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Multi-Modal and Multi-Aspect Holistic Human-Robot Interaction

FORTIS

FORTIS Open Call #2
Annex 1.1 – Technical Specifications

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Disclaimer

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1 Introduction

This document, referred to as Annex 1.1 FORTIS Technical specification for OC#2, offers a comprehensive outline of FORTIS OC#2 topics, specifications and requirements, as well as the available FORTIS modules. This opening chapter introduces the core topics. To learn more about FORTIS technical specifications and system architecture check our public deliverable D1.2 FORTIS 1st technical Specifications and system architecture.

The FORTIS Open Call #2 (OC#2) involves two major topics (Figure 1). Topic OC#2.1 "Pushing towards the deployment of FORTIS" focuses on deploying the FORTIS solution by recruiting industry and societal partners to integrate their own systems with FORTIS technologies, using existing pilots to demonstrate how it all works. Topic OC#2.2 "Exploiting the FORTIS solution in other key sectors" expands on this by attracting end users from entirely different sectors, specifically those involving human-robot interaction (HRI) with civilians, to prove that the FORTIS solution is both scalable and easily adaptable to new environments.

FORTIS Open Call #2 indicative budget is EUR 3 142 746.92: EUR 2 065 373.46 for Topic OC#2.1 and EUR 1 077 373.46 for Topic OC#2.2. Topic OC#2.1 foresees providing a contribution of up to EUR 250 000.00 for at least 8 projects and up to EUR 170 000.00 for at least 6 applications for Topic OC#2.2.

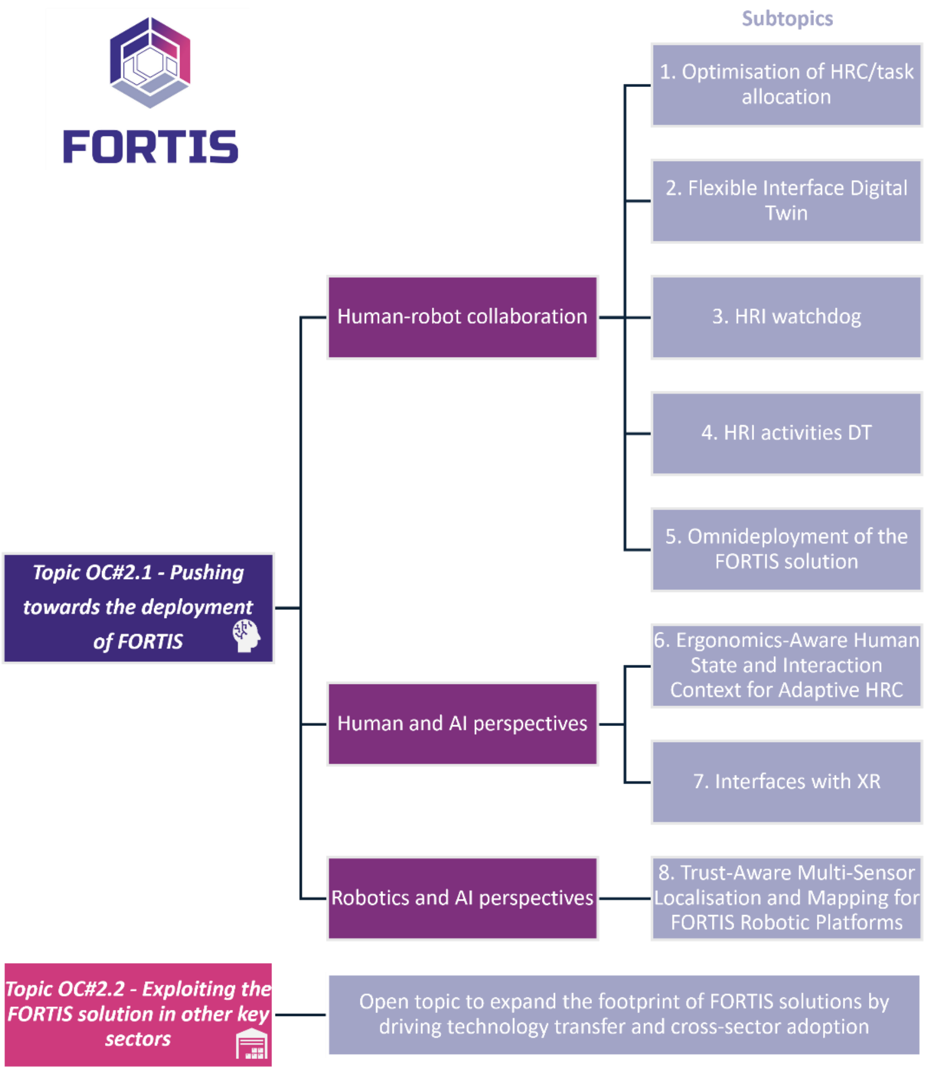

Figure 1. FORTIS OC#2 topics and subtopics.

2 Topic OC#2.1: pushing towards the deployment of FORTIS

Applicants must submit their proposals for one of the FORTIS topics and subtopics. Below a description of the subtopics for OC#2.1 is provided, with a description, technical requirements and key aspects that the proposal should address and an example real world application.

2.1. Human-robot collaboration

Subtopic 1: Optimisation of HRC/task allocation

a) Description:

Coordinating humans and robots in highly dynamic industrial environments (factories, logistics, airports) is a challenging task. Due to the complexity of modelling human behaviour and the safety regulations governing robotic systems, allocating tasks between humans and robots is not trivial. The FORTIS project aims to deploy its human-friendly robotic solutions in environments where task allocation can be optimised in real time with minimal knowledge about the human operating around the robot.

The project seeks to advance the state of the art in adaptive task and resource allocation for HRC (human - robot collaboration). By leveraging real-time context awareness, human-centric intelligence, and optimization capabilities, FORTIS aims to enable the dynamic allocation of tasks between human operators and robotic systems while balancing operational efficiency, flexibility, and safety. In this sense, supporting collaborative and trustworthy human–robot operations, allowing organizations to optimize the use of available resources and improve overall performance in complex and evolving industrial environments.

For this open call, proposals are invited to adapt the Rapid and Agile resource allocation toolkit into applications that address the challenges of real-time task and resource allocation in human–robot collaborative settings, contributing to more efficient, resilient, and adaptive industrial operations.

b) Technical requirements

Proposals should demonstrate how the FORTIS Rapid and Agile Resource Allocation Toolkit can be adapted, integrated, and validated in human–robot collaborative environments. The emphasis is on extending the applicability and impact of the FORTIS solution rather than developing new task allocation algorithms.

Applicants are expected to address the following aspects:

Adaptation to New Application Domains

- Demonstrate the applicability of the FORTIS Rapid and Agile Resource Allocation Toolkit in a new industrial environment or use case.
- Address operational challenges specific to the targeted domain, such as manufacturing, logistics, warehousing, maintenance, transportation, or airport operations.
- Define the relevant resources, tasks, constraints, and operational objectives of the selected use case.

Integration with Existing Systems

- Integrate the FORTIS toolkit with existing operational platforms, robot fleets, warehouse management systems, manufacturing execution systems, or other relevant software and hardware infrastructure.

- Develop interfaces, connectors, or middleware components required to enable seamless data exchange and deployment.

Human–Robot Collaboration Support

- Configure and adapt the toolkit to support task allocation scenarios involving human workers and robotic systems.
- Demonstrate how the proposed application considers operational constraints related to safety, workload distribution, resource availability, and collaboration efficiency.
- Enable practical deployment under realistic conditions where only limited information about human operators may be available.

Context-Aware Resource Allocation

- Exploit available contextual and operational information to improve resource allocation decisions.
- Incorporate relevant data sources, such as task status, resource availability, environmental conditions, or workflow information, to support dynamic allocation processes.

