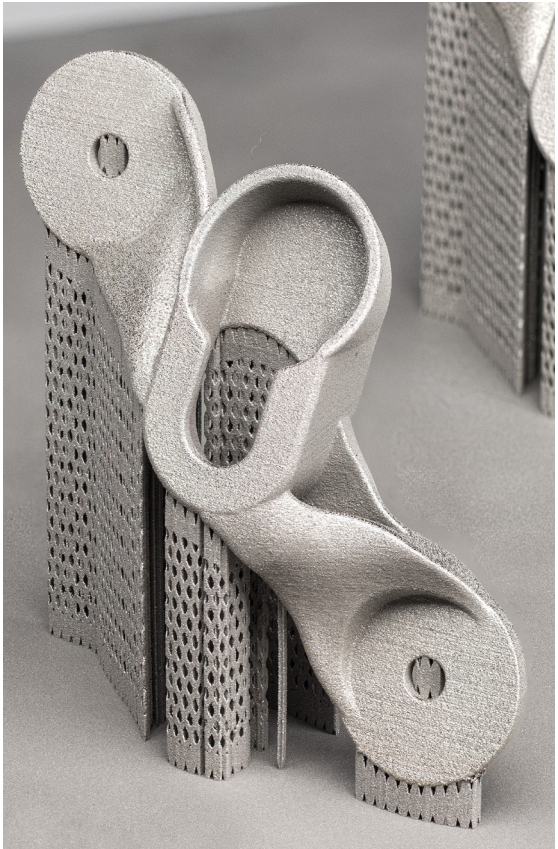
First, a competency based training concept wasdefined in line with the 4 components instructional design principles (4C/ID). This concept focuses on whole task training. Theory and part task practice are integrated to support the whole task scenario. Based on the outcome of the training needs analysis, qualification profiles were defined. Finally the training, including supporting materials, was developed. Besides training materials, an assessment method also was developed, allowing student coaching and evaluation. This method comprises competencies including their observable behaviours and can be used for continuous coaching and assessment.

Project partners
Royal Netherlands Air Force:
Royal Military Air Force School (KMSL)

Start: May 2014
Duration: 3 years

Additive Manufacturing for Netherlands Royal Air Force

NLR has more than 50 years of experience of metals which is incredibly important for additive manufacturing research, together with knowledge of aircraft certification. With the increased understanding of the printing process and subsequent reproducibility, applications using metal printed parts in aircraft components are becoming feasible from an economic point of view are now much closer. Of course, you can print the same thing twelve times in one print job, then test eleven of them and put the twelfth in the aircraft. But that obviously makes the twelfth component far too expensive. You want to be able to print such a component in large numbers, be able to detect production faults, and know for certain that approved components can be fitted in the aircraft.

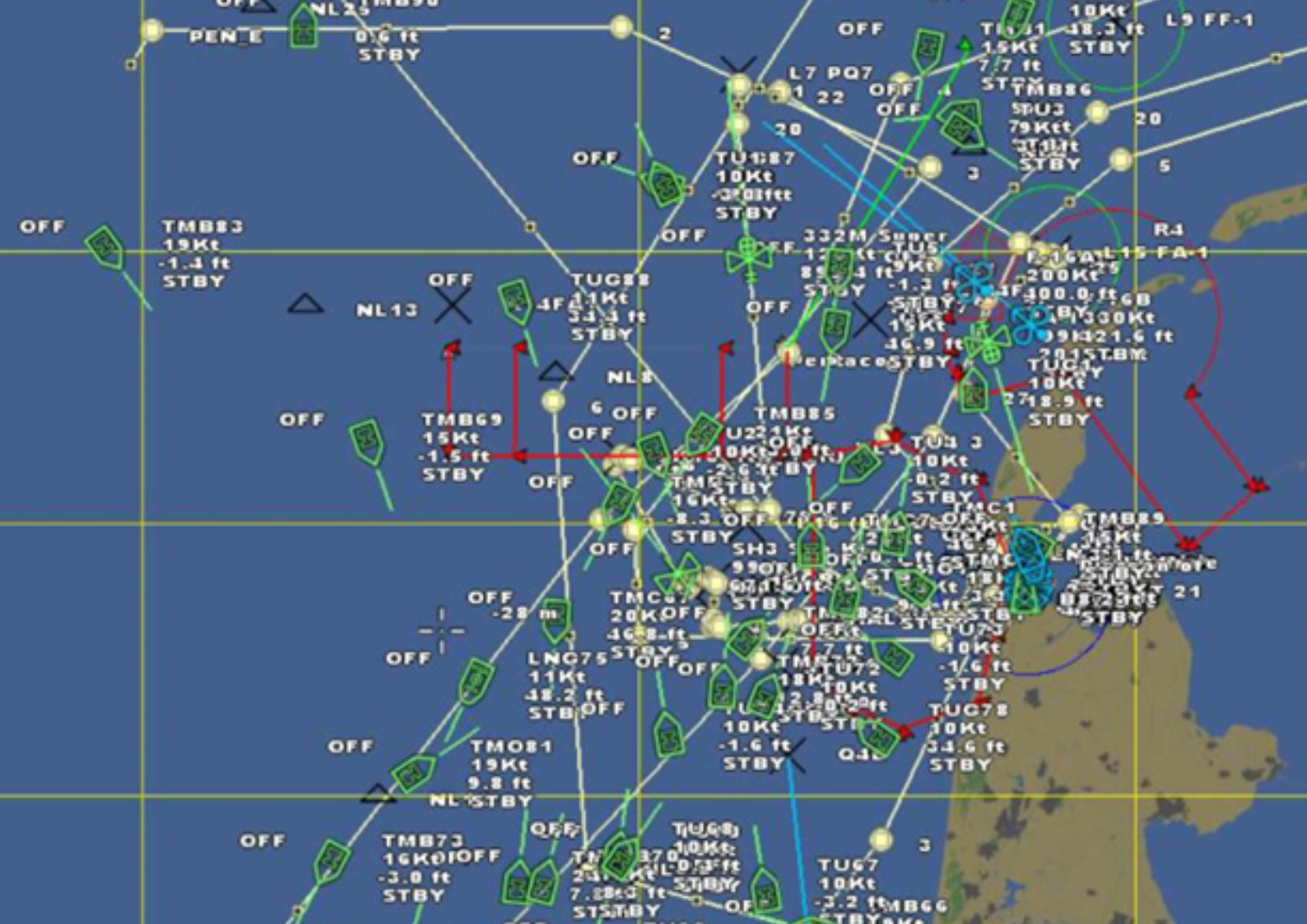


First for the Royal Netherlands Air Force

The first printed product in the Netherlands by metal additive manufacturing that actually flew on a helicopter at year-end 2016 was a ladder mount for the NH90 helicopter of the Royal Netherlands Air Force.

It is a coupling that is affixed to the helicopter and to which a ladder can be mounted so as to perform maintenance. Although hardly a critical part from an operational point of view, it was a good case to start with. It showed how it could be useful for an organisation like the air force. Metal additive manufacturing also raises an important logistics-critical question for the air force, namely whether on a mission you can print parts locally instead of taking them with you or having them sent out.

The 3D-printed ladder bracket is 40% lighter but stronger and more durable than the original design. 3D printing enables the Royal Netherlands Air Force to have parts produced faster, reduce maintenance costs, and at the end improve the deployability of her weapon systems. The Royal Netherlands Air Force commissioned the development of the ladder bracket. The project was a collaborative venture, with Fokker Aerostructures responsible for engineering, NLR-Netherlands Aerospace Centre for 3D printing and testing, BPO-Delft for redesign and the Defence Materiel Organisation for certification.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TMB86
TU1:87
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TMB83
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TUG88
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STBY
TMB69
15Kt
-1.5 ft
STBY
TMB85
TMC1
TMB89
LNG75
11Kt
48.2 ft
STB
TMO81
19Kt
9.8 ft
TMB73
16Kt
-3.0 ft
STBY
TU67
10Kt
-3.2 ft
TMB66
TUG78
10Kt
34.6 ft
STBY
L9 FF-1
R4
L15 FA-1

Threat Environment NH-90 FMFT

WHY?

The Royal Netherlands Air Force (RNLAF) owns a NH-90 Full Mission Flight Trainer (FMFT) to train their NH-90 crew. The threat environment can be simulated in high detail and consists of complex databases. For realistic training the simulator databases need to be filled with specific data. To maintain these databases (threat environment, entity data, etc.) simulator knowledge is needed. The RNLAF has outsourced their NH-90 simulator database maintenance to NLR.

HOW?

NLR maintains the NH-90 FMFT threat environment databases based on:

- The requirements provided by the NH-90 simulator instructors
- Simulator knowledge that has been accumulated by NLR over the past decades

WHAT?

Threat Environment databases:

- Compatible with the NH-90 FMFT
- Correlated which each other
- Continuously expanded and improved

Project partners
Customer: Royal Netherlands Air Force
Research organisation: NLR

Start: 2009
Duration: ongoing

Project partners
Industry (EU): Leonardo Helicopters, GIEI
Research organisations: NLR, DLR
Universities: UoL, POLIMI, JMUL

Start: May 2019
Duration: 3 years

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

RoCS: Rotorcraft Certification by Simulation

WHY?

Before an aircraft may enter into operation in civil airspace, it must obtain a type certificate from the responsible aviation regulatory authority. The compliance demonstration is the lengthiest and most expensive part of the certification process. The driving factor for the cost and duration is the amount of ground and flight testing required. Moreover, certain certification flight test activities, particularly those involving demonstrations of control system or engine failures, can be classified as high-risk. The reduction in the scope of the test activities made possible by the exploitation of advanced analysis methods such as flight simulation, therefore, offers an immediate benefit in terms of the overall certification cost, schedule and safety.

HOW?

The RoCS consortium aims to explore the possibilities, limitations, and guidelines for best practices for the application of flight simulation to demonstrate compliance to the airworthiness regulations related to helicopters and tiltrotors. First, the paragraphs that are potentially suitable for compliance demonstration via piloted flight simulation are selected in consultation with the European Aviation Safety Agency.

Next, metrics will be proposed and evaluated to measure the simulation model predictive fidelity and simulator facility cueing fidelity. These metrics will be the basis for the RoCS open-access guidelines on fidelity requirements and best practices. Finally, the proposed guidelines will be verified through a simulator flight test campaign at Leonardo Helicopters using the LH AWARE simulator that will be upgraded in the course of the project.

WHAT?

The use of flight simulation to support rotorcraft certification activities has potential benefits in terms of safety, economy, time, and effectiveness. Flight test safety is increased by virtue of providing the option to perform high-risk demonstrations in a simulated environment. The economy of rotorcraft certification is improved by reducing the amount of flight test time and reducing the risk of damages. The relatively swift turnaround of a simulator campaign compared to flight testing improves the time-to-market and, therefore, the competitiveness of the European rotorcraft industry. Finally, the possibility to test numerous configurations and easily gather test data at a marginal increase in cost and time contributes to the overall effectiveness of the compliance demonstration process.

Project partners
Defence Helicopter Command (DHC) of the Royal Netherlands Air Force
Joint IV Commando (JIVC) of the Ministry of Defence

Start: June 2016
Duration: 2.5 years

Redesign of helicopter training

WHY?

The Defence Helicopter Command of the Royal Netherlands Airforce expressed a need for a common, modernized approach for the qualification training of all their platforms.

HOW?

In cooperation with Subject Matter Experts (operational pilots/load masters and instructors), a competency based training needs analysis was performed. Competency profiles were identified for CH-47 pilots and load masters and for the AH-64 pilots. Idealized Mission Qualification Training (MQT) outlines were designed, that would lead to fully combat-ready pilots and loadmasters for a wide range of (adverse) operational conditions. This is based on the assumption that modern tactical simulators are available, suitable live ranges are available and scheduling issues do not exist. Such ideal training conditions are important for creating and working with a clear vision of training.

With the idealized training setups in mind, actual MQT were developed, implemented and evaluated.

User requirements for a multi-ship/multi-type (MSMT) simulation facility were also identified and a roadmap to a future idealised MSMT system concept was suggested.

All activities were facilitated by NLR and new, science-based approaches were applied as far as acceptable for the SMEs, who are the 'owners' of the products.

WHAT?

The project produced ideal and actual MQT for AH-64 and CH-47 crews. Furthermore, user requirements, a system concept and a roadmap for an MSMT simulation facility was provided.

The method applied is a competency-based training approach that applies the train-as-you-fight principle from the start. This primarily whole-task training setup is built up according to principles (for example gradually increasing complexity) that optimize cognitive load throughout the training.

Virtual Cockpit

WHY?

Training devices that fit your training needs often require large investments and are usually type specific. There are currently no training devices that allow a highly realistic interaction between the pilot and cockpit instruments, without the disadvantages associated with expensive high-end devices. Virtual Cockpit bridges this gap by providing the technology to do just that: low-cost and high-fidelity training technology.

HOW?

By combining NLRs state-of-the-art modelling & simulation and customer operational knowledge we created a radical new low-cost mixed reality cockpit solution with natural human machine interaction capabilities. Our concept involves the smart integration of Commercial Off-The-Shelf (COTS) products, 3D printing, Virtual Reality, and finger/hand tracking into a type-customisable simulated working environment with a natural feel.

The concept was evaluated and improved with operational experts in several iterations throughout the project.

WHAT?

The result is a concept demonstrator that allows highly realistic interaction and provides pilots with all the visual, auditory and haptic experience and feedback that they need for a high-fidelity training experience. This technology concept also provides the ability to build a highly configurable and mobile setup with a small footprint that is still low-cost.

Project partners
Industry (NL):
Cinoptics, provision of high-res VR-optics

Start: October 2016
Duration: 2.5 years


VIPER 3
VIPER 4
MISSILE 2
COBRA 2
COBRA 1
MISSILE 1
SA-10

Embedded Training and LVC:

Effective training for Joint and Combined Airpower

WHY?

One of the major issues in conducting live training with 5th generation fighters (like the F-35) is training range space and how to create an tactical threat environment that challenge the capabilities of these modern fighters. These fighters have long-range sensor and weapon delivery capabilities. Training and exercises take therefore more and more place in an environment where live systems operate together with man-in-the-loop simulators or in a live environment that is enriched and stimulated by computer generated players and events. Such a Live Virtual Constructive environment opens up new opportunities but at the same time it calls for other demands than traditional live or simulation environments.

HOW?

NLR investigates and implements training solutions that include live, embedded, and virtual mission training. We play a major role in international working groups (NATO, EDA, SISO) in solving interoperability issues and defining standards and reference architectures for LVC environments. We facilitate the integration of Live Virtual Constructive components to support the military operator during battlefield operations, mission planning/rehearsal, joint exercises and mission training.

WHAT?

We can combine live, virtual, and constructive training in a fully interconnected exercise. We promote downscaling where possible, and fit for purpose training solutions. NLR offers a combination of education and training expertise with all the technological knowledge available to offer you the best advice on the employment of Live Virtual Constructive training. We have, with our partner Airbus Defence and Space Netherlands, developed an Embedded Training (ET) software system for fighter and trainer aircraft. With this ET system the pilot interacts with the synthetic threats by using his unmodified cockpit controls and displays. For example, he or she performs identification, fires weapons, and applies countermeasures. Synthetic threats will show a realistic intelligent behavior. For example, they fire missiles at the real aircraft and apply countermeasures when they are attacked.

Project partners

Partners: NLR and Airbus Defence and Space Netherlands

Integration of MALE RPAS into European Airspace

WHY?

To test and validate the airspace integration CONOPS, NLR has developed the MALE RPAS Real-time simulation Facility (MRRF). The MRRF consists of two pre-existing NLR simulators, namely the NLR ATM Research Simulator (NARSIM) and the Multi UAS Supervision Testbed (MUST). Here, NARSIM is used to simulate air traffic, and provides working positions for air traffic controllers and aircraft pilots. MUST, on the other hand, is the RPAS simulator, and it functions as the pilot ground control station. For CONOPS development, the well-known GA-ASI SkyGuardian aircraft, which has been procured by several European air forces, is used as a representative MALE RPAS.

HOW?

At present, the regulatory environment in Europe requires Medium Altitude Long Endurance (MALE) Remotely Piloted Aircraft Systems (RPAS) to fly in segregated airspace. Furthermore, each and every MALE RPAS flight needs to be approved by National Aviation Authorities (NAAs), and this process can be time consuming. Such restrictions limit the operational efficiency of MALE RPAS operations in Europe.

To overcome these issues, and regularize MALE RPAS operations in Europe, it is necessary to develop and validate a comprehensive Concept of Operations (CONOPS) to enable the safe and efficient integration of MALE RPAS into controlled and uncontrolled European airspace. To this end, NLR has partnered with General Atomics – Aeronautical Systems Inc. (GA-ASI) to:

1. Develop and test CONOPS to integrate MALE RPAS into European airspace, taking into account both nominal and non-nominal conditions
2. Provide empirical evidence to convince all relevant stakeholders that MALE RPAS operations are safe and efficient to fly in European airspace

Project partners
General Atomics - Aeronautical Systems Inc. (GA-ASI)

Start: October 2018
Duration: 2 years

WHAT?

An iterative, step-by-step, approach has been adopted for CONOPS development. The project has just completed Step 1(Q4 '18 – Q2 '19), which focused on developing procedures to mitigate several contingency scenarios that can occur in unsegregated airspace in the vicinity of a civilian airport. The considered scenarios included loss of link between the pilot and the RPAS and engine failure, amongst others. The developed procedures were tested using a real-time simulation experiment in the MRRF with real air traffic controllers, as well as real RPAS and airliner pilots. The results strongly indicate that the new procedures developed in this project make it possible for MALE RPAS to fly safely and efficiently in civil European airspace alongside other manned air traffic.

Future steps are planned to further improve the fidelity of the MALE RPAS airspace integration CONOPS. This includes testing the effectiveness of TCAS II, as well as to also consider the use of novel technologies such as Detect and Avoid (DAA). The onboard DAA radar provides RPAS pilots with additional situational awareness of the non-cooperative traffic situation around their aircraft, and it is intended to further increase the safety of RPAS operations.

High Energy Laser Lab (HEL LAB)

WHY?

Governments are facing a upcoming threat of small and cheap air vehicles (drones) intruding restricted air-space. The use of High Energy Laser as an effector against these threats is an potential upcoming technology. Research of effective ways to detect and neutralize these vehicles with a minimum of collateral damage is essential and urgent.

HOW?

Research relevant aspects of the HEL technology, system integration and operational deployment. Since July 2018 Royal NLR is conducting tests in its HEL LAB to research the effects of laser energy on different types of materials (e.g. aluminum, composites). Each material has its own properties that result in a required amount of energy over a minimal dwell time. The essence of our research is to determine the most efficient way of effecting an object.

Project partners

Netherlands MOD (NL)

Research organisations: The Royal Netherlands Aerospace Centre (NL)

Start: June 2018

Duration: Ongoing

WHAT?

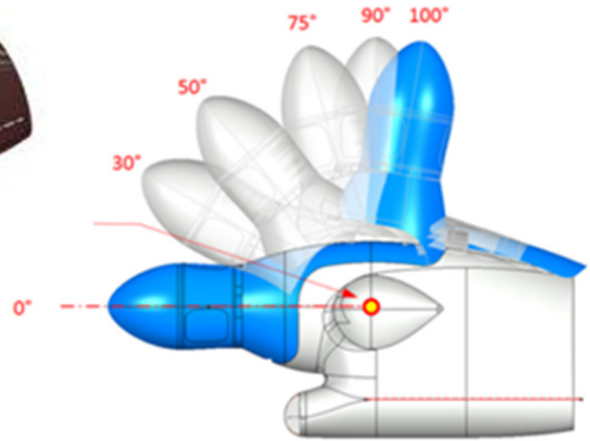
The main R&D activities of the project are:

- The effects of laser energy on materials.
- Developing an interaction model in which materials and the effect of laser energy are calculated.
- The impact of the way of targeting an intruding object with laser energy.
- Safety issues of the use of laser energy in an environment (civil and military).
- Integration of potential systems on aircraft platforms

Royal NLR

Dedicated to innovation in aerospace

Other showcases



Project partners
Industry (EU): SZEL-TECH, P.W. METROL
Research organisations: NLR (coordinator), ILOT

Start: November 2019
Duration: 3 years

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

HIGHTRIP: HIGH speed civil Tilt Rotor wind tunnel Project

WHY?

The aerodynamic configuration of the Next Generation Civil Tilt Rotor (NGCTR) needs to be characterized at high speed by a dedicated wind tunnel test campaign. Within the EU CleanSky 2 program new T- and V-tail empennages were designed and fabricated in the NEXTTRIP project, envisaging use for higher speeds. In order to fully exploit this research, HIGHTRIP will design a new model based on NEXTTRIP design philosophy and scale, re-using the new (instrumented) NEXTTRIP empennages. If complete re-use is not feasible, basic design, balances and remote controls will be re-used to limit the costs. Consequently, the exact model scale will result from sizing NEXTTRIP empennage to the NGCTR Technology Demonstrator geometry.

HOW?

The partners will work together to design and manufacture new fuselage and new wing in the HIGHTRIP model, based on the NEXTTRIP tails and NICETRIP parts. NLR will coordinate the HIGHTRIP project and will perform wing design and manufacture. The Polisch partners will focus on the design and manufacturing of the new fuselage. NLR will subcontract the non-powered high speed wind tunnel test to ONERA-S1MA, resulting in a data package (on model scale) corrected for wind tunnel effects. To provide full scale Reynolds number data and perform aerodynamic characteristics analysis at high speeds and full scale conditions, extrapolation to full scale Reynolds numbers will be done by CFD.

WHAT?

The Next Generation Civil Tilt Rotor fast rotorcraft concept aims to deliver superior vehicle productivity and performance. The aerodynamic configuration definition of the novel tilt rotor NGCTR Technology Demonstrator needs to be validated further at high speeds. By exploiting outcomes and facilities of NICETRIP (FP6) and NEXTTRIP (CleanSky 2) projects and providing a full scale high speed database of different empennage configurations, HIGHTRIP provides a vital contribution for the validation of an innovative tilt rotor concept, the configuration of which will go beyond current architectures of this type of aircraft.

Development of composite drag stay for Airbus A350-1000

Within the CS2 Systems ITD a CFRP drag stay for the A350-1000 is being developed in the Core-Partner project HECOLAG. The goals for the CFRP structure are a weight saving of over 30% at recurring cost similar to the current aluminium drag stay as manufactured by Liebherr-Aerospace. The CFRP drag stay is designed by Fokker Landing Gear (part of GKN Aerospace) in cooperation with NLR, to requirements set by Liebherr Aerospace. Within the project NLR has focused on automated manufacture of preforms for these types of complex geometries. The present design is optimized for automated preform manufacturing and offers a weight saving of approximately 40%. The tooling for prototype manufacturing is designed and built by Compose Tooling. Functional prototypes are being manufactured by NLR and will be tested in 2019 by Fokker Landing Gear.

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

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

ACASIAS:

Advanced Concepts for Aero-structures with Integrated Antennas & Sensors

WHY?

ACASIAS target is to reduce fuel and emissions through drag reductions and weight savings. The overall objective of ACASIAS is to contribute to the reduction of energy consumption of future aircraft by improving aerodynamic performance and by facilitating the integration of novel efficient propulsion systems such as contra-rotating open rotor (CROR) engines.

HOW?

The aerodynamic performance is improved by the conformal and structural integration of antennas. The installation of CROR engines is facilitated by installation of an Active Structural Acoustic Control (ASAC) system in the fuselage. The integration of such a system in fuselage panels will reduce annoying noise in the cabin caused by multi-harmonic sound pressure level which is radiated by CROR engines. CROR engines are able to realize up to 25% fuel and CO2 savings compared to equivalent technology turbofan engines. The project will bring together 11 partners from 6 countries covering the three main disciplines required: (composite) structures, advanced antennas and miniaturized sensors in a multi-disciplinary project.

WHAT?

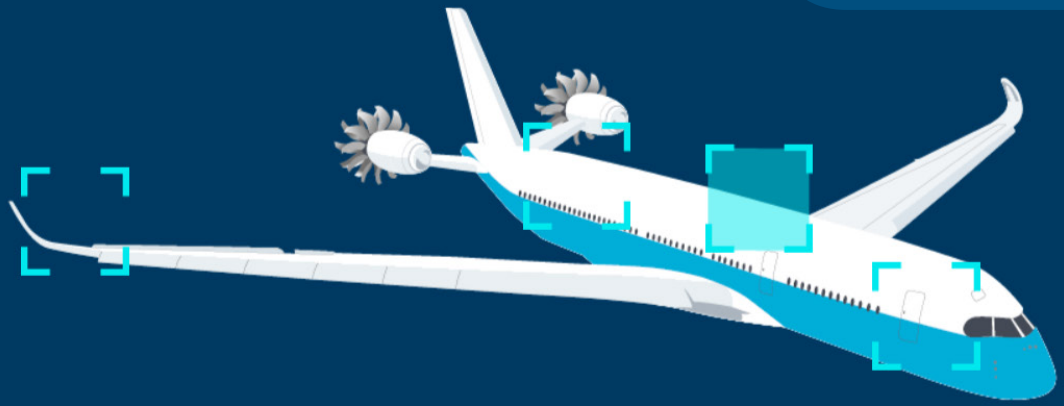
The ACASIAS project focuses on challenges posed by the development of aero- structures with multifunctional capabilities. The following structural concepts are considered:

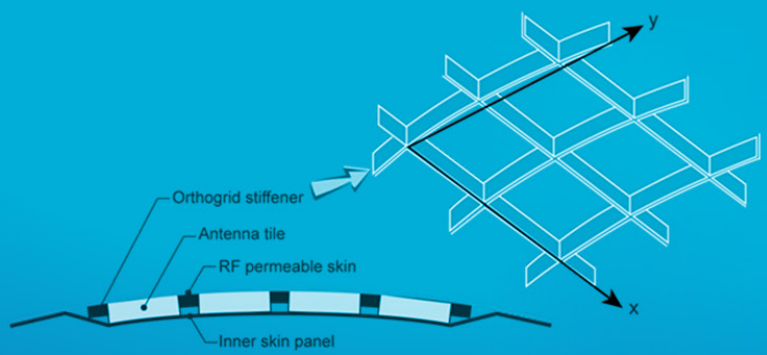
- A composite stiffened ortho-grid fuselage panel for integrating Ku-band SATCOM antenna tiles
- A fuselage panel with integrated sensors and wiring for reduction of CROR cabin noise
- A smart winglet with integrated blade antenna (integrated substrates into special foam, partly covered by a glass/quartz epoxy layer)
- A Fibre Metal Laminate GLARE panel with integrated VHF communication slot antenna

Project partners

Industry (NL)	: GKN Fokker Aerostructures, GKN Fokker Elmo
Industry (EU)	: EVEKTOR
SME (EU)	: IMST, INVENT, Trackwise, L-Up
Research organisations	: NLR, DLR, CIMNE, VZLU
Start	: June 2017
Duration	: 3 years

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





A composite stiffened ortho-grid fuselage panel for the integration of a Ku-band SATCOM antenna array

Project partners

Industry (NL)	: GKN Fokker Elmo
Research organisations	: NLR
Start	: June 2018
Duration	: 2 years

Electromagnetic Compatibility (EMC)

Crosstalk

WHY?

Crosstalk between cables in aircraft causes electromagnetic interference. Therefore, appropriate electromagnetic models need to be developed which predict the crosstalk between wires in cable bundles and between cable bundles. Shielding and twisting are usually applied to reduce crosstalk. Therefore, the electromagnetic models need to able to predict crosstalk between unshielded untwisted wires but also between twisted and shielded wires. The position of the wires in a cable bundle is in most cases not fixed. This causes uncertainty in the amount of crosstalk in practical cable bundles.

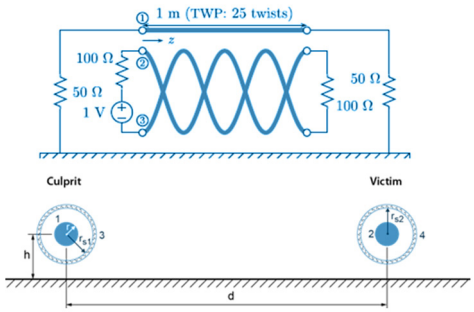
HOW?

The effects of cable shielding are taken into account by means of the transfer impedance of the shield. The transfer impedance can be measured or calculated from analytical models. The effects of twisting are taken into account by dividing the helix forms into many small, uniform segments. The total crosstalk can then be calculated by cascading all those small segments of the entire transmission line.

For the statistic analysis of crosstalk in cable bundles, first a prediction is made of the potential position of the wire in the bundle. The crosstalk is then computed very efficiently by using the Stochastic Reduced Order Models (SROM) method.

WHAT?

Both deterministic and stochastic models have been derived for crosstalk in cable bundles and between cable bundles. These models will be implemented in the design software for cable harnesses.



Zero-G Flight Testing Capability

WHY?

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

Newly certified and operational in 2018-2019
Executed by NLR

HOW?

- A modified and instrumented Cessna Citation II research aircraft capable of performing zero or partial gravity flight maneuvers
- A relatively small aircraft which allows for favorable cost, yet provides enough cabin space for many low gravity applications
- A flight test organization which offers flexible (re)scheduling of flights and a short time between project request and flight test execution
- Part 21 based design organization to support installation of your application onboard our aircraft
- A flexible and affordable flight test facility representing almost one century of experience

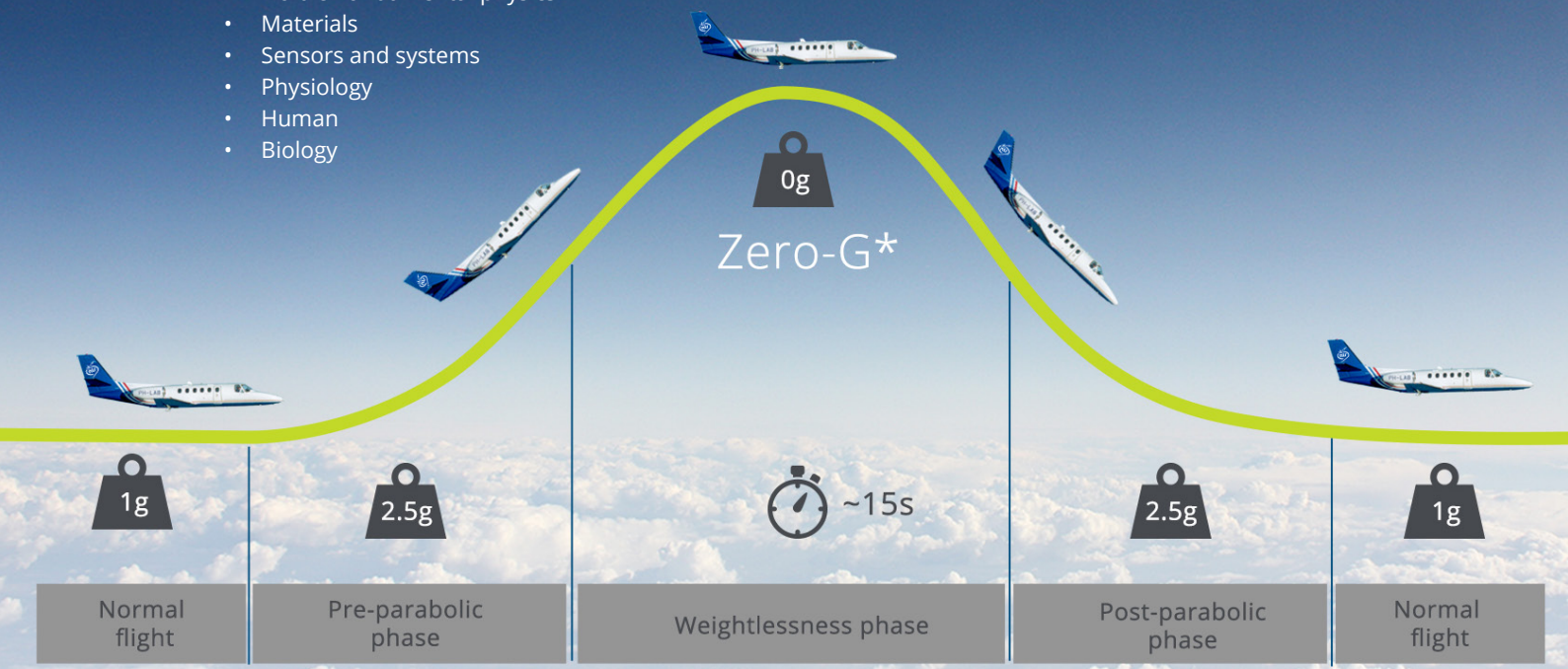
WHAT?

