Optimised ATM network services

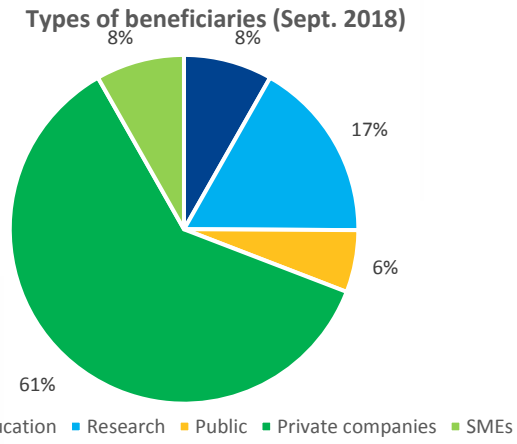
Session introduction

Oznur Uygur

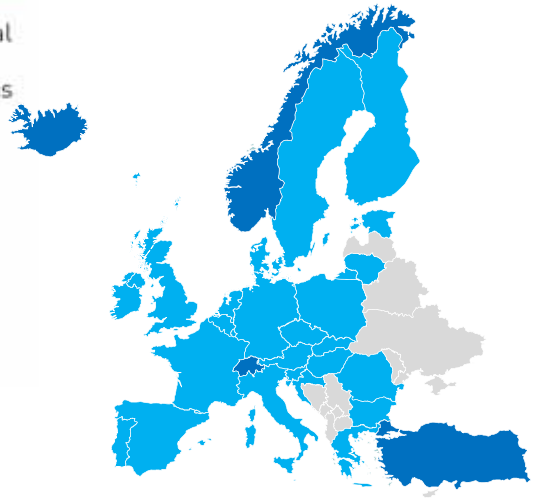
SESAR Joint Undertaking

SESAR: Technological pillar of Single European Sky and key enabler for the Aviation Strategy

SESAR 2020 projects: blended academic & industrial expertise



26 EU Member States participating



EU Member States with SESAR 2020 funding

Third-countries with SESAR 2020 funding (also incl. Israel, Australia, United States, Canada...)

2019 2020 aerodays TANDEM

Bucharest, 27-30 May 2019

European Commission

SESAR Innovation Pipeline: integrated approach

EXPLORATORY RESEARCH

Explores new concepts beyond those identified in the European ATM Master Plan or emerging technologies and methods. The knowledge acquired can be transferred into the SESAR industrial and demonstration activities.

INDUSTRIAL RESEARCH & VALIDATION

Assesses and validates technical and operational concepts in simulated and real operational environments according to a set of key performance areas. This process transforms concepts into SESAR Solutions.

VERY LARGE SCALE DEMONSTRATIONS

Tests SESAR Solutions on a much larger scale and in real operations to prove their applicability and encourage the early take-up of solutions.

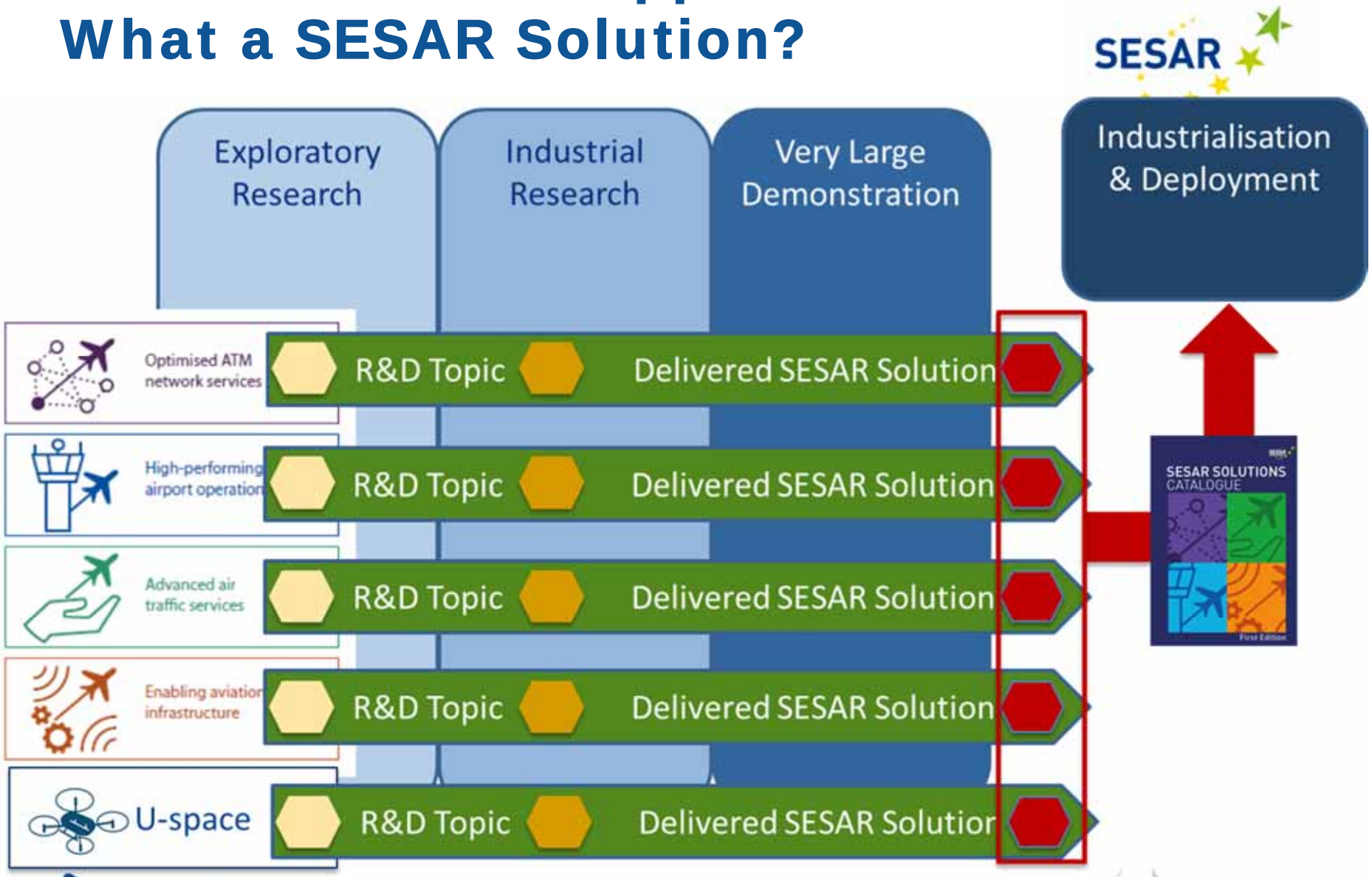
Solution –oriented approach
What a SESAR Solution?

SESAR Solution: Programme output of R&I activities which relates to either an operational or a technological improvement which have been designed, developed and validated in response to performance needs identified in the European ATM Plan.

There are two type of SESAR Solutions:

- SESAR ATM Solutions
- SESAR Technological Solutions

Solution –oriented approach
What a SESAR Solution?



