Accelerating the future of aerospace

R&D solutions for Air Traffic Management

Royal NLR - Netherlands Aerospace Centre

Products and Services for ANSPs

Efficiency			**U-space & Innovative Air Mobility**
Safety & Human Performance			**Training**
Airspace & Flight Procedure Design			**Sustainability & Enviroment**

Let's realise 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, products and services.

Henk van Dijk
Vice President Aerospace Operations
Royal NLR – Netherlands Aerospace Centre

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.

TOPICS

- **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.

TOPICS

- **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.

Topics

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

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.

A SELECTION OF OUR CAPABILITIES

- **U-space and IAM ConOps development**
  NLR has vast experience in creating operations concepts for IAM, detailing the procedures, requirements and system configuration for the performance of drone flights.
- **U-space implementation**
  NLR is an active player in the U-space ecosystem, looking into the development of U3 and U4 services and serving as a testing and validation partner for its deployment. We are especially active in separation and conflict management services, looking into Detect and Avoid systems and procedures to improve the safety of operations.
- **ATM-UTM integration**
  The work performed in U-space implementation has to be coordinated and integrated with regular ATM procedures. NLR is involved in the development and validation of procedural and collaborative interface U-space services to facilitate ATM-UTM integration.
- **IAM vertiports development**
  This involves conceptualising vertiport operations, defining infrastructure requirements, and establishing processes to support drone operations. NLR has the ambition to develop a vertiport at the Amsterdam office, besides the current NLR drone test facility in Marknesse.

Development of U-space Services

For example: Hyperlocal wind nowcasting for drones by drones

NLR develops advanced services supporting more complex operations in dense areas such as assistance for Detect & Avoid and U-space Weather Information Services. To provide drone operators with information about the actual and forecasted weather situation, NLR developed a service to provide hyperlocal wind nowcasting for drones by drones.

Due to their light-weight nature, small drones can be vulnerable to wind. This is particularly true for low altitude operations in urban areas where both wind speed and direction can change abruptly. To safely realise numerous applications of drones in urban areas, real-time and accurate knowledge of low altitude winds is needed. To develop this service NLR executed the METSIS project (METeo Sensors In the Sky).

THE CHALLENGE

The goal of the METSIS concept was to estimate and communicate hyperlocal wind information to drone operators in real time using data measured by the drones themselves, i.e., by using drones as an aerial wind sensor network. The novelty of the METSIS concept is that a network of drones were used to not only measure the wind states at the locations of the drones themselves, but to estimate the 3D wind field within the area encompassing the wind measurements as well, using the Meteo-Particle Model (MPM). The resulting wind field estimates, which are updated when new measurements are received from individual drones, can be used by drone operators for numerous applications, including for the computation of wind optimised routes to improve mission safety and efficiency (i.e., battery life/ range).

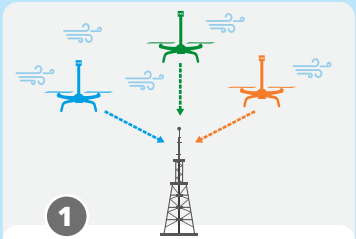
WHAT DID WE DO

Royal NLR performed a proof-of-concept experiment using four drones to determine the feasibility and accuracy of the concept at low altitudes. For the experiment, ultrasonic anemometers were mounted to each drone to measure local winds. The calibration of the wind sensors was tested using the NLR Anechoic Wind Tunnel. Subsequently, flight-tests were performed at the NLR Drone Centre to evaluate the effect of obstacles, drone motion, measurement density, and measurement errors on concept accuracy. Wind fields estimated during the flight-tests were published to the AirHub Drone Operations Center (DOC) system to demonstrate the communication of this data to U-space end-users in real-time. The results indicated that the METSIS concept is a promising solution for the wind nowcast component of the U-space weather information service.

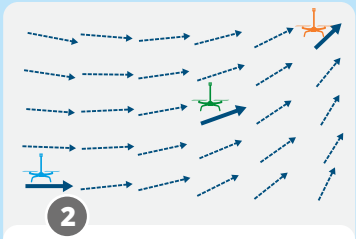
METSIS is co-funded by the European Union.
This message doesn't necessarily reflect the views of the EU.

THE SOLUTION

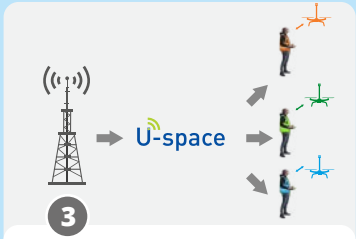
The METSIS concept consists of three main steps:



1 Airborne drones measure instantaneous wind states and transmit data to a ground station.



2 Ground station uses the Meteo Particle Model (MPM) to estimate the wind field in real time.



3 The ground station communicates wind field data to drone operators via the U-space weather information service.

METSIS drone-anemometer configuration

Project partners
Research organisation : Royal NLR
Industry: Airhub

Schiphol Amsterdam

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's Safety Institute 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.

A SELECTION OF OUR SAFETY RELATED SERVICES COMPRISES:

- 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

Data science for safety management

Providing actionable insights from data across a range of application domains

THE CHALLENGE

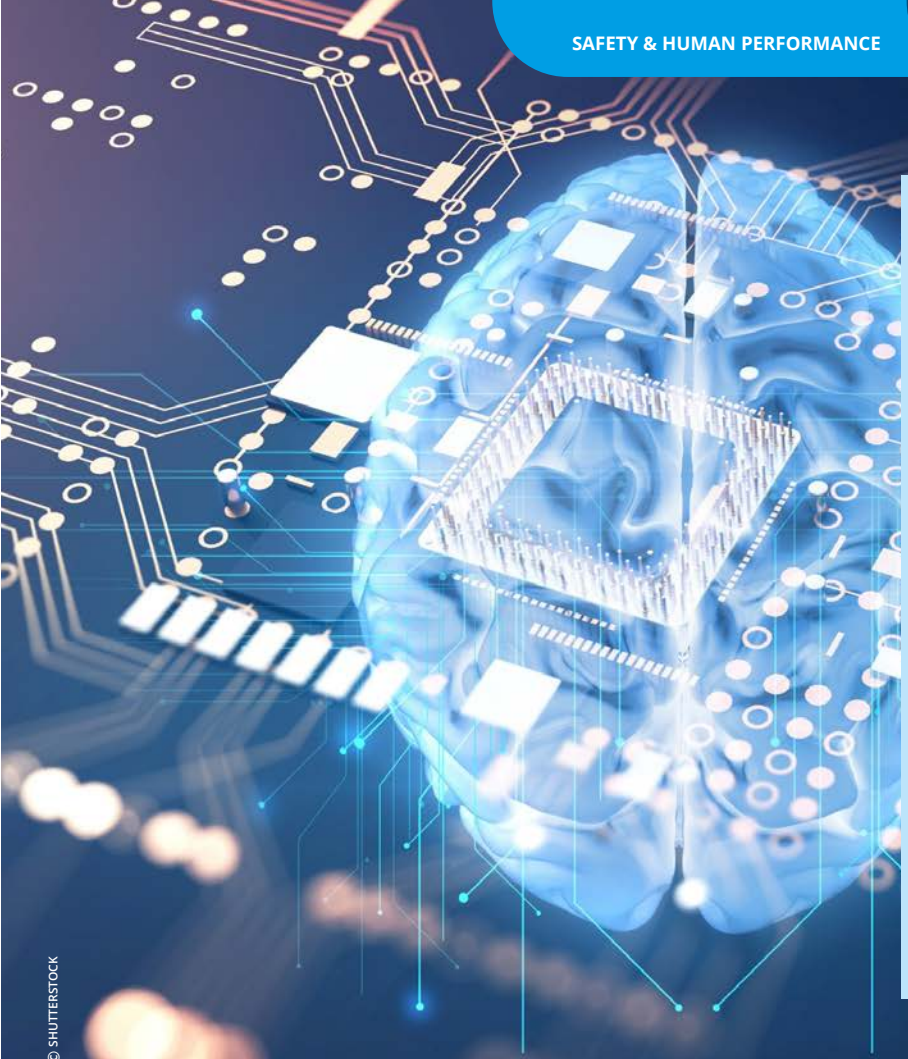
How can you give value and meaning to the abundance of data within your organisation? The application of data science has the potential to enhance the quality of (risk) assessments, improve understanding of the effectiveness of control measures, and facilitate better data-driven decision-making. By applying 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

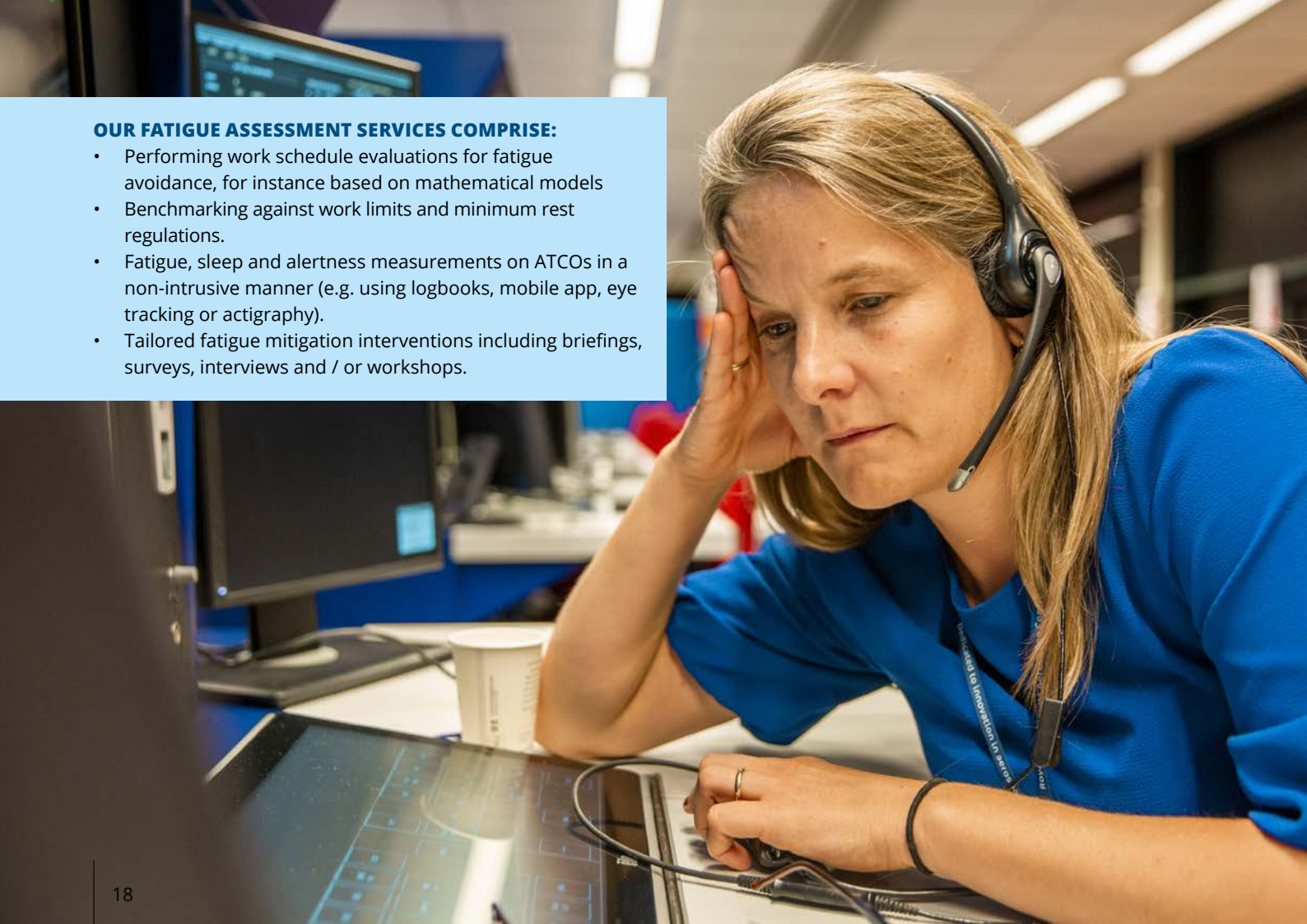
NLR possesses a solid knowledge base, as well as experience and expertise in applying data science and machine learning to safety management. Data can reveal the effects of changes, such as the introduction of new technologies or procedural modifications on safety, efficiency, human performance, and 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.



© SHUTTERSTOCK

A SELECTION OF OUR CAPABILITIES AND SERVICES BASED ON DATA SCIENCE APPLICATIONS:

- 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.



OUR FATIGUE ASSESSMENT SERVICES COMPRISE:

- 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.

WE SUPPORT ATCO TRAINING ORGANISATIONS WITH SPECIFIC, CLIENT-TAILORED MODULES INCLUDING:

- EBT program implementation (gap-analysis)
- evolution workshops to support the transition to EBT
- instructor EBT courses
- data-analytics-as-a-service to identify specific, and even individual, training needs
- measurement of program training effectiveness and
- measurement of instructor concordance.

EBT: Evidence Based Training Implementation and Performance Support

THE CHALLENGE

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

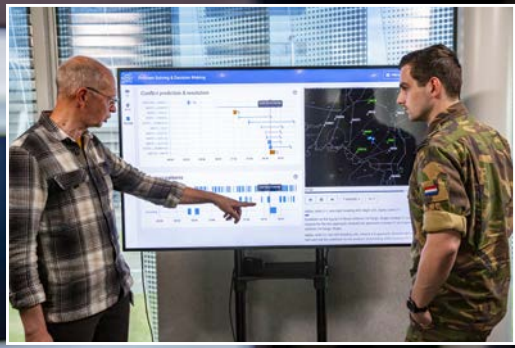
EBT aims to develop ATCOs in several core competencies, instead of providing training in a narrow, familiar and repetitive set of tasks. By developing competencies, an ATCO is effectively prepared to manage safety and performance in many different situations, not only those they have been explicitly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

Evidence Based Training offers that 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. Our support modules are highly engaging, interactive and specifically designed to empower training managers, instructors and National Aviation Authorities (NAAs) to deliver and oversee effective competency-based training and assessment (CBTA) in the form of EBT.



Project partners
Dutch Ministry of Defence, TNO
Duration: 2022 - 2025

Adaptive Learning Ecosystems

Realising performance based training for (military) ATC training

With Performance-Based Training (PBT) we seek to support personalised training through enhanced performance metrics, learning analytics and stakeholder support throughout the learning and development process. The Adaptive Learning Ecosystem Programme works towards tailored concepts for Royal Netherlands Forces, providing a reference architecture and maturing advanced analytics. The INSPECT (Instructor Support for Performance Based Training) project provides an example, focusing on instructor's insight into trainees' cognitive processes.

THE CHALLENGE

Learning Analytics often focuses on the needs of training managers. In contrast, the INSPECT project aims to support the learning process itself by enabling instructors to gain insight into trainees' cognitive processes, related to:

- Situational Assessment
- Workload Management
- Problem Solving & Decision Making

WHAT DID WE DO

The INSPECT project resulted in two prototypes to support analytics within a training session with:

- An Instructor Live Tool, which provides real-time insights into the trainees Situational Assessment
- A Debrief Tool that allows instructors to review and analyse training sessions with trainees focusing on the three cognitive competencies.

The Adaptive Learning Ecosystems Program develops predictive performance models to support personalised learning over a range of training sessions.

THE SOLUTION

An elementary learning ecosystem is needed to store and process large amounts of data from various systems within the existing training environment. The data includes eye-tracking data, audio recordings, and radar screen recordings. An analysis framework enables the calculation of metrics from this data. Meaningful usage of the data requires a user-friendly and comprehensive dashboard.

Understanding Air Traffic Controller Skill Decay & Competence Retention

THE CHALLENGE

Skill decay can lead to a decline in performance and an increase in (the risk of) errors, which in turn can have severe consequences in safety-critical professions such as aviation. For ATCOs, the consequences of skill decay can be catastrophic, making it essential to understand and mitigate this phenomenon.

WHAT DID WE DO

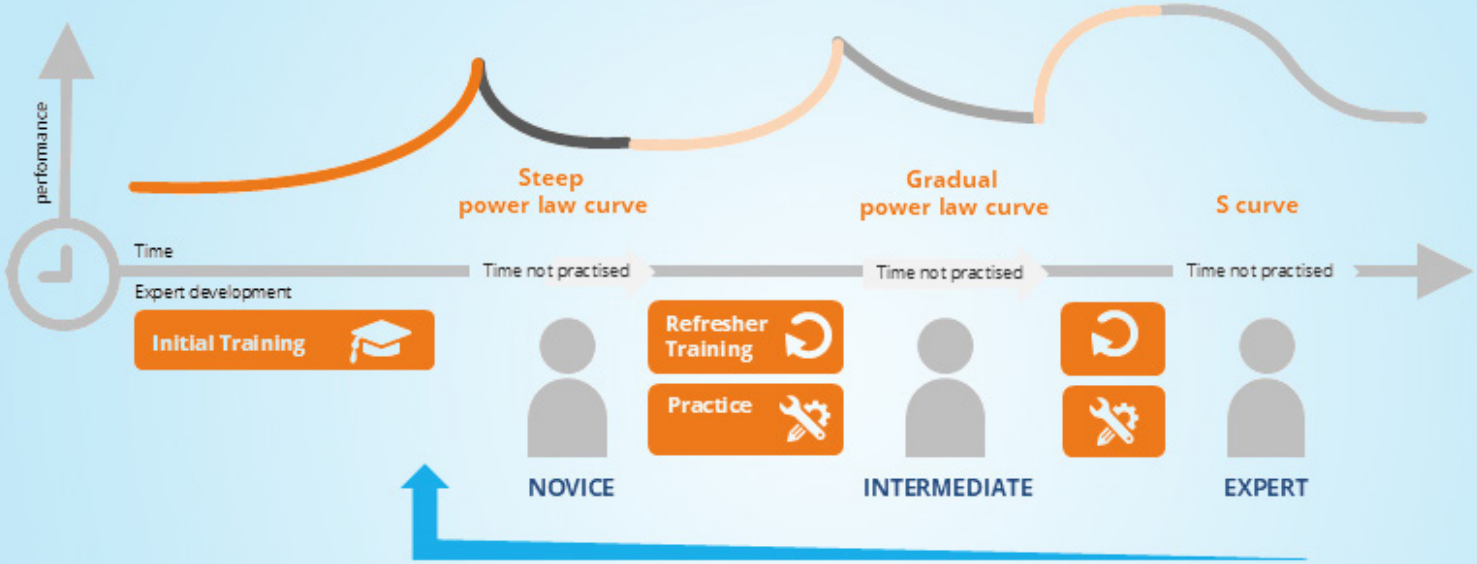
To address this challenge, we conducted a comprehensive study that combined a meta-literature review with multiple experiments to gain a deeper understanding of the factors that influence competence retention and how skill decay and retention can be predicted. One study focused on Air Traffic Controllers (ATCOs) looking at how different factors can influence the retention and skill decay. One finding was that the level of experience significantly influences the retention curve.

THE SOLUTION

Our research has resulted in the *Competence Retention Model*, a framework that helps understand the competence retention process. This model provides valuable insights into the factors that contribute to competence retention and decay, enabling the development of targeted training programmes and strategies to support Air Traffic Controllers and other safety-critical professionals.

Project partners
Dutch Ministry of Defence, TNO
Duration: 2018 - ongoing

Competence retention model



Factors influencing the slope of the learning / retention curves

Quality of Training
Feedback
Spacing
Media usage

Task / Competency
Procedural | Cognitive | Physical
Open-loop | Closed-loop
Elementary | Complex

Personal Factors
Motivation
Cognitive ability / Flexibility
Self-efficacy
Age

Conditions
Personal
Environmental
Organisational

Airspace and flight procedure design

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.

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

Both standard straight RNP approach procedures and more advanced procedures, such as procedures with the inclusion of Radius to Fix or RNP AR procedures, or even STARS with inbuilt merging and sequencing mechanism.

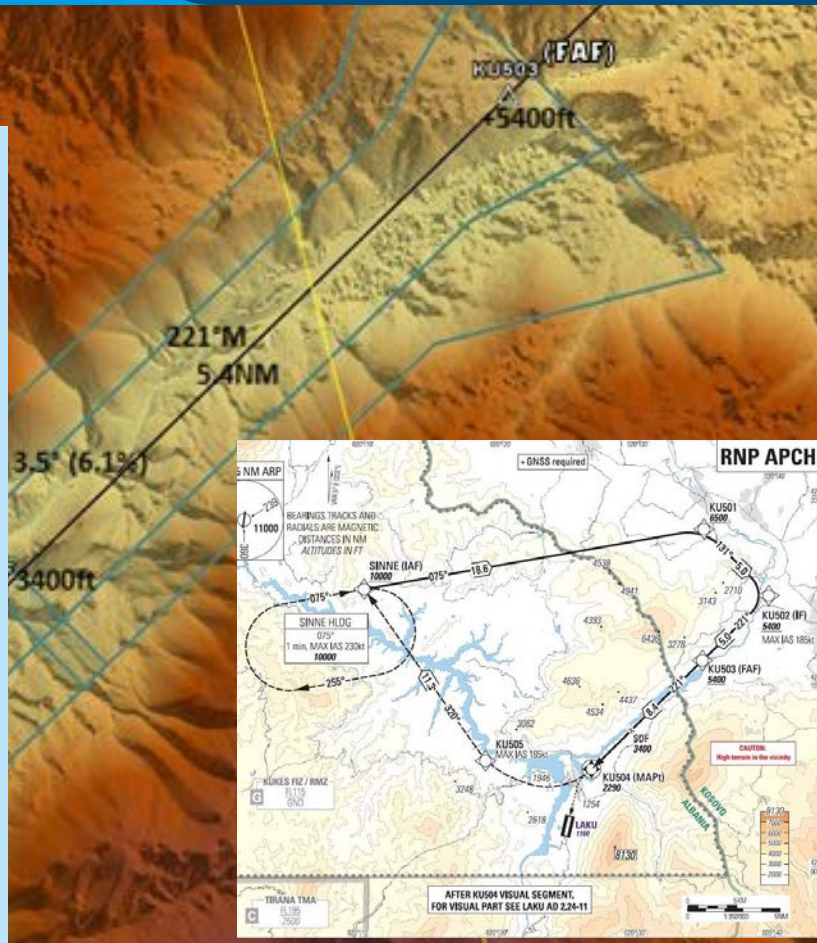
Specific procedures for rotorcraft such as point in space or low level RNP networks are within the capabilities of NLR. Airspace design is feasible for all types of airspace, such as TMA, CTR and ACC.

Aeronautical studies

These are sometimes needed as part of the flight procedure design process, or for example when new obstacles (e.g. windmills, tower flats, and so on) are planned in close proximity to an airport. These studies are aimed at evaluating the impact of those obstacles on new or existing flight procedures.

Unmanned aircraft

NLR offers research capabilities for the integration of unmanned aircraft into airspace, developing drone-specific procedures even if no internationally recognised standards exist to date.



ITARO

INTEGRATED TMA • AIRPORT • RUNWAY OPERATIONS

Project partners
Royal NLR, DLR, NATS, EUROCONTROL, DSNA, INDRA and Heathrow Airport

THE SOLUTION

The ITARO project (Integrated Airport, TMA and Runway Operations, 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.

Integrating SESAR Solutions

THE CHALLENGE

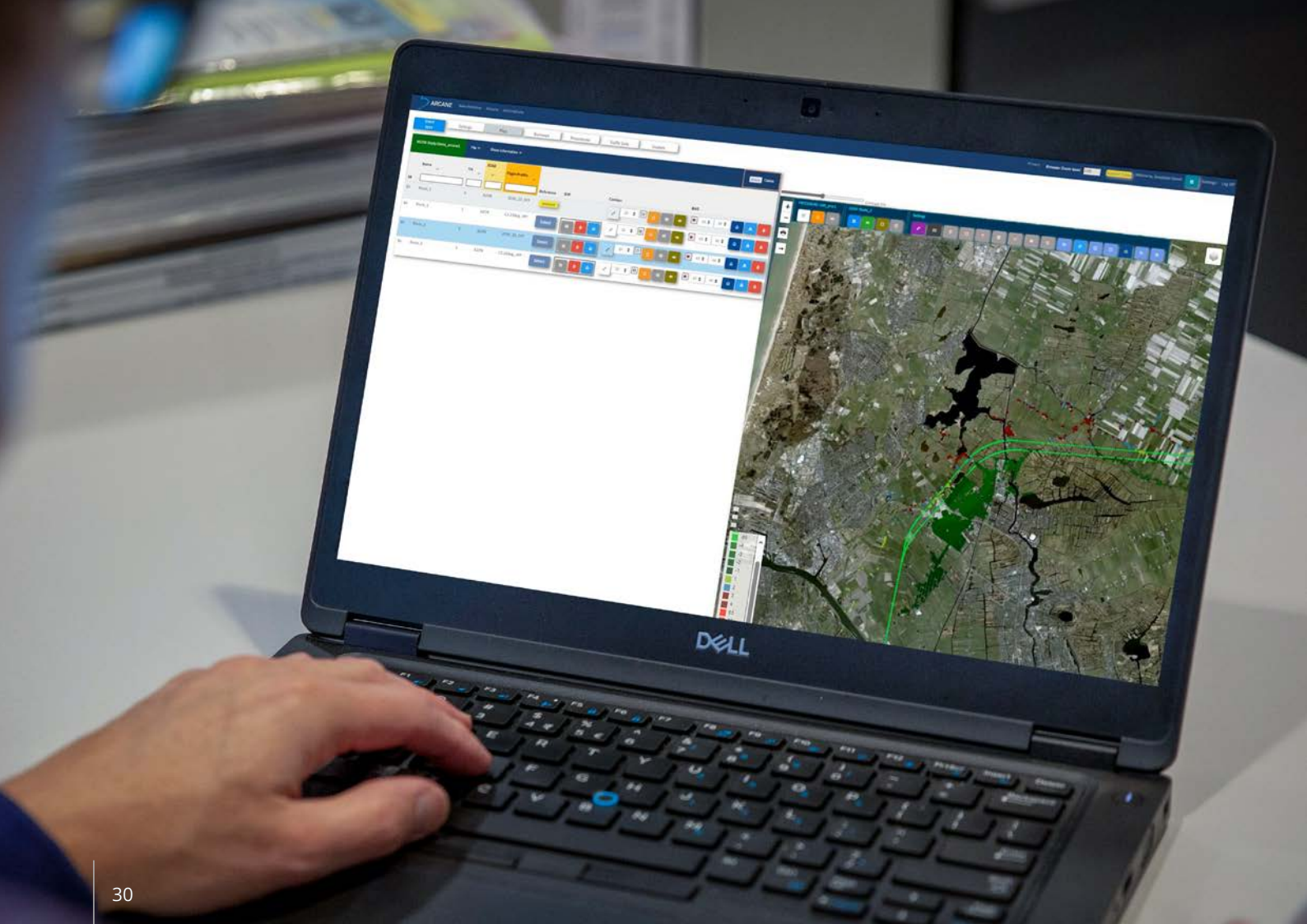
Over the past decades the Single European Sky ATM Research (SESAR) programme has been working intensely to deliver sustainable ATM solutions. These SESAR Solutions are being brought towards higher Technology Readiness Levels (TRLs) via Industrial Research (IR) projects and towards (pre-)deployment via 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.

This project has received funding from the SESAR 3 Joint Undertaking under the European Union's Horizon 2020 research and innovation programme.


DELL

Aircraft Route Customiser & 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 DID WE DO

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.

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.

FANOMOS: Flight And NOise MOnitoring System

Providing flight data & track information and in-depth analyses

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

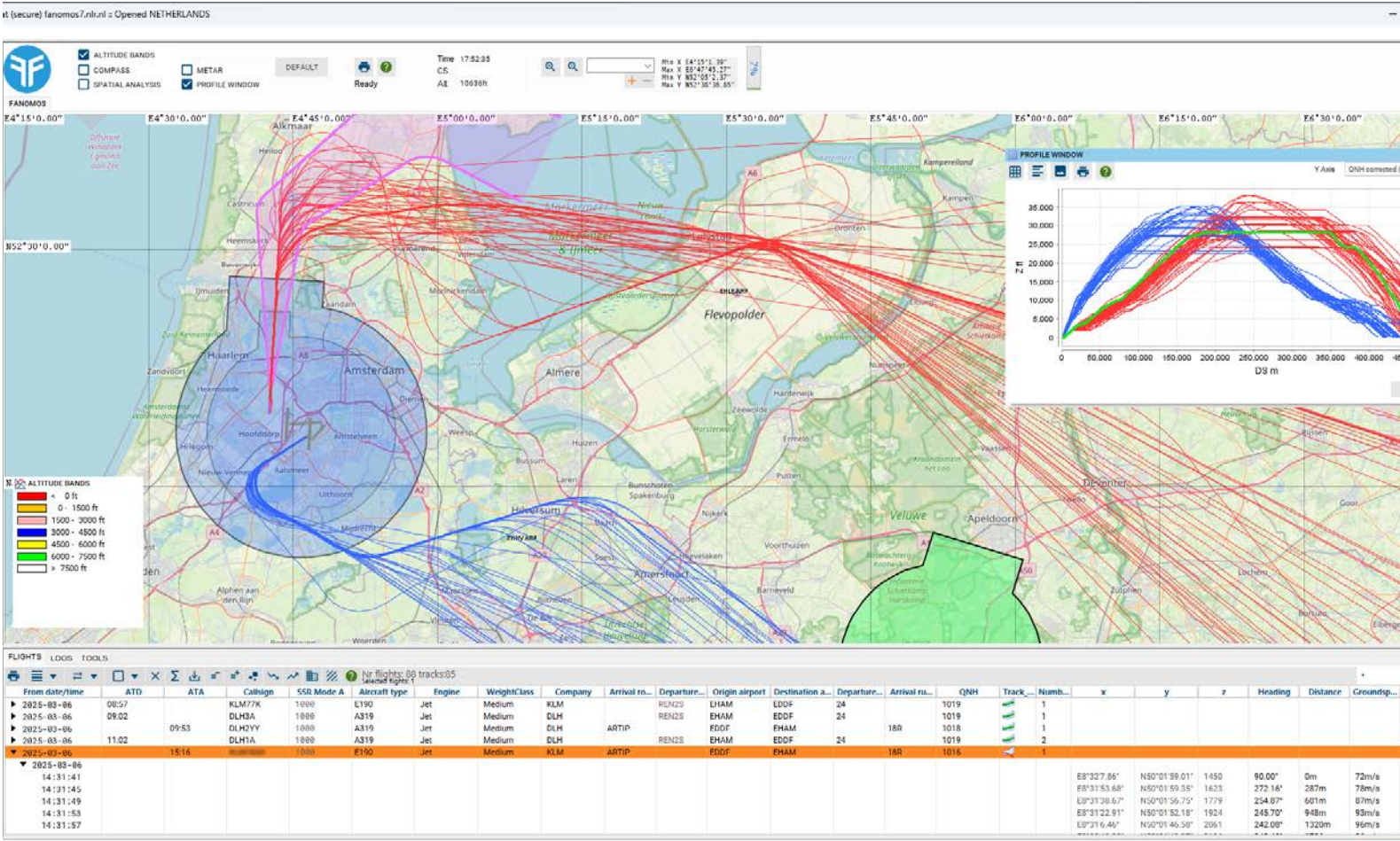
NLR has long standing experience in radar data processing, flight track monitoring and environmental impact studies. In FANOMOS, data collected from flight data monitoring serve as a solid basis to analyse the impact of flight operations in environmental impact studies, for instance. These studies can 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