Performance Assessment and Validation

- Validate the adapted solution in a representative operational environment, either through pilot deployments, realistic simulations, or digital twin environments.
- Define and measure relevant Key Performance Indicators (KPIs), such as:
  - Resource utilization.
  - Task completion time.
  - Throughput and productivity.
  - Operational flexibility.
  - Human workload balancing.
  - Reduction of idle time.
- Demonstrate the benefits of the proposed application compared to existing operational practices.

c) Real-world scenario(s):

Suitable applications of the FORTIS Rapid and Agile Resource Allocation Toolkit can be found in a wide range of industrial environments where human workers and robotic systems must collaborate under changing operational conditions. Examples include warehouses where autonomous mobile robots and operators jointly perform picking and transportation tasks, manufacturing facilities where collaborative robots assist workers on assembly lines, airports where personnel and autonomous vehicles coordinate ground operations, and industrial plants where maintenance activities must be dynamically assigned based on resource availability and operational priorities. In these scenarios, the toolkit can support the real-time allocation of tasks and resources by adapting to variations in workload, workforce availability, robot capabilities, and process constraints. Applicants are encouraged to demonstrate how the FORTIS solution can be integrated into such environments to improve operational efficiency, resource utilization, flexibility, and resilience while enabling safe and effective human–robot collaboration

d) Integration of FORTIS solutions

The applicants are expected to deploy and validate the FORTIS Rapid and Agile Resource Allocation Toolkit and other toolkits related to it or replace some of these toolkits with their own development integrating real-time or historical data streams from legacy systems, enterprise platforms, IoT infrastructures, or process data collection systems. The objective is to demonstrate the practical applicability of the FORTIS approach in supporting adaptive, data-driven task and resource allocation for human–robot collaborative operations.

e) Expected outputs

- A validated deployment of the FORTIS Rapid and Agile Resource Allocation Toolkit in a relevant industrial environment, demonstrating its applicability to real-world human–robot collaboration scenarios.
- Demonstration of improved operational performance through quantitative evidence based on relevant Key Performance Indicators (KPIs), such as resource utilization, task completion time, throughput, workload balancing, operational flexibility, or reduction of idle time.
- Validation of human–robot collaboration workflows, showing how the solution supports safe, efficient, and trustworthy interaction between human operators and robotic resources in dynamic environments.
- A use-case demonstrator, showcasing the practical benefits of the FORTIS approach and providing a clear pathway towards operational deployment.

Subtopic 2: Flexible Interface Digital Twin

a) Description:

Digital Twins are becoming a key enabler for the design, monitoring, optimization, and validation of human–robot collaborative systems. Within the FORTIS project, significant effort is dedicated to the creation of digital representations of human–robot interactions, where human models, robotic systems, environmental information, and operational processes are integrated to simulate, predict, and evaluate collaborative activities. These digital representations support the development of safer, more efficient, and human-centric robotic solutions by providing a virtual environment where different operational scenarios can be tested before deployment.

However, current Digital Twin implementations are often highly tailored to specific environments, applications, or operational workflows. Such tight coupling limits their scalability, reusability, and adaptability across different industrial sectors and use cases. As organizations increasingly require flexible solutions capable of supporting dynamic production systems, changing workflows, and heterogeneous robotic platforms, there is a growing need for Digital Twin frameworks that can easily adapt to new operational contexts without extensive redevelopment efforts.

The FORTIS project aims to address this challenge through the development and deployment of a Flexible Interface Digital Twin capable of supporting multiple use cases through configurable and modular interfaces. By decoupling the Digital Twin core functionalities from application-specific implementations, the solution can facilitate seamless integration with diverse human–robot collaboration environments, simulation tools, robotic platforms, enterprise systems, and data sources.

For this open call, proposals are invited to adapt, extend, and validate the FORTIS Digital Twin framework by developing flexible interfaces and integration mechanisms that enable the rapid deployment of Digital Twin solutions across different industrial scenarios. The objective is to demonstrate how configurable and interoperable Digital Twin architectures can enhance the usability, scalability, and impact of the FORTIS human–robot collaboration solutions.

b) Technical Requirements

Proposals should demonstrate how the FORTIS Digital Twin framework can be adapted, extended, integrated, and validated through the development of flexible interfaces capable of supporting multiple industrial use cases. The emphasis is on increasing interoperability, configurability, and deployment flexibility rather than developing entirely new Digital Twin platforms.

- Demonstrate the development or adaptation of configurable Digital Twin interfaces that support multiple industrial applications.
- Enable the dynamic configuration of Digital Twin components, data models, and visualization elements without requiring significant redevelopment efforts.
- Support plug-and-play integration of new assets, sensors, human models, robotic systems, and operational processes.
- Develop interfaces, APIs, middleware components, or data connectors required for seamless interoperability.
- Enable bidirectional communication between physical systems and Digital Twin components.
- Support the simulation, analysis, and monitoring of collaborative human–robot activities.
- Incorporate real-time and historical data sources to maintain synchronization between the physical environment and its digital representation.
- Develop flexible visualization interfaces that can be adapted to different user roles and operational needs.
- Demonstrate configurable dashboards, visualization tools, or immersive interfaces that facilitate operational understanding and decision support.

c) Real-world Scenario(s):

Suitable applications of the FORTIS Flexible Interface Digital Twin can be found in a wide variety of industrial environments where human operators and robotic systems interact within dynamic operational contexts. Examples include manufacturing facilities where Digital Twins are used to evaluate production changes before implementation, warehouses where collaborative robots and operators coordinate logistics activities, airports where ground operations can be simulated and optimized, and maintenance environments where work processes and resource allocation are continuously monitored and improved.

In these scenarios, the Digital Twin can provide a configurable virtual representation of both physical assets and human–robot interactions, enabling simulation, monitoring, predictive analysis, and operational optimization. Applicants are encouraged to demonstrate how flexible interfaces can facilitate the rapid adaptation of the Digital Twin to new operational requirements, equipment configurations, workflows, and user needs while reducing deployment effort and increasing scalability across different domains.

d) Integration of FORTIS Solutions

Applicants are expected to deploy and validate the FORTIS Digital Twin framework and associated human–robot collaboration components by integrating data streams from robotic platforms, simulation environments, IoT devices, enterprise systems, sensor networks, or operational databases. The proposed solutions should demonstrate how flexible interface mechanisms enable the adaptation of the Digital Twin to different industrial use cases while maintaining interoperability with the broader FORTIS ecosystem.

Particular emphasis should be placed on integrating human models, robot models, environmental representations, and operational data into a unified Digital Twin environment capable of supporting simulation, monitoring, decision support, and performance analysis. Applicants may also extend or replace selected interface components with their own developments, provided compatibility with the FORTIS architecture and objectives is maintained.

e) Expected Outputs

- A validated deployment of the FORTIS Flexible Interface Digital Twin in a relevant industrial environment, demonstrating adaptability across multiple use cases.
- Demonstration of successful integration between the Digital Twin and heterogeneous industrial systems, including robotic platforms, sensors, enterprise applications, or simulation environments.
- Validation of human–robot interaction modelling capabilities through representative collaborative operational scenarios.
- Quantitative evidence of improved interoperability, deployment flexibility, scalability, and usability based on relevant Key Performance Indicators (KPIs).
- A use-case demonstrator showcasing the benefits of flexible Digital Twin interfaces and providing a clear pathway toward adoption in diverse industrial sectors.
- Documentation, integration guidelines, or reusable interface components that facilitate the future deployment and extension of the FORTIS Digital Twin framework.

Subtopic 3: HRI watchdog

a) Description:

FORTIS aims to develop a reusable HRI Watchdog to assess human-robot interaction practices, data flows and AI-enabled system behaviour during development, testing and real-world deployment. The toolkit should identify potential ethical, safety, privacy, cybersecurity and regulatory risks, including those related to the EU AI Act and the Cyber Resilience Act.

The solution may use an AI-assisted monitoring agent to detect problematic patterns, generate traceable alerts and recommend actions for human review. It should support developers and operators without replacing legal assessment, formal compliance evaluation or human decision-making.

b) Technical requirements

The Watchdog should implement the guidelines and assessment criteria developed within FORTIS and may extend them when justified by the proposed approach or use case. The proposed solution should address the following requirements:

- **Risk assessment:** Identify potential ethical, safety, privacy, cybersecurity and regulatory concerns based on authorised evidence from the assessed system, development process or deployment.

