In-Position Technologies
www.iptech1.com

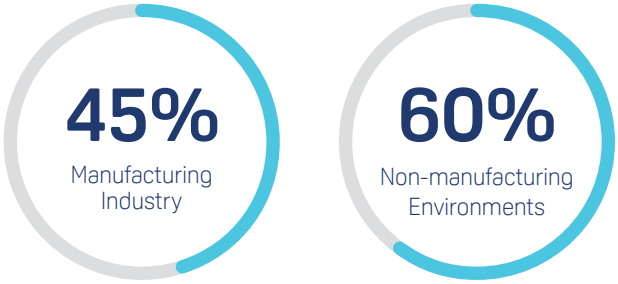
Your guide to a **safe mobile robot installation**

Increased use of AMRs makes **AMR safety more relevant than ever**

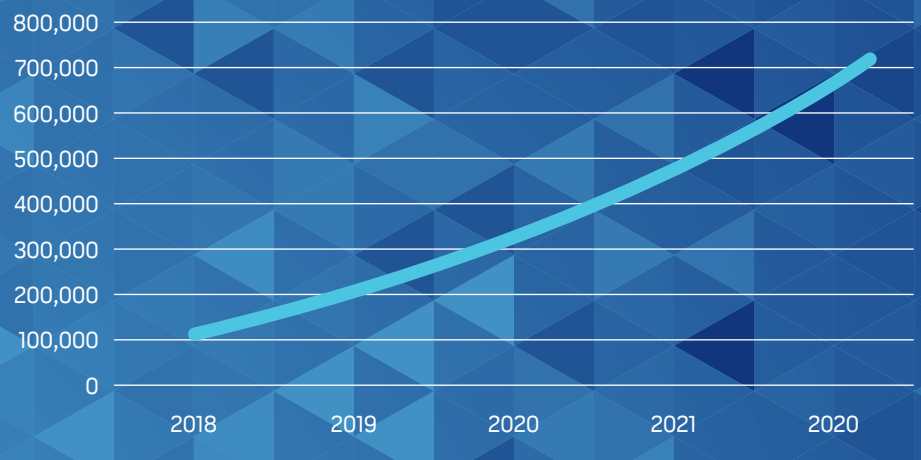
Autonomous mobile robots (AMRs) are increasingly used to automate the transportation of materials through industrial buildings, leaving companies with questions on how to ensure a safe robot installation. Companies must understand the requirements of relevant safety standards, including the responsibilities of robot manufacturers, integrators, and end users.

According to the International Federation of Robotics (IFR), the market for AMRs in logistics automation is booming, with an expected increase from 110,000 in 2018 to more than 700,000 in 2022. This represents a CAGR of 45% in the manufacturing industry and 60% in non-manufacturing environments such as e-commerce and hospitals. While these mobile robots are designed to navigate safely around people, rapid changes in the market can leave companies with questions on how to ensure a safe mobile robot installation. With an increasing number of AMRs being installed, new AMRs on the market, and new customers with limited experience with this new technology, the topic of mobile robot safety is more important than ever.

Expected AMR CAGR for 2019-2022



AMRs in logistics automation



Source: IFR

Which safety requirements should AMRs live up to today?

AMRs are designed to work safely in environments with people.

AMRs complete their given missions using sensors and software algorithms to maneuver through dynamic environments, avoiding obstacles and for some AMRs recomputing their path on-the-fly. Extensive built-in safety mechanisms allow the robots to navigate collaboratively around human co-workers by slowing down, changing direction, or stopping to avoid collision. These safety features are key to the success of mobile robots, but companies deploying AMRs need to go a step further to ensure workers' ongoing safety. Safety standards are made to ensure machines and robots operate in a way that do not bring humans into dangerous situations when working with them.

With two safety laser scanners for 360° field of view and two 3D cameras in front, MiR robots navigate safely and smoothly around dynamic obstacles and people.

It is important to distinguish between the **AMR**, which is the mobile robot itself, and the **AMR system**, which is the AMR (or fleet of AMRs), charging stations, load transfer stations, top modules that is mounted on the AMR to create a complete machine, and other peripheral equipment within the environment where the AMR operates.

The AMR is defined as the out-of-the box mobile robot without top modules and without the customer environment taken into account. AMRs from MiR are designed according to all relevant safety standards and MiR provides guidelines to the commissioning of the full AMR system.

AMR

AMR system

Understanding applicable standards, laws, and directives for mobile robots to ensure a safe AMR system.

Legal requirements must also be understood and properly applied in order to ensure that mobile robot applications remain as safe and reliable as they are intended to be.

In response to the rapid adoption of AMRs, global standards organizations are updating and developing guidelines for the safe design, manufacture, and commissioning of mobile robots. The development of this new technology has been faster than the development of relevant standards. But in the meantime, mobile robot manufacturers, purchasers, and integrators must enforce safety requirements using a variety of existing standards that focus on similar applications of industrial vehicles, even though these were not written specifically for AMRs.

