

TADA

TADA - Terminal Airspace Digital Assistant

30th September 2026

Joint Open Day - TADA, ORCI and AWARE projects

Agenda

- 01 HOW TADA works
- 02 Demonstration
- 03 Validation roadmap
- 04 RTS results
- 05 Conclusions and next steps

TADA overview and goal

Consortium Partners

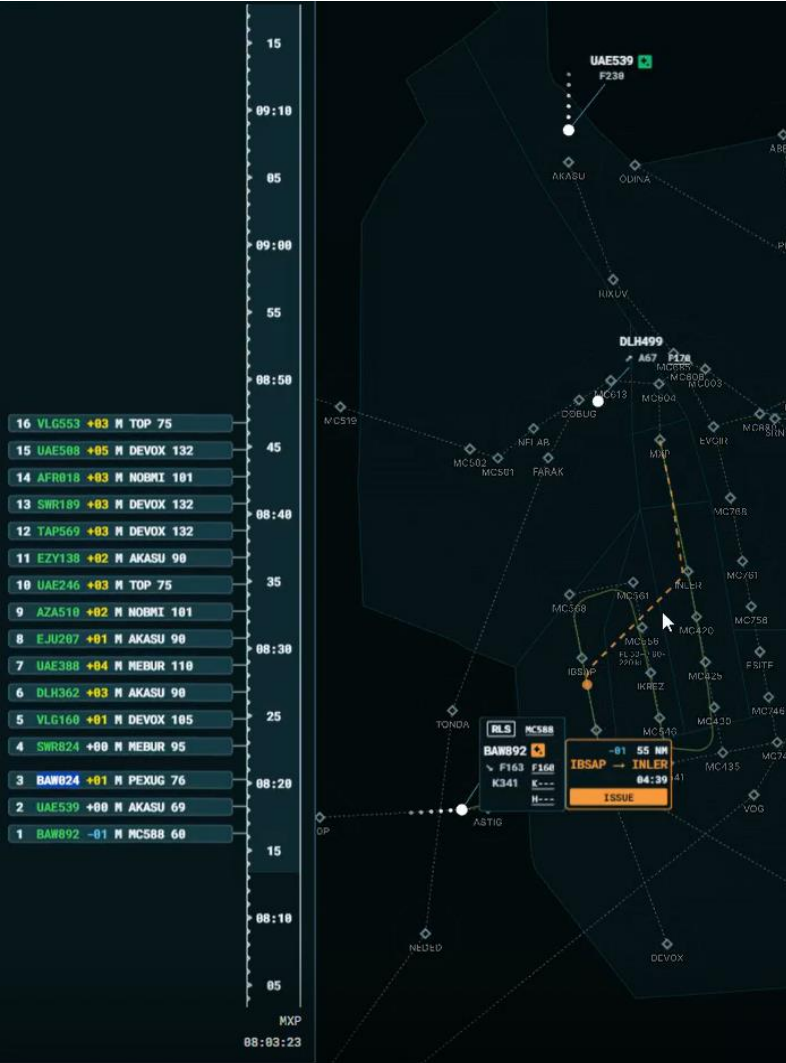
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FREQUENTIS



How TADA works



- dynamically **receives sequence** and **TTG/TTL information from AMAN** (Arrival manager).
- uses RL algorithms to generate a 4D proposed trajectory (4DPT) for each inbound flight.
- supports ATCOs in meeting the 4DPT by **showing the trajectory and the proposed ATC instructions**.

- in **Terminal Airspace** with **moderate to heavy traffic density** and operational complexity.
- from the moment flights enter the TMA until they initiate their final approach.



How TADA works

ATCOs are **supported up to a Level 1-** corresponding to **EASA 1B level**. Full authority is kept in terms of decision of action to be implemented.

EASA AI level 1B – Human assistance

Dynamic trajectory optimization: suggested trajectories that optimize AMAN sequencing while considering aircraft trajectory, profiles and speeds, ensuring alignment with the appropriate sequence of arrivals (AMAN).

DEFINITION	EASA AI level	PERCEPTION Information acquisition and exchange	ANALYSIS Information analysis	DECISION Decision and action selection	EXECUTION Action implementation	Authority of the human operator
LEVEL 0 LOW AUTOMATION Automation gathers and exchanges data. It analyses and prepares all available information for the human operator. The human operator takes all decisions and implements them (with or without execution support).	1A	●	●		◐	 FULL
LEVEL 1 DECISION SUPPORT Automation supports the human operator in action selection by providing a solution space and/or multiple options. The human operator implements the actions (with or without execution support).	1B	●	●	◐	◐	 FULL
LEVEL 2 RESOLUTION SUPPORT Automation proposes the optimal solution in the solution space. The human operator validates the optimal solution or comes up with a different solution. Automation implements the actions when due and if safe. Automation acts under direction.	2A	●	●	◐	●	 FULL
LEVEL 3 CONDITIONAL AUTOMATION Automation selects the optimal solution and implements the respective actions when due and if safe. The human operator supervises automation and overrides or improves decisions that are not deemed appropriate. Automation acts under human supervision.	2B	●	●	●	●	 PARTIAL
LEVEL 4 CONFINED AUTOMATION Automation takes all decisions and implements all actions silently within the confines of a predefined scope. Automation requests the human operator to supervise its operation if outside the predefined scope. Any human intervention results in a reversion to Level 3. Automation acts under human safeguarding.	3A	●	●	●	●	 LIMITED

How TADA works

From traffic state to 4D trajectories with TADA RL agents

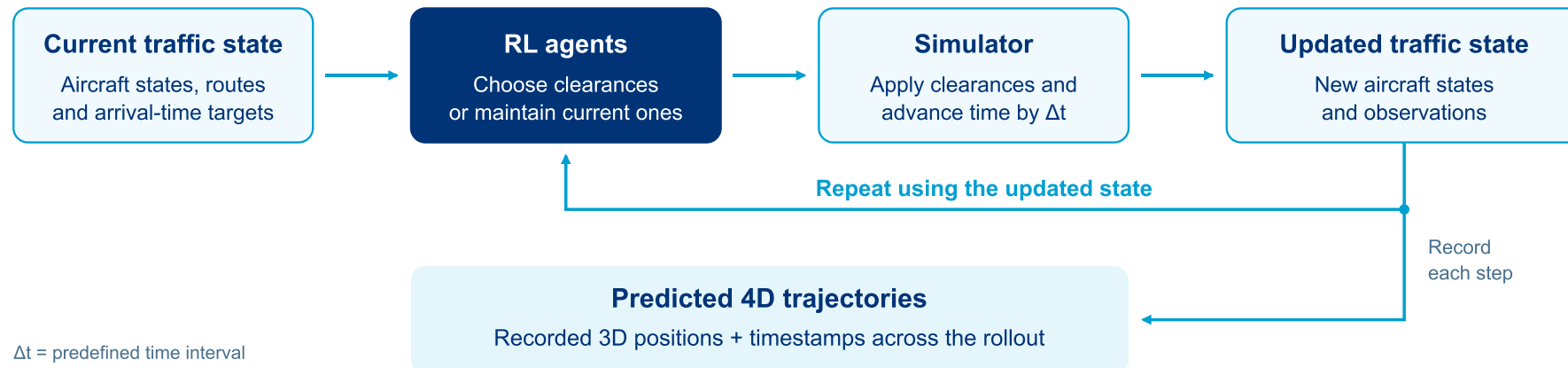
Two feasible approaches

- Single-agent: One agent controls multiple aircraft centrally.
- Multi-agent: One agent per aircraft, sharing a common policy - the approach explored in RTS.

Multi-agent model and training

- Inputs and outputs: Uses aircraft state, route and nearby traffic to select a clearance or maintain the current one.
- Network: Flight-plan encoding, neighbour attention and recurrent memory.
- PPO training: Rewards balance separation, arrival-time accuracy and fewer instructions.

Generating the 4D trajectories



How TADA works

HMI overview

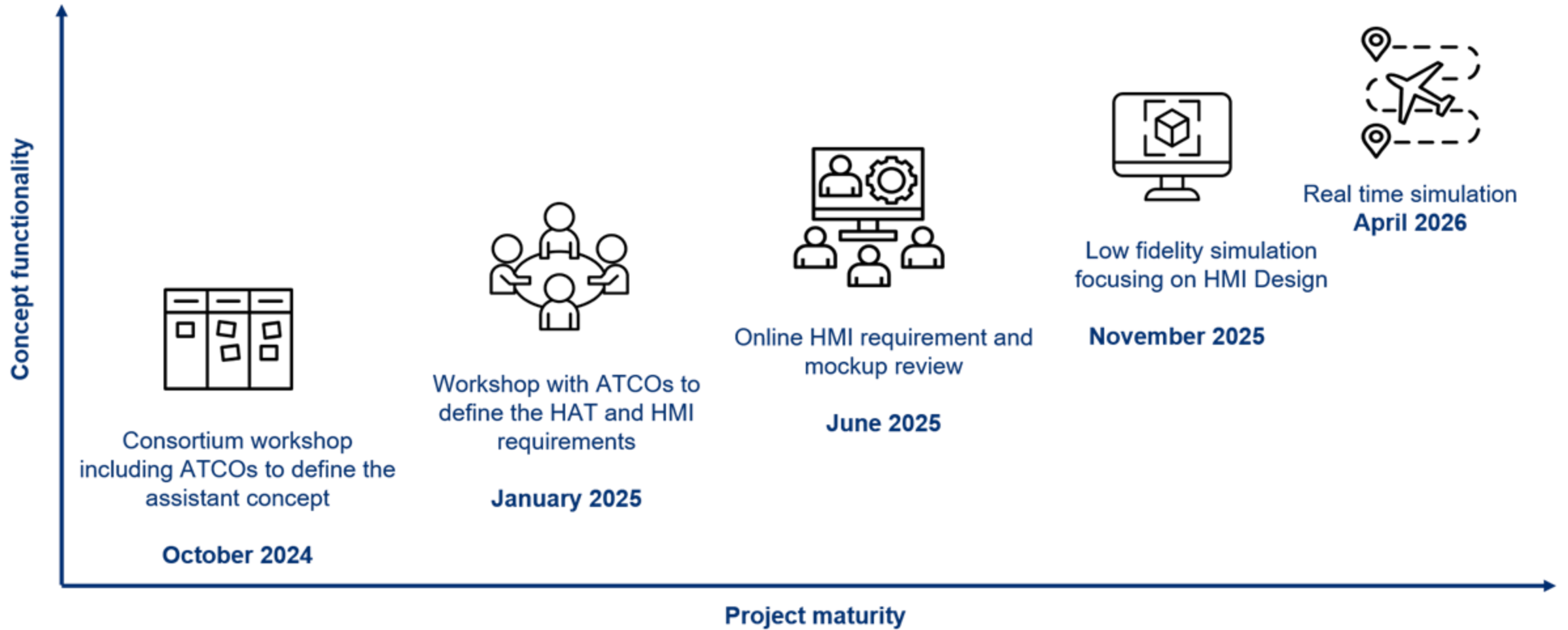
- On-demand display of the full 4DPT of the flight
- Display of the instructions to be issued
- Alert for flight deviations from the 4DPT's tolerance envelope.



How TADA works

DEMO

TADA Validation roadmap



Final validation results

RTS AT ENAV facilities in Rome Ciampino (2 days)

6 participants

ENAV approach controllers,
executive positions

3 sectors

1 Feeder, MXP inbounds, BGY
inbounds

80% capacity

20 arr/hr MXP RWY35L, 11
arr/hr BGY RWY28

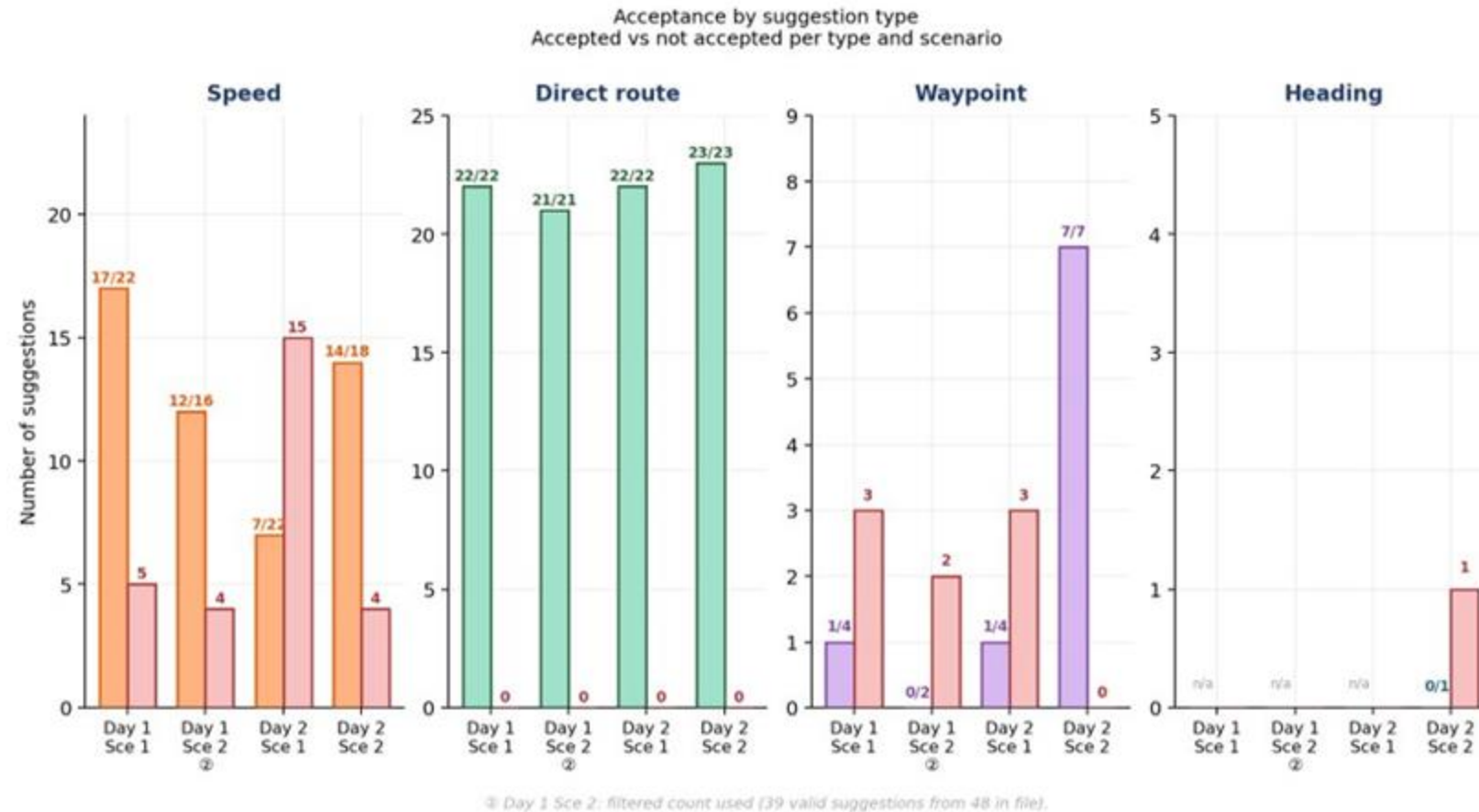
45 min

per run, over two simulation
days

Run	Traffic	Purpose
No-TADA / TADA	Arrivals only — MXP trombone, BGY point merge	Baseline arrival management
No-TADA / TADA	Arrivals plus departures from both airports	Mixed-traffic robustness
Autoexec	All suggestions executed automatically	Performance ceiling at 100% compliance

Final validation results

OPERATIONAL FEASIBILITY

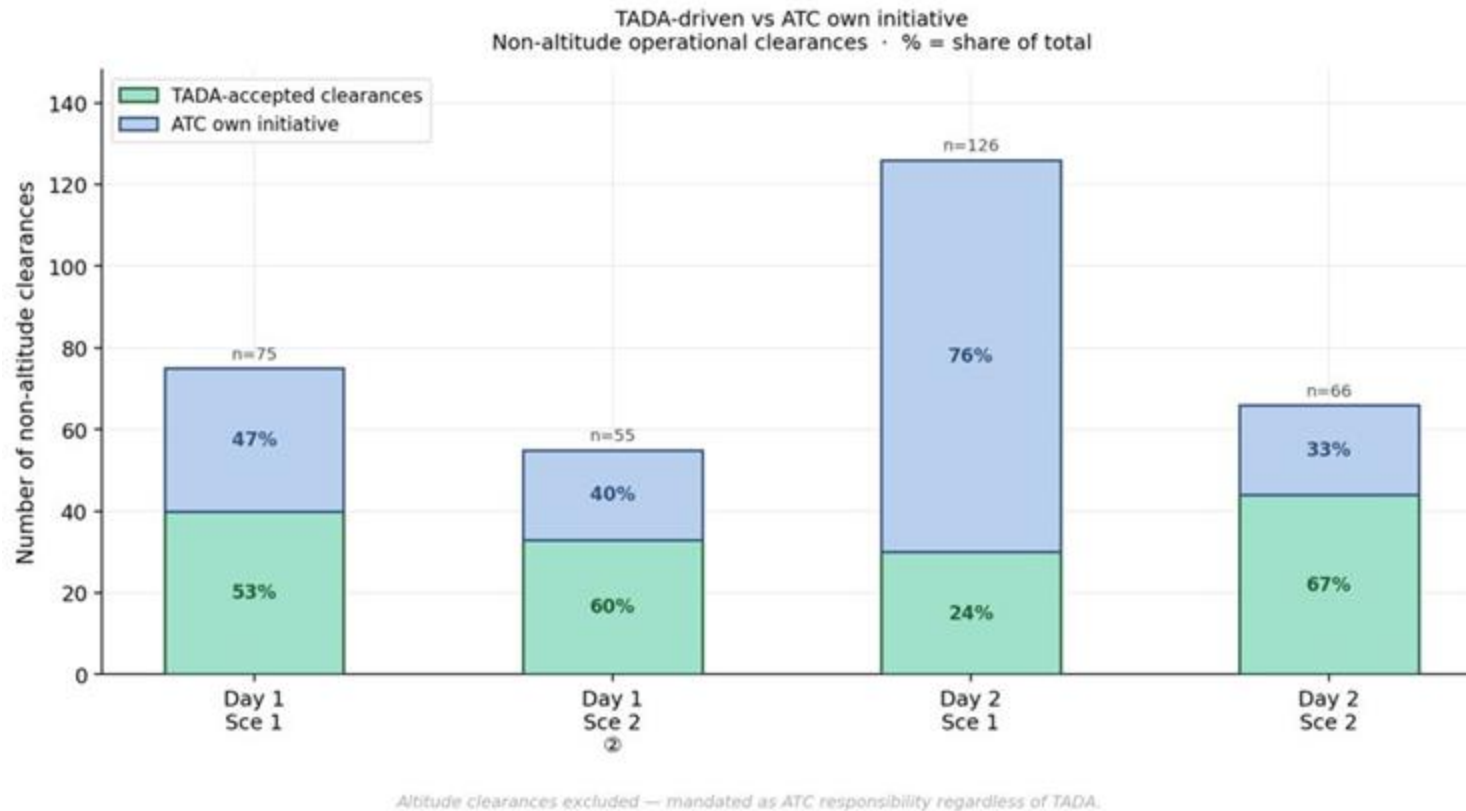


TADA guidance was generally accepted into ATC decision-making.

- **Direct routing (DCT)** suggestions achieved 100% acceptance. Demonstrating ATCOs confidence in TADA's route optimisation capability.
- **Speed** suggestions showed the greatest variability across scenarios, reflecting differing levels of ATC reliance.
- **Waypoint** suggestions were also selectively applied.

Final validation results

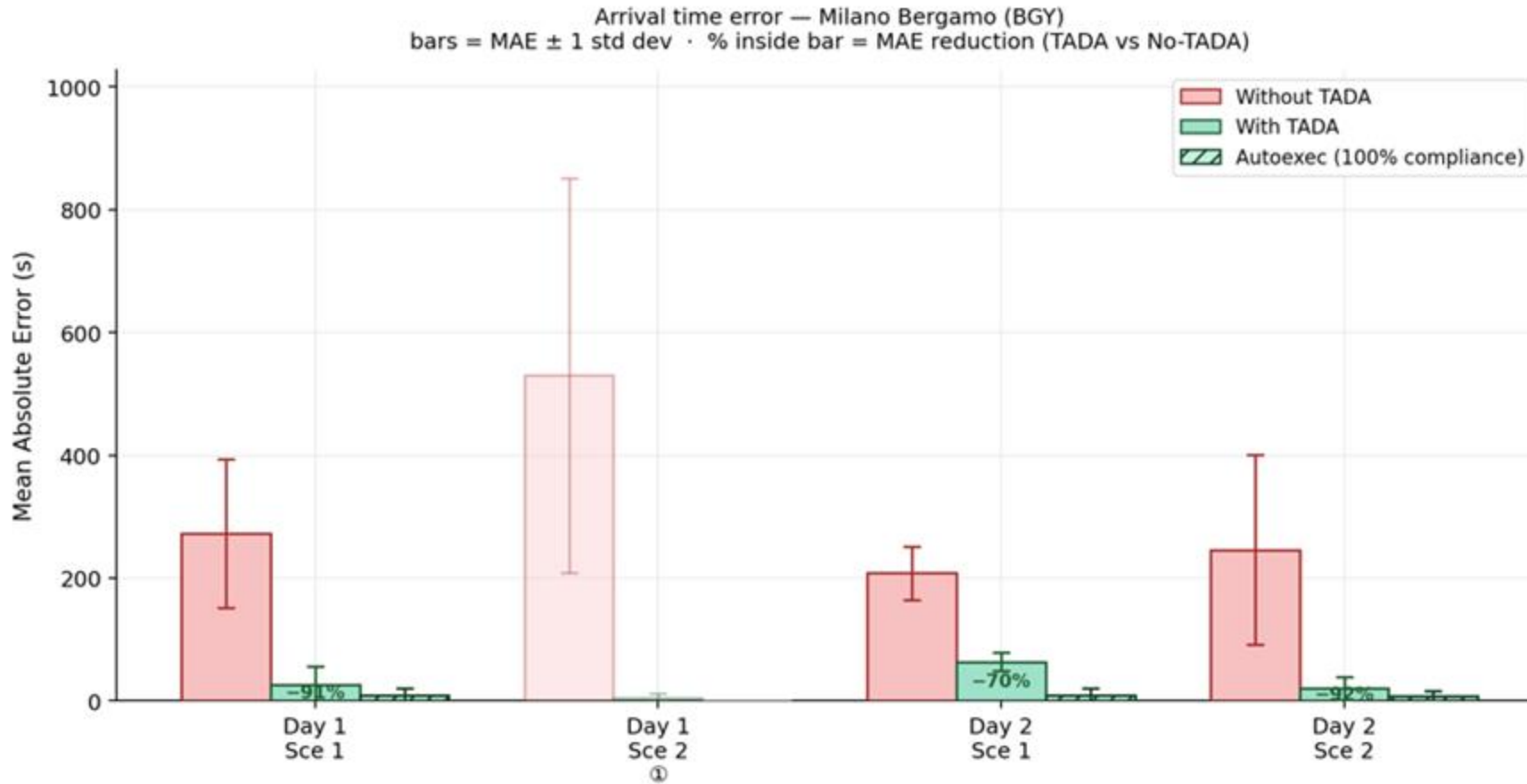
OPERATIONAL FEASIBILITY



TADA-driven clearances accounted for the majority of non-altitude operational decisions, confirming that TADA was meaningfully integrated into the ATCO workflow across the simulation exercise.

Final validation results

OPERATIONAL EFFICIENCY (predictability and arrival times)



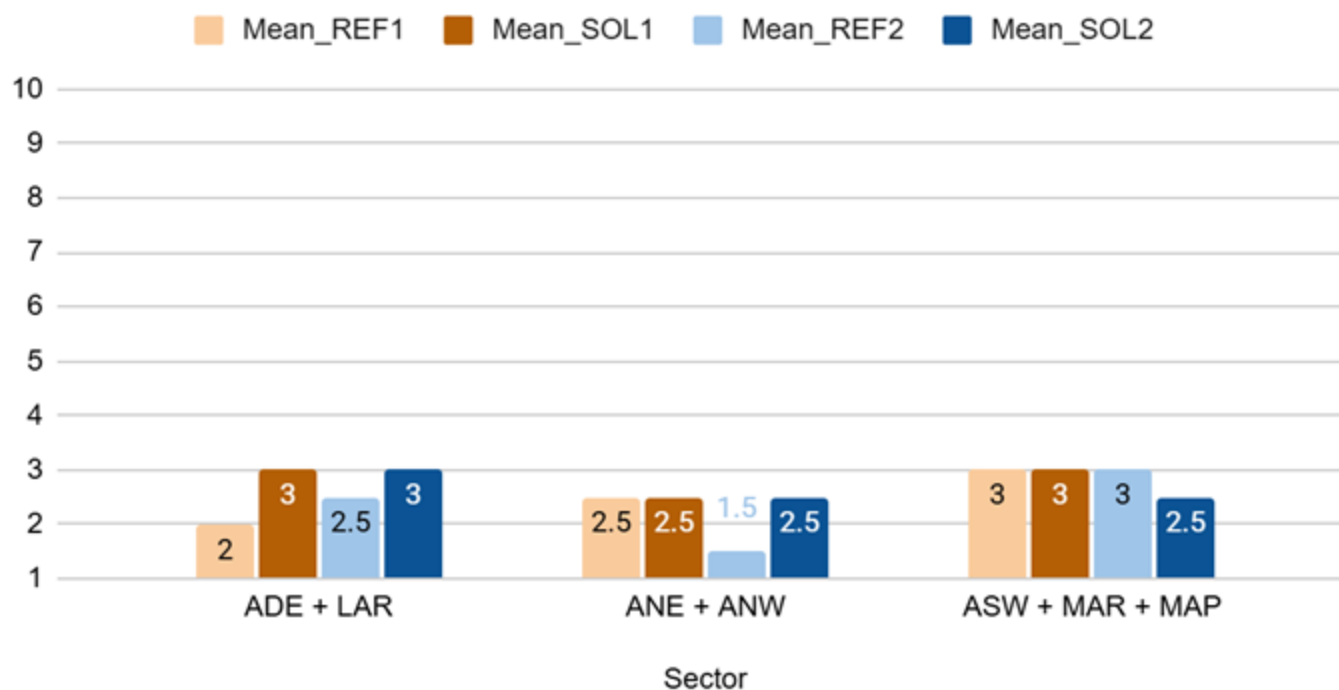
① Day 1 Sce 2: recording truncated — excluded from conclusions.

- The predictability improvement attributable to TADA was more pronounced at BGY (Bergamo) than at MXP (Milano Malpensa) across all valid scenarios.
- MAE reductions ranged from 21% to 92% at MXP and from 70% to 92% at BGY.
- Across all valid scenarios and both airports, the introduction of TADA produced substantial and consistent reductions in arrival time error.

Final validation results

COGNITIVE WORKLOAD (questionnaire)

Workload comparison by sector between references and solutions



- **Workload slightly higher with TADA (+0.5 to +1 Bedford point) but not statistically different**
- **The small increase is likely due to the initial learning curve.**
- **Findings suggest that workload may decrease further as controllers gain operational experience.**

Final validation results

COGNITIVE WORKLOAD (data logs)



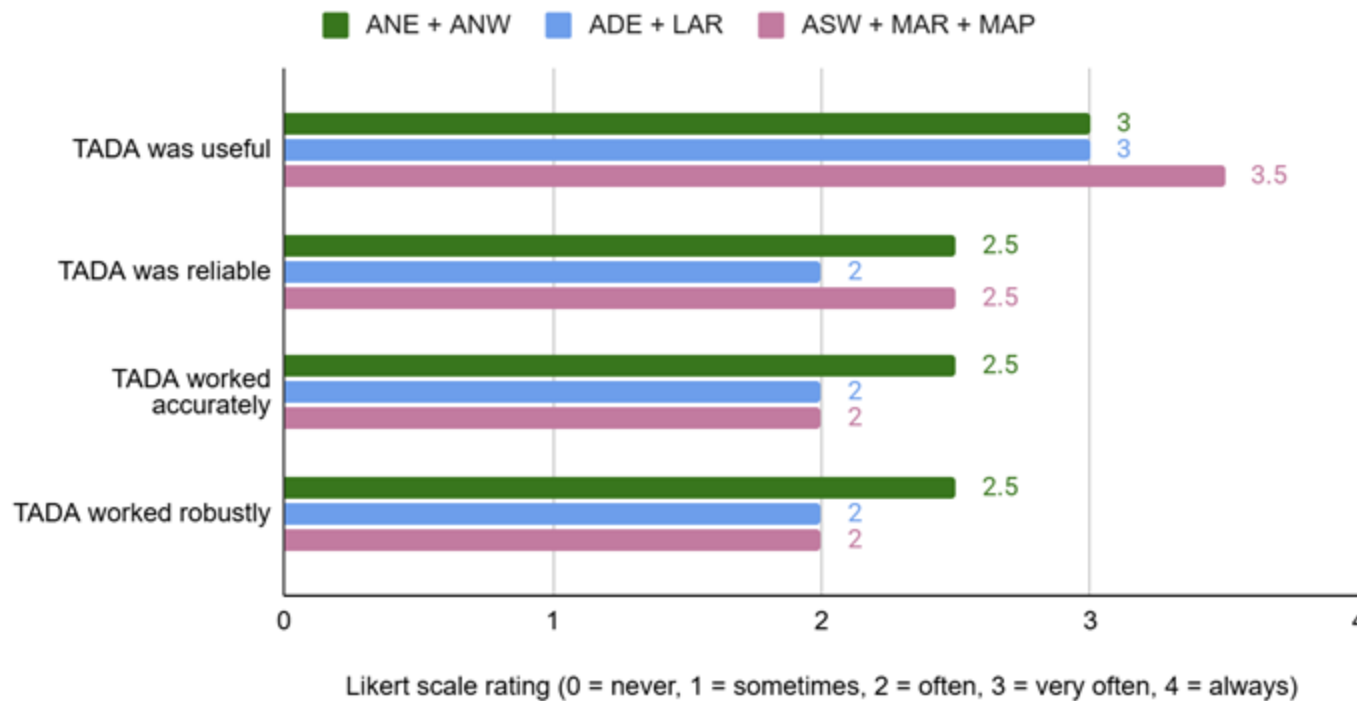
- ATCOs issued **fewer non-altitude clearances with TADA across all scenarios.**
 - -28.9% (Scenario 1)
 - -79.4% (Scenario 2)
- **Effect is stronger in higher traffic density** (Scenario 2) = TADA's benefit scales with traffic complexity
- Each clearance represents communication effort (~10–15 s), so **reductions imply lower operational demand.**

Final validation results

TRUST

ATCOs trust in TADA

Based on usefulness, reliability, accuracy and robustness of the system



- Overall, **ATCO trust in TADA is sufficient**
- The system is seen as **very useful**
- **Reliability and accuracy** are rated as “good but not perfect”
- Some ATCOs were cautious because they were still getting used to the system
- They also felt **TADA sometimes does not fully match their usual working strategies**

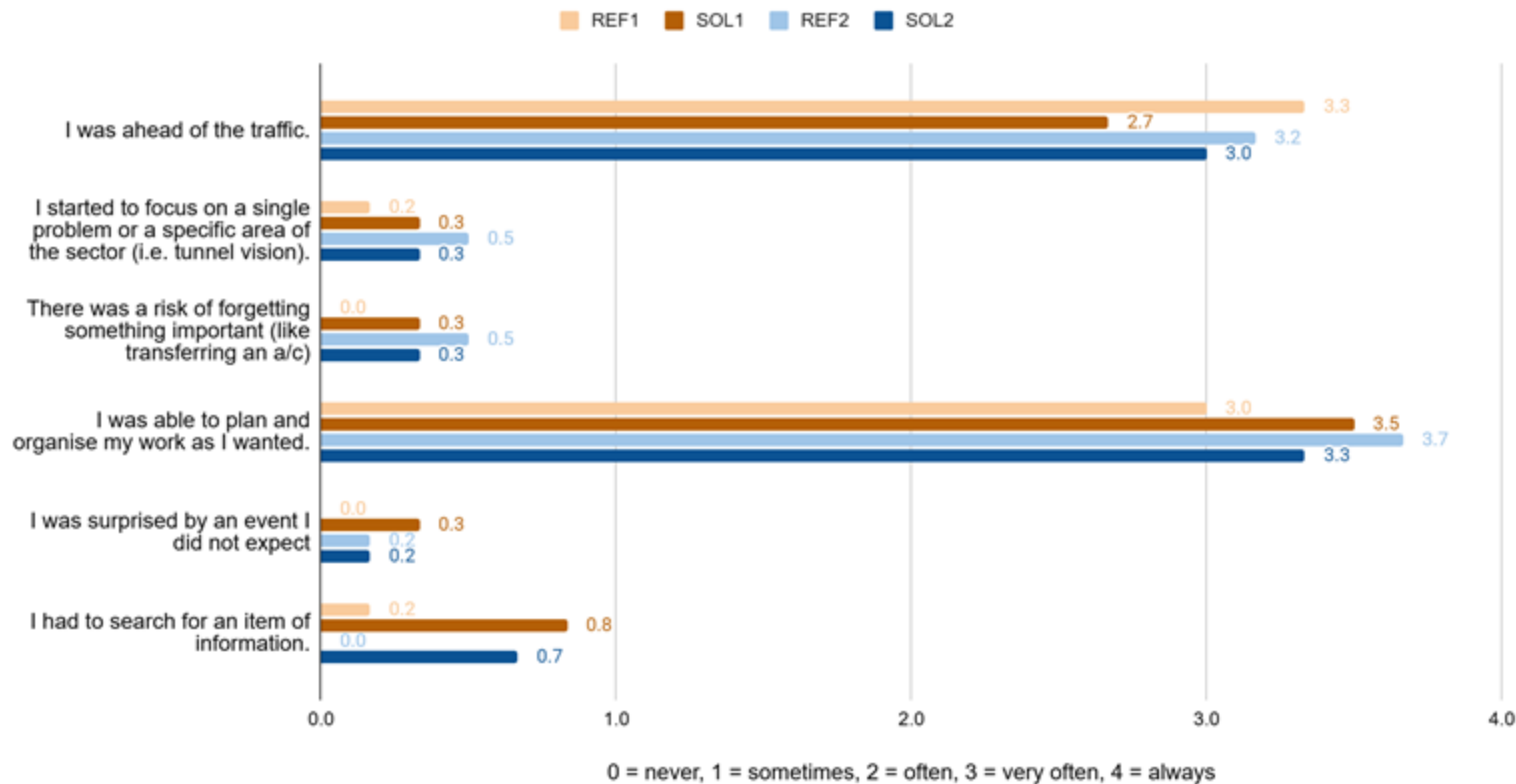
Conclusion: Trust is acceptable now, but is expected to improve with experience and system improvements.

Final validation results

SITUATION AWARENESS

Situational awareness (REFs and SOLs)

Comparison between reference and solution scenarios per each situational awareness parameter



Measured across 6 factors (anticipation, attention, memory, control, predictability, information access).

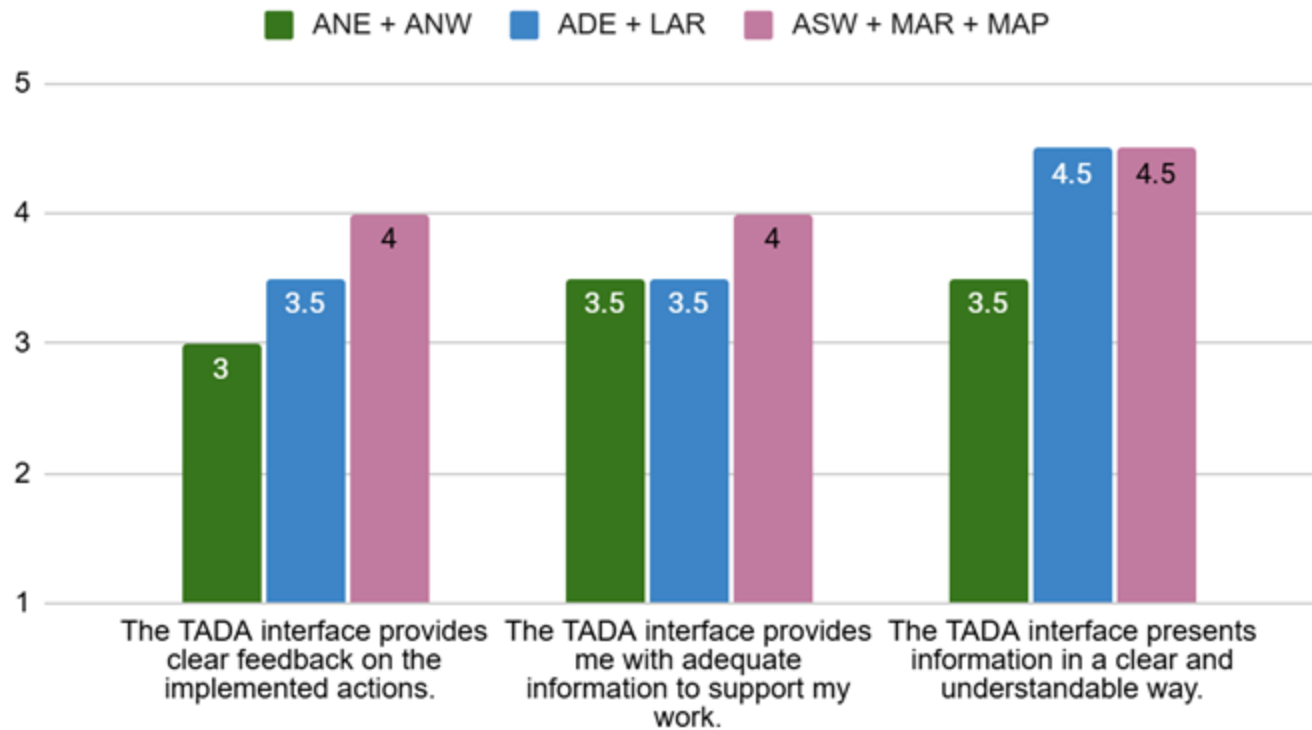
- Overall **SA was similar in both TADA and reference scenarios.**
- No major negative effects, but **ATCOs felt less proactive and less in control with TADA.**
- Slight advantage for no-TADA in anticipation and information search.

Conclusion: No improvement in situational awareness with TADA.

Final validation results

USABILITY

TADA usability



Usability is generally high, with ratings from neutral to strongly positive.

- ATCOs across all sectors rated the system usable.
- Best rated aspect: clear and understandable information presentation (up to 4.5/5).

Main improvements requested:

- Better timing of suggestions
- Clearer colour meanings
- Simpler and more ordered suggestions

Final validation results

POTENTIAL IMPACT ON SAFETY



TADA interface impact on ATCO situation awareness

TADA suggestions tend to guide the ATCOs attention and workflow because it works as an 'attention getter'.



'Out of the loop' & automation complacency

More than one ATCO mentioned that in very high workload scenarios they must trust the system because they do not have enough cognitive resources to check all the suggestions provided by the system.



ATCOs skill reduction

ATCOs seem to agree that TADA has the potential to reduce skills over time. ATCOs reported to feel that their role was a little bit passive "as they shifted from actively building the traffic sequence(s) to just checking TADA's suggestions are suitable".



Sticking to standard procedures

One ATCO mentioned TADA made them feel more constrained and potentially could lead ATCOs in working in a way that is closer to procedures.

Note: Weather events and mixed traffic (arrivals and departures) were out of scope of TRL2 activities.

Conclusions

1 Operational Feasibility

TADA is technically and operationally feasible

2 4D Trajectory Generation

Generate safe, realistic 4D Proposed Trajectories (4DPTs) using historical and synthetic data

3 AMAN Predictability

Improves AMAN predictability by stabilizing estimated landing times earlier via AI shortcut predictions

FUTURE RESEARCH PRIORITIES

Decision-Making Control

Balance automation to ensure ATCOs retain ultimate decision-making control.

Skill Degradation Mitigation

Develop strategies to mitigate ATCO skill degradation caused by relying on automated 4D sequencing.

Recommendations for future steps



TADA and AMAN integration

TADA and AMAN should become a single integrated tool to ensure data is continuously exchanged and updated



Adverse Weather Scenarios

Include adverse weather scenarios in next-stage validations to better support ATCOs when standard sequencing is disrupted



Expand Traffic Coverage

Broaden future testing to cover all Terminal Manoeuvring Area (TMA) traffic, including outbound flights, overflights, and unstructured arrival procedures.



Emergencies & System Degradation

Research system functionality and ATCO responses during flight emergencies or TADA system degradations.



Extended Controller Training

Increase training duration during future validations to build controller confidence and deep system understanding.

TADA

Thank you!