- **Configurable monitoring:** Allow the applicable guidelines, assessment criteria and risk thresholds to be configured or extended according to the use case.
- **Traceable findings:** Generate understandable findings indicating the identified issue, supporting evidence, risk level and recommended action for human review.
- **Controlled access and non-retention:** The solution should follow a non-retention principle. It should not use FORTIS source code, toolkit data, models, documentation or assessment inputs for training, secondary analysis or any purpose that has not been explicitly authorised. Assessments should preferably rely on metadata, test evidence, anonymised information or temporary local processing.
- **Software ownership and licensing:** When assessing proprietary software, the Watchdog should operate without copying, modifying or redistributing it. The use of open source components should respect their applicable licence conditions. Applicants should explain how they will protect confidentiality, intellectual property and trade secrets.
- **Validation:** The Watchdog should be validated in at least one representative FORTIS development, testing or deployment workflow using suitable technical and user-centred KPIs.

Applicants should document the assessment methodology, the FORTIS guidelines implemented or extended, the required inputs, the configuration options and the measures applied to ensure secure and confidential processing.

c) Real-world scenario(s):

The HRI Watchdog should be applicable across all FORTIS pilots and to different HRI systems, regardless of the robot, task or operational environment. During development and testing, it may assess selected documentation, data flow descriptions, interaction workflows, configurations, test results and other explicitly authorised evidence to identify potential ethical, safety, privacy, cybersecurity or regulatory concerns.

During real-world deployment, the Watchdog may be used on demand to assess a controlled set of system events, monitoring outputs or operational evidence. It should generate traceable findings and recommendations for human review without requiring permanent integration with the assessed toolkits, unrestricted access to their internal operation or the retention of their data or proprietary information.

Applicants may select any FORTIS pilot or relevant HRI application for validation, provided that the scenario demonstrates the Watchdog's use during development, testing or deployment and measures its contribution to risk identification, traceability and responsible human oversight.

d) Integration of FORTIS solutions

The HRI Watchdog should be developed as an independent and reusable assessment tool that can be applied to FORTIS toolkits and applications when required. It is not expected to be permanently integrated into the toolkits or to continuously access their internal operation.

During development, toolkit owners may use the Watchdog to assess selected evidence, such as data-flow descriptions, interface specifications, interaction workflows, test results, configuration information or explicitly authorised system events. During deployment, it may be activated to analyse a controlled set of operational events or monitoring outputs, when permitted by the toolkit owner and the deployment conditions, subject to authorisation by the toolkit owner and the specific deployment conditions.

The Watchdog should access only the information required for the authorised assessment and should not retain toolkit data, source code, models, documentation or proprietary information after the assessment has been completed.

Subtopic 4: HRI Activities DT

a) Description:

Human–Robot Interaction (HRI) is a fundamental component of the FORTIS vision for enabling safe, trustworthy, and efficient collaboration between humans and robotic systems in industrial environments. The FORTIS DT (Digital Twin) framework is expected to provide analysis, simulation, monitoring, and decision-support capabilities for both human operators and robots while executing individual and collaborative tasks. Through digital representations of humans, robots, and operational environments, the FORTIS solution aims to support the design, optimization, and validation of collaborative workflows across a range of industrial applications.

However, while humans and robots can be individually represented within a Digital Twin environment, the interactions between them constitute a distinct and equally important element that can itself be digitally twinned. Human–Robot Interactions involve dynamic exchanges of information, actions, intentions, decisions, and responses that directly influence the effectiveness, safety, and success of collaborative operations. As interaction scenarios lie at the core of FORTIS, representing these activities as Digital Twin entities creates new opportunities for monitoring, analysing, predicting, and optimizing collaboration processes.

The FORTIS project seeks to advance the state of the art by developing an Interaction-Centric Digital Twin capable of modelling HRI activities and propagating their effects on the human operator, the robotic system, and the achievement of the interaction objective. Such a Digital Twin should capture the evolution of collaborative activities, contextual factors influencing interactions, and the resulting impact on operational performance and collaboration quality.

For this open call, proposals are invited to develop, adapt, and validate frameworks for digitally twinning Human–Robot Interaction activities, including the definition and implementation of Key Performance Indicators (KPIs) and metrics that characterize interactions from three complementary perspectives: the human, the robot, and the interaction goal. The objective is to demonstrate how interaction-aware Digital Twins can improve the understanding, assessment, optimization, and trustworthiness of collaborative operations in real-world industrial environments.

b) Technical Requirements

Proposals should demonstrate how the FORTIS HRI Activities Digital Twin can be developed, integrated, and validated in real-world or realistic industrial environments. The emphasis is on representing, monitoring, assessing, and analysing Human–Robot Interaction activities and their impact on operational outcomes.

- Develop digital representations of Human–Robot Interaction activities, events, and workflows.
- Model the relationships between human actions, robot behaviours, environmental conditions, and interaction outcomes.
- Capture the temporal evolution of collaborative activities and interaction states.
- Support the representation of both routine and dynamic interaction scenarios.
- Define and implement metrics that assess HRI activities from the perspectives of:
    - Human operators.
    - Robotic systems.

- Interaction goals and task outcomes.
- Establish mechanisms to evaluate the quality and effectiveness of collaboration.
- Define and validate a set of Key Performance Indicators (KPIs) for HRI Digital Twins.
- Consider indicators related to:
    - Collaboration efficiency.
    - Task success rate.
    - Human workload.
    - Human trust and acceptance.
    - Robot responsiveness.
    - Interaction fluency.
    - Communication effectiveness.
    - Safety and risk reduction.
    - Goal achievement.
- Enable data exchange between the HRI Digital Twin and relevant simulation, monitoring, or analytics platforms.
- Develop interfaces, APIs, or middleware components required for interoperability.

c) Real-world Scenario(s):

Suitable applications of the FORTIS HRI Activities Digital Twin can be found in industrial environments where human operators and robotic systems collaborate to achieve shared objectives. Examples include collaborative assembly lines where workers and robots perform coordinated manufacturing tasks, warehouses where operators interact with autonomous mobile robots during picking and transportation operations, maintenance activities where technicians collaborate with robotic assistants, and airport operations where personnel and autonomous systems jointly execute ground-handling procedures.

In these scenarios, the HRI Activities Digital Twin can continuously monitor and analyse interaction processes, evaluate collaboration quality, identify inefficiencies, and predict the impact of different interaction strategies on overall task performance. By digitally representing interaction activities and their consequences, organizations can gain deeper insights into collaborative workflows and improve operational effectiveness, safety, and user acceptance. Applicants are encouraged to demonstrate how the proposed solution supports interaction-aware decision-making and contributes to more trustworthy and efficient Human–Robot Collaboration.

d) Integration of FORTIS Solutions

Applicants are expected to deploy and validate the FORTIS HRI Activities Digital Twin framework by integrating it with the broader FORTIS Digital Twin ecosystem, including human models, robot models, context-aware monitoring systems, simulation tools, and operational data platforms. The objective is to demonstrate the practical applicability of interaction-centric Digital Twins in supporting the analysis and optimization of Human–Robot Collaboration processes.

The proposed solutions should leverage real-time and historical interaction data originating from sensors, robotic platforms, wearable devices, enterprise systems, or simulation environments. Applicants may integrate additional analytics modules, KPI evaluation tools, visualization capabilities, or interaction modelling components, provided that compatibility with the FORTIS architecture and objectives is maintained.

e) Expected Outputs

- A validated HRI Activities Digital Twin capable of representing, monitoring, and analysing Human–Robot Interaction activities in a relevant industrial environment.
- A framework of KPIs and metrics that characterize interactions from the human, robot, and interaction-goal perspectives.
- Demonstration of successful integration with the FORTIS Digital Twin ecosystem, including human models, robot models, and operational data sources.
- Quantitative evidence of improved understanding, monitoring, and optimization of Human–Robot Collaboration based on relevant performance indicators.
- Validation of interaction-aware simulation and predictive analysis capabilities supporting collaborative decision-making.
- A use-case demonstrator showcasing the practical benefits of interaction-centric Digital Twins and providing a clear pathway toward deployment in industrial Human–Robot Collaboration applications.

Subtopic 5: Omnideployment of the FORTIS solution

a) Description:

This topic focuses on the omnideployment of the FORTIS solution, enabling system modules to be deployed either fully on edge devices, entirely on centralized/edge servers, or dynamically partitioned across both to optimize hardware usage and system latency. The FORTIS ecosystem comprises heterogeneous AI modules with vastly different computational footprints, ranging from heavy Vision-Language Models (VLMs), Large Language Models (LLMs), and transformer-based segmentation models (e.g., SAM3), to lightweight LSTM networks and classical perception tools.

The objective is to develop a smart orchestration, optimization, and hardware recommendation framework for deploying FORTIS AI modules across heterogeneous computing infrastructures. Rather than performing unsafe live code migration during operation, the solution will establish pre-deployed edge/server configurations and intelligently route processing streams according to real-time operational requirements, such as network latency, computational load, energy consumption, and hardware availability. During an onboarding and profiling phase, the framework will benchmark the provided FORTIS ROS2 packages across candidate hardware platforms, **using NVIDIA Jetson devices as the reference upper-performance target for edge deployment**. The framework will then evaluate whether optimized versions of the models can achieve comparable performance on lower-cost edge devices, or whether execution should instead be assigned to more capable edge platforms or server infrastructure. Based on these performance profiles, the framework will automatically apply optimization techniques—including model quantization, tensor optimization, parameter reduction, and parallelization—to maximize execution efficiency. A key objective is to evaluate the cost-performance trade-off of different deployment strategies, recommending whether a workload is more efficiently executed on a cluster of lower-cost edge devices, a high-performance edge platform, or an offloaded server infrastructure. No new datasets will be required or provided for this topic; the focus is strictly on the optimization, orchestration, and deployment of existing FORTIS models.

b) Technical requirements

Proposals should deliver an end-to-end profiling, optimization, and deployment orchestration framework compatible with ROS2 (preferably Humble).

To facilitate the optimization process, **proposals may include an optional onboarding and profiling phase**, during which candidate FORTIS ROS2 packages and pre-trained models are automatically benchmarked on target hardware platforms. This phase can collect metrics such as inference speed (FPS), latency, memory footprint, power or thermal consumption, and resource utilization to characterize the computational requirements of each module.

Based on these profiling results, or through equivalent analysis methods, the framework should implement automated optimization techniques, including model quantization (e.g., INT8/FP16 using TensorRT or ONNX Runtime), pruning, tensor optimization, parameter reduction, or other approaches that enable computationally demanding perception and cognition modules (e.g., TK2.2) to execute efficiently on resource-constrained edge devices.

The solution must include a **hardware recommendation engine** capable of evaluating the computational requirements of the provided packages and recommending the most cost-effective deployment architecture. The recommendation should assess the trade-off between performance, resource consumption, and hardware cost, determining whether a workload is best executed on lower-cost edge devices, high-performance edge platforms (e.g., NVIDIA Jetson devices), or server-class infrastructure.

The framework should support configurable operational constraints, such as maintaining a minimum target frame rate (e.g., 10 FPS) and preserving a minimum acceptable accuracy after optimization (e.g., at least 60% of accuracy on representative test datasets). Based on these constraints, it should generate deployment recommendations comparing candidate hardware configurations and optimization strategies.

During execution, the framework should support intelligent routing of data and computational tasks between pre-deployed edge and server nodes according to real-time operational conditions, such as network latency, bandwidth availability, and computational load. The solution should avoid requiring live migration of running applications and instead dynamically select among pre-deployed execution endpoints.

The solution must be open-source, fully documented, and expose well-defined interfaces that allow existing ROS2 packages to be integrated with minimal or no manual modification, without requiring developers to manually rewrite the core logic of the provided FORTIS packages.

c) Real-world scenario(s):

In a typical FORTIS deployment, multiple robots or intelligent sensing systems execute perception, cognition, and human-robot interaction modules with significantly different computational requirements. Some applications may require running computationally intensive models, such as foundation segmentation models, vision-language models (VLMs), or multi-modal perception pipelines, while others rely on lightweight safety or monitoring algorithms. Depending on the available network connectivity, computational resources, and operational constraints, the most efficient deployment strategy may vary considerably.

An omnideployment framework could automatically profile these workloads, optimize the models through techniques such as quantization or tensor optimization, and recommend the most suitable hardware architecture. For example, in environments with limited or unreliable connectivity, the framework may recommend executing optimized models locally on high-performance edge devices (e.g., NVIDIA Jetson platforms) to guarantee real-time operation. Conversely, in environments with reliable, high-bandwidth local networks, the framework could recommend deploying lightweight components on lower-cost edge devices while offloading computationally intensive tasks to shared edge or server infrastructure. As operational conditions evolve (e.g., network degradation, increased computational load, or thermal throttling), the system would dynamically reroute processing among pre-deployed execution nodes to maintain the required performance.

The topic is intentionally **pilot-agnostic** and is applicable across all FORTIS operational environments. In **Pilot 1 (Construction)**, it could optimize the deployment of perception and human-robot collaboration modules on mobile construction machinery operating under variable connectivity. In **Pilot 2 (Railway Infrastructure)**, it could balance computation between inspection vehicles, edge devices, and centralized servers during long-range infrastructure monitoring. In **Pilot 3 (Manufacturing)**, it could orchestrate AI workloads across multiple collaborative robots and workstations to efficiently share computational resources within the factory. The key objective is to enable cost-aware, adaptive deployment of AI modules by balancing computational performance, hardware cost, and operational constraints, allowing the same FORTIS software components to be efficiently executed on heterogeneous edge-cloud infrastructures without requiring manual reconfiguration.

d) Integration of FORTIS solutions

The proposed omnideployment framework will consume standard FORTIS ROS2 packages and existing benchmark datasets provided for development and validation. No additional data acquisition campaigns or creation of new external datasets are expected from applicants; the focus of the open call is exclusively on algorithmic optimization, profiling, and deployment orchestration of existing FORTIS models and software components.

The framework will interface with perception and cognition toolkits—primarily **TK2.2 FORTIS AI-based Human Cognition Toolkit**—to profile, optimize, compress, and deploy computationally intensive AI models. The solution should also integrate with system-level orchestration and resource management components, including **TK3.4 FORTIS Multi-Robot Dynamic Reconfigurability Toolkit / Fleet Management System (FMS)** for multi-robot task coordination and dynamic workload distribution, and **TK4.4 FORTIS Resource Allocation and Optimization Toolkit** for resource-aware optimization and allocation across heterogeneous computing infrastructures. Where relevant, the framework may leverage contextual information provided by **TK4.2 FORTIS HRI Digital Twin** to support deployment decisions based on the operational environment and task requirements.

FORTIS will provide baseline ROS2 (Humble) packages, pre-trained model weights, representative test bags/data, and detailed specifications of the available reference hardware configurations (including NVIDIA Jetson-based edge platforms) to support profiling and validation. Direct online access or remote execution on FORTIS hardware is not foreseen within the open call. Applicants may use the provided hardware specifications and, where needed, perform additional profiling on their own equivalent or alternative hardware platforms to evaluate and extend the proposed optimization strategies.

2.2. Human and AI perspectives

Subtopic 6: Ergonomics-Aware Human State and Interaction Context for Adaptive HRC

a) Description:

This topic focuses on extending the FORTIS Human-Centred Toolkits with an ergonomics-aware human state and interaction-context module for adaptive human-robot collaboration (HRC). The proposed solution should estimate and interpret worker ergonomic risk indicators during collaborative tasks involving humans, robots, and/or autonomous machines. The module may combine wearable and non-wearable sensing, with preference for robot-centric or infrastructure-based sensing whenever feasible, to infer posture quality, effort/fatigue proxies, workload-related indicators, task phase, role, and confidence/uncertainty of the assessment. The objective is not only to monitor ergonomics offline, but to transform human-state information into robot-actionable context that can support real-time behavioural adaptation by robots, the Fleet Management System (FMS), and FORTIS communication and interaction toolkits. Examples include adapting robot speed, distance, waiting behaviour, task sequencing, confirmation loops, or communication modality when a worker is under strain, fatigue, high workload, or constrained posture.

b) Technical requirements

Proposals should deliver a deployable module able to estimate ergonomic and human-state indicators in realistic HRC conditions. The solution should support, at minimum, posture/pose-based ergonomic assessment, task-phase recognition, worker role/context identification, and a confidence score associated with each output. The use of recognised ergonomic or workload assessment references, such as RULA, REBA, OWAS, ISO-based postural assessment, NASA-TLX, or equivalent validated indicators, is encouraged when appropriate.

The module should be completely open source and expose its outputs through clear and documented interfaces compatible with FORTIS integration needs, using ROS2 messages (preferably Jazzy Jalisco), REST APIs, or equivalent middleware interfaces. Outputs should include timestamped and pseudonymised worker identifiers, estimated ergonomic state, task context, confidence level, and optional adaptation recommendations. The system should support near-real-time operation with latency compatible with safe HRI decision-making and should be robust to partial occlusions, changing illumination, protective equipment, noisy environments, and variable worker body types.

Privacy and ethics-by-design are mandatory. The solution should minimise raw personal data processing whenever possible, support pseudonymisation or anonymisation, and avoid unnecessary storage of identifiable video, audio, or physiological data. The module should also be documented with installation instructions, interface specifications, and validation procedures. Applicants should provide quantitative evidence of performance through baseline comparison, including ergonomic risk reduction, detection/classification accuracy, latency, robustness, and impact on human workload or task execution.

c) Real-world scenario(s):

In the FORTIS construction pilot (Pilot 1), workers collaborate with autonomous or robotised heavy-duty machines during material transport and sandwich panel assembly. In such scenarios, workers may guide machines, stabilise loads, align panels, clear obstacles, or intervene when a robot requests assistance. These tasks may involve awkward postures, repetitive actions, limited visibility, cognitive load, and proximity to heavy machinery. An ergonomics-aware module could identify when a worker is maintaining a strained posture while aligning a panel, when a worker is overloaded during a repetitive support task, or when the system should delay, slow down, or modify a robot action to reduce human effort.

The topic is intentionally pilot-agnostic and may also apply to the other pilots where humans work near robots under physical or cognitive load, including infrastructure inspection and maintenance (Pilot 2) and manufacturing (Pilot 3). The key requirement is that the solution demonstrates how human-state information can move beyond monitoring and actively support safer and more adaptive collaboration.

d) Integration of FORTIS solutions

The proposed module should integrate primarily with the FORTIS Human-Centred Toolkits. It may consume data from TK2.1 FORTIS Human-Centred Data Collection Toolkit and provide interpreted ergonomic and contextual outputs to TK2.2 FORTIS AI-based Human Cognition Toolkit, TK2.3 FORTIS Human-Robot Interaction Context Toolkit, and TK2.4 FORTIS Multi-modal Adaptive Human-Robot Communication Toolkit.

The module should also provide actionable outputs to robot-centric and system-level toolkits. For example, ergonomic state and interaction context may be consumed by TK3.2 FORTIS Robot Gateway to adapt robot actions or safety gates, by TK3.4 FORTIS Multi-Robot Dynamic Reconfigurability Toolkit / FMS to reassign or resequence tasks, by TK4.1 FORTIS HRI Digital Twin to visualise human-state and ergonomic risk, by TK4.2 FORTIS Resource Allocation and Optimisation Toolkit to include human workload constraints in planning, and by TK4.3 FORTIS Human-safe and Private Solution Watchdog to raise safety or privacy alerts when relevant.

FORTIS will provide ROSbags, robot sensor configurations, test scenarios, and integration support.

Subtopic 7: Interfaces with XR

a) Description:

To increase human immersion, situational awareness, and interaction effectiveness during Human-Robot Interaction (HRI), the FORTIS project aims to extend its multimodal interaction capabilities through innovative Augmented Reality (AR) and Extended Reality (XR) interfaces, including AR/MR smart glasses. The objective is to bring humans and autonomous systems closer together by enabling intuitive, context-aware communication in complex industrial environments where traditional interfaces (e.g., screens, tablets, or handheld devices) may be ineffective due to noise, poor visibility, limited accessibility, or occupied hands.

The proposed solution should exploit the data, services, interaction context, and multimodal capabilities provided by the FORTIS ecosystem to enable users to perceive, understand, and interact naturally with embodied AI systems, including individual robots, robotic fleets, and their associated digital representations. Smart glasses should act as a **bi-directional interaction node**, combining wearable sensing capabilities with an intuitive communication interface. On one side, they should provide additional perception capabilities by streaming first-person-view (POV) video, audio, and other relevant user context information to FORTIS perception and cognition modules. On the other side, they should deliver relevant information back to the user through immersive and context-aware AR/MR visualizations.

The interface should provide users with meaningful information about robot status, intentions, planned actions, task progress, environmental conditions, safety constraints, and requests for human intervention. By visualizing robot states and future actions directly in the user's field of view, the system should improve human understanding of autonomous behaviours, increase trust in robotic systems, and support safer decision-making during collaborative tasks.

The solution should also enable intuitive bidirectional interaction mechanisms, allowing users to provide commands, confirmations, corrections, or feedback through one or more natural modalities, such as gestures, gaze, voice, touch, or spatial annotations. These mechanisms should support situations in which direct physical interaction with robots is unsafe, inefficient, or impractical, enabling workers to guide and supervise autonomous systems while maintaining awareness of the surrounding environment.

A key aspect of the topic is the evaluation of human factors and usability. Proposed solutions should include a human-centric assessment of UI/UX aspects, considering operator preferences, workload, cognitive effort, and interaction effectiveness under realistic industrial constraints. The evaluation should consider challenging environmental conditions, including dust, noise, low illumination, occlusions, protective equipment, distance from robots, and limited connectivity, to identify the most effective XR communication strategies.

The proposed AR/XR interface should complement the existing interaction channels available within FORTIS and should not rely on a single communication modality. Instead, it should provide robust multimodal interaction capabilities capable of adapting to different operational conditions and user needs.

The objective is to deliver a reusable and deployable AR/XR interface that integrates with the FORTIS ecosystem, enhances human understanding of robot behaviour, enables safe and efficient bidirectional communication, and supports more adaptive, reliable, and trustworthy human-robot collaboration across different FORTIS scenarios.

b) Technical requirements

Proposals must deliver an integrated AR/MR software module together with an accompanying human-factors evaluation study. The proposed solution should demonstrate both the technical integration of XR interfaces within the FORTIS ecosystem and the ability to identify the most effective interaction modalities for industrial human-robot collaboration.

From a technical perspective, the AR/MR system should support the integration of wearable smart glasses as a **bidirectional interface between the operator and the FORTIS framework, enabling real-time exchange of information between the wearable device, edge components, and remote FORTIS services.** The solution should exploit available communication infrastructures, such as Wi-Fi, 5G, or equivalent low-latency connectivity technologies, to support reliable data streaming and interaction with FORTIS cloud/edge resources when required. The glasses should provide wearable sensing capabilities by streaming relevant information, such as point-of-view (POV) video, audio, and head-tracking data (if available), into the FORTIS network through standard communication interfaces (e.g., ROS2 Humble, REST APIs, or WebRTC-based solutions). This information should complement the existing perception and cognition capabilities of FORTIS, for example by providing additional views of the environment, detecting objects or events outside the robot's field of view, or capturing operator context such as gaze direction, attention, or position. Conversely, the interface should receive, and present real-time information generated by FORTIS services, such as robot states, safety alerts, task instructions, and contextual recommendations, enabling effective human-robot collaboration.

The proposed AR/MR interface should enable intuitive and efficient communication between operators and robotic systems through lightweight and natural interaction mechanisms. Depending on the capabilities of the selected hardware, this may include voice commands, head gestures, hand gestures, gaze-based interaction, or other suitable modalities. The solution should allow users to provide commands, confirmations, corrections, or feedback without requiring external devices or interrupting their primary tasks.

The interface should provide context-aware AR visualizations and alerts that improve situational awareness and support safer collaboration. Examples include safety-related notifications, such as visual or audio warnings when a robot approaches an operator from an unsafe direction or when a user enters a restricted area; notification mechanisms for situations where a robot requires human assistance but traditional communication channels are ineffective due to environmental noise or other constraints; and navigation or task guidance through AR overlays, such as virtual waypoints, directional cues, or floor-path indications synchronized with the FORTIS Digital Twin and robot task planning information.

In addition to the technical development, proposals should include a human-centric evaluation of the proposed XR interaction paradigms. The study should assess usability, operator preferences, cognitive workload, and effectiveness under realistic industrial conditions representative of FORTIS scenarios, including challenging environments with high noise levels, variable lighting, dust, occlusions, protective equipment, and other operational constraints. The evaluation should investigate trade-offs between different XR design choices, such as lightweight interfaces versus richer visual information, visual notifications versus audio feedback, and spatial navigation cues versus traditional indicators.

The outcome of the human-centric assessment should include a comprehensive XR UI/UX recommendation guideline describing which interaction modalities and information presentation strategies are most suitable for different industrial contexts, with the objective of maximizing situational awareness while minimizing cognitive overload and interaction complexity.

Applicants should provide complete interface specifications, installation and deployment instructions, user documentation, and validation procedures to facilitate integration and reuse within the FORTIS ecosystem. Core software components developed within the scope of the proposal should preferably be made available as open-source software, following FORTIS interoperability principles.

The proposed solution should also address safety, privacy, and usability aspects by preventing unsafe or unauthorized interactions, minimizing unnecessary processing and storage of personal data, and considering user comfort, accessibility, ergonomics, and cognitive workload during prolonged industrial operation.

c) Real-world scenario(s):

The proposed AR/XR interface is intended to support human-robot collaboration across diverse FORTIS operational environments, where workers and autonomous systems must interact safely and efficiently under challenging conditions. By combining wearable sensing capabilities with context-aware AR feedback, the solution can improve situational awareness, provide intuitive communication channels, and support safer decision-making when traditional interfaces are ineffective due to noise, poor visibility, distance, or occupied hands.

In **Pilot 1 (Construction)**, AR interfaces can support safer collaboration between workers and heavy autonomous machines operating in dynamic environments. For example, when a robot performs material transport or assembly tasks near workers, the XR system could provide visual, audio, or haptic warnings about robot movements, planned trajectories, blind spots, or potential safety risks. The interface could also allow workers to provide feedback or assistance requests without interrupting their ongoing activities.

In **Pilot 2 (Railway Infrastructure)**, XR technologies can assist operators during inspection and maintenance activities performed over large and complex infrastructures. The interface could provide navigation guidance through AR overlays synchronized with the FORTIS Digital Twin, highlight relevant inspection points, and augment human perception by streaming additional sensor information from the operator's viewpoint. This could support workers in locating faults, understanding robot observations, and coordinating with autonomous inspection systems.

In **Pilot 3 (Manufacturing)**, AR/XR interfaces can enhance collaboration between operators, multiple robots, and production systems in highly structured but fast-changing environments. When several robots or automated systems operate simultaneously within the same workspace, the interface could help operators understand which robot requires attention by providing spatially anchored overlays, robot identifiers, status information, and task-related notifications directly associated with the corresponding machine. The solution could provide hands-free notifications about robot status, production tasks, or required human intervention, allowing operators to confirm actions, correct robot behaviours, or provide instructions through natural interaction modalities such as voice, gestures, or gaze. By linking digital information to the physical robot through AR visualization, the system can reduce ambiguity, improve coordination within multi-robot environments, and support safer and more efficient human-robot collaboration.

The topic is intentionally **pilot-agnostic** and should demonstrate how AR/XR interfaces can be adapted to different industrial contexts. The key objective is to provide a reusable interaction layer that enhances human understanding of autonomous systems, enables reliable bidirectional communication, and contributes to safer, more efficient, and more trustworthy human-robot collaboration across FORTIS scenarios.

d) Integration of FORTIS solutions

The proposed AR/XR interface should integrate bi-directionally with the FORTIS ecosystem, primarily through ROS2 Humble and the communication interfaces exposed by the relevant FORTIS toolkits. The XR module should act as an additional interaction layer between humans and autonomous systems, providing both wearable sensing capabilities to enrich FORTIS perception and cognition pipelines and an immersive interface for delivering context-aware information and enabling human input.

The proposed solution should be responsible for the functionalities directly related to the XR device, including the acquisition, processing, and interpretation of data collected through smart glasses. The glasses should provide multimodal information such as point-of-view (POV) video, audio streams, spatial information, head pose, gaze-related information, and user interaction signals. Based on these inputs, the XR module should implement the required processing capabilities to extract relevant human context, such as gaze or attention estimation, gesture recognition, user intent interpretation, and identification of objects or events that may not be directly observable by robotic systems. The resulting information should be made available to the FORTIS Human-Centred Toolkits, particularly **TK2.1 FORTIS Human-Centred Data Collection Toolkit** and **TK2.2 FORTIS AI-based Human Cognition Toolkit**, supporting multimodal human understanding and interaction modelling.

The AR/XR interface should consume contextual information generated by the FORTIS Human-Robot Interaction and communication toolkits to provide users with meaningful and adaptive feedback. In particular, integration with **TK2.3 FORTIS Human–Robot Interaction Context Toolkit** should enable the XR interface to exploit the broader operational context, including human, robot, and environmental information, while **TK2.4 FORTIS Multi-modal Adaptive Human–Robot Communication Toolkit** should support the selection and delivery of appropriate communication modalities, such as visual overlays, audio feedback, or other XR-based interaction mechanisms. The interface should complement existing communication channels by providing an immersive and context-aware interaction modality.

The solution should also integrate with robot and fleet-level information provided by the FORTIS ecosystem. Through **TK3.2 FORTIS Robot Gateway**, the XR interface should access standardized robot information, actions, and safety-related states required for interaction. Integration with **TK3.3 FORTIS Robotic Intelligibility Toolkit** should enable the visualization of robot status, explanations, events, or execution rationales, improving operator understanding of autonomous decisions. For multi-robot scenarios, information from **TK3.4 FORTIS Multi-Robot Dynamic Reconfigurability Toolkit** should allow the XR interface to represent fleet-level status, task allocation, and human-robot coordination information.

The AR/XR interface should further integrate with the FORTIS Digital Twin and resource management capabilities. Spatial annotations, navigation guidance, and virtual object visualization should be synchronized with the environment and task information provided by **TK4.2 FORTIS HRI Digital Twin**, ensuring accurate alignment between digital and physical spaces. In addition, interaction with **TK4.4 FORTIS Resource Allocation and Optimization Toolkit** should support the visualization of relevant safety constraints, resource allocation decisions, and human-centred operational information.

FORTIS will provide the necessary APIs, ROS2 communication bridges, Digital Twin environments, and access to the relevant interaction toolkits to support integration and validation. Access to FORTIS datasets is not mandatory for the development of the XR interface, unless the proposed solution requires specific datasets for additional perception, feedback generation, or validation functionalities.

2.3. Robotics and AI perspectives

Subtopic 8: Trust-Aware Multi-Sensor Localisation and Mapping for FORTIS Robotic Platforms

a) Description:

This topic aims to strengthen the FORTIS Robotic Toolkits with a robust multi-sensor localisation and mapping module for mobile robotic platforms operating in semi-structured, dynamic, and partially GNSS-denied environments. The solution should fuse data from available sensing sources, when available, such as LiDAR, stereo/RGB-D cameras, IMU, GNSS-RTK, wheel odometry, joint states, fiducial markers, or other proprioceptive/exteroceptive sources, to provide reliable pose estimation, mapping, localisation diagnostics, and map alignment for FORTIS robots. The key technical requirement is trust-aware sensor fusion: the system should dynamically assess the reliability (and unavailability) of each sensing modality and adapt localisation and mapping accordingly, rather than assuming that all sensors are equally reliable at all times.

The topic is not intended as a generic SLAM add-on only. It should deliver a localisation and mapping capability that is aware of its own uncertainty, detects degraded sensing conditions, and provides diagnostics that can be used by robot navigation, the FMS, the Digital Twin, and safety supervision layers. The solution should support different FORTIS mobile robotic platforms and should degrade gracefully when not all sensing modalities are available.

b) Technical requirements

Applicants should provide a deployable localisation and mapping module compatible with ROS-based robotic systems, supporting ROS2 (preferably Jazzy Jalisco). The solution should use standard ROS interfaces whenever possible, including TF, odometry, pose-with-covariance, point clouds, maps, diagnostics, and navigation-compatible localisation outputs. Custom messages should be avoided unless technically justified and fully documented.

The module should support multi-sensor fusion from at least two complementary sensing families, such as LiDAR + IMU, vision + IMU, LiDAR + odometry, GNSS + LiDAR, or equivalent combinations. It should explicitly estimate sensor trust, confidence, or covariance, and should detect degraded conditions such as GNSS loss, poor visual texture, lighting changes, dust, LiDAR occlusions, wheel slip, temporary sensor dropout, vibration, and repetitive or metallic structures. The system should expose localisation quality indicators to higher-level components, enabling robots or the FMS to decide whether to continue, slow down, re-localise, request human assistance, or switch to a safer operating mode.

The expected outputs include real-time robot pose, pose uncertainty, local/global map updates, localisation health status, and, where applicable, alignment with existing Digital Twin representations. The solution should be open source and computationally feasible for on-robot deployment, including documentation with installation instructions, launch files, configuration parameters, APIs, and validation procedures. Performance should be assessed through quantitative KPIs, including localisation accuracy, orientation accuracy, update frequency, robustness to sensor degradation, recovery time after localisation loss, and improvement over single-sensor baselines. Alignment with FORTIS KPIs such as localisation accuracy, loop-closure robustness, map update capability, and multi-sensor fusion improvement is expected.

c) Real-world scenario(s):

In the FORTIS construction pilot (Pilot 1), mobile robots operate in outdoor and semi-outdoor construction-like areas with uneven terrain, heavy machinery, metallic structures, workers, pallets, panels, and changing obstacles. The autonomous loader must transport materials while maintaining robust localisation despite wheel slip, vibration, dust, partial GNSS degradation, and moving workers. The robotised telehandler must support sandwich panel assembly near a metallic structure where occlusions, limited visibility, repetitive geometric features, and large moving parts may affect localisation and mapping reliability. In both cases, localisation is safety-critical because navigation, manipulation, collision avoidance, Digital Twin synchronisation, and FMS task execution depend on accurate and timely robot pose estimates.

The same challenge is also relevant to other FORTIS pilots, including infrastructure inspection and maintenance (Pilot 2) and manufacturing (Pilot 3), as well as future deployments where robots move between indoor/outdoor zones, under changing lighting, near metallic infrastructure, or in environments where a single localisation modality cannot be trusted continuously. The proposed solution should therefore be sufficiently general to support different robot types and sensor configurations while being validated in at least one FORTIS-relevant robotic scenario.

d) Integration of FORTIS solutions

The proposed module should integrate primarily with TK3.2 FORTIS Robot Gateway, providing localisation, mapping, diagnostics, and uncertainty outputs to navigation, action execution, and safety-related robot behaviours. It should feed standard robot pose and map information to TK3.4 FORTIS Multi-Robot Dynamic Reconfigurability Toolkit / FMS, enabling task monitoring, reallocation, and robot availability assessment based on localisation health. It should also provide synchronised pose and map updates to TK4.1 FORTIS HRI Digital Twin so that the virtual representation of the site remains aligned with the physical robot and environment.

Where relevant, the module may consume semantic information from TK2.2 FORTIS AI-based Human Cognition Toolkit, for example to distinguish humans or dynamic objects from static map structures. Its localisation quality indicators may also be used by TK4.2 FORTIS Resource Allocation and Optimisation Toolkit to avoid assigning tasks to robots operating under degraded localisation, and by TK4.3 FORTIS Human-safe and Private Solution Watchdog to trigger safety responses when localisation uncertainty exceeds acceptable thresholds.

FORTIS will provide ROSbags, robot sensor configurations, test scenarios, and integration support.

3 Topic OC#2.2: exploiting the FORTIS solution in other key sectors

Applicants must submit their proposals for one of the FORTIS topics. Below a description of the Fortis topics for OC#2.2 is provided, with a description of the topic, the technical requirements and key aspects that the proposal should address and an example of application where the solution of the topic is applied.

Topic: exploiting the FORTIS solution in other key sectors

a) Description:

This open call topic aims to expand the footprint of FORTIS solutions by engaging end-users in entirely new domains beyond the current pilot frameworks. The core focus is on driving technology transfer and cross-sector adoption, specifically targeting real-world use cases centered around civilian human-robot interaction (HRI). Selected projects will be expected to deliver a tangible demonstration of FORTIS solutions in action, backed by a clearly defined lifecycle and well-structured Key Performance Indicators (KPIs).

Applicants are expected to identify a relevant use case within one of the eligible sectors - namely agriculture, farming, forestry, mining, fishing, healthcare, events, airports, shopping malls, among others - and integrate two or more FORTIS ROS packages into their proposed solution. Rather than developing entirely new technologies, proposals should focus on demonstrating the applicability, usability, and added value of the FORTIS ecosystem in realistic operational conditions.

Details on the toolkits and respective ROS packages are available at https://fortis-project.eu/toolkits/. Selected projects will receive technical support from relevant FORTIS partners to integrate the chosen components. Applicants are responsible for adapting the solution to their specific use case (including the data needed for any training or calibration of the existing FORTIS toolkits), performing validation activities, defining quantitative and qualitative KPIs, and providing evidence of the achieved results. The expected outcome is a tangible demonstration of the selected FORTIS technologies, supported by a well-defined lifecycle and clear documentation highlighting the benefits and challenges of transferring the technology to a new sector.

b) Target sectors

Applicants should align the following sectoral guidelines:

- **Primary Sectors (Priority ≥50% funding):** Agriculture, mining, forestry, and fishing.
- **Other Eligible Sectors:** Healthcare, events, airports, and shopping malls.
- **Explicit Exclusions:** Projects focusing on construction (outdoor activities), manufacturing (material delivery/AGV logistics), or railway maintenance **will not be considered**.

c) Validation requirements

The purpose of this topic is to validate the applicability and effectiveness of FORTIS solutions in new operational domains. Applicants are expected to demonstrate the successful adoption of one or more FORTIS components within a representative use case belonging to the selected sector.

The proposed validation activities should focus on the practical deployment of FORTIS technologies, evaluating their ability to support real-world Human-Robot Interaction scenarios and provide measurable benefits to end-users.

Applicants shall:

- identify the FORTIS components relevant for their use case from the available FORTIS toolkit catalogue;
- define a validation strategy describing the operational scenario, deployment methodology, and evaluation procedure;
- define appropriate Key Performance Indicators (KPIs) to assess the performance, usability, and impact of the adopted solution;
- perform validation experiments in representative real-world conditions;
- analyse the results and discuss the benefits, limitations, and potential for wider adoption of FORTIS technologies in the selected sector.

The validation methodology should consider both technical and application-oriented aspects, including, when relevant:

- system performance and reliability;
- robustness under realistic environmental conditions;
- interaction quality between humans and robots;
- usability and acceptance by end-users;
- improvement of the targeted operational process.

Applicants are encouraged to collect and provide datasets generated during the validation activities whenever applicable. These datasets may contribute to further improvement and assessment of FORTIS technologies.

Technical support during the integration and deployment phases is **exclusively limited to the FORTIS technology components**. FORTIS partners will **not** provide support for third-party robot platforms, external software, or non-FORTIS hardware integration. Applicants remain fully responsible for the operation and compatibility of their own platforms. However, applicants should ensure that the proposed solution addresses a meaningful need within their target sector and that the selected FORTIS technologies are appropriate for the intended application.

FORTIS provides a modular ecosystem composed of perception, interaction, communication, digital twin, and robotic capabilities. Applicants may select the components most relevant to their application scenario. A catalogue of available FORTIS modules and a short description is provided in Section 5 (Annex).

d) Deliverables

Selected projects are expected to provide concrete evidence of all validation activities performed, demonstrating the successful adoption of FORTIS solutions within their proposed use cases. The delivered materials must illustrate how the selected FORTIS components have been integrated, evaluated, and applied in the target sector, explicitly highlighting the achieved results and the overall impact of the solution.

To fulfil these requirements, applicants must provide a comprehensive **Validation Report** detailing the selected application scenario and objectives, the specific FORTIS components integrated into the solution, the experimental setup, and the overall validation methodology. This report must present the achieved results, evaluate the defined Key Performance Indicators (KPIs), and detail key lessons learned alongside actionable recommendations for future adoption.

Alongside the primary report, applicants must submit a dedicated **KPI Report** providing a rigorous quantitative and qualitative assessment of the implemented solution. This document must outline the defined evaluation criteria, present all measured performance results, and provide a direct comparison between expected and achieved outcomes.

In addition, applicants are required to supply supporting **Technical Documentation** describing the system architecture and integration approach, technical interfaces between the FORTIS components and the applicant's platform, and all relevant system setup, deployment requirements, and operational constraints.

When applicable, applicants must also provide a **Dataset Collection** consisting of datasets gathered during the validation campaign, accompanied by all necessary metadata and documentation to support the future assessment and continuous improvement of FORTIS technologies.

Finally, to facilitate the practical demonstration of the results, applicants must deliver **Demonstration Material**, such as video footage or other suitable evidence, showing the deployed FORTIS solution operating in a real-world, operational scenario to illustrate its practical applicability and adoption potential in the targeted sector.

4. Conclusions

This document serves as an informative resource detailing the FORTIS toolkits and the topics to which the applicants should apply for OC#2. It complements the FORTIS Guide for Applicants by providing a comprehensive understanding of the FORTIS solutions and topics specification offered by the consortium. The information provided herein should support third parties in elaborating their own proposals.

5. Annex: Available FORTIS Modules Catalogue

Note: Please note that the modules and descriptions listed below reflect the current state of technical development within the project. As the FORTIS ecosystem evolves, slight updates or adjustments to individual components may occur prior to project implementation.

Toolkit	Component / Module	Description
FORTIS Human-Centred Data Collection Toolkit	Data Ingestion Module	Handles the continuous real-time collection and formatting of raw data from multiple multimodal streams, including RGB cameras, microphones, BLE, and USB devices.
	Data Pre-processing Module	Provides functionalities for pre-processing, standardizing, and annotating data (tagging and labelling), while ensuring synchronization across data streams via indexing markers.
	Data Storage & Management Module	Manages the secure storage of annotated data, indexes it for quick retrieval, and ensures accuracy by detecting and preventing data corruption.
	Data Interface Module	Provides APIs and subscription mechanisms that allow external systems to access stored data in real-time, ensuring seamless integration through standardized formats.
FORTIS AI-based Human Cognition Toolkit	Scene - 3D Model Construction	Reconstructs a 3D model (mesh) of an object from a series of RGB-D images captured from multiple viewpoints.
	Scene - Object Segmentation & Detection	Detects and segments objects in 2D and 3D using textual prompts or 3D models, tracks objects across frames, predicts 6D poses, detects 2D markers, and performs safety checking via Vision-Language Models (VLMs).
	Scene - Anomaly Detection	Identifies patterns or behaviors that deviate from expected norms and classifies anomalies by differentiating between normal and abnormal events.
	Human - Pose & Activity Detection	Localizes human bodies and hands, estimates joint keypoints, recognizes and tracks hand gestures, and classifies physical activities.
	Human & Scene Status Manager	Senses environmental conditions (e.g., sound levels, lighting, dust, fog) and detects human factors such as physiological status, stress, and heat stroke.
FORTIS Human-Robot Interaction Context Toolkit	Context Collector	Collects and processes real-time data needed for context, including human/scene status, simulated plans, and robot states.
	Context Interpreter	Interprets human-to-robot messages, recognizes dangerous tipping points (e.g., lack of safety equipment), interprets robot errors, and decides if commands or responses need to be generated.
	Robot-Human Message Manager	Determines the specifications of robot-to-human messages (tone, urgency, politeness, emotion) and generates

		personalized text-based content based on interaction history and context.
	Human Long-Term Interaction Manager	Builds and maintains an interaction history for each human to contextualize interactions relative to ongoing tasks.
FORTIS Multi-modal Adaptive Human-Robot Communication Toolkit	Human-Robot Communication Identifier	Continuously monitors humans in the scene to estimate the possibility of interaction for each individual.
	Human-Robot Message Recognition	Integrates multimodal data to recognize communications, parses natural language teaching commands, transcribes multilingual speech into robot commands, and performs lip reading for noisy environments.
	Robot-Human Modality Selector	Dynamically adjusts identification targets, estimates modality relevance based on context, and utilizes an acknowledgment system to verify human understanding.
	Robot-Human Message Composer	Composes and delivers the final multi-modal message to the human user.
FORTIS Robot Gateway	Robot Drives & Low-Level Firmware	Provides real-time control capabilities over ROS, tracks arm poses, supports robust protocols like J1939 CAN for heavy-duty machinery, and handles robotic manipulation tasks such as gripper control and joint kinematics.
	Path Planning & Navigation	Converts raw sensor data into ROS-compatible messages, provides a hardware abstraction layer, dynamically calculates optimal paths, detects obstacles, and generates motion commands for path tracking
	Simultaneous Localisation and Mapping (SLAM)	Creates and updates global maps using sensor fusion (LiDAR, IMU, GNSS), estimates robot pose, and identifies and corrects positional drift.
	Action Server Management	Executes predefined or dynamically generated manipulation tasks and monitors hardware components to report malfunctions to the ROS environment.
FORTIS Robotic Intelligibility Toolkit	Robot Capability Manager	Models hardware capabilities and plans task-level robotic actions that adapt to human presence and scene status.
	Motion Discretization Engine	Plans primitive-level actions that match robot-to-human messages, manages ROS action requests, and intervenes to prevent accident risks during motion execution.
FORTIS Multi-Robot Dynamic Reconfigurability Toolkit	Fleet Management System	Monitors the status of all robots, human workers, and ongoing tasks, while maintaining real-time synchronization with the digital twin.
	Legacy Connectors	Manages the allocation, monitoring, and dynamic reconfiguration of tasks assigned to robots and humans in response to environmental changes.

FORTIS HRI Digital Twin	DT Connectors	Connects the digital twin to data sources of the real-world resources and the scene using multiple protocols.
	DT Modelling & Simulation Tools	Models the physical and psychological statuses of interacting partners and provides a simulation mode for testing resource planning and workflows.
	DT Dashboard	Offers configurable views to monitor resource status, present modelling parameters, sound alarms for potential risks, and analyze HRI configurations.
FORTIS Resource Allocation & Optimization Toolkit	Plan Configurator	Generates and dynamically updates initial resource allocation plans to maximize Machine Utilization Rate and Labor Productivity.
	Optimizers	Handles complex scheduling needs, such as overlapping shifts and varying availability, and learns from ongoing operations to improve task allocation dynamically.

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