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

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

other):

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



*) Low gravity flight also possible (e.g. Moon, Mars)

Royal NLR in brief

One-stop-shop	Global player with Dutch roots	>100 100 years young	Amsterdam, Marknesse, Schiphol
Innovative, engaged and practical	For industry and government	For civil and defence	632 employees
€ 73 M revenue	75% Dutch, 21% EU and 4% international	Active in 29 countries	Extremely high client satisfaction

About NLR

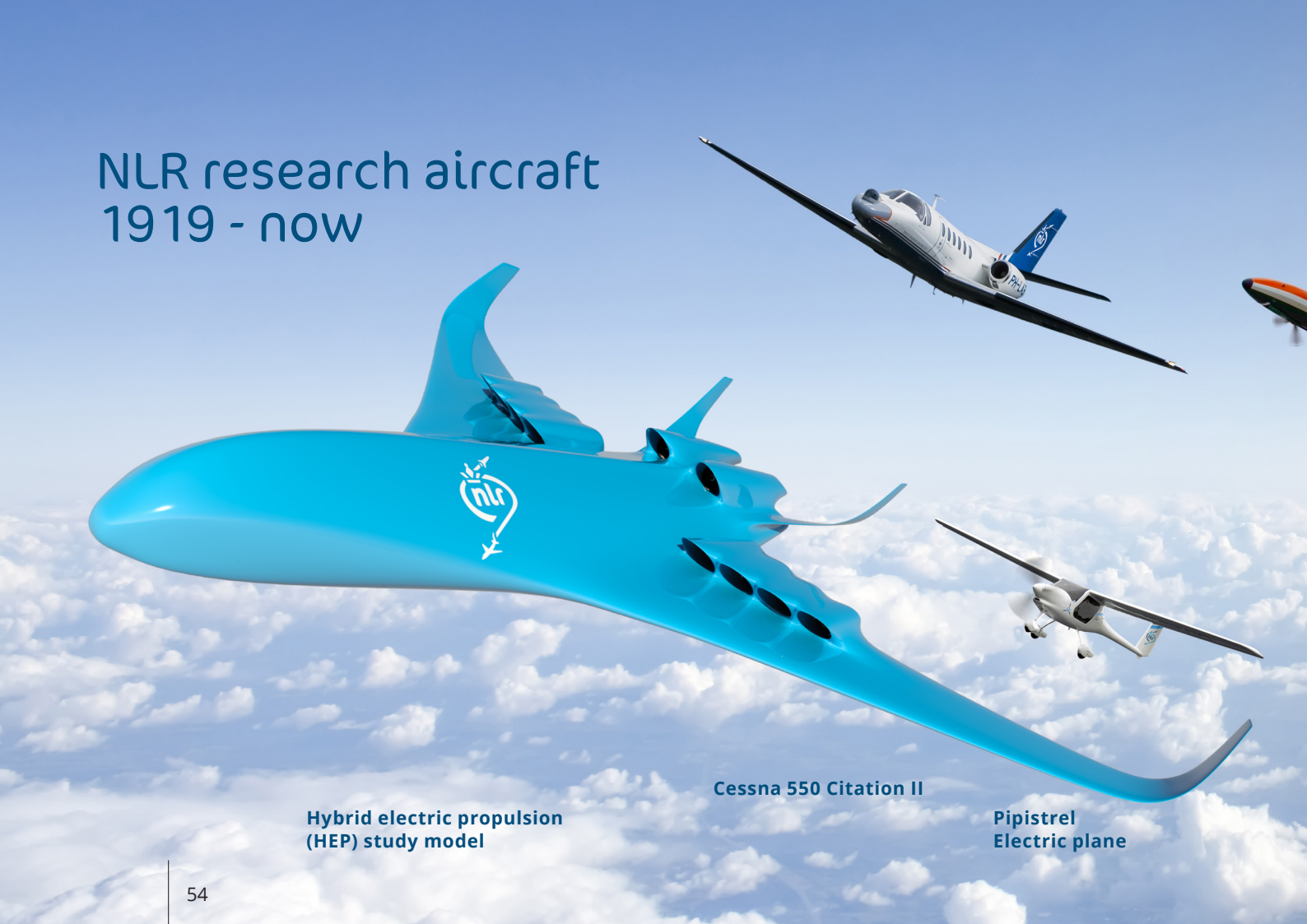
Royal Netherlands Aerospace Centre

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

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

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

NLR research aircraft 1919 - now



Cessna 550 Citation II

Hybrid electric propulsion (HEP) study model

Pipistrel Electric plane

Fairchild Swearingen SA226-TC Metro II

Hawker Hunter T.7

Fokker F.VIIa PH-NLL

Queen Air

Fokker S.14.1 Machtrainer

Fokker F.II PH-RSL

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