Accelerating the future of aerospace

R&D solutions for Air Traffic Management

Products and Services for ANSPs

Efficiency

U-space & Innovative Air Mobility

Safety & Human Performance

Training

Airspace & Flight Procedure Design

Sustainability & Enviroment

Accelerating competitive and sustainable aviation

The challenge for civil aviation operators is to achieve competitive and sustainable aviation. The growing demand to increase efficiency, sustainability, safety and security, enhance resilience and reduce costs requires innovative solutions.

That is why Royal NLR focuses its innovative R&D and solutions within the Air Traffic Management domain on delivering sustainability, efficiency, safety & human performance improvements and on tools that put stakeholders in command of their current and future performance.

NLR has been an ambitious, knowledge-based organisation for more than a hundred years now. We continue to translate trends and developments into actual solutions for the aviation companies, air traffic control, airports, regulatory bodies and governmental authorities. Our in-house applied research and unique research facilities ensure that NLR stays on top of new developments and innovations.

NLR has a great deal of knowledge and experience and offers products and services that can help you in civil aviation operations.The projects in this booklet showcase our capabilities and approach. We invite you to discover more about our research, productsand services.


Arrivals
KBOS Local
VFR
Departures

EFFICIENCY

To enhance the efficiency of ATM systems, NLR develops, prototypes and validates innovative concepts and tools. This is achieved using NLR's Air Traffic Management Real-time Simulator (NARSIM), which comprises three main facilities: NARSIM Tower facility, NARSIM Radar facility and NARSIM Remote Tower facility.

VALIDATION AIRCRAFT

NARSIM
RADAR SIMULATOR

INTEGRATION WITH
THIRD PARTY SYSTEMS

NARSIM
Tower Simulator

NARSIM Tower facility

The NARSIM Tower facility uses a 360 degrees field-of-view projection screen, 11m in diameter and 4.5m high, equipped with a laser projection system that results in eye-like resolution and an immersive experience of looking out of a control-tower on an airport. With room for 9 controller working positions setup for different roles, NARSIM Tower is one of the largest tower research simulators in Europe.

The tower visual system can simulate realistic weather conditions, such as bad visibility, snow and rain and also supports day and night view on a multitude of airports. All current and modern tower controller system support tools are available such as radar surveillance systems, multilateration ground radar, flight data processing and its UIs, safety nets, stopbar and light control panels, A-SMGCS (Advanced Surface Movement Guidance and Control Systems) tools, voice communication systems and electronic flight strips.

NARSIM Tower has a proven track record and has been used as a validation platform in European ATM research (SESAR) by research centres and ANSPs but also as a training platform in the training of new Air Traffic Controllers or in the conversion training introducing new operational subsystems. The system supports the simulation of all types of traffic (fixed wing air traffic, helicopters, drones, ground vehicles, etc.) typically found in an airport environment.

CAPABILITIES

- Validation of (Advanced) Surface Movement Guidance and Control Systems (A-SMGCS)
- Validation of Human Machine Interfaces for controller working positions
- Studies of airport capacity, safety and efficiency under dense traffic and marginal visibility
- Testing and optimisation of future tower procedures and airport infrastructures, including legislation and safety assessment
- Development and validation of ATM automation tools, including data link applications, by Collaborative Decision Making (CDM) and Gate-to-Gate operations;
- Remote Tower operations, including video surveillance support

NARSIM Radar facility

The NARSIM Radar facility consists of 29 radar controller working positions. Each working position can act as a tactical, planner or feeder position for controlling upper-airspace en-route, area control or approach and terminal area traffic. The radar working positions can be run to emulate (in both hardware and software) any ATC platform such as iCAS/iTEC (INDRA), AAA (LVNL), MADAP system (EUROCONTROL), ATCAS P2 (DFS), TopSky (Thales) and others. Our customers include LVNL, MUAC (EUROCONTROL), LFV, DFS, AustroControl and several military ANSP's.

The underlying system is a trajectory based operations (TBO) system with the following main features:

- Enhanced Mode-S (e.g. for Pilot Selected Level)
- ADS-C/CPDLC (e.g. Extended Projected Profile, EPP)
- Planning and support tools like arrival management (AMAN/XMAN), interval management (IM), time-based separation (TBS), optimised runway delivery (ORD)
- Coordination tools like SYSCO/OLDI
- Safety net systems like Short Term Conflict Alert (STCA) and Medium Term Conflict Alert (MTCD) and Monitoring Aids (MONA)

The software supports multi-centre operations (i.e. multiple centres with different centre concepts and systems run in a single simulation). Interoperability with live systems is possible through the use of industry standard protocols.

An integrated radio/telephone system allows the air traffic controller to communicate with pilots, other air traffic controllers or adjacent sectors or centres.

CAPABILITIES

- Research into Human Machine Interfaces (HMI)
- Air traffic controller assistance tools
- Development, visualisation and validation of ATM concepts and procedures
- Support of qualitative and quantitative safety assessment
- Applications of data link and Air Ground integration in general
- Shadow mode validations in an operational environment
- ATC courses and controller training
- Demonstrations
- Prototyping

NARSIM Remote Tower facility

The NARSIM Remote Tower environment can be used for remote tower research and training; both single airport and multiple airport operations are supported. The system consists of nine 4K HD screens in 120 degrees arc to simulate the view from remote cameras on one or several airports at the same time. The two controller working positions are equipped with three 5K screens each, a touch screen for voice communication and (simulated) Pan-Tilt-Zoom camera operation and can be equipped with the same tools and systems as the full NARSIM Tower.

CAPABILITIES

- Validation of Multiple Remote Tower concepts
- Prototyping of Remote Tower systems
- Planning tools for Multiple Remote Tower operations


Sky
Taxi
PH-008
PH-008

U-SPACE & INNOVATIVE AIR MOBILITY

The increasing use of unmanned aircraft demands enhanced integration and coordination between ATM and UTM systems. NLR is at the forefront of this development, leveraging its expertise in U-space and drone operations through involvement in national and European projects, and in collaboration with key stakeholders.

Innovative Air Mobility

THE CHALLENGE

Innovative Air Mobility (IAM) is the latest mobility revolution, enabling faster, more efficient and sustainable transport solutions. However, there are a number of challenges to overcome in order for IAM to become a reality: such as the organisation of the lower-level airspace, the scale up of operations in a safe way, integration with ATM, the development of an architecture system and infrastructure that can support operations and public acceptance. Research and innovation into Innovative Air Mobility and U-space development will enable the deployment of this new transport mode.

HOW CAN WE SUPPORT YOU?

NLR has vast experience with U-space and IAM topics, being involved in several national and European projects for the development and implementation of U-space and drone operations. NLR maintains contact with governments, industry, research centres and universities, ensuring that knowledge of U-space and IAM is spread throughout the whole value chain. As such, NLR has been a key player in enabling drone operations in the Netherlands and serves as an advisor for their implementation in other European countries.

We recently developed a research agenda for drones in cooperation with all major Dutch stakeholders that will form a guideline for a national and international strategy for the Dutch government up to 2030. NLR also developed the U-space roadmap for the Dutch government for the rollout of the U-space services between 2021 and 2025. At a European level, we are active in several SESAR projects for the integration of drones into airspace, the development of the U-space ecosystem, deployment of IAM, and ATM-UTM integration.

CAPABILITIES

- U-space and IAM ConOps development
- Development of operational concepts for IAM
- U-space implementation
- Implementation of U-space ecosystem
- ATM-UTM integration
- Development and validation of U-space services
- IAM vertiports development
- Developing and testing concepts for vertiport operations (At NLR drone test facility)

ENSURE

ATM-Uspace Interface and Airspace Reconfiguration Service

Building on the foundations of the Dynamic Airspace Reconfiguration (DAR) concept and ATM interfaces developed in project AURA, the SESAR-funded ENSURE project aims to further automate and streamline the process for seamless data exchange between air traffic management (ATM) systems and unmanned air traffic management (U-space) systems.

THE CHALLENGE

The increasing presence of unmanned aircraft in European airspace necessitates a unified interface between ATM and U-space systems to prevent collisions and ensure safe traffic segregation. Furthermore, ATM interfaces are required to dynamically reconfigure and delegate airspace, and visualise the impact of airspace changes to tactical air traffic controllers.

WHAT WE ARE DOING

Based on the definitions of a CISP and related DAR procedures, we have designed user interfaces for the two key ATM roles in the DAR concept: airspace managers and air traffic controllers. These interfaces facilitate flexible airspace sharing between manned and unmanned traffic, enabling safe drone operations over the North Sea. NLR tested the interfaces through real-time simulations and with a drone demonstration flight in 2025-2026.

PARTNERS
View all partners on:
sesar.eu/projects/ensure

DURATION
2023-2026

FUNDING
SESAR 3 Joint Undertaking
GA no. 101114732

THE SOLUTION

Our solution enables the safe and efficient coexistence of manned and unmanned aircraft in shared airspace. The common information service provision (CISP) interface and user interfaces for airspace managers and tactical controllers developed in ENSURE will help evolve current standards and regulations, facilitating growth in the UAS market. This will allow organisations like ATC the Netherlands and the Royal Netherlands Navy to conduct safe operations in shared airspace, while aligning with U-space services definitions for future integration.