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


FANOMOS
ALTITUDE BANDS
COMPASS
SPATIAL ANALYSIS
METAR
PROFILE WINDOW
DEFAULT
Ready
Time 17:52:35
CS
Alt 10636ft
E4°15'0.00"
E4°30'0.00"
E4°45'0.00"
E5°00'0.00"
E5°15'0.00"
E5°30'0.00"
E5°45'0.00"
E6°00'0.00"
E6°15'0.00"
E6°30'0.00"
N52°30'0.00"
Alkmaar
Amsterdam
Haarlem
Almere
Flevopolder
Hilversum
Amersfoort
Veluwe
Apeldoorn
Zandvoort
Zaandam
Ijmuiden
Huizen
Bussum
Laren
Baarn
Soest
Nijkerk
Barneveld
Voorthuizen
Putten
Ermelo
Harderwijk
Zeewolde
Dronten
Kampen
Kampereiland
Lelystad
Enkhuizen
Hoofddorp
Amstelveen
Aalsmeer
Uithoorn
Nieuw Vennep
Heemskerk
Castricum
Heiloo
Alphen aan den Rijn
Leiden
Zoetermeer
Delft
Rijswijk
Wassenaar
Voorschoten
Leidschendam
Voorburg
Den Haag
Scheveningen
Monnickendam
Edam
Volendam
Purmerend
Diemen
Weesp
Bunschoten-Spakenburg
Leusden
Barneveld
Zutphen
Lochem
Deventer
Goor
Rijssen
Hengelo
Enschede
Hengelo
Oldenzaal
Almelo
Borculo
Eibergen
PROFILE WINDOW
Y Axis
QNH corrected
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0
0
50.000
100.000
150.000
200.000
250.000
300.000
350.000
400.000
DS m
ALTITUDE BANDS
< 0 ft
0 - 1500 ft
1500 - 3000 ft
3000 - 4500 ft
4500 - 6000 ft
6000 - 7500 ft
> 7500 ft
FLIGHTS
LOGS
TOOLS
Nr flights: 86 tracks:85
From date/time
ATD
ATA
Callsign
SSR Mode A
Aircraft type
Engine
WeightClass
Company
Arrival ro...
Departure...
Origin airport
Destination a...
Departure...
Arrival ru...
QNH
Track_...
Numb...
x
y
z
Heading
Distance
Groundsp...
2025-03-06 08:57 KLM77K 1000 E190 Jet Medium KLM REN2S EHAM EDDF 24 1019 1
2025-03-06 09:02 DLH3A 1000 A319 Jet Medium DLH REN2S EHAM EDDF 24 1019 1
2025-03-06 09:53 DLH2YY 1000 A319 Jet Medium DLH ARTIP EDDF EHAM 18R 1018 1
2025-03-06 11:02 DLH1A 1000 A319 Jet Medium DLH REN2S EHAM EDDF 24 1019 2
2025-03-06 15:16 1000 E190 Jet Medium KLM ARTIP EDDF EHAM 18R 1016 1
2025-03-06
14:31:41 E8°32'7.86" N50°01'59.01" 1450 90.00° 0m 72m/s
14:31:45 E8°31'53.68" N50°01'59.35" 1623 272.16° 287m 78m/s
14:31:49 E8°31'38.67" N50°01'56.75" 1779 254.87° 601m 87m/s
14:31:53 E8°31'22.91" N50°01'52.18" 1924 245.70° 948m 93m/s
14:31:57 E8°31'6.46" N50°01'46.58" 2061 242.08° 1320m 96m/s

LIVE | SUMMARY

2021-10-08 12:46:12

Callsign ICAO	Callsign IATA
AFR16RC	LH 1034
ABFLUG	ANKUNFT
12:39	-:-

FRA	>	CDG
EDDF FRANKFURT	678km	LFPG PARIS

HÖHE		SPEED
15297ft 4663m	E170	691km/h
		HEADING 267°

START ANALYSE

60000 ft (18287 m)
21000 ft (6400 m)
18000 ft (5486 m)
15000 ft (4571 m)
12000 ft (3657 m)
9000 ft (2743 m)
6000 ft (1828 m)
3000 ft (914 m)
0 ft (0 m)

CALLSIGN AFR16RC (LH 1034)
AC TYP E170
HÖHE 15297ft (4663m)

Münstermaifeld
Boppard
Nastätten
Aarbergen
Idstein
Friedrichsdorf
Bad Homburg
Karben
Nidderau
Oberursel
Kronberg
Bad Vilbel
Bruchköbel
Langenselbold
EDFG
Erlensee
Niedernhausen
Kelkheim
Eschborn
Maintal
Hanau
Freigericht
Sankt Goar
Taunusstein
Frankfurt am Main
Mühlheim am Main
Oberwesel
Kaub
Schlangenbad
Wiesbaden
Hofheim
Kelsterbach
Obertshausen
Alzenau
Bacharach
Lorch
Nordenstadt
Neu-Isenburg
Heusenstamm
Seligenstadt
WIE / ETOU
FRA / EDDF
Eltville am Rhein
Oestrich-Winkel
Rheinböllen
Mainz
Walldorf
Dreieich
Dietzenbach
Rodgau
Hosbach
Russelsheim am Main
Geisenheim
Ingelheim am Rhein
Mörfelden
Langen (Hessen)
Rodenbach
Aschaffenburg
Babenhausen
HHN / EDFH
QMZ / EDFZ
QEF / EDFE
EDFC
Bingen
Stromberg
Trebur
Groß-Gerau
Nieder-Olm
EDEL
Weiterstadt
Dieburg
Darmstadt
Groß-Zimmern
Groß-Umstadt
Nierstein
Oppenheim
Roßdorf
Elsenfeld
Bad Kreuznach
EDGP
Riedstadt
Reinheim
Mühltal
Erlenbach am Main
Pfungstadt
Höchst i. Odw.
EDRS
Seeheim-Jugenheim
Bad König
Gernsheim
Zwingenberg
EDRG
Obermoschel
Meisenheim
EDGU
Osthofen
Reichelsheim
Miltenberg
Biblis
Bensheim
Lindenfels
EDFU
EDFO
ETEK
Baumholder
Kirchheimbolanden
Furth
Amorbach
Monsheim
Worms
Bürstadt
Heppenheim
Rockenhausen
EDEP
EDFV
Lampertheim
Hemsbach
Wolfstein
Winnweiler
EDGZ
Eisenberg (Pfalz)
Grünstadt
Frankenthal (Pfalz)
Viernheim
Mudau
Kusel
Otterberg
Mannheim
EDRF
MHG / EDFM
Schriesheim
Dossenheim
Eberbach
Hirschhorn (Neckar)
Kaiserslautern
RMS / ETAR
Landstuhl
Heidelberg
Waldmohr
Neckargemünd
Schifferstadt
Schwetzingen
EDGM
Haßloch
Neustadt an der Weinstraße
Leimen
Mosbach
EDEH
EDFX
EDRL
Speyer
EDRX
Homburg
34

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.

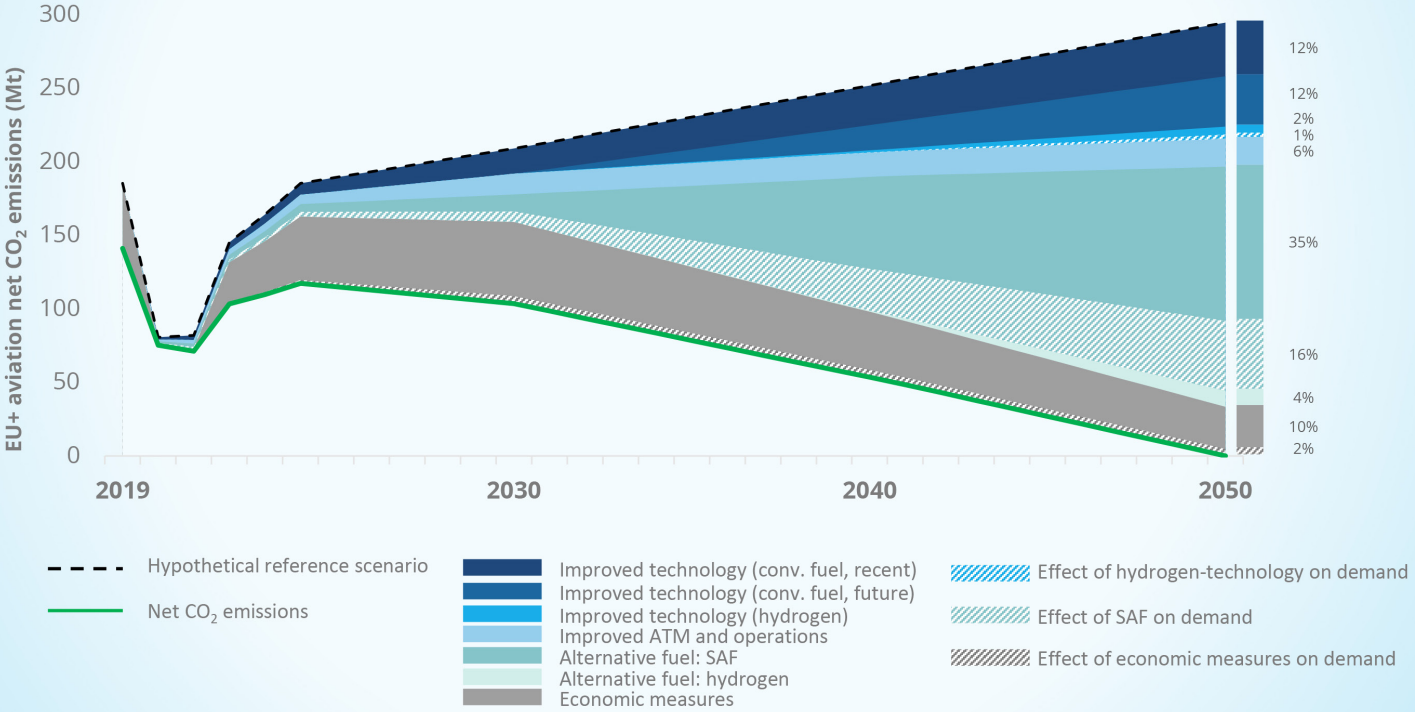
FLIGHTCATCHER:

- An online communication tool for displaying aircraft operations and environmental impact (noise) in a comprehensible manner via the Internet See DFS STANLY_Track as a solution for communication about 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 of public understanding of complex airspace around an airport
- Creation of dedicated systems for those customers looking for a tailor-made product that is adaptable to other modules such as environmental impact (noise)

Clients : A4E, ACI-EUROPE, ASD, CANSO, ERA
Research organisations: Royal NLR, SEO Amsterdam Economics

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?

HOW WE CAN SUPPORT YOU

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 short term actions 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.

Key drivers of emission reductions by 2030 will be economic measures (24%), aircraft efficiency (8%), and operations (7%). By 2050, Sustainable Aviation Fuels (39%) and technology improvements (26%) will lead the way. Achieving this goal will require a significant investment of €1,300 billion, compared to a business-as-usual scenario, to support decarbonisation efforts and reduce emissions.

**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).*

NLR in brief

One-stop-shop

Global player with Dutch roots

100+

Since 1919

Amsterdam, Marknesse
Rotterdam, Noordwijk, Brussel

Innovative, involved and practical

For industry and governmental

For civil and defence

800+
staff

€ 127 M turnover

78% Dutch, 19% EU and 3% worldwide

Active in 24 countries

Very high customer 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 ANSPs in solving challenges in ATM, helping to ensure effective, safe and sustainable operations.

Royal NLR is ready to assist in:

- Real Time ATC simulation
- Developing, prototyping and validating new ATC concepts and tools
- Safety Case and Risk Assessments
- Data Science for Safety Management
- U-space and UTM-ATM integration, Innovative Air Mobility and U-space Services
- Fatigue Risk Management
- Evidence Based Training, Implementation and Performance Support
- Adaptive Learning Ecosystems
- Air Traffic Controller Skill Decay & Competence Retention
- Airspace and Flight Procedure Design
- Flight Data & Track Analysis
- Net Zero European Aviation

For more information:

Roland Vercammen

Business Manager Aerospace Operations

+31 88 511 31 08 | +31 623 34 77 60

roland.vercammen@nlr.nl

NLR Amsterdam

Anthony Fokkerweg 2

1059 CM Amsterdam

+31 88 511 3113

info@nlr.nl www.nlr.org

NLR Marknesse

Voorsterweg 31

8316 PR Marknesse

+31 88 511 4444

info@nlr.nl www.nlr.org

© Royal NLR - Netherlands Aerospace Centre

E1662-07 - April 2025