The most applicable standard for AMRs is currently **EN 1525:1997** ("Safety of industrial trucks – Driverless trucks and their systems"). This standard applies to an automated guided vehicle (AGV) as well as its systems and also applies to the commissioning and preparation of the environment in which the robot will be used. EN 1525 is a European standard that establishes strict safety requirements for vehicles from AGVs to industrial trucks, which often are larger and heavier than AMRs and can have a completely different setup. One key difference is that EN 1525 does not take autonomous navigation into account. However, EN 1525 fills the void for safe implementation of mobile robots until newer standards are adopted that also address potential hazards connected to AMRs. The ANSI/ITSDF standard **B56.5-2012** is an American standard that was also written to address AGVs and has the same scope as EN 1525. An update of B56.5 was published in August 2019.

Upcoming standards

Standards organizations worldwide are working on new standards that address AMRs. The successor to EN 1525 as the most applicable standard for AMRs is **ISO/FDIS 3691-4**: "Driverless industrial trucks and their systems," which is scheduled for release in January 2020. ISO/FDIS 3691-4 addresses safety concerns for internal logistics and the hazards related to recompute paths on-the-fly, which are key aspects of AMRs. The new standard will provide detailed requirements for commissioning mobile robots as well as environment and work-cell design.

There are also other standards in progress that will likely have impacts on manufacturers, users, and integrators of mobile robots in the future. These include **ISO 10218**, **prRIA 15:08**, and **prUL 3100**, each of which addresses different aspects of AMRs and their implementation. MiR strives for the highest level of safety and cooperates closely with these standards organizations on new standards, providing updates to customers and integrators as appropriate and making sure that the robots comply with current as well as future standards.

Like standards, laws related to worker-safety and machinery can vary widely by geography. In the European Union, a user can assume that a mobile robot that has a CE mark is safe and meets relevant standards because it has been designed and manufactured according to the Machine Directory (MD). This means that if the robot is used as promoted or described in the manual and an injury occurs, the manufacturer, rather than the customer, can be liable for the injury.

It's important to note that the CE mark only covers the robot itself, and not the AMR system as a whole. When one or more mobile robots are deployed into a facility with top modules, loading stations, and chargers, the full system also needs to be CE marked by the part that is responsible of commisioning the AMR system.

The American representative organization to ISO is the American National Standards Institute (ANSI). ANSI develops and promotes safety guidelines which, although voluntary, are adopted by nearly every industry throughout the country. A related association, the Industrial Truck Standards Development Foundation (ITSDF), administers safety standards relating to the design, operation, and maintenance of industrial vehicles. Separately, overall worker safety regulations in the United States are established and enforced through the Occupational Safety and Health Administration (OSHA), which is a federal entity whose standards are legally required to be met in the workplace. OSHA requirements are defined in Title 29 of the Code of Federal Regulations, Part 1910, which is broken down into a number of subparts that apply to the use of mobile robots. These include 1910.212 "General requirements for all machines" and 1910.178 "Powered industrial trucks." Mobile robot users and integrators should note that OSHA and state regulators have the ability to make ANSI/ITSDF standards mandatory and can cite organizations for noncompliance.

Summary:
What's important to know about safety standards and regulations?

- Standards and laws that are amended for AMRs are under development and planned to be introduced in 2020.
- Safety standards are developed to ensure that robots do not bring humans into dangerous situations when working with them. Therefore it is important that your AMR manufacturer follows the current standards that are developed for logistics applications to make sure you have a safe AMRs and AMR system.
- Safety standards and laws are determined locally by country/region, so deployed AMRs must meet those local standards.
- The European standard EN 1525:1997 and the CE mark provide a good framework when it comes to safety for the AMR as well as the AMR system. While it is not a requirement to comply to EU laws and standards outside the EU, it makes sense to use these principles to ensure a safe AMR system across all regions.
- For global manufacturers that are making global use of AMRs, the European standards and laws provide a good framework that can be applied to all factories with an amendment to address local aspects.

MiR robots: Designed for safety

Primary safety measures, such as the sensors and algorithms built into MiR mobile robots, are designed to maximize safe performance in expected use. But a fundamental part of meeting machinery safety standards is to include additional functions that address unanticipated risks to ensure that the robots react safely even if primary control systems fail for any reason. MiR robots meet EN1525 and B56.5 and implement relevant safety functions, as shown in this table. The MiR500 and MiR1000 have more functional safety than the two smaller robots, MiR100 and MiR200. This is because the MiR500 and MiR1000 are heavy duty robots that potentially can do more harm than the small robots and therefore, more safety functions are requiered. The safety functions of the MiR robots are documented with a Sistema report, that can be shared by MiR by request.