KLM
Schiphol Amsterdam

SAFETY & HUMAN PERFORMANCE

NLR supports organisations across various industries in achieving their safety objectives by providing tailored solutions that combine data-driven insights with expert knowledge to inform decision-making and optimise operational and human performance.

CAPABILITIES

- Solutions for increased runway throughput
- Advice on improving your Safety Management System
- Advice on improving your safety culture
- Safety and risk Assessments
- Obstacle Assessments / Aeronautical Studies
- Identification and monitoring of risks
- Support in how to mitigate safety risks

Safety case and risk assessment

Support in dealing with complex safety challenges in ATM

THE CHALLENGE

It may be necessary to develop or modify air traffic management (ATM) operations and procedures, for example to optimise capacity, efficiency or environmental impact. These new modifications can only be introduced after the safety of the changes has been assessed and deemed to be compliant with appropriate safety criteria. It is very challenging to complete the safety case due to the complexity of safety risks in ATM and because of insufficient insight into the interdependencies between capacity, efficiency and safety. This could lead to poor decision-making and suboptimal ATM performance.

A professional and high quality safety case and underlying (safety) assessment is a precondition for the safe, efficient, environmental friendly and high capacity ATM operation. It requires a thorough understanding of the complexity of ATM operations, technology and procedures, solid methods for safety modelling and risk assessments, and sufficient data to support analysis.

In addition, the presentation of the safety case has to be such that accountable managers and other decision makers are able to act upon it. NLR has a solid track record of delivering those needs for ANSPs.

HOW WE CAN SUPPORT YOU

NLR provides support in developing safety cases, by supplying underlying safety data, expert judgment or process organisation advice. Furthermore, we are able to take responsibility for developing a complete safety case for you. To do so, we use state-of-the-art insights, models and techniques (e.g. data science) to support the development of the safety case. Our key strength is the ability to combine the pure operational and local perspective with the expertise of safety methods, processes and regulations. Our safety assessments methods and models can be applied to various types of air transport safety studies, for instance parallel approaches, operations in limited visibility, taxiway take-offs, ground collisions, etc.

Data science for safety management

Providing actionable insights from data across a range of application domains

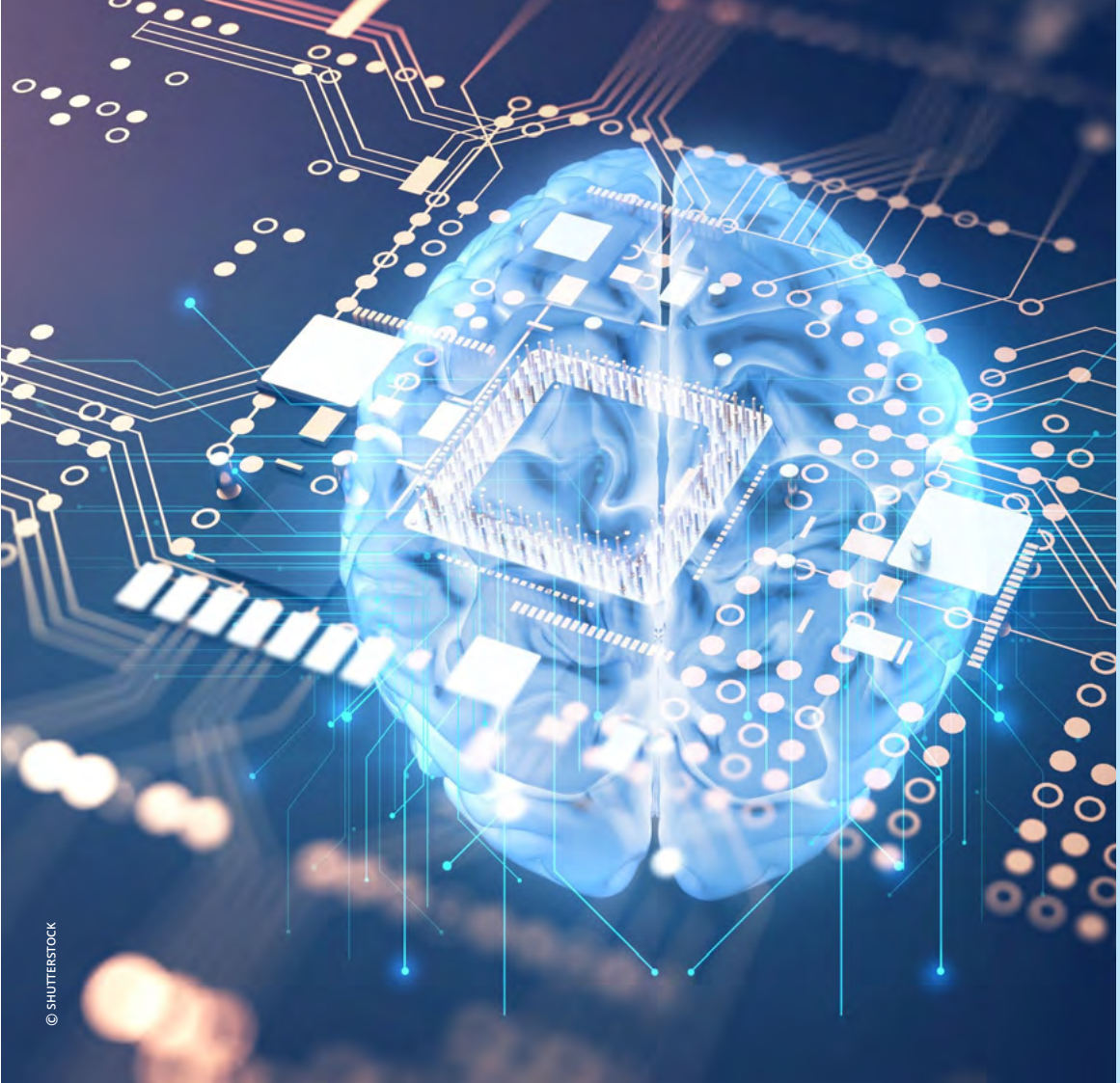
THE CHALLENGE

How can you give value and meaning to the abundance of data within your organisation? The application of data science has the potential to enhance the quality of (risk) assessments, improve understanding of the effectiveness of control measures, and facilitate better data-driven decision-making. By applying data science techniques, ANSPs can optimise ATM-operation to meet operational needs. However, many organisations struggle to utilise the abundance of data to its full potential or lack efficiency in data mining and integration.

Data science techniques combine operational expertise, programming skills, mathematics and statistics to extract knowledge, actionable information and insights on safety and operational performance from (operational) data. Data science practitioners apply those techniques to predefined datasets, like radar tracks (e.g. as NLR's FANOMOS), meteo data, occurrence reports, fleet data etc. Data visualisation is another important aspect of data science. It provides visual context through maps, graphs and interactive dashboards. This makes the data more natural for the human mind to grasp and makes it easier to identify trends, patterns, and outliers within large data sets.

HOW WE CAN SUPPORT YOU

NLR possesses a solid knowledge base, as well as experience and expertise in applying data science and machine learning to safety management. Data can reveal the effects of changes, such as the introduction of new technologies or procedural modifications on safety, efficiency, human performance, and other areas of interest within the ATM system. NLR can identify the best application of data science within ANSPs and convert operational data of any organisation into actionable insights.



CAPABILITIES

- Automatic classification of safety occurrence reports
- Automatic detection of 'outlier' flights in flight data or radar data
- Monitoring of ground radar data for safety (precursor) events and trend analysis, e.g. detection of deviations from standard procedures
- Data collection and integration of (worldwide) safety and operational data (FLORIS data warehouse, FANOMOS)
- Machine Learning application to analyse causal factors and relations between causal factors in a large repository of accident / incident reports.
- AROT (Actual Runway Occupancy Time) and CTL (Clearance To Land) margin data analysis for implementation of RECAT-TBS
- Data analysis of radar tracks for ILS Localiser and Glidepath deviations

CAPABILITIES

- Performing work schedule evaluations for fatigue avoidance, for instance based on mathematical models
- Benchmarking against work limits and minimum rest regulations.
- Fatigue, sleep and alertness measurements on ATCOs in a non-intrusive manner (e.g. using logbooks, mobile app, eye tracking or actigraphy).
- Tailored fatigue mitigation interventions including briefings, surveys, interviews and / or workshops.

Fatigue risk management for air traffic service providers

THE CHALLENGE

Fatigue is a well-recognised human factor that leads to reduced alertness and subsequent safety issues, and needs to be adequately managed. Since fatigue can be caused by a wide variety of factors such as workload, night shifts, sleep debt or circadian disruption, fatigue risk management and mitigation is not an obvious and straightforward task.

Since 2020, the International Civil Aviation Organization (ICAO) amendments to Annex 11 require that ICAO States establish duty limits and specify certain scheduling practices for air traffic controllers. Hence, ANSPs have to implement their fatigue management processes and procedures in accordance with ICAO guidance and States regulations.

Assessing the contributing factors in your organisation is essential in order to implement tailored and effective fatigue risk management strategies.

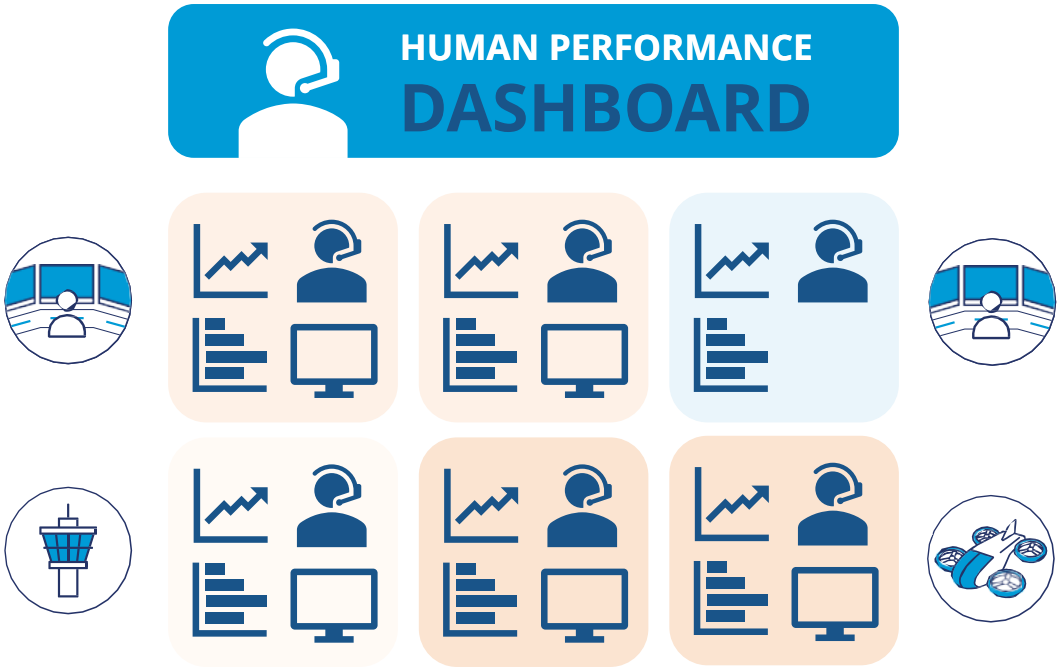
HOW WE CAN SUPPORT YOU

The way in which a fatigue risk management system (FRMS) is implemented very much depends on the ANSP. First we need to identify the current situation of the ANSP, so as to establish what the ANSP aims to accomplish and how the ANSP can be supported. For example, if an ANSP intends to optimise its fatigue level status, it requires a different approach from a benchmark against other organisations, ensuring that all regulations are implemented correctly. NLR can support ANSPs in focusing on what is important for its specific situation.

NLR can bring together workplace, organisational, regulatory and scientific expertise through an inspiring team of human factors, training and safety experts. We provide assistance in developing and implementing optimal work schedules, identifying fatigue causes and hazards within your organisation, and optimising FRMS. Our support is modular and can be tailored to meet the specific needs and preferences of ANSPs.

THE SOLUTION

The project is exploring standardisation concepts and procedures for D/F-RTS in air traffic management and developing new methods and techniques that support Human Performance (HP) and security assessments for Human-in-the-Loop (HIL) systems in such an environment.



VISORS

Validation Infrastructure Supporting Remote Simulations

As air traffic management (ATM) concepts evolve, validation processes are becoming increasingly complex. The SESAR project VISORS aims to promote interoperability among ATM validation platforms, enabling more efficient and cost-effective validation of new systems and procedures.

THE CHALLENGE

Within the SESAR project VISORS, NLR and its partners are evaluating the technical and economic aspects of cybersecure Distributed/Federated Real-Time Simulations (D/F-RTS) as a viable means to help simplify the validation process for new ATM systems and procedures.

WHAT WE ARE DOING

NLR is contributing to the development of distributed simulations by conducting economic analysis and standardising human performance assessment. To achieve this, the team is developing and validating standardised protocols and metrics.

Key developments include:

- Concept design of a Human Performance Dashboard to monitor multiple federated humans in D/F-RTS. This dashboard will provide a centralised platform for tracking human performance in simulated environments.
- Utilizing the High-Level Architecture (HLA) standard for human object data to exchange Human Performance data in D/F-RTS, enabling seamless communication between different simulation systems.

PARTNERS

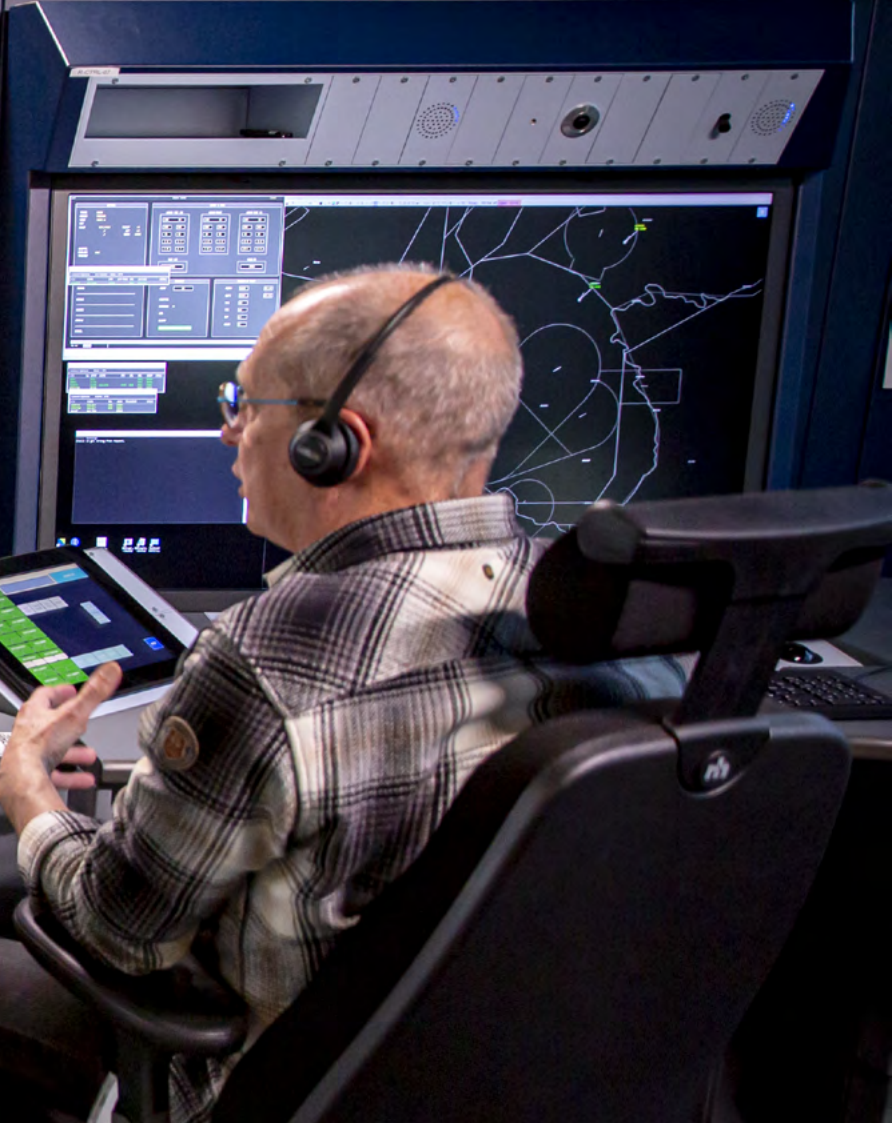
View all partners on:
sesar.eu/projects/visors

DURATION

2024-2027

FUNDING

SESAR 3 Joint Undertaking
GA no. 101167000



TRAINING

NLR designs, develops, and implements competency-based aviation training by analysing needs, creating training solutions and learning ecosystems, applying learning analytics, and ensuring quality and effective adoption.

CAPABILITIES

- CBTA programme implementation
- Instructor CBTA courses
- Data-analytics-as-a-service to identify specific, and even individual, training needs
- Measurement of programme training effectiveness
- Measurement of instructor concordance.

Competency-Based Training & Assessment

THE CHALLENGE

How can you make training as efficient as possible, in terms of time and budget? We believe that high-quality Competency-Based Training & Assessment (CBTA) is ideal for both the ANSP and the ATCO alike. CBTA was developed over the last ten years, combining data-driven training with competency-based training. CBTA generates competency data and uses this data to adapt the ATCO's recurrent training to focus on actual competency training needs. In this way, CBTA provides an elegant framework to continuously improve ATCO core competencies.

CBTA aims to develop ATCOs in several core competencies, instead of providing training in a narrow, familiar and repetitive set of tasks.
By developing competencies, an ATCO is effectively prepared to manage safety and performance in many different situations, not only those they have been explicitly trained for.

CBTA offers additional efficiency because it:

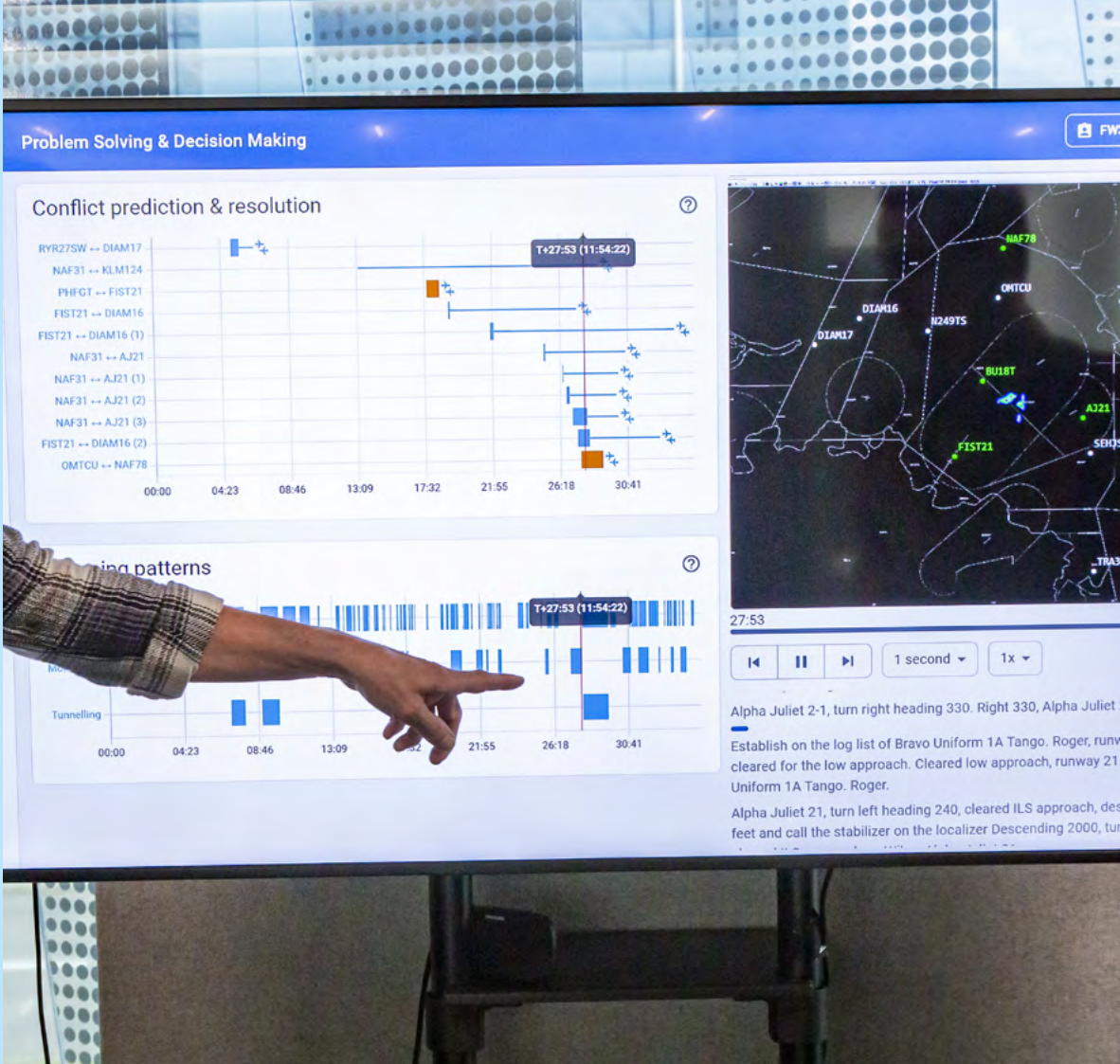
- automatically adapts the training to the needs of each individual ATCO. No time is wasted on competencies which are already mastered by this ATCO.
- provides training in several core competencies which allow ATCOs to act efficiently in an array of situations, without the need to train each individual special situation separately.

HOW WE CAN SUPPORT YOU

NLR assists operators in achieving reliable ATCO development programmes by leveraging our experience with Competency Based Training & Assessment (CBTA), Evidence-Based Training (EBT), and Performance-Based Training (PBT). We can support training departments in developing, maintaining and evaluating high quality CBTA.

THE SOLUTION

This project explores innovative training solutions to address these challenges, leveraging cutting-edge technologies such as Artificial Intelligence (AI), data analytics, and simulation-based training. The goal is to create a personalised, adaptive, and effective training environment that supports the development of air traffic controllers' skills and competences.



The future of ATCO training

Improving the efficiency and effectiveness of air traffic controller (ATCO) training is crucial for safe and efficient airspace operations. Our research project is tackling this challenge head-on, focusing on personalised learning ecosystems, evidence-based training, family of systems, and human performance.

PARTNERS
Royal NLR, LVNL

DURATION
2023-2028

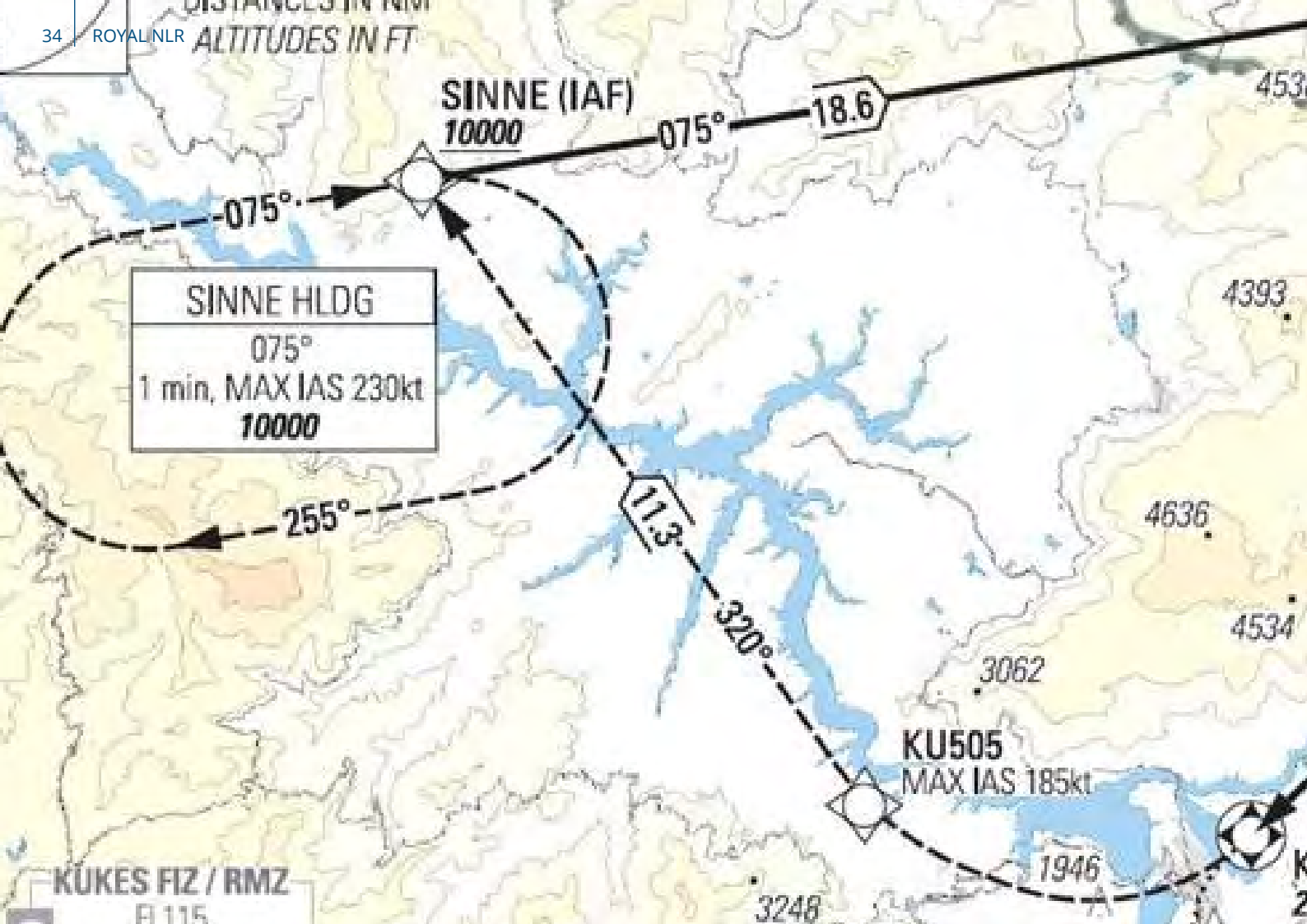
THE CHALLENGE

Air traffic controller training is complex, requiring a high level of skill and knowledge. The training path is extensive and includes essential on-the-job training, which can make it challenging to adjust to individual trainee needs. It is therefore vital to strike the right balance between complexity and simplicity for long-term employability.

WHAT WE ARE DOING

NLR works in partnership with LVNL and other air traffic control organisations to research, develop, and test new training concepts and tools. Key aspects include:

- Using objective data to inform training decisions and optimise performance
- Exploiting speech recognition technology to improve training effectiveness
- Investigating the effects of aging on operator performance to ensure long-term employability and effectiveness in air traffic management.


DISTANCES IN NM
ALTITUDES IN FT
SINNE (IAF)
10000
075°
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1 min, MAX IAS 230kt
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255°
11.3
320°
4393
4636
4534
3062
KU505
MAX IAS 185kt
1946
3248
KUKES FIZ / RMZ
FL115

AIRSPACE & FLIGHT PROCEDURE DESIGN

With growing demand on airspace and airport capacity, the need for innovative solutions to optimise air traffic management becomes increasingly important. NLR can help airports and aviation stakeholders in addressing these complex challenges by using dynamic airspace configuration, for example.

THE SOLUTION

The ISLAND project is evaluating smart sector design concepts for optimal configurations to meet safety, workload and KPI targets, improve network and local traffic, and load prediction from D-1 to T-2h. We are also working on advanced tools to predict traffic demand and optimise capacity, as well as developing network performance indicators to measure resilience and efficiency. Additionally, we are exploring new methodologies and algorithms to estimate implementation costs and manage airborne arrival delays, balancing CO_2 reduction with pre-departure delays through advanced prediction, decision support, and impact assessment.

ISLAND

Island Suite for Local and Network Demand and capacity

As demand on airspace and airport capacity continues to grow, innovative solutions are needed to optimise air traffic management. The ISLAND project explores how dynamic adaptation of airspace structures to meet demand can improve flight handling around airports. However, changing airspace structures is extremely complex and poses significant challenges. The project is investigating Dynamic Airspace Configuration (DAC) as a potential solution.

THE CHALLENGE

DAC involves adaptable airspace layouts that respond to real-time traffic demands. By employing automation, AI, and machine learning, DAC enables proactive adjustments and informed decision-making. Operational services play a key role, defining roles and processes for stakeholders and promoting shared situational awareness through collaboration. Effective control of airborne delays is also crucial, relying on network management measures and target times in order to balance traffic demand, capacity, economic efficiency and environmental impact.

WHAT WE DID

NLR is developing an operational concept for DAC in close collaboration with its partners. Our work is focused on researching a solution for real-time traffic demand forecasting and intelligent sector design. We have created prototype systems, which were subsequently validated through real-time simulation experiments using the NLR Air Traffic Control Simulator (NARSIM) by air traffic controllers of our local Air Navigation Service Provider (ANSP).

PARTNERS

View all partners on:
sesar.eu/projects/island

DURATION

2023-2026

FUNDING

SESAR 3 Joint Undertaking
GA no. 101114715

AIRSPACE AND INSTRUMENT (OR VISUAL) FLIGHT PROCEDURE DESIGN WITH A FOCUS ON PBN PROCEDURES

NLR can accommodate various procedures, including standard RNP approach procedures, RNP AR, and STARS with merging and sequencing mechanisms. NLR can also perform airspace design for all types of airspace, such as TMA, CTR, and ACC, and support specific rotorcraft procedures.

AERONAUTICAL STUDIES

These studies assess the impact of obstacles, such as wind turbines or high-rise buildings, on new or existing flight procedures near airports.

UNMANNED AIRCRAFT

Research on integrating unmanned aircraft into airspace, developing drone-specific procedures in the absence of international standards.

Intelligent solutions for next-level airspace management

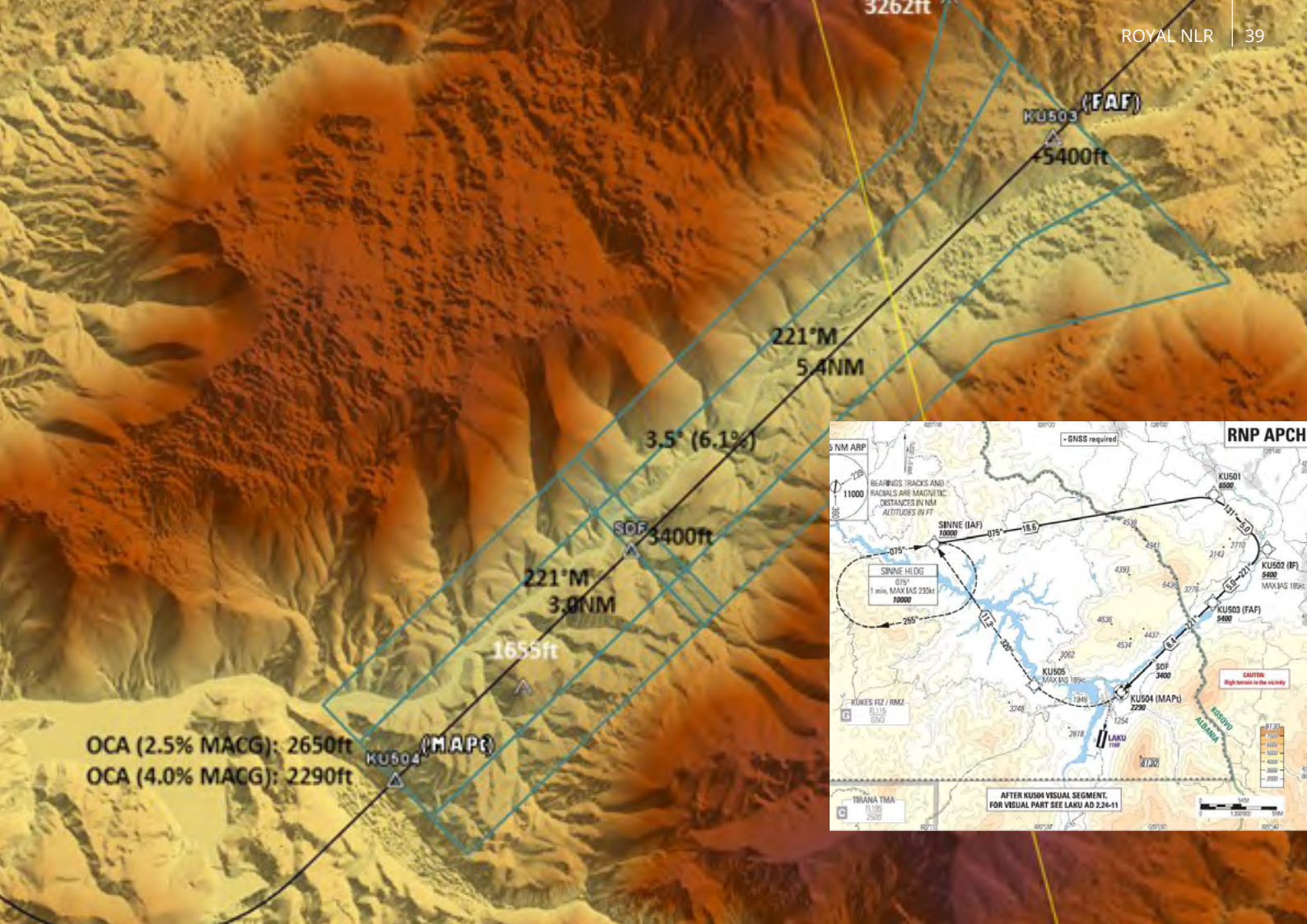
THE CHALLENGE

All over the world airspace is experiencing the emergence of new civil and military users, both manned and unmanned. However, airspace volume is physically limited, the aviation industry needs to reduce its global environmental impact but capacity growth is expected to grow again to pre-corona times. With these constraints, there is a need for an efficient and well organised airspace. Existing airspace and flight procedures therefore need to be optimised in order to comply with these efficiency, capacity and environmental constraints. Performance-based navigation (PBN) flight procedures are a crucial aspect in this process concerning the modernisation of airspace and flight procedures.

HOW WE CAN SUPPORT YOU

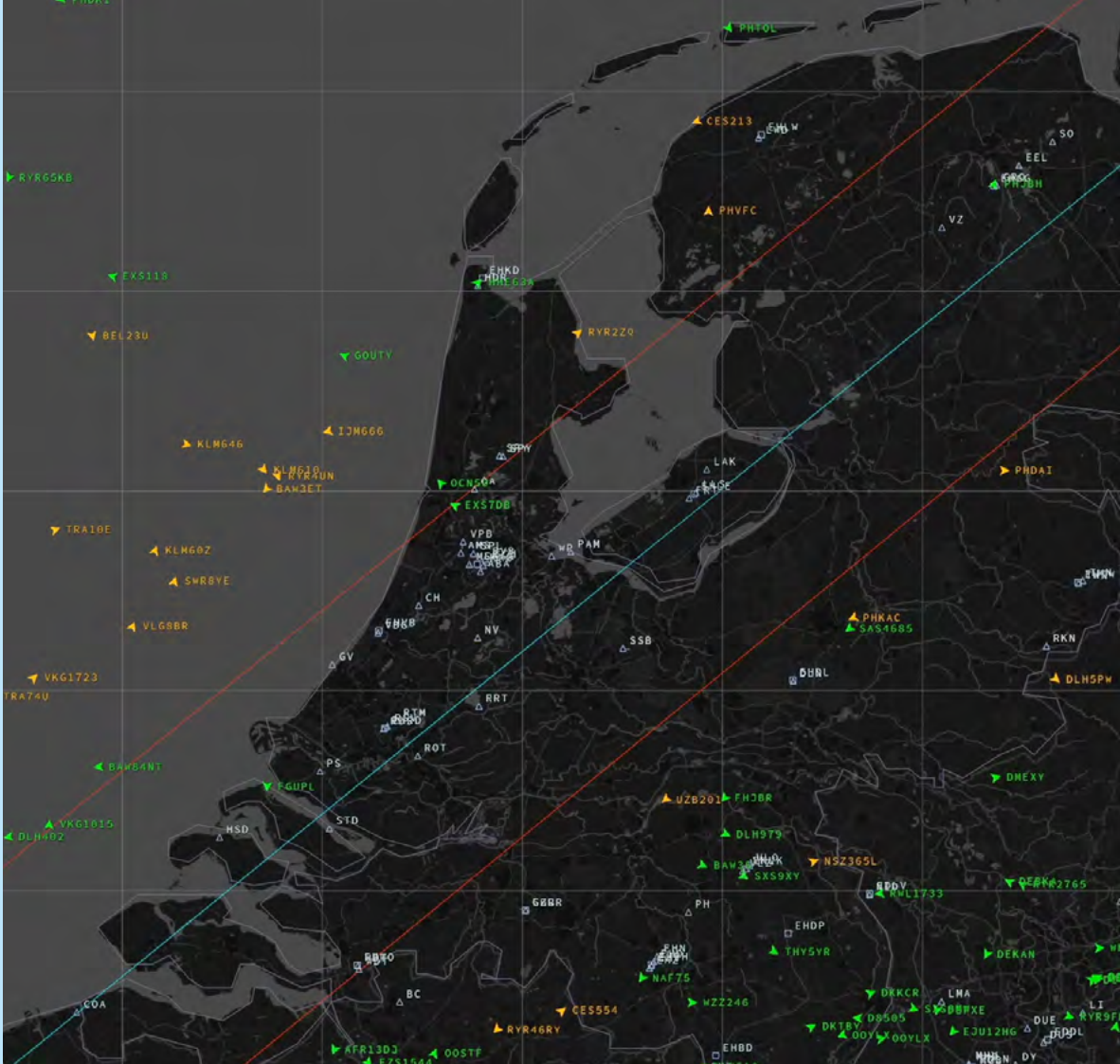
NLR has the required expertise and internationally recognised software tools to assist ANSPs, airports and governments with their airspace and flight procedure design needs. We are able to perform complete designs from scratch (for example for new airport development) and design modifications to existing airspace or flight procedures. In short, NLR can offer you a unique 'one-stop shop' from design to fast-time and real-time validation, to charting and support to AIP publication. This includes access to our in-house flight validation and calibration aircraft, which caters to airspace and flight procedure design projects. In doing so, NLR strictly follows the guidelines and standards as defined by ICAO (e.g. flight procedures design projects ICAO doc 9906), and other international organisations such as Eurocontrol and EASA.

NLR is able to conduct flight tests with NLR Research Aircraft, for which it has approval according to EASA Part 145, Part 21 (national DOA) and Part-M, and has a Service provider certificate (ILT-2024/1844) for Validation of Flight Procedures.


3262ft
KU503 (FAF)
5400ft
221°M
5.4NM
3.5° (6.1%)
SDF 3400ft
221°M
3.0NM
1655ft
OCA (2.5% MACG): 2650ft
OCA (4.0% MACG): 2290ft
KU504 (MAPt)
RNP APCH
- GNSS required
BEARINGS TRACKS AND RADIALS ARE MAGNETIC. DISTANCES IN NM. ALTITUDES IN FT
SINNE (IAF)
SINNE HLDG
KU501
KU502 (IF)
KU503 (FAF)
KU505
KU504 (MAPt)
SDF
LAKU
CAUTION: High terrain in the vicinity
KOSOVO
ALBANIA
TIRANA TMA
AFTER KU504 VISUAL SEGMENT, FOR VISUAL PART SEE LAKU AD 2.24-11

THE SOLUTION

The findings show that a structured approach combining improved space object tracking capabilities, predefined risk assessment zones, and collaborative decision-making between ATM and space operations stakeholders can significantly enhance both safety and efficiency during uncontrolled re-entry events. Recommendations are proposed for integrating these procedures into existing ATM frameworks to better prepare for the increasing interaction between the space and aviation domains.



Space debris resilience

With growing activity in space, higher airspace, and conventional ATM domains, the likelihood of uncontrolled space object re-entries impacting airspace operations is increasing. Such events pose a potential safety threat to airborne traffic and challenge the efficiency of current ATM procedures.

THE CHALLENGE

It is difficult to have a specific and exact warning for an expected re-entry event due to the uncertainty of the exact time and location of a space object re-entry. This research investigated how ATM should deal with uncontrolled re-entries from space. The study created a use-case scenario in which a returning space object is detected shortly before its expected entry into Dutch airspace above Amsterdam Schiphol Airport, one of Europe's busiest hubs.

WHAT WE DID

In 2025, NLR developed a simulation of a space object re-entering Dutch airspace to explore possible operational responses within this limited timeframe. For instance, flights were categorised into affected and non-affected groups to facilitate prioritisation, ensuring that aircraft most at risk or constrained by operational needs received immediate attention. In addition, the study identified the importance of providing controllers with visualisation tools depicting the predicted impact zone and uncertainty area and time window, allowing for better situational awareness and decision-making under time pressure.

ITARO
INTEGRATED TMA • AIRPORT • RUNWAY OPERATIONS

THE SOLUTION

The ITARO project (SESAR2020 PJ.37-Wave3) is a one of a kind project that combined an IR- and a VLD part to bring together several individually developed SESAR Solutions into an integrated operation, a first step towards pre-deployment.

Several important validation exercise activities have been performed by Royal NLR (and partners) in the ITARO project to further close the gap between Industrial Research & Development and (pre-) deployment, aiming at greener flights and improved punctuality (e.g. less delays) contributing to more sustainable aviation.

ITARO

Integrated Airport, TMA and Runway Operations

THE CHALLENGE

Over the past decades the Single European Sky ATM Research (SESAR) programme has been working intensely to deliver sustainable ATM solutions. These SESAR Solutions are being brought towards higher Technology Readiness Levels (TRLs) via Industrial Research (IR) projects and towards (pre-)deployment via Very Large Demonstrations (VLDs). The challenge is to combine and integrate individually developed SESAR Solutions, while not losing the established benefits of the individual Solutions. Proper integration therefore requires a detailed understanding of the local ANSP operations and of the specific in-and-outs of the SESAR Solutions to be integrated.

HOW WE CAN SUPPORT YOU

Royal NLR has the expertise and facilities to prepare, set up, integrate and assess the performance and implication of the integrated novel SESAR Solutions for you local ANSP situation. As demonstrated in the ITARO project, the integration of novel SESAR Solutions can be assessed at for instance the Fast Time Simulations (FTS) level, a Real Time Simulation (RTS) level, or even via operations in a real live environment, for instance using a Flight Test operation, or any other means, like hardware-in-the-loop testing, etc.

Royal NLR operates several facilities, like NARSIM (NLR's ATC Research Simulator) for (remote-) tower and radar operations with ATCo in-the-loop human factors validations as well as with dedicated tools, like FANOMOS (Flight track And Noise Monitoring System) for environmental impact studies, or with eye-trackers to measure human performance, or with PREPAIRE, allowing to set up testing scenarios. Furthermore remote coupling of NARSIM to your own simulation environment is feasible. The NLR flight test aircraft is available to bring the Solution validations to a real high TRL level with flying in a real operational ATC environment. Furthermore, Royal NLR has vast expertise to support you in various validation setups (shadow-mode or other), or in your quest for answers on how to properly integrate SESAR Solutions.

PARTNERS

View all partners on:
sesar.eu/projects/itaro

DURATION

2021-2022

FUNDING

SESAR 3 Joint Undertaking
GA no. 101017622


KLM

SUSTAINABILITY & ENVIRONMENT

NLR has extensive experience in monitoring airport noise and flight tracks, as well as analysing aircraft fuel use, emissions, and local air quality. We can help you gain valuable insights and inform aviation policy decisions, drawing on our many years of expertise in this field.

