Dedicated to innovation in aerospace

Training and Simulation for Defence

Royal Netherlands Aerospace Centre

100 YEARS

Welcome to Royal NLR. We invite you to discover more about innovative training and simulation programmes we develop for military forces and other clients. The common goal is to make training more effective and efficient.

Our vision of military training is founded on competency-based and performance-based training (PBT) concepts using integration and interoperability of live, virtual and constructive elements. Our approach focuses on a thorough process of analysis, design, development and implementation with the client.

Our staff have detailed knowledge of and expertise in training, simulation, human behavioural assessment and regulations for military forces. This knowledge is combined with applied technical research and development in simulation. NLR actively develops innovative training technologies and training media. These capabilities and our in-house research infrastructure ensure that NLR can oversee the entire spectrum and stay on top of – and ahead of – new developments and innovations in military training and simulation.

Our approach has resulted among other things: in international used interconnected tactical simulators for fighter pilots, a training needs analysis and competency based training redesign for helicopter crews, and the development of new concepts and doctrines for 5th generation Air Forces. Overall, the result is an optimum blend of live and low, medium and high-fidelity simulator training for our clients. This offers you the best possible service and advice. The projects in this brochure showcase our unique approach.

NLR – Royal Netherlands Aerospace Centre

Instructional design process for blended learning

To assure continuous deployment readiness, military forces need to make their training more effective and efficient. The time spent flying must be as effective as possible. This means more customised and less expensive training through an optimum blend of live, low-level and high-level fidelity simulated training. A modern vision of training in which the integration and interoperability of military systems are acknowledged is important for this approach. Only then a thorough genuine understanding of training needs and an analysis of the simulation requirements can be guaranteed.

Applied technical research and development for low to high-fidelity simulators

To back up the instructional approach to more effective and more efficient training, NLR carries out applied technical research and development in human behaviour assessment and simulation. These developments focus on interconnectivity between training devices, performance data collection and analysis, and effective realism using artificial intelligence, virtual crew members and coaches. NLR has realised connectivity between pilots and fighter control, between live and simulated platforms and between human and computer generated forces.

The combined approach of instructional design and applied technical research leads to enhanced accessible training devices resulting in more effective training opportunities. It also allows training for more complex and interconnected scenarios that are hard to achieve in a live environment. Finally, it provides the possibility of performance measurements, a fundamental requirement for performance based training.

The '**ADDIE**' approach from Royal NLR:

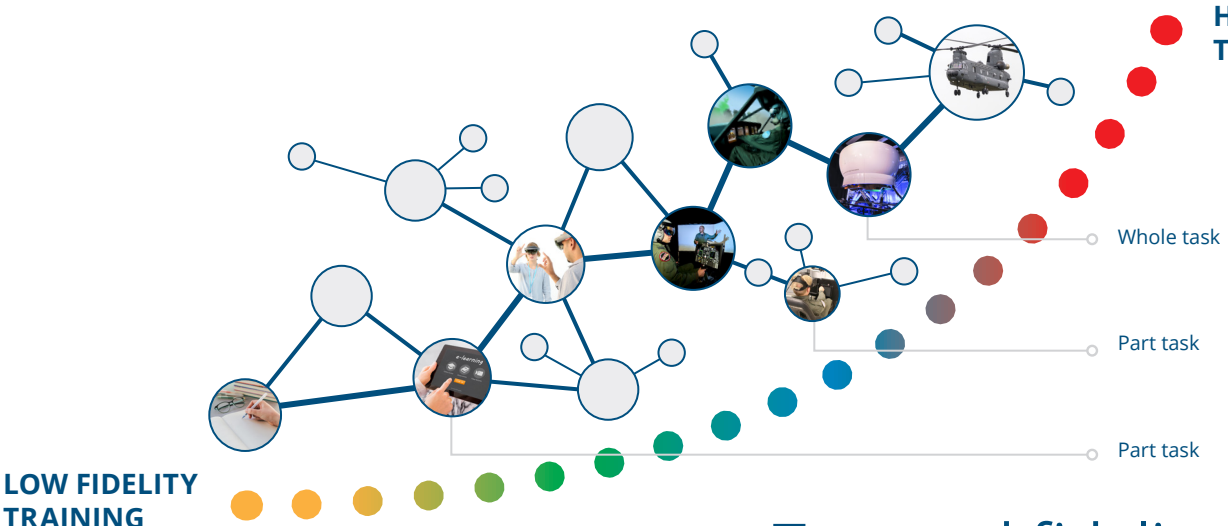
Analysis: analyse the operational training needs and determine the required competences through a Training Needs Analysis. The result: a qualification profile

Design: produce a rough outline of the training course. Define the learning scenarios and goals in line with the training needs. Determine the required supporting and procedural information. The result: a training blueprint

Development: develop and select training and simulation materials and tools. The result: training and simulation materials.

Implementation: support the whole change process and get all the stakeholders involved. The result: new or revised training

Evaluation: monitor the process and the product continuously. Perform experiments and evaluations to test and improve the training regularly. The result: gaps resolved and improvements made.



Targeted fidelity

Showcases

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?

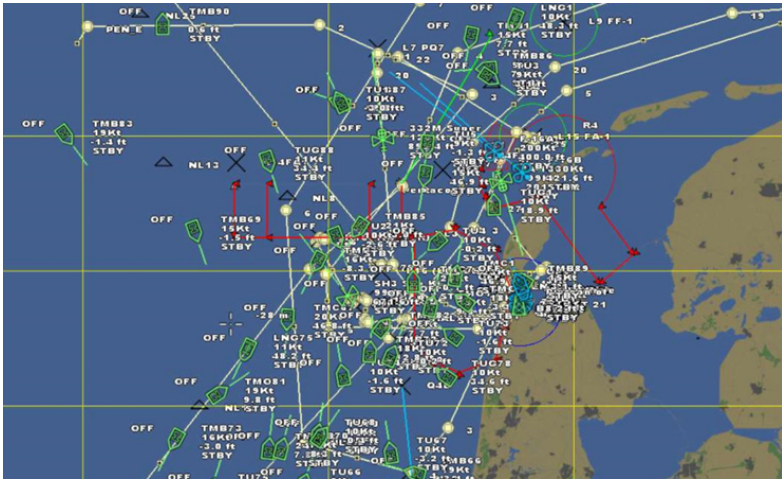
NLR maintains the NH-90 FMFT threat environment databases based on:

- 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
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.

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

Smart Bandits

Intelligent opponents in mission simulation

WHY?

In military simulations, computer-generated forces (CGFs) are autonomous entities that represent friendly, neutral or hostile air, ground surface, or sub surface-based units, platforms or individuals. The behaviour that CGFs display in the simulations is modelled to resemble realistic human behaviour. CGFs are typically used in application areas such as training, mission rehearsal, concept development and experimentation (CD&E) or decision support. For each application, the CGFs require different behaviour models. However, traditional modelling techniques do not give scope for expression and keep modellers from quickly developing new models. Therefore, new approaches to behaviour modelling are required.

HOW?

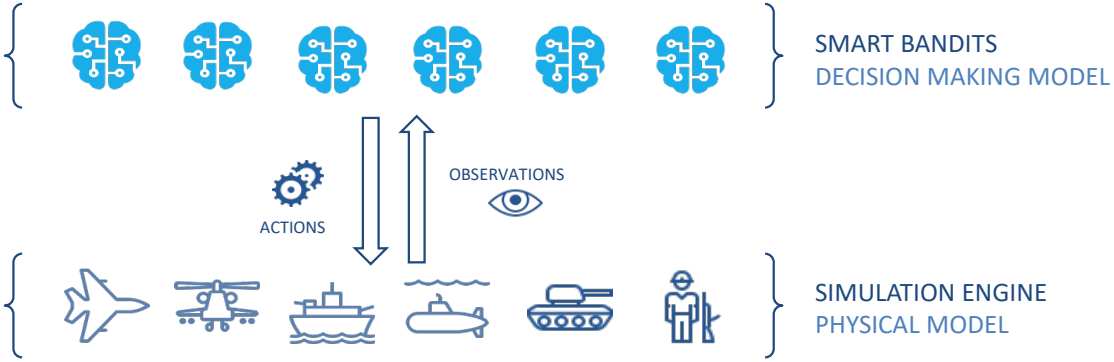
The aim of the Smart Bandits project is to explore various approaches to modelling human-like behaviour. To this end, we carried out research in two main directions, namely human behaviour and computational modelling. In the area of human behaviour, we specifically studied situational awareness (i.e. the perception of the environment) and theory of mind (i.e. beliefs, desires and intentions). In the area of computational modelling, we studied the use of machine learning techniques for enhancing classical modelling techniques such as finite-state machines and behaviour trees. A key component of the Smart Bandits project was the evaluation of newly developed techniques in human-in-the-loop simulations, such as in NLR's Fighter 4-Ship networked F-16 simulator.

Project partners
Research organisations:
NLR, VU University Amsterdam

Start: 2010
Duration: improvements ongoing

WHAT?

The results of the studies are combined in a user-friendly graphical behaviour modeling tool. The tool is named Smart Bandits after the project. It enables modelers to quickly implement behaviour models and to link the new models to the CGFs in a simulation engine. While the CGFs make their observations in the simulated world, the Smart Bandits tool calculates their next actions. During simulations, the behaviour models can easily be inspected to see what the CGFs are thinking. Apart from being an intuitive modeling tool, Smart Bandits continues to be a platform for behaviour modelling research. NLR is continuously experimenting with new modelling techniques and new ways of interacting with CGFs.



Project partners
Royal Dutch Airlines KLM

Start: June 2016
Duration: 2.5 years

Augmented reality for maintenance training

WHY?
KLM expressed the need for more innovative training media to modernise and improve maintenance training.

HOW?
To ensure well integrated use of training media, the project started with a review of the current training design and analysis of current training content. Subsequently, there was a study of whether Augmented Reality (AR) could add value for the aircraft systems that are difficult to train through traditional classroom training. Requirements for the AR application and training design were defined before starting actual development. Finally the prototype was evaluated through an experiment.

The project is performed in a highly interactive and agile way. Bi-weekly sprints were held with experts from relevant areas such as maintenance experts, application developers, human machine interface experts and educational experts, which ensured accuracy and acceptance of intermediate and final results.

WHAT?
The result of the project is a modernised, problem-based training design for maintenance training that enhances understanding of the systems and system interaction. This design comprises less traditional instruction and more trainee activity via paper-based assignments and problem-based AR scenarios.

The experiments proved that trainees score better using AR when it is fully integrated in the training design; trainees retained more of what they learned, had deeper understanding and retention time was longer compared to the traditional classroom training. Important lessons learned are the importance of shared AR and a maximum of 20 minutes wearing the AR goggles.

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.

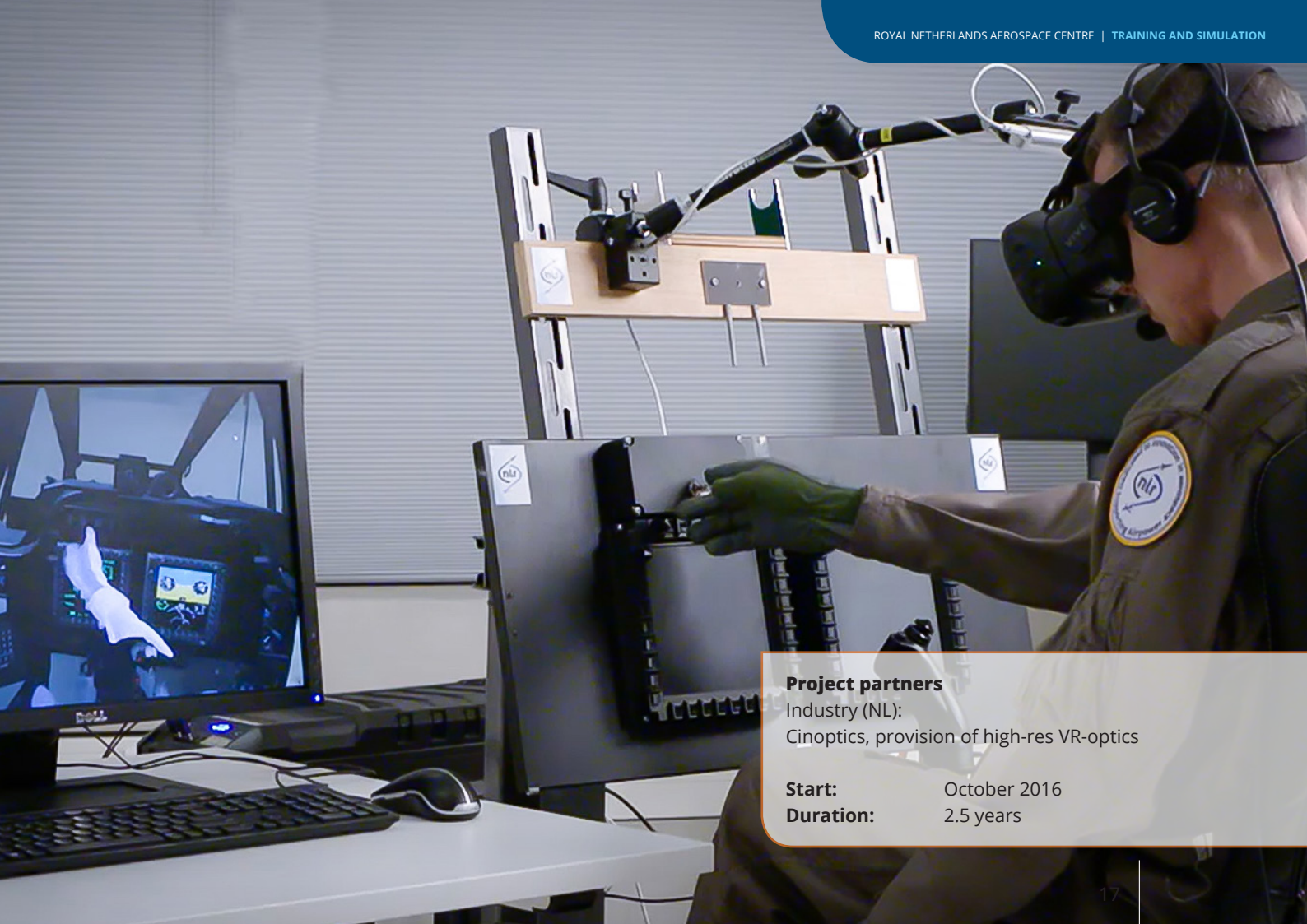
HOW?

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

Project partners
NL MOD

Start: February 2018
Duration: 3 months

JLV 360

Virtual Reality training made easy for both trainee and instructor

WHY?

Shooting 360 videos is easy and is used more and more to familiarise and even train people in various situations by immersing them using Virtual Reality goggles. Supporting flight training using these 360 videos in combination with VR goggles however, is more difficult.

The resolution of video capturing and VR hardware is typically too low to allow reading displays, which is of particular importance to flight training. Although high end equipment may offer some relieve, it still does not solve the problem completely and lowers the accessibility, ease of use and affordability of the setup.

HOW?

NLR and NL MOD joined forces to incorporate VR in the initial flight training curriculum of military pilots. By using an agile design and development approach, we were able to co-create an application that allows incorporating the benefits of VR training to re-experience earlier training flights and get the most out of the actual flight time with instructors.

WHAT?

NLR has developed a VR application that makes it easy for both flight instructors and trainees to use VR as training support. There is an app for that. Trainees can easily re-experience a flight, including readable instruments, whenever and wherever they want. Instructors can easily add and configure new training content. Combining 360 video with high resolution insets ensure readable imagery and smart editing options to counter the resolution limitations from current VR devices.

NH-90 Full Mission Flight Trainer Evaluation

WHY?

The purpose is to perform evaluations on the compliance of the NH-90 simulation devices to their respective regulations and/or standards. The NH-90 simulation can be split into two separate devices that can be used separately for specific crew training and combined for full mission flight training.

- Full Flight Simulator (FFS) used for pilot training
- Virtual Sensor Trainer (VST) used for sensor operator training
- Full Mission Flight Trainer (FMFT), used for mission training with Pilots, Tactical Coordinator and Sensor Operator.

HOW?

For evaluation of the FFS, the NLR evaluation team will first evaluate the Qualification Test Guide (QTG) of the FFS. Based on the results of this evaluation, the project team will determine if an on-site evaluation can be conducted. The on-site evaluation will take several days in which the devices are assessed objectively by re-running QTG tests, functionally, and subjectively as per regulation set. The VST is not able to provide objective data, so all tests performed on the VST will be subjective and functional tests.

Furthermore, the military aspects of the devices are not accounted for in the civil regulations agreed between simulator operator and manufacturer. In order to gain an understanding in the military/tactical capabilities of the devices, interviews will be conducted with experts of all crew types involved in operations on the devices.

WHAT?

The result of the project will be an evaluation process (including V&V reports) making it possible to determine:

- Whether the NH-90 FFS, VST, and FMFT are performing in accordance with the relevant regulations that will ensure safe operation of the NH-90 and its subsystems
- Whether devices are suitable for training Pilots, Sensor Operators and Tactical Coordinators in both individual tasks, as well as in a mission setting.

Project partners
Government (NL):
Project Bureau NH-90, Test Flight Office
Research organisations: NLR

Start: July 2014
Duration: ongoing

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.

Swiss Armed Forces Simulator Portfolio Rationalisation

WHY?

Many nations are facing the question what to do with their end-of-life simulators and how to ensure their replacements will be, more (cost-) effective, efficient, and future-ready. The Swiss Armed Forces are investigating possible options for developing a new portfolio of training simulators. The options should fit the envisaged Swiss Armed Forces future training needs and budget for 2030 and beyond.

HOW?

A corporate training needs analysis was carried out to identify current and future demands and to review the major training facilities. A training and technology scan was carried out, together with a small benchmarking activity. This led to the formulation of a training & simulation vision advisory, including measures for an integrated simulation architecture and infrastructure.

Three different options were formulated for realising the training demands and constraints. One option aimed for simulator replacement with limited change ('Minimize Change'), a second option aimed to take advantage of the large variety of envisaged training media, including VR, AR, MR, and PC-based simulation ('Richly Blended'). A third option aimed to maximize PC-based simulation ('Lean & Agile'). All options require a considerable level of integrated simulation infrastructure. The three options were compared in terms of initial investments, cost reduction and training value against the current situation ('business as usual') as baseline.

A roadmap was outlined towards implementation of the selected option.

WHAT?

The project provided guidance for a high-level outline of options for a future training simulator portfolio with a broad outline of an implementation roadmap and plan for the Swiss Armed Forces. The key to the succes of the selected option is to formulate a modern vision on training and simulation.

	Option 0 No Change	**Option 1** Minimize Change	**Option 2** Richly Blended	**Option 3** Lean & Agile
Sustainability & Future Proofing				
Accessibility & Availability				
Interoperability & Integration				
Modularity & Reusability				
Scalability & Adaptability				
Openness & Standardization				

Note – given ratings are fictive and don't represent the Swiss Armed Forces situation

Project partners
Armasuisse, Swiss Armed Forces
Hulleman Expertise

Start: September 2017
Duration: 1.5 years

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.

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 supports military forces in solving any challenge in modelling & simulation, ensuring effective realism and cost efficiency.

Royal NLR

- defines training & simulation vision
- performs operational training needs analysis
- designs training blue prints
- defines training media in line with training needs
- supports training implementation
- carries out training evaluation

For more information:

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