Combined AI and Data solutions for DECISION SUPPORT

# Challenge 3.2

## Automated machine selection for parts production

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### Challenge and context

Many complex production processes are still partially controlled by operators with highly specialized, tacit knowledge that is difficult to formalize and document, posing risks to product quality, process reliability, and long-term industrial competitiveness if lost. At the same time, shopfloor operations often rely on simple but repetitive manual tasks, such as pick-and-place activities involving movement between workstations, which require coordinated perception, manipulation, and locomotion but are rarely described in a way that enables direct automation. The challenge is therefore twofold: to capture and structure human instructions and operator know-how, and to translate them into executable actions for robotic systems operating in dynamic production environments. In this context, adaptive DWI are essential, as they enable instructions to be both human- and machine-readable and adaptable to operational conditions. The AID4SME framework provides a foundation for addressing these challenges through AI-driven decision support, knowledge representation, and cyber-physical systems. As a representative use case, the project focuses on enabling a humanoid robot to learn and execute a simple pick-and-place task with locomotion between workstations based on human-provided instructions. This use case represents the execution layer of decision support, where high-level decisions—such as machine selection for parts production—are translated into actionable instructions and physically carried out on the shopfloor by the robot. In this way, the project demonstrates a practical pathway for bridging human expertise, AI-based decision-making, and autonomous robotic execution in real production environments.

### Use case and expected solution

The challenge addresses the need to formalize and digitalize operator knowledge and translate it into actionable instructions for robotic systems. Capturing and representing this knowledge requires combining structured knowledge capture methodologies with AI-based approaches capable of linking human actions with process context. The use case focuses on a practical and demonstrable scenario, where a humanoid robot learns and executes a simple pick-and-place task involving locomotion between workstations based on human-provided instructions. The proposed solution leverages imitation learning and reinforcement learning to enable the robot to learn from demonstrations and structured DWI, transforming human-readable instructions into robot-executable workflows. The approach is supported by theoretical and methodological developments, including knowledge representation, instruction modelling, and AI-based learning strategies. The resulting system will demonstrate that a humanoid robot can reliably execute a defined task in an industrial setting, enabling improved process consistency, reduced dependency on manual execution, and a scalable pathway for integrating human-centric AI and humanoid robotics into smart manufacturing systems.

### Specification for use case

The use case focuses on enabling a humanoid robot to autonomously perform a simple pick-and-place task involving locomotion between two or more workstations in a production environment at LTH Castings. The humanoid robot is to be provided by the solution provider and is not part of the playground infrastructure. The task includes object detection, grasping, transportation, and precise placement, while navigating safely between predefined locations on the shopfloor.

The system shall support the following functional specifications:

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- Task definition and execution: Pick an object from a defined source location (e.g., bin or fixture), Walk to a target workstation using predefined or dynamically generated paths, Place the object at a designated position with sufficient accuracy and repeatability
- Instruction handling: Input provided as human-readable instructions (text and/or video-based demonstrations), Transformation of instructions into structured DWI, Conversion of DWI into robot-executable action sequences
- Learning and adaptation: Use of imitation learning for initial task acquisition, Use of reinforcement learning for optimisation and robustness, Ability to adapt execution based on environment conditions (e.g., object position variability)
- Perception and navigation: Multi-modal perception using stereo vision (≥3 cameras) and LiDAR, Object detection and localisation, Environment mapping and safe navigation between workstations
- Development approach: Initial validation in simulation environment (digital twin of workspace), Gradual transition to real-world deployment (Sim2Real), Use of virtual sensors and synthetic data where applicable.

## Expected solution

The resulting system will demonstrate that a humanoid robot can reliably execute a defined task in an industrial setting, enabling improved process consistency, reduced dependency on manual execution, and a scalable pathway for integrating human-centric AI and humanoid robotics into smart manufacturing systems.

## Key Performance Indicators

Key Performance Indicators (KPIs) should clearly demonstrate the relevance and impact of the proposed solution. They must address at least two of the following dimensions: resource optimisation, Green Deal objectives, and social impact. All KPIs must be SMART (Specific, Measurable, Achievable, Relevant and Time-bound), ensuring they remain quantifiable throughout the project.

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