FANOMOS

Flight and Noise Monitoring System

THE CHALLENGE

There is a continuous need for improved flight efficiency and reduced environmental impact of flight operations. To support this, a trusted basis for flight data is required for the purposes of conducting accurate and detailed analyses. The best approach for a wide range of stakeholders e.g. ANSPs, airports, airlines, community and governments, is to monitor these flight data accurately in real-life.

Benefits:

- Shared flight data for different studies, e.g. environmental impact studies
- Real-life flight data serve as a trusted knowledge base
- Enabler for long-term trend analysis

HOW WE CAN SUPPORT YOU

NLR has long standing experience in radar data processing, flight track monitoring and environmental impact studies. In FANOMOS, data collected from flight data monitoring serve as a solid basis to analyse the impact of flight operations in environmental impact studies, for instance. These studies can be conducted for real-time as well as for historic data. For future scenarios, for which monitored data are not available, simulated flight data can be fed into the monitoring system to compare historic and future situations.

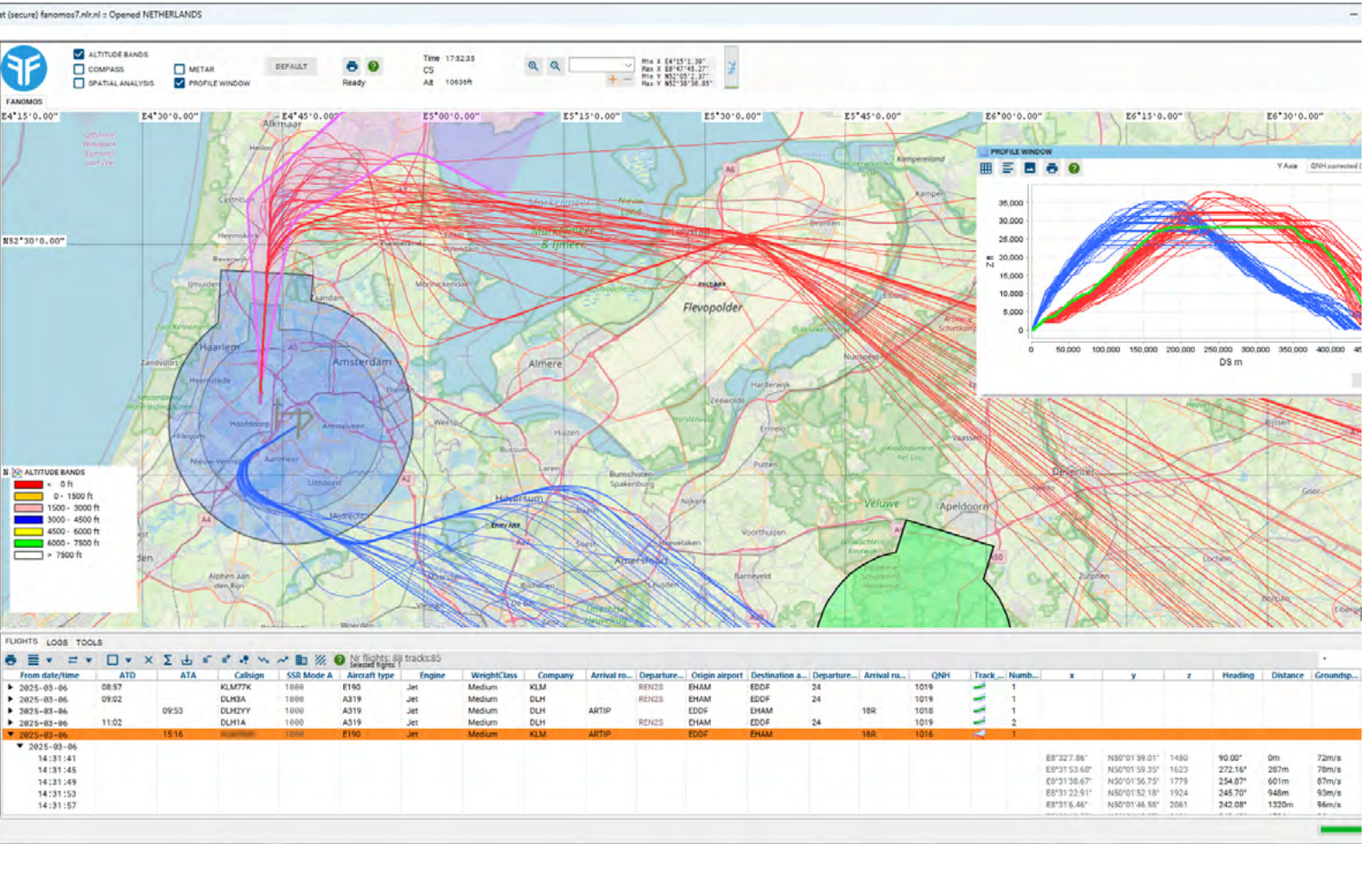
FANOMOS can be offered in different ways:

- FANOMOS software product to be embedded in your own ICT infrastructure
- Access to NLR's FANOMOS server to facilitate your own analyses
- A web service access (REST API) for coupling flight data with your own information systems
- Consultancy services whereby NLR conducts analyses and studies for you

CAPABILITIES

Based on the collected flight data the impact of aircraft operations is analysed and presented. This provides more in-depth insight. Monitoring data facilitate several goals:

- Impact studies such as environmental assessments
- Safety studies
- Flight performance studies and trend analysis
- Information sharing
- Improvement of model input data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14:31:49 E8°31'38.67" N50°01'56.75" 1779 254.87° 601m 87m/s
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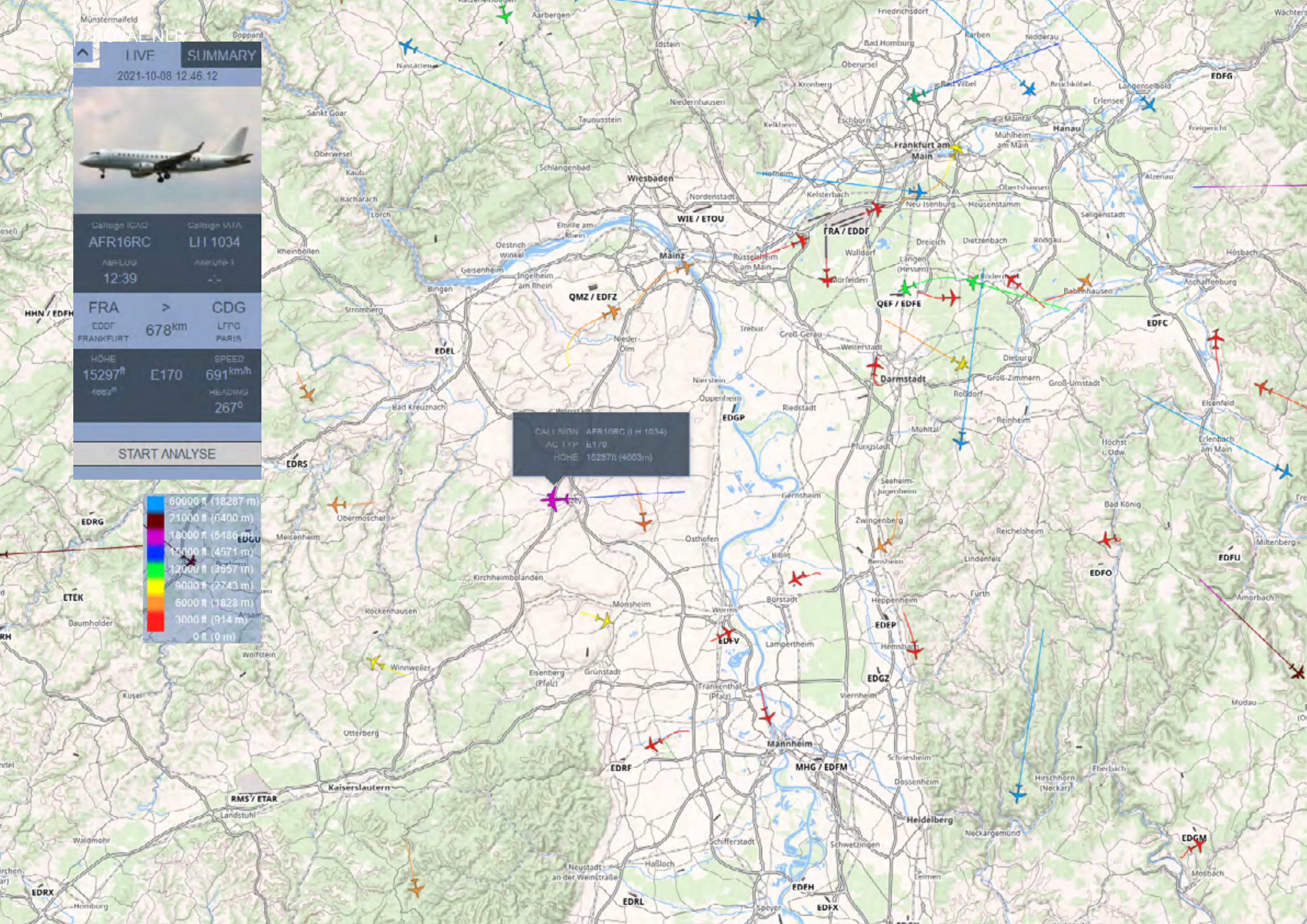
14:31:57 E8°31'6.46" N50°01'46.58" 2061 242.08° 1320m 96m/s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Mainz
Frankfurt am Main
FRA / EDDF
Darmstadt
Mannheim
Heidelberg
Kaiserslautern

FlightCatcher

Providing insight on flight track data for the public

THE CHALLENGE

Transparent communication is essential for airports, airlines and ANSPs to build a good relationship with the people who live near the airport. Providing information and explaining where airplanes fly and why they deviate from a normal situation is one of the most challenging tasks in communicating with your community.

Goals

- Provide insight on flight operations
- Improve relationship with local communities
- Reduce costs for complaint analysis

HOW FLIGHTCATCHER CAN SUPPORT YOU

In close cooperation with the German ANSP Deutsche Flugsicherung DFS, Royal NLR developed the web-based flight tracking service FlightCatcher. This service is based on NLR's long-term experience in radar data processing, flight track monitoring and environmental impact calculations. As part of the airport's community engagement strategy FlightCatcher offers the general public insight into air traffic with maximum transparency.

CAPABILITIES

- An online communication tool displaying aircraft operations and environmental impact (noise) in a clear manner. Similar to DFS STANLY_Track for German air traffic visualisation and analysis of real-time flight movements and historical flight tracks
- Accurate replay of flights for analysis of historical flight data
- Functionality showing nationwide detailed flight information
- Building public understanding of complex airspace around airports
- Creating bespoke systems for customers, adaptable to modules like environmental impact (noise)

THE SOLUTION

We created a pioneering tool that merges airspace design with real-time noise evaluation. As users draw routes, it quickly assesses noise impacts, guiding airspace designers towards optimised solutions. The outcome: a balance between efficient air traffic and reduced noise pollution.

ARCANE

Aircraft Route Customiser and Noise Evaluator

ARCANE is a tool created to integrate airspace design and air traffic noise effects, providing a more holistic approach to evaluating the impact of air traffic on the environment. The primary function of ARCANE is to allow users to create and modify routes within an airspace environment. The tool can evaluate and compares the noise effects resulting from drawn routes, enabling users to assess and optimise their designs based on noise effect considerations. This capability supports the development of more efficient and environmentally friendly airspace designs.

THE CHALLENGE

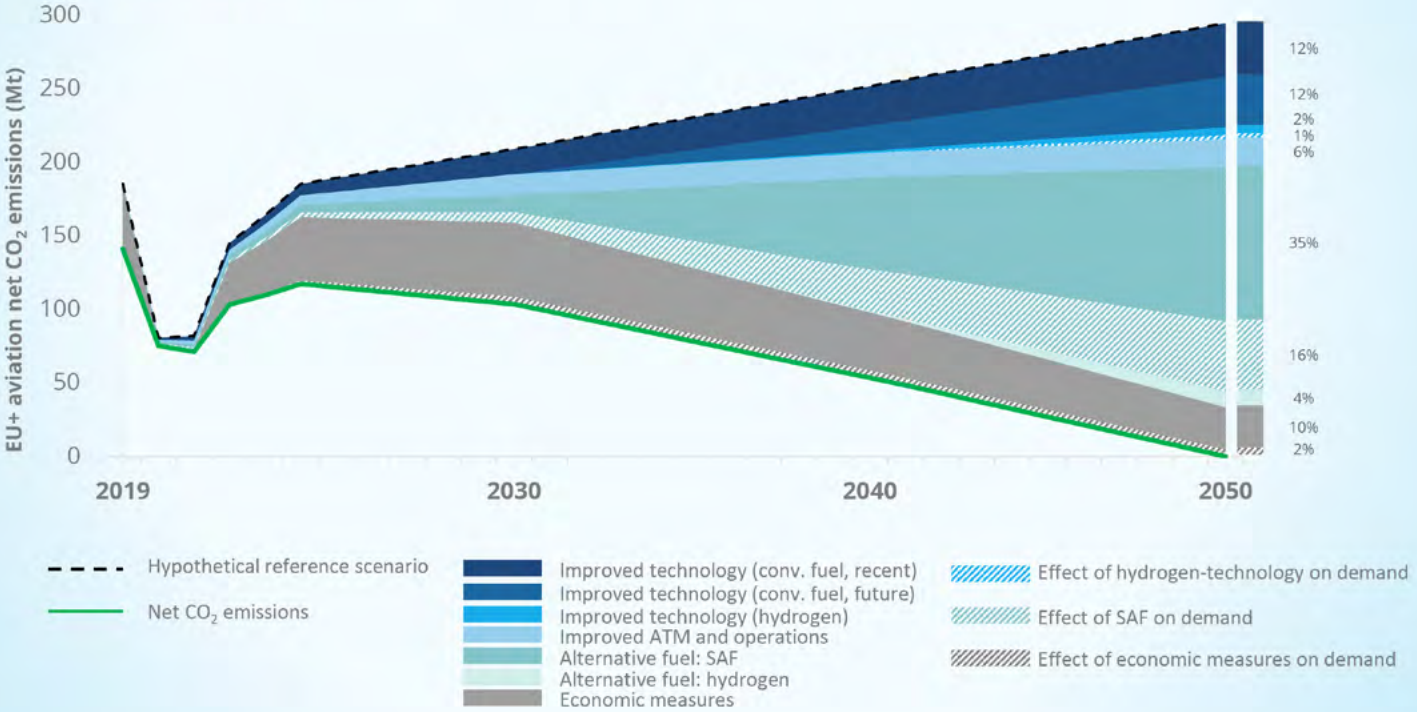
This research project focuses on integrating airspace design and air traffic effects to minimise environmental impact. The aim is to create noise assessment tools that enable the optimisation of flight routes, ultimately enhancing airspace efficiency and sustainability.

WHAT WE DID

We applied our expertise in airspace design, noise modelling, and simulation to develop an innovative tool. By leveraging NLR's capabilities in air traffic management and environmental impact assessment, we researched and integrated noise evaluation methodologies. Our team utilised advanced modelling techniques and collaborated with stakeholders to ensure the tool meets real-world needs.

Decarbonisation Roadmap for European Aviation

All flights in scope



Destination 2050

A Route to Net Zero European Aviation

THE CHALLENGE

Aviation must continue to reduce its climate impact. But how? In what ways can the aviation industry mitigate emissions, while ensuring development possibilities within the domain?

1. What can we expect from technology, operations, fuels and economic measures contribute between now and 2050?
2. What do industry and policymakers need to do to capture these benefits?
3. What targets can we set for 2030 and 2050?

WHAT WE DID

The Destination 2050 roadmap, developed by NLR and SEO at the request of A4E, ACI EUROPE, ASD, CANSO and ERA, presents a decarbonisation pathway to net-zero European aviation by 2050. It provides a well-supported foundation for tackling aviation's decarbonisation challenge, guiding government and industry action. The report includes a bottom-up analysis of energy efficiency measures and emission reduction assessments. Developed with stakeholders, including airlines and manufacturers, it demonstrates a sustainable aviation future is possible and beneficial, combining state-of-the-art knowledge with economic data from SEO and insights to support a push toward sustainability.

THE SOLUTION

The latest report finds net zero CO_2 emissions from flights departing the EU+* can be achieved by 2050, if short-term actions are taken and the measures are implemented on time. These include, among others:

- Ensuring aircraft not yet introduced enter into service as planned
- Timely implementation of ATM Master Plan objectives
- Supporting supply chain development, increased feedstock availability and renewable energy deployment for increased SAF uptake
- Establishing a net zero target for all market-based measures.

**The revised and updated DESTINATION 2050 roadmap report has considered CO_2 emissions from the combustion of fuel by scheduled passenger and cargo flights departing from airports in the EU, United Kingdom or EFTA (Iceland, Norway, Liechtenstein and Switzerland).*

About NLR

Royal Netherlands Aerospace Centre

POLICY SUPPORT

INDUSTRIAL DEVELOPMENT

APPLIED RESEARCH

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.

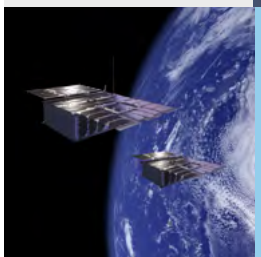
Royal NLR stands for practical and innovative solutions, technical expertise and a long-term design vision, regarding their fixed wing aircraft, helicopter, drones and space exploration projects. This allows NLR's cutting-edge technology to also find its way into successful aerospace programmes of OEMs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

NLR in brief

AMSTERDAM, MARKNESSE, ROTTERDAM, BRUSSELS

1000+
STAFF

144M
TURNOVER



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sesar JOINT UNDERTAKING

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