Generic Technologies

Future Engineering

GT17-875SF – Adaptive human-machine interfaces for enhanced data monitoring and operations

Budget: 1200 k€ - **Duration**: 24 months - **Current / Targeted TRL:** 3 / 6 - **TD** 8

Objective:
To develop an adaptive and immersive interface that enhances real-time monitoring and decision-making by integrating advanced visualization tools, extended realities (XR), digital twin data and Model Based Systems Engineering (MBSE) to support co-engineering in design, training, Assembly, Integration, and Test (AIT) and operations.
Description:
Modern aerospace operations demand continuous monitoring and interpretation of vast telemetry and design datasets to ensure mission success. Traditional monitoring methods are increasingly challenged by data overload, leading to high cognitive workload, slower response times, and reduced anomaly detection effectiveness. These challenges are especially critical during spacecraft operations, astronaut activities, testing, and mission planning.

This activity aims to develop an intelligent, adaptive, and immersive user interface that enhances operator efficiency, reduces cognitive load, and improves situational awareness and decision-making across design, integration, and operational contexts. By integrating XR, artificial intelligence, MBSE and digital twin technologies, the solution will provide advanced visualization tools capable of:
- Presenting telemetry, test, and design data in a structured, semantically rich, and interactive 3D environment.
- Dynamically highlighting critical insights using real-time data analytics and predictive models.
- Supporting collaborative engineering and reviews, root-cause analysis, and predictive maintenance.
- Enhancing spatial and temporal understanding through immersive AR/VR environments tailored to operator needs.
The outcome will be a reference approach and software architecture for next-generation human-machine interfaces in space missions. The prototype will demonstrate improved operator performance, more efficient spacecraft control, and faster, more informed decision-making.

The activity includes the following tasks:
- Analyse use cases, state-of-the-art solutions, user requirements, and trade-offs for enhanced monitoring across design, AIT, and operations.
- Develop a prototype adaptive interface leveraging XR, AI, and digital twin integration with MBSE and ontology-based semantics.
- Evaluate the solution’s performance across multiple domains and define a roadmap for technology maturation.

Deliverables: Prototype, Report, Software

Application/Need Date: All missions. TRL6 by 2028 **Mission Classification:** alpha, beta, gamma, delta

THAG Roadmap: Model Based for System Engineering (2024) – Consistent with activity AIM H12 “Model Based System Engineering Explorer (MB-SEE)”.