trinity ENGAGE WITH AGILE MANUFACTURING

D3.5. Assessment of the applied standards in use case demonstrations

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1 Introduction

The goal of this task is to evaluate the feasibility of the applied standards in each use case demonstration. This report will provide a detailed assessment of standards, their exploitation and identified barriers regarding the standard type and maturity of the technology, including aspects related to Cybersecurity. This analysis will also assess the possibilities with up-coming/expected standards with respect to technologies used in the use-case demonstrations.

Overall, standards play a critical role in ensuring the safety, interoperability, and performance of robotics systems, as well as supporting their regulation and adoption in different industries. Standards ensure that different components operate together seamlessly, without requiring custom integration efforts for each new combination of components. Related to robotics, safety standards help ensure that robots operate safely in different environments and under various conditions. Safety standards can also help to minimize the risk of injury to people who work with or around robots. Standards ensure that robots meet minimum levels of quality, reliability, and functionality and can also help developers and customers to compare different robots and select the best one for their needs. In addition, standards may help regulatory bodies to develop appropriate guidelines for the use of robots in different contexts, such as manufacturing.

For the purpose of this deliverable, we collected information related to standards from internal and 3rd party use cases. This includes applicable standards, their relation to the use case, and possible restrictive aspects that need to be considered. This information is provided in both appendices.

Please note that this deliverable is closely related to Deliverable 8.6. “Report on Standardization with recommendations for standardization bodies”. With this in mind, the information gathered in D3.5 and its conclusions served as an additional input for D8.6.

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2 Related standards

Based on the collected data, provided in appendices, one of the most important standards for robotics is SFS-EN ISO 12100 "Safety of machinery" that provides a framework for ensuring the safety of machinery and equipment. Overall, while the "Safety of machinery" standard provides a useful framework for ensuring the safety of machinery and equipment, there are several areas and technologies where it may need to be updated or expanded to account for the unique risks associated with technologies such as artificial intelligence and cybersecurity. These risks might be related to aspects of data quality and integrity and decision-making principles, to name a few.

Besides risks, artificial intelligence provides means for improving the safety of machinery. Overall, AI can help improve the safety of machinery by enabling real-time monitoring and predictive maintenance, fault detection and faults diagnosis, enabling autonomous operation, adapting safety features, and analyzing safety data. Ultimately, AI can help to identify potential safety risks before accidents occur, and enable corrective actions to be taken, reducing the risk of accidents and injuries. Fortunately, AI and especially machine learning is gaining more attention among different industries and is included in modern standards such as CEN ISO/TR 22100-5:2022.

Standards in use cases and demonstrations that are related to digitalization are: IEC 62541, ISO 23247-1, ISO 10303-1:2021, ISO 62264, ISO 9241-210:2010, and ISO/IEC 20922:2016. These standards are related to data transfer protocols, digital twins, system integration and human centered design of interfaces. By following these standards, it is possible to implement cybersecure and interoperable applications. Barriers of the communication standards such as IEC 62541 contain different implementations of the data structures between manufacturers, are incompatible between different standard versions, and they lack standardized communication. In many cases, systems are compatible so that they can be connected, and communication can be established, however, dissimilar data structures prevent systems from interoperating at the semantic level where standards define common dictionaries and data models.

None of the use case/demonstration owners reported that they followed any cybersecurity standard such as NIST 800-82 or NISTIR 8183. Cybersecurity issues in manufacturing industry have potential to threaten factory operations, lead to theft and cause physical damage to manufacturing systems and people. The lack of cybersecurity in use cases and demonstration might be due to the fact that cybersecurity is non-existent in the current robotics standards and therefore cybersecurity has not been considered carefully enough. TRINITY consortium is aware of the importance of cybersecurity and is actively disseminating information about it. In addition, necessary actions have been taken to improve cybersecurity of use cases and demonstrations.

Of the new upcoming standards, the updated ISO 10218 standard incorporates collaborative robot system safety functions from ISO/TS 15066. One of the barriers of ISO/TS 15066 has been focusing only on the robot alone and not to complete application. Incorporation enables collaborative application development, verification, and validation. In addition, the updated ISO 10218 will contain important aspects of cybersecurity and collaborative application requirements: hand-guided control, power and force limiting, speed and separation monitoring. Furthermore, technical requirements from ISO/TR 20218 concerning end effectors and loading stations and RIA TR R15.806 concerning pressure and force testing related to collaborative robots are integrated in the new version of ISO 10218. Currently fragmented standards related to collaborative robotics will be integrated into a single standard as an essential tool for manufacturers, integrators, and health and safety bodies. One of the challenges of applying ISO 10218 and ISO/TS 15066 has been the separation into a standard of industrial robotics and to a technical specification for cobots. Strict interpretation has been to apply ISO 10218 for cobots and industrial robots since there has been no

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standard defining safety aspects related to cobots; only the technical specification. The upcoming new version of ISO 10218 combines the two and provides an official standard for both cobots and industrial robots.

It is likely that not all related standards are identified for use cases. Instead, technical implementations often following common practices and standards guiding the work are not known. This relates to the fact that standards have existed for a long time and are obvious parts of daily work.

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3 Conclusions

In conclusion, robot standards are essential to ensure the safe and reliable operation of robots in various settings, e.g. industrial manufacturing. Adherence to these standards helps to minimize the risks of accidents, malfunctions, and other negative outcomes that could result from the use of robots. Robot standards provide a common set of guidelines for the design, manufacturing, and operation of robots, which can facilitate interoperability and collaboration between different robots and systems. This can lead to greater efficiency, productivity, and innovation in various industries. Moreover, following robot standards can also help to build trust and confidence in the use of robots by demonstrating that they have been rigorously tested and verified to meet certain performance and safety criteria. This can be particularly important in some areas such, where robots are increasingly being used in collaboration with people.

Cybersecurity is becoming an increasingly important issue in the field of robotics, as robots become more connected and integrated into various networks and systems. As such, it is crucial to develop and implement strong cybersecurity measures to protect against potential cyber-attacks that could compromise the safety and functionality of robots. One key challenge in cybersecurity for robotics is the complexity of the systems involved. Robots often use a variety of software and hardware components, each with its own potential vulnerabilities, and are typically connected to other devices and networks. This creates a large attack surface that can be difficult to secure and monitor. To address cybersecurity related challenges, it is important to develop cybersecurity standards and best practices specific to robotics. This includes implementing secure coding practices, regularly updating software and firmware, and using secure communication protocols. Additionally, training and educating robot operators on cybersecurity risks and best practices can help to mitigate potential threats. In conclusion, cybersecurity is a critical concern in robotics, and it is important to address it through the development and implementation of robust cybersecurity measures. Doing so will help to ensure the safety, reliability, and functionality of robots, and will enable the continued growth and development of this important technology.

Despite their importance, robot standards still have some limitations that need to be addressed. One of the main challenges is the rapid pace of technological innovation, which can make it difficult for standards to keep up with the latest advances in robotics and related technologies. Additionally, the current robot standards may not adequately address some of the newer types of robots, such as collaborative robots and mobile robots, which are becoming increasingly common in a wide variety of industrial applications. These robots typically require different safety considerations and design principles than traditional industrial robots, and standards may need to be updated to reflect these differences. Another limitation is that the following of the current robot standards are often voluntary and not necessarily legally binding, meaning that manufacturers and users may not always follow them. This can lead to inconsistencies in safety and performance across different robots and systems and may create a lack of trust in the safety of robotic technology. Some argue that the current robot standards may not go far enough in ensuring the ethical use of robots, particularly in areas such as artificial intelligence and machine learning. As robots become more autonomous and capable of making decisions on their own, there is a growing need for ethical guidelines and standards to ensure that they are used in a responsible and beneficial way. Fortunately, these new aspects are considered in the newer versions of standards.

Overall, while robot standards are an important step towards ensuring the safe and reliable use of robots, there is still much work to be done to keep up with the rapidly evolving technology and to address the ethical and legal issues that arise from their use. The benefits of adhering to robot standards are clear: improved safety, reliability, efficiency, interoperability, and trust. As the use of robots continues to expand,

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it is essential that these standards be developed and followed to ensure that they are used in a way that maximizes their potential benefits while minimizing their potential risks.

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Appendix A: Applied standards in internal use cases

Use-Case 1: Collaborative assembly with vision-based system

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction.	
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	Setting requirements for the robot used in the demonstration setup.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	Setting requirements for the robot application demonstrated in the used case.	The implementation of a demonstrator was done using a collaborative robot, therefore the standard is not directly applicable
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplements the requirements and guidance on collaborative industrial robot operation given in ISO 102181 and ISO 102182. The demonstrator handles collaborative robot and the guidelines of the standard are taken into account. The main focus the work is to define a model to monitor safety margins with a depth sensor and to communicate the margins to the operator with an interactive User Interface. The work focuses on the third scenario of ISO/TS where the operator-robot distance is communicated interactively.	Additional safety-devices based on machine vision and projector systems cannot be used alone without safety-approved systems
SFS-EN ISO 13857:2019	Safety of machinery. Safety distances to prevent hazard zones being reached by upper and lower limbs	The testing parameters for the KPI evaluations in D3.4 were defined based on the upper limb intrusion dimensions defined in the standard.	

Use Case 2: Collaborative dis/assembly with augmented reality interaction

From robotics safety point of view the standards related to Use Case 2 are the same as for the Use Case 1 except for the ISO 13857 as safety distances do not apply when using the AR based approach.

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk	Basic principles for implementing a safe system including risk assessment and risk reduction.	

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Acronym	Name	Feasibility	Barriers
	assessment and risk reduction		
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	Setting requirements for the robot used in the demonstration setup.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	Setting requirements for the robot application demonstrated in the used case.	The implementation of a demonstrator was done using a collaborative robot, therefore the standard is not directly applicable
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplements the requirements and guidance on collaborative industrial robot operation given in ISO 102181 and ISO 102182. The demonstrator handles collaborative robot and the guidelines of the standard are taken into account. The main focus the work is to define a model to monitor safety margins with a depth sensor and to communicate the margins to the operator with an interactive User Interface. The work focuses on the third scenario of ISO/TS where the operator-robot distance is communicated interactively.	Additional safety-devices based on machine vision and projector systems cannot be used alone without safety-approved systems

Use case 3: Collaborative Robotics In Large Scale Assembly, Material Handling And Processing

Acronym	Name	Feasibility	Barriers
EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction principles.	
EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	Use case 3 is focused on using industrial robots in collaboration with humans. The use case focuses on state-of-the-art safety-approved safety devices allowing people to be located at a relatively close approximity of a robot working area. In addition, safety is increased by additional non-safety-approved devices. This standard is related to the use through safety-approved devices.	Additional safety-devices based on machine vision and machine learning cannot be used alone without safety-approved systems.
EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2:	See the comment above. This standard is related to the use case through integration of safety-approved safety devices.	

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Acronym	Name	Feasibility	Barriers
	Robot systems and integration		
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplements the requirements and guidance on collaborative industrial robot operation given in ISO 102181 and ISO 102182. Although the use case focuses on using industrial robots, this standard is taken into account.	As the use case focuses on industrial robots, this standard is not directly applicable.
ISO/TR 20218-1:2018	Robotics — Safety design for industrial robot systems — Part 1: End-effectors	This standard is related as the use case is using standardized devices and. It is important to choose end-effectors that are designed and implemented following this standard.	Additional safety systems do not follow the standard.
EN ISO 13854:2019	Safety of machinery. Minimum gaps to avoid crushing of parts of the human body	The standard is followed when designing the robot cell. This standard supplements SFS-EN ISO 12100.	
EN ISO 13855	Safety of machinery. Positioning of safeguards with respect to the approach speeds of parts of the human body	The standard is followed when designing the robot cell and related safety devices. This standard supplements SFS-EN ISO 12100.	
CEN ISO/TR 22100-5:2022:fi	Safety of machinery. Relationship with ISO 12100. Part 5: Implications of artificial intelligence machine learning	Additional safety systems are based on machine vision and machine learning (detecting people using 360 degree cameras). This is not a safety approved (standard-wise) device and cannot be used alone to implement a safe robotic system.	

Use case 4: Integrating digital context to the digital twin with AR/VR of the robotized production

Acronym	Name	Feasibility	Barriers
EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction principles.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	Evaluated suitability of this technical specification to a case where digital twin with AR/VR technology is used in design process of the robotized production	
ISO 23247-1	General principles and requirements for developing digital twins in manufacturing	Evaluated how the basic principles and requirements can guide developing digital twins in manufacturing	

Use case 5: Automated robotic welding

Acronym	Name	Feasibility	Barriers
IEC 62541	OPC Unified Architecture	Used to enable communication between machines and for control of the systems.	

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Acronym	Name	Feasibility	Barriers
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction principles.	
SFS-EN ISO 14120	Safety of machinery. Guards. General requirements for the design and construction of fixed and movable guards	Safety button and light curtain fence are implemented in the system.	

Use case 6: Digitalization of a production environment

Acronym	Name	Feasibility	Barriers
IEC 62541	OPC Unified Architecture	Used to enable communication between machines and for control of the systems.	
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction principles.	

Use Case 7: Robot workcell reconfiguration

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction principles.	
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	UC 7 uses robots to reconfigure passive reconfigurable modular elements.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	UC 7 uses robots integrated with other active and passive elements on a hardware and software level.	
ISO/TR 20218-1:2018	Robotics — Safety design for industrial robot systems — Part 1: End-effectors	Multiple modular and various end-effectors in use.	
SFS-EN ISO 13854:2019	Safety of machinery. Minimum gaps to avoid crushing of parts of the human body	Active and robot aided passive reconfigurable elements pose potential hazards of crushing.	
SFS-EN ISO 14120	Safety of machinery. Guards. General requirements for the design and construction of fixed and movable guards	Movable guards could be needed for reconfigurable elements.	
CEN ISO/TR 22100-5:2022	Safety of machinery. Relationship with ISO 12100. Part 5: Implications of artificial intelligence machine learning	Reconfiguration action and movements are not programmed by hand but gained through machine learning and optimization.	
SFS-EN ISO 11161 + A1	Safety of machinery. Integrated manufacturing systems. Basic requirements. Amendment 1	Modular workcell includes a variety of interconnected actuators.	

Use Case 8: Efficient programming of robot tasks by human demonstration

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Acronym	Name	Feasibility	Barriers
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction principles.	
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	Robots are used to demonstrate or execute a demonstrated task.	
ISO/TS 15066	Robots and robotic devices — Collaborative robots	Collaborative robots being used in close proximity to humans, e.g. manual guidance.	
SFS-EN ISO 13855	Safety of machinery. Positioning of safeguards with respect to the approach speeds of parts of the human body	Robots/actuators executing tasks learned via human demonstration.	
CEN ISO/TR 22100-5:2022	Safety of machinery. Relationship with ISO 12100. Part 5: Implications of artificial intelligence machine learning	Execution of movements not programmed by hand but gained through human demonstration, machine learning, and optimization.	
SFS-EN ISO 13849-2	Safety of machinery. Safety-related parts of control systems. Part 2: Validation	Robot control systems can be adapted through human demonstration and optimization.	

Use case 9: Dynamic task planning & work reorganisation platform

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	Several tasks are assigned to robotic resources. Reassign the pending tasks in case of inability to execute previous plan due to an unexpected event. The standards are used to provide output acceptable by industry.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	Same as above, the task & reassigning application is allocating tasks to robots that should comply to this standard to be accepted by the industry.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	Same with the above but it is applied to collaborative robots which have less restrictions in terms of task sharing	

Use case 10: AR based operator support in HRC / HRI framework for operator support in HRC operations

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	Use case 10 is focused on using AR application to support human operators while working with industrial robots. The AR application is providing information to the operator, from	

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Acronym	Name	Feasibility	Barriers
		robot and safety controllers that comply to this standard. In other words, operator safety awareness is increased by projecting safety-related information through the AR application.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	Same as above, the AR application is providing information to the operator, from robot and safety controllers that comply to this standard.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplement the requirements and guidance on collaborative industrial robot operations given in ISO 102181 and ISO 102182.	As the use case focuses on industrial robots, this standard is not directly applicable.

Use case 11: Robotized serving of automated warehouse

Acronym	Name	Feasibility	Barriers
ISO 10303-1:2021	Industrial automation systems and integration — Product data representation and exchange	The use case uses STEP files for exchange of 3D objects in Computer-aided design (CAD) and related information	

Use case 12: User-friendly human-robot collaborative tasks programming

Acronym	Name	Feasibility	Barriers
ISO 62264	Enterprise-control system integration	For integration of the system with an ERP/MES	
ISO 10218-1.2	Robots and robotic devices. Safety requirements for industrial robots.	This standard can be related to this use case through need of setup of safety of the robot for collaboration with humans.	The implementation of the demonstrator was done using a collaborative robot, therefore the standard is not directly applicable
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplement the requirements and guidance on collaborative industrial robot operations given in ISO 102181 and ISO 102182.	

Use case 13: Deployment of mobile robots in collaborative work cell for assembly of product variants

Acronym	Name	Feasibility	Barriers
ISO 62264	Enterprise-control system integration	For integration of the system with an ERP/MES	

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Acronym	Name	Feasibility	Barriers
ISO 10218-1.2	Robots and robotic devices. Safety requirements for industrial robots.	This standard is related to this use case through setup of safety of the mobile robot for collaboration with humans.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplement the requirements and guidance on collaborative industrial robot operations given in ISO 102181 and ISO 102182.	

Use case 14: Virtualization of a robot cell with a real controller

As the use case features purely virtual realization of the robotic system, the demonstrator itself is not realized according to specific standards. However, the physical robotic system is realized according to relevant robotic standards, but this real system is not in the scope of the demonstrator.

Use case 15: Industrial IoT Robustness Simulation

Acronym	Name	Feasibility	Barriers
	.NET Standard 2.0	Simulation module is developed completely in C# and based on the given standard	
		Other standards not applicable because UC 15 was a purely simulated application.	

Use case 16: Handling and assembly module

Acronym	Name	Feasibility	Barriers
EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction principles.	
EN ISO 14120	Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards	Basic principles for implementing guards including principles for the construction of fixed and movables guards.	
EN ISO 13855	Safety of machinery — Positioning of protective equipment with respect to the approach speeds of parts of the human body	Basic principles for the arrangement of safety devices.	
EN ISO 11161	Safety of machinery - Integrated manufacturing systems - Basic requirements	Basic principles for safety measures for manufacturing systems with several components.	
EN ISO 13849	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design	Basic principles how to design safety-related parts of the control systems.	
EN ISO 14119	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection	Basic principles how to design interlocking devices that are associated with safety guards and barriers.	

Use case 17: Artificial intelligence based stereo vision system for object detection, recognition, classification and pick-up by a robotic arm

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Acronym	Name	Feasibility	Barriers
ISO/TR 20218-1:2018	Robotics — Safety design for industrial robot systems — Part 1: End-effectors	Usage of end-effectors following this standard.	
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction principles.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	Evaluated suitability of this standard, the building blocks of the system could support it if required, however additional safety-related systems then should be incorporated.	

Use case 18: Rapid development, testing and validation of large scale wireless sensor networks for production environment

Related standards not applicable, as this is an IoT related demonstrator and none from the standard list applies.

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Appendix B: Applied standards in 3rd party demonstrators

Details of use and applicable standards were asked from the 3rd parties. Unfortunately, all of them did not provide these. The ones that provided the requested information can be found below.

AGILE

Acronym	Name	Feasibility	Barriers
ISO/TS 15066:2016	Safety requirements for collaborative industrial robot systems and the work environment.	AGILE has implemented an innovative vision-based safety system for Human-Robot Collaboration (HRC) in a cable assembly process shared workspace.	The implemented safety system is based on machine vision This is not a safety approved device and cannot be used alone to implement a safe robotic system.

SNIPE

Not following any standards.

EACHPack

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	EACHPack is focused on implementing a robotized sorting system for parcel posts. To improve safety, a vision-based safety people tracking system has been implemented. The safety system detects when a human operator enters the workspace of the manipulator and sends the information of the operator presence and position to the robot controllers to adjust its speed based on the standard. In other words, operator safety is increased by adjusting the robot behaviour according to the human distance from the robot.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	Same as above, the vision-based human tracking system is providing information to the robot controller, to comply the robot behaviour with the requirements defined by this standard.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplement the requirements and guidance on collaborative industrial robot operations given in ISO 102181 and ISO 102182.	

LDM-AUTO

Acronym	Name	Feasibility	Barriers
IEC 62541	OPC Unified Architecture	Used to enable communication between PLC, robot and LMD-Auto controller.	

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Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	The robot works in a closed cell. By automation and process control we can avoid that operators need to enter the cell.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	See the comment above.	
ISO 15609-1:2019	Specification and qualification of welding procedures for metallic materials — Welding procedure test	Used for defining our welding processes.	

ROBOLIBRI

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	The Library Robot is based on collaboration with humans. The use case focuses on state-of-the-art safety-approved safety devices allowing people to be located at a relatively close approximity of a robot working area. In addition, safety is increased by additional non-safety-approved devices. This standard is related to the use through safety-approved devices.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	See the comment above.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplement the requirements and guidance on collaborative industrial robot operations given in ISO 102181 and ISO 102182.	

RoSo-UPB

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction		
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration		

TRAINMAN-MAGOS

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	Trainman Magos is focused on implementing a platform to program robot arms and grippers to perform movements similar to the human hand using a dedicated glove and a s/w for data collection and processing. The safety requirements defined by the standards should be met during the path planning and execution from the robot controller.	
ISO 9241-210:2010	Ergonomics of human-system interaction - Part 210: Human-	The designed system can be used for ergonomics analysis and validation of workplace.	

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Acronym	Name	Feasibility	Barriers
	cantered design for interactive systems		
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplement the requirements and guidance on collaborative industrial robot operations given in ISO 102181 and ISO 102182.	

Digi-SAAP

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	The Screw Driving Robot is based on collaboration with humans. The use case focuses on state-of-the-art safety-approved safety devices allowing people to be located at a relatively close approximity of a robot working area. In addition, safety is increased by additional non-safety-approved devices. This standard is related to the use through safety-approved devices.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	See the comment above.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplement the requirements and guidance on collaborative industrial robot operations given in ISO 102181 and ISO 102182.	

ICON

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	The “Safe Human Detection in a Collaborative Work Cell” TRINITY module integrated in ICON allows the operator to work safely alongside the robot, creating dynamic and adaptive safety areas exploiting a safety-approved sensor that recognizes the presence of the human and adjusts the speed of the robot accordingly.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	See the comment above. This standard is related to the use case through integration of safety-approved safety sensor.	
CEN ISO/TR 22100-5:2022:fi	Safety of machinery. Relationship with ISO 12100. Part 5: Implications of artificial intelligence machine learning	The TRINITY module “Projection-based Interaction Interface for HRC” introduces an additional safety system based on machine vision. It consists in automatically stopping the robot if the operator crosses a red dynamic safety contour projected around the robot on the working table. This is not a safety approved (standard-wise) device and cannot be used alone to implement a safe robotic system.	

ATLANTES

Not following any standards.

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AURORA

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	The 3D Scan Robot is based on collaboration with humans. The use case focuses on state-of-the-art safety-approved safety devices allowing people to be located at a relatively close approximity of a robot working area. In addition, safety is increased by additional non-safety-approved devices. This standard is related to the use through safety-approved devices.	
CEN ISO/TR 22100-5:2022	Safety of machinery: Implications of artificial intelligence machine learning	Execution of movements not programmed by hand but gained through human demonstration, machine learning, and optimization.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplement the requirements and guidance on collaborative industrial robot operations given in ISO 102181.	

BRILLIANT

Acronym	Name	Feasibility	Barriers
ISO-10218_2011	Robots and robotic devices — Safety requirements for industrial robots — Part 2: Robot systems and integration	It supported the work cell design, development and integration.	
ISO-TS-15055_2016	Robots and robotic devices — Collaborative robots	It supported the work cell design, development and integration.	
ISO/IEC 20922-MQTT	MQ Telemetry Transport or Message Queue Telemetry Transport	It supported the communication between the different software components.	
CANNIER			

MCPPS

Acronym	Name	Feasibility	Barriers
ISO/IEC 20922:2016	Message Queuing Telemetry Transport (MQTT)	For the communication between different devices and control system	
IEC 62541	OPC Unified Architecture	For the communication between different devices and control system	

PROTON Robots

Acronym	Name	Feasibility	Barriers
ISO 3691-4:2020 (Part 4)	Industrial Trucks - Safety Requirements And Verification - Part 4: Driverless Industrial Trucks And Their Systems	The standard establishes clear limits in terms of safety in the coexistence between people and autonomous vehicles. It regulates aspects such as the minimum safety distance between the AGVs and the fixed elements of the operational envirinment (e.g. industrial plant or rail infrastructure in our case) to avoid collisions with other equipments or with the	Currently not known restrictions

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Acronym	Name	Feasibility	Barriers
		operators who could be working around them. It also mentions other aspects such as the minimum performance levels that the system's security functions must have, such as speed control, brake control, and establishes how to avoid potential risk by equipping the autonomous machines with sensors, communications, etc.	
ISO 13849-1	Safety of machinery	General principles for design to ensure safety of the machine	Currently not known restrictions
ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots Part 2: Robot systems and integration	Basic safety requirements for our mobile robots	Currently not known restrictions

RECOPRODAS

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration		
ISO/TS15066	Robots and robotic devices — Collaborative robots		

RoboCut

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	RoboCut is focused on implementing a robotized system that automates the production of cardboard packaging of different sizes and materials. The implemented robotic system does not interact with human operators and follows the safety requirements defined by the standards.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	Same as above.	

Robs4Steel

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	Robs4Steel is focused on implementing a robotized visual inspection system for the automated remote inspection of furnaces.	

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Acronym	Name	Feasibility	Barriers
		The implemented robotic system does not directly interact with human operators and follows the safety requirements defined by the standards.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	Same as above.	

SHAFTS

Acronym	Name	Feasibility	Barriers
IEC/EN61000-4-4	Electrical Fast Transient (EFT)	Robustness against electromagnetic disturbances required to work in challenging environment (e.g. next to forge induction oven)	
SHARKY			

SHIPWELD

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic safety and risk management for all machinery	Basic risk assessment, use of cobot and nature of additions did not add risks to off the shelf product
SFS-ISO/TR 14121-2	Safety of machinery — Risk assessment — Part 2: Practical guidance and examples of methods		See above

SPINEYE

Acronym	Name	Feasibility	Barriers
SFS-EN ISO 10218-1:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 1: Robots	The Screw Driving Robot is based on collaboration with humans. The use case focuses on state-of-the-art safety-approved safety devices allowing people to be located at a relatively close approximity of a robot working area. In addition, safety is increased by additional non-safety-approved devices. This standard is related to the use through safety-approved devices.	
SFS-EN ISO 10218-2:2011	Robots and robotic devices. Safety requirements for industrial robots. Part 2: Robot systems and integration	See the comment above.	
ISO/TS 15066:2016	Robots and robotic devices — Collaborative robots	This standard supplement the requirements and guidance on collaborative industrial robot operations given in ISO 102181 and ISO 102182.	

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VISDEBURR

Acronym	Name	Feasibility	Barriers
IEC 62541	OPC Unified Architecture	Used to enable communication between machines and for control of the systems.	
SFS-EN ISO 12100	Safety of machinery. General principles for design. Risk assessment and risk reduction	Basic principles for implementing a safe system including risk assessment and risk reduction principles.	
CEN EN 1525:1997	Safety of industrial trucks - Driverless trucks and their systems	All safety functions of the mobile robot (MIR100) are enabled which support this standard.	

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