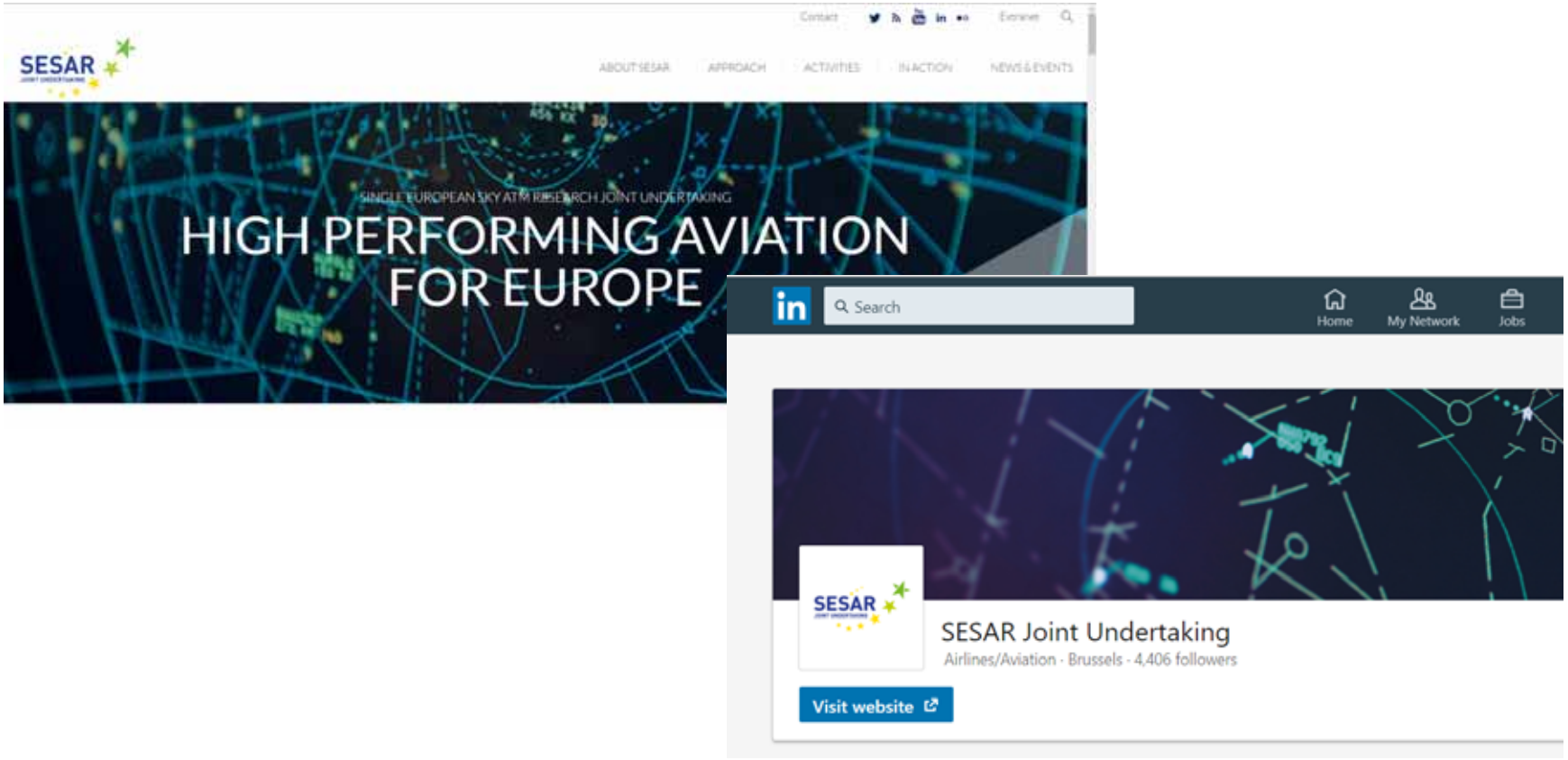
DELIVERING TIMELY SOLUTIONS

- **63 SESAR Solutions** and **candidate solutions** in the pipeline
- **40+ already under deployment** across Europe
- Disseminated through **EU aviation standards**
- Clear associated benefits: **safety, efficiency, capacity and the environment**
- **Globally applicable**

- **www.sesarju.eu**

Communication

https://www.sesarju.eu



SESAR 2020 Projects to be presented in this session

PJ08 AAM

Evo ATM
Evolutionary ATM

PJ09 DCB

PJ07 OAUO

Thank you !

Bucharest, 27-30 May 2019

Integrating Social Aspects in an Agent Based Model of Air Traffic Management System: a Case Study

Eng. Domenico Pascarella, Ph.D.

Intelligent Systems, Verification & Validation **Laboratory**

Scientific & technical goals

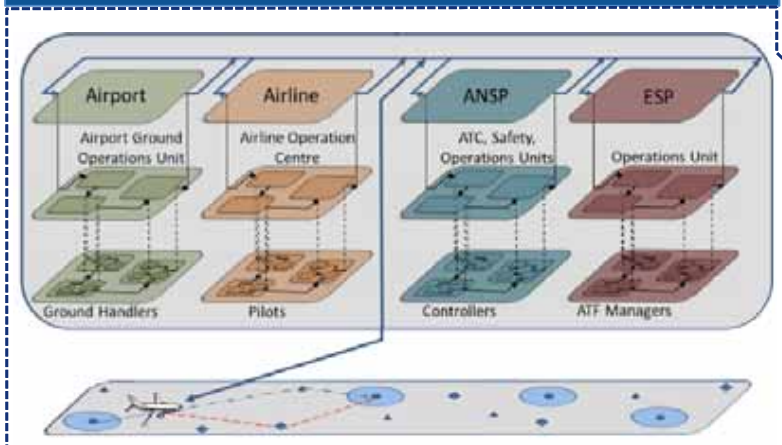
Call for Proposal
SESAR-ER3-06-2016

Challenge

To better understand and model how architectural and design choices influence the ATM system and its various behaviours

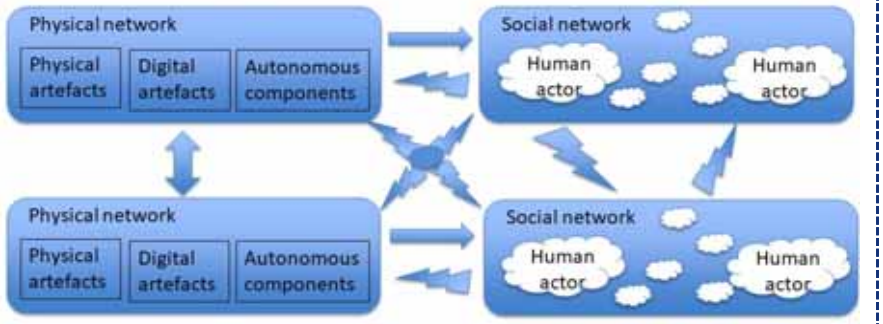
Context

ATM as a **complex socio-technical system**



Scope

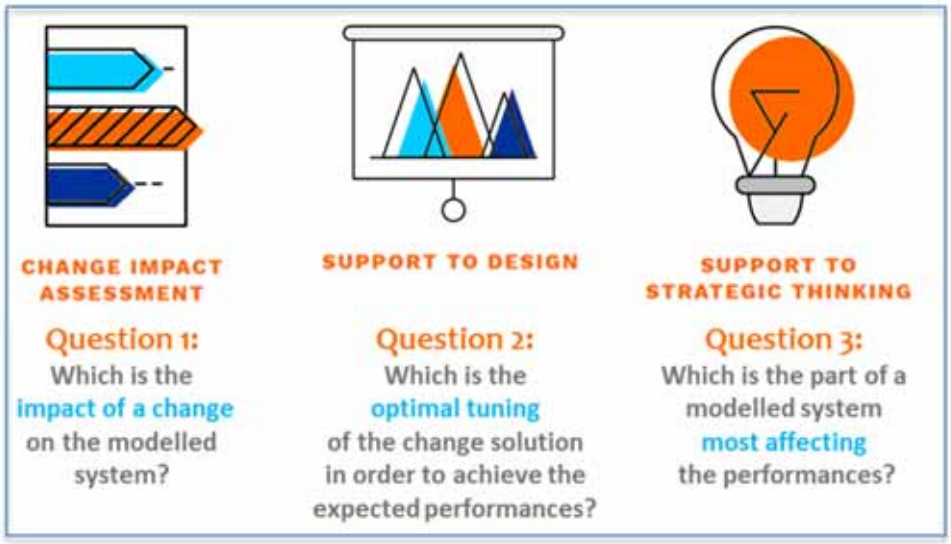
- Start by capturing the characteristics of today's system, to then analyse and propose approaches for **change management**
- Innovative ideas for ATM system design incorporating **flexibility** Formal mathematical approaches at **early phases of system design**
- Better understanding of the **interdependencies** among the different ATM subsystems and their impact on the overall ATM system



Scientific & technical goals

Main Goal

*To build a **methodological framework** to model how architectural and design choices influence the ATM system and behaviors, and vice versa how the expected ATM performances influence the design choices*



Detailed Goals

Modelling the functionalities of ATM architecture by using the **agent-based paradigm** for a proper integration technical and human aspects	G1
Combining the agent-based paradigm with an **evolutionary computing** approach in order to define a solver which identifies an optimal tuning of the change	G2
Combining the agent-based paradigm with **sensitivity analysis** to understand the influence of parameters on the performances at different levels	G3
To setup the proper **performance framework** at system level and at component level	G4
To deliver an **open demonstrator** to show the effectiveness of the approach in known scenarios (**Direct Routing** & **Free Routing**)	G5

Scientific & technical goals

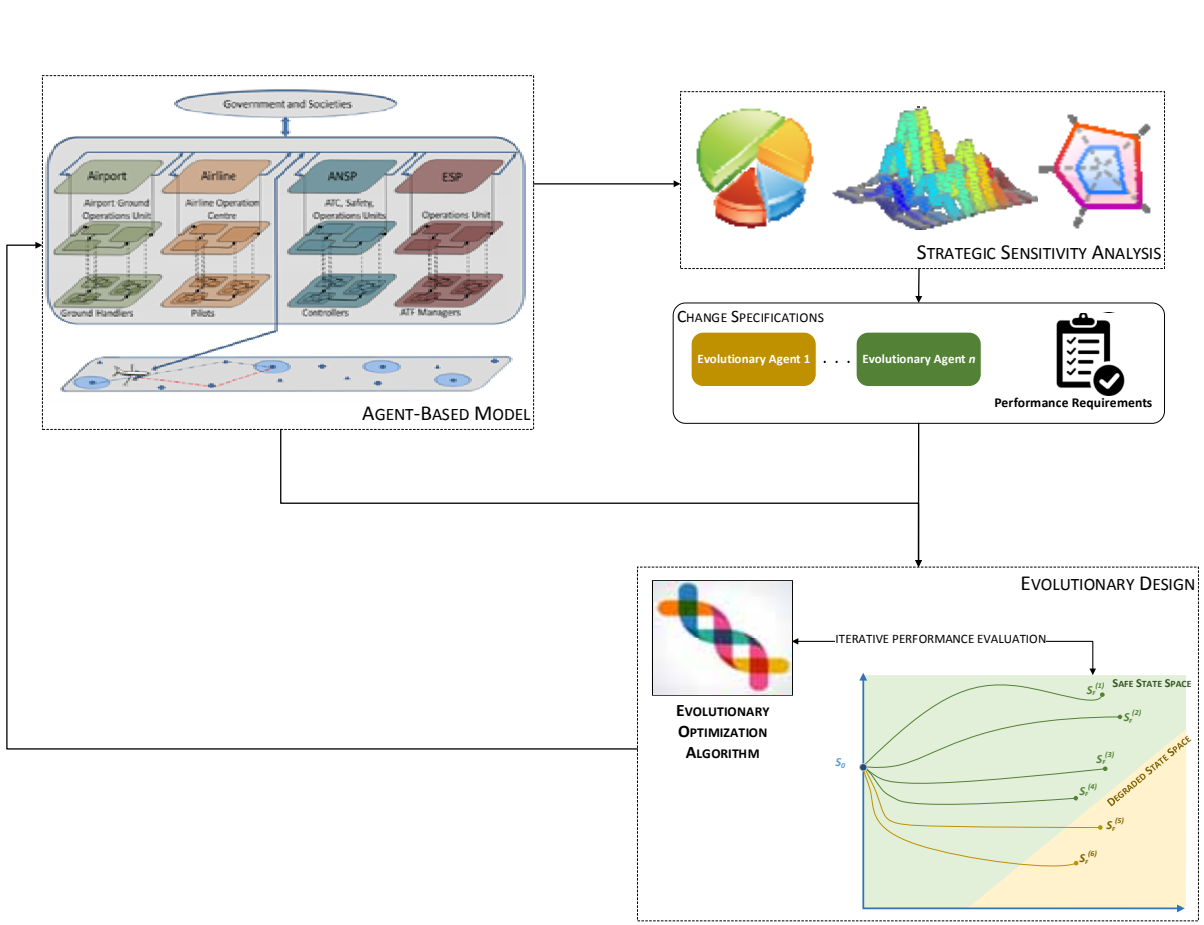
Combines in a unique **methodological framework**

Agent-Based Modelling
for the automated **Change Impact Analysis**

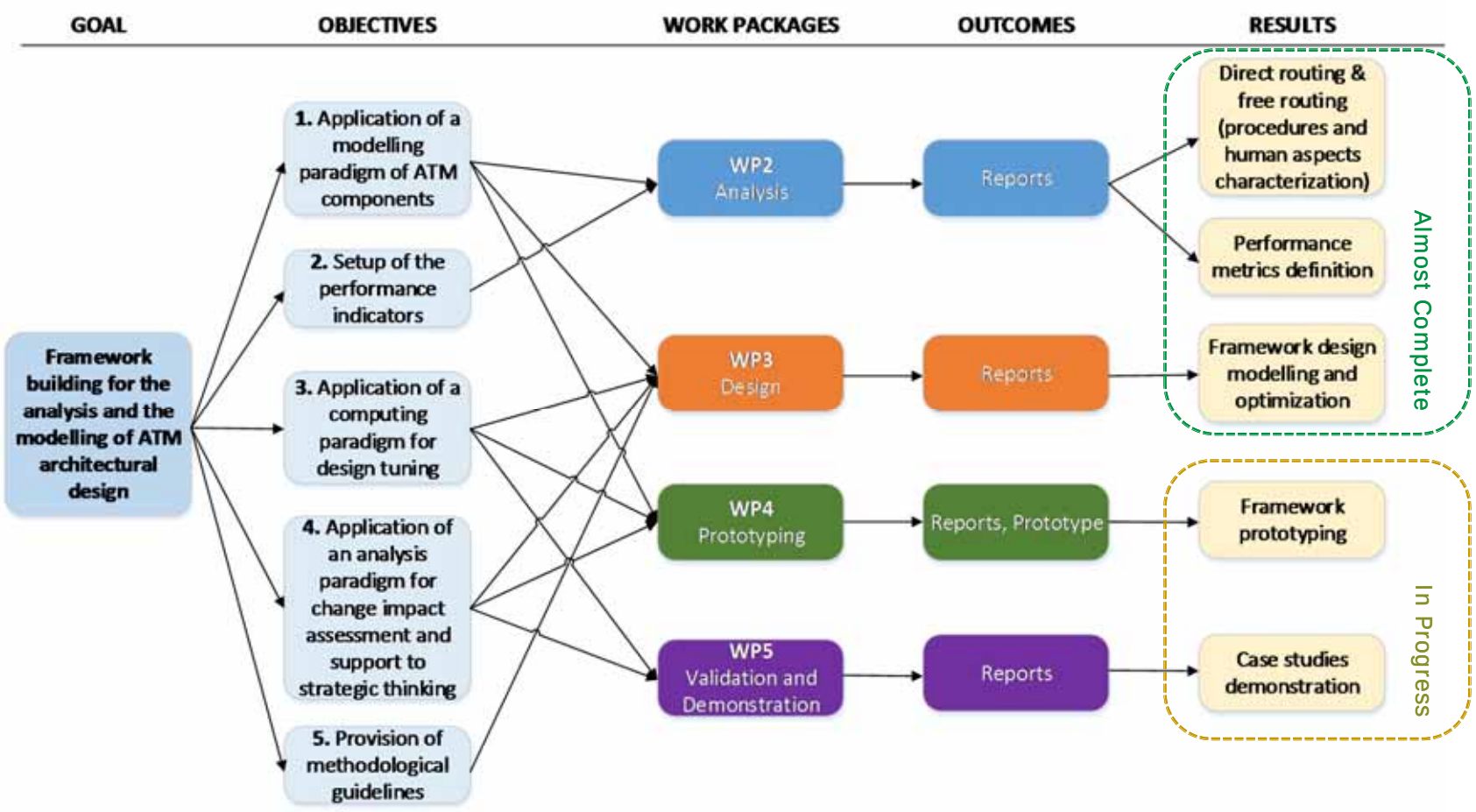
Evolutionary Computing
for the automated reasoning on the **Support to Design**

Sensitivity Analysis
for the automated reasoning on the **Support to Strategic Thinking**

to **reduce human-in-the-loop activities** in preliminary analysis of changes

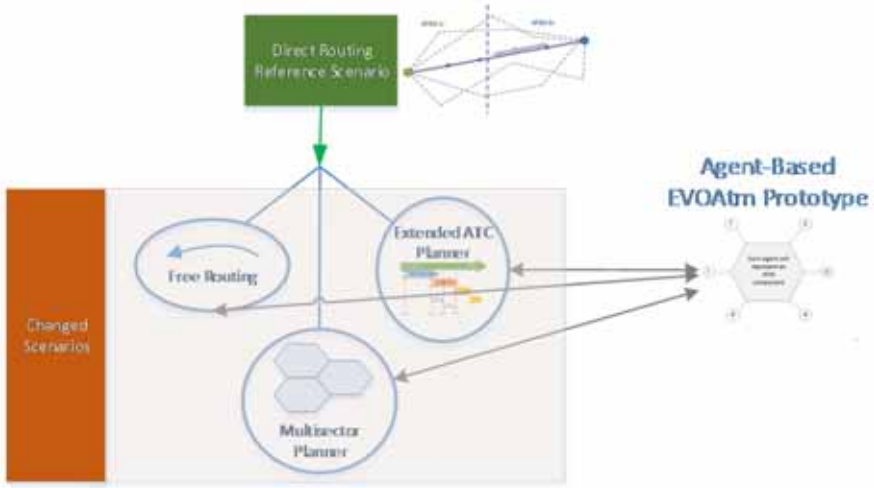


Main achieved and expected results

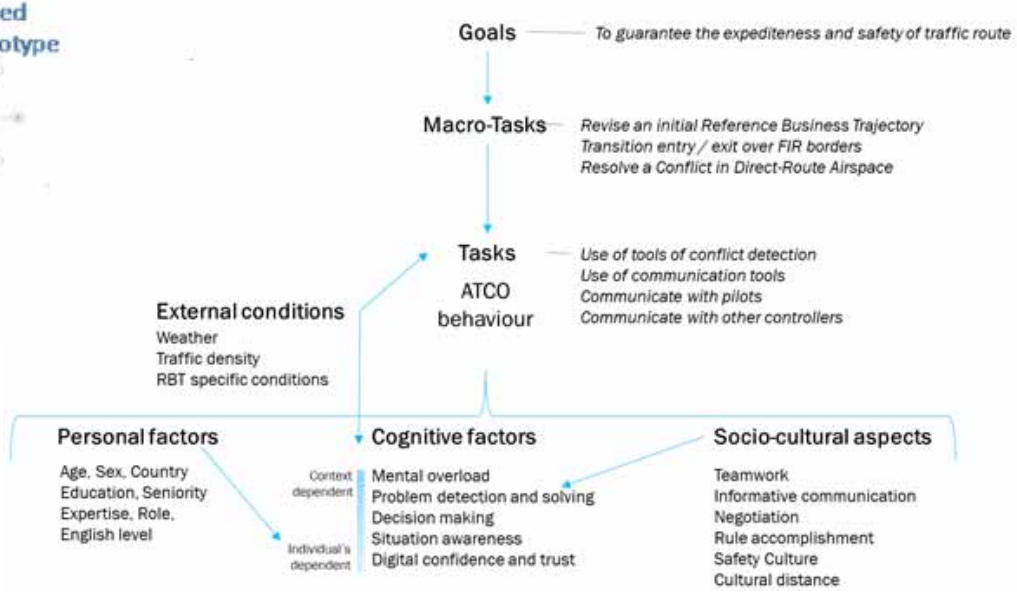


Main achieved and expected results

Three-Level Analysis (Procedures, Human Characterization, Performance)



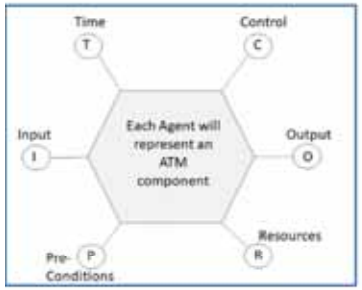
KPA	PM1 Timeliness	PM2 Fuel Consumption	PM3 Separation	PM4 ATCO Workload
EFFICIENCY	*	X	X	X
COST-EFFECTIVENESS	X	*	X	X
SAFETY	-	-	*	X
ENVIRONMENT	X	X	-	-
HUMAN RESOURCES	X	-	-	*



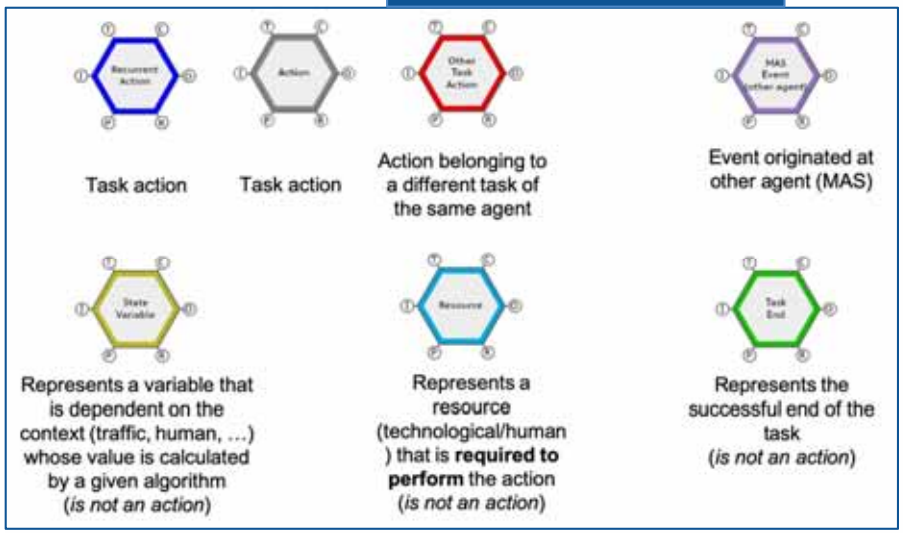
Main achieved and expected results

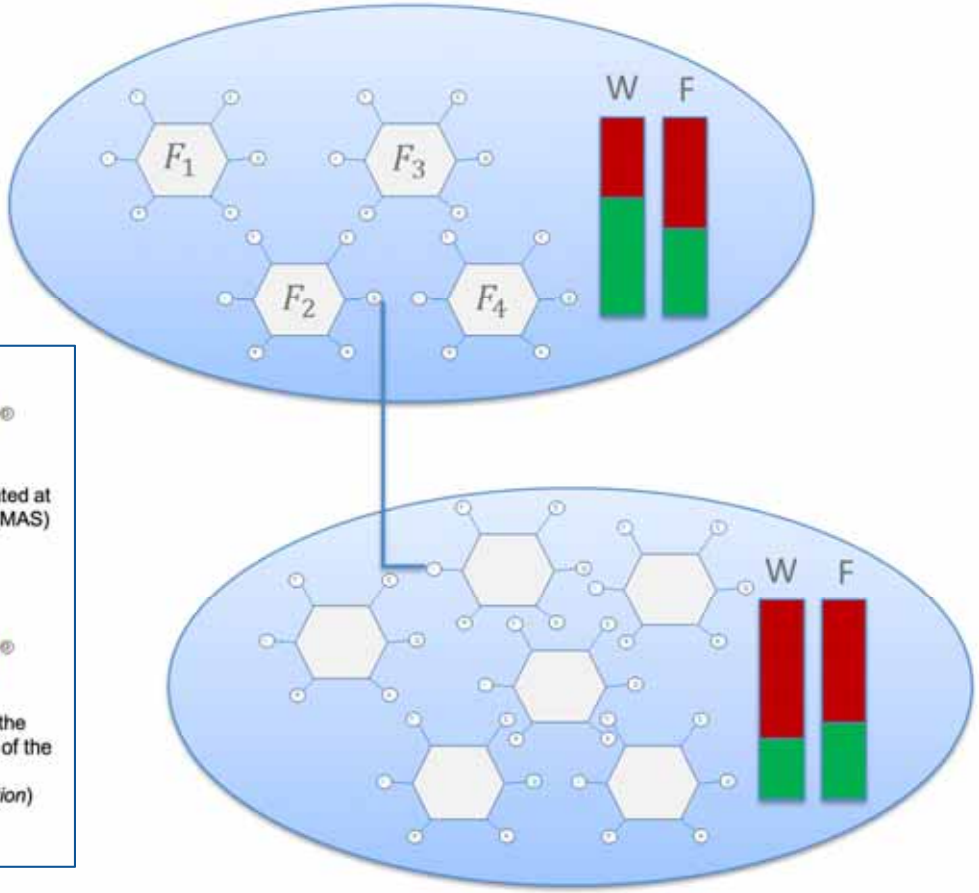
Design – Agent-Based Modelling

Innovative specification by **FRAM** notation



EVOAtm FRAM Catalogue





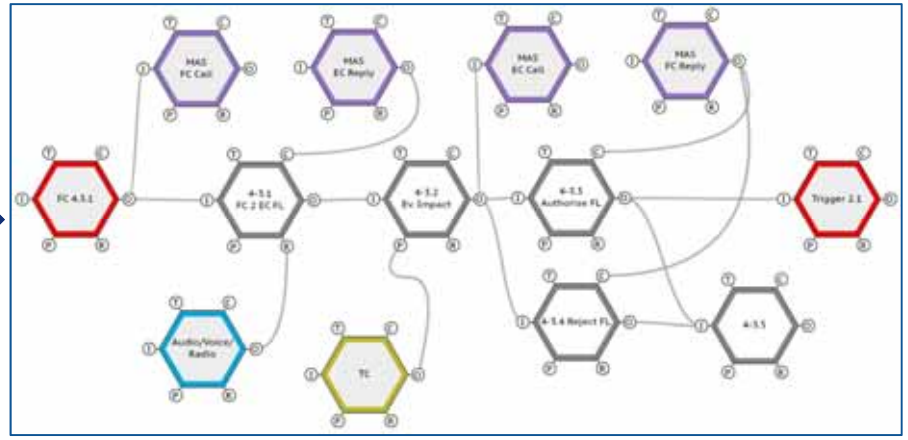
Main achieved and expected results

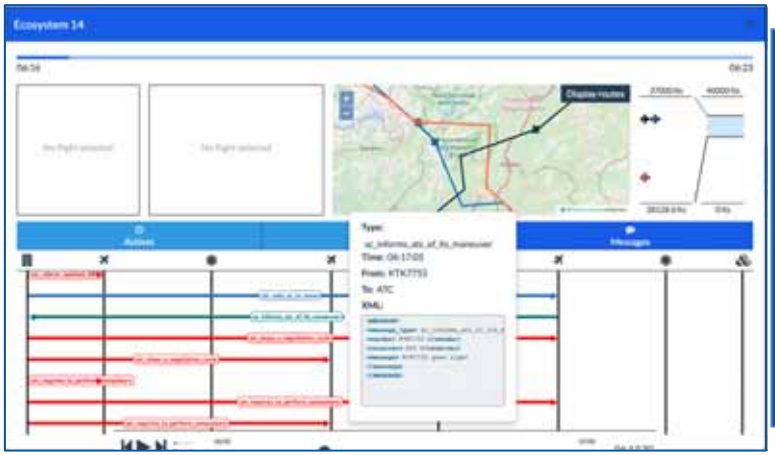
Design – Agent-Based Modelling

Flow Characterization

EC – Flight Handover

FRAM Model



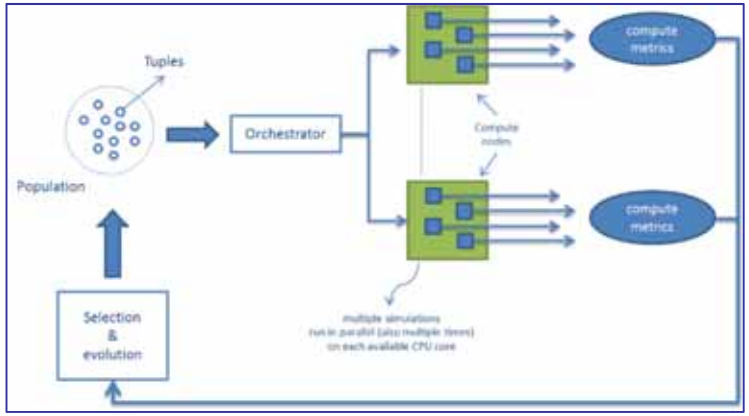


Agent Ontology

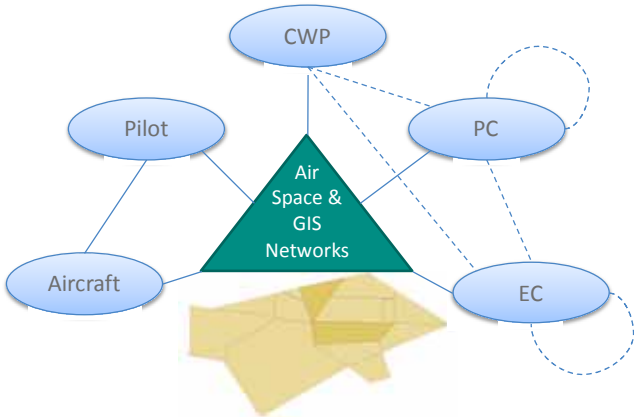
Main achieved and expected results

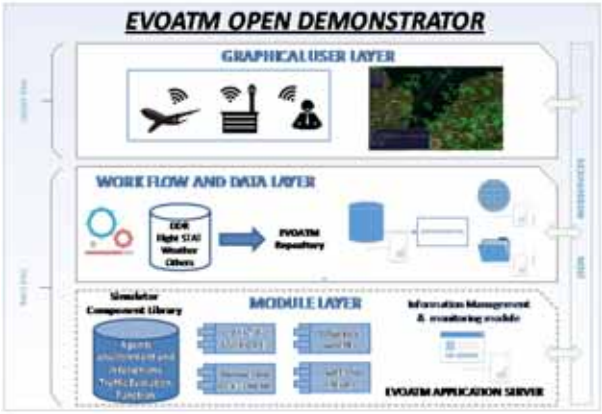
Prototype – Open Demonstrator and Evolutionary Multi-Objective Optimization

Exploratory Research (ER) project targeted to an applied research (V1 maturity or TRL 2)



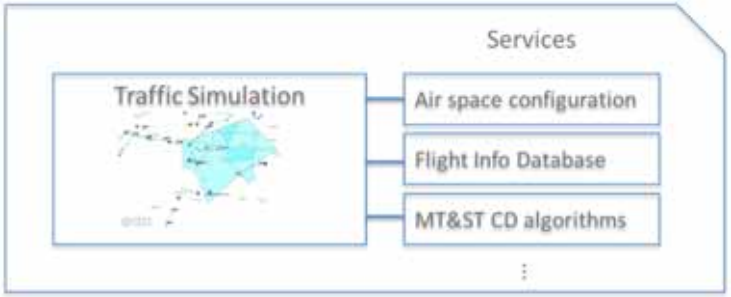
Optimal tuning of ABS parameters



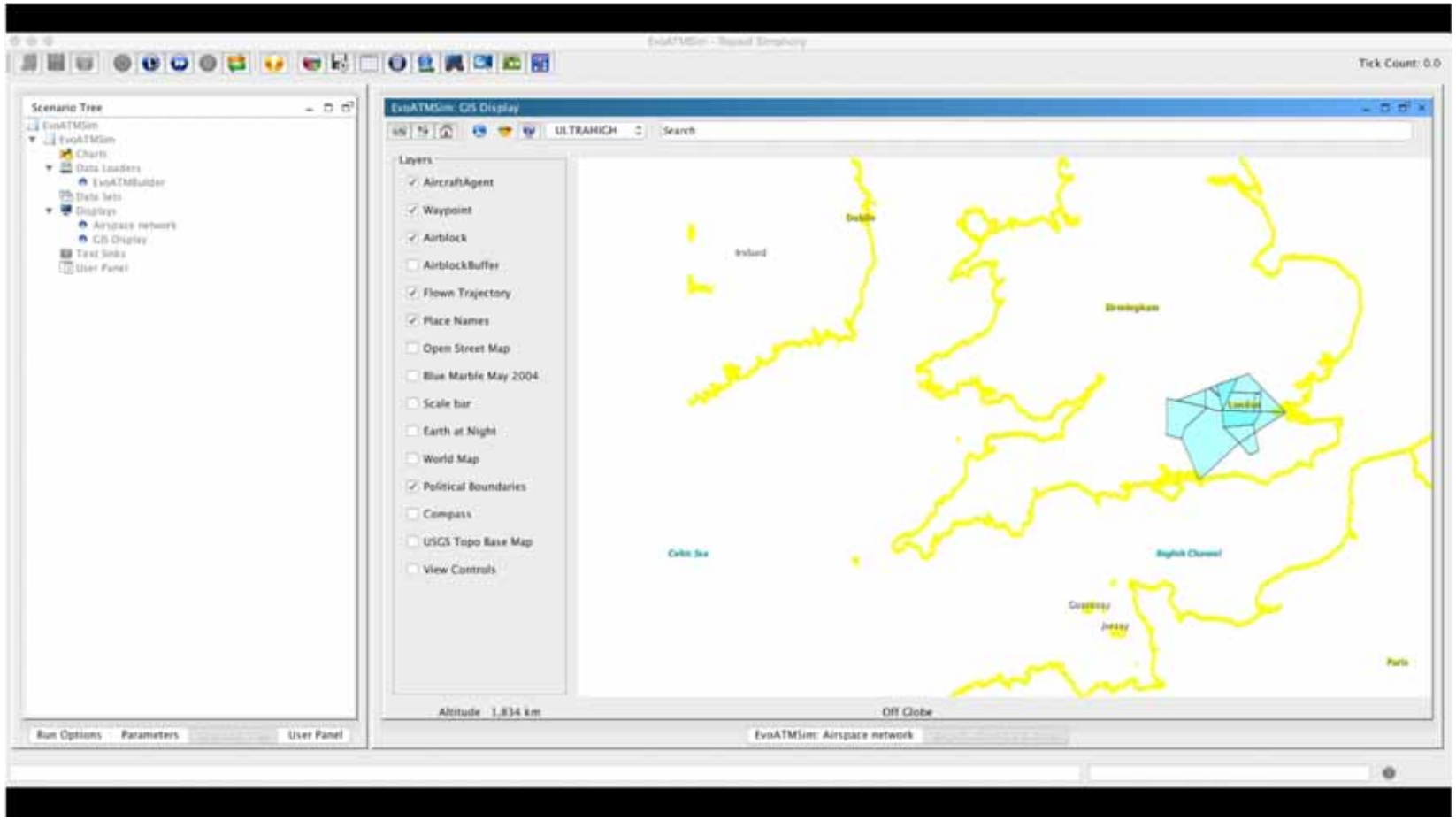


EVOAtm ABS

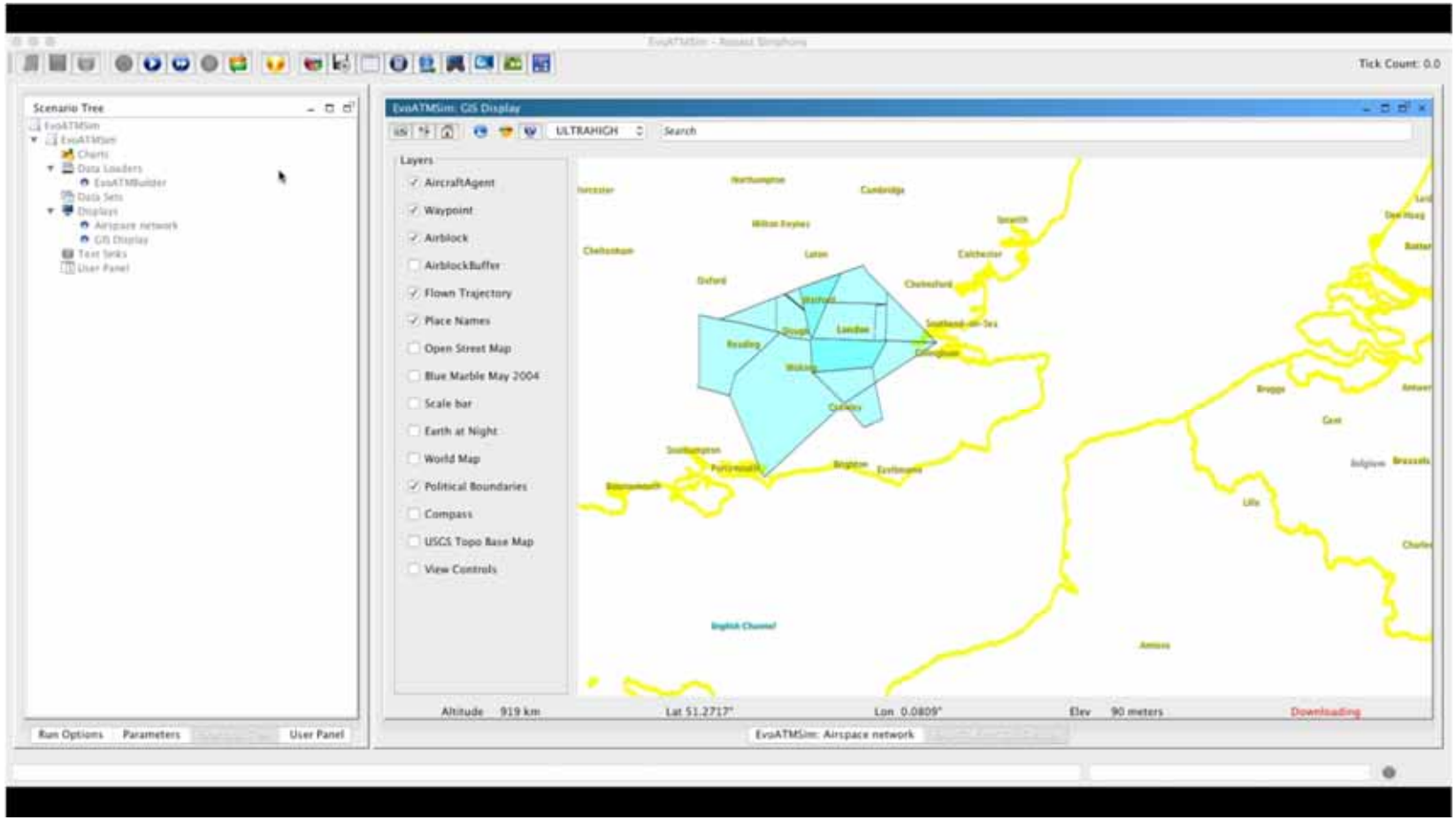
EVOAtm Libraries



Main achieved and expected results



Main achieved and expected results



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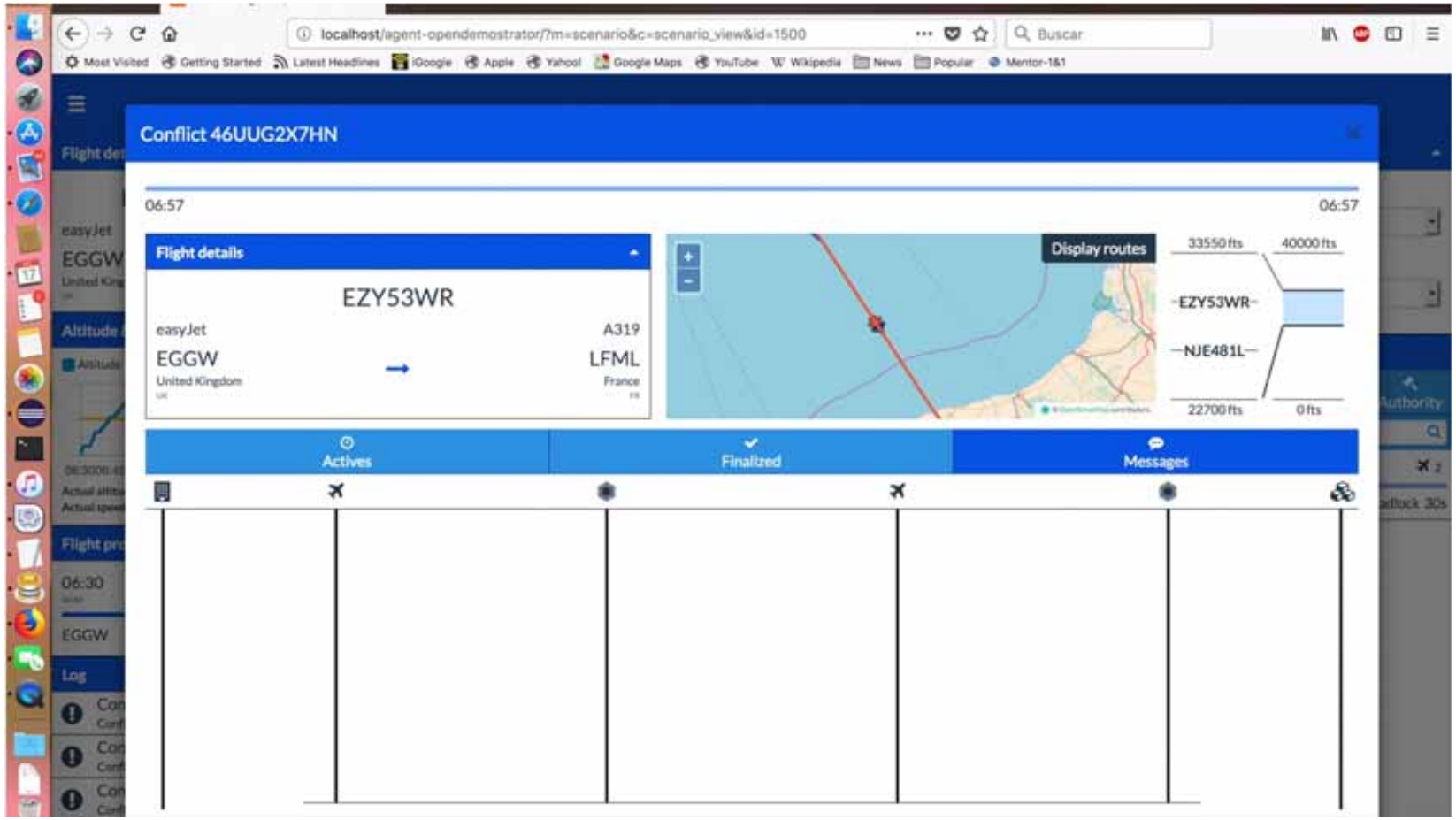

Potential gaps and challenges

Faced Challenges

- **Accuracy** of the hybrid model-based process (FRAM + MAS) for the abstraction level
- **Accuracy** of the cognitive characterization
- **Computability** of the multi-objective optimization for the support to design
- **Computability** of the sensitivity analysis for the support to strategic thinking
- **Cost-efficiency** and **user-friendliness** of the methodological workflow
- **Validity** of the methodology (Advisory Board support – ENAV, ENAIRE, etc.)

Further Research

- **Extension** of ABS functions & tasks catalogue
- **Extension** of human characterization
- **Refinement** of the methodological workflow

Cross-cutting issues (tech & non-tech.)

- Detailed analysis of **Sibling Projects**

- State-of-the-art analysis for the faced challenges
  - PACAS
  - CASSIOPEIA
  - ELSA
  - MAREA
  - AURORA
  - APACHE

- Possible cooperation with **DOMINO**
  - Mutual participation in the Advisory Boards

Impacts

Expected Impacts

- *Provide suitable means of assurance for validation or evidence to support decision-making*
  - Early high-level validation of ATM solutions with human characterization
  - Discover of emergent aspects of the changes
  - Effective tuning & feedback for the design
  - Reduced human support for validation

- *Provide suitable means of assurance for validation or evidence to support strategic thinking*
  - Automatic identification of the most critical components/parameters for the performance dimensions
  - Pushing of a proactive approach

Impacts to Assess

- *Patent for the Open Demonstrator*
  - OD evolution through maturity gates

- *Integration with other platforms*

Useful infos and acknowledgements

EVOAtm (EVOlutionary ATM)
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EVOAtm project has received funding from the SESAR Joint Undertaking with GA No. 783189 under European Union's Horizon 2020 research and innovation programme

Thank you !

Bucharest, 27-30 May 2019

Advanced airspace management

SESAR PJ08

Giuseppe MURGESE
EUROCONTROL

Operational Context

Today's airspace architecture is largely structured around national boundaries with sectors designed to reflect controller workload.

The factors within the current architecture that limit overall maximum capacity, as well as the scalability and resilience of the System are not new and are already known by the industry.

Operational Context

Factors limiting overall capacity	• Non-optimal organisation of airspace • Limited use of data communications • Limited opportunity to create new sectors • Limited automation support for controllers
Factors limiting capacity scalability and resilience	• Limited predictability • Limited information sharing and interoperability • Limited flexibility in the use of controller resources across ACCs • Geographical constraints on air traffic service provision

Research carried out by EUROCONTROL as part of the Advanced Airspace Management Project PJ08 within Europe's Single European Sky ATM Research (SESAR) modernization Programme proposed a radically different approach:

"The 'packaging' of en route routes, optimized trajectories, airspace reservations and ATC sectors into ***Airspace Configurations*** *which are designed and* ***dynamically*** *managed together* ***to respond*** *flexibly to* ***different performance objectives*** *that* ***vary in time and place****"*

The Dynamic Airspace Configurations (DAC) Concept in S2020

Operational & technical goals

- DAC uses information about predicted traffic demand and user preferred trajectories to work out dynamically defined airspace sectors (including Cross-border Airspace configurations) in response to different performance objectives

- DAC facilitates Civil/Military Coordination -> Dynamic Mobile Areas of two types - DMA type 1 and 2
- DAC is also a CDM process based on Integrated ASM/ATFCM services (managed both at Local and Network Level)

- Automation/system support for integrated Airspace design and management is key -> Investigating the use of AI techniques

- Performance oriented -> more efficient Capacity management
- Fixed route structure with pre-defined sectors (today) -> Full Free Route Airspace Operations (tomorrow)

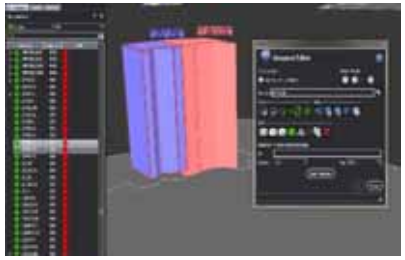
The main expected results

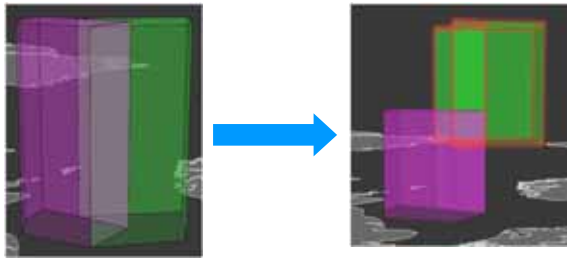
- Enhance the functions building sectors and configurations that can be dynamically adapted in response to changes in traffic patterns

