HAIKU workshop

Key results from early SESAR AI projects and new SESAR 3 AI projects

Alessandro Prister, SESAR 3 Joint Undertaking

26 June 2023

Co-funded by the European Union

SESAR 3 JU New instrument to Implement the Vision

Accelerate through research & innovation the delivery of an inclusive, resilient & sustainable Digital European Sky

50+ founding members representing entire aviation value chain (incl. new entrants)

- Horizon Europe - EUR 600 million
- Eurocontrol – up to EUR 500 million (in-kind & financial contributions)
- Industry - EUR 500 million minimum (in-kind & financial contributions)

Additional funds via Connecting Europe Facility (in coordination with CINEA) to the value of at least EUR 200 million.

SESAR 3 JU Members

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- aena
- GROUPE ADP
- Aeroporti di Roma
- AIRFRANCE
- Air Navigation Services of the Czech Republic
- AIRBUS
- AIRTEL ATN
- Alliance for New Mobility Europe
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- austro control
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- BULATSA
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- Collins Aerospace
- Copenhagen Airports CPH
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- DRONE ALLIANCE EUROPE
- dgac DSNA
- easyJet
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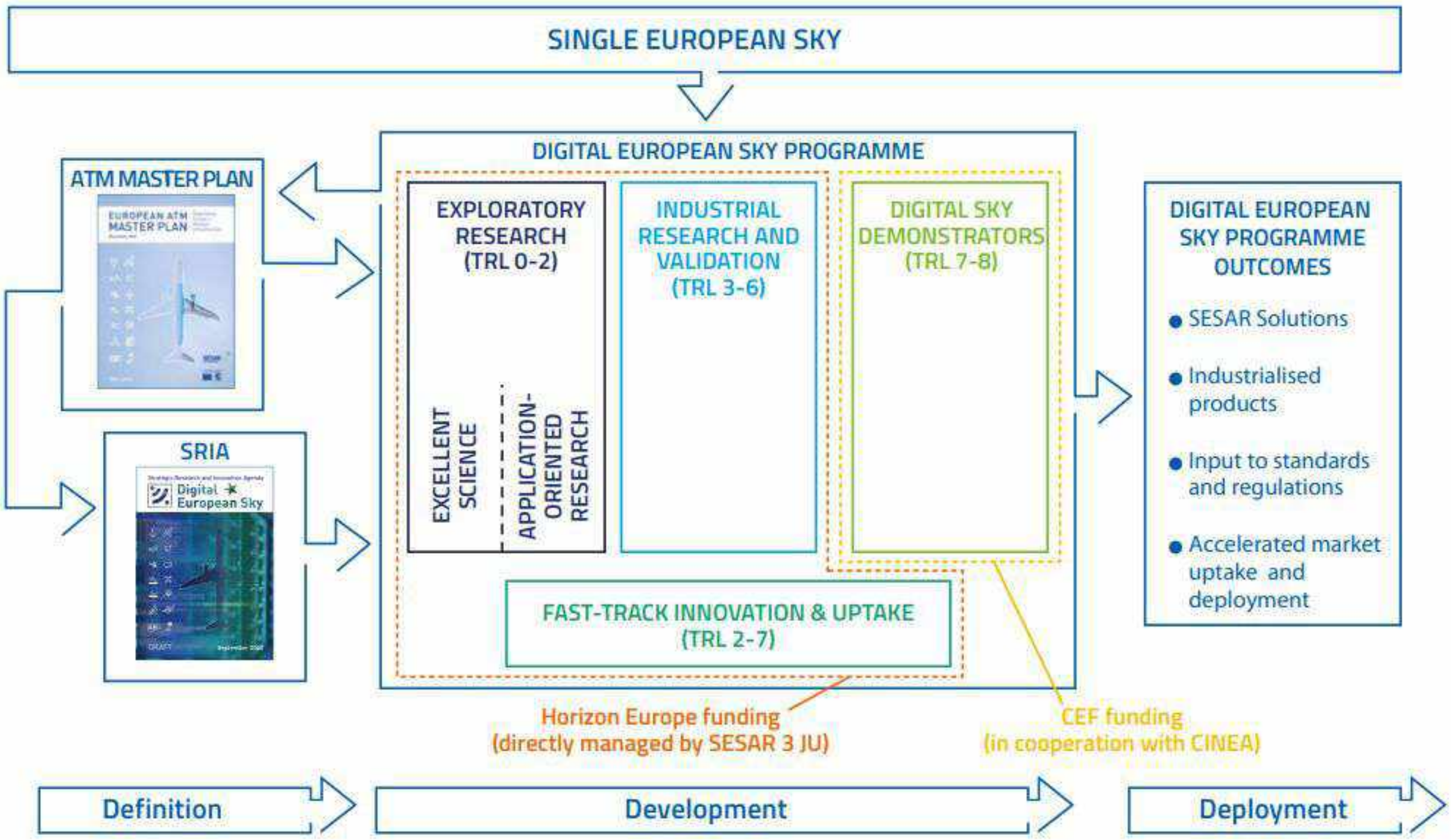
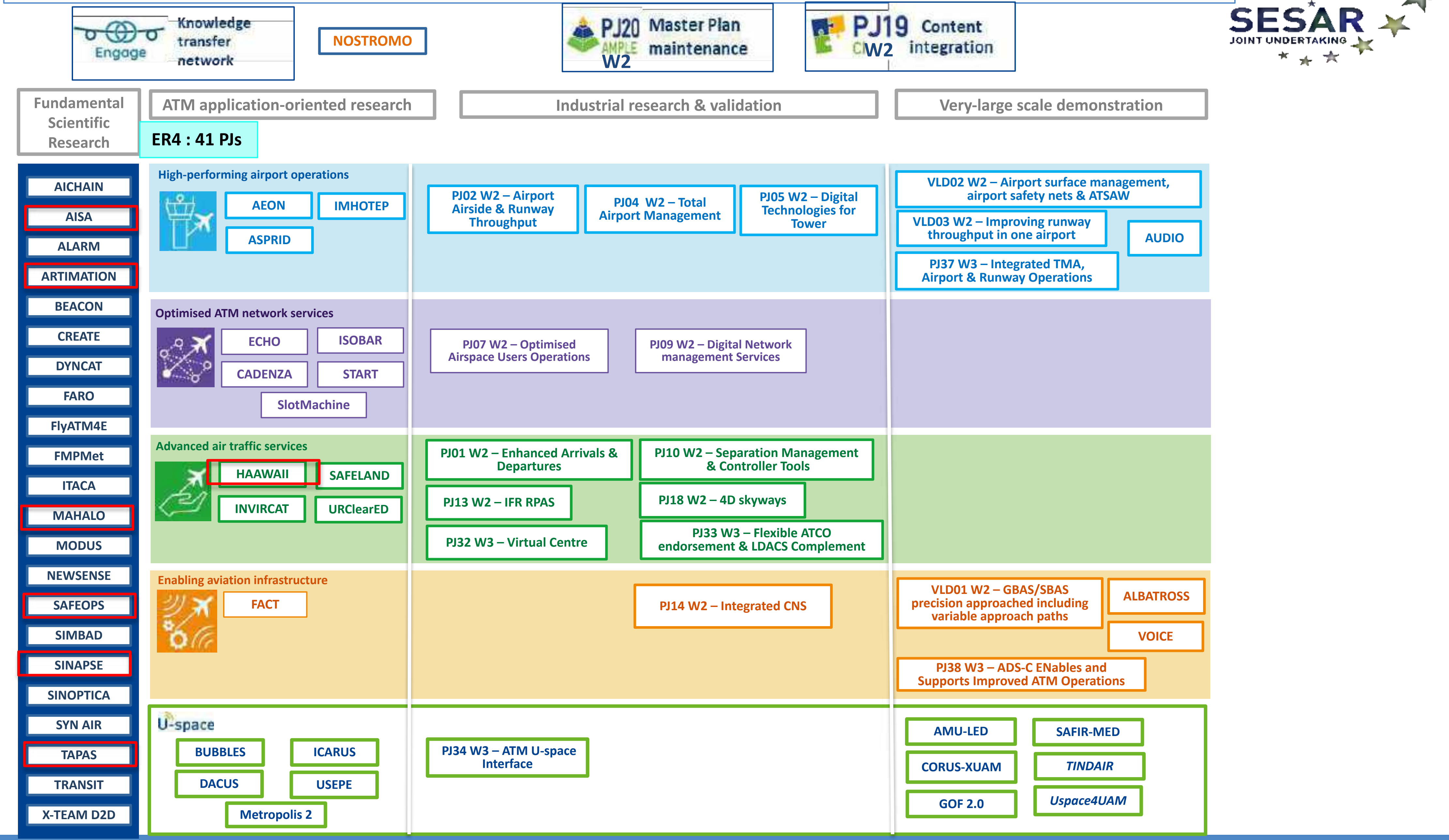
- RYANAIR
- SAAB
- SAFRAN
- Schiphol Group
- SEA MilanAirports
- SINTEF
- Swedavia Airports
- THALES
- VOLOCOPTER
- VTT

SESAR 3 Joint Undertaking – research clusters



SESAR 2020 WBS on January 2021



Some achievements from SESAR 2020 AI projects

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HAAWAII

- *The digitization of controller-pilot-communication can be used to significantly enhance ATM safety and reduce ATCOs workload.*
- *HAAWAII built on very large collections of speech data, to develop, using ML, a new set of speech recognition models for the London TMA and Icelandic Enroute airspace.*
- *Objective 1:Exploit massive amounts of ATC voice and surveillance data (for AI-based speech recognition and understanding).*
- *Objective 2: Automatically recognize and understand the controller-pilot communication from operational data.*

Achieved results:

- **Automatic detection of readback errors between ATCO and pilot**
  - 82% of the occurring readback or hearback errors could be identified automatically

SINAPSE

- *SINAPSE proposed an intelligent and secured aeronautical datalink communications network architecture design based on the Software Defined Networking (SDN) architecture model augmented with AI to predict and prevent safety services outages, to optimize available network resources and to implement cybersecurity functions protecting the network against digital attacks.*

Achieved results:

- Identified the AI methodologies suitable for cybersecurity and safety services.
- Prototyped datalink failure prediction solution using real-time monitoring over ANSP network
- ML methodologies predicted failures for satellite data and voice link communications.
- Achieved promising performance results using operational data for cybersecurity and safety use cases.

AISA, ARTIMATION, MAHALO, SAFEOPS and TAPAS

- The five ER4 projects have some commonalities :
  - They prototyped their specific Solutions designed for increasing automation in ATM in different operational contexts (CD&R, ATFCM, Delay Prediction for optimising the use of runways, Go-Arounds Prediction), by using different ML techniques.
  - They carried out Human-In-The-Loop validation activities with ATCOs by running highly automated eXplainable Artificial Intelligence (XAI) scenarios using the prototyped solutions and the developed Visualization tools, aiming to identify needs and strategies for addressing Transparency, Explainability Conformance, Situation Awareness and Trust in the considered operational cases, paving the way for the application of AI/ML technologies in ATM environments.

White Paper on AI in ATM

- AISA, ARTIMATION, MAHALO, SAFEOPS and TAPAS delivered a common White Paper on “*AI in ATM : Transparency, Explainability, Conformance, Situation Awareness and Trust*”.

- It reports the progress on the research performed by these projects using AI when developing their respective Solutions, and their initial findings.

[*Link to White Paper*]

TAPAS

- *TAPAS objective was the exploration of highly automated eXplainable Artificial Intelligence (XAI) scenarios through Human-In-The-Loop validation activities and Visual Analytics, to identify needs and strategies to address transparency and explainability in the operational cases considered, paving the way for the application of these AI/ML technologies in ATM environments.*

Achieved results:

- ATFCM and CD&R use cases tested.
- eXplainable AI prototypes developed for Automation levels 2 & 3 in both use cases.
- Integration with Visual Analytics tools to provide explanations to ATCOs on AI decisions.
- Real Time Simulations in ATC platforms involving ATCOs from ENAIRE and PANSA.
- Principles for Transparency in AI/ML applications in ATM.

AISA

- *The AISA project investigated how to increase automation in ATM. To achieve this, the project explored domain-specific application of transparent and generalizable AI methods.*
- *This project developed an intelligent situationally-aware system allowing the AI to take part in shared (or team) situational awareness alongside ATCO team members.*
- *The AI is also able to explain the reasoning behind its decision when confronted with the same problem as the ATCO.*

Achieved results:

- Proof-of-Concept prototype system was developed.
- 48 monitoring tasks were automated (artificial situational awareness).
- 2 human-in-the-loop experiments involving 20 ATCOs were performed.
- Risk assessment: library of more than 70 risks and hazards, more than 140 mitigation measures.

SAFEOPS

- *SafeOPS investigated an AI-based decision support tool for ATC in the context of go-arounds. The project researches how ATCOs handling go-arounds could use the predictive information to adapt their strategies, avoiding knock-on effects that can accompany go-arounds; and thereby increasing safety and resilience.*
- *SafeOPS developed an AI-model, which can predict go-arounds and enhanced a risk assessment method.*

Achieved results:

- A ML model for predicting go-arounds was developed.
- A Human-In-The-Loop simulation exercise was run with ATCOs to evaluate the ML model's impact on safety, capacity and resilience in the go-around scenario.
- A benefit to safety and resilience in complex go-around situations can be achieved by allowing ATCOs to handle go-around situations proactively.

MAHALO

- *MAHALO focused on two constructs of human-AI interaction:*
  - *Conformance, defined as the apparent strategy match between human and AI systems.*
  - *Transparency, which refers to the degree to which the system makes its internal processes apparent to the operator.*
- *MAHALO conducted two field simulations at two sites, with 34 ATCOs , to evaluate the impact of Conformance and Transparency on ATCOs acceptance, agreement, workload, and general subjective feedback.*

Achieved results:

- *MAHALO developed ML solutions for Conflict Detection and Resolution via:*
  - *Supervised Learning - to mimic controller solutions*
  - *Reinforcement Learning to generate ATCO independent optimized solutions*
- *Defined guidelines on how to incorporate conformance and transparent mechanisms of AI solutions to conflict detection and resolution.*

ARTIMATION

- Objective: Provide Transparency and Explainability to AI, build a conceptual framework for building human-centric XAI and provide user guidelines for further AI algorithm development with AI transparency.
- *The project assessed the impact of different Visualisation techniques for AI algorithms providing Explainability to the ATCO Conflict Detection and Resolution task, and the impact of an Explainable AI (XAI) tool supporting the ATCOs Delay Prediction task for optimising the use of runways.*

Achieved results:

- *Two XAI solutions were developed considering Transparent AI models with Explainability, 1) for the Delay Prediction and Propagation tool and 2) for the Conflict Detection and Resolution tool.*
- *In terms of AI methods developments, Random Forest (RF), LSTM, and Genetic algorithms are applied, and for the explanation, LIME, SHAP, Model centric explainability and user-centric explainability were considered.*

AISA, ARTIMATION, MAHALO, SAFEOPS, TAPAS Video

- AISA, ARTIMATION, MAHALO, SAFEOPS and TAPAS delivered a joint video that was presented at SESAR Innovation Days in Budapest in Dec 2022
- It illustrates the key achievements of the five SESAR ER4 projects.

- link to Video

JOINT UNDERTAKING

New SESAR 3 AI projects

FLAGSHIPS

FLAGSHIPS	Exploratory Research – Fundamental	Exploratory Research – Applications-oriented	Industrial Research and Validation	Fast Track Innovation and Uptake	Digital Sky Demonstrators
Connected and automated ATM	ASTAIR, HYPERSOLVER	SMARTS, CODA	FCDI, MIAR, FCA		Call (September 2022) CEF-T-2022-SIMOBGEN-SESAR-DSDA-WORKS
Air-ground integration and autonomy			SOLO, ECHO 2, IRINA, NETWORK TBO		
Capacity-on-demand and dynamic airspace	HUCAN		ISLAND, IFAV3	FASTNet, KAIROS	
U-space and urban air mobility	ImAFUSA, MUSE	AI4HyDrop		EUREKA, OperA, ENSURE, SPATIO, SAFIR-Ready	U-ELCOME, EALU-AER, BURDI
Virtualisation and cyber-secure data sharing	SEC-AIRSPACE			VITACY, CNS DSP	Call (September 2022) CEF-T-2022-SIMOBGEN-SESAR-DSDA-WORKS
Multimodality and passenger experience	MAIA	MultiModX		SIGN-AIR	
Aviation green deal	AEROPLANE, E-CONTRAIL	Green-GEAR	CICONIA, DYN-MARS, GEESE, GALAAD, CONCERTO		ECHOES, HERON
Artificial Intelligence for aviation	SynthAIR, TRUSTY	ASTRA	JARVIS	DARWIN	
Civil/military interoperability and coordination			MITRANIO	HARMONIC	

Transversal: Engage 2, AMPLE3, PEARL

SynthAIr

Improved ATM automation and simulation through AI-based universal models for synthetic data generation

SynthAIr's mission is to increase the level of automation of ATM system by delivering **novel AI-methods for synthetic data generation**. This will leverage the potential of synthetic data for tackling structural **obstacles** such as **data access** and **scarcity**, **privacy** issues and **bias in the data**, for **accelerating** the **adoption** of **AI in ATM system**

SINTEF
TUDelft
EUROCONTROL
deepblue CONSULTING & RESEARCH

Objectives

IMPROVE	DEVELOP	EVALUATE	VALIDATE	RECOMEND	ACCELLERATE
understanding of AI-based synthetic data generation methods	Universal AI methods for generating realistic synthetic ATM-data	privacy and diversity of the generated synthetic data.	impact of synthetic data through **operational use cases**	Conclusions, principles, best practices based on the experimental results and analysis..	the uptake of AI in the ATM system and ESTABLISH mechanism for collaboration.

Use Cases

Passenger Flow Prediction

Synthetic Traffic Generator simulations

Flight Delay Prediction

Turnaround Time Prediction

TRUSTY

- Enhance the trustworthiness of AI-powered decisions in the context of remote digital towers (RDTs).

A proof-of-concept of a **trustworthy intelligent system** for RDTs including visualization, explanation, and generalization with **adaptability, accuracy, robustness, interpretability, fairness, accountability, and user acceptability** to ensure safe and reliable decision support.

Mälardalen University

SAPIENZA

ENAC

deepblue

Objectives

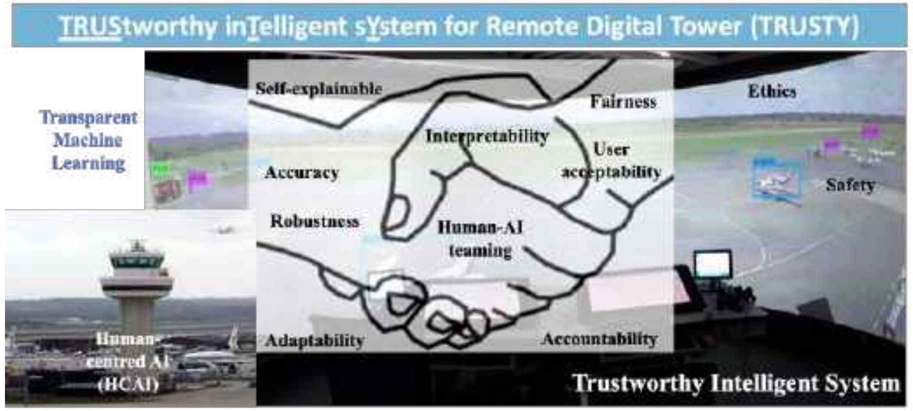
The overall objective of **TRUSTY** is to do research and development on a trustworthy intelligent system for the RDTs application domain i.e., *taxiway inspection (i.e., bird hazard, presence of drones, drones and the need for drone protection, autonomous vehicle monitoring, human intrusion, etc.) and runway monitoring (approach and landing) misalignment warning*.

- Provide a “Self-explainable” and “Self-learning system” for critical decision-making.
- Provide ‘Transparent ML models’ incorporating interpretability, fairness, and accountability based on human-centred XAI and active learning.
- TRUSTY will use HCAI explanation and HAIT that can be easily accepted by the RDTs operators.
- TRUSTY aims to improve the transition process towards the use of RDTs by providing more trust to RDTs operators through transparent and explainable systems

TRUSTY

- Enhance the trustworthiness of AI-powered decisions in the context of remote digital towers (RDTs).

Overall, the goal of TRUSTY is to provide adaptation in the level of transparency to enhance the trustworthiness of AI-powered decisions in the context of RDTs. While in an actual tower, operators have direct visual access to the **taxiway and runway monitoring**, the RDTs concept only provides such information through video transmission with a warning and the corresponding explanation.



TRUSTY system for remote digital towers (RDTs)

TRUSTY will consider several approaches, and they are listed:

- 'Self-explainable and Self-learning' system for critical decision-making
- 'Transparent ML' models incorporating interpretability, fairness, and accountability
- 'Interactive data visualization and multimodal human-machine interface/interactions (HMI), i.e., Graphical User Interface (GUI)' for smart and efficient decision support
- 'Adaptive level of explanation' regarding the user's cognitive state.
- "HCAI" to enhance the trustworthiness of AI-powered systems.
- "Human-machine collaboration (HMC) or Human-AI teaming (HAIT)" to consider user feedback to insure some computation flexibility and the users' acceptability

ASTRA
Key objectives

1. **Develop an AI-based Flow Management Position (FMP) function to predict and resolve traffic hotspots** at least 1 hour before they are predicted to occur
2. **Develop Human Machine Interface (HMI) concepts** to allow interaction between operators (namely FMP personnel) and the proposed function
3. **Demonstrate and validate the FMP function and associated HMI concepts** by conducting human-in-the-loop Real-Time Simulations (RTS) in a representative operational environment with operational staff

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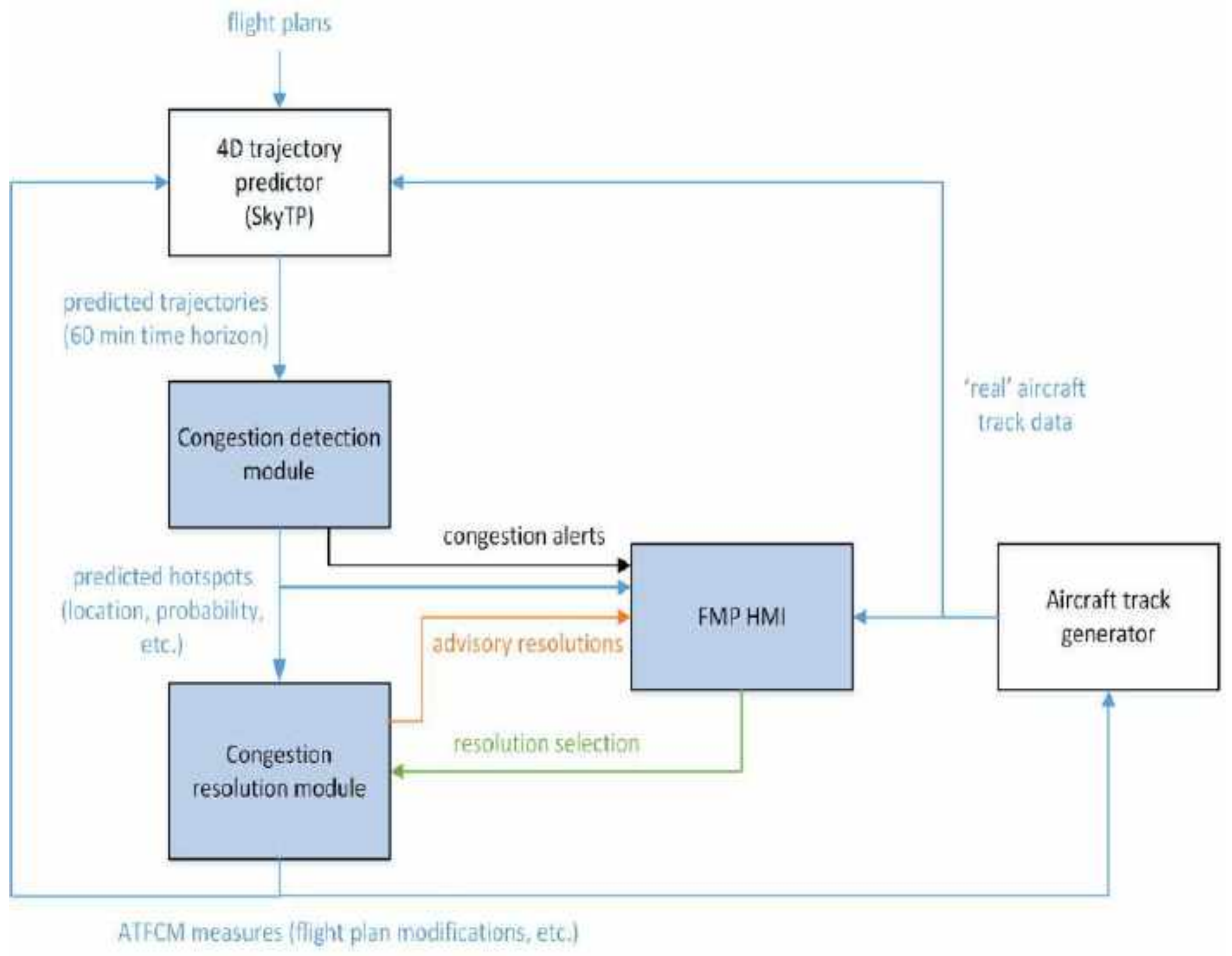
Institute of Aerospace Technologies
INGENAV skyguide skysoft deepblue

ASTRA

High-level logical architecture



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ASTRA
AI aspects

- Unsupervised ML will be used to predict and identify hotspots 1 hour in advance on the basis of complexity metrics
- Deep Reinforcement Learning (RL) – or similar ML techniques – will be used to resolve any predicted hotspots by means of ATFCM measures (FL changes, 'Direct to' commands, etc.)
- Historic and synthetic data will be used, including surveillance data and/or flight plan data from OpenSky ATM and/or Eurocontrol's Aviation Data for Research
- Explainable AI techniques will be used to give an insight into the algorithms' solutions

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JARVIS AI for Aviation IR01

Deliver three AI-based ATM solutions (digital assistants) to support pilots, ATC operators and airport operators in non-safety and safety critical operations.

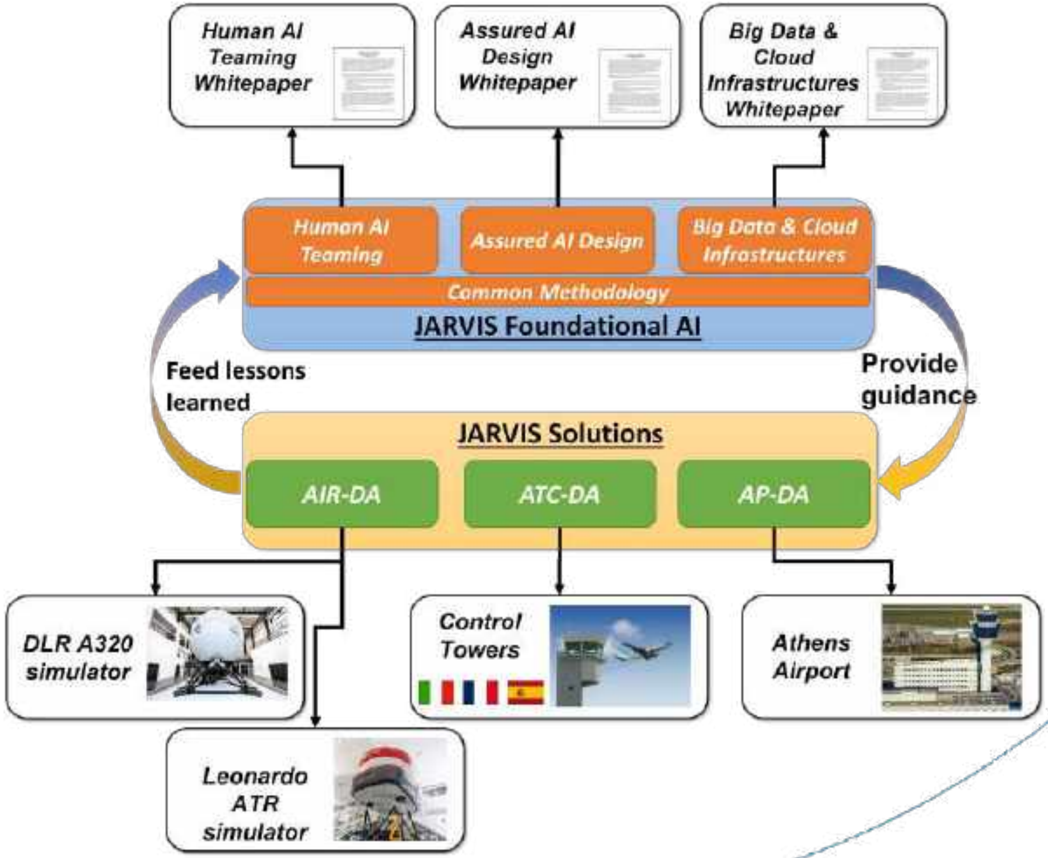
Solution 1: Design and validate an airborne digital assistant to support pilots in current and future operations.
Team: Collins Aerospace (lead), Boeing, Deep Blue, DLR, NLR, Leonardo

Solution 2: Design and validate an ATC digital assistant to support ATC operators in different tasks (Conflict Resolution, Planning, Optimization).
Team: CIRA (lead), Airbus DS, ENAC, ENAV, ENAIRE (and CRIDA), INDRA, Leonardo, NAIS

Solution 3: Design and validate an airport digital assistant to support airport operators in several operative, safety tasks.
Team: Athens International Airport (lead), EUROCONTROL, Indra, Swedavia

JARVIS at glance

Coordinator: Stefano Riverso (Collins Aerospace)
Beneficiaries: 16 organizations
Solutions: 3
EU Budget: €10.847.805,53
Period of performance: Jun 23 – May 26



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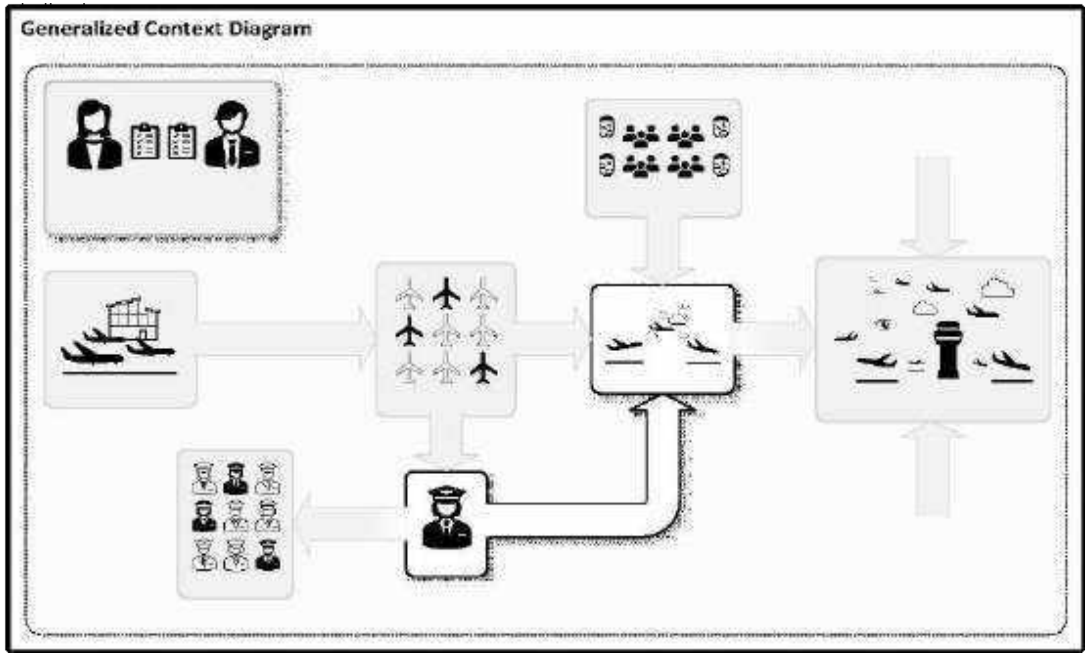
JARVIS Solution 1 – Airborne Digital Assistant (TRL4)

Objectives

- Design, develop and deliver an on-aircraft collaborative, transparent, trustworthy, and intelligent digital assistant platform for pilots in support of Single Pilot Operations and Reduced Crew Operations.
  - Develop an innovative and adaptive human-centric HMI
  - Develop an advanced AI-based decision aide system
  - Develop AI-based automated functions and routines
  - Leverage cybersecurity and AI assured design frameworks to drive the airborne digital assistant lifecycle



Exercise 1 – A320 Flight Simulator
Exercise 2 – ATR Flight Simulator
Collins Aerospace leads the overall exercise
DLR and Leonardo leading validation exercises
Deep Blue and NLR focusing on human assessments and integration human-AI teaming

JARVIS Solution 2 – ATC Digital Assistant (TRL4)

Objectives

- Design an ATC Digital Assistant
- Develop and validate the different functionalities of the ATC Digital Assistant
  - AI-powered Conflict Resolution
  - Automated Flight Plan Corrector
  - Advanced short term air traffic forecasting
  - Direct Path Recommendation
  - Automated OLDI Coordination Message Corrector

CIRA, ENAV, Leonardo, NAIS

Exercise 1 – AI-Powered CORA
ENAV leads the overall exercise, provides the platform
CIRA models the AI Algorithms
Leonardo prototypes the algorithm in Industrial Environment
NAIS in details leads HP assessment, CBA Safety Assessment – supports the package deliveries

Airbus DS, ENAC

Exercise 2 – AI-Powered CORA
ENAC leads the overall exercise
Airbus develops the AI prototype
ENAC provides the data and platform and support the AI tuning

CRIDA, ENAIRE, INDRA

Exercise 3 – Spanish Exercise Automated Flight Plan corrector (ENAIRE)
Exercise 4 – Digital Assistant for Direct Path Recommendation (ENAIRE)
Exercise 5 – Automated OLDI Coordination Message Corrector (ENAIRE)
Exercise 6 – Advanced short term air traffic forecasting (INDRA)
CRIDA support the AI tuning
INDRA develops prototypes in industrial environment
ENAIRE provides the platform

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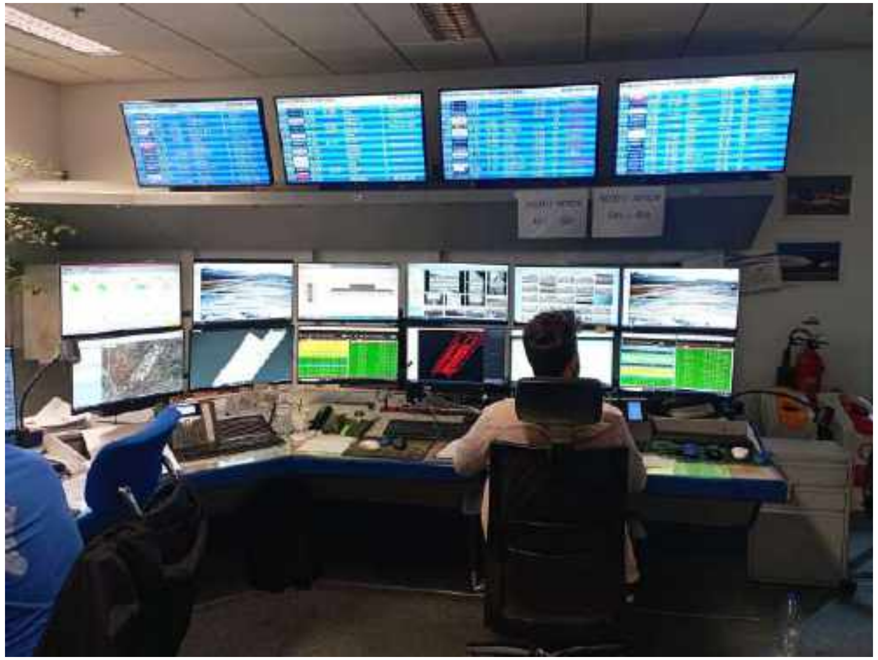
JARVIS Solution 3 – Airport Digital Assistant (TRL6)

Objectives

- Assess and demonstrate the AI technology capabilities across the whole spectrum of airport operations, in a balanced way, touching on both aviation safety and operational efficiency, airside and landside.
- Reveal the hidden potential of higher operational efficiency, as a result of enhanced aviation safety.
- Use of AI for planning of more predictable operational processes, end-to-end.



Exercise 1 – Digital APOC – Aviation Safety
Exercise 2 – Digital APOC – Operational Efficiency
Athens International Airport leads the overall exercise
INDRA delivers technology ecosystem
Swedavia supports requirements and use cases definition
EUROCONTROL keep solid regulatory and standardization alignments across airports operations

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Who is behind Darwin? The consortium

Honeywell

DLR

PIPISTREL
BY TEXTRON eAVIATION

EUROCONTROL

EASA
European Aviation Safety Agency

SLOVENIA CONTROL

Darwin Goals

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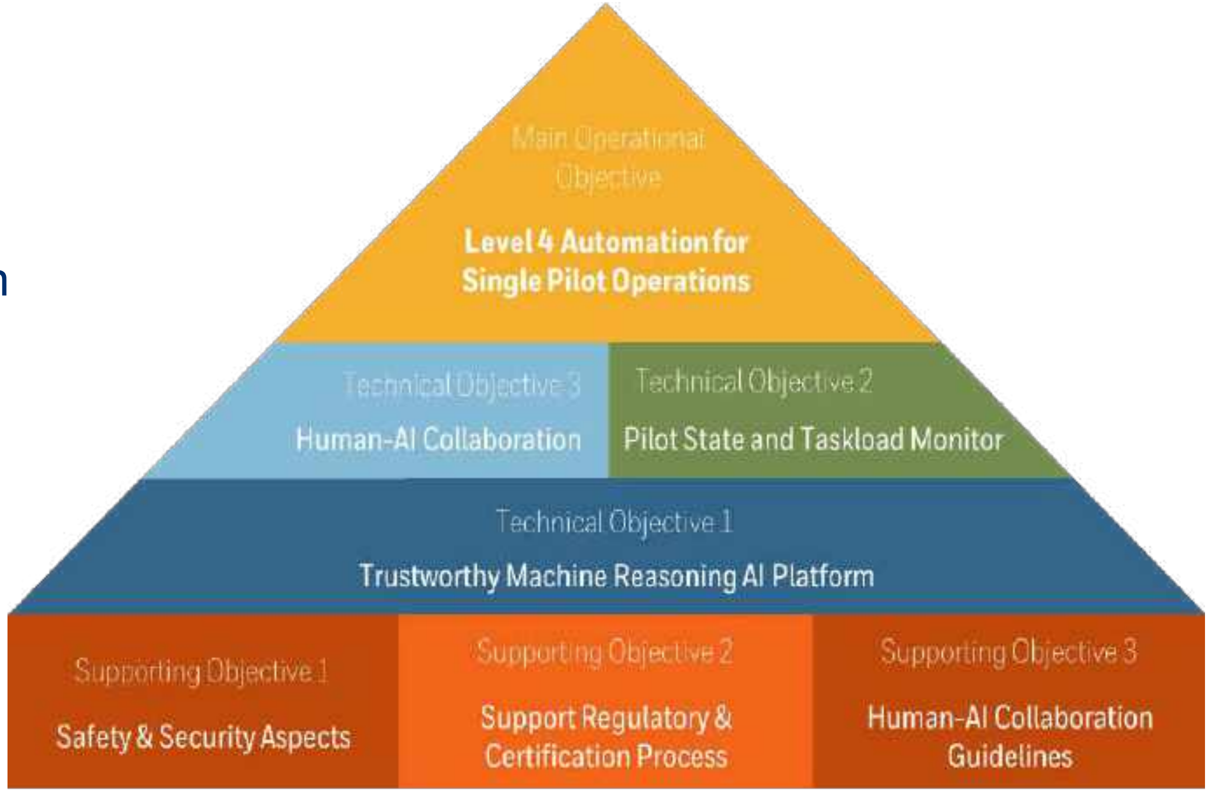
- Develop **Adaptable Automation** capable of dynamically (re)assign tasks between a pilot and a set of digital assistants based on the pilot health state, and both current and predicted task load.
- Develop **procedures for ATM** together **with** related **operational and interoperability requirements** on ground/airborne systems and services.
- Demonstrate feasibility of the Adaptable Automation and procedures through their realization in real environment.

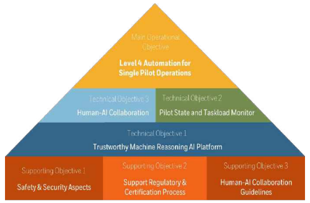
DARWIN Project Objectives (1/3)

Main Operational Objective

- Demonstrate **dynamic distribution** of on-board activities between pilot and automation on a CS-23 scenario, with same or lower workload.
- Provide a set of **guidelines** for:
  1. Design of human-AI collaboration on-board of an aircraft;
  2. Interaction between the aircraft entity (pilot-AI) and air traffic controllers;
  3. Regulatory authorities;
  4. Creators of tasks/tasklists.
- **Validate** that DARWIN concept enables efficient Human-AI collaboration, maintains or reduces human workload in the cockpit (eMCO/SPO vs multi-crew flight deck), while pilot still maintains necessary situational awareness and can take over full control of the mission, if necessary, in both nominal and non-nominal scenarios (e.g., pilot incapacitation, emergency landing, go-round).



DARWIN Project Objectives (2/3)



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Technical Objective 1

Develop & Validate Trustworthy Machine Reasoning AI Platform

- Develop reusable, safety-critical decision-aiding and decision-making platform enabling the implementation of principles and features for the highly regulated aviation market
- Mature it to TRL7

Technical Objective 2

Develop & Validate a Pilot State and Taskload Monitor

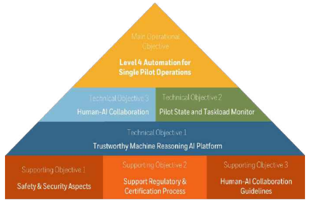
- Develop a monitor for non-invasive detection of potentially dangerous human states – including incapacitation – and assessing pilot performance and taskload
- Mature it to TRL7

Technical Objective 3

Develop and Implement Human-AI Collaboration technology

- Develop AI-powered Adaptable Automation and collaboration concept in 2 phases:
  - Phase A - Agile concept formation, prototyping and early validation
  - Phase B – Agile Maturation
- Mature it to TRL7

DARWIN Project Objectives (3/3)



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Supporting Objective 1

Conduct Safety & Security analysis for Level 4 Automation for SPO

- Assessing both cyber and physical risks of Level 4 Automation

Supporting Objective 2

Develop Certification & Regulatory Approach

- Will include review of existing regulatory standards, identification of gaps and definition of mitigation strategies for Trustworthy Machine Reasoning and Human-AI Collaboration

Supporting Objective 3

Develop Human-AI Collaboration Guidelines

- Will focus on how human – AI interaction shall happen

DARWIN Expected Results

1. Adaptable Automation & Human-AI collaboration CONOPS
2. Implemented Adaptable Automation at TRL7
3. Implemented Pilot State & Taskload Monitor at TRL7
4. Implemented Trustworthy Machine Reasoning Platform at TRL7
5. Successful validation concluded through a demonstration in the real environment
6. Task data format for Human-AI collaboration
7. Recommendations for Standards & Regulations updates
8. Guidelines

hucan
Holistic Unified Certification Approach for Novel ATM-related systems based on advanced automation

HUCAN
Key objectives

- Review the most prominent trends and challenges in advanced automation and AI-powered applications in different domains, with particular focus on ATM.
- Analyse the legal and regulatory features and critical issues of automated/AI technologies, including an assessment of the current certification systems, highlighting their potential and limits.
- Design novel methods and procedures of certification of ATM-related systems based on high levels of automation, including AI-powered ones.
- Develop a set of suitable guidelines and associated toolkit for the development of automation and AI technologies, with the aim of streamlining the certification/approval thereof.

deepblue nlr EUI DLR CIRA Centro Italiano Ricerche Aerospaziali d-flight

HUCAN
AI aspects

- Although the focus of the project is on highly automated systems, including the AI-powered ones, the project does not foresee AI-based activities and will not design and develop AI-based tools.
- However, its AI aspects are extremely relevant as the project will explore the key topic of how to certify highly automated and AI-powered solutions and will propose a holistic approach to certification
- The project will refer to 4 case studies specifically focused on solutions for capacity on demand and dynamic airspace allocation. Cooperation with other AI-based projects is more than welcome.

More detailed information on SESAR 2020 AI Projects (backup slides)

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Thank you for your attention!

More information:

alessandro.prister@sesarju.eu

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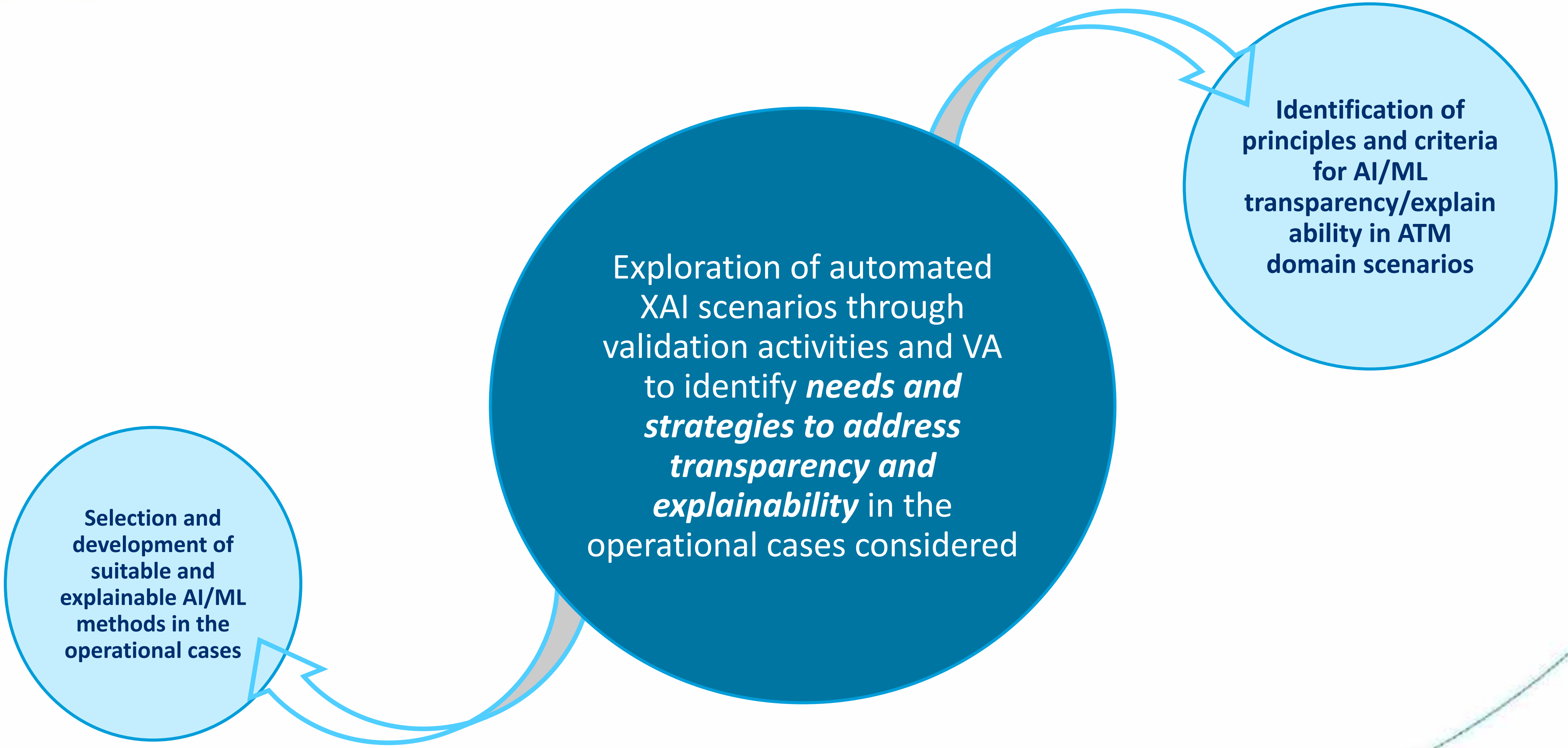
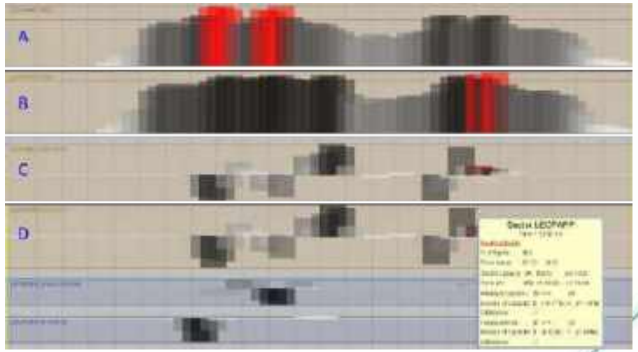
TAPAS research objectives



JOINT UNDERTAKING

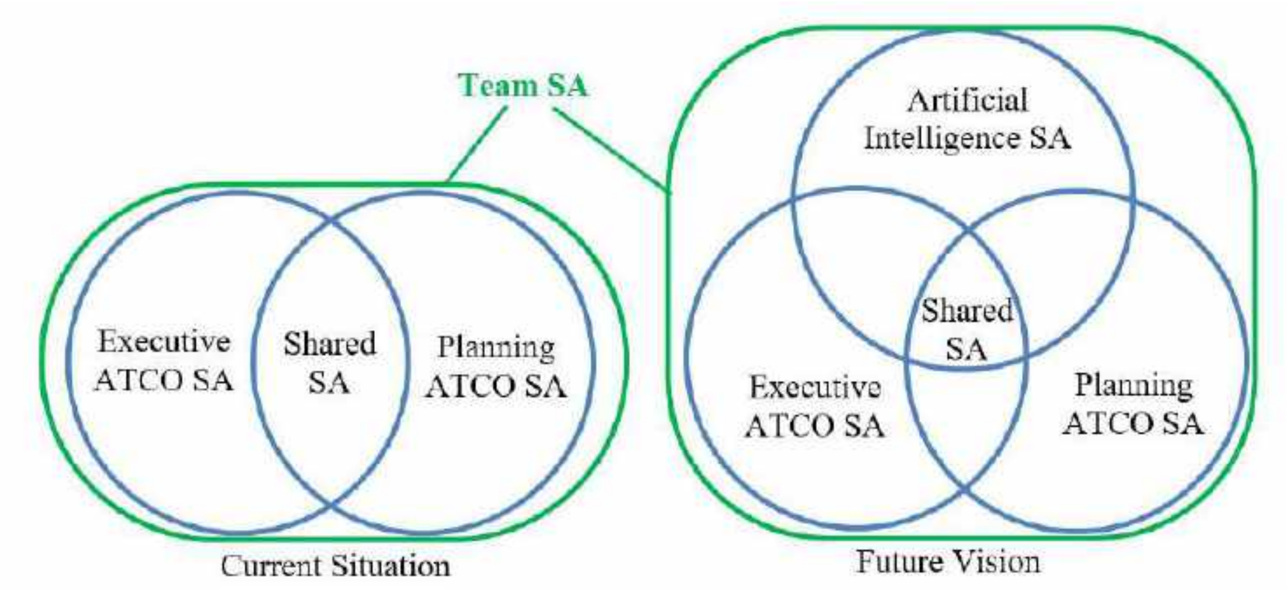
TAPAS Research results

- Two different use cases tested: ATFCM and CD&R
- XAI (eXplainable AI) prototypes developed for Automation levels 2 and 3 (as defined in ATM MP), in both use cases
- Integration with Visual Analytics tools to facilitate the provision of explanations on AI decisions
- Real Time Simulations in ATC platforms involving experts ATCOs from ENAIRE and PANSA
- Principles for Transparency in AI/ML applications in ATM (*general, feeding EASA roadmap*)



AISA Objectives

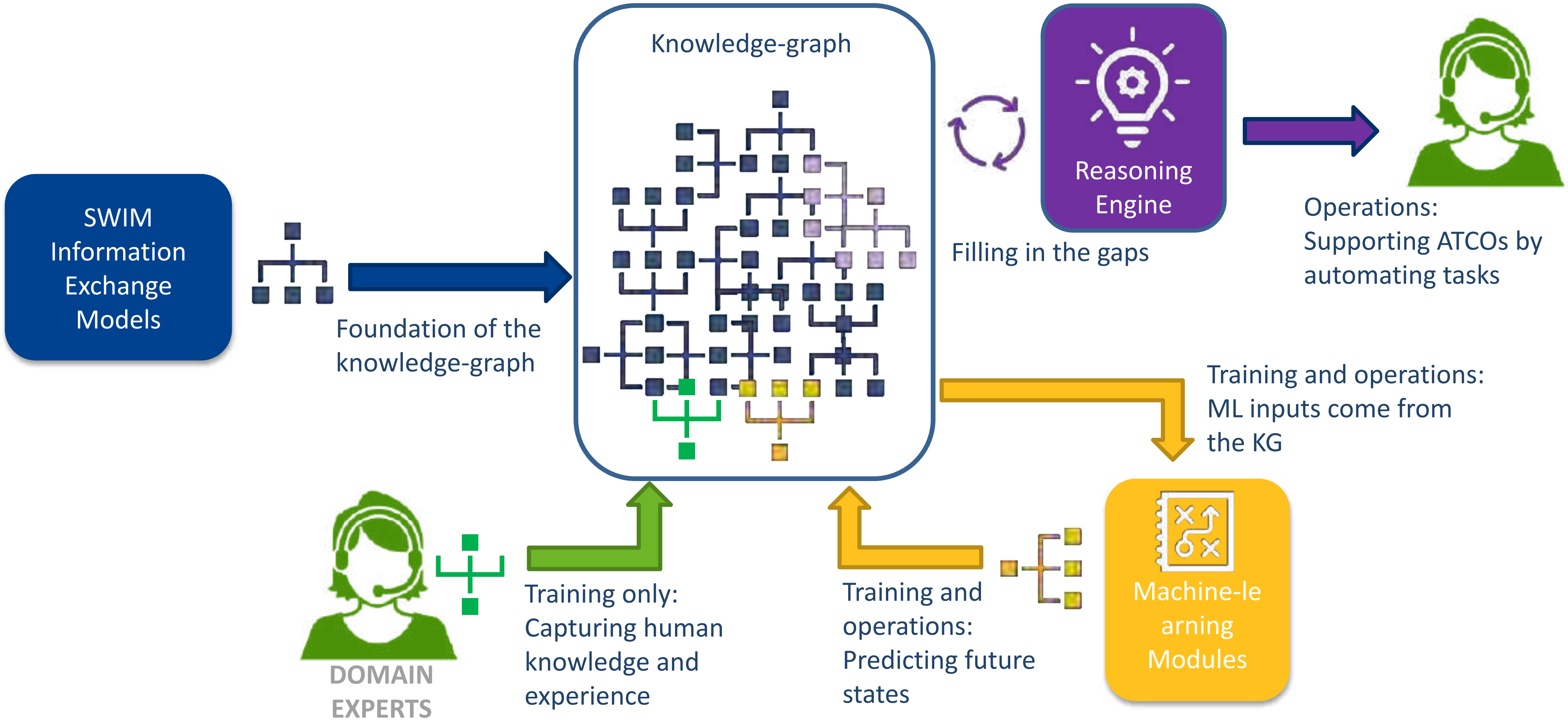
- Explore the effects of human-machine distributed situational awareness
- Improve transparency and explainability



AISA should be aware of:

- the traffic situation
- its own (system's) state
- other team member's states

AISA System


SWIM
Information
Exchange
Models
Foundation of the
knowledge-graph
Knowledge-graph
Reasoning
Engine
Filling in the gaps
Operations:
Supporting ATCOs by
automating tasks
Training and operations:
ML inputs come from
the KG
Machine-le
arning
Modules
Training and
operations:
Predicting future
states
Training only:
Capturing human
knowledge and
experience
DOMAIN
EXPERTS

AISA Results

- Proof-of-concept system developed
- 48 monitoring tasks automated (artificial situational awareness)
- 2 human-in-the-loop experiments
  - 1st: to gather data, to compare human vs artificial SA, 20 licensed ATCOs, 5 exercises each
    - Result: in the scope of the experiment, human and artificial SA are comparable (human underperforms a bit)
  - 2nd: to see how much support can be provided to ATCOs, 16 ATCOs, 5 exercises each, providing support via audio
    - Result: ATCOs dislike using audio for this, support is often not provided at the required time, plenty of room for improvement
- Risk assessment: library of more than 70 risks and hazards, more than 140 mitigation measures

MAHALO

Modern ATM via Human/Automation Learning Optimisation

LINKÖPING UNIVERSITY

LFV

TU Delft

CHPR

deepblue

EUROCONTROL

ANACNA

How should we build Machine Learning?

Conformance

Does automation seem to match human strategies?

Transparency

Is automation's inner process explainable to human?

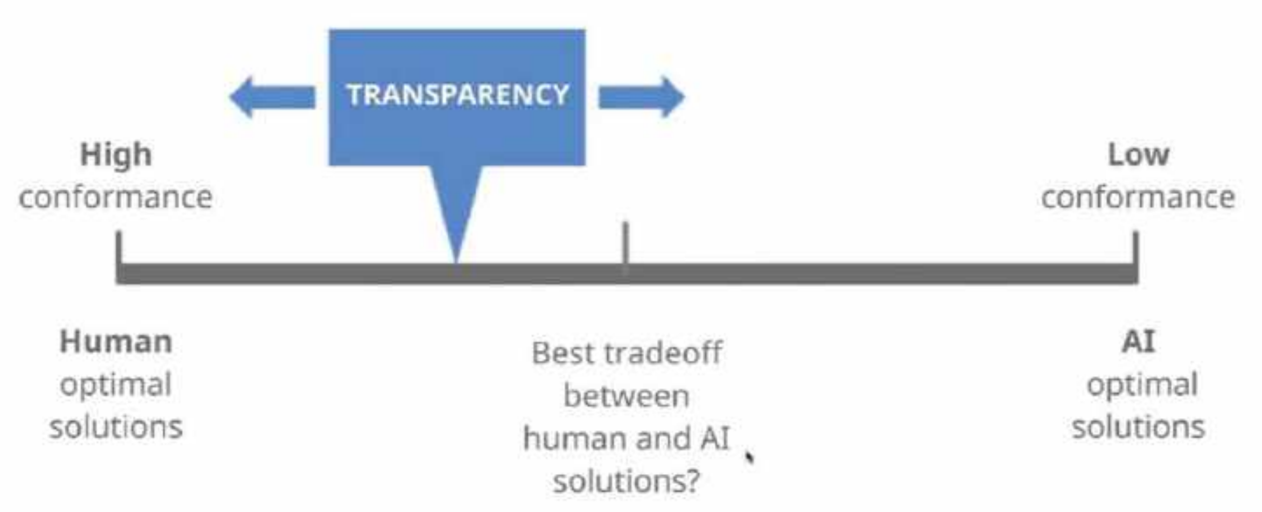
		TRANSPARENCY	
		Low	*High*
	Low	**Stupid automation** *"It's doing a strange thing, and I don't understand why…"*	**Peculiar automation** *"It's doing a strange thing, but I understand why…"*
	High	**Confusing automation** *"It's doing the right thing, but I don't understand why…"*	**Perfect automation** *"It's doing the right thing, and I understand why…"*

MAHALO objectives

Develop ML solutions for CD&R via:

- **Supervised Learning** - to mimic controller solutions (conformal)
- **Reinforcement Learning** – to generate (ATCO independent) optimized solutions

Empirically evaluate conformance and transparency



Goal: Derive general design lessons

Strategic conformance

"the apparent strategy match between human and automation solutions"

Automation transparency

AGENT TRANSPARENCY

DISPLAY TRANSPARENCY

EXPLAINABLE AI

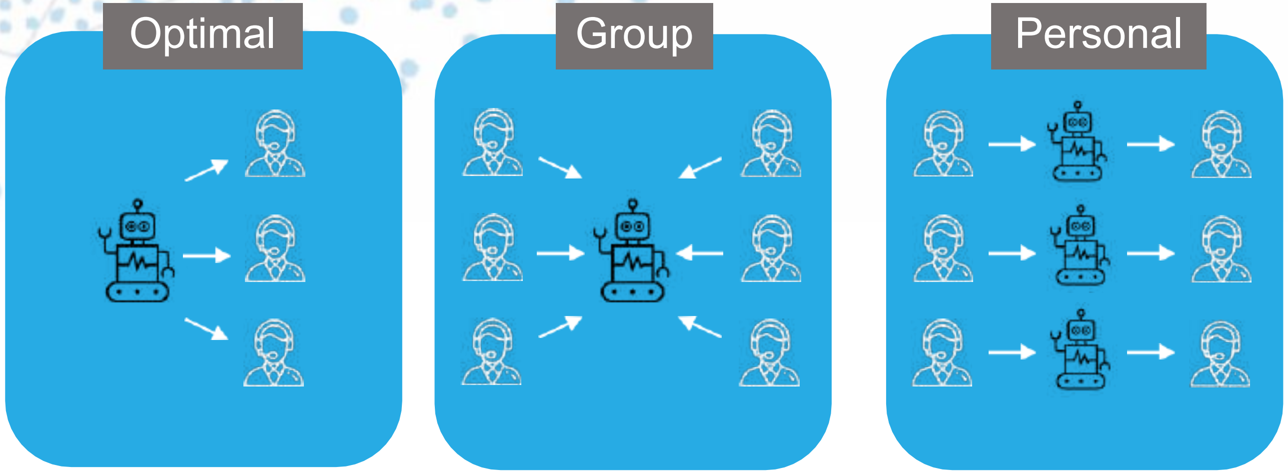
ML INTERPRETABILITY

INTELLIGIBILITY

"the automation's ability to afford understanding and predictions about its recommendations and behavior"

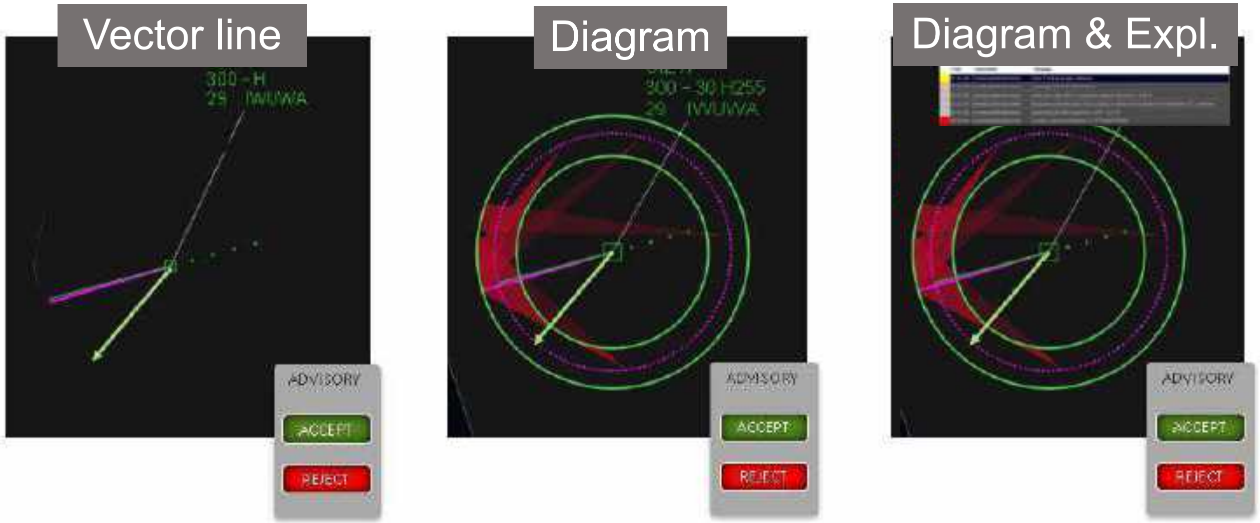
Conformance & Transparency variables

Conformance

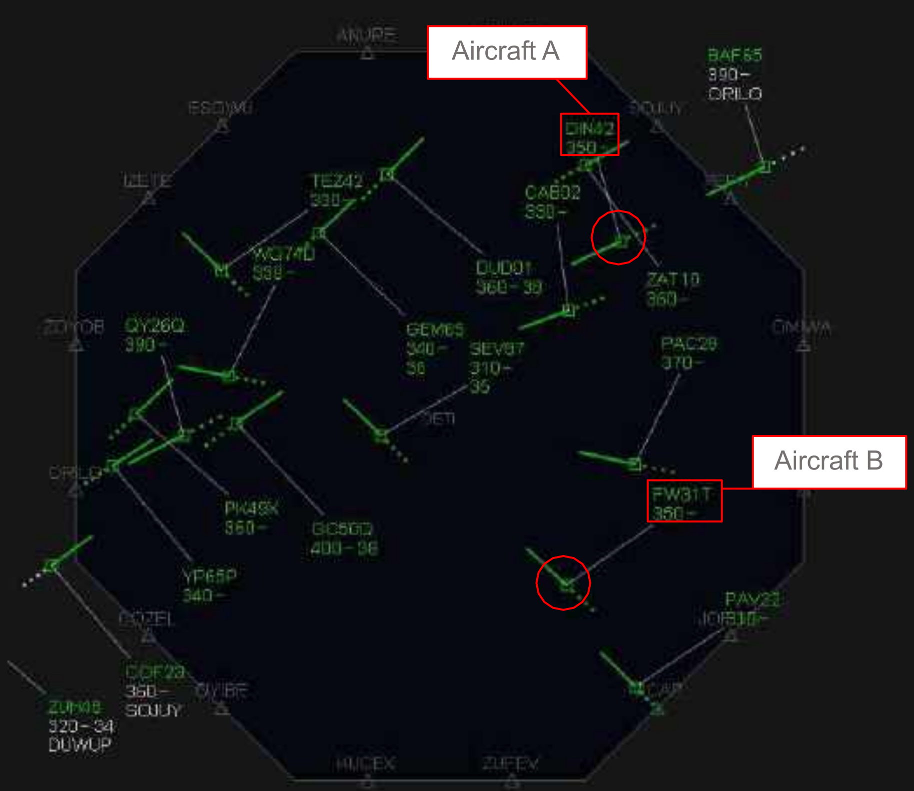


LO
W
HIGH

Transparency



Scenarios



Scenario A

Scenario B

- Conducted a state-of-the-art review of ML advances to CD&R;
- Developed & demonstrated a ML CD&R capability;
- Designed an experimental user interface & simulation capability;
- Integrated ML capabilities with the simulator & interface;
- Conducted a pair of two-phase experiments (Training pre-test, and Main experiment) with 36 controllers that varied ML model conformance and advisory transparency
- Provided results showing:
  - effects of strategic conformance on advisory response;
  - advisory response was affected by the match between preferred and proposed separation distance; and
  - no effects of transparency.

MAHALO

Modern ATM via Human/Automation Learning Optimisation

SafeOPS Scenario and Objectives

Scenario:

Go-Arounds:

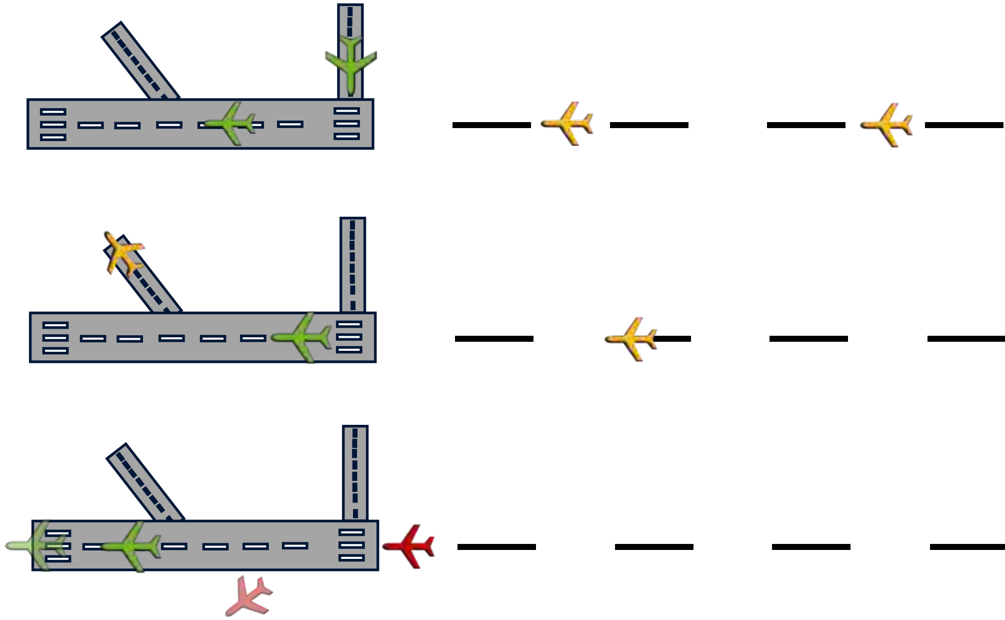
- Go-arounds are standard procedures for ATCOs and Pilots
- On average, 3 out of 1000 approaches result in a go-around

Under certain conditions, go-arounds can become complex, e.g:

- High congestion
- Conflicting departure and missed approach procedure

Knock-on effects:

- Separation challenges
- Wake turbulence challenges
- High (peak) workload for ATCO and Pilots to ensure safety



Objectives:

Develop an AI/ML tool for go-around predictions and explore it in terms of achievable performance metrics as well as explainability.

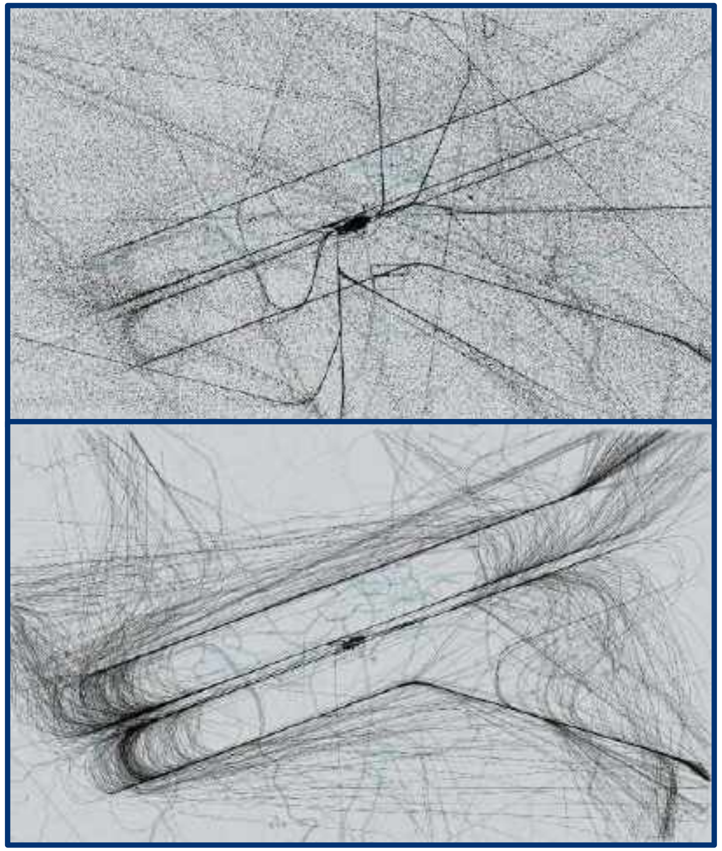
Enhance a risk assessment method, such that it can cope with the introduced AI/ML based solution for the described go-around scenario.

Investigate the AI/ML-based decision support solution and evaluate the effects on capacity, safety, and resilience in the go-around scenario

SafeOPS (Ai) Achievements

Results:

- SafeOPS performed a benchmark study on various ML algorithms and assessed their suitability for predicting go-arounds. Based thereon, an ML model for predicting go-arounds was developed.
- Based on the ML prototype, SafeOPS performed a Human-In-The-Loop simulation exercise with Controllers to evaluate the ML model's impact on safety, capacity and resilience in the go-around scenario.
- In conclusion, SafeOPS found that these proactive solutions benefit the safety and resilience of the ATM system in complex go-around situations by providing controllers more time and the possibility to handle go-around situations proactively.
- On the contrary, proactive tactics can reduce capacity/efficiency in case of false prediction, but only negligible, compared to the overall capacity increase foreseen in the eATM Master Plan.



One day of position information from the training data set in EDDF before and after data cleaning

ARTIMATION
Key objectives

1. **Research Objective: Provide transparency and explainability to the AI, build a conceptual framework for building human-centric XAI and provide user guidelines for further AI algorithm development and application with AI transparency in ATM domain**

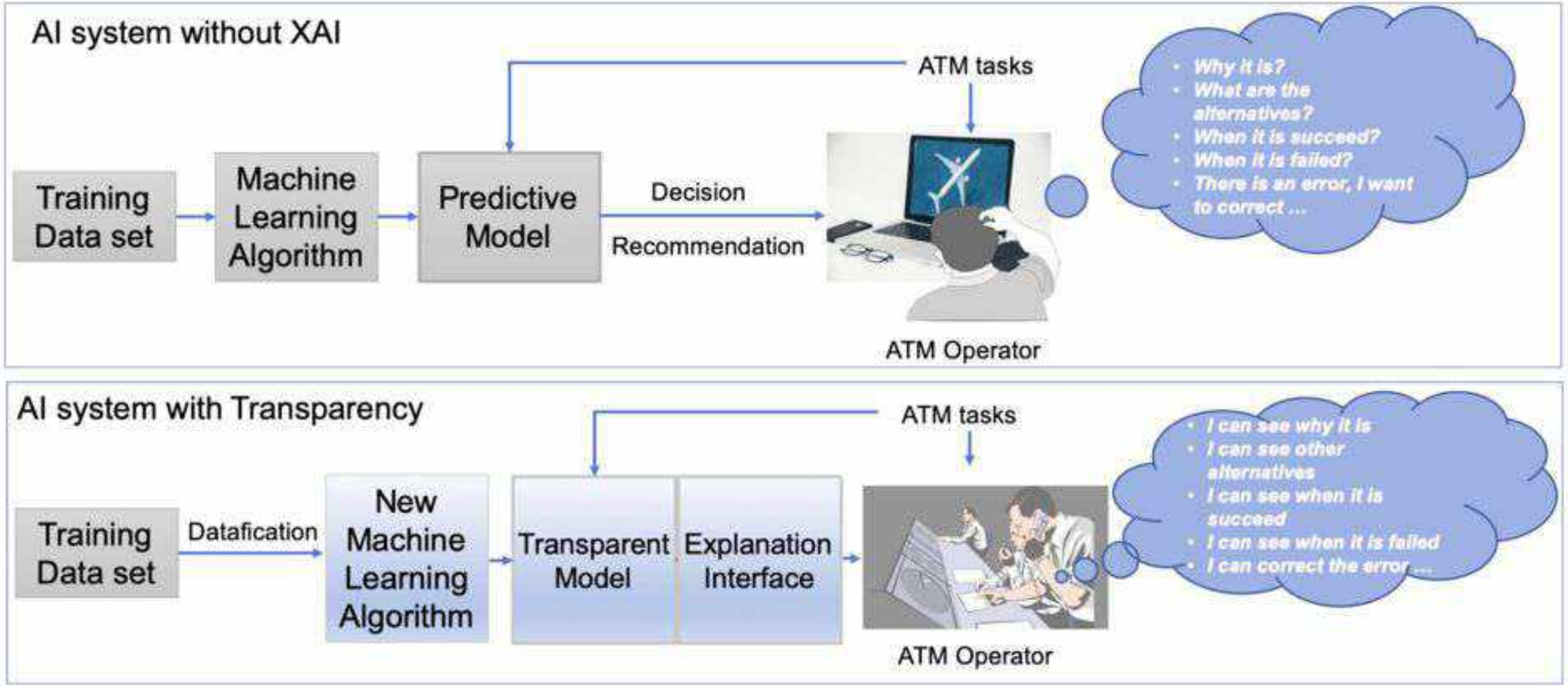
2. **Technical Objective: Design human-AI-interaction (hAIi) to provide a data-driven storytelling. And define a data exploration approach through visual analytics and evaluate the XAI by novel immersive analytics technologies with virtual reality and Brain-Computer Interface (BCI) systems**

3. **Social Objective: Develop transparent AI models for ATM operators with better integrated approach between them and AI, with guidelines for shortening the training period.**

This project has received founding from the SESAR Joint Undertaking grant agreement No. 699381 under European Union's Horizon 2020 research and innovation programme

SESAR-ER4-01-2019

ARTIMATION
High-level logical architecture



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ARTIMATION
AI aspects

- Two **XAI solution** tools have been developed considering transparent AI models with Explainability, 1) for the delay prediction and propagation tool and 2) for the Conflict detection and Resolution (CD&R) tool.
- In terms of **AI methods developments**, Random Forest (RF), LSTM, and Genetic algorithms are applied, and for the explanation, LIME, SHAP, Model centric explainability and user-centric explainability were considered.
- A **lifelong machine learning** framework and integration of a causal model for explaining the delay prediction tool were investigated.
- The development of **user-centric explainable artificial intelligence** and **adaptive human-computer interface** for explaining the conflict detection and resolution tool.

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SESAR-ER4-01-2019

HAAWAII

DLR

idiap RESEARCH INSTITUTE

isavia ANS Air Navigation Services

CROATIA CONTROL

BRNO UNIVERSITY OF TECHNOLOGY

austro CONTROL

NATS

HAAWAII – Main Objectives and Use Case CPDLC / Radar Labels

- **Objective 1 → Exploit massive amounts of ATC voice and surveillance data (for AI-based speech recognition and understanding)**
  - 4100 hours incl. silence (3024 hours from ISAVIA, 1104 hours from NATS incl. London TMA)
  - 500 hours without silence (83 hours from ISAVIA, 403 hours from NATS)

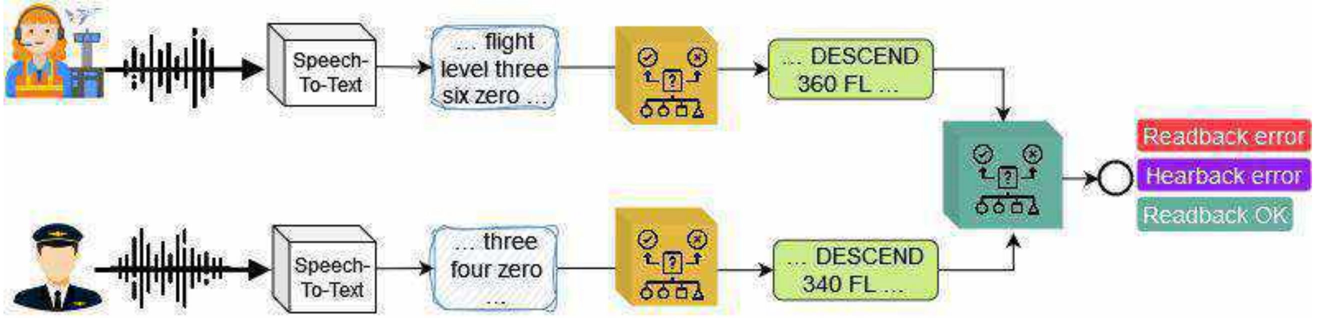
- **Objective 2 → Automatically recognize and understand the controller-pilot communication from operational data**
  - Callsigns correctly recognized: Up to 97.5% (ATCO), 96.0% (Pilot)
  - Commands correctly recognized (incl. callsign): Up to 93.0% (ATCO), 80.0% (Pilot)
  - Errors not automatically detected: Up to 3.6% (ATCO), 9.7% (Pilot)

- **Use Case 1: Automatic Pre-filling of radar labels and CPDLC messages with voice information**
  - Up to 93% of CPDLC relevant content could be recognized automatically
  - Up to 95% of the content for radar label maintenance could be recognized automatically

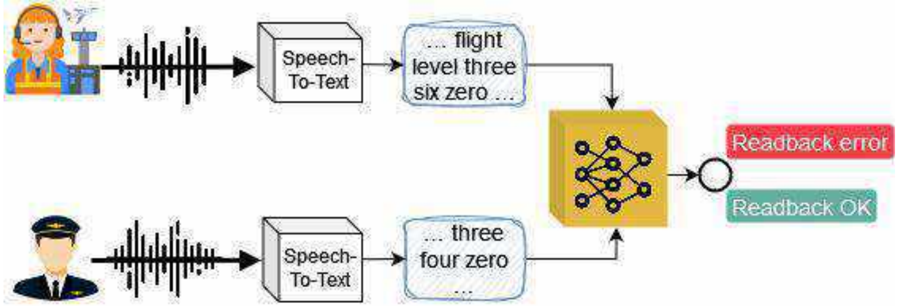
HAAWAII – Use Case Readback Error Detection

- **Use Case 2: Automatic detection of readback errors between ATCO and pilot**
  - 82% of the occurring readback or hearback errors could be identified automatically
  - With 67% a lot of events are still falsely identified as readback errors (further research is needed)

- **Readback Error Detection results are achieved combining two independent approaches**
  - Rule-Based Almost no data needed, but lots of implementation effort for algorithms
  - Data-Driven(AI) Lots of data examples with readback errors (hard to collect) needed
  - **Future Challenges**
    - Which kind of readback error needs ATCO attention?
    - How to collect large amounts of operational recorded readback errors (seldom events) to advance AI approaches?



Rule-Based Approach



Data-Driven Approach

HAAWAII – Applied Technologies

Speech Recognition

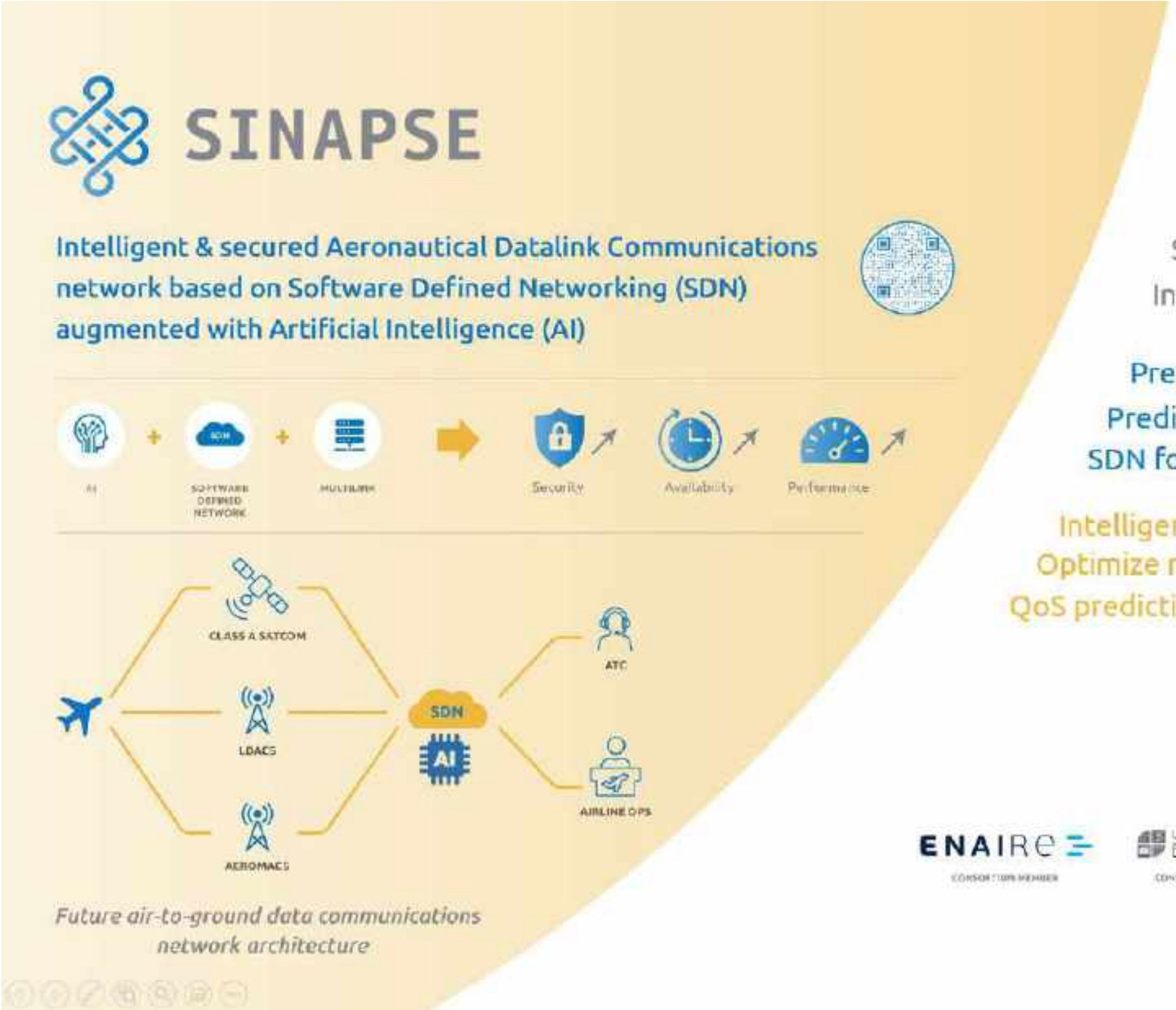
Acoustic Model	Hidden Markov model combined with a CNN-TDNNF. Around 31M parameters.
Language Model	Typical 3-gram language model.

Speech Understanding

Rule-Based	Algorithm based implementation of ontology from SESAR PJ.16-04. and HAAWAII.
Data-Driven-1	Named Entity Recognition with a fine-tuned BERT language model.
Data-Driven-2	Pre-trained T5 model fine-tuned on ATC data.

Readback Error Detection

Rule-Based	State machine implementation, keeps track of the ATCO-pilot communication state.
Data-Driven	Sequence classifier based on BERT pre-trained encoder in a cross-encoder setup.



Intrusion and Prevention Detection System

Securing AI for Cybersecurity Attacks

Intelligent Cybersecurity Functions

Prevent ATN CPDLC Provider Abort

Predict safety services outages

SDN for ATN powered by AI

Intelligent future multi-link

Optimize networking

QoS prediction

ALTYS TECHNOLOGIES

ENAIRE

UNIVERSITY of BRADFORD

FREQUENTIS

Project website

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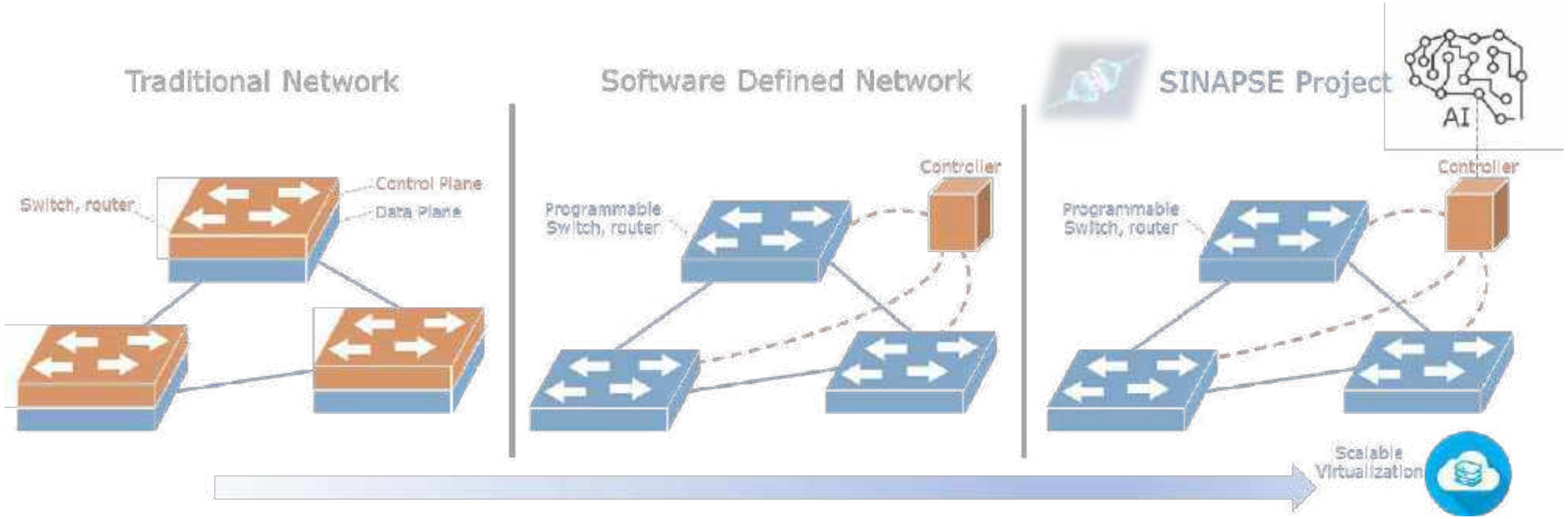
SINAPSE objectives

Intelligent & secured Aeronautical Datalink Communications network based on Software Defined Networking (**SDN**) augmented with Artificial Intelligence (**AI**)

- Predict and prevent safety services outages (e.g., ATN CPDLC)
- Optimize networking (e.g., QoS prediction and path selection)
- Intelligent Cybersecurity functions



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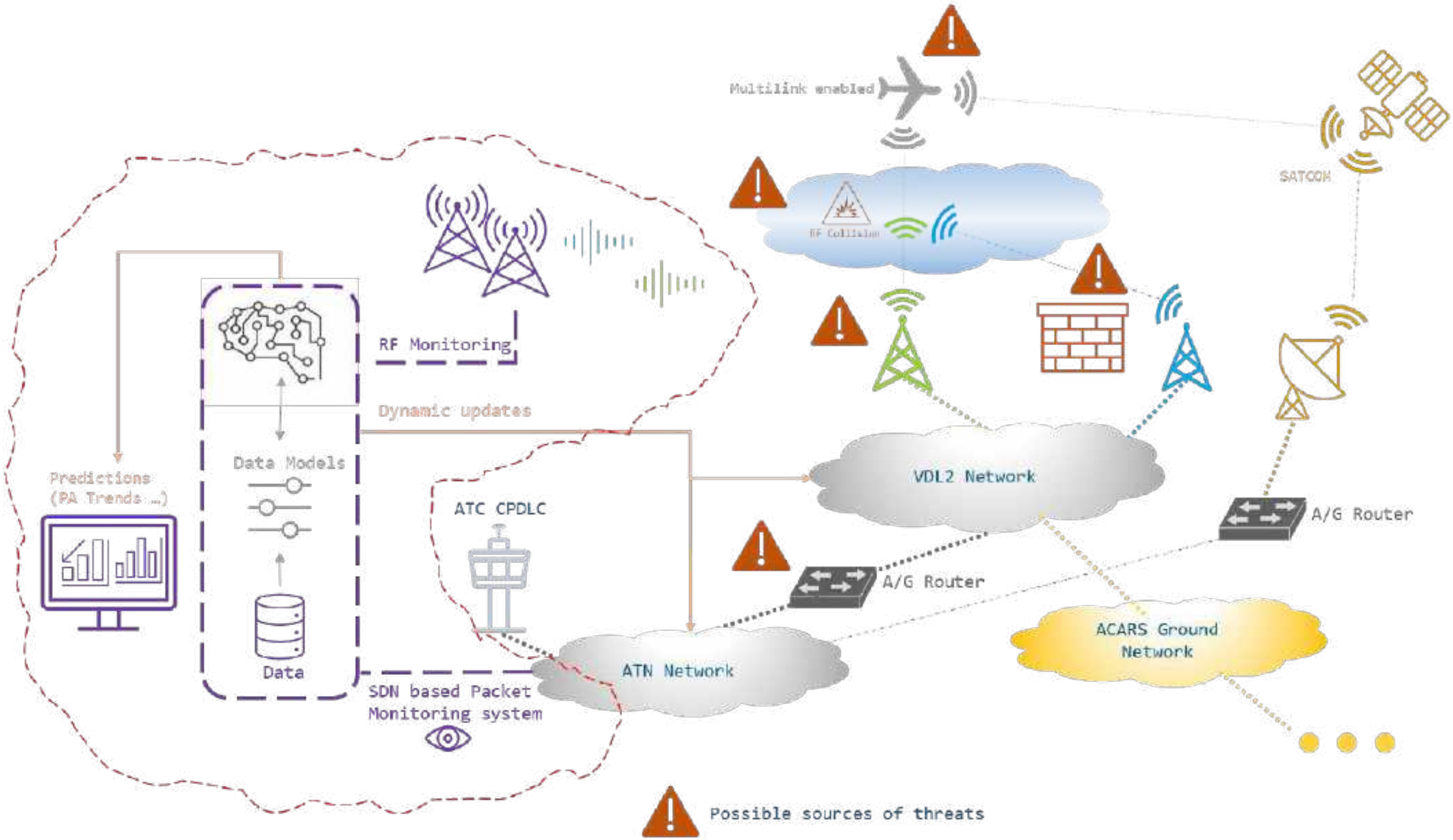
Predict and prevent safety services outages



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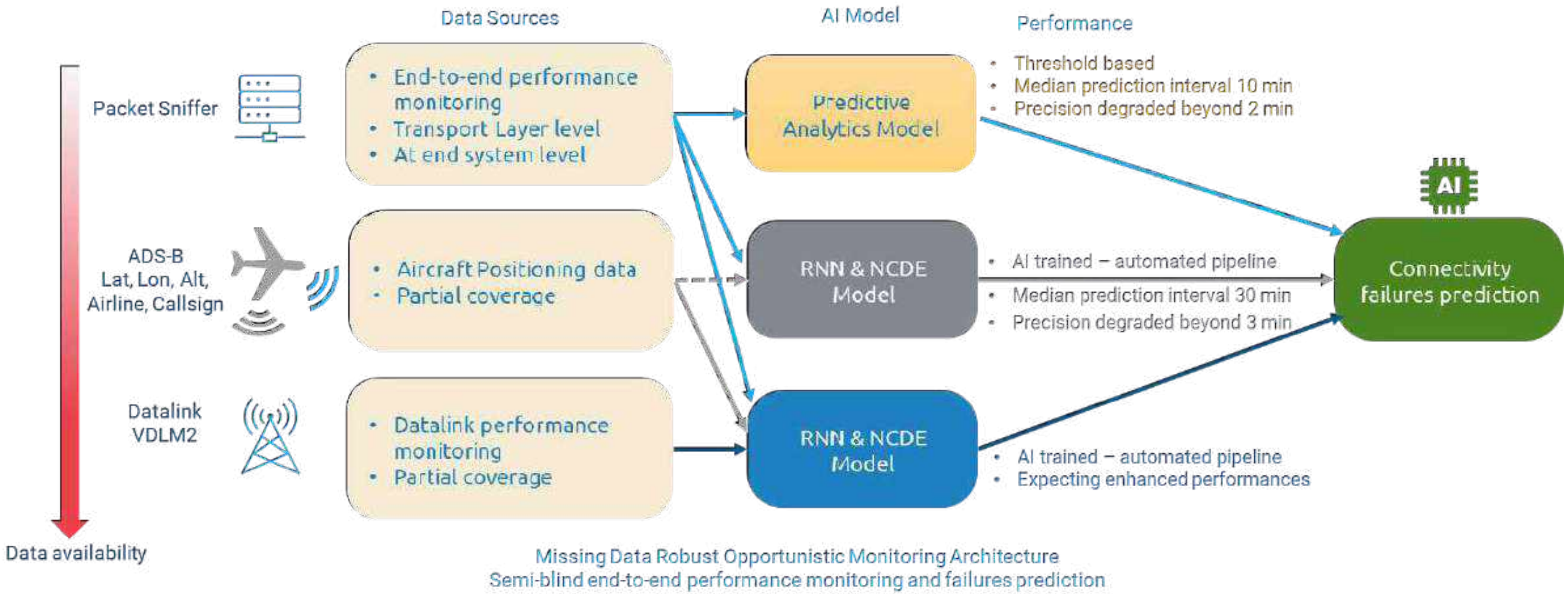
AI/ML approach Prediction



DATA Availability

- Complementary top to down
- Unbalanced data as rear outage events

DATA Sources

- Network
- Positioning
- Radios

Type of ML Models

- RNN & NCDE Models can predict using partial data (i.e., attributes not always available)

Predictions

- Cross check with detected events from operational system

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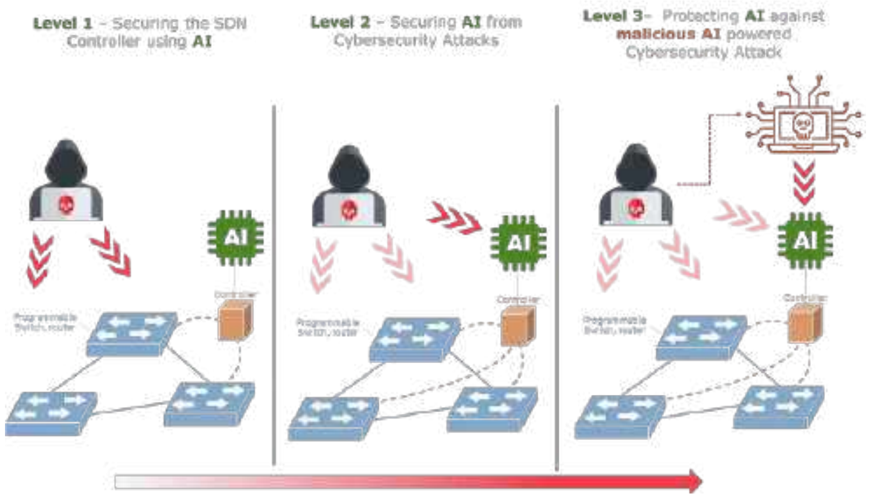
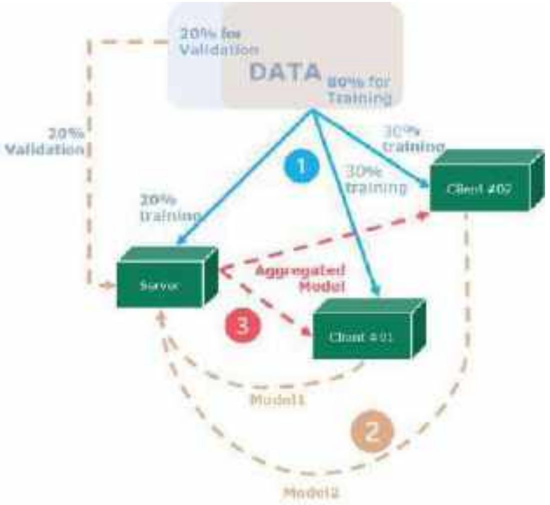
AI Methodologies, Prototypes and Results

- Identified **AI methodologies** suitable for **cybersecurity** and **safety services**, including **RNN**, **LSTM** and **NCDE**.
- **Promising performance** results using operational data for cybersecurity and safety use cases
- **Prototyped datalink failure prediction** solution using real-time monitoring over ANSP network
- ML methodologies **predicted failures for satellite data and voice link communications**
- **Federated collaborative learning prototyped** and assessed for cybersecurity models





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