AI Situational Awareness Foundation for Advancing Automation — AISA

Concept of Operations Workshop

On-line meeting, 16 September 2020

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

Overview

Purpose of the Workshop:

- Present the AISA ConOps to stakeholders
- Gather feedback on ConOps
- Discussion about future work

Agenda:

- Presentation 45 minutes
- Q&A, discussion 45 minutes

Presentation:

- Future ConOps
- AISA Project
- AISA ConOps

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AISA Consortium

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ZAV Center for Aviation

AISA project has received funding from the SESAR JU under grant agreement No 892618 under European Union's Horizon 2020 research and innovation programme.

AISA Framework

This project addresses the call topic "*Digitalisation and Automation principles for ATM*".

The framework for this project is to propose a solution which builds the foundation for successful cooperation between human and machine.

The scope of the project is to present a vision of automation in a specific ATM operational environment (en-route ATC) and address the challenges of transparency and generalization.

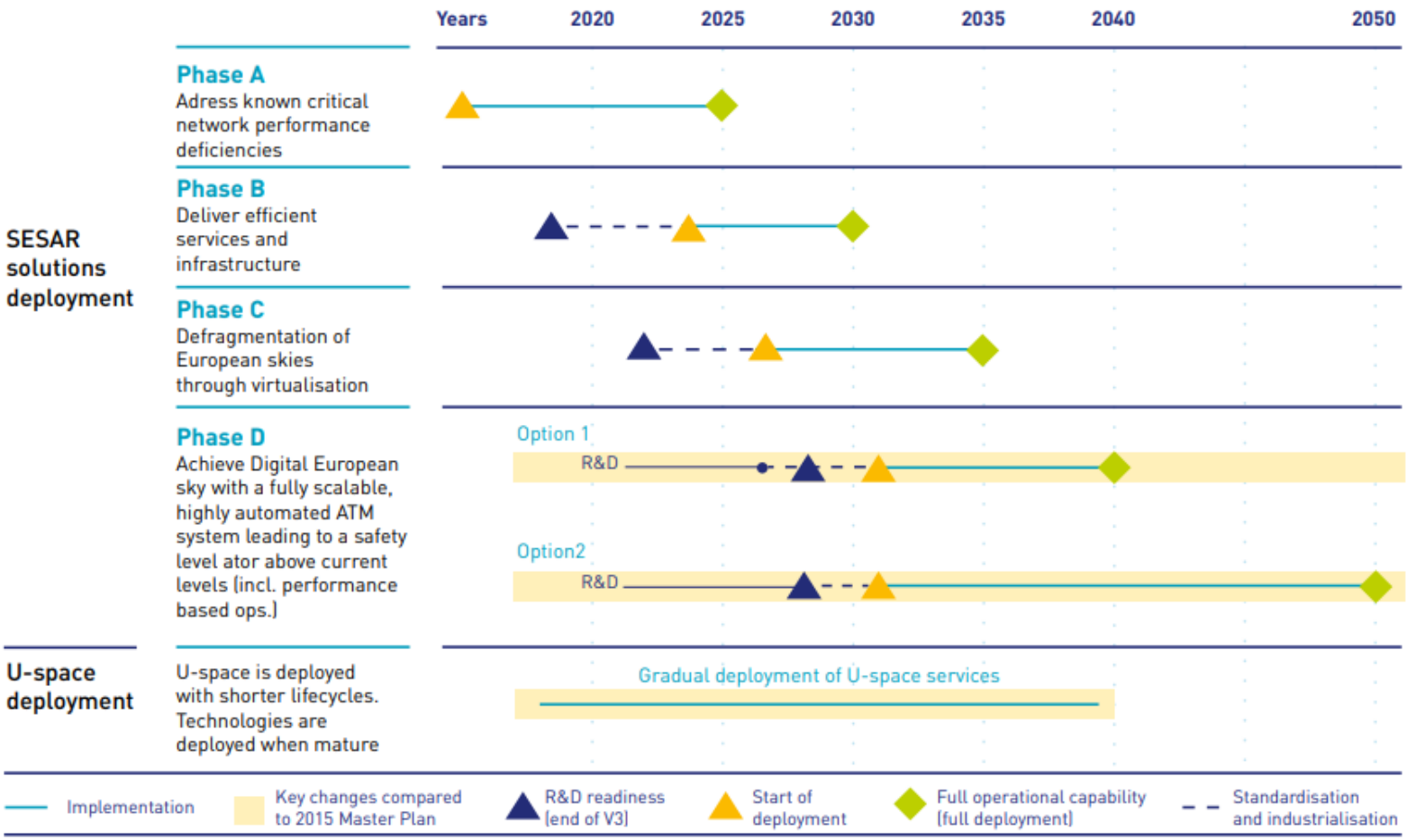
Future ConOps According to ATM Master Plan

Future ConOps

- Prepared according to ATM Master Plan and the SESAR ConOps
- Used here to ‘set the stage’ for AISA
- Concept of Operations explains more about ‘what?’ will be done
- AISA is more about ‘how?’ will things be done

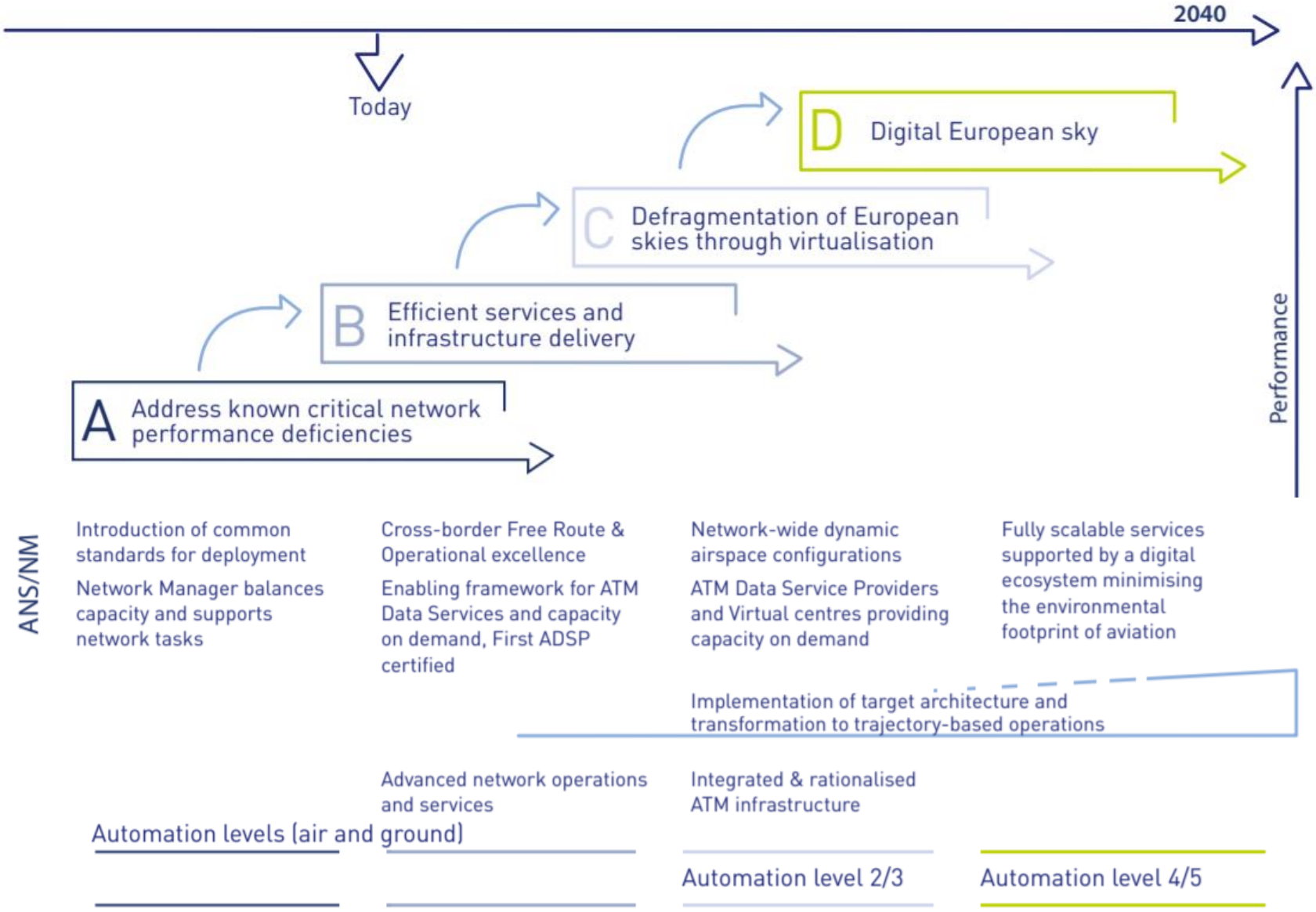
Future ConOps

FIGURE 16. **TARGET ROLLOUT OF SESAR**



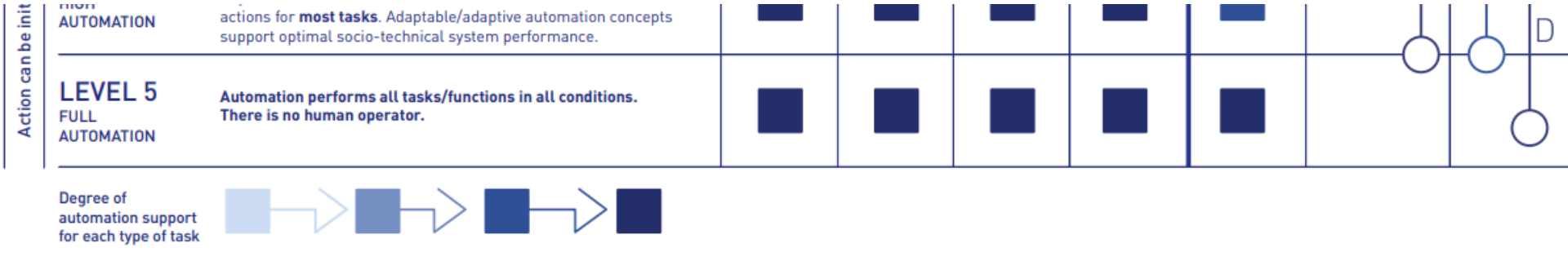
European ATM Master Plan

WP 2 – Concept of Operations (6)



WP 2 – Concept of Operations (7)

Definition	Definition of level of automation per task				Automation level targets per MP phase (A,B,C,D)		
	Information	Information	Decision and	Action	Autonomy	Air traffic control	U-space
LEVEL 2 TASK EXECUTION SUPPORT	Automation supports the human operator in information acquisition and exchange, information analysis, action selection and **action implementation** for **some tasks/functions**. Actions are always initiated by Human Operator. Adaptable/adaptive automation concepts support optimal socio-technical system performance.						
LEVEL 3 CONDITIONAL AUTOMATION	Automation supports the human operator in information acquisition and exchange, information analysis, action selection and action implementation for **most tasks/functions**. **Automation can initiate actions** for **some tasks**. Adaptable/adaptive automation concepts support optimal socio-technical system performance.						



Future ConOps – SESAR Operational Key Features

Optimised ATM Network Services

- Optimised AU operations
- Advanced airspace management
- Advanced DCB

Advanced Air Traffic Services

- Advanced air traffic services and trajectory management
- Conflict management
- Enhanced arrival and departures

High Performing Airport Operations

Transversal Topics

- Trajectory-based Operations
- Free route operations

- SESAR ConOps

Future ConOps – En-route ATCO's Tasks

- **What will ATCOs tasks look like in 2035 and 2040/2050?**
- Difficult to predict exactly, especially for 2040/2050 horizon
- Some tasks:
    - ...will be made obsolete
    - ...will be delegated to automation
    - ...will be supported by automation
    - ...will be new

Future ConOps – En-route ATCO's Tasks

E.g. Conflict Management

Currently:

- Conflict detection - done by ATCO with support of CDT
- Conflict resolution - done by ATCO (EC)
- Conformance to the solution - done by ATCO (EC), supported by conformance monitoring tools
- Update aircraft's plan - done by ATCO (EC)

SESAR ConOps for 2035:

- Strategic conflict detection and resolution – done by Network Manager via Reference Business Trajectory negotiation
- Early (medium- to long-term) conflict detection – done by Planner Controller (MSP or EAP) with support of MTCD tools and coordinated via *Integrated Network Manager and Extended ATC Planner* (INAP)
- Early conflict resolution – done by EC or PC of the upstream sector, supported by conflict resolution tools, accomplished via RBT negotiation, coordinated via INAP
- Tactical conflict detection – done by CDT, monitored by ATCO
- Tactical conflict resolution – proposed by CR tools, approved by ATCO, uploaded via CPDLC
- Conformance management – fully automated

Future ConOps – En-route ATCO's Tasks

Future ATCO's tasks:

- More automation/tools
- More integration
- More interdependencies
- More coordination
- Changing roles

Many hurdles along the way. One of them: **How to make human and machine work together?**

What do we want from AI/automation?

*European Aviation/ATM industry and European Network operations shall rely on **Trustworthy Human Centric AI** solutions to:*

- *improve its operational performances and international competitiveness*
- *support the realization of recent EU initiatives focusing on aviation/ATM digitalization*

Further exploration of the potential of AI in aviation/ATM should be strengthened in areas of:

- *high impact on aviation/**ATM performance** and environment*
- ***human-machine collaboration***
- *safety-critical operations*
- *safety intelligence tools and cyber threat intelligence services*

- **European Aviation/ATM AI High Level Group**
  FlyAI Report, 2020

A small detour - AI Waves

	1st Wave	2nd Wave	Modern 2nd Wave	3rd Wave
When:	1960s – 1980s	1980s – 2010s	2010s –	2020s –
Technology:	Expert Systems	Machine Learning	Deep Learning	?
Algorithms:	Logical Rules	Statistical Methods	Statistical Methods	? Hybrid Methods
Learning:	Difficult	YES	YES	YES
Uncertainty:	NO	YES	YES	YES
Explainable:	YES	NO	NO	YES
Data Needs:	Modest	Large	Huge	Modest

Adapted from Jésus García

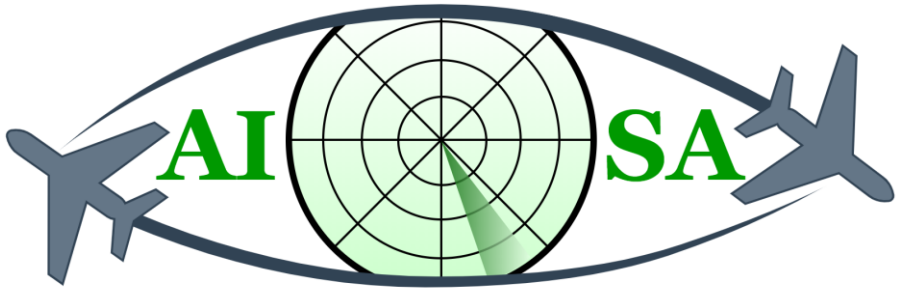
Desirable Traits of AI/Automation

- Safety
- Efficiency
- Collaboration
- Coordination
- Complementarity
- Explainability
- Small data needs

Avoid:

- Deskilling
- Annoyance
- OOTL
- Complacency

Some of these goals can be achieved by human and machine sharing the situational awareness



AI Situational Awareness Foundation for Advancing Automation — AISA

AISA Objectives

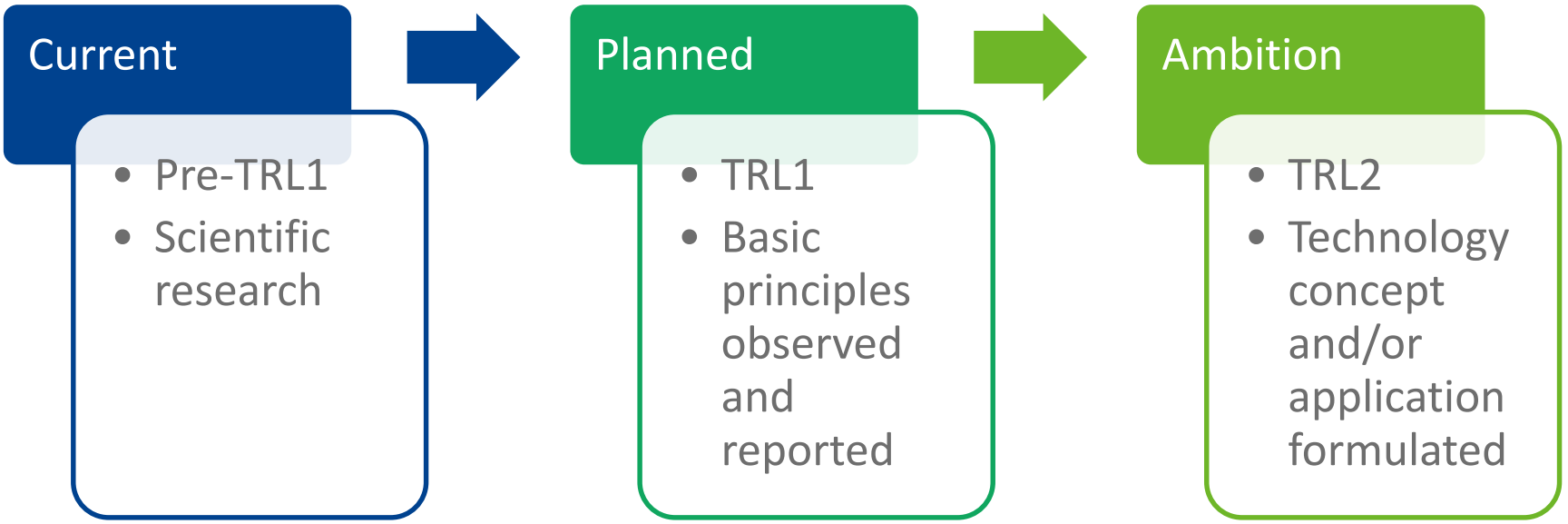
Overall objective:

- Increase the possibility for introduction of automation in air traffic management (ATM) by researching domain-specific application of transparent and generalizable artificial intelligence methods.

Specific objectives:

- Explore the effects of human-machine distributed situational awareness and opportunities for automation of monitoring tasks in en-route operations.
- Identify the data needed by air traffic controller (ATCO) to ensure that the proposed solution is correct (transparency) and develop the method to provide that data (explainability).
- Investigate methods for adaptation of the automated system to changes of the environment ensuring business continuity and safety

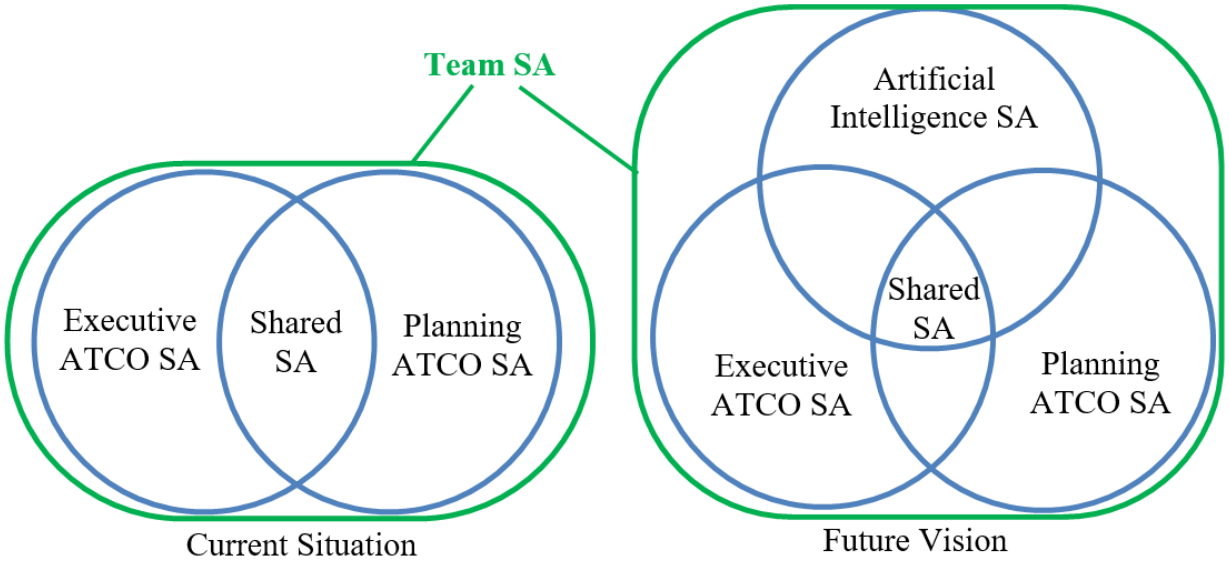
AISA – Project Positioning



AISA Framework

Situational awareness *or* ***situation awareness*** *(**SA**) is the perception of environmental elements and events with respect to time or space, the comprehension of their meaning, and the projection of their future status.*

- Endsley

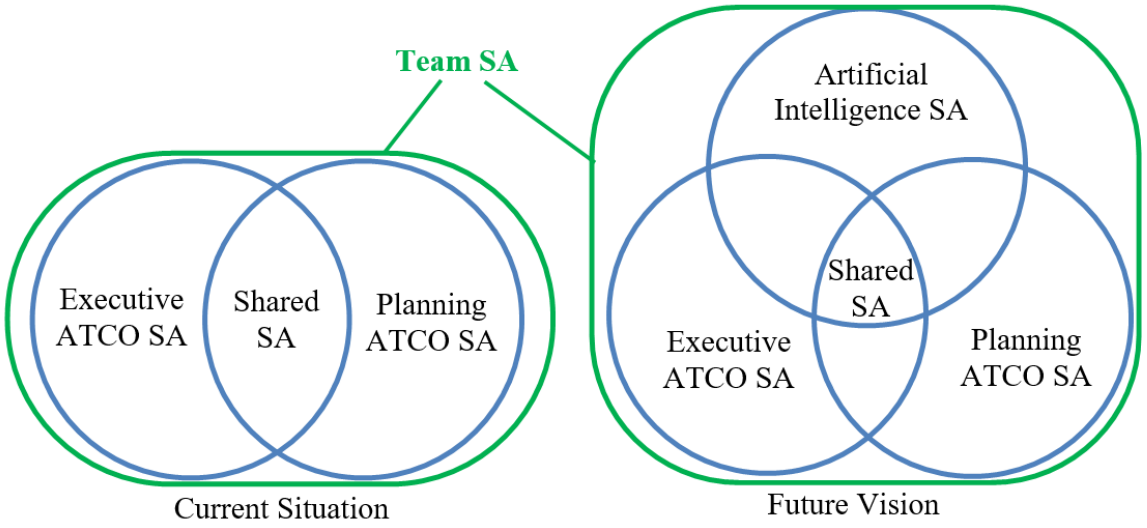


Artificial Situational Awareness as a Foundation for Further Automation

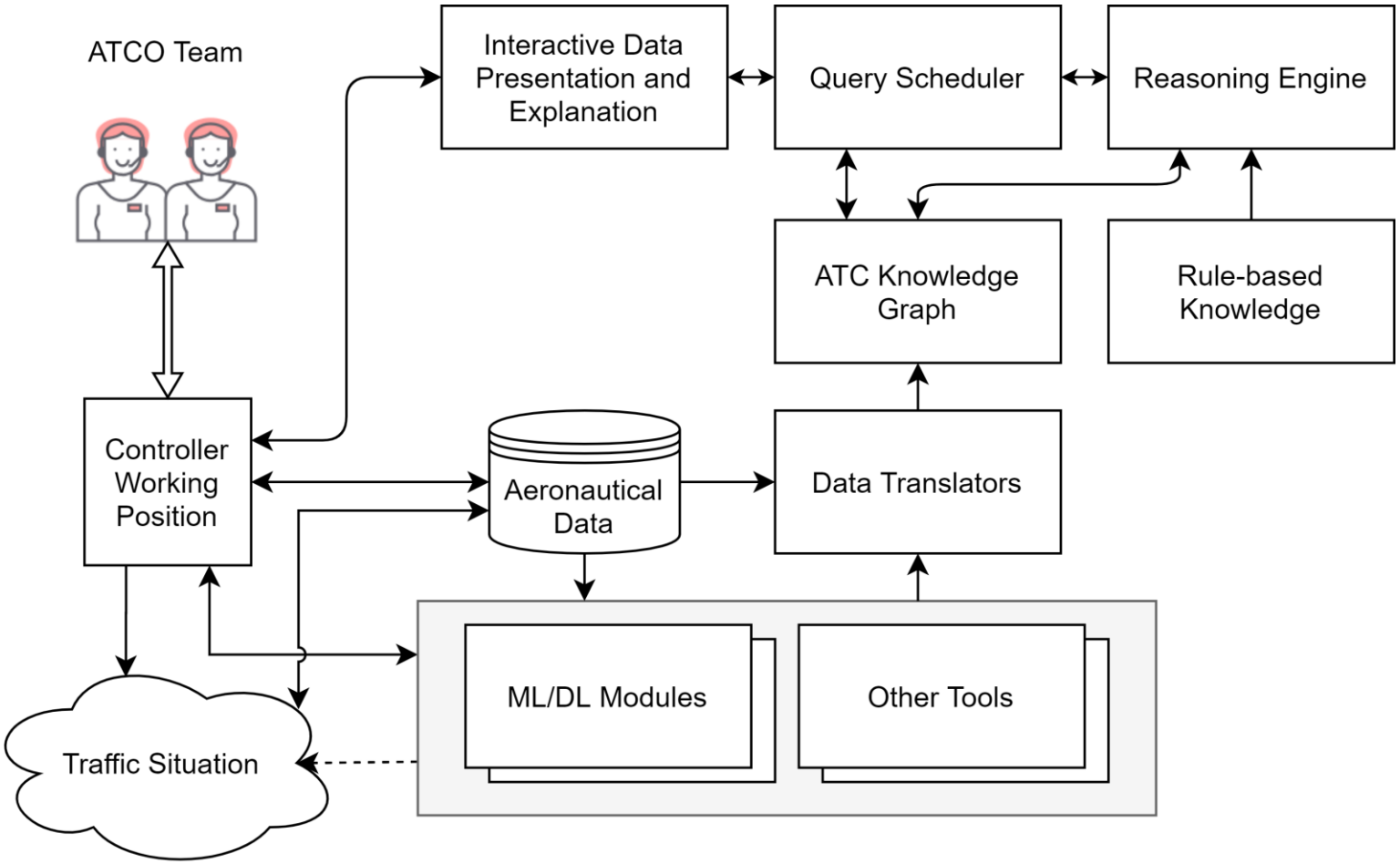
AISA Framework

Our assumptions are:

- Ideally, TSA represents the complete situation with all interactions among aircraft, humans and systems, including accurate representation of system and human states.
- Essential component of TSA is the ability to project future states from current ones.
- A single actor (machine or human) does not have to have complete SA; in this way SA is only partial for each actor.
- Individual SA should overlap to the extent that makes the operations safe and practicable.
- TSA should be distributed among actors in a way that favors individual strengths.



AISA Architecture



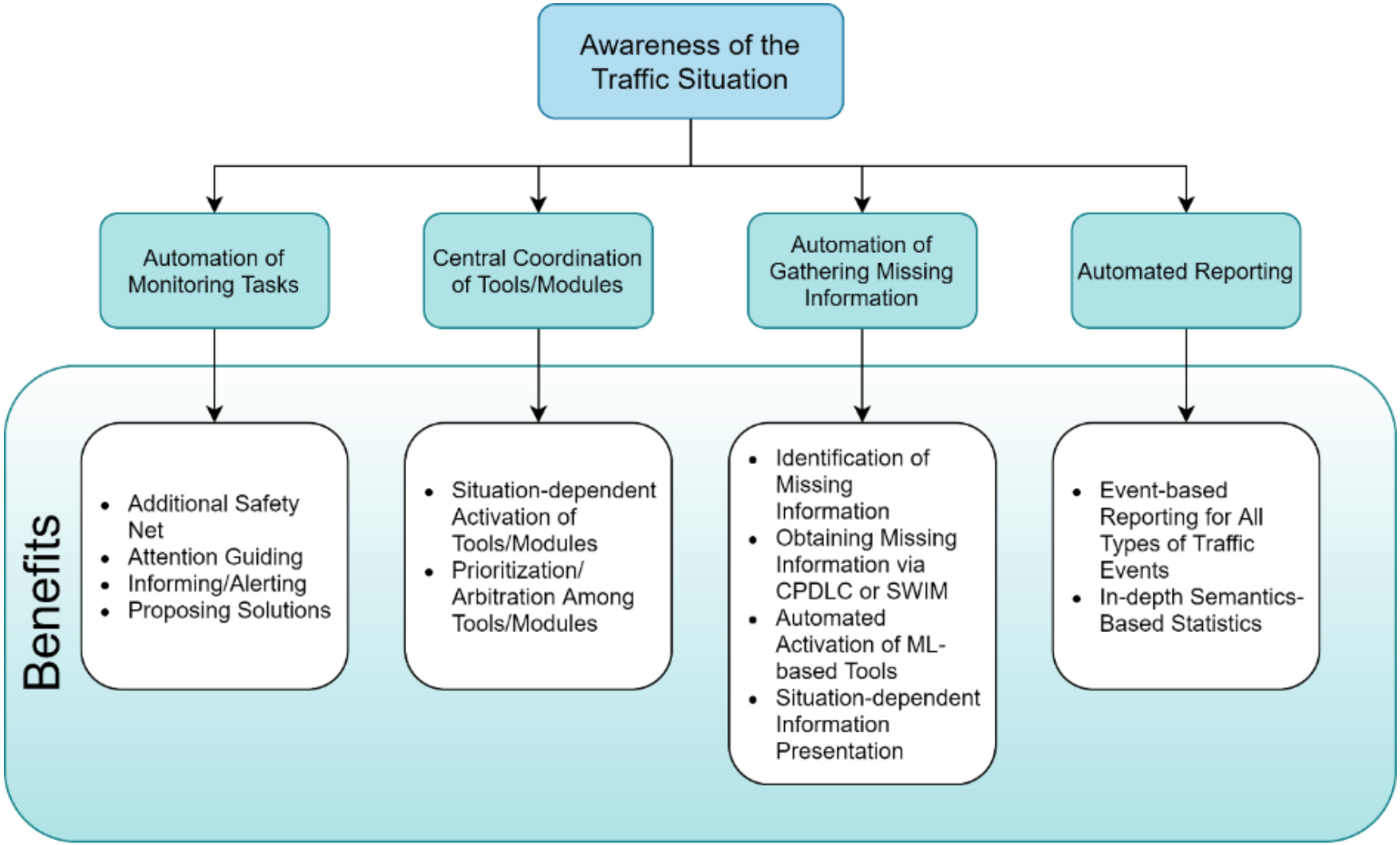
Aware of What?

AISA should be aware of:

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

Caveat: Significant difference between AISA project goals and envisioned application of AISA in 2035 or 2040/2050

Awareness of the Traffic Situation



Conflict Management example

Task	Actor	Method	Potential role of AISA
Strategic CD&R	NM	RBT negotiation	
Early conflict detection	Planner Controller (MSP or EAP)	Supported by MTCD tools and coordinated via INAP	Checking plausibility of MTCD results, checking for missing data needed for optimal tool operation
Early conflict resolution	EC or PC of the upstream sector	Supported by CR tools, accomplished via RBT negotiation, coordinated via INAP	Providing explanation of the effects of the proposed solution, checking plausibility of the solution
Tactical conflict detection	System (CDT), monitored by ATCO	CDT	Autonomous activation of the CDT tool, timely informing ATCO, alerting ATCO if conflict is overlooked, filtering relevant traffic
Tactical conflict resolution	Approved by ATCO	Proposed by CR tools, uploaded via CPDLC	Plausibility check, checking the effect of CR results on other traffic
Conformance management	System	Comparison of actual trajectory to RBT	Checking adherence to closed-loop clearances, reminding ATCO of open-loop clearances

Awareness of the System State

- Checking ML/DL modules:
  - ML/DL modules are ‘black-boxes’
  - Monitoring inputs to check if the ML/DL module was trained on such data
  - Monitoring ML/DL outputs to check the plausibility of the results
  - Monitoring ML/DL module’s performance (e.g. accuracy)
- Monitoring status of other ATCO tools
- Self-monitoring:
  - Checking for missing data
  - Checking own performance (e.g. query execution time)

Awareness of Team Member's State

- Difficult to do right
- Educated guessing

Some possibilities:

- Workload can be inferred based on the traffic complexity
- Complexity can be estimated by ML systems trained for complexity assessment
- Activation or near-activation of safety nets can be a sign of overload or OOTL effect
- Ignoring system's suggestions can be a sign of annoyance

AISA Expected Impact

Contribution to the Call Expected Impacts

'Projects are expected to provide principles that could enable higher levels of automation that are predicted to lead to an improvement of ATM performance, in particular cost efficiency, capacity and safety'

- Call Technical Specification

- ✓ positive effects on safety – AISA introduces an additional safety net
- ✓ positive effects on capacity – AISA takes over some of the ATCO's monitoring tasks thus reducing workload
- ✓ other performance areas – AISA enables other automation technologies

Overall positive impacts can be expected in the society due to reduced costs of air traffic which can improve mobility and economic growth.

Thank You!

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