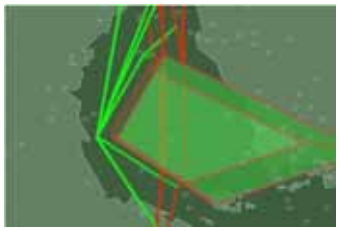
- Develop Flexible Airspace designed to deploy the resources (ATCOs) needed for meeting the forecasted AUs' traffic demand

- Develop the Dynamic Mobile Areas, temporary volumes of airspace designed to separate the activities performed inside from civil traffic

- Planning and activation of Airspace configurations through an integrated collaborative decision making process

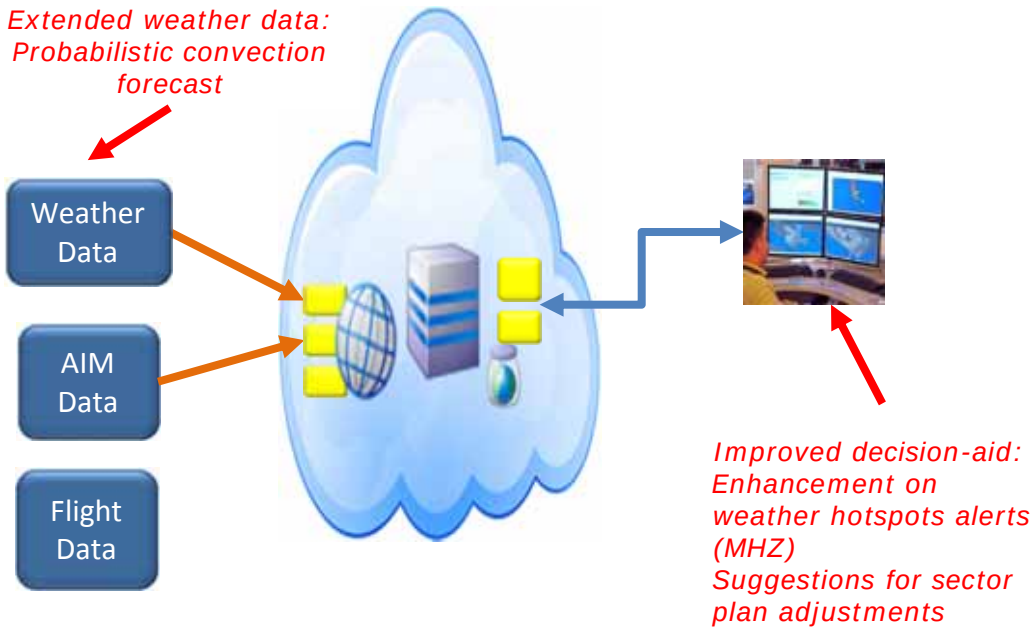






The main expected results

- Impact assessment of hazard zones due to weather phenomenon (evolving in 4D), and their integration in the DAC process
- Introduction of Dynamic Mobile Areas type 3



The main achieved results

- Performance Assessment of Dynamic Sectorization and DMAs type 1 and type 2
- Acceptance and workability of DAC from ATCOs' perspective
- DAC in a flow-centric approach
- Operational feasibility of the DAC Planning CDM process at Regional and Local level
- Use of AI techniques to define Capacity of Dynamic Airspace Configurations

The main Benefits & Impact

- Flexible use of airspace and increase of airspace Capacity through Dynamic Airspace Configurations including DMAs (supported by automated tools)
  - Increase (1,79%, Validation Target) of en-route capacity in nominal conditions under Free Route Airspace
  - DAC and DMA decrease flight duration variability in Free Route Airspace compared to static ARES

- Improved Efficiency through ATFCM/ASM integration
  - Cost Efficiency through optimum use of available human resources
    - Increase of Cost Efficiency (0,53%, Validation Target) of the flight per ATCO hours
  - Increased Fuel Efficiency
    - Positive impact on Environment (fuel efficiency, 4.85%)

The main Benefits & Impact

- Improved management of available airspace and coordination between Military authorities and Airspace Users
  - Positive impact on Civil and Military Collaboration and Coordination (no target)

- Military flight and operational efficiency increased by performance improvements to civil stakeholder
  - Relationships DMA types 1 and 2 allocation management concept with the Business and Mission Trajectory, Free Routing and DCB concepts
  - Evidence of Operational feasibility of the concept and performance benefits when the Concept is integrated into the in the Free-Route environment

- Effective exchange of information (collaborative decision making in planning)
  - Evidence of the usability of automated support for the decision-making process assessing and comparing different airspace configurations based on complexity

Potential gaps and challenges

- Current Airspace (non-optimal) organization – **Airspace Architecture Study by NM and SJU**
- Limited opportunities to create new sectors - **Airspace Architecture Study by NM and SJU; DAC evolution in S2020**
- Limited predictability - **Airspace Architecture Study by NM and SJU**

- Civil-Military ATM integration – **Civil Military Stakeholder Committee (CMSC) proposal; DAC and DMAs evolution in S2020**

- Limited automation (for controllers) to build dynamic sectors allowing better workload balance – **Further use of Artificial Intelligence (AI) techniques in S2020**

Useful info and acknowledgements

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https://www.eurocontrol.int/articles/advanced-airspace-management-sesar-2020-pj08-aam

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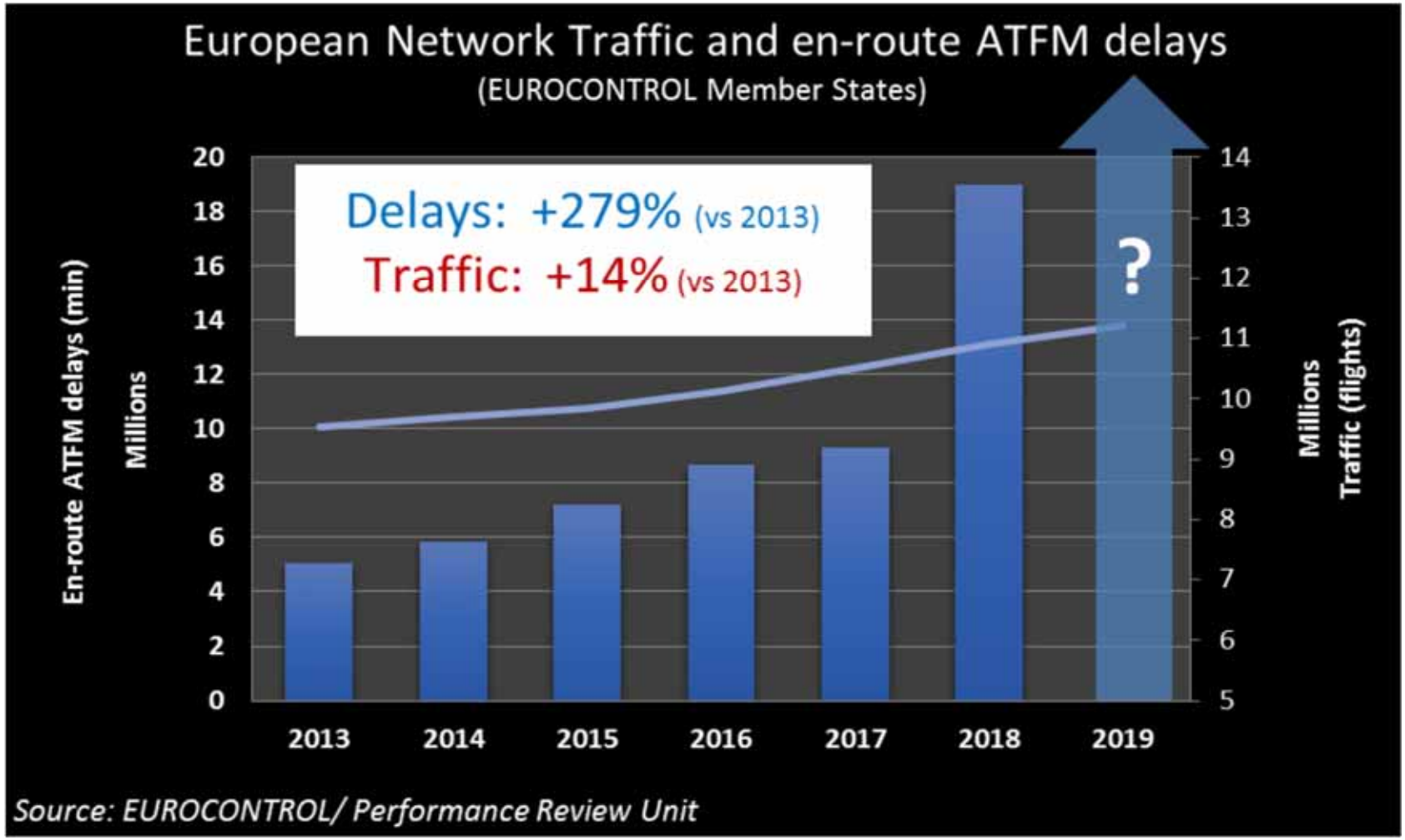
Thank you !

Bucharest, 27-30 May 2019

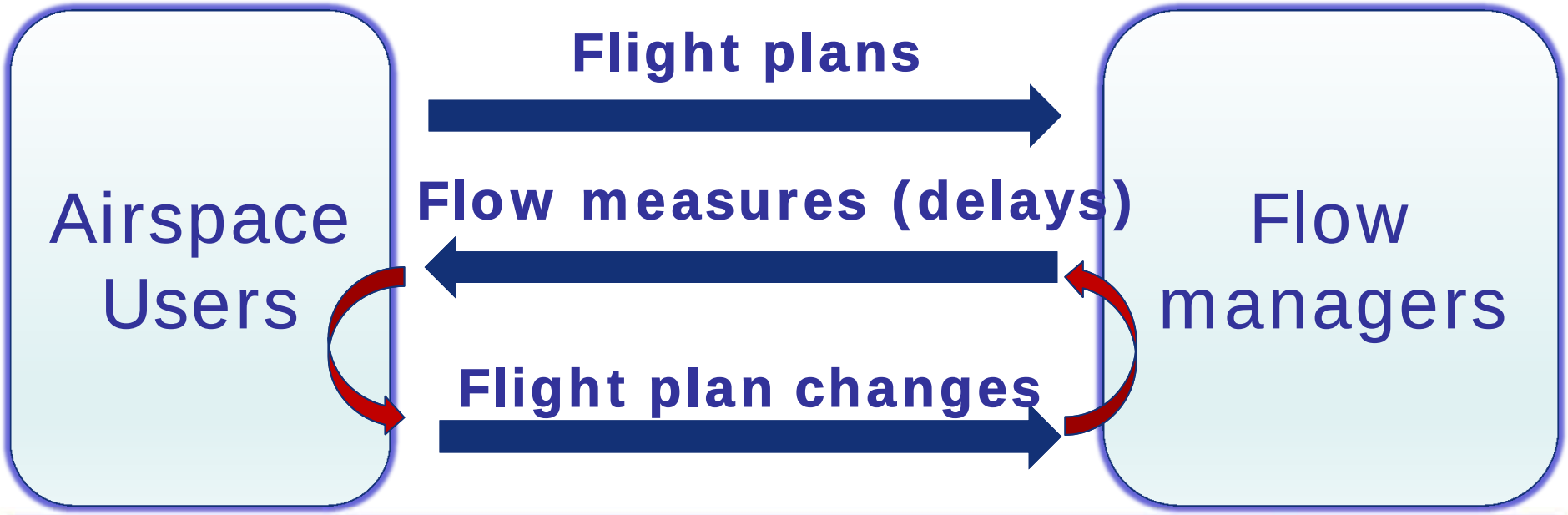
Airspace Users preferences

SESAR OAUO and DCB Projects
Gérard MAVOIAN
EUROCONTROL

Operational context



Operational goals



- Minimise impact of flow measures on AUs flight costs
- Better use spare network capacity
- Reduce operators workload through increased automation
- Increase network planning stability in the day of operations

Technical goals

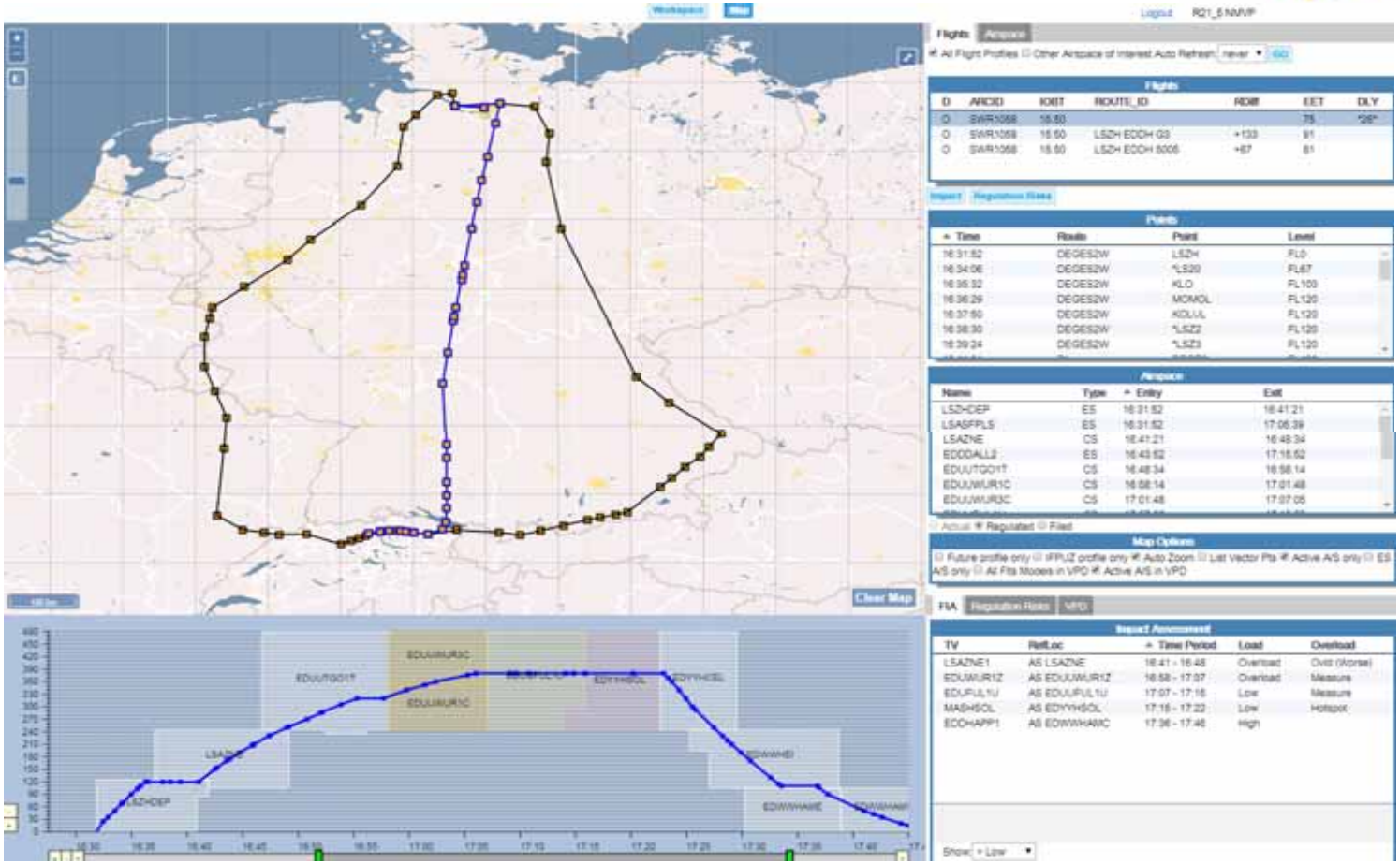
New flow management services to support Airspace Users flight planning

- Detailed congestion information along planned trajectories
- Advanced what-if functions
- B2B services to enable automation of AU decisions
- Worldwide standardisation context (ICAO FF-ICE)

New procedure for AUs to express their preferences

- A criticality indicator can be set by AUs for “important flights” of their fleet for which punctuality is critical
- Flow managers look at “protecting” these flights by:
  - Removing or reducing ATFCM delay if possible
  - or proposing alternative route/vertical profile to avoid/reduce delay

Prototype developments



Example of congestion information along planned trajectories

Main expected benefits

Delay reduction

25% reduction can be targeted in winter days due to better use of spare network capacity

AU operating costs reduction

~7000 flights with ATFCM delay and 1000 flights plan changes due to ATFCM reasons in busy days => partial automation may significantly reduce dispatchers workload.

Delay costs reduction

For critical flights, ATFCM delay cost: 10K€ – 20K€ per flight.

Network stability

Around 15 % of the Airspace Users flight plan changes can be avoided thanks to better awareness of ATFCM situation

Potential gaps and challenges

Need to mitigate the risk of increased network demand instability due to automation of Airspace Users' decisions

- Introduction of "protection spots" concept for flow managers to "control" Airspace users' flight plans changes
- Change equity rules in ATFCM delay allocation by penalising late flight plan changes creating new network problems

Prioritisation of critical flights shall not impact equity

- Ensure transparency by sharing information between all actors during operations and in post-operations
- Clear rules about the number of "critical flights" allowed per user

Impact

Inputs to the Network Manager implementation plans

- Aircraft Operator What-if Re-route evolutions (short term)
- Flight Delay criticality Indicator (short term)
- FF-ICE planning service implementation plan (2022-2025)

Inputs to standardisation groups related of FF-ICE increment 1 (ICAO)

SESAR Wave 2 will further address system interoperability aspects between flow management and Airspace users flight planning systems.

Useful info and acknowledgements

SESAR OAUO 07.01 solution
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SESAR DCB 09.03 solution
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Stella.saldana@eurocontrol.int

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Thank you !

Bucharest, 27-30 May 2019