Regulatory Issues Affecting Autonomous Mobile Robots

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Executive Summary

The world of Autonomous Mobile Robots (AMR) is evolving so quickly that new safety standards are required to ensure that manufacturers produce safe machines and that these machines can be safely deployed. There are a handful of current safety standards which collectively cover part of the concerns with modern AMRs, but a gap exists for some of the leading edge AMR applications. New standards are being developed with the goal of holistically covering current and future AMR applications. This article looks at the current state of safety standards and what's coming soon.

The Existing Safety Standards

There are a variety of vehicle types which operate within the warehouse and on the manufacturing floor. This includes the spectrum of manned vehicles such as fork trucks and other vehicles, along with unmanned vehicles. On the unmanned vehicle side, there are two distinct types of vehicle automation: (1) Automatic Guided Vehicles (AGV) and (2) Autonomous Mobile Robots (AMR). The key differentiation between an AGV and an AMR is that AGV's do not leave their defined lanes during operation, while AMRs are free to navigate around obstacles which appear in their path. Let's look at the current safety regulations for AGVs and AMRs and take a look at what is changing in the near future.

There are two safety standards which currently cover the autonomous mobile robot space:

1. ANSI/RIA R15.06-2012 (ISO 10218-1:2011)

The first is ANSI/RIA R15.06-2012: *American National Standard for Industrial Robots and Robot Systems- Safety Requirements* (revision of ANSI/RIA R15.06-1999)[1]. R15.06 primarily covers some of the basic requirements for AMRs. A lot has happened since this standard was last revised in 2012.

2. ANSI/ITSDF B56.5-2012

The second standard is ANSI/ITSDF B56.5-2012: *Safety Standard for Driverless, Automatic Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles*[2]. This standard defines the safety requirements relating to the elements of design, operation, and maintenance of powered, not mechanically restrained, unmanned automatic guided industrial vehicles and the system of which the vehicles are a part. It also applies to vehicles originally designed to operate exclusively in a manned mode but which are subsequently modified to operate in an unmanned, automatic mode, or in a semiautomatic, manual, or maintenance mode.

There are also a handful of related safety regulations which include some language about mobile robots and/or AGVs. This list includes:

- DIN EN 1525 Safety of industrial trucks - Driverless trucks and their systems
- DIN ISO 3691-4 Driverless industrial trucks and their systems
- ISO 13482:2014 Safety requirements for personal care robots
- ISO TS 15066:2016 Robots and Robotic Devices – Collaborative Robots
- 2006/42/CE Directive on Machinery and Amending

[1] https://www.robotics.org/bookstore-prod.cfm?category_id=118&product_id=426

[2] http://www.itsdf.org/cue/b56-standards.html

What's Missing with these Safety Standards?

First of all, the evolution of AMRs over the last 15 years has created a broad range of machines and markets. Everything from AMRs in the warehouse to the home. One of the key chasms in the world of AMRs is the safety requirement differences between "service" AMRs and "industrial" AMRs. While the intent is that no AMR harm a human, service robots operate in the realm of the "public". The "public" is defined as untrained individuals who interact with the robot, without any prior experience or knowledge of its operation. Working environments for service robots might include operation in a grocery store, a retail store, a mall, a hospital, on the sidewalk or in the home.

On the other hand, industrial AMR applications operate within (or on) the facility of a business in which the robot interactions are with corporate employees or trained individuals. The key difference here is that the humans surrounding the AMR understand that it is automated, and have some overview of its operating procedures. In these use cases, the robot may be moving large, heavy or dangerous payloads. As a result, the safety performance and fault tolerances for industrial AMRs are different than for a service AMR.

E-stop Handling

Error recovery is another key issue that isn't adequately covered in the current AMR safety standards. For example, in an e-stop situation, cutting power to a mobile robot's motors (as is the standard for industrial robot arms), may actually cause the robot to crash or tumble. Mobile robots actually may require a controlled stop, under computer control, in an e-stop situation. None of the existing standards take into account the new use cases that are being fulfilled by modern AMRs, making the need for revision necessary.

Mobile Manipulation

One of the primary use cases for AMRs is the addition of a robotic arm to an AMR base. Known as "Mobile Manipulation", this enables the AMR to add manipulation as a function of the AMR. This use case has only recently become viable in the market, with the launch of products such as the IAM Robotics SWIFT[3] AMR, the KUKA LBR iiwa[4] and the Stäubli HELMO[5] AMR. None of the existing standards include any language about how and when the mