Poster Exhibition

Airports

CIRA	Solutions for Increased General Aviation and Rotorcraft Airport Accessibility - The GRADE Project	Antonio Vitale, Edoardo Filippone, Alexander Zarbov, Thomas Lueken, Gabriella Duca, Johan Debattista, Marco Cappella, Thomas Rausch and Giuseppe Del Core
Slot Consulting	Radian Project	Roland Guraly, Andrej Kocsis and Seyed Reza Mirhossein
Slot Consulting	Data driven insight in aircraft taxi time	Andrej Kocsis, Roland Guraly and Reza Mirhossein
UAB	No More Surprises: Stand Assignment Algorithm with Likelihood of Turnaround Time Deviation	Margarita Bagamanova and Miguel Mujica Mota
University of Belgrade	Contemporary wildlife risk challenges and habitat management in the vicinity of airports	Aleksandra Nesic and Olja Cokorilo

Airspace and TBO

LVNL	Analysis of Vertical Flight Trajectory Efficiency, a quantitative study on the effects and causes of climb restrictions for flights departing Amsterdam Airport Schiphol	Marc Eijkens
University of Trieste	ADAPT - Advanced Prediction Models for Trajectory-Based Operations (TBO)	Tatjana Bolic, Lorenzo Castelli, Giovanni Scaini, Remon van den Brandt, Mihaela Mitici, René Verbeek, Andrew Cook, Luis Delgado, Gérald Gurtner, Giuseppe Frau, Giuseppe Pappalardo, Rosario Nunzio Mantegna and Salvatore Micciché

Data-driven Techniques

Innaxis	Technical exhibit and demonstration of DataBeacon: The Secure AI Multi-Sided Platform for Aviation	Samuel Cristobal, Jorge Martin and Jens Krueger
Nanyang Technological University	Learning Air Traffic Controller Strategies with Real-Time Neural and Physiological Feedback	Sameer Alam, Sim Kuan Goh, Ngoc Phu Tran, Duc-Thinh Pham and Vu Duong
University of Salzburg	Advances in ATM simulation by using global flight simulation framework NAVSIM	Kurt Eschbacher, Martin Mayr, Carl-Herbert Rokitansky and Fritz Zobl
UPC	Deep Reinforcement Learning for Multiple Drones Air Traffic Management	Ender Cetin, Guillem Muñoz, Enrique Pastor and Cristina Barrado

Economics, Organizational and Legal

Amsterdam University of Applied Sciences	Aviation collaborative research	Frenchez Pietersz
University of Belgrade	Route charging per airport-pair in Europe - How to come up with unit rates? Impacts of traffic distribution over charging zones	Goran Pavlovic

Human Factors

LFV	The Resilient Properties of Multiple Remote Tower Operations: LFV RE5	Anthony Smoker, Billy Josefsson and Jonas Lundberg
Linköping University	Augmented Reality (AR) for ATCO supervisors	Per Larsson, Jonas Unger, Jonas Lundberg and Billy Josefsson
PHYSIP	An automated algorithm for the assessment of drowsiness based on a single EEG channel: validation results and method - 3	Christian Berthomier, Marie Brandewinder, Jeremie Mattout and Jacques Taillard
University of Bologna	What if controllers would no longer be limited by what the human eye can see out of the tower windows? The RETINA project	Sara Bagassi

Meteo and Environment

BIRA-IASB	An Early Warning System for multiple airborne hazards to aviation in the EUNADICS-AV project	Nicolas Theys, Hugues Brenot, Lieven Clarisse, Lucia Mona, Nikos Papagiannopoulos, Margarita Vazquez-Navarro, Pascal Hedelt, Timo Virtanen, Delia Arnold, Michelle Parks, Guðrún Petersen, Simona Scollo, Mauro Coltelli, Juhani Lahtinen and Klaus Sievers
CNR-IMAA	Advances in the observations for natural airborne aviation related hazards in the frame of EUNADICS-AV project	Lucia Mona, Nikolaos Papagiannopoulos, Francesco Marchese, Alfredo Falconieri, Piet Stammes, Jos de Laat, Arnoud Apituley, Heikki Lihavainen, Jussi Paatero, Timo Virtanen, Nicolas Theys, Alexander Haefele, Rolf Rufenacht and Maxime Hervo
MeteoSolutions	An Approach to Define Adverse Weather Zones Based on the Flight Management Performed by Pilots in Convective Weather Events	Ulrike Gelhardt, Jürgen Lang and Stefan Schwanke

Modelling and Simulation		
CIRA	EvoATM: an evolutionary agent-based modelling Open Demonstrator for change design and impact assessment in ATM	Gabriella Duca, Gabriella Gigante, Domenico Pascarella, Marta Sánchez Cidoncha, Miquel Angel Piera, Mario Ciaburri, Luiz Manuel Braga da Costa Campos and Jose Luis Muñoz Gamarra
ENAC	PFV : ENAC's flying testbed A new platform for Aeronautical and Air Traffic Control applied research	Jean-Paul Imbert and Railane Benhacene
Honeywell	EMPHASIS (EMPowering Heterogenuous Aviation through cellular SIgnalS) Project Overview	Petr Casek
LFV	An Empiric Stress Test Validation for Multi Remote Tower Safety Assessment	Lothar Meyer, Billy Josefsson, Maximilian Peukert and Jonas Lundberg
Public University of Navarre	Application of the paradigm of nets-within-nets to air traffic management	Juan-Ignacio Latorre-Biel, Iñigo Leon-Samaniego and Emilio Jimenez-Macias
UPC	Easy BADA integration in python for rapid prototyping	Ramon Dalmau, Marc Melgosa Farrés and Xavier Prats
UTM and UAS		
ENAC	CLear Air Situation for uaS	Fabien Bonneval, Jim Sharples and Yannick Jestin
UPC	Building a safe and socially acceptable concept of operation for drones flying at the very low level	Cristina Barrado, Enric Pastor, Andreas Volkert, Andrew Hately and David Martin
Engage		
Engage	Thematic Challenge 1: CNS vulnerability and security	Paula López
Engage	Thematic Challenge 2: Data-driven trajectory prediction	Dirk Schaefer
Engage	Thematic Challenge 3: Efficient use of MET data	Tatjana Bolić
Engage	Thematic Challenge 4: Novel market mechanisms in ATM	Andrew Cook

Advances in the Observations for natural airborne aviation related hazards in the frame of EUNADICS-AV project

EUNADICS-AV

Background

The vulnerability of the European aviation system to the airborne hazards was evident in 2010. Observations were available at a certain level both at the ground and from space, but they were not efficiently provided to relevant actors in terms of timing and formats.

The EUNADICS-AV

The observational component of the H-2020 project EUNADICS-AV ("European Natural Disaster Coordination and Information System for Aviation") aims to:

- ❑ make existing observations more accessible, more visible and more usable
- ❑ foster the development of tailored products driven by users

Actions

Review of existing observations

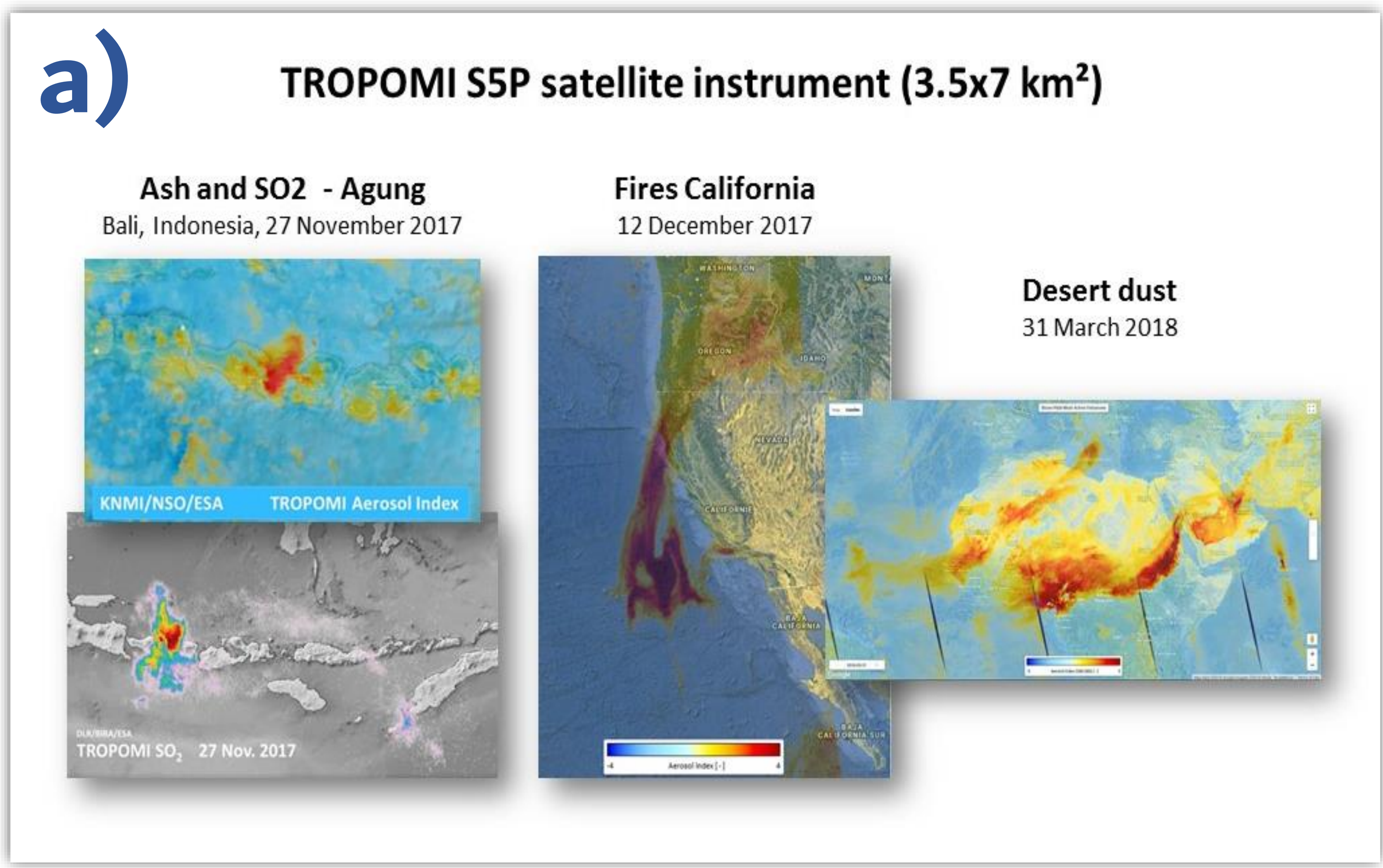
\+

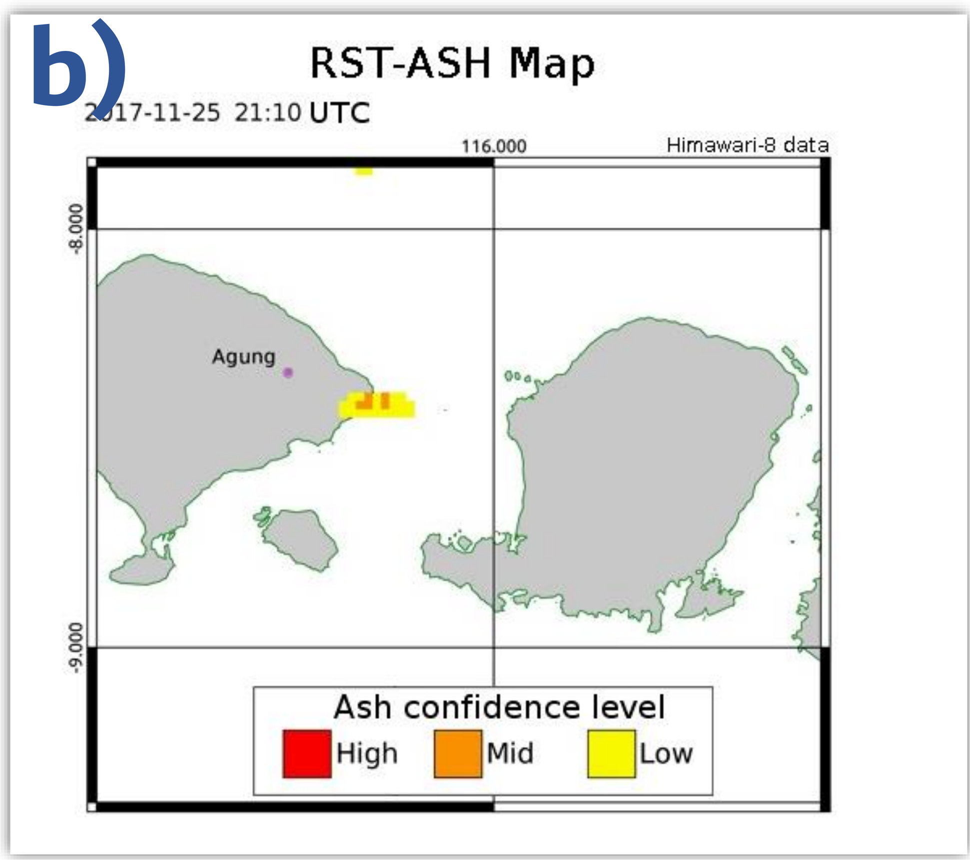
Collection of user recommendations

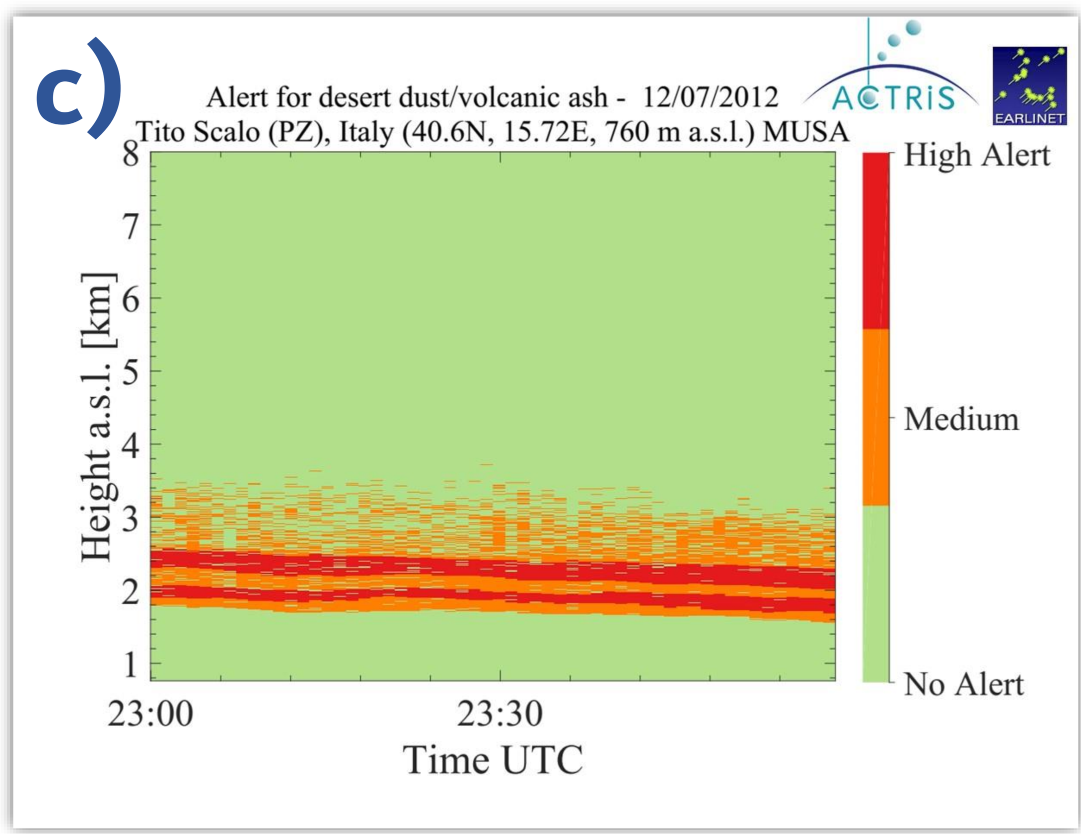
Prioritization of tailored product development

Maximization of data availability impact

a) tailored products
finer resolution and open data
b) visualization of hazard
colour coded risk zone
c) visualization of lidar imagery
plume altitude information availability







Perspectives

Quantification of products uncertainty: cross calibration and validation of the products – test cases and long term studies whenever possible

Harmonization and interoperability of data transfer and format: the system feasibility will be tested and showed during the VOLCEX (Volcanic Ash Experiment) exercise in March 2019.

The EUNADICS-AV project has received funding from the European Union's Horizon 2020 research programme for Societal challenges - smart, green and integrated transport under grant agreement no. 723986.

Consiglio Nazionale delle Ricerche

Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat

FINNISH METEOROLOGICAL INSTITUTE

BIRA-IASB

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

L. Mona[1], N. Papagiannopoulos[1], F. Marchese[1], A. Falconieri[1], J. Stammes[2], J. de Laat[2], A. Apituley[2], H. Lihavainen[3], J. Paatero[3], T. Virtanen[3], N. Theys[4], A. Haefele[5], R. Rufenacht[5], M. Hervo[5]

1: CNR 2: KNMI 3: FMI 4: BIRA-IASB 5: MeteoSwiss

Early Warning System for multiple airborne hazards to aviation in EUNADICS-AV project

EUNADICS - AV

www.eunadics.eu

Early Warning System aimed at ATM and stakeholders

Ash, SO_2, desert dust, radioactive or fire plume observations

Observations	Instruments [GB] [SAT] [IS]	Sources alert	Alert products availabitity
Vol. depol.arisation ratio	**Lidar**	Volcano / Desert dust	Existing
Attenuated backscatter coeff.	**Auto. lidars & ceilometers**	Volcano / Desert dust / Forest fire	2019
SO_2 profiles	**UV spectrometer** network	Volcano	2019
Plume height	**Radar**	Volcano	Existing
Ash index	AQUA / **AIRS**	Volcano	Existing
SO_2	AQUA / **AIRS**	Volcano	Existing
SO_2	AURA / **OMI**	Volcano	Existing
SO_2	MetOp-A & B / **GOME-2**	Volcano	Existing
Aerosol classification	MetOp-A & -B / **IASI**	Volcano / Desert dust	2019
AOD (ash & dust)	MetOp-A & -B / **IASI**	Volcano / Desert dust	2019
Ash index	MetOp-A & -B / **IASI**	Volcano	Existing
SO_2	MetOp-A & -B / **IASI**	Volcano	Existing
Mass loadings (SO_2)	MetOp-A & -B / **IASI**	Volcano	2019
SO_2 plume height	MetOp-A & -B / **IASI**	Volcano	Existing
Ash mask	MSG / **SEVIRI**	Volcano	2019
Ash column load	MSG / **SEVIRI**	Volcano	2019
Ash top height	MSG / **SEVIRI**	Volcano	2019
AOD	MSG / **SEVIRI**	Desert dust	2019
Dust index	MSG / **SEVIRI**	Desert dust	2019
SO_2	Sentinel-5p / **TROPOMI**	Volcano	Existing
SO_2 plume height	Sentinel-5p / **TROPOMI**	Volcano	2019
SO_2	Suomi-NPP / **OMPS**	Volcano	Existing
Ash index	Sentinel-3A / **SLSTR**	Volcano	2019
Ash top height	Sentinel-3A / **SLSTR**	Volcano	2019
Thermal anomaly	Terra & Aqua / **MODIS**	Forest fire	Existing
Thermal anomaly	Suomi-NPP / **VIIRS**	Forest fire	Existing
Seismicity	**SIL seismic** network	Volcano	Existing
Volcanic tremor	**Seismic stations**	Volcano	2019
Gamma radiation	**Network of detectors**	Nuclear	Existing

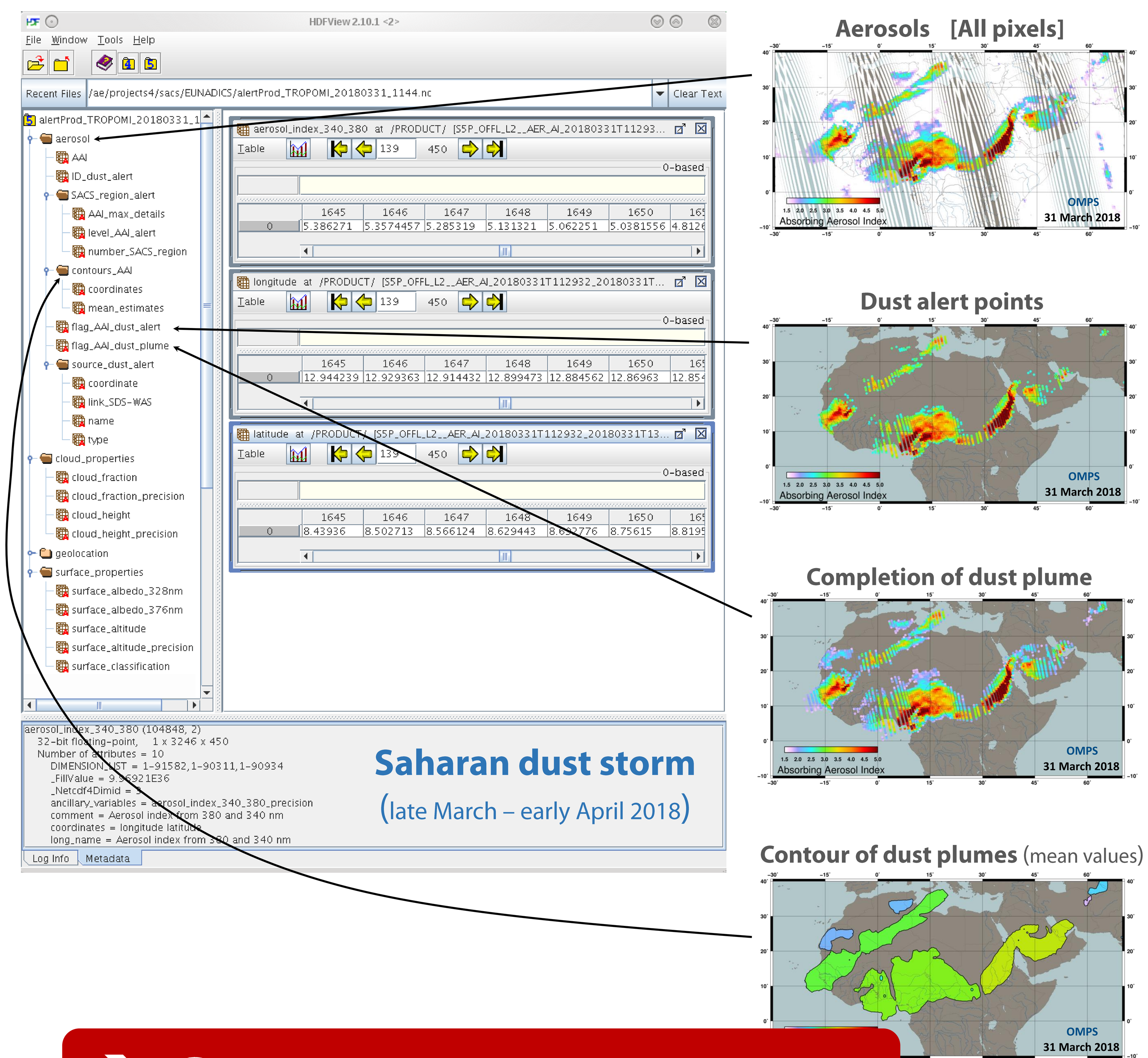
Email notifications

- Event ID (type, location, severity, observations)
- links to Google-Earth and near real-time images,
- links to alert products & data portal

Data files transfer

- Alert data products (with associated ID of event)
- Alert-START and -STOP files (traceability of event)

Example of alert product (NetCDF)



➔ Contact us to get access

This project has received funding from the European Union's Horizon 2020 research and and Innovation Programme, under Grant Agreement [723986].

(1) BIRA-IASB (2) ULB (3) CNR (4) DLR (5) STUK (6) ZAMG (7) Icelandic Met Office (8) INGV (9) FMI (10) KSAW

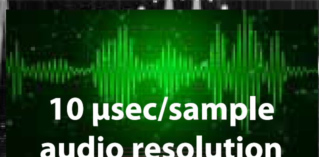
H. Brenot[1,*], N. Theys[1], L. Clarisse[2], L. Mona[3], N. Papagiannopoulos[3], M. Vazquez-Navarro[4], P. Hedelt[4], J. Lahtinen[5], D. Arnold-Arias[6], M. M. Parks[7], G. Petersen[7], M. Coltelli[8], S. Scollo[8], T. Virtanen[9], K. Sievers[10] and WP5 team of EUNADICS-AV project.