Safety functions in the MiR Robots

FUNCTION	MiR100	MiR200	MiR500	MiR1000
E-stop	PLd, cat 3	PLd, cat 3	PLd, cat 3	PLd, cat 3
Field switching	Fail-safe*	PLd, cat 3	PLd, cat 3	PLd, cat 3
Personnel detection	PLd, cat 2	PLd, cat 2	PLd, cat 3	PLd, cat 3
Overspeed detection	Fail-safe*	PLd, cat 3	PLd, cat 3	PLd, cat 3
Field muting			PLd, cat 3	PLd, cat 3
Safety limited speed			PLd, cat 3	PLd, cat 3
Safe guarded stop			PLd, cat 3	PLd, cat 3
Locomotion			PLd, cat 3	PLd, cat 3
System E-stop			PLd, cat 3	PLd, cat 3

*Fail-safe means it is designed to fail to a safe state and are single failure tolerant but not designed according to ISO 13849

Manufacturer, integrator, and customer responsibilities in ensuring a safe AMR system workspace

A safe workplace requires joint effort from the AMR manufacturer, the integrator of the AMR system, and the end user. It is essential that roles and responsibilities between the parties are clarified. The guidelines provided by the European MD help customers and integrators ensure a safe workspace as the MD takes into account both the AMR and the full AMR system. By law, it is not required to follow the MD outside EU/EOS, but it is recommended to do so as it describes the current state-of-the-art for safe AMR installations.

The manufacturer of the AMR must provide a vehicle that is designed to be commissioned in a safe AMR system and provide adequate information for integration and operation. This means that the manufacturer is responsible for specifying intended use and limitations of the AMR, which is typically to transport materials without a driver in industrial environments. The manufacturer must CE-mark the AMR according to intended use through compliance to safety standards for AGVs, comply to complementary standards to address all risks, and provide integrated safety functions to address hazards expected in the intended use.
In addition to designing a safe robot, the manufacturer must also provide adequate documentation, including instructions regarding commissioning of the AMR into an AMR system, operating instructions for operation and maintenance of the AMR, and a list of identified residual risks for the AMR. Ultimately, the manufacturer is responsible for providing a safe AMR out of the box with all the required documentation.

At the time of installation, the responsibility moves to the integrator of the system. **The integrator of the AMR system** (which may be the end user if they are integrating the robot themselves) is responsible for providing an installation where all hazards are addressed or identified and providing adequate information for operation. Because AMRs can be programmed to move throughout a building, factory, or warehouse, the integrator who commissions the AMR must anticipate potential safety hazards and program the robot to act appropriately in compliance with safety standards. Commissioning also extends to the top module. If the robot is commissioned outside of those limitations, the integrator (or user) must incorporate additional protections to ensure that safety standards are met for the full robot application. The integrator must therefore specify the intended use and limits of the AMR system and make a risk assessment of the AMR system in the light of the AMR manufacturer's specifications, intended use, and limitations. As the application changes from an AMR to an AMR system, the integrator must CE-mark the AMR system according to the new intended use, and provide documentation consisting of operating instructions for operation and maintenance of the AMR system and a list of identified residual risks from risk assessment for the AMR system.

Once the AMR system has been deployed, **the end user** is responsible for setting up and following procedures for operation and maintenance of the AMR system. The end user must ensure that the intended use and limitations are met, and set up procedures for inspections and maintenance for the AMR system, including warning and markings. The end user should define safe operating procedures for operators and define training for operators, other staff, and visitors for safe operation.

This process seems complicated. Therefore, MiR has made guidelines for integrators as well as end-users to ensure a correct commissioning of the robots.

Summary:
Roles and responsibilities to ensure a safe AMR system workspace

AMR manufacturer provides	Integrator provides	End user ensures
Spefications of intended use and limitations of the AMR	Specifications of intended use and limitations of the AMR system	Intended use and limitations are met
CE marked AMR*	Risk assesment of AMR system	Procedures for inspections and maintenance for the AMR system are established
Integrated safety functions to address hazards in the intended use	CE-marked AMR system*	Safe operations for operators are defined
Instructions regarding commissioning the AMR into an AMR system	Verication of the proper functions of the safety features	Training for operators, other staff and visitors for safe operations are provided
Operating and maintenance instructions	Operation and maintenance instructions for the AMR system	
List of identified residual risks of the AMR	List of identified residual risks of the AMR system	

* Only required by law in the EU

Deploy a safe AMR installation in close cooperation with your AMR manufacturer

The state-of-the-art in the design and implementation of mobile robots is changing rapidly, and standards organizations are challenged to keep up. Compliance with current standards developed for logistics systems is still relevant, however. Many factors must be taken into account when deploying not just an AMR but an AMR system, which is often working in many different locations of a facility and in different applications. Users and integrators should expect guidance from robot manufacturers in order to reap the benefits of AMRs while ensuring workers' safety. At the same time, users must ensure that chosen AMR manufacturers are up to date with current and future safety standards and laws not limited to the AMR itself.

Documentation for safe robot commissioning, including how users and integrators can document compliance, are available on request from MiR by contacting your local MiR team.

mir-robots.com

Follow us: