

CODA

Human-Machine Performance Envelope: a Controller Adaptive Digital Assistant evaluation

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SESAR Innovation Days 2025

Agenda

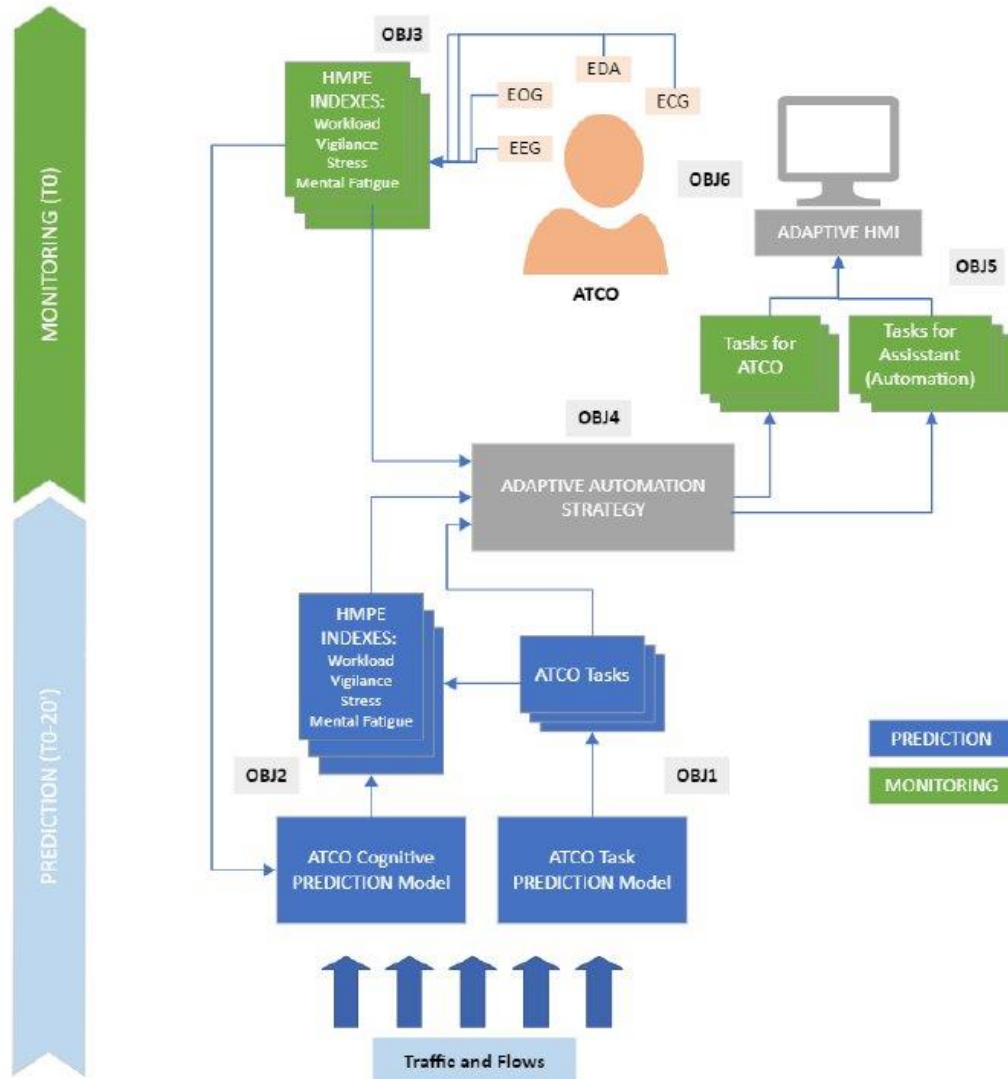
- **Description of CODA DA concept**, outlining its objectives, and architecture
- **Explanation of the methodology** used to derive **Human–AI Teaming (HAT) requirements**
- **Description of the final validation exercises**
- **Summary of key outcomes, validation results, user feedback, and lessons** for future adaptive AI assistant development in ATM.



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Adaptable Systems to improve Human AI Teaming



CODA is a **SESAR** exploratory research project

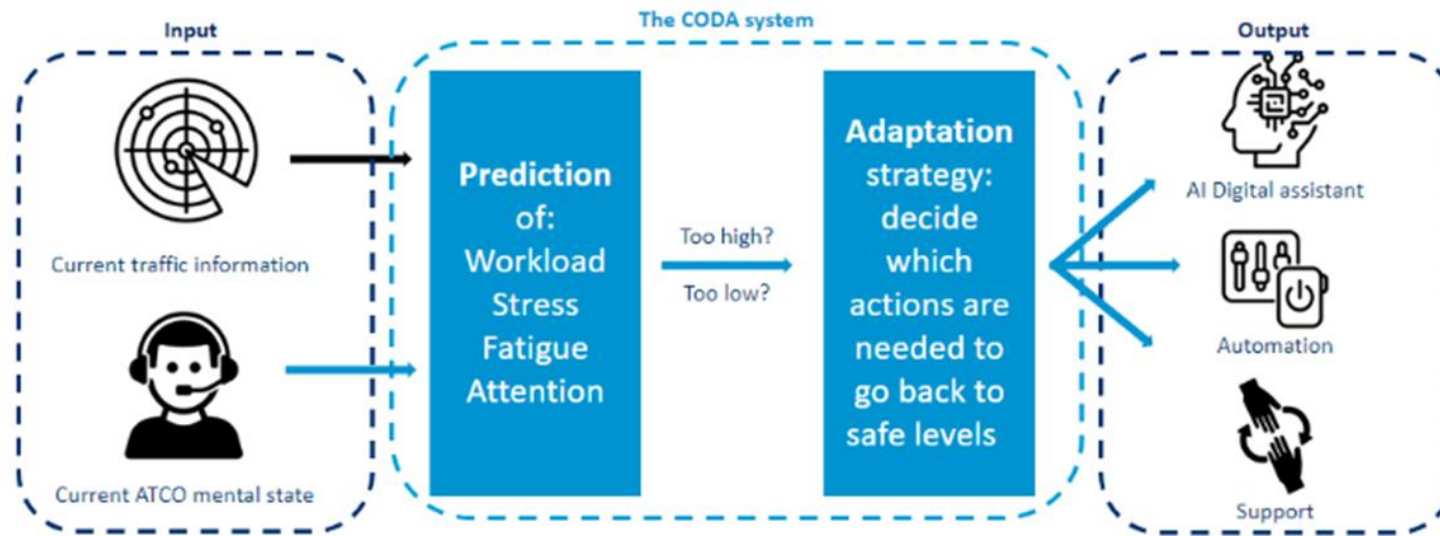
The goal is to **strengthen collaboration between Air Traffic Controllers and Artificial Intelligence systems**

HOW DOES CODA WORKS?

The system proposes the **delegation of certain aircraft to the AI**, considering several factors:

- The **current and predicted traffic**
- The **controller's mental state** (workload, fatigue, stress, and vigilance)
- The **current and upcoming control tasks**.

En-route use case, multiple other applications



“ONE **TOOL** RULE THEM ALL”

It has to be *emphasised* that the CODA system is not a tool per se. It is a **technological enabler, to be integrated into ATM systems** (not limited to en-route CWP), providing adaptation capabilities.

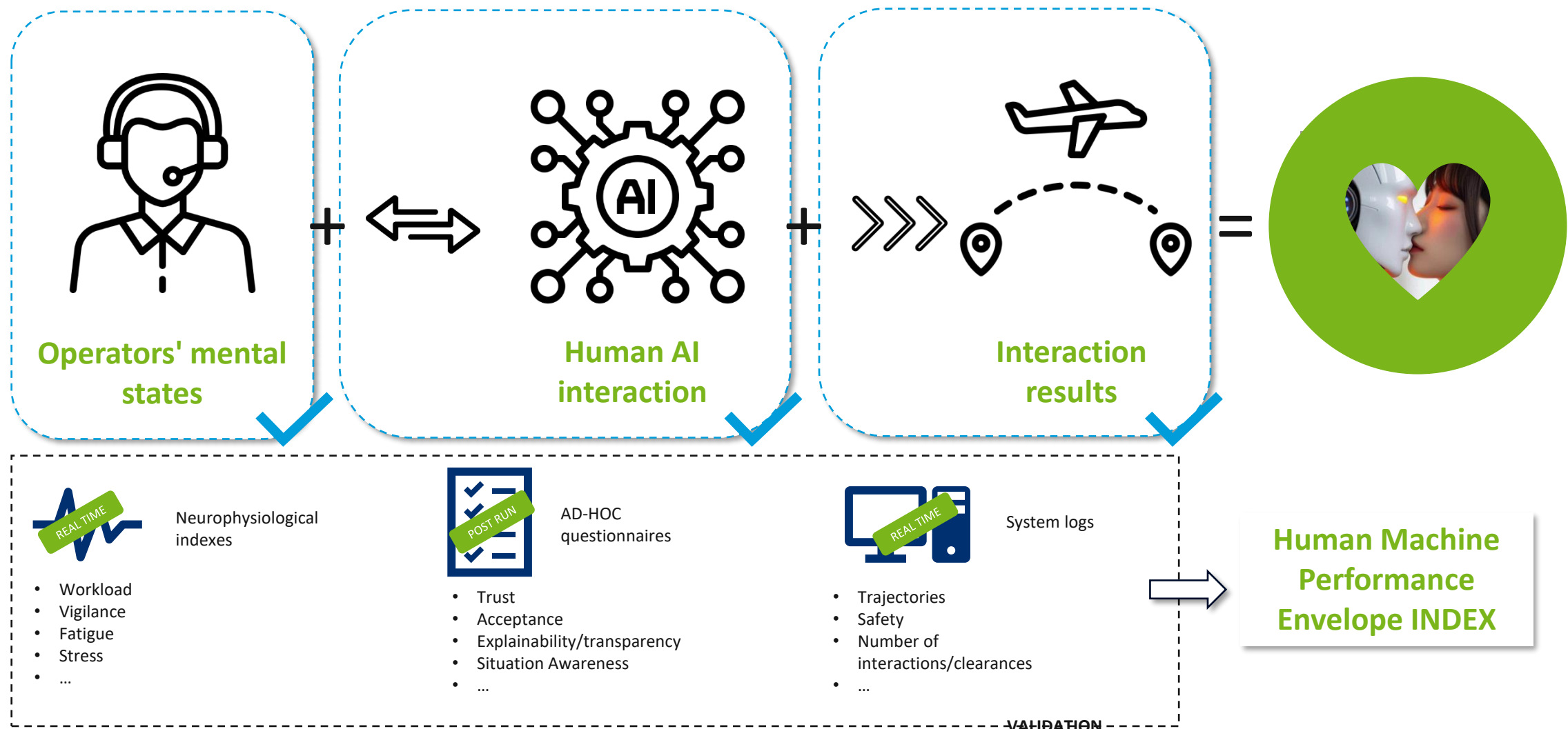
The AI tools/Digital assistants that are expected to be activated by the adaptation strategy are out of the scope of the project.



CODA Approach to Human AI Teaming



“A” definition for Human – AI Teaming

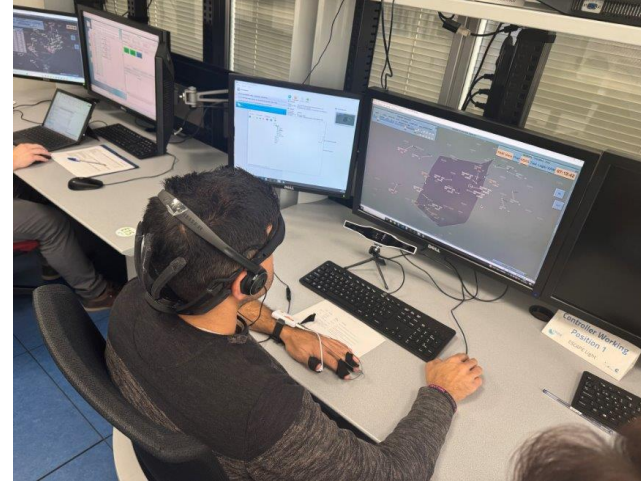


CODA system validation



Concept, prediction modules and finals system validation

EXE3: Final Human in the Loop simulation



Human-in-the-Loop Simulation

- **When:** 17–20 March 2025
- **Where:** CRIDA premises at Universidad Politécnica de Madrid
- **Who:** 4 ATCOs (IFATCA)
- **Objective:** Validate CODA system