* Contact Author: brenot@oma.be http://sacs.aeronomie.be

Virtual Reality Sound Field Surveillance for a Local and Remote Tower Environment

UNIWERSYTET MUZYCZNY
FRYDERYKA CHOPINA

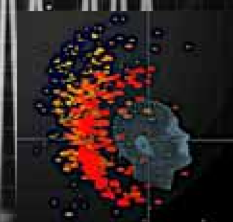
Very High
Temporal Resolution
64+ Channel Recording
3D microphone arrays



System Highlights:

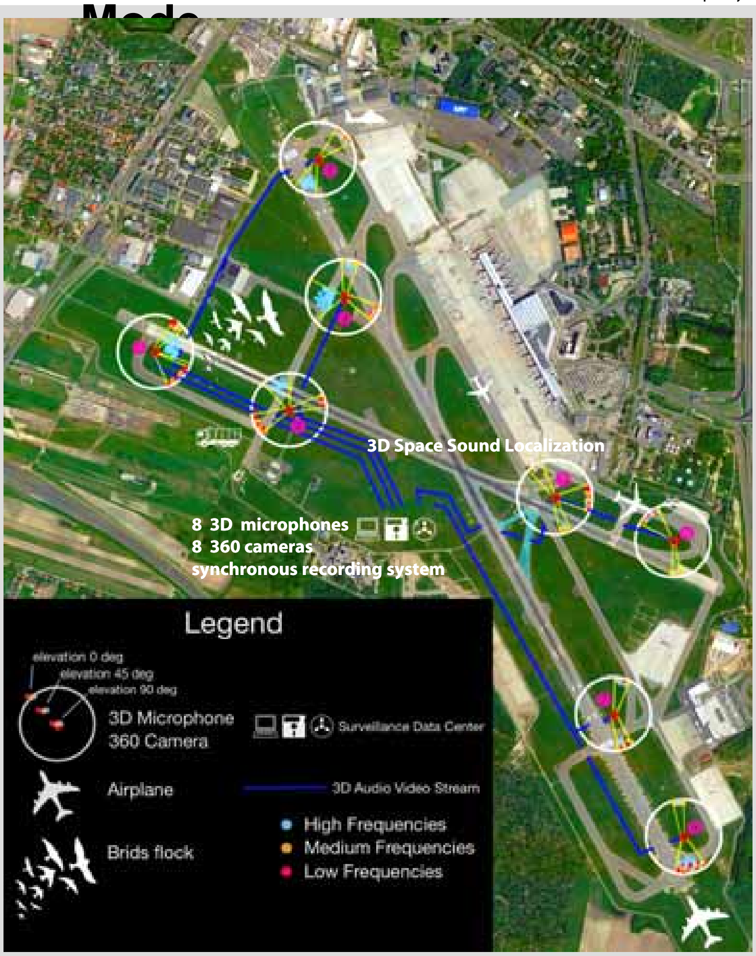
- Designed for Reduced Aerodrome Visibility Conditions
- Night, Fog, Rain, Storm etc.
- 3D Airport Area Accident/Crash Analysis
- 2 Independent Local & Global Operation Modes
- 24/7 Surveillance 360 Audio/Video Data Center
- Sample Accurate A/V Synchronization

Head Tracked
3D Binaural
Sound Display

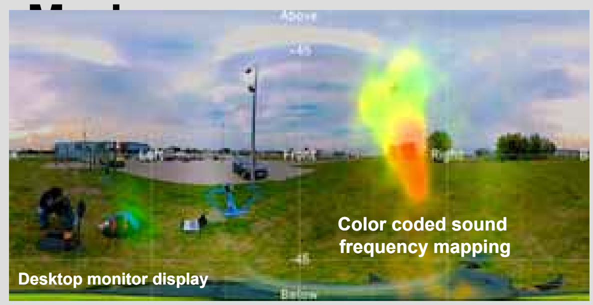


full paper available:
https://tinyurl.com/yb2cqbvu

GLOBAL Surveillance Mode



LOCAL Surveillance Mode



Andrzej Artymowicz, PhD Sound Engineering and Musical Arts
The Frederic Chopin University of Music, Warsaw, Poland andrzej.artymowicz@chopin.edu.pl

EvoATM

An evolutionary agent-based modelling Open Demonstrator for change design and impact assessment in ATM

Evo ATM
Evolutionary ATM

An overview on EvoATM

EvoATM project is aimed at building a framework to better understand and model how architectural and design choices influence the ATM system and its behaviours, and vice versa how the expected ATM overall performances drive the innovation design choices.

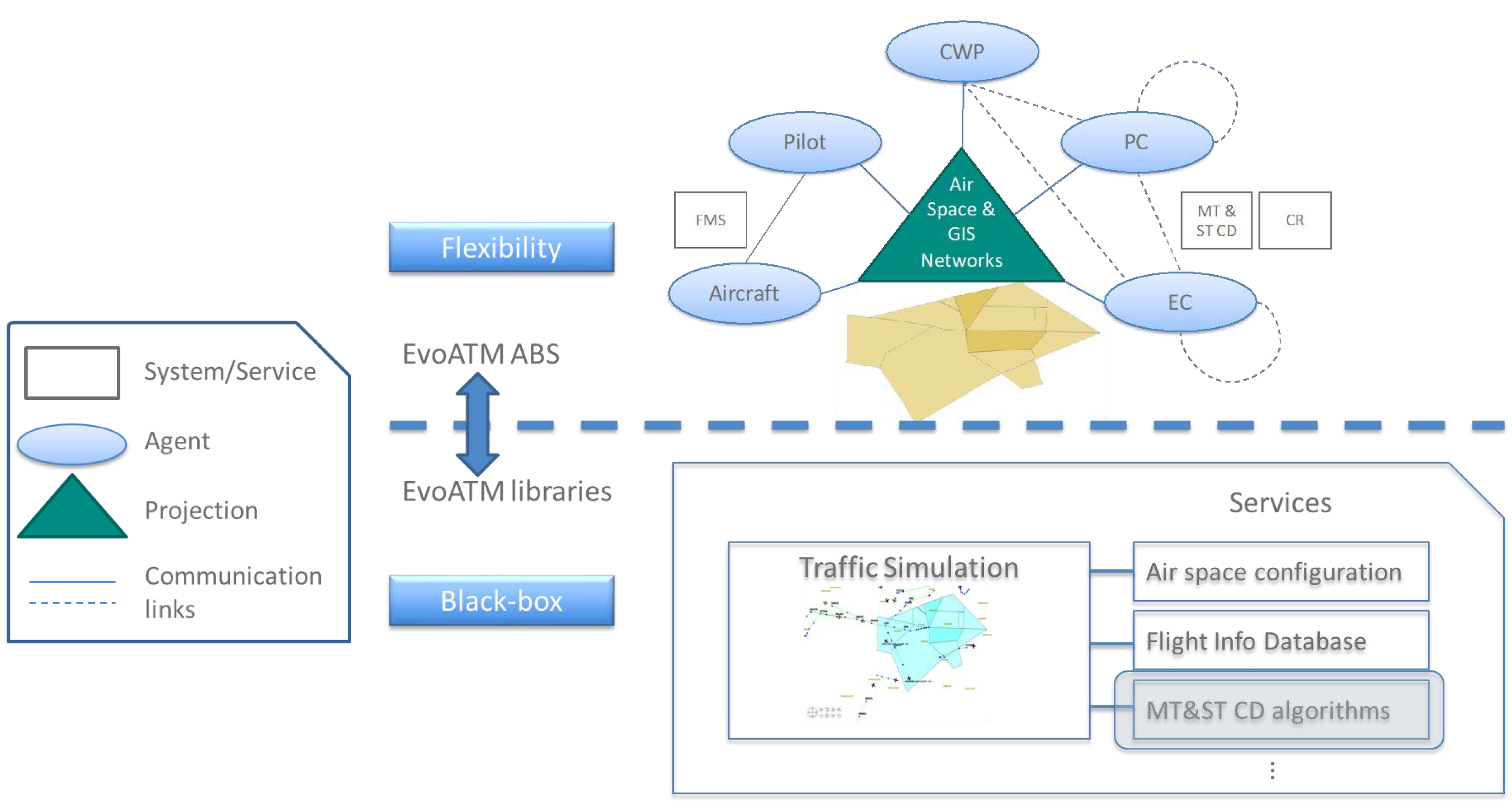
It intends to propose a **novel and cost-effective approach for ATM analysis and simulations** to understand and validate benefits from changes in an ATM system, by taking advantages from scientific techniques enabling to grasp and to model the socio-complexity of ATM.

EvoATM will provide a framework supporting all the steps of the typical **Change Process**:

- understanding which element has to be changed since most affects the associated and desired performances;
- optimally tuning the identified parameters characterizing the behavior of each part of the change in order to assure the optimal design solution matching the desired performances;
- assessing the impact of the change in terms of the obtained final performances.

EvoATM model features

To each step is associated a technique: the agent-based modelling and simulation, integrated with statistical analysis and the evolutionary computing allows a model representing the a subsystem of ATM and its components and their reciprocal interactions and effects.

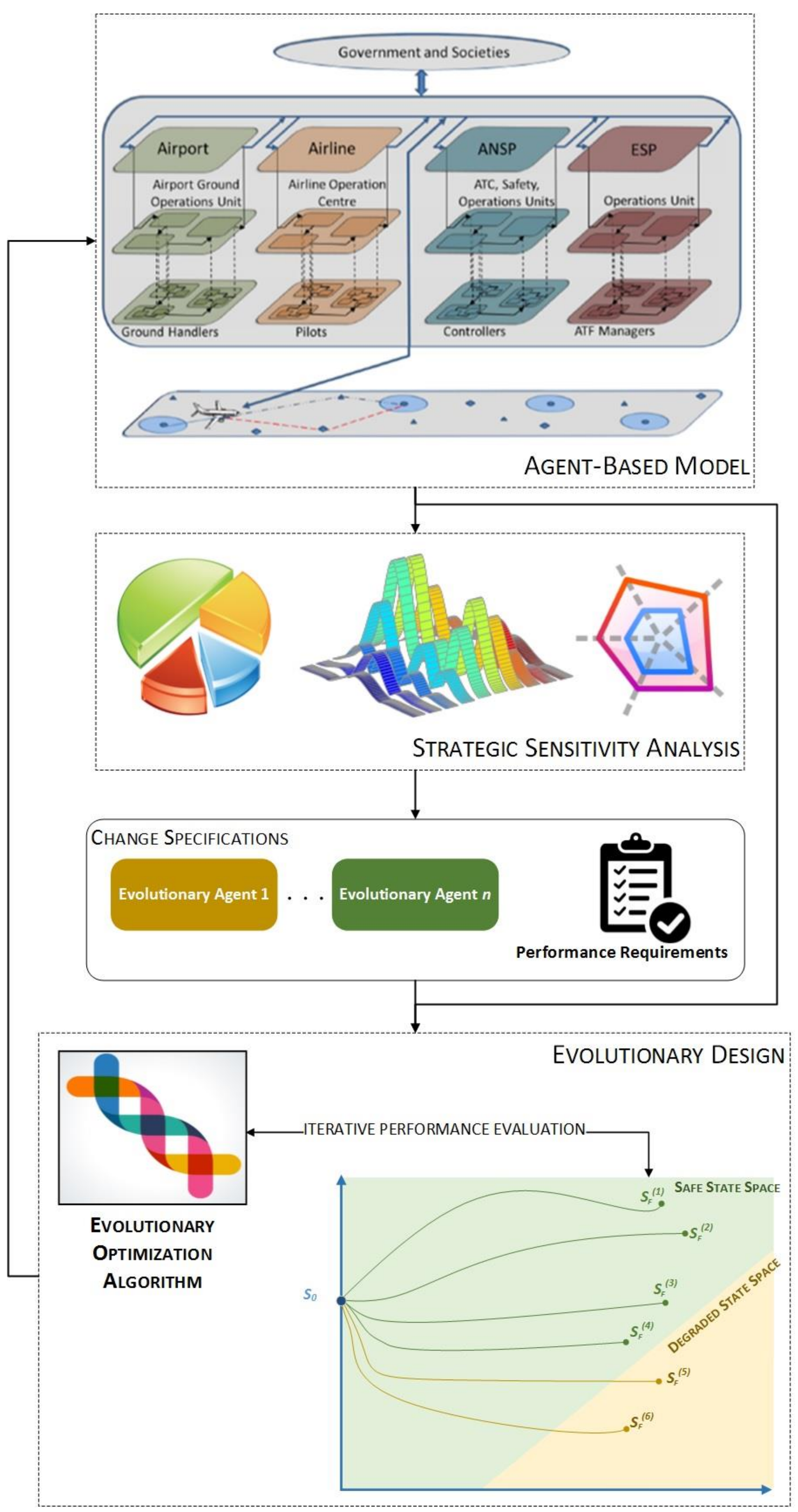


EvoATM simulation framework architecture

EvoATM expected results

The completion of EvoATM project will result in:

- an innovative methodological approach to the change process;
- a unique formalism taking advantages from multiple formalisms combined to address the specific EvoATM environment;
- an Open Demonstrator implementing a specific subsystem of ATM demonstrating the effectiveness of the EvoATM approach which will represent a test case, suitable to be applied to other ATM parts.



EvoATM Change Management Process

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 783189

CIRA Centro Italiano Ricerche Aerospaziali
aslogic
CRIDA I+D+i - ATM
ISSNOVA Institute for Sustainable Society and Innovation
UAB Universitat Autònoma de Barcelona
PEDECE

Authors

Gabriella Gigante, Domenico Pascarella *CIRA*; Marta Sánchez Cidoncha *CRIDA*; Miquel Angel Piera *Universitat Autònoma De Barcelona*; Gabriella Duca, Mario Ciaburri *ISSNOVA*; Luiz Manuel Braga Campos *PEDECE*; Jose Luis Muñoz Gamarra *ASLOGIC*
g.gigante@cira.it

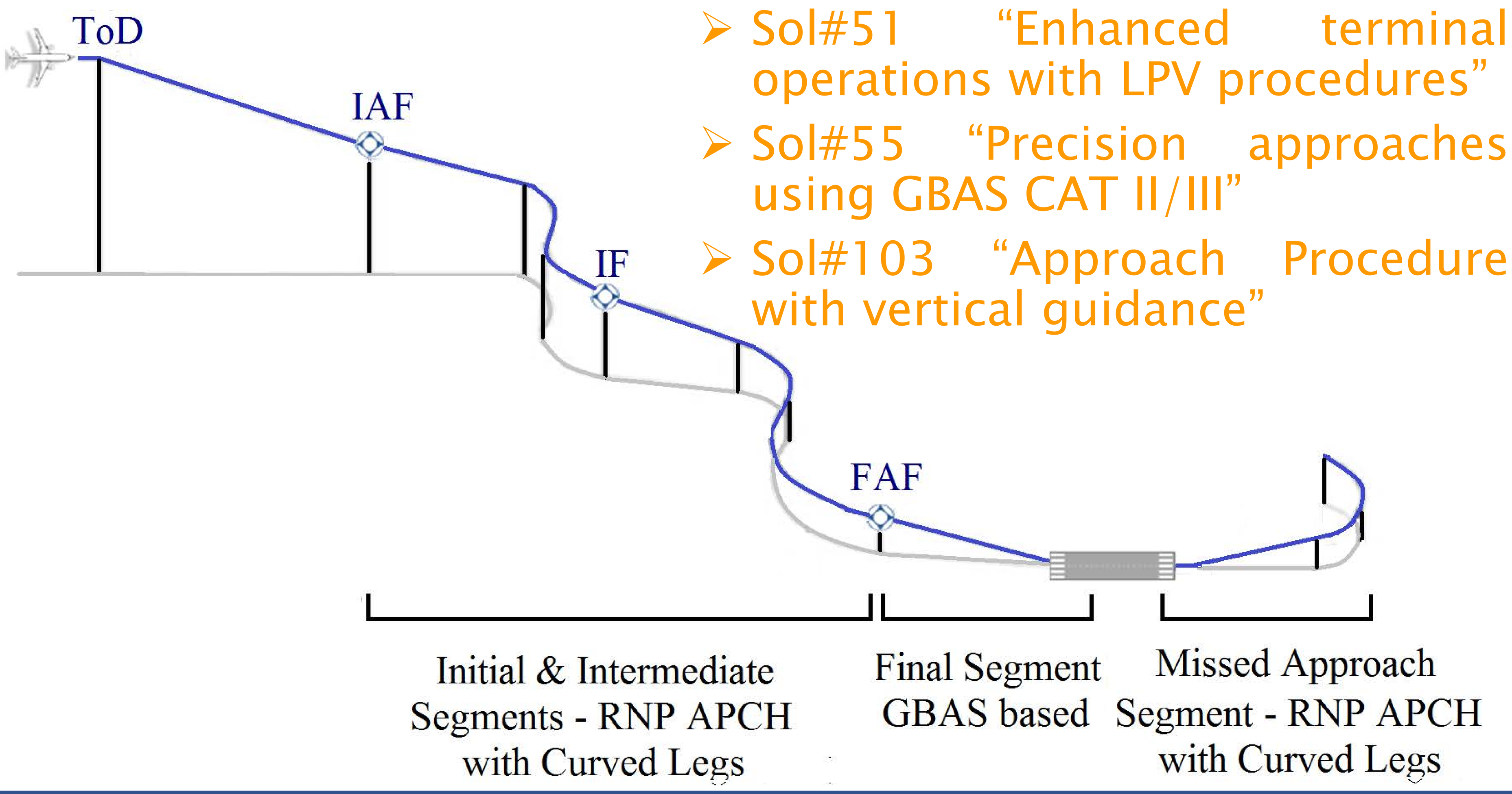
GRADE Project

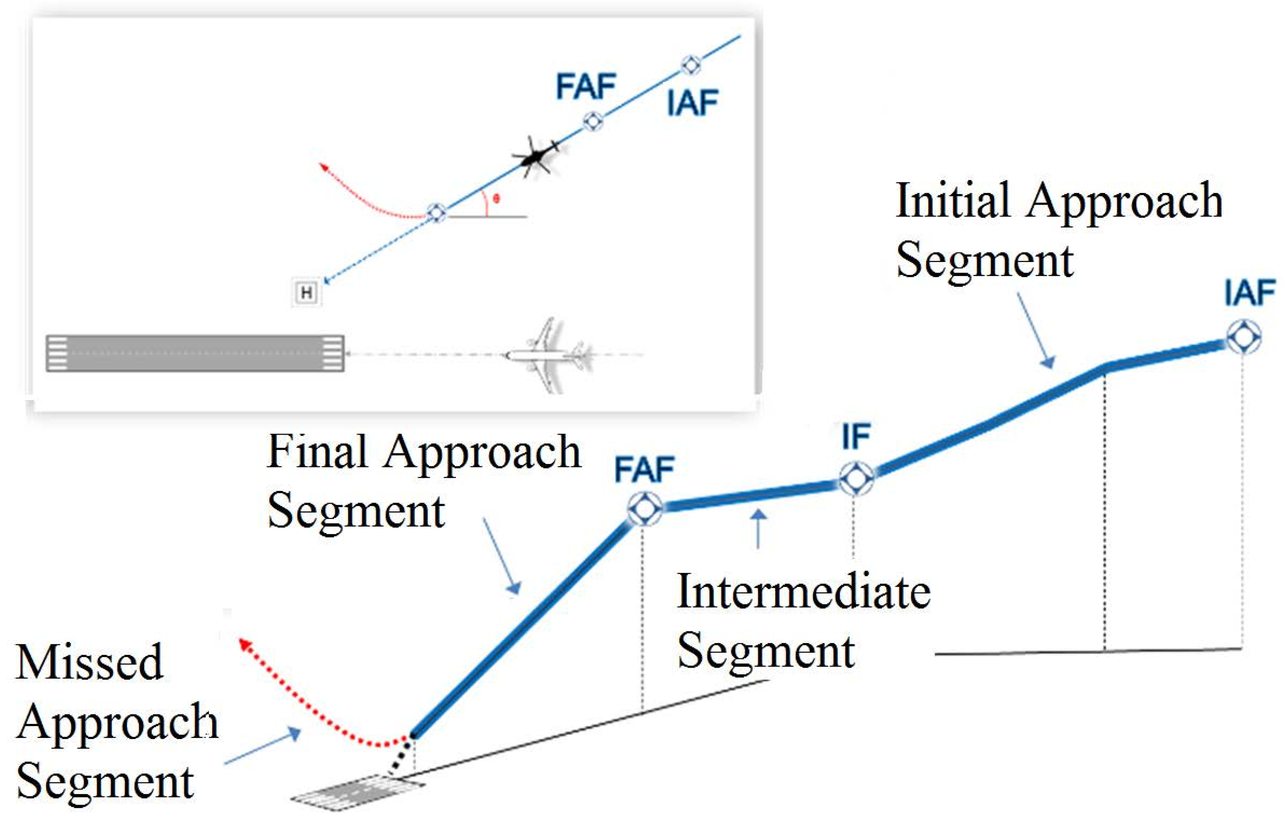
Solutions for Increased General Aviation and Rotorcraft Airport Accessibility

Project Overview

GRADE main objective is to demonstrate the applicability to General Aviation (GA) and Rotorcraft (RC) of SESAR Solutions #51, #55, #103, #113, in order to facilitate the integration of GA and RC in airspace and airports where the SESAR concepts are implemented

- Sol#51 "Enhanced terminal operations with LPV procedures"
- Sol#55 "Precision approaches using GBAS CAT II/III"
- Sol#103 "Approach Procedure with vertical guidance"
- Sol#113 "Optimised Low Level IFR routes for rotorcraft"

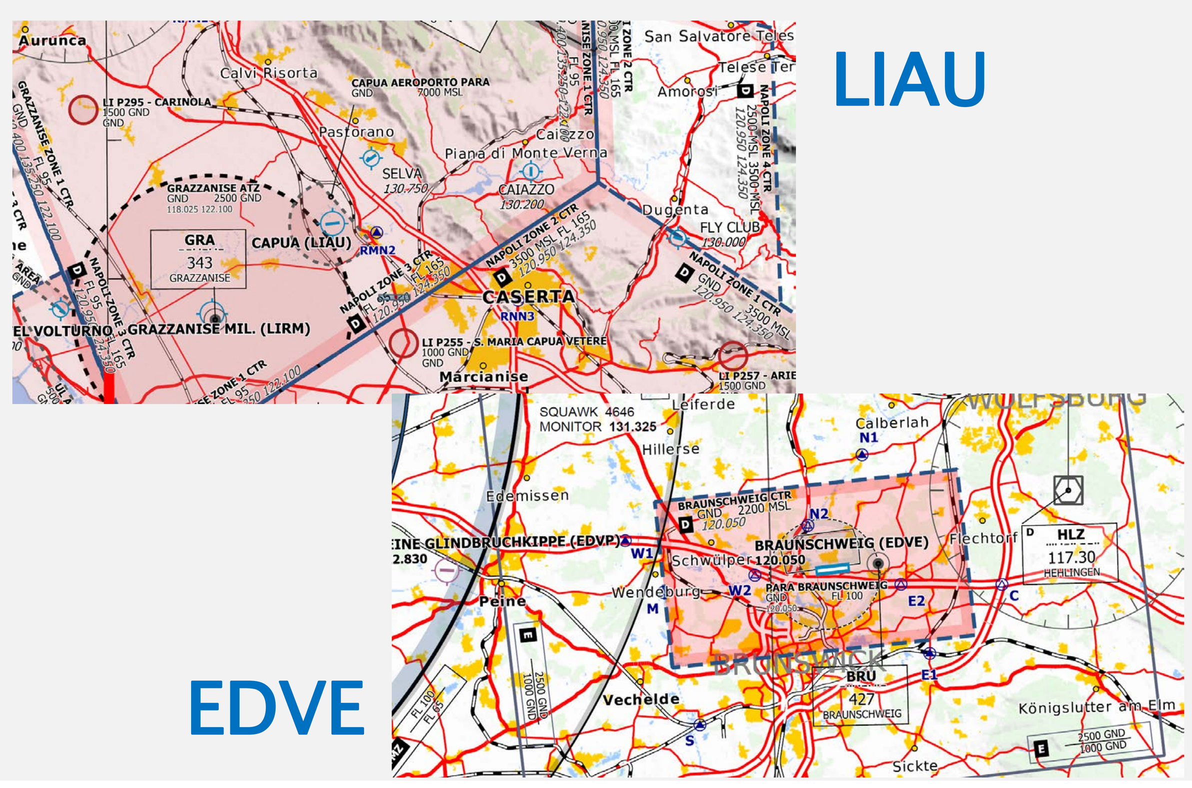




Demonstration

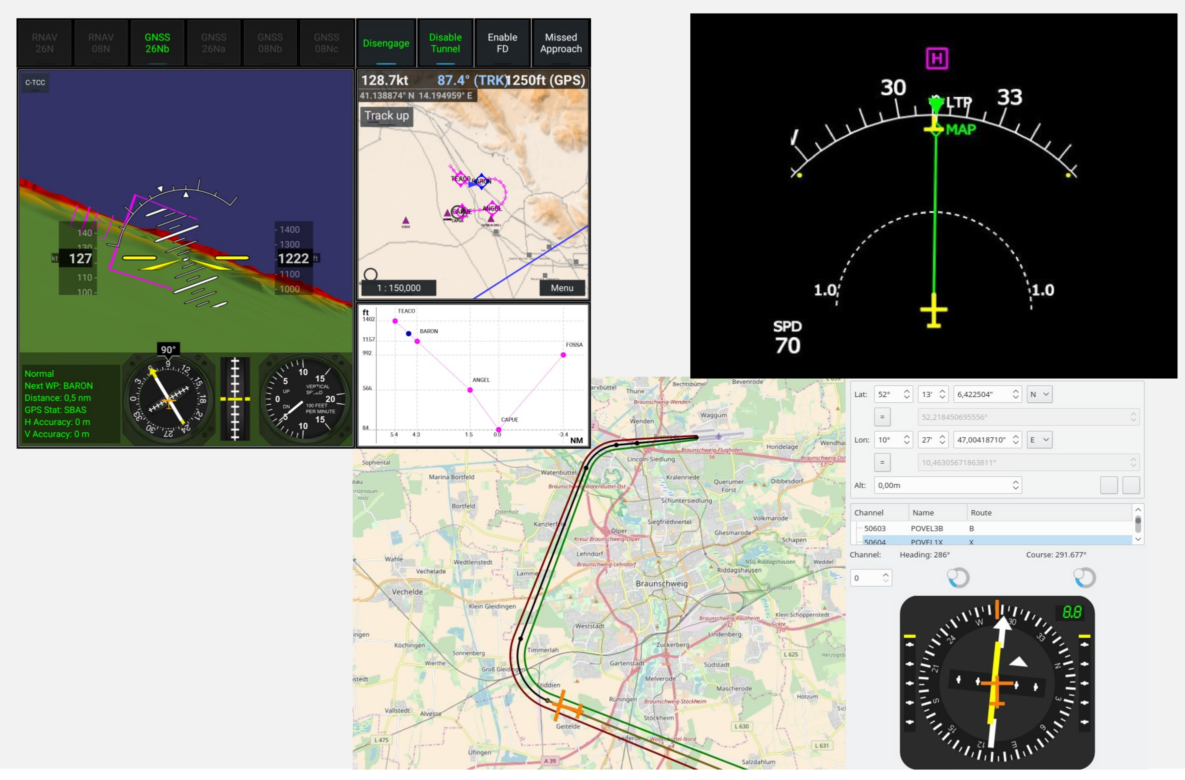
- Five demonstration exercises (2 Real Time Simulations & 3 Flight Trials) to be performed in Italy & Germany
- Addressed KPA: Capacity, Safety, Environment, Human Performance

Two Locations



Three Platforms

Three Prototypical Navigators



Project Progress

- Demo Plan and Scenarios Design completed
- Two campaigns of Real Time Simulations (RTS) with Hardware and Human in the loop performed
- Two Open Days held during the RTS process

Next Steps

- Test report on the outcomes of the RTS campaigns analysis (January 2019)
- Flight Trials Demonstration (Summer 2019)
- Project Final Workshop (October 2019)

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement 783170

CIRA Italian Aerospace Research Centre · BULATSA · DLR · MATS · nais · Technische Universität Braunschweig · Università degli Studi di Napoli Parthenope

A. Vitale, L. Verde, E. Filippone, A. Zarbov, T. Lueken, G. Duca, J. Debattista, M. Cappella, T. Rausch, G. Del Core
a.vitale@cira.it

SESAR 2020 PJ.10 PROSA

An Approach to Define Adverse Weather Zones Based on the Flight Management Performed by Pilots in Convective Weather Events

Objective

This subproject within the SESAR2020 PJ10 framework aims to define two-dimensional convective areas that pose a safety risk to commercial air traffic because of prevailing severe weather conditions, such as lightning or hail, and which are therefore to be avoided by aircraft.

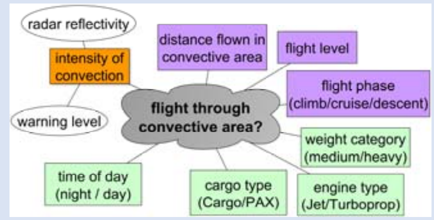


Fig. 1. Influencing parameters identified via interviews with pilots.

Data and Method

For the study two meteorological data bases were used to define convective areas:

- NowCastMIX-Aviation (NCM-A) provided by Deutscher Wetterdienst (DWD, German Meteorological Service) for aeronautical meteorology. This warning product differentiates between five severity categories: heavy rain (warning level (WS0)), light (WS1), moderate (WS2), heavy (WS3) and extreme thunderstorm activity (WS4); Fig.2, left.
- Radar Reflectivities from DWD weather radars; Fig.2, right.

To incorporate lateral navigation behavior anonymized 4D-flight trajectories were provided by DFS.

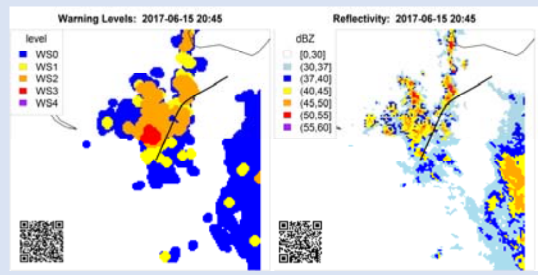


Fig. 2. Merging of flight trajectory with meteorological products.

The study area was limited to the lower airspace controlled from Bremen ACC and around 60 thunderstorm situations in Northern Germany in the year 2017. In addition, pilot interviews have been conducted identifying and prioritising (from high to low: orange to violet to green) the most influencing parameters regarding their lateral avoidance behaviour (see Fig.1).

Results

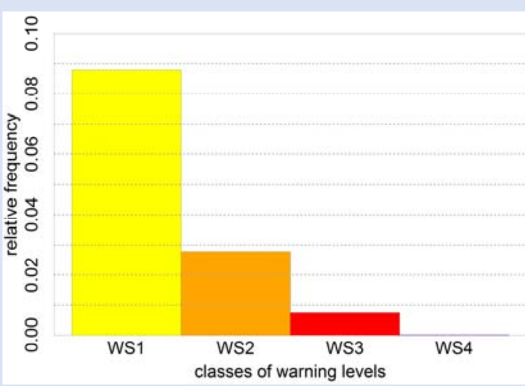


Fig. 3. The number of crossings of convective areas decreases rapidly with increasing warning level.

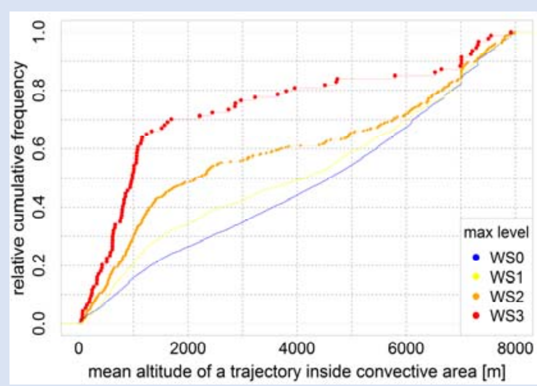


Fig. 4. A strong behavior dependence on the flight altitude is noticeable. Situations with WS3 are flown through in more than 60 % during landings.

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement [734143]

DFS Deutsche Flugsicherung

MeteoSolutions

U. Gelhardt[1], J. Lang[1], S. Schwanke[2] – ulrike.gelhardt@meteosolutions.de

[1] MeteoSolutions GmbH, [2] DFS Deutsche Flugsicherung GmbH

RADIAN project – UAS related networking

RADIAN

About RADIAN:

Full title: Facilitating Collaboration in Research and Development to Foster Further Innovation in European AeroNautics.
Instrument: EU funded Horizon 2020 project (AAT)
Timeframe: 1 October 2016 – 30 September 2019
Website: www.h2020-radian.eu

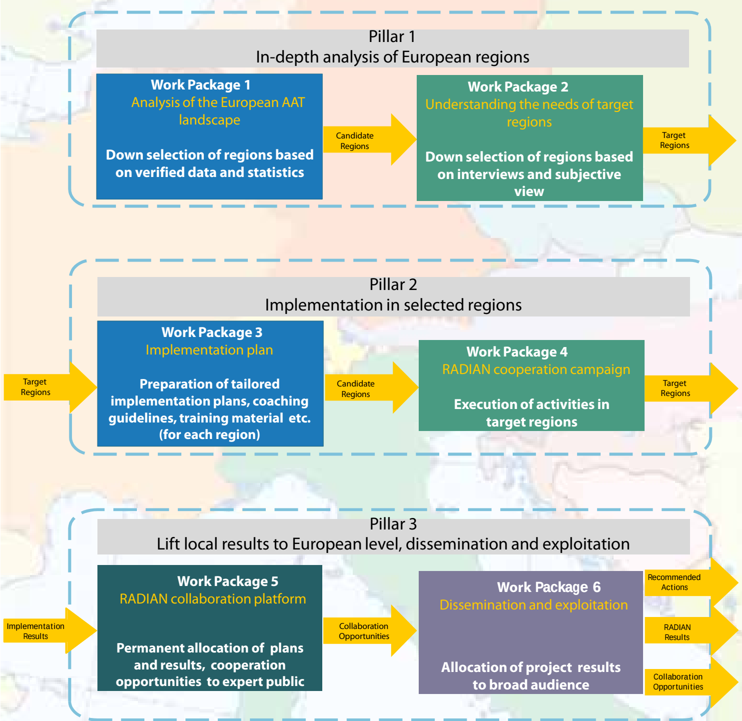
The most relevant activity for SESAR activities is to facilitate information sharing and network building in the field of Unmanned Aircraft Systems' (UAS) and drone related developments. The project supports building new research and supply chains by facilitating networking.

Objectives:

- To try to make the European aviation research arena more integrated.
- Supporting some key players from selected European regions to be more involved in European research programmes.

RADIAN tries to facilitate networking from many angles:

- Among leading member states in aviation research and states which are yet less integrated of the geographic Europe
- Via direct channels (facilitation meetings at selected regions, workshops) and indirect channels (dissemination of best practices, ARCPORT platform, etc.)
- both in aeronautics and air transport research



The RADIAN project considers following areas of interest related to UAS:

- Ground – air communication
- Technical solutions
- ATM related issues
- Regulatory aspects
- Possible areas of implementation
- Application possibilities and use cases

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 724109

Andrej Kocsis, Reza Mirhossein, Roland Guraly, Slot Consulting www.slotconsulting.eu

Vertical Flight Trajectory Efficiency

A study on the effects and causes of climb restrictions for flights departing Amsterdam Airport Schiphol

knowledge & development centre
Mainport Schiphol

Introduction

In the ideal situation each flight departs such that it can fly a continuous climb departure without any interruptions. Accommodating continuous climb operations is not always achievable due to airspace design limitations and ATC procedures. The expected benefits of continuous climb operations include increased fuel efficiency, cost effectiveness and improved capacity. The objective of this research is to identify the causes that obstruct the execution of continuous climb departures while flights are under control of Dutch ATC. The effect of interrupted climb segments is quantified in terms of additional fuel consumption.

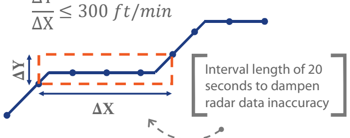
Methodology

This research follows a similar methodology as developed by the Performance Review Unit (PRU)[1] to detect level segments. The primary difference in this research is the addition of determining the effects of level segments on fuel consumption.

Detect level segments

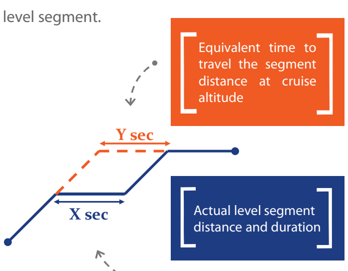
- Determine if flight is still in climb phase.
- Minimum interval length of 20 second.

$$\frac{\Delta Y}{\Delta X} \leq 300\ ft/min$$



Determine additional fuel consumption

EUROCONTROL Base of Aircraft Data (BADA) is used to estimate the fuel burn for both the actual level segment and equivalent segment at the requested cruise altitude. The difference in fuel burn is considered the inefficiency caused by the level segment.



Influence of operational variables

The standard instrument departure route (SID), departure runway, coordination exit point, and aircraft type of all flights are analysed in order to determine how these factors affect the rate of occurrence, distance, and additional fuel consumption of level segments.

Data Analysis

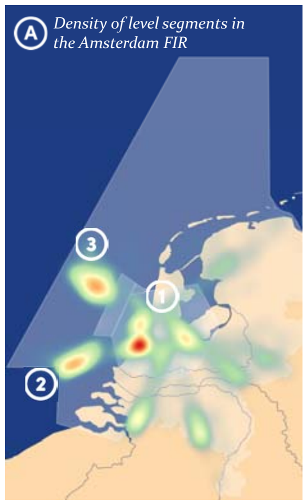
Location and altitude

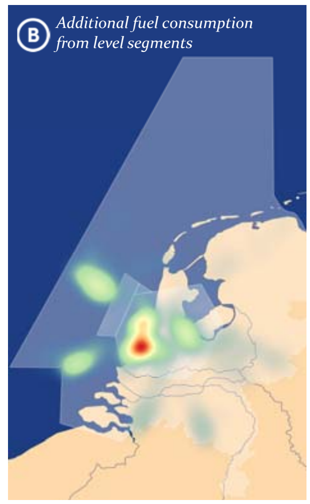
Level segment are concentrated in three distinct regions and altitudes of the Amsterdam FIR:

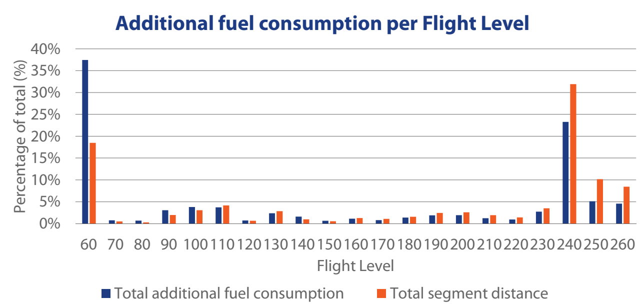
1. South-West Schiphol TMA at FL60.
2. South-West border with London AC at FL240.
3. North-West border with London AC at FL240.

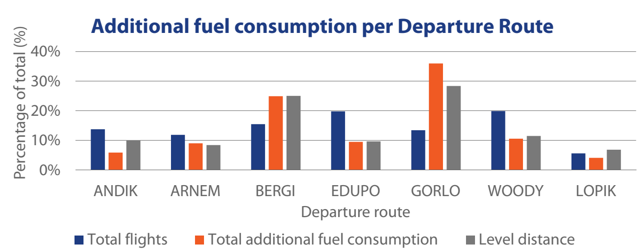
Additional fuel consumption

The majority (37.5%) of the additional fuel consumption is due to level segments located in the Schiphol TMA at FL60 , while only 18% of the total level segment distance is at this altitude.









Vertical Trajectory Efficiency 2017

	February	July
Number of flights	16,910	23,505
% interrupted flights	9.9%	7.8%
Additional fuel consumption (kg)	20,027	21,138
Total time spent level (min)	1,665	1,882
Average time spent level per affected flight (sec)	59.7	61.6

Conclusion

Interrupted climb: Over 9**0%** of all flights are able to fly a continuous climb departure while under control of Dutch ATC. The PRU determined that 80% of all flights are considered as continuous climb operations at Amsterdam for the entire climb phase.

Airspace design and ATC procedures:
The majority of the level segment distance occurs at the hand-over altitude of FL240 near the border with the UK. Intersecting departure and arrival routes require vertical separation and produce most of the low altitude level segments in the Schiphol TMA.

Environmental impact: A total of **250,000 kg** fuel was consumed on top of the regular fuel burn, primarily due to level segments in the Schiphol TMA. Each affected flight consumed on average **12 kg** of additional fuel. This is similar to the 15kg of additional fuel per impacted flight according to PRU research[2], which included the entire climb phase. The additional fuel consumption results in nearly **800,000 kg** of CO_2 emissions per year.

Recommendations

Enhance hand-over agreements with neighbouring ANSPs to accommodate continuous climb departures.

Develop solutions to reduce the effect of crossing departure and arrival routes in the TMA when redesigning the airspace.

Analyse the vertical trajectory efficiency of arrivals and determine their influence on departures in the Schiphol TMA.

Acknowledgement

This work was supported by Air Traffic Control the Netherlands (LVNL), KLM, Amsterdam Airport Schiphol (AAS), and the Amsterdam University of Applies Sciences (AUAS). The author gratefully acknowledges the helpful discussions with Alina Zelenevska (LVNL), Evert Westerveld (LVNL), Coen Vlasblom (KLM), Boudewijn Lievegoed (AAS), Ferdinand Dijkstra (FerWay), and Frenchez Pietersz (AUAS).

References

1. S. Peeters and G. Guastalla, "Analysis of en-route vertical flight efficiency," EUROCONTROL, 2017.
2. EUROCONTROL. "Vertical Flight Efficiency," Performance Review Unit, 2008.

Amsterdam University of Applied Sciences

Marc Eijkens – Marc.Eijkens@hva.nl

Schiphol Group LVNL KLM

Contemporary wildlife risk challenges and habitat management in the vicinity of airports

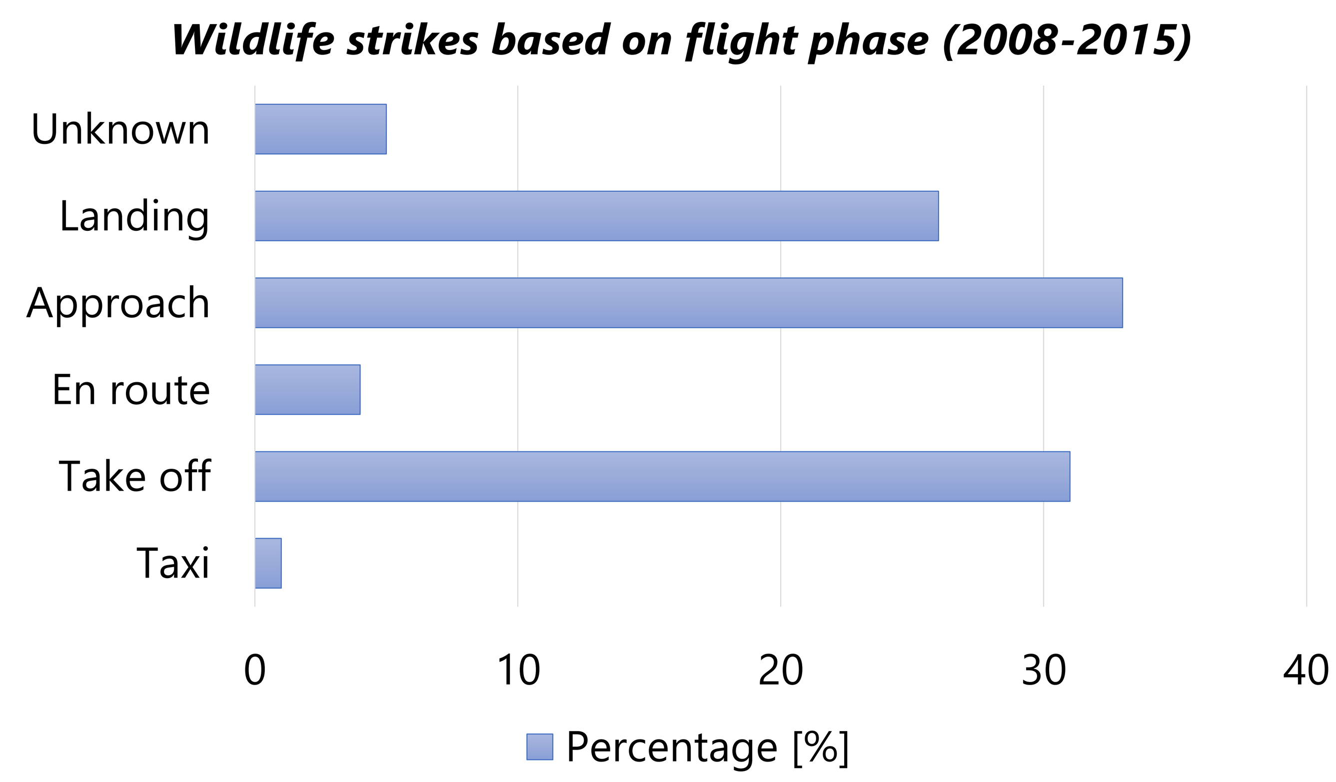
University of Belgrade

Faculty for Transport and Traffic Engineering

Abstract

Wildlife hazard as one of challenges in aviation requires creative strategies, diligent performance and detail oriented approach. Increasing air traffic volume and population of some animal species together with undesirable combination of airport's area characteristics contribute to increased wildlife strike risk. Special pressure is on airports to provide safe environment but are the airports capable to provide and maintain safe conditions independently?

Low FL – High risk



Strikes should be reported in cases strike is observed or the evidence is found on the aircraft. Remains found within 250 ft of the RWY central line or within 1000 ft of a RWY end also should be documented.

Area critical elements

Airports should conduct an inventory of wildlife attracting sites within the ICAO defined 13 km circle.

Water rich areas – Lakes, wetland, sea, irrigation system, wastewater, artificial reservoirs, precipitation accumulating, large areas of open shallow water.

Construction sites - Excavated land brings insects at the surface and creates voids. Insects are food for many species and formed voids are used as a shelters.

Areas with agricultural fields or woodland - Risk will depend on crop type. It is recommended to cultivate the corps that are less attractive to animals like beets, potatoes, chicory, etc. Trees and shrubs may provide shelter, roosting, resting place and food.

Closeness to sewage and landfill - Sewage and landfills are spacious and convenient for the different animal species. Besides, even smaller subjects like uncovered waste bins may affect wildlife occurrences.

Human influence - Feeding animals in the airport's vicinity, leaving them the food or building up farms.

Areas covered with grass - If grass is not too tall this kind of surface is convenient environment for the birds. Plane grassy areas are particularly risky.

Risk mitigation measures

The area of concern is wider than airport property, indicating that for the proper habitat management raising public awareness is necessary. Although airport's role it is vital, resources and power are limited. Efficient habitat management may require measures like landfill relocation, forest and shrubs removal, water drainage, airport fencing, using disperse devices, tracking radars, pyrotechnic and chemical aids, seeding program review and many others. Habitat management plan should be developed for each airport considering particularities and characteristics of the specific airport area.

Conclusion

Habitat management is unable to entirely eliminate wildlife strike risk. Every party in aviation in its working domain may contribute to the process of wildlife risk mitigation. Due to complexity, engagement of external participants is needed. The research shows general airport limitations, critical elements and points out potential of the local community for the effective wildlife risk mitigation.

PhD Candidate, **Aleksandra Nešić**, University of Belgrade, Faculty for Transport and Traffic Engineering, aleksandra.nesic@air-mark.com
Prof. dr **Olja Čokorilo**, University of Belgrade, Faculty for Transport and Traffic Engineering, o.cokorilo@sf.bg.ac.rs

pyBADA

Easy Base of Aircraft Data (BADA) integration in Python for rapid prototyping

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Introduction

- **BADA** is an aircraft performance model (**APM**) developed and maintained by **EUROCONTROL**.
- **pyBADA** is a **Python** library for aircraft performance **modelling**, trajectory **prediction** and **optimisation**, and **visualisation** with BADA, build on **CasADi**, an open-source tool for optimisation and algorithmic differentiation.
- pyBADA is **multi-platform** and easy to install → pip install ssh://user.name@bleriot.upc.edu/path/pyBada
- pyBADA implements:
    - BADA3, BADA4
    - BADAH

CasADi

- At the core of CasADi is a **symbolic framework** that allows the user to construct symbolic expressions.

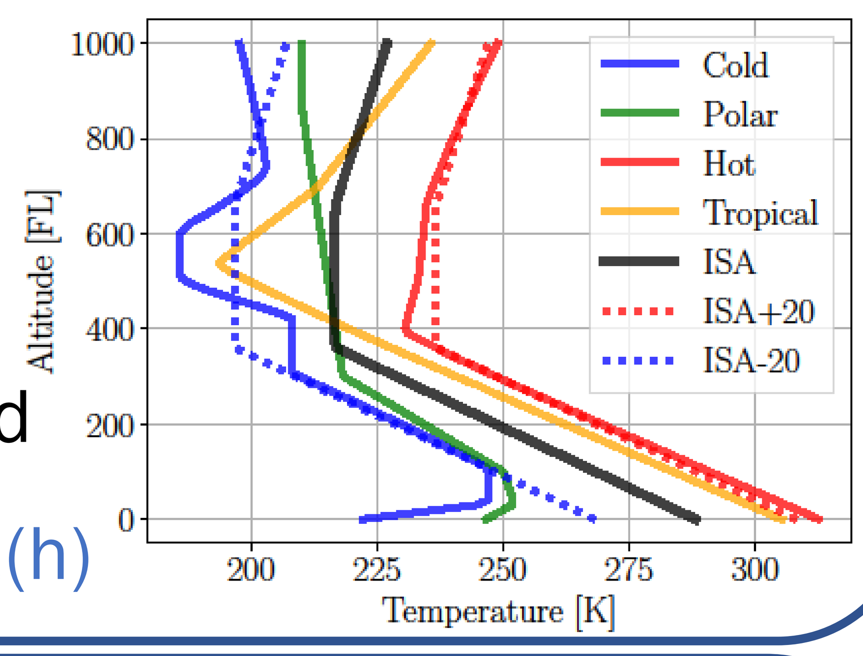
Numeric:
```
x = 3
y = 5
z = x^2 + y
>14
```

Symbolic:
```
x = SX.sym('x')
y = SX.sym('y')
z = x^2 + y
>x^2 + y
gradient(z,x) >2*x
```

Atmosphere

- Implements **the standard atmosphere models:**
    - ISA (international standard atmosphere)
    - MIL-STD-210A standard

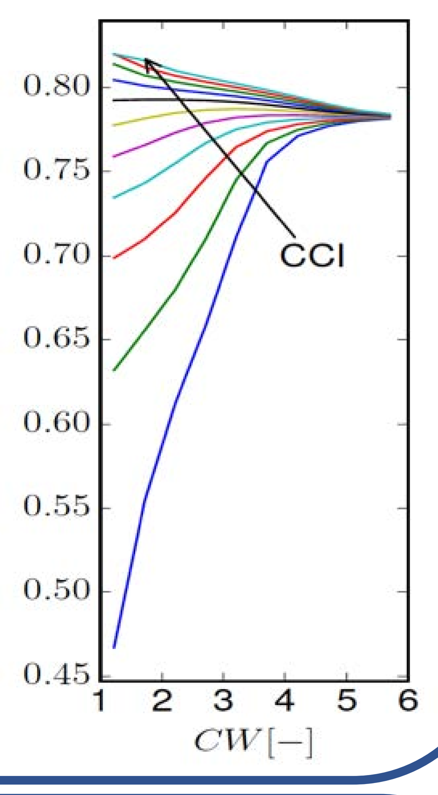
theta = atmosphere.theta(h)



Optimisation

- Calculates **optimal speeds** with wind:
    - Maximum range cruise (MRC)
    - Long range cruise (LRC)
    - Economic cruise speed (ECON)
    - Maximum endurance cruise (MEC)

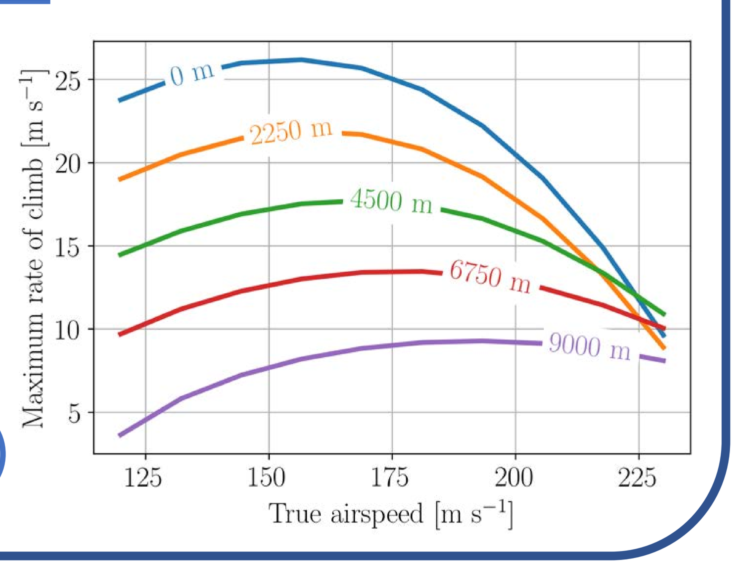
opt.MrcMach(aircraft,delta,theta,m,w)
>0.78



Visualisation

- Provides tools for visualisation of **aircraft trajectories, aircraft envelope** and **performance.**

visualisation.plot
(x=v, y=(Tmax-D)*v/(m*g), z=h)



Performance

- Automatically **parses** the BADA datasets.
  aircraft = performance.bada3("XXX.OPF")
- Evaluates the **performance functions** of the BADA model at given flight conditions.

Numeric:
```
v = 447
T= 3.6
aircraft.ff(v=v, T=T)
> 3.39
```

Symbolic:
```
v = SX.sym('v')
T= SX.sym('T')
aircraft.ff(v=v, T=T)
> 0.94·(1 + v/1.0E+05)·T
```

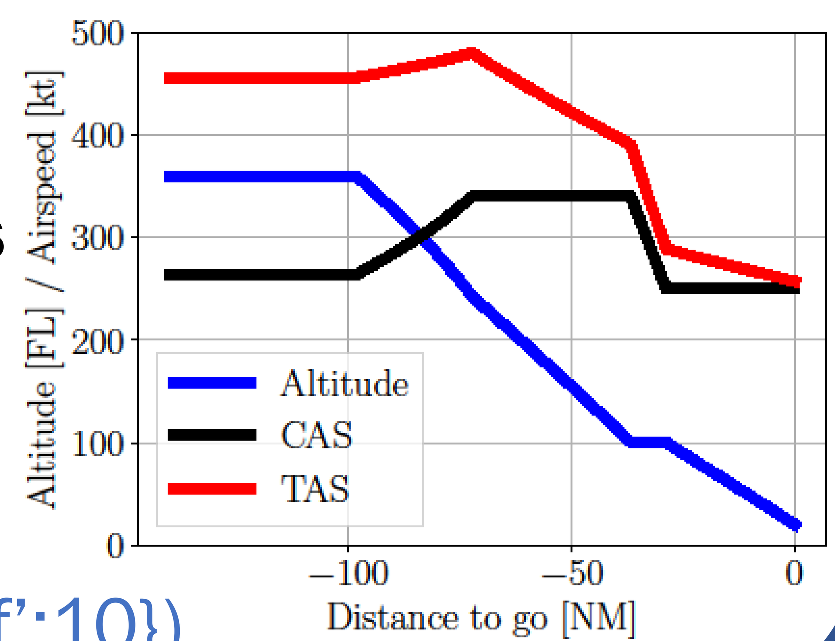
- Easy and fast implementation of the BADA APM and **derivatives** for **optimisation** and **sensitivity analysis.**

$$\mathrm{ECCF} = \frac{CI}{M\sqrt{\tau\gamma_a R}+w} + \frac{\delta\theta^{\frac{1}{2}} W_{mref} a_0 L_{HV}^{-1}}{M\sqrt{\tau\gamma_a R}+w} \sum_{i=0}^{4}\sum_{j=0}^{4} f_{5i+j+1} M^i \left(\frac{1}{2W_{mref}} p_0 k S M^2 \mathrm{K} \left(\left(d_1 + \frac{d_2}{(1-M^2)^{\frac{1}{2}}} + \frac{d_3}{(1-M^2)} + \frac{d_4}{(1-M^2)^{\frac{3}{2}}} + \frac{d_5}{(1-M^2)^2}\right) + \left(d_6 + \frac{d_7}{(1-M^2)^{\frac{3}{2}}} + \frac{d_8}{(1-M^2)^3} + \frac{d_9}{(1-M^2)^{\frac{9}{2}}} + \frac{d_{10}}{(1-M^2)^6}\right)\left(\frac{2mg}{\delta p_0 k S M^2}\right)^2 + \left(d_{11} + \frac{d_{12}}{(1-M^2)^7} + \frac{d_{13}}{(1-M^2)^{\frac{15}{2}}} + \frac{d_{14}}{(1-M^2)^8} + \frac{d_{15}}{(1-M^2)^{\frac{17}{2}}}\right)\left(\frac{2mg}{\delta p_0 k S M^2}\right)^6\right)\right)^j$$

Trajectory prediction

- Computes trajectories given the **initial conditions**, a sequence of **flight intents** and **weather conditions.**

xf = pred.predict(x0,intent, mode, {'tf':10})



pyBADA has been used in...

- Real-time **optimal planning** and **guidance.**
- **Fuel estimation** from surveillance data.
- Generation of **realistic scenarios** for the assessment of wake-vortex hazards in en-route airspace.

Apache R-WAKE SUPPORTED BY SESAR JOINT UNDERTAKING

Ramon Dalmau, Marc Melgosa & Xavier Prats – Techincal University of Catalonia
ramon.dalmau@upc.edu, marc.melgosa@upc.edu & xavier.prats@upc.edu

Data-driven Insight in Aircraft Taxi Time

Objective:

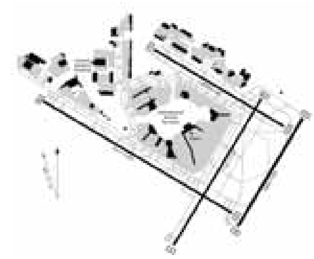
Leverage advanced analytics to process/analyze the airport operational data to deploy the best prediction model on the sample and population data in order to obtain an acceptable mean of aircraft taxi time prediction.

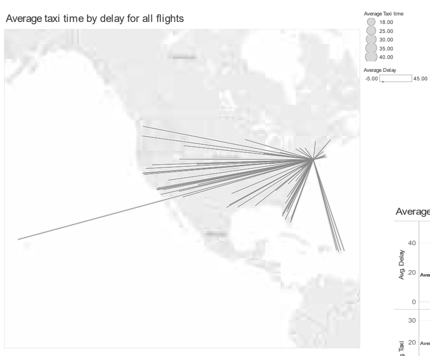
1 Data Sourcing

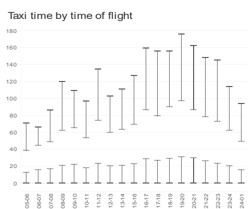
Retrieved data from BTS are for all departure and arrival flights at JFK airport in four months of 2017(Jan, Apr, Jul and Oct) in order to have the annual trend and capture seasonality.
Data includes 6 Airlines, 62 Airports & average daily weather data (11 Var.)

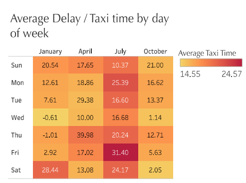
TAXI Time structure:

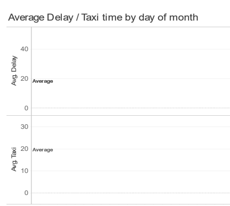
- Range : from 5 to 176 min
- Mean : 20.18 min
- Sd : 14.08 min
- Remove 5% percentile from Taxi time
- Remove 5% & 95% percentile from Delays

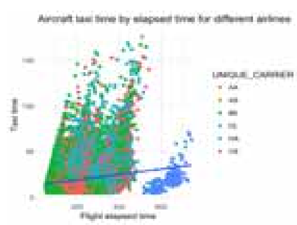












2 Explore the Data

Flight routes as well as day of the week/month would have effect on the target variable.

Taxi time Predictors Hypothesis :

- Elapsed time
- Flight time block
- Weather events
- Day of week/month
- Origin & destination airport

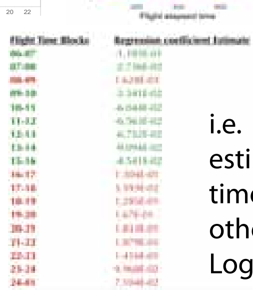
3 Prediction Models

Regression models:

- Linear regression (0.7581)
- LASSO (0.7579)
- Regression tree (0.6864)

Supervised ML models:

- Random Forest (0.7731)
- GBM (0.7747)

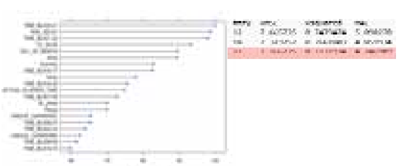


Regression

i.e. Flights between 13 to 14 is estimated to have 9.09 % less taxi time than other flights with constant other variables;
Log(Taxi Time) = a + **b** (time blocks**)**

Tree-based model

Random Forest model



GBM model

Annual saving estimation according to A-CDM pre-departure sequence benefits for a congested airport:

150k taxi min	**2300 Tones of fuel**
2.5 M € in fuel	**1.4 M € in delay**

4 Validation

Prediction model performance on train data shows that GBM model has the highest prediction power.
The RMSE value on the test dataset confirms the external validity of the selected model with a slight higher value (RMSE = 7.1526) than the one on the train dataset (RMSE = 7.0649).

Reza Mirhossein, Roland Guraly, Andrej Kocsis, Slot Consulting Ltd., www.slotconsulting.eu

Collaborative Aviation Research

Research collaboration between Air Traffic Control the Netherlands, KLM, Schiphol Airport and universities

knowledge & development centre
Mainport Schiphol

Industry challenges

Aviation is facing challenges in Europe, because of the continued growth of air traffic, airspace is becoming more crowded, airports are running towards their maximum limits. The ability to absorb changes in supply and demand has decreased, we need to research how we can be more efficient with the available capacity, so that growth within the boundaries becomes possible.

Collaboration to move forward

Collaboration between Air Traffic Control the Netherlands (LVNL), KLM, Schiphol Airport and Ministry of Infrastructure and Water Management, in the KDC - Centre of Excellence (CoE) generates results that are only attained through the objective and active involvement of aviation organizations. A joint undertaking between industry and universities, allows BSc and MSc graduates to research detailed and sensitive company information nonetheless still create results available to the public domain and the whole aviation sector.

How it works - Methodology

Graduate students research current challenges (figure 1) in the Dutch aviation industry and especially concerned with Schiphol Airport.

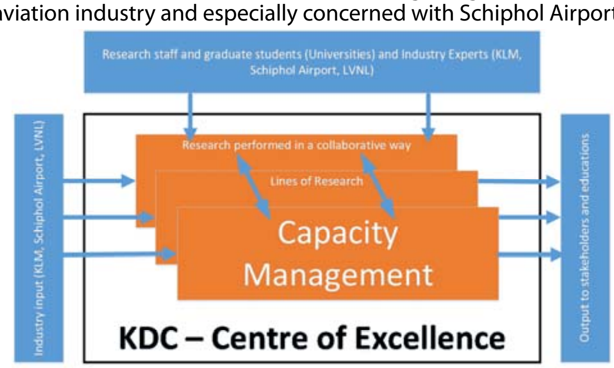


Figure 1: Centre of Excellence setup

Industry stakeholders provide:

- *access to experts from their own or outside their organization and to data that is not always in the public domain*
- *objective feedback on the research of the graduates without influencing/steering the research direction*

Universities provide:

- *graduate students throughout the year, that perform data analysis, simulations and qualitative fine tuning of the findings*
- *academic access to knowledge unattainable by the organizations by providing supporting research staff*

Governance

Manager from the major stakeholders, represent company interests and guard sector benefits. The CoE is financed by the Dutch government and is located at the LVNL, which is the most neutral position. Managers mutually agree on the research topics, and select research students based on the content of their research proposal.

Data Sharing

Researchers and research students sign an agreement with the LVNL; that covers data sharing and usage protocols in addition publication restrictions for all involved stakeholders. Final results are approved by the managers, before publication. Data access and sharing between organization for research is provided through the respective experts and departments of KLM, Schiphol Airport and LVNL.

What it delivers - Results

The past year has led to 15 current topics being researched, covered topics are among:

- *Level segments identification in Dutch Airspace [2]*
- *Insights in airline strategies' impacting gate occupancy [3]*
- *Insights into strain on the On-Time Performance (figure 2) due to traffic growth [4]*

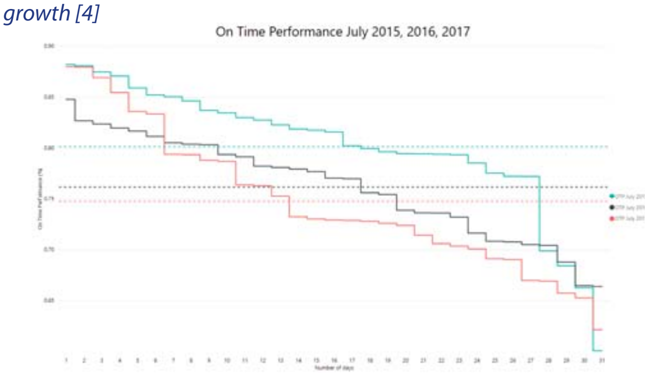


Figure 2: Development of OTP during July 2015, 2016, 2017 (CDM portal Schiphol, 2018)

Why it works - Conclusions

Collaboration on this level achieves more opportunities for the aviation industry than separately researching developments and challenges.

Recommendations

"Collaboration with universities is highly recommended to create new knowledge and insights." – Westerveld, 2018 (Manager Strategy & Capacity @LVNL)

Acknowledgement

The Centre of Excellence is supported and only possible due to the commitment of the managers from the LVNL, KLM, Schiphol Airport, Universities and Ministry of Infrastructure and Water Management.

References

[1] Centre of Excellence. (2018). Retrieved from https://www.kdc-mainport.nl/index.php/nl/centre-of-excellence
[2] Eijkens, M. (2018). Analysis of Vertical Flight Trajectory Efficiency. Amsterdam.
[3] Ringelberg, M. (2018). Airline Strategies' Impact on Gate Occupancy. Amsterdam.
[4] Westerveld, E. (2018). KDC Research Agenda. Amsterdam.
[5] Wouters, R. (2018). Impact of Local A-CDM on the Operational Efficiency at Mainport Schiphol. Amsterdam.

Amsterdam University of Applied Sciences | Schiphol Group | LVNL | KLM Royal Dutch Airlines | SkyTeam

MR. FRENCHEZ PIETERSZ MSC, F.PIETERSZ@HVA.NL & FRENCHEZ.PIETERSZ@LVNL.NL
Amsterdam University of Applied Sciences - Aviation Academy & Knowledge Development Centre Schiphol - Centre of Excellence
Amsterdam, the Netherlands

PFV : ENAC's flying testbed

A new platform for Aeronautical and Air Traffic Control applied research

The PFV is a Socata TB10 aircraft originally operated for pilot training and modified to test new concepts or on-board equipment in various research fields like surveillance, UAV detect and avoid, antennas, human factors, human machine interfaces (HMI), data link communications. PFV has been certified by EASA in order to be operated in 3 modes: pilot training, data gathering ('big data' mode) or 'research mode' (right side of the cockpit emptied of original instrumentation and fitted with prototype HMI).The PFV is operated and maintained by ENAC personnel.

DATA ACQUISITION SYSTEM

Data coming from avionic (GPS, XPDR, ADS-B in, EFIS), engine, IMU (inertial measurement unit), pilot's command and attitude are recorded (capacity of 400h) and broadcasted by the data acquisition system.

WINGTIP CAMERAS

Two high performance monochrome cameras have been placed one per wingtip for detect and avoid applications or precise localization and mapping.

HMI PROTOTYPING AREA

The right side of the cockpit when in research mode, can be equipped with prototype instrumentation and connected in real time to the data acquisition software. Physiological sensors may also be connected to feed those HMIs.

ADDITIONNAL ANTENNAS

The PFV allows to test new types of antenna, several dedicated spaces have been made in its structure for this purpose. There is also one multiband GPS antenna available per wingtip for applications like attitude assessment.

MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE ET SOLIDAIRE — PRÉFET DE LA RÉGION OCCITANIE — La Région Occitanie Pyrénées - Méditerranée — toulouse métropole — Contrats de plan ÉTAT-RÉGION Bâtir aujourd'hui la France de demain

Jean-Paul Imbert / Railane Benhacene achil-contact@recherche.enac.fr

CLASS

Surveillance of UAS traffic

CLEAR AIR SITUATION FOR UAS

Mission: a stepping stone for surveillance of UAS

- Merge existing technologies to build core functions of U-Space
- Increase maturity level of these technologies
- Define Use Case Scenarios and Key Performance Indicators (KPIs) to assess the performance of future U-Space systems
- Provide baseline results through live and simulated trials

Scenarios and KPIs

Stakeholders' requirements gathered in a workshop yielded 6 design scenarios and 17 Key Performance Areas

Scenarios:

- GNSS failure leading to intrusion in an airport
- Instrument Landing System calibration
- Conflicts in an emergency situation
- Aerial work on high voltage lines
- Urban pollution sampling

KPIs:

Extract of KPIs relating to Accuracy, Detectability and False Classifications

KPI Name	KPI Definition	KPI Description
Horizontal Position Error (ePosH)	$RMS(pos_H^T - pos_H^R)$	pos_H^T = Tracker Horizontal position pos_H^R = Reference Horizontal position
Vertical Position Error (ePosV)	$RMS(pos_V^T - pos_V^R)$	pos_V^T = Tracker Vertical position pos_V^R = Reference Vertical position
Probability of Update (PU)	$\frac{N_{DD}^T}{N_{DD}^R}$	N_{DD}^T= Drone Detections from Tracker N_D^R= Total Drone Detections from Reference
Mean Gap per track (mGAP)	$\frac{1 - PU}{N_{DT}^T}$	N_{DT}^T= Drone Tracks from tracker
False Positive Rate (FPR)	$\frac{N_{AT}^T - N_{DT}^T}{\Delta t}$	N_{AT}^T= All tracks from tracker Δt= time duration

Implementation

Merge and increase maturity level of:

- Airbus' Drone-It! cooperative surveillance system
- Aveillant's radar (non-cooperative)
- NTNU's Data fusion between Drone-It! and Aveillant's radar
- Unifly's Real-time UTMS
- Drones built and flown by ENAC with its Paparazzi open source autopilot.

Testing

2 real flight campaigns:

- June 2018: training the radar with 2 fixed wing drones. Paparazzi logs provides the reference data
- October 2018: Integration of Drone-It and Unifly systems to the CLASS architecture

PAPARAZZI
The Free Autopilot

Deconfliction

CLASS deconfliction takes place at a tactical level - i.e. during the flight - and before Detect and Avoid.

Airbus is working on a drone-drone tactical deconfliction algorithm, but the notion of "conflict" needs to be refined.

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement 763719.

NTNU UNIFLY AIRBUS AVEILLANT A Thales company ENAC ECOLE NATIONALE DE L'AVIATION CIVILE

Fabien BONNEVAL – fabien.bonneval@enac.fr , Jim SHARPLES, Yannick JESTIN,
Mohammed Jahangir – mohammed.jahangir@aveillant.com

Learning Air Traffic Controller Strategies with Real-Time Neural and Physiological Feedback

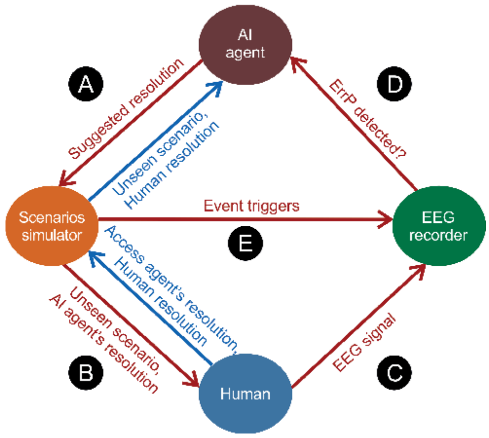
MOTIVATION & OBJECTIVES

- To design and develop an Artificial Intelligence (AI) agent as conflict resolution advisor to assist Air Traffic Controllers (ATCOs).
- The AI agent can learn strategies of ATCOs to resolve conflicts.
- The AI agent can employ learned knowledge to suggest human-like conflict resolutions.

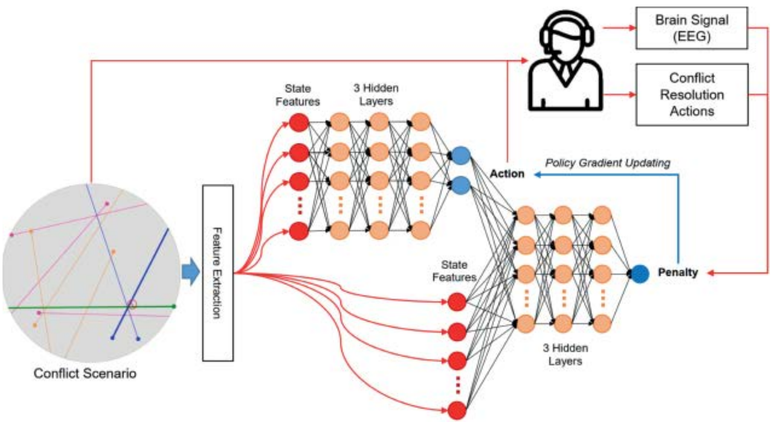
APPROACH

- The AI agent learns ATCOs' strategies by employing Deep Deterministic Policy Gradient (DDPG) on conflict resolution actions given by ATCOs.
- Air traffic conflict scenarios are presented to ATCOs through an interactive traffic simulator and their resolution preferences are characterized.
- ATCOs' electroencephalography (EEG) (i.e. error-related potential (ErrP)), while performing resolution, is recorded and corelated for the training of the AI agent.

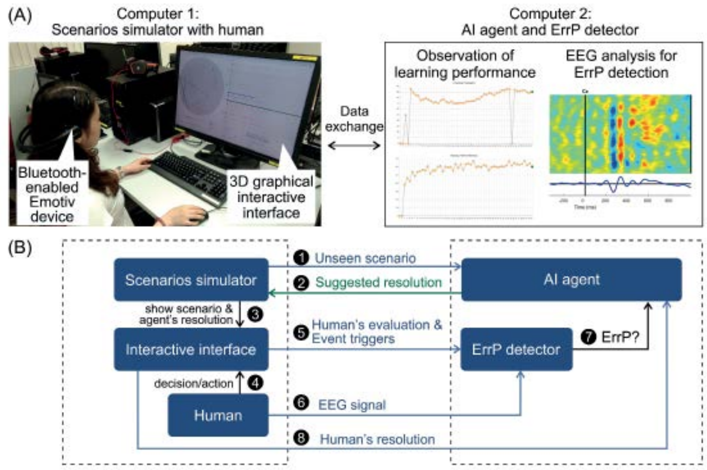
SYSTEM COMPONENTS



LEARNING MODEL

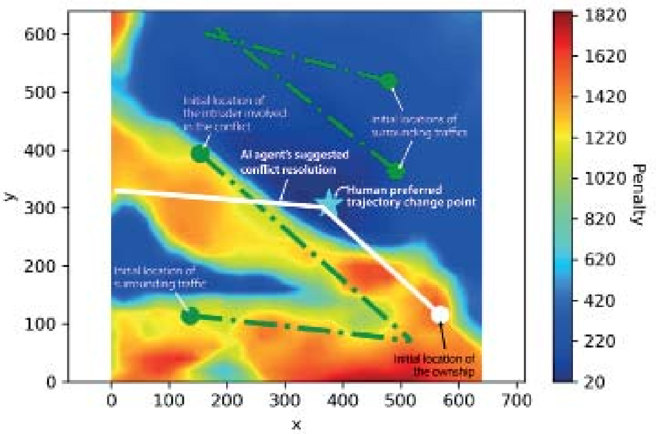


EXPERIMENTS

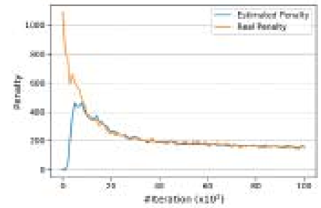


PRELIMINARY RESULTS

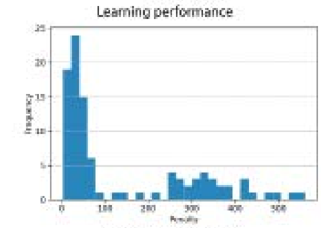
- AI model converges after 10,000 iterations.
- A conflict resolutions preference map is estimated by the AI model.
- 65% of AI agent suggested conflict resolution manuvear matches ATCOs proposed manuvear.
- Psycho-physiological signals can augment AI model learning performance.



A sample scenario with human preference and suggested resolution



Learning performance



Distribution of penalty

This research has been partially supported under
Air Traffic Management Research Institute (NTU-CAAS)
Grant No. M4062429.052

Sim Kuan Goh skgoh@ntu.edu.sg
Ngoc Phu Tran phutran@ntu.edu.sg
Duc-Thinh Pham dtpham@ntu.edu.sg
Chunyao Ma M180146@e.ntu.edu.sg
Sameer Alam* sameeralam@ntu.edu.sg
Vu Duong vu.duong@ntu.edu.sg
AIR TRAFFIC MANAGEMENT RESEARCH INSTITUTE, NANYANG TECHNOLOGICAL UNIVERSITY, SINGAPORE
*Corresponding author

adapt

Advanced prediction models for flexible trajectory-based operations

Read more about the project
https://adapt-h2020.eu
Contact: Lorenzo Castelli
lorenzo.castelli@dia.units.it

A data driven approach to strategic planning

ADAPT develops strategic models and tools, enabling strategic planning (early information sharing), by providing information on trajectories and flight flexibility (through the assignment of time windows (TWs) and network hotspots.

Network wide assessment tactical assessment

Network-wide assessment of the trajectories and TWs determined by the ADAPT models, will be performed using the tactical simulation, to identify whether the conflict detection and resolutions needed operationally could be performed within the assigned TWs.

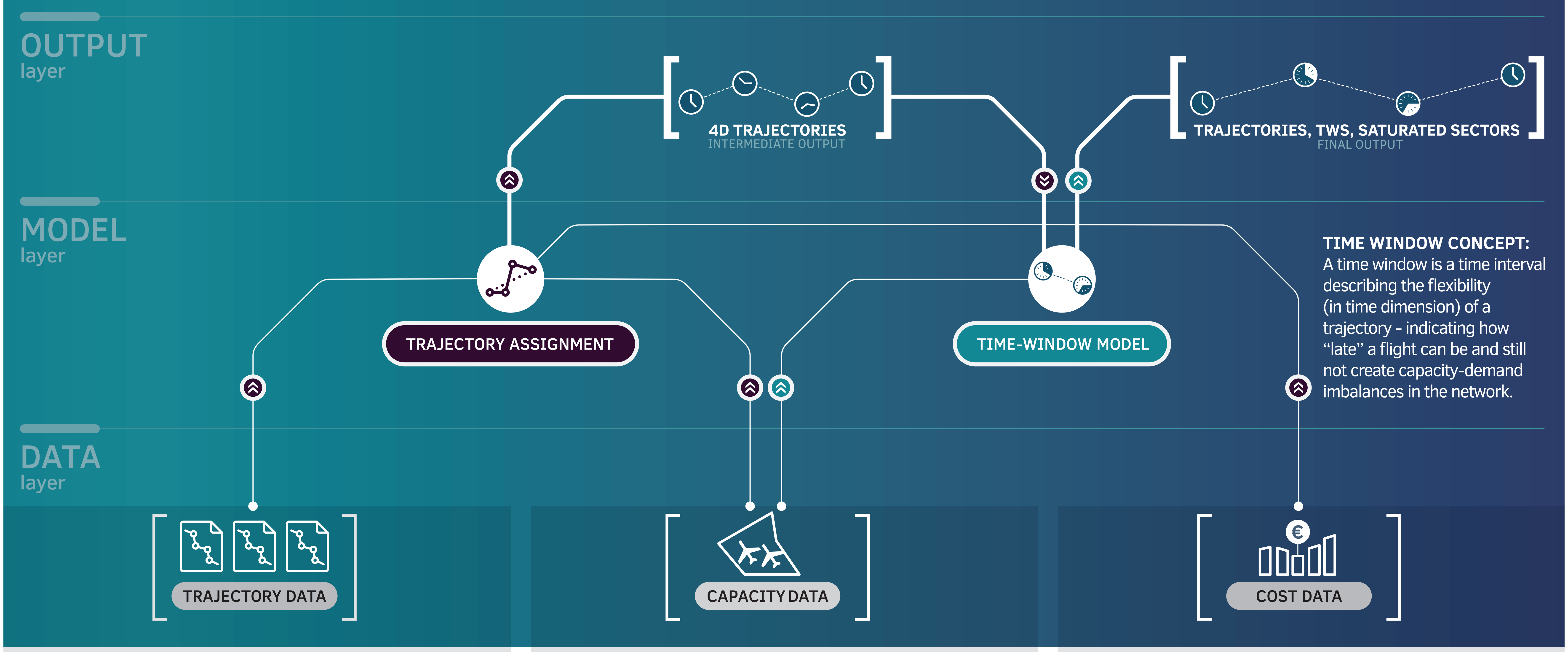
Flight centric assessment performance assessment

Flight-centric assessment looks into the individual flight performance where fuel consumption, weather conditions and arrival delay of individual flights are simulated and then compared to the assigned strategic 4D trajectory and TW.

From complex results to meaningful visualization

The outcomes of the project will be developed into static and dynamic visualizations, abstracting the relevant features and allowing users to understand the type and operational impact of the models.

ACTORS: ANSPs, Airports, Airlines, Regulators | **TIME FRAME:** 6 months before day of operations.



EUROCONTROL's DDR2 flight demand and trajectories

- **(m1)** the last filed flight plans
- **(m0)** initial flight plans

- m1 for trajectories and sector crossings
- m1 and m0 for departure times

EUROCONTROL's DDR2

Data regarding the airspace environment such as:

- **sector shapes**
- **sector activations**
- **sector and airport capacities**

DELAY & ANS PROVISION COSTS

Cost of delay models developed by the University of Westminster (Cook & Tanner, 2015) revised for 2017.

Cost of ANS provision to calculate route charges:

- Central Route Charge Office unit rates
- Oceanic rates

SCENARIO DEFINITION

To be able to assess ADAPT models, a baseline is compared with the ADAPT solution scenario.

BASELINE SCENARIO
Obtain a realistic baseline scenario through route assignment disregarding sector capacities. Consistent with current practice of not considering capacities at strategic phase.

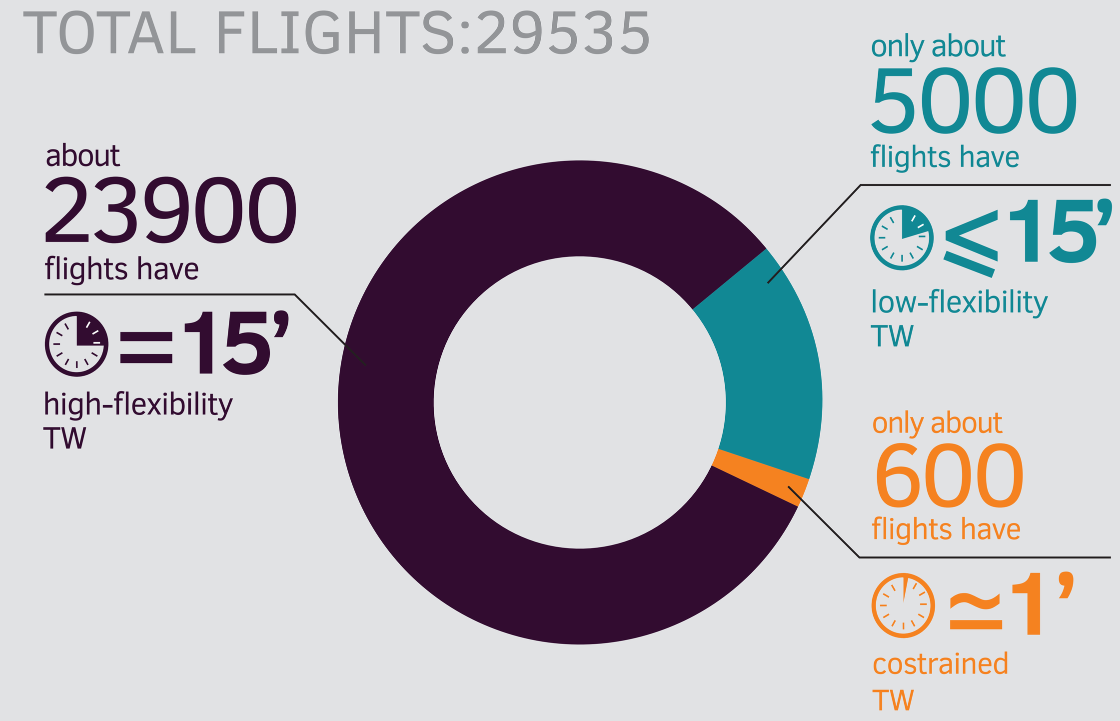
SOLUTION SCENARIO
Application of ADAPT models on the Sep.1st 2017 traffic. The models process 29 535 flights, over 22 862 sector-hours. The optimal solution is found in less than 3 minutes, with the optimality gap less than 0.1%.

1 SEPT 2017	**Test day:** Busy but not unduly disrupted day.

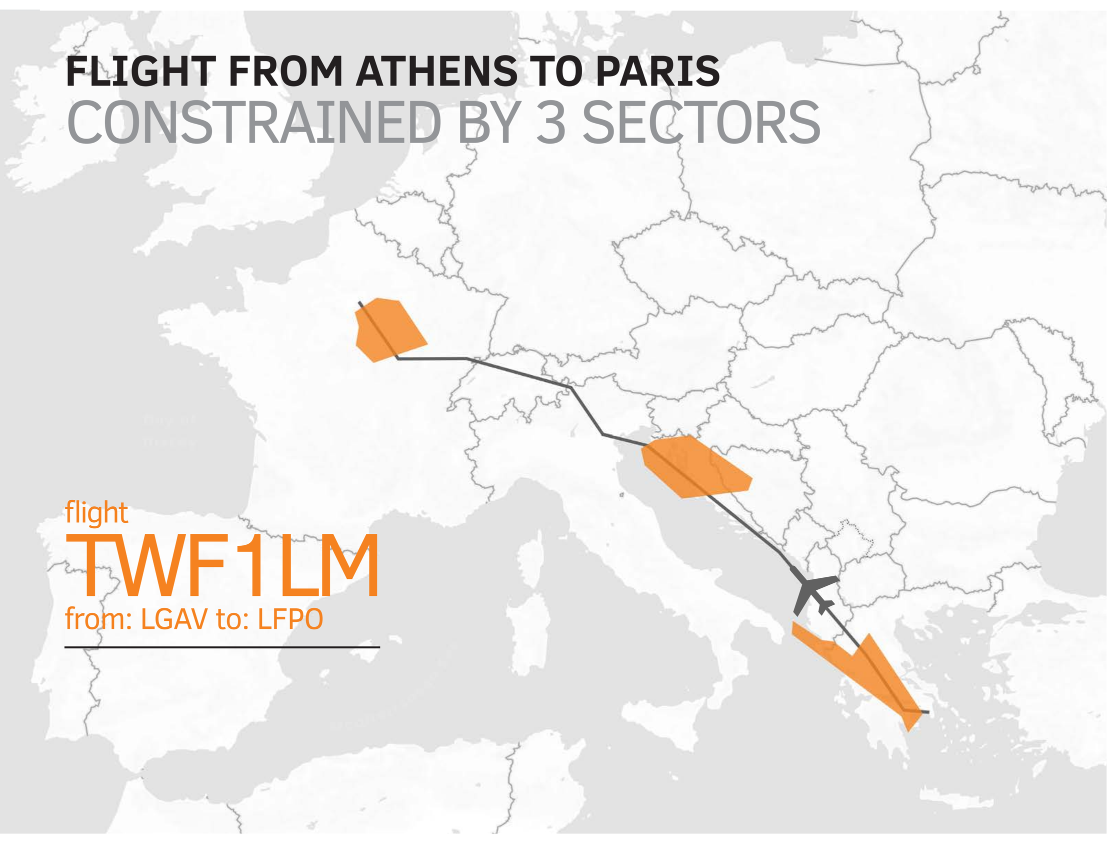
PRELIMINARY RESULTS

In the baseline, capacity is breached in a number of sector-hours, while that is not the case in the solution scenario.

TIME WINDOW DISTRIBUTION
TOTAL FLIGHTS:29535



FLIGHT FROM ATHENS TO PARIS
CONSTRAINED BY 3 SECTORS



NEXT STEPS

Development and assessment of the ADAPT solution and metrics definition:

Tactical assessment of ADAPT solution:
- Network-wide: focus on operational suitability of TWs for the entire European network.
- Flight-centric: considering fuel consumption and delay of individual flights.

Metrics definition:
- A (strategic) measure of the (economic) risk of saturated sectors.
- Statistical robust metrics on sector level, e.g. di-FORK, complexity metrics, percolation.

This project has received funding from the SESAR Joint Undertaking under grant agreement No°783264 under European Union's Horizon 2020 research and innovation programme.

UNIVERSITÀ DEGLI STUDI DI TRIESTE
deepblue
UNIVERSITÀ DEGLI STUDI DI PALERMO
UNIVERSITY OF WESTMINSTER
TU Delft

Route charging per airport-pair in Europe - How to come up with unit rates?

Impacts of traffic distribution over charging zones

ATM system in Europe

- highly fragmented (37 ANSPs)
- areas of responsibility limited to national borders
- ANS provision costs recovered at the level of individual ANSPs

Current charging scheme

- Central Route Charging Office (CRCO)
- Commission Regulation (EC) No 1794/2006
- Charging zones with different unit rates
- Unit rate: forecast cost-base / forecast service units
- Charge: service units * unit rate
- Service units = distance factor * weight factor

Negative effects

- detours around expensive charging zones
- more fuel consumption and CO_2 emissions
- increased demand unpredictability

Airport-pair charging

- route independent, no incentive to take detours
- mass and distance factor remain

***Challenge**: choosing the airport-pair unit rate (APUR) to recover individual ANSP costs. Naive solution:*

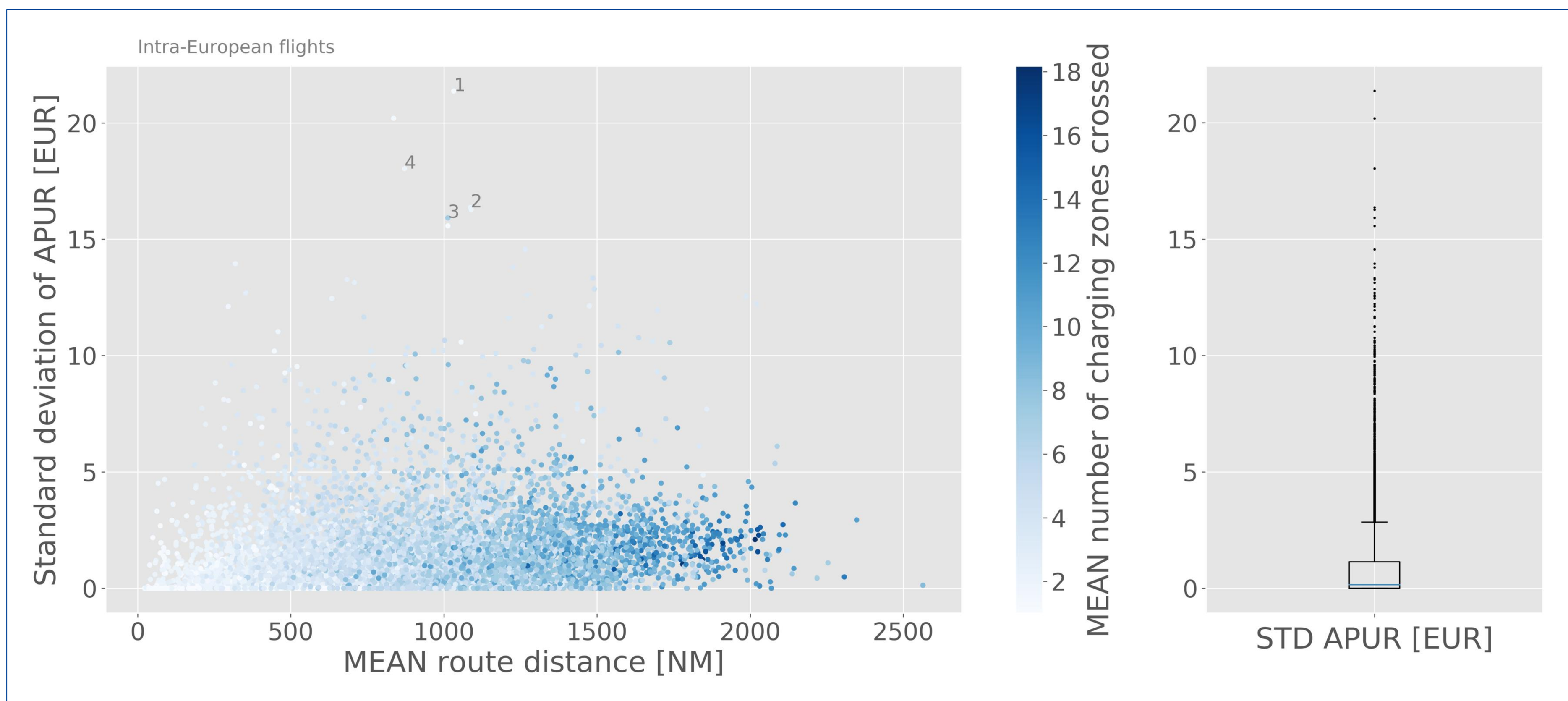
$$\mathrm{APUR} = \sum_{i=1}^{n} w_i * t_i \qquad \sum_{i=1}^{n} w_i = 1$$

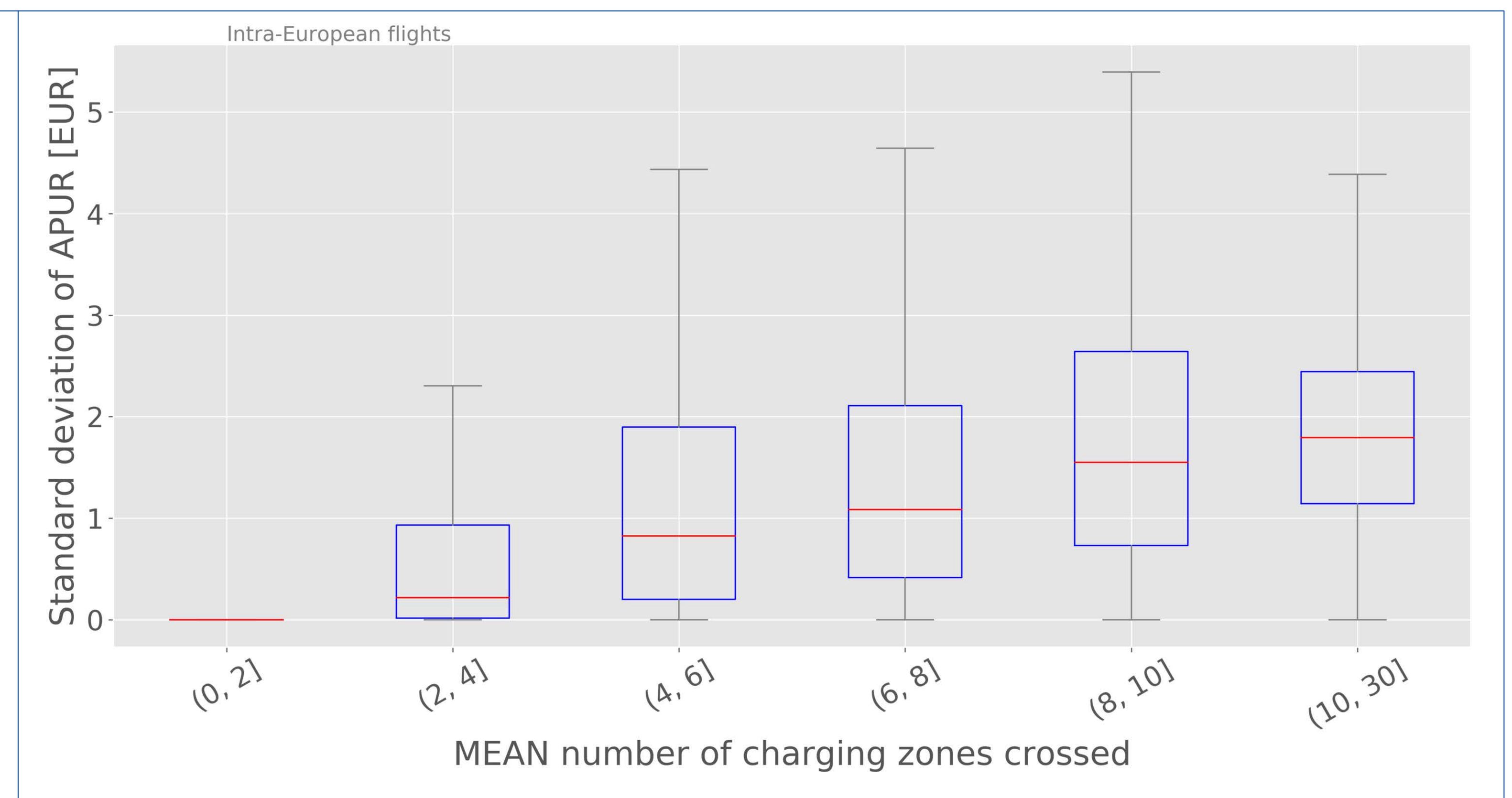
$\mathbf{w_i}$ – estimated relative share of ANSP **i** in total service provision for a given airport-pair;
$\mathbf{t_i}$ – unit rate of ANSP **i** (as calculated by CRCO);

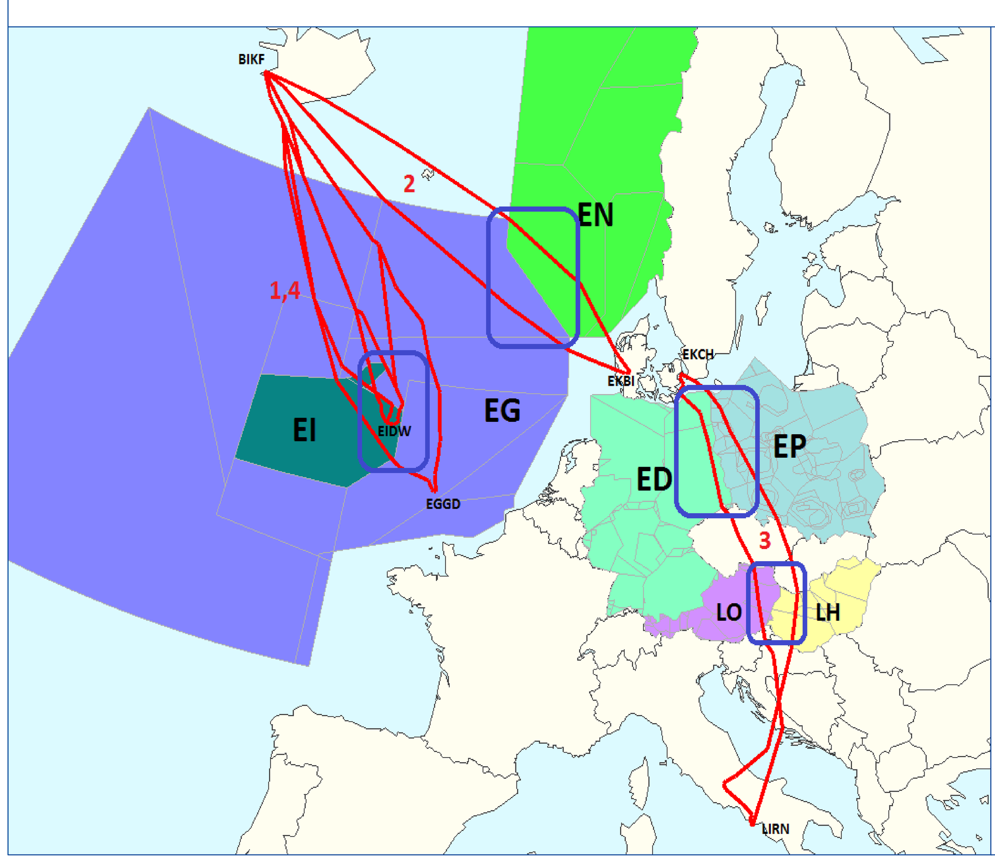
***Question:** what is the impact of traffic distribution and ATM fragmentation on APUR?*