Key Points:

- Real-time ops with ATCO & AI supervisor
- Same CWP for both roles
- CODA proposed flights 7 min before sector entry
- AI supervisor confirmed assignments
- ATCO saw AI flights 2 min before entry
- Yellow circle marked AI flights
- ATCO could reassign if needed

Final Validation, data collection

EXE3: Final Human in the Loop simulation

Objective assesment of Workload, Stress, Fatigue, Vigilance

- Electroencephalography (EEG): brain electrical activity
- Hearth Rate & Hearth Variation Rate: heart beating activity
- Galvanic Skin Response (GSR): electrical skin activity

- Voice: fundamental frequency

Additional research activities

At the end of each run: questions about teaming quality
At the end of the sim.: questions on overall impact on ATCO Job

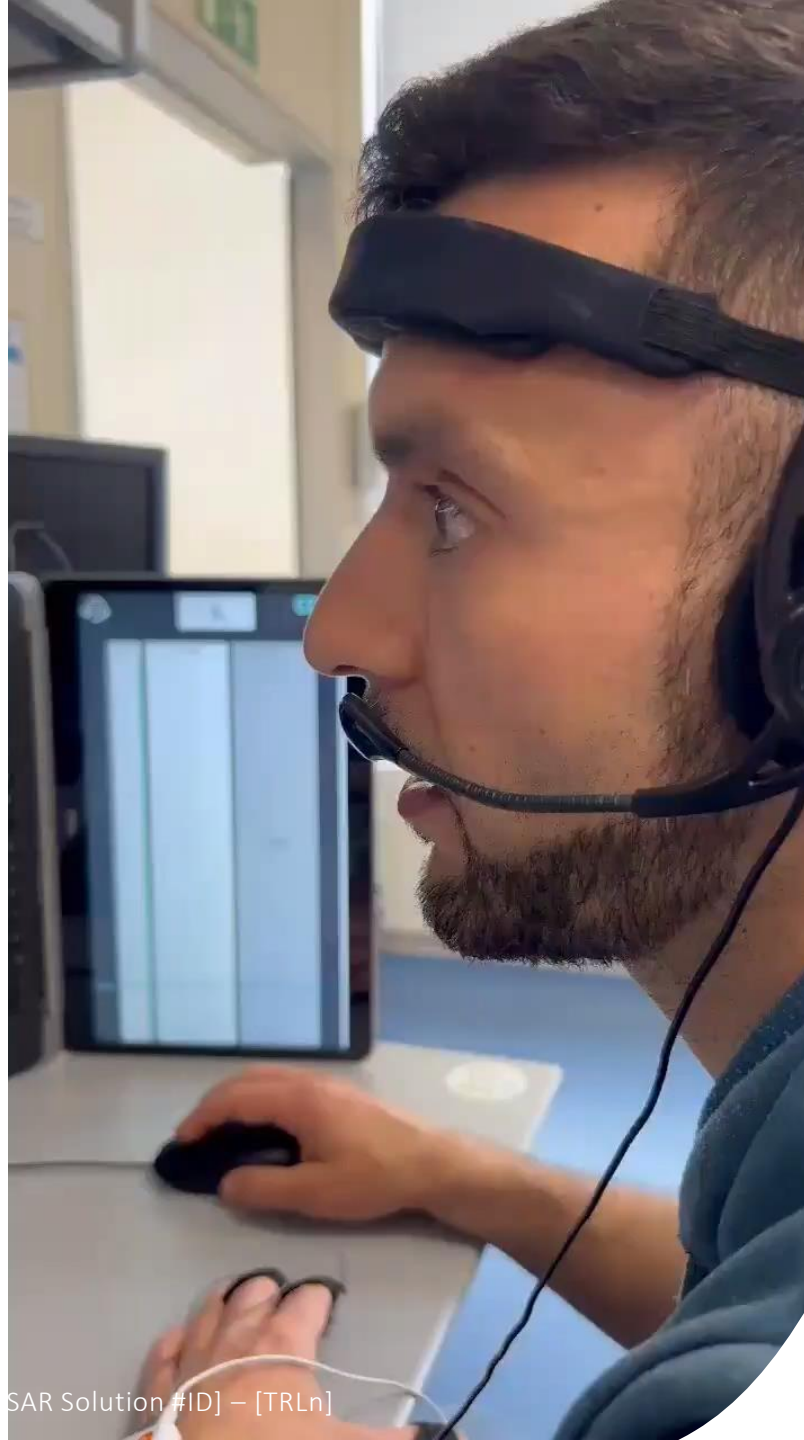
- Questionnaires
- Debriefings

Open discussion. Useful to get information to make sense of our results

Performance measures

- Radar tracks
- Control events
- Flight plans
- Radio communication

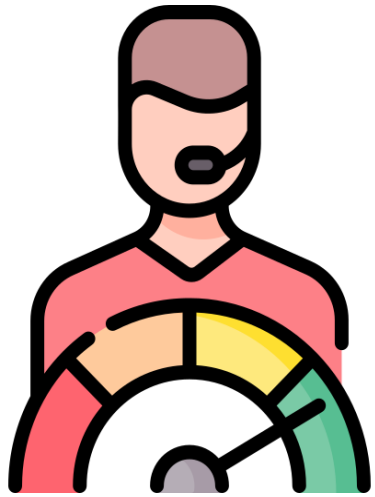
To get a measurement of the overall performance in terms of traffic management and safety



High level results



HITL Validation Final results (1)

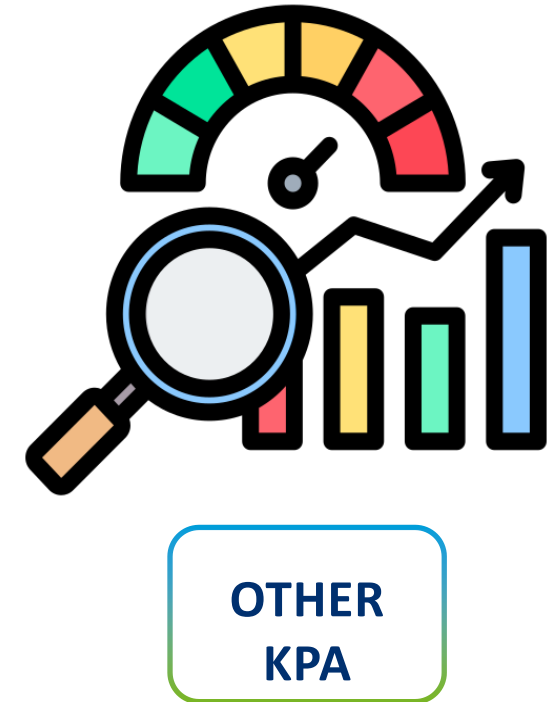


Human Performance

- A generally positive impact on **ATCO performance**
- Improved **vigilance and situation awareness**, reduced **stress and fatigue**
- Not significant change in mental **workload** (due to learnability curve plus a need for monitoring AI-managed aircraft)
- Relatively clear **responsibilities and tasks** as well as new procedures for ATCOs
- CODA's **task allocation** was reported to be logical and efficient
- The **HMI** was relatively supportive but there's still room for improvements
- The **HMPE framework** proved to be a strong indicator of controller-AI collaboration, showing that CODA consistently maintained balanced workload, sustained performance, and positive teaming without compromising safety or trust.

HITL Validation Final results (2)

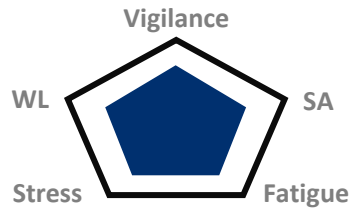
- CODA maintained **safety** in normal conditions and measurably reduced conflicts during peak traffic
- CODA delivered slight improvements in **operational efficiency**
- No measurable improvement in **cost efficiency** was observed
- No measurable impact on en-route throughput was observed, CODA will likely enable an increase in capacity



The Next Step in Human–AI Teaming Research

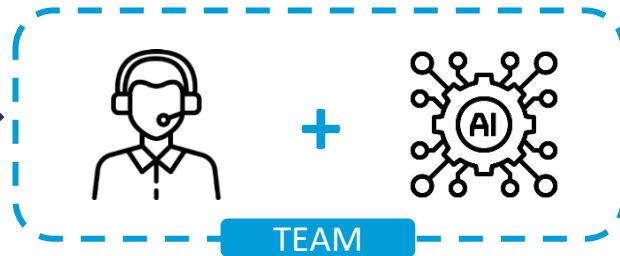
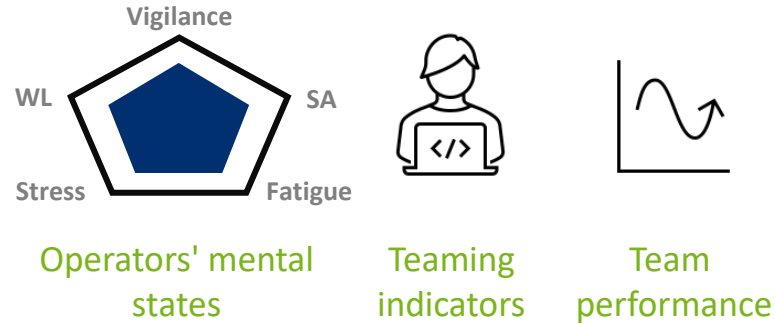
Previous projects

HPE



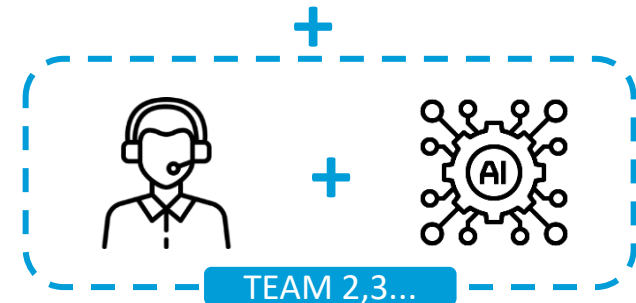
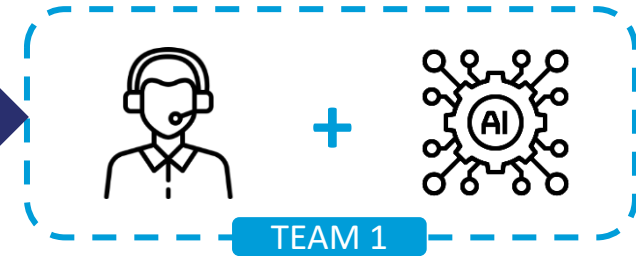
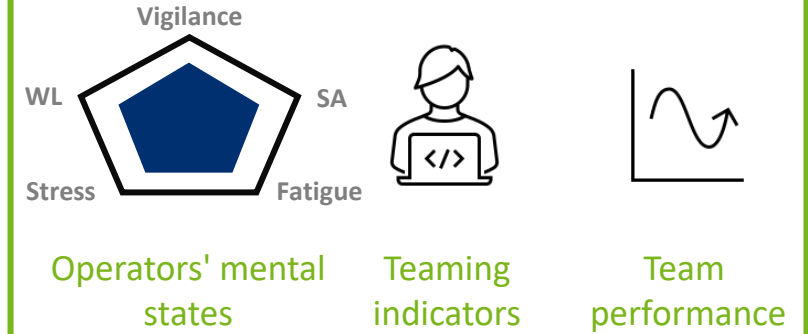
CODA

HMPE



Future research

TMPE



Thank you!