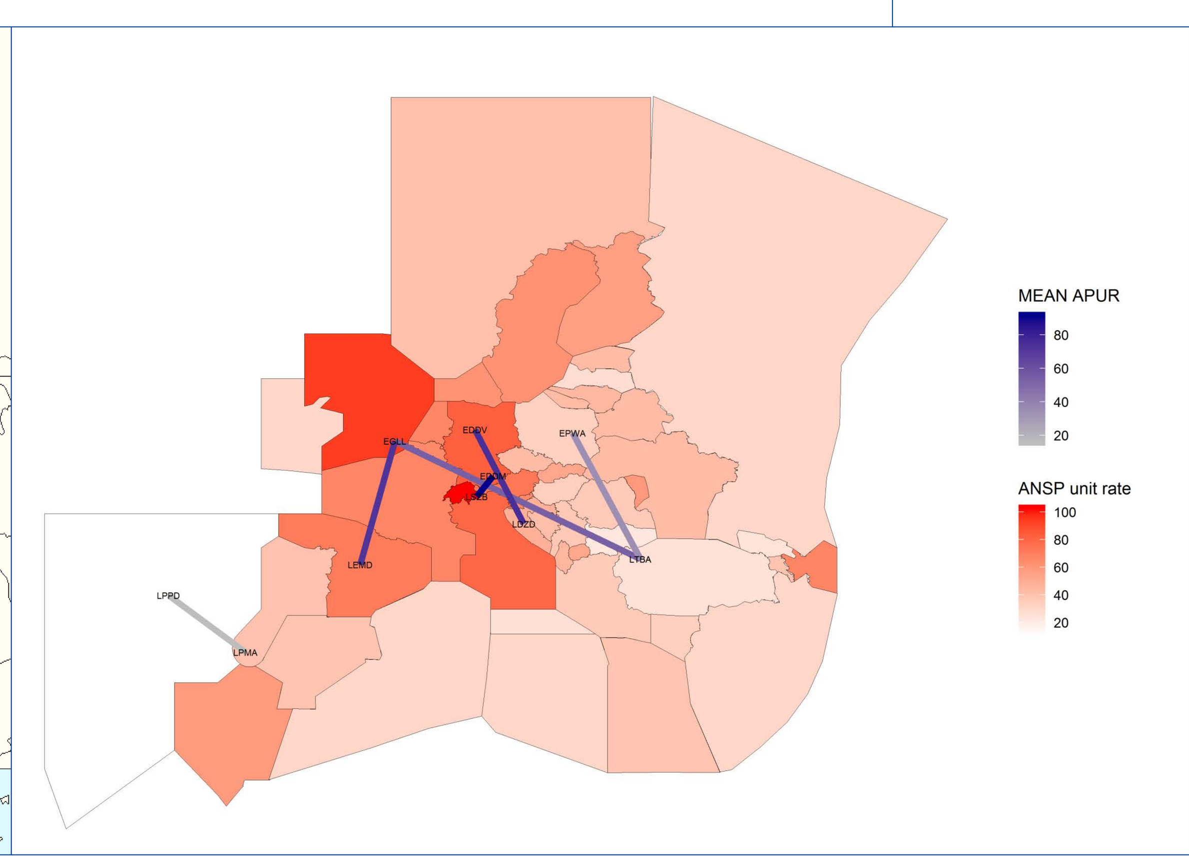
Analysis – historical flights

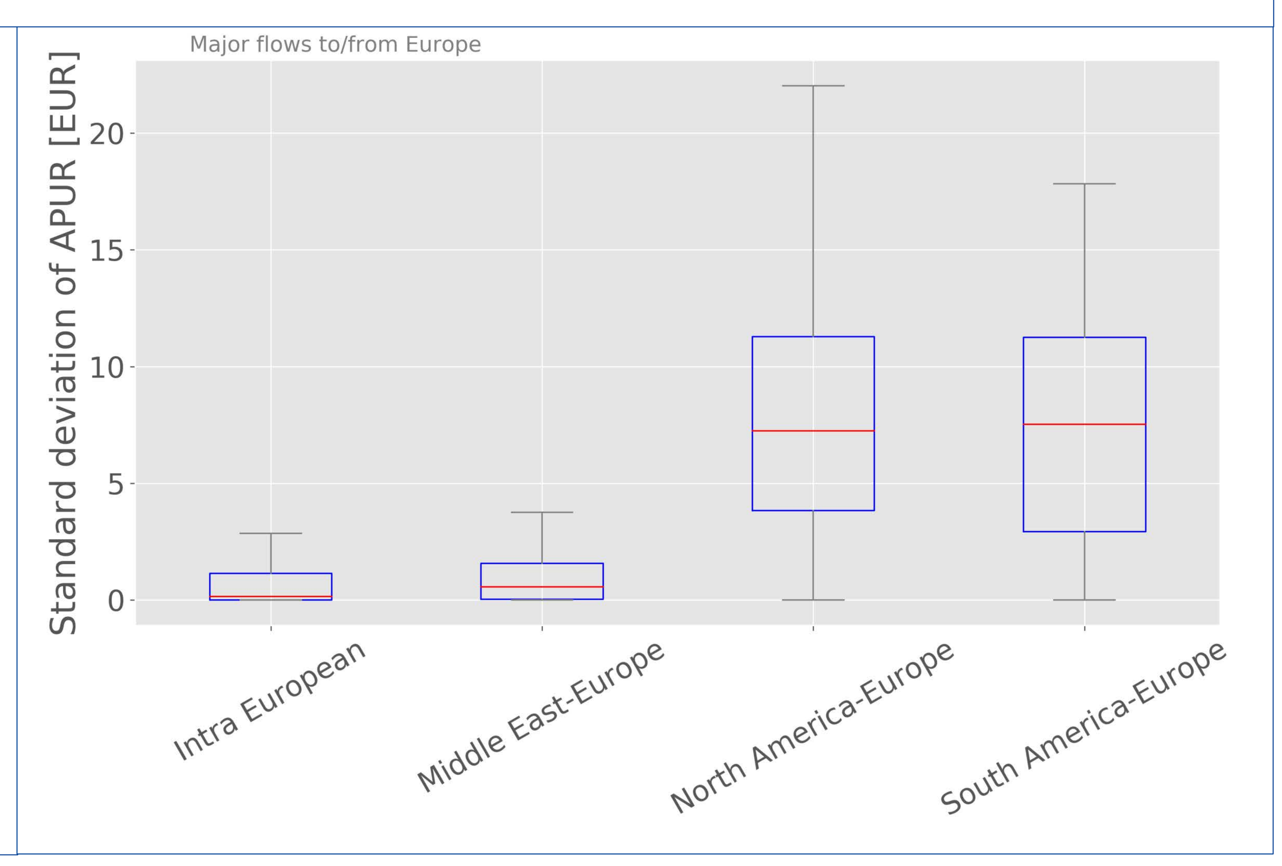
- 61 days of traffic (June & July 2016)
- airport-pairs with at least 10 days of traffic
- 1,768,992 flights and 20,677 airport pairs
- daily variability of ANSP shares and APUR











University of Belgrade
FACULTY OF TRANSPORT AND TRAFFIC ENGINEERING

GORAN PAVLOVIC – g.pavlovic@sf.bg.ac.rs

AR for ATCO

Augmented Reality (AR) for ATCO supervisors

This study investigates how virtual and augmented reality (AR/VR) can be used to visualize ATCO information from measured data such as heart rate, breathing patterns, body temperature and stress level. This project have designed and implemented a proof-of-concept visualization pipeline for evaluation of how ATCO supervisors can monitor the ATCO status during operation.

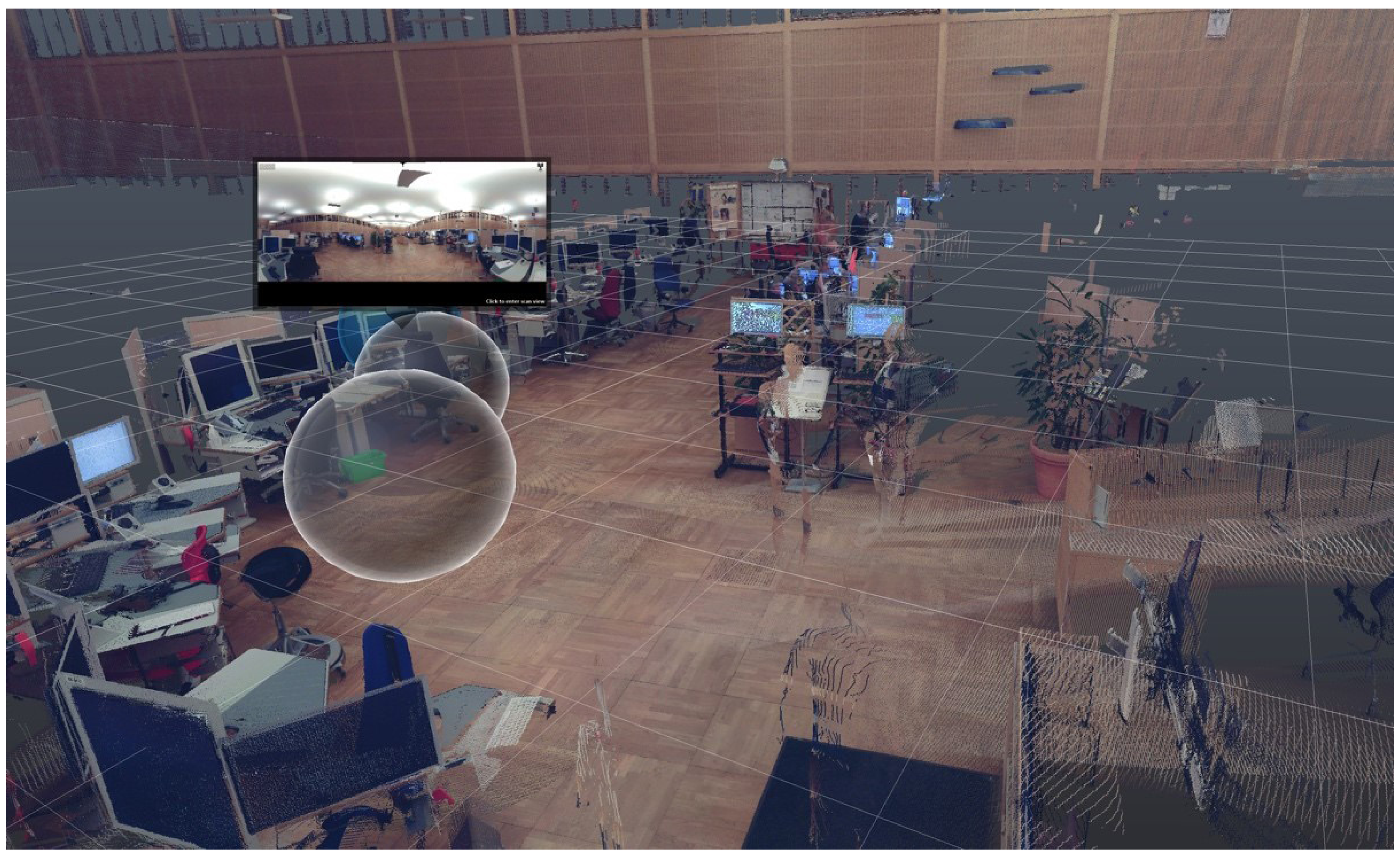


Figure 1. A visualization of the 3D scanned environment point cloud and camera locations

Figure 2. AR view that shows the different data sources visualized with different geometry.

The pipeline consists of three main components: scene digitization, on-line recording of video and stress-level measurements, and AR visualization.

In a first step, a coarse 3D model of the scene is built using photogrammetry or time of flight laser scanning, LIDAR, as illustrated in Figure 1 and described in [Unger et al. 2015]. The purpose of the 3D model, or point cloud is to map the workstation of each ATCO so that the measured stress-level information can be anchored in 3D and into the 360-video used in the on-line capture. This enables rendering of virtual 3D objects representing the measured information into the captured 360-video stream(s) in real-time.

Given the scanned 3D model of the environment and the registered 360-video cameras the information describing the state of the ATCOs is then visualized using different geometric shapes and colors, and rendered into the captured video sequences. The 360-video allows the supervisor to see both the active ATCOs and the stress-level information from a birds-eye-view with unrestricted view directions from the location of each of the cameras.The visualization can be done both using head-mounted-display systems as well as conventional monitors.

As a case study, the project scanned and created AR visualizations from the air traffic control center (ATCC) at Sturup airport in Sweden, see Figure 2..

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement [number]

LINKÖPING UNIVERSITY

Per Larsson (per.g.larsson@liu.se) Jonas Uner (jonas.unger@liu.se) Billy Josefsson (billy.josefsson@lfv.se)

No More Surprises

Stand assignment algorithm with likelihood of turnaround time deviation

Objective:

To generate a robust stand assignment, optimized and balanced for various stakeholders

- **Airport** → Efficiently use the capacity, minimize waiting time
- **Airline** → Minimize non-profit time, depart on time
- **Government** → Reduce environmental impact, control the border
- **Passenger** → Receive high quality service

Methodology:

PROBABILISTIC MODELLING

Estimation of delay probability distribution, from historical data

DELAY – AWARE STAND ASSIGNMENT

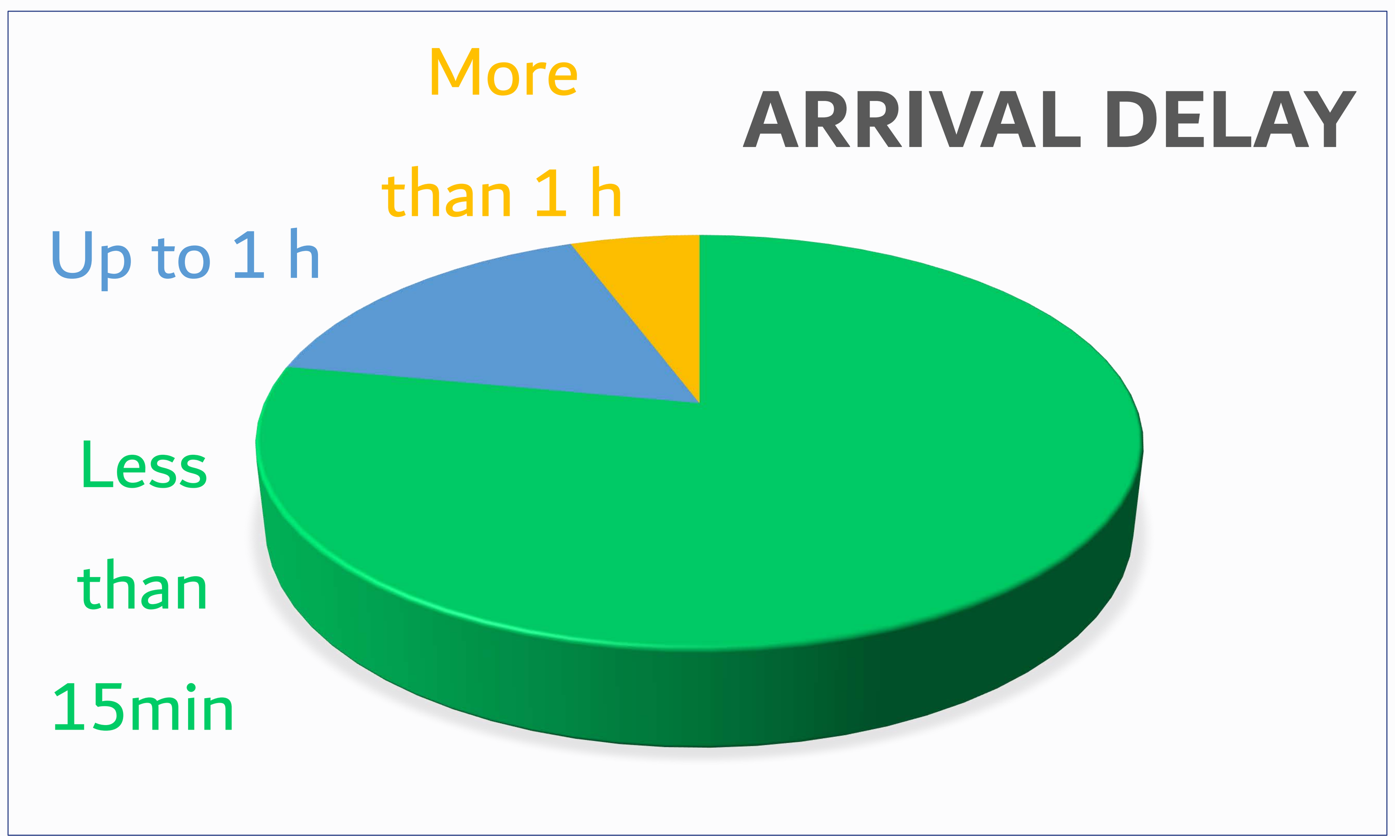
Generation of stand assignment, considering probable delays

STAND ASSIGNMENT OPTIMIZATION

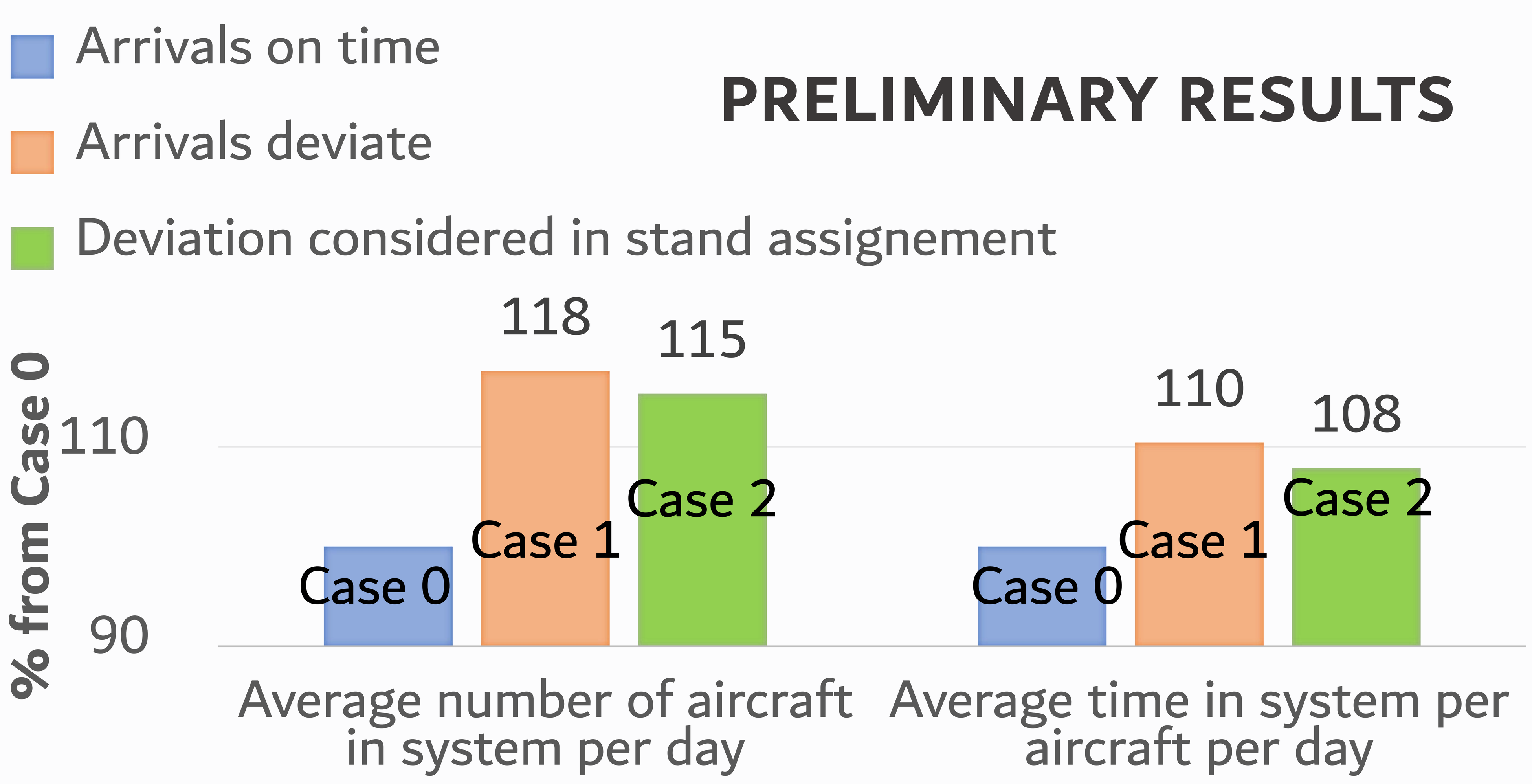
Optimization of generated assignment to maximize stakeholders benefits

- ✓ Optimization
- ✓ Robustness
- ✓ Real time adjustment
- ✓ Risk estimation
- ✓ Waiting time reduced on 2%/day

Case study: Mexico City International Airport



- Saturated runway capacity
- 2 terminals, 91 parking positions
- Approx. 45 million PAX per year (2017)



Universitat Autònoma de Barcelona

Amsterdam University of Applied Sciences

MARGARITA.BAGAMANOVA@UAB.CAT

M.MUJICA.MOTA@HVA.NL

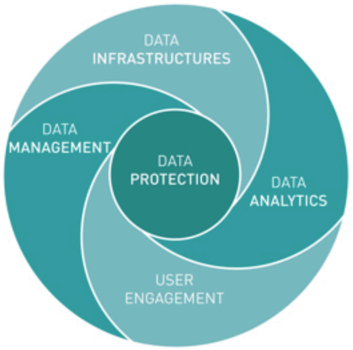
DataBeacon

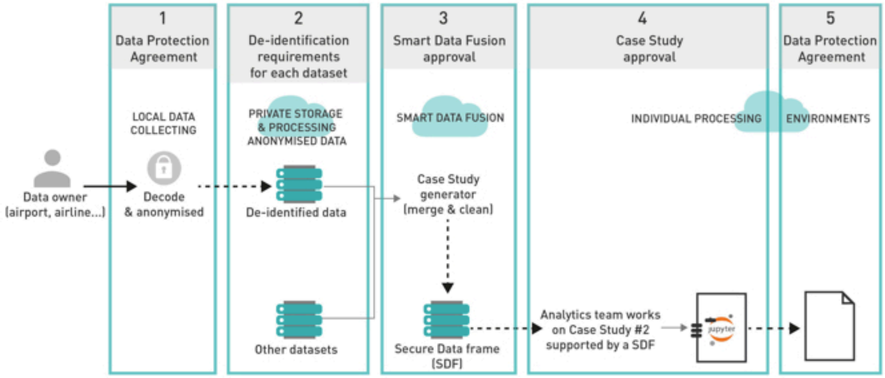
The Secure AI Multi-Sided Platform for Aviation

DataBeacon is a multi-sided data platform (MSP) for aviation data. It encourages the collaboration of aviation stakeholders, research institutions and industry interest and facilitates their exchange of information, thereby enabling value creation for all participants.

DataBeacon is built around confidential data sharing from aviation stakeholders and advanced data analytics applied to the shared data.

- **Fusion** of **de-identified** datasets into Secure Data Frames (SDF)
- **Accessibility** to the de-identified datasets for data analyses.
- **Information sharing** based on the analysis of restricted and confidential data among aviation stakeholders
- Data access **logging** and limitations, data access is continuously monitored.





Aviation datasets **ready to use** for data analysts: as soon as new data comes into the platform, a data pipeline is engaged to improve the quality of the datasets by cleaning the data and merging it with different sources.

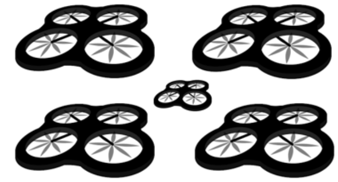
- **Anonymized** data. Aviation datasets are anonymized as soon as new data comes into the platform in order to hide crew or passenger identities along with private business details.
- **Flexible** deployment. Two solutions for data acquisition, either by setting up a private cloud environment or by deploying a processing node inside the network of the data owner. This sort of hybrid deployment fits companies that are concerned with the future use of its data.
- **Availability**. The cloud infrastructure is fault tolerant, meaning that as soon as one node of the infrastructure is down, it is restarted and set up automatically. Data storage is distributed among several nodes to reduce the possibility of data loss.
- **Scalability**. Each data analyst who joins the platform will have access to a dedicated cluster to carry their analytics. The data analyst will have a dashboard to check the performance of the cluster and scale up if necessary using a simple web interface. Also the infrastructure itself can be extended by any means as well as each cluster can be extended to increase performance and capacity.
- **Security**. Storage and data preparation clusters are isolated from each other and linked with a dedicated cluster broker in order to ensure data is shared to the right nodes and automatically deleted if a data owner leaves the infrastructure. All elements of the infrastructure need to authenticate themselves. Data in rest and in motion is encrypted.

innaxis TADOREA KNOWLEDGE DISCOVERY FOR AVIATION Fraunhofer ITWM

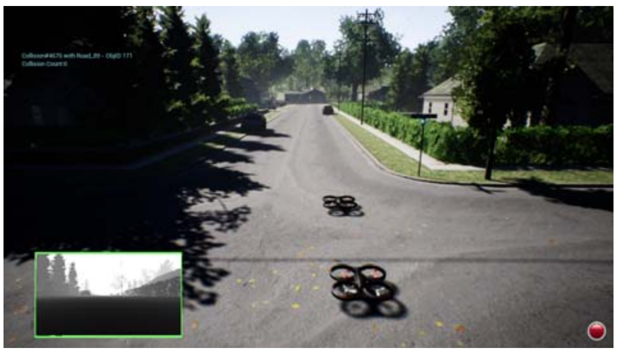
Samuel Cristobal (sc@innaxis.org*) and Jorge Martín, Innaxis Research and Foundation. Madrid, Spain

Dr. Jens Krüger, Fraunhofer Institute for Industrial Mathematics. Kaiserslautern, Germany

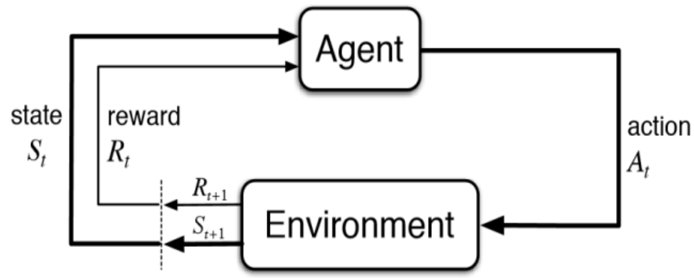
Deep Reinforcement Learning for Multiple Drones Air Traffic Management



This research is a PhD candidate of SESAR Engage KTN PhD funding. In this research, the capabilities of a fully autonomous drone based on deep reinforcement learning (DRL) are presented. DRL is an artificial intelligence field where agents learn how to achieve a certain goal from interaction. DRL has shown successful results for training and controlling a drone.

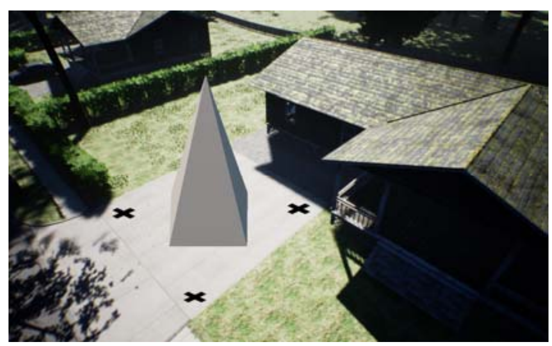


The realistic flight simulator, called "AirSim", is used to train and control the aircraft in a geofenced region inside a suburb environment. Multiple drones will be used instead of one. Drones try to reach the specified destinations inside the area called Drone Port.



The basic elements of DRL: the agent (the drone), the environment (the airspace) and the interactions between both. Hereby, the agent gets the depth camera image as state and the score as reward. The most important components of DRL are the agent, which is basically the learner and decision-maker, and the conditions or surroundings with whom the agent interacts, formerly called, the environment. The interaction is carried during a sequence of discrete time steps t. The agent is the quad-copter drone able to execute 3 or 6 actions depending on the model and the environment is the AirSim simulator.

The suburb environment has full of obstacles such as trees, electric cables, houses etc. and drones should learn not to collide with any obstacle and with each other. The training is full autonomous, and it can take up to 4 days.



The drones have to be able to act autonomously to make clear landing and reach the destinations with the help of Drone Port service as fast as possible but without collisions.

UPC UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

eetac

Ender Çetin, Guillem Muñoz, Enric Pastor, Cristina Barrado

ender.cetin@upc.edu

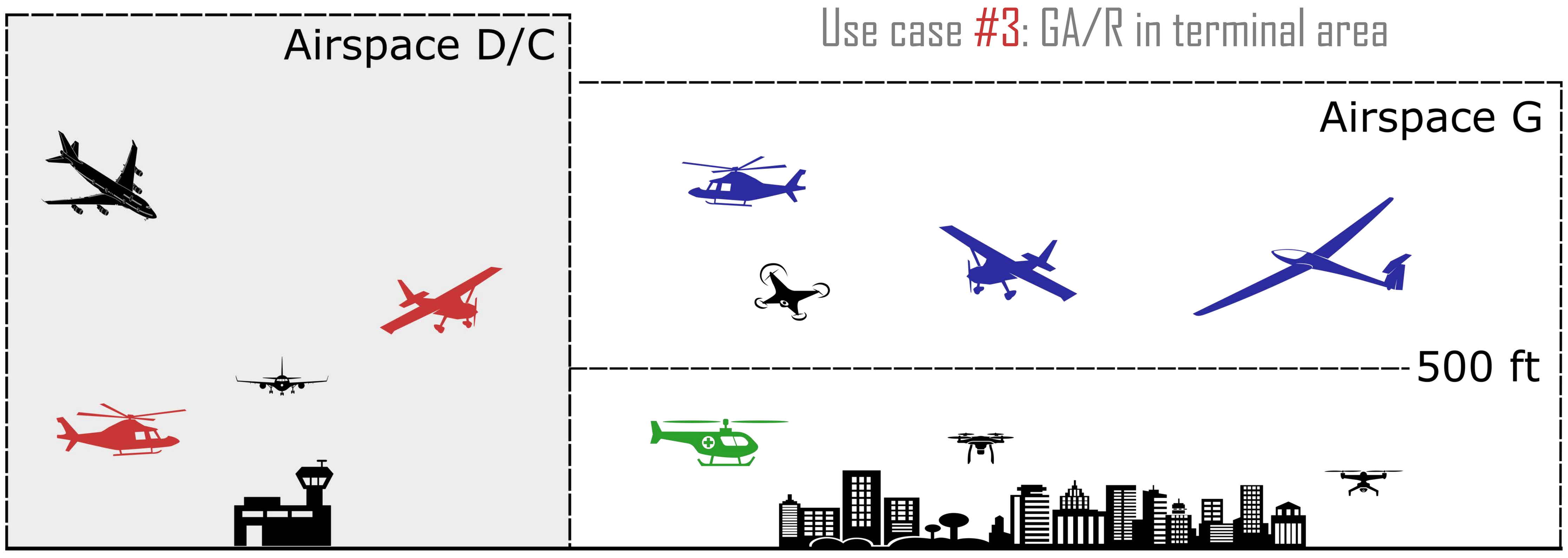
EMPHASIS

EMPowering Heterogenous Aviation through cellular SIgnalS

The research project aims to increase safety and reliability of General Aviation/Rotorcrafts (GA/R) operations at low altitude as well as their interoperability with other airspace users – such as commercial aviation or emerging drone operations. We plan to achieve this through affordable Communication, Navigation and Surveillance (CNS) capabilities benefiting, among others, from existing and future mobile RF network infrastructure.

Project Use Cases:

Use case #1: GA/R in airspace G
Use case #2: Rotorcraft below 500ft
Use case #3: GA/R in terminal area



Includes icons created by abdul karim, CombineDesign, Evan Shuster, Karla Design, leo-graph.com, Lluisa Iborra, mohkamil, Nick Bluth, Oeda, parkjisun, Will Sullivan from Noun Project

Communication

Investigating use of existing (3G/LTE) and future (5G) cellular infrastructure to:

- provide low-cost data-link for low-altitude GA/R operations,
- provide additional source of positional data (multilateration)

Navigation

Aiming to enhance accuracy, integrity, and availability of GNSS navigation by considering:

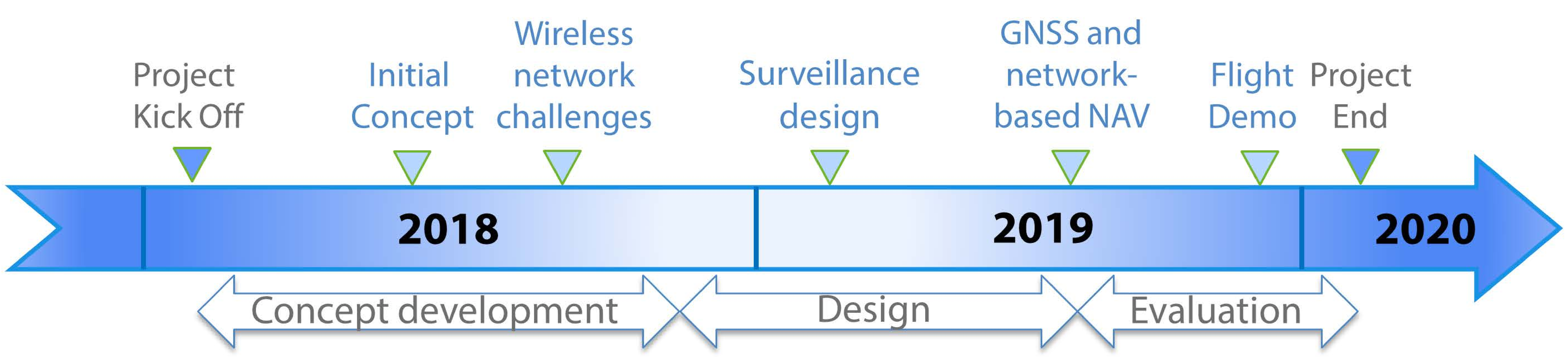
- inertial navigation systems (INS)
- 4G/5G positioning
- autonomous integrity monitoring (eRAIM)

Affordability and Certification

Affordability is an important requirement for GA community and the costs associated with certification of onboard systems play a key role here. Within the project the aim is to explore possible approaches how to achieve the objectives of the certification process through alternative means benefiting from evolution of today's flight environment and taking into account specificities of low altitude operations.

Surveillance

With progressively growing number of users flying in low altitude airspace, including drones or urban air mobility, interoperability among them becomes a critical requirement. The key enabler is in this context a suitable cooperative surveillance. The project EMPHASIS aims to develop and test the concept of such surveillance building on the ADS-B concept while addressing specific needs of low altitude airspace and of GA/R community and taking into account interoperability with new users.



This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement 783198

Honeywell THE POWER OF CONNECTED · AIRBUS DEFENCE & SPACE · TAMPERE UNIVERSITY OF TECHNOLOGY · evektor

Petr Cásek, Ľuboš Korenčiak, Thilo Fath, Elena Simona Lohan, Jukka Talvitie, Martin Růžička

Concept of operations

Socially acceptable … at the very low level

The 'problem' of drones growth (Emerging technology)

Drones are **FUN** !

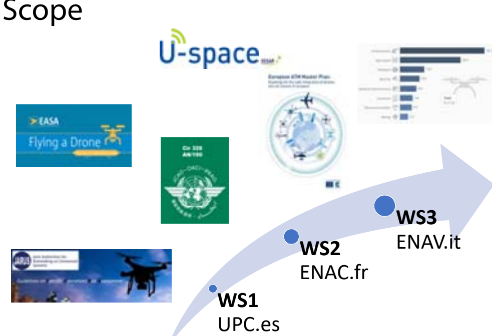
Drones are **useful**

Drones may be **noisy**…

and too many are **awful** !

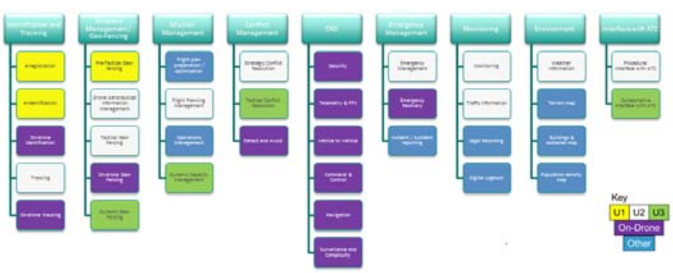
Drones are eyes in sky **confidentiality** ?

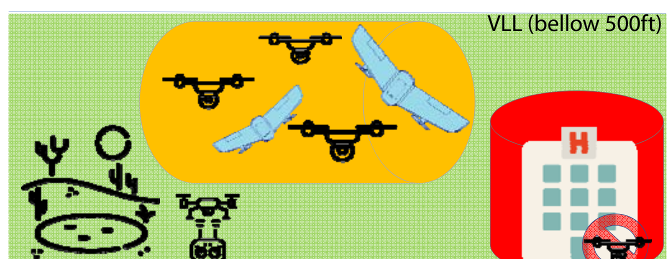
Scope



The CORUS ConOps V1.0

- U-Space services and drone capabilities
- Airspace classification in 3 'colors'
- Types of operations
- Rules of the air
- Separation minima
- No air routes





Source images: ICAO, SJU, EASA, flaticon.com, APANT, DaveSimonds, freepik, aerosociety

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement RIA-763551

CORUS project – corus-info@eurocontrol.int

The Resilient Properties of Multipe Remote Tower Operations: LFV RE5

AMPLIFY TEAMWORK WITH AUTOMATION

A study of the resilient properties of a hypothesised Multiple Remote Tower (MRTWR) Work system as a Remote Tower Centre was undertaken to explore operational capabilities to adapt and sustain an ATS service. A resilience engineering assessment method developed by SESAR [1] was used. Multiple-Mode-of-operation differs in the ability to provide air traffic services at multiple airfields remotely in a single controller working. The number of remote towers that can be operated from one RTM is assumed to be three. Multiple-mode-of-operation requires a different social organisation of the work system

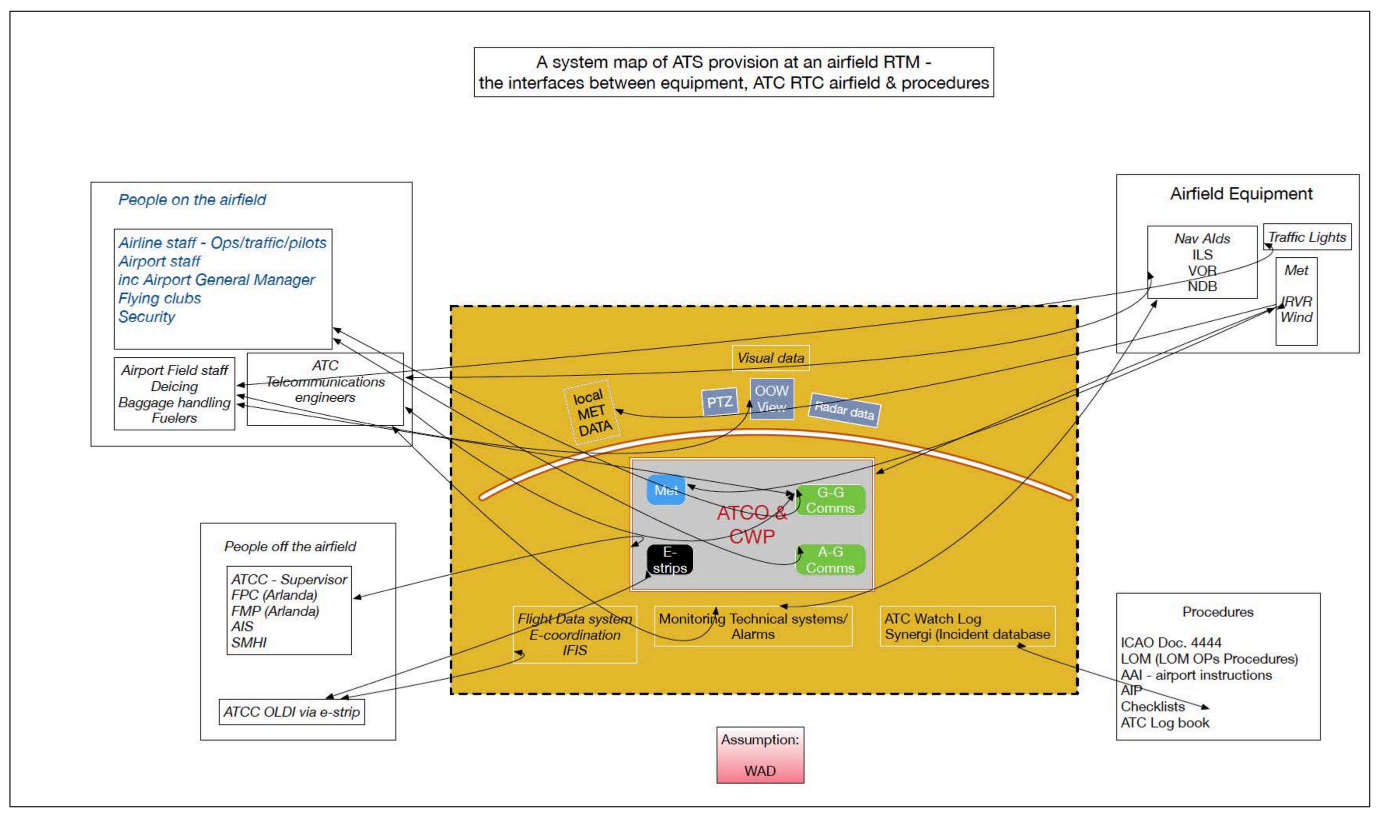


Figure 1: RE5 MRTWR System Model

The RTM ATCO providing ATS at 2 or 3 airfields simultaneously is limited in the extent of the tasks that can be undertaken concurrently, including coordination and communication tasks. The nature of work-as-imagined/done [3] is thus different from single-mode-of-operation. RE5 assumes multiple-mode-of-operation ATS provision for five airfields of varying density of traffic and disparate traffic characteristics that are combined into one Remote Tower Centre.

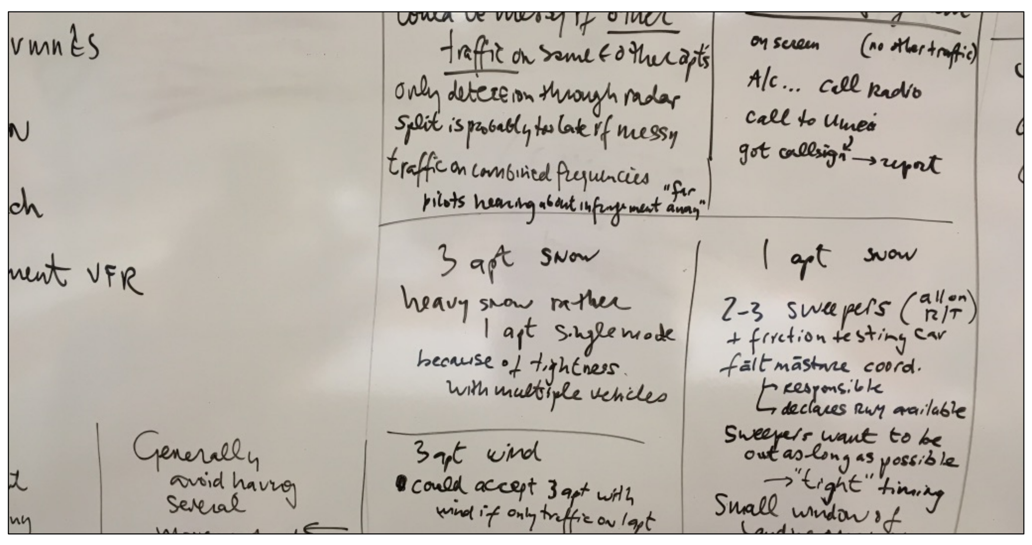


Figure 2: Eliciting strategies

The SESAR SRM Resilience Engineering Assessment method takes a systems approach to understanding a socio-technical system or work System in the current operation as well as assessing the envisaged work system design of the future.

The principal data collection tool is a workshop with practitioners experienced in the current Operation and the envisaged operation & the future concept of operation. The workshop elicits a picture of the operational landscape, both current and future, to build a system view of the work system. The emphasis is on work as done and other archetypes of work for a typical operational day [2].

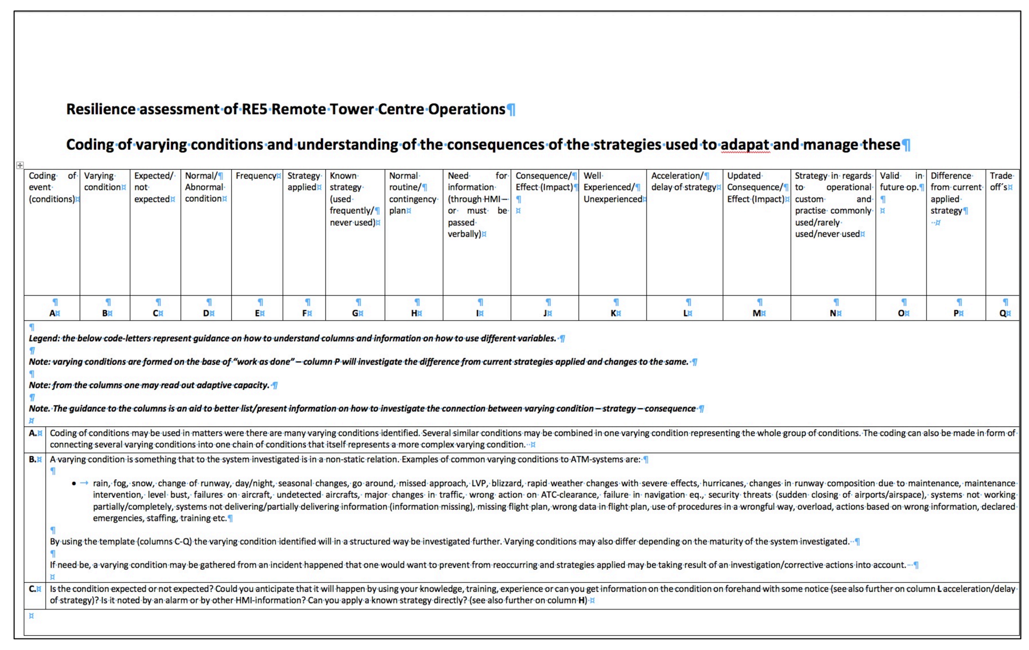


Figure 3: Coding resilient performance

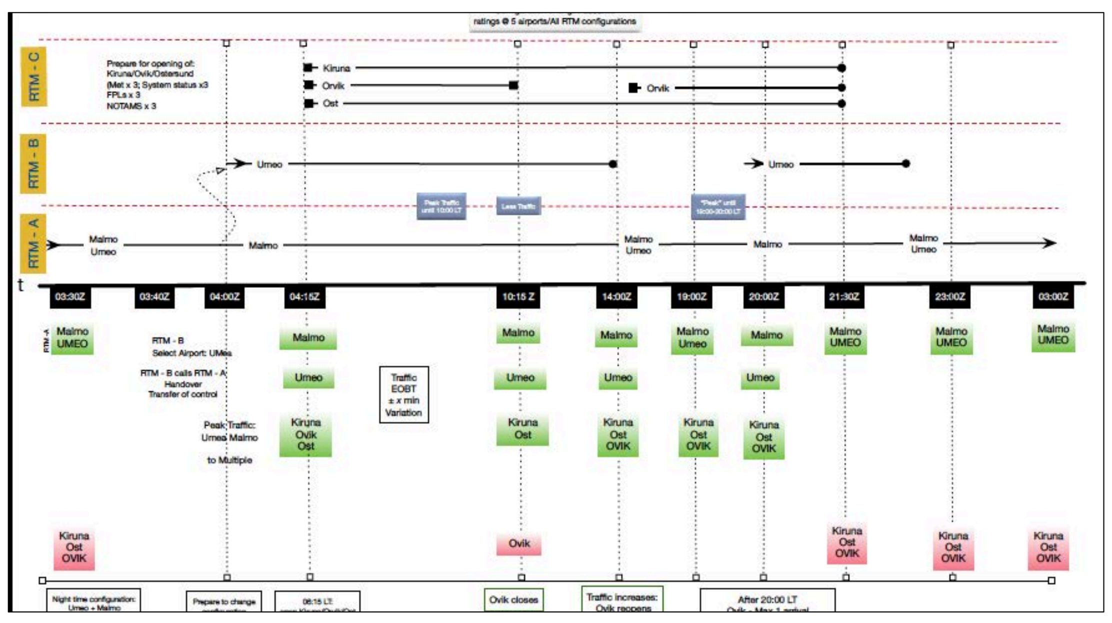


Figure 4: Visualisation of the work system

Workshop data is coded using a Resilience Engineering coding frame (figure 3) that considers seventeen aspects of adaptive strategies, the sources of resilience drawn upon and exploring the coordination costsand consequences of the strategy for defined actors in the work system. Work system resilience is investigated using the Systemic Resilience model [3] and visualisations of the work system that are derived following the style of multi-actor representations, [4], visualisations of the flow of tasks [6] and analysis of adaptive capacity [5] depicted in Figure 4.

The organisation of an RE5 RTC differs in that the scale of the operational work system with new actors and artefacts. This was found to hold the potential for new sources of resilience that expand the capacity for manoeuvre and introduces new ways to configure the operational environment. This new ability to adapt could be gained through the interfaces and interactions with adjacent ATSUs as well as from intrinsic RTC properties.

[1] SESAR P16.06.01, D26 - *Guidance to Apply the SESAR Safety Reference Material*, Edition 00.02.01, 9th March 2015

[2] I.K. Moppett and S.T. Shorrrock, "Working out wrong side blocks". *Anaesthesia*. vol. 74, pp. 407–420, December 2017

[3] Lundberg, J and Johanneson., "Systemic resilience model". *Reliability Engineering and System Safety*., Vol 141., pp. 22-32, 2015

[4] Branlat, M., "*Challenges to Adversarial Interplay Under High Uncertainty: Staged-World Study of a Cyber Security Event*". Ohio State University, 2011. https://etd.ohiolink.edu/

[5] Lundberg, J and Woltjier, R. The Resilience Analysis Matrix (RAM): visualising functional dependencies in complex socio-technical systems". Proceedings of the 5th Resilience Engineering Association Symposium, Soesterberg, July 2013

Anthony Smoker, Lund University, Sweden
Anthony_john.smoker@tfhs.lu.se

Billy Josefsson, LFV, Norrköping, Swedenbilly.josefsson@lfv.se

Jonas Lundberg, LIU, Norrköping, Sweden
jonas.lundberg@liu.se

Rogier Woltjer, FOI, Stockholm, Sweden
rogier.woltjer@gmail.com

An Empiric Stress Test Validation for Multi Remote Tower Safety Assessment

AIR NAVIGATION SERVICES OF SWEDEN

Introduction

Current LFV research activities focus on the foreseen approval process of a Multi Remote Tower-Concept of Operations. The concept bases on the assumption that tower controllers are capable to provide tower control services at two airports with low traffic density at a time while workload turns out well-balanced.
Methods for the Empiric Risk Assessment of Socio-Technical Systems in ATM (MERASSA) is a concept method that was proofed and validated at the Multi Remote Tower - case with the objective to enrich the safety assessment with empiric data, to evaluate the hazards and to benchmark the level of safety compared to a single airport remote tower.

Method

The design of the stress test relies on a scenario at Sundsvall and Örnsköldsvik Airport in a 90 minute simulator run. Test procedures are embedded for building up a certain test situation:

- 2 equipment handling tests: The test person is instructed to release the emergency squawk or set a certain frequency at a certain airport. These tests address the possible confusion of equipment.
- 3 conflict tests: The test person is confronted with the sudden appearance of obstacles on the runway and a flight path approximation in the CTR between a VFR and IFR movement that the test person is supposed to identify and solve by separating the VFR. These tests address the attention on the Out-the-Window view and radar.
- 6 Situation Present Assessment Method (SPAM): The test person is asked for operational relevant parameters such as QNH, braking action values, wind speed and position of A/Cs in the CTR. These tests address the possible confusion of operational information.

The primary safety metrics are speed and correctness of response. The test person was instructed to act as fast as possible when a test procedure was applied.

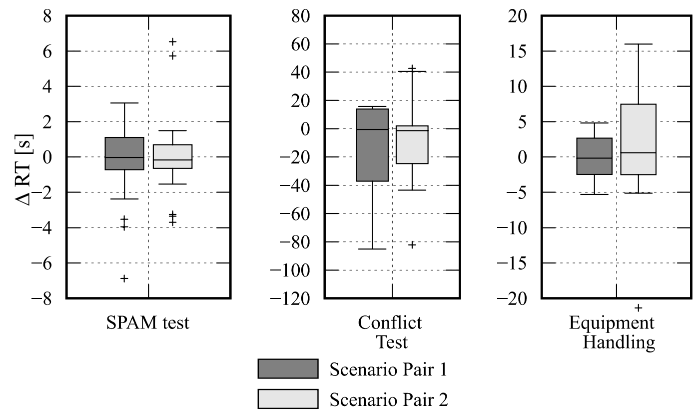
Results

Six LFV tower controllers from RTC Sundsvall, Tower Stockholm-Arlanda and Tower Kristianstad were trained in a 2 days session and passed then each 2 single and 2 multi scenarios. The sequence of trials alternated between single and multi-scenarios as a "crossover" design for counterbalancing confounding factors.

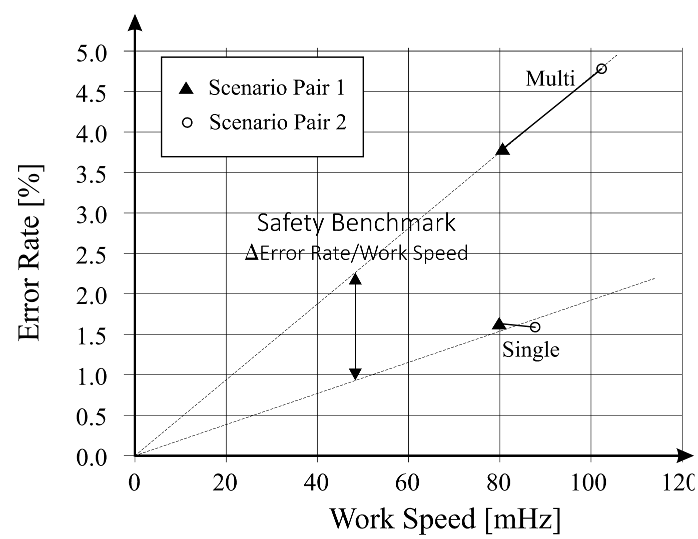
A total of 238 reaction time samples could be collected and were paired as following:

$$RT = RT_{multi} - RT_{single}$$

The box plot shows the resulting distribution of the tests of the independent scenario pairs 1 and 2.



The inverse of reaction time is the working speed. Combined with the errors committed during the test, each scenario can be related to a working point on the mean speed vs. accuracy plane. For showing the trade-off between both these metrics, we regard accuracy as the error rate. The linear regression indicates a 142% higher error rate for multi scenario conditions at the same working speed.



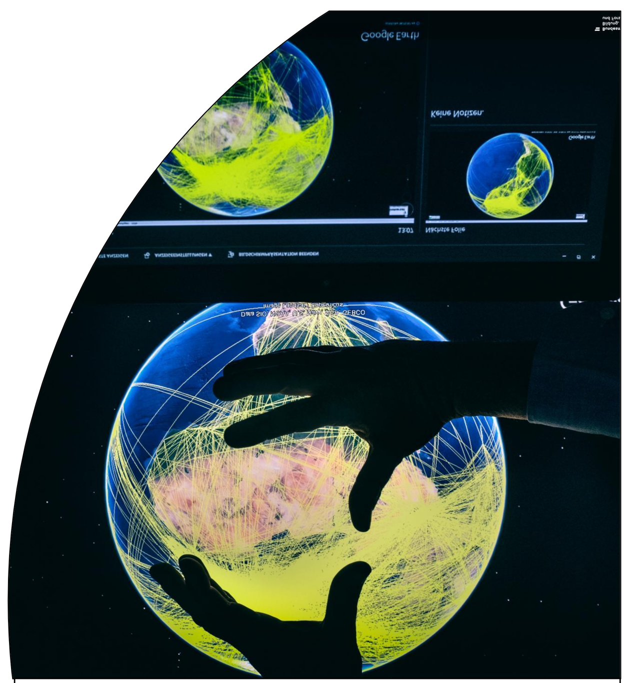
In summary, it is assumed that working under multi scenario conditions is burdened by a test person's working habit that is well trained and optimized to a single runway layout. A clear need to develop training methods that help the ATCOs to manage attention can be concluded.

Lothar Meyer , Billy Josefsson, Maximilian Peukert {lothar.meyer, billy.josefsson, maximilian.peukert}@lfv.se

Jonas Lundberg jonas.lundberg@lu.se

NAVSIM - Global Flight Simulation Framework

UNIVERSITY of SALZBURG



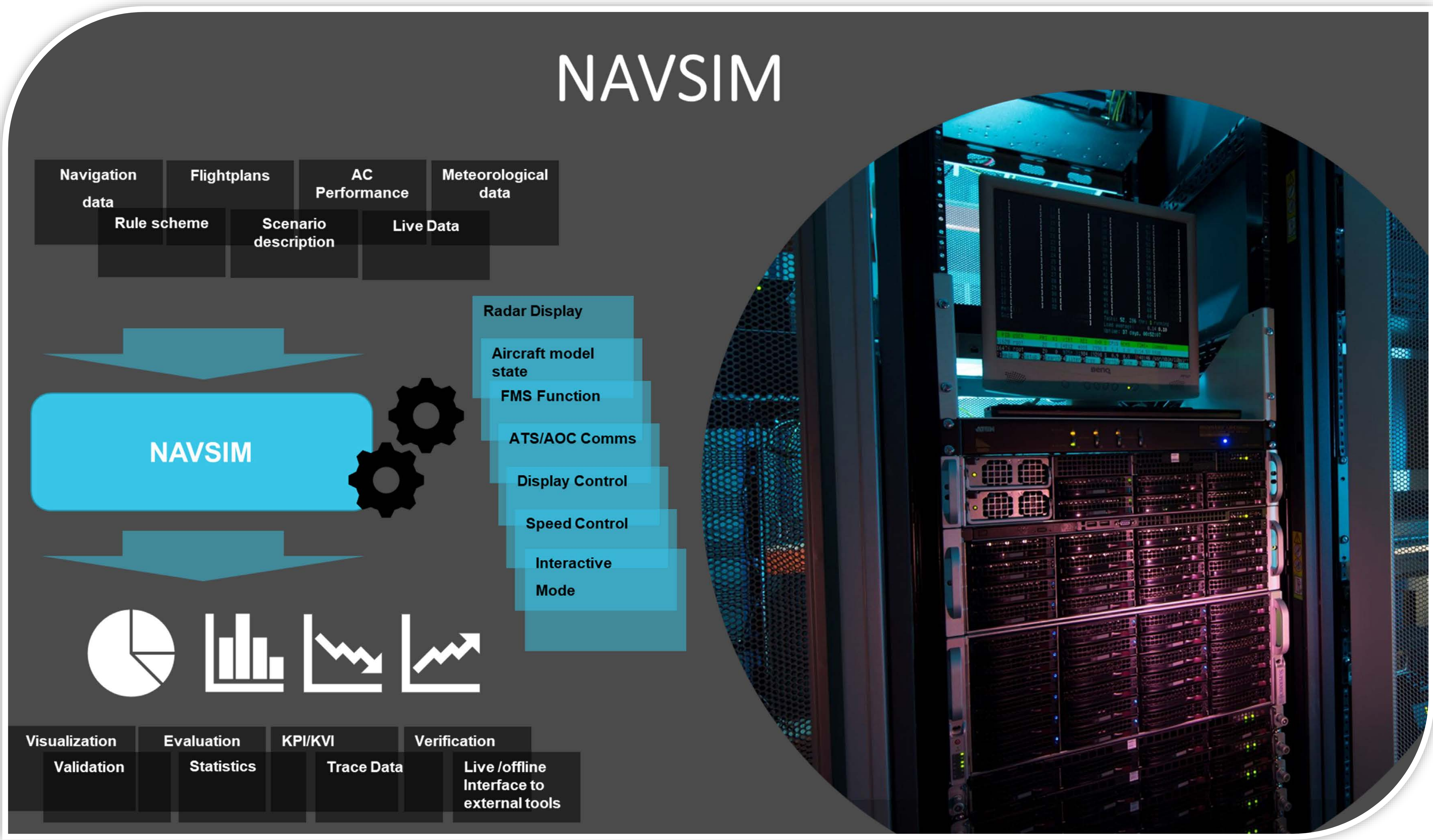
NAVSIM Air-Traffic-Generator

NAVSIM - Advances in ATM Simulation

Since 2002, University of Salzburg, in close cooperation with Mobile Communications R&D Forschungs GmbH has developed and continuously enhanced NAVSIM a consistent ATM/ ATC/ CNS/ MET simulation framework.

This framework allows to simulate actual and future world-wide air traffic very accurately and is also capable to simulate corresponding aspects of this domain like aeronautical data-link technology's, for example VDL Mode 2, L-DACS and/or Satellite links.

NAVSIM FlightSim Interface



NAVSIM has been used in numerous national and international projects for large scale simulations, system performance evaluations and human in-the-loop with features such as:

- World-wide Gate-to-Gate Air Traffic Simulation
- Detailed Aircraft Performances (EuroControl BADA)
- 1+ million Nav-data (as used for FMS)
- Using sophisticated Simulation Techniques
- Simulate more than 80.000 Aircrafts (AC) simultaneously
- Generic FMS for each Aircraft
- Today's and any future (predicted) Air Traffic
- Simulation running in Real time or Fast Time mode
- Inclusion of third party test equipment and products
- Supports Evaluation of NextGen / SESAR concepts
- Generic Flight Strip Tool
- Arrival/ Departure Manager (AMAN/ DMAN)
- Simulation, optimization and human-in-the-loop training for working position:
  - Clearance Delivery ,
  - Apron 1, Apron 2, Ground,
  - Tower
- Visualization of detailed airport scenarios
- Dispatch and Airline Operations:
  - Full 4D flight planning including MET

NAVSIM Airport Support Tools

Carl-Herbert Rokitansky, Kurt Eschbacher, Gerda Renate Heger, Martin Mayr, Fritz Zobl

Institute of Computer Sciences / Aerospace Research Department
University of Salzburg
Salzburg, Austria
www.aero.sbg.ac.at

NAVSIM Remote & Tower Simulator

MEEGAWAKE

Guidelines for Drowsiness Assessment using Objective Sleepiness Score

PHYSIP Enabling EEG

Objective

- Electroencephalography (EEG) remains the reference method to study drowsiness.
- Muzet proposed Objective Sleepiness Score [1]: EEG and EOG visual analysis → drowsiness state (table 1)
- A single-EEG automatic algorithm (AA) was developed and validated vs. Muzet (VA1) [2].
- Objective: improve the use of the OSS by proposing guidelines that explicit the visual scoring criteria.

Methods

- 19 volunteers: 2h-driving simulator after biocalibration (CBS test)
- 2 data sets analyzed by VA1 and AA, DS1 (n=3) to quantify the impact of changing the scoring rules. DS2 (n=16) to assess inter-scoring agreement.
- Expert VA2 analyzed twice DS1: i) using the literal scoring rules ii) relying on CBS test content. VA2 analyzed DS2 also using CBS content
- Simplified 3-state drowsiness scale by merging states: OSS0-1 (no clear sign), OSS2 (confirmed) and OSS3-4 (marked).

Objective Sleepiness Score	EEG content, α and θ cumulative duration	Blinks and eye movements
OSS0	negligible	normal
OSS1	less than 5s	normal
OSS2	less than 5s or less than 10s	slow normal
OSS3	less than 10s or more than 10s	slow normal
OSS4	more than 10s	slow

Table 1: OSS criteria derived from EEG (Fz, C3, P3, O1) and EOG content, 1 drowsiness score every 20s-epoch.

Results

- On DS1, the 5-state (resp. 3-state) AV1 vs. AV2 agreement increased from 15% (resp. 70%) (fig.1a) when applying literal rules, up to 83% (resp. 96%) (fig.1b) when relying on CBS test as criteria calibration.
- See Table for agreements on DS2.

% 5-state / 3-state	AV1	AV2	AV1 ∩ AV2	AA
AV1		73		72
AV2	88			64
AV1 ∩ AV2				79
AA	90	86	94	

Table 2: Agreements (%) for the 5-state and the 3-state (blue) comparisons.

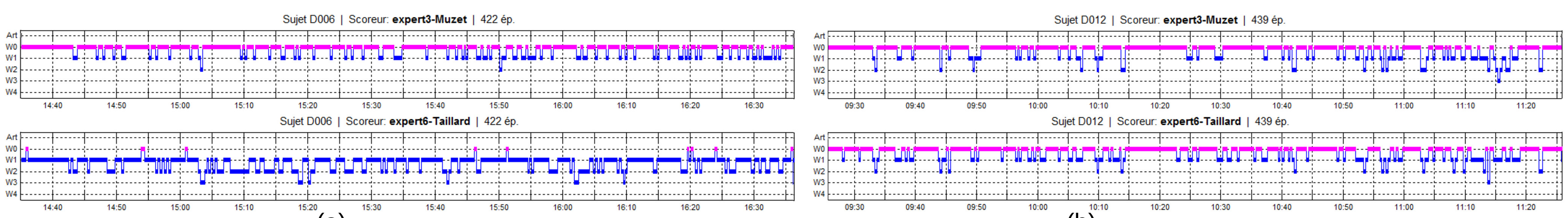


Figure 1: Comparing AV1 (upper plot) and AV2 when AV2 ignored (a) or took into account (b) the CBS test.

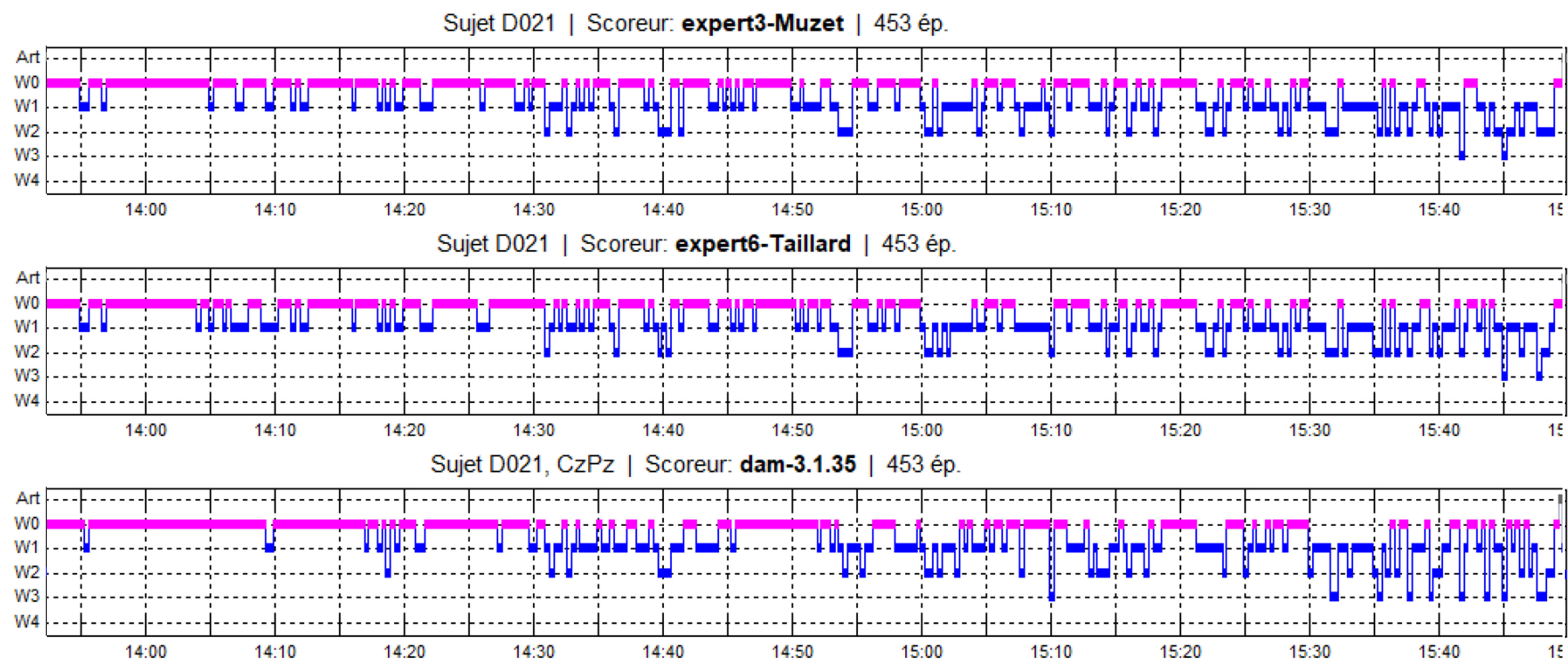


Figure 2: Comparison between AV1 (upper plot), AV2 (middle) and AA (lower), for one subject of DS2.

Conclusion

- Taking into account the calibration phase is key to visual scoring, α and θ rhythms used to determine drowsiness states must be defined by their characteristics as they appear during the CBS test.
- Agreements are very good on a simplified 3-state scale, which may be sufficient in many operational situations
- For the full 5-state scale, comparisons shown significant differences between visual analyses, showing that the refining the scoring rules is still a work in progress, and justify to pursue this work in further studies.

[1] Muzet et al. Preventing driver drowsiness at the wheel: can steering grip sensor measurement contribute to its prediction? Proc. of 4th Eur. Congress and Exhibition on Intelligent Transport Systems and Services, Budapest, 24-26 May 04

[2] Berthomier et al., Real-Time Automatic Measure of Drowsiness based on a Single EEG Channel. J. Sleep Res., 17:P434, 2008.

SANPSY SOMMEIL-ADDICTION-NEUROPSYCHIATRIE · université de BORDEAUX · Inserm · cnrs

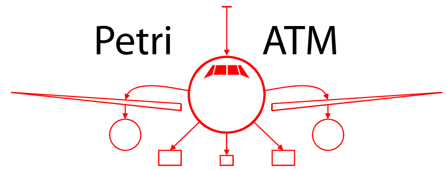
Berthomier C [1], Brandewinder M [1], Mattout J [2], Taillard J [3]

1. Physip, Paris, France 2. CRNL, INSERM U1028, UMR 5292, Lyon, France 2. Bordeaux University, USR CNRS 3413 SANPSY, Bordeaux, France

Correspondence: M.Brandewinder@physip.fr

Petri nets in ATM

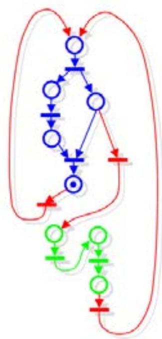
Application of the paradigm of nets-within-nets to air traffic management



Petri nets

Modeling formalism for discrete event systems:

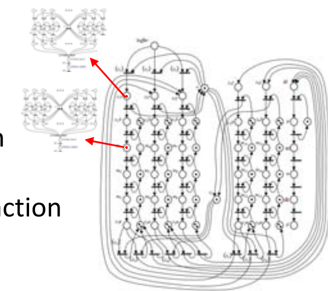
- Graphical and matrix-based representations
- Analysis techniques
- Adaptability (many classes)
- Variety of tools for editing and analyzing PN
- Application success in many fields



Nets-within-nets

Class of Petri net:

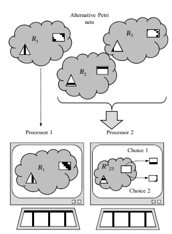
- System net (general framework)
- Token nets (population of individuals)
- Communication/interaction by synchronization



Modeling and simulation

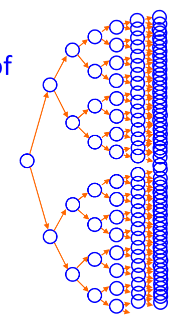
Calculation of the evolution of the model of a real system.

- Variety of simulation tools
- Configuration of the simulation
    - Decision variables
    - What-if analysis
- Performance evaluation



State space exploration

Exhaustive exploration:
Select all the feasible combinations of values for the decision variables:
- Combinatorial explosion
- Simulation and performance evaluation (outcome of the decision)
Metaheuristics for exploring promising regions



Optimization

Selection of the best decision

- Exploration of the solution space (select promising solutions)
- Simulate the solution and model of the system
- Quality of the solution (objective function)
- Repeat until a termination criterion is met
- Compare solutions
- Stochastic parameters and Monte Carlo simulation

Petri nets applied to ATM

Problems that can be addressed:

- Unmanned Aircraft System Traffic Management-UTM
- Aircraft collision avoidance in congested airspace
- Real time slot reallocation in airports under congestion caused by weather conditions.

Simulation models based on nets-within-nets:

- Context (airport, airspace, etc): system net
- Population (aircrafts, passengers, etc): token nets

upna
Universidad Pública de Navarra
Nafarroako Unibertsitate Publikoa

UNIVERSIDAD DE LA RIOJA

Juan-Ignacio Latorre-Biel. Department of Engineering. Public University of Navarre. Campus of Tudela (Spain), juanignacio.latorre@unavarra.es

Iñigo Leon-Samaniego, Emilio Jiménez-Macías. Department of Electrical Engineering. University of La Rioja (Spain), inigo.leon@gmail.com, emilio.jimenez@unirioja.es

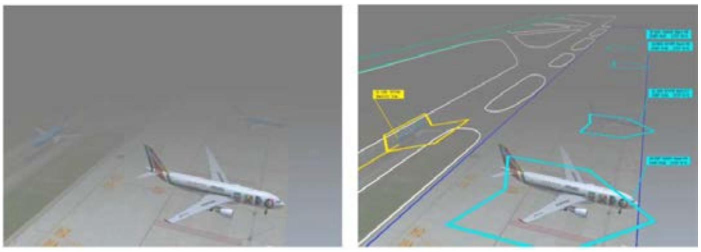
RETINA

Augmented Reality for Advanced Airport Control Towers

RETINA (Resilient Synthetic Vision for Advanced Control Tower Air Navigation Service Provision) investigates the potential and applicability of **Augmented Reality** display techniques for the Air Traffic Control (ATC) service provision by the **airport control tower.**

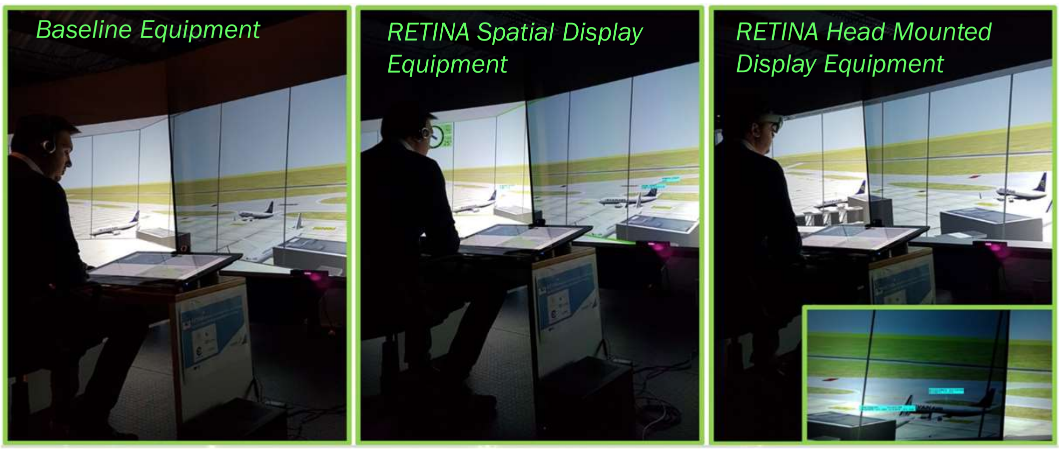
CONCEPT

Augmented Reality technologies offer the opportunity of moving information, that is currently available on the head down interface in the control tower, to **head up view**, by means of digital transparent overlays superimposed over the out of the window view, leading to safe operations under **any meteorological conditions** while maintaining a high runway throughput, equal to good visibility.



Out of the Control Tower window view in fog condition: the power of Augmented Reality

VALIDATION



The RETINA concept was developed, implemented and validated by means of **human-in-the-loop simulations** where the external view was provided to the user through a high fidelity **3D model** in an **immersive environment.**

EUROCONTROL | UNIBO | LUCIAD | CRIDA | ENAV

SESAR JOINT UNDERTAKING

This project has received funding from the SESAR Joint Undertaking under grant agreement No 699370 under European Union's Horizon 2020 research and innovation programme.

Founding Members

EUROPEAN UNION EUROCONTROL

CONTACT:
SARA BAGASSI
UNIVERSITY OF BOLOGNA
sara.bagassi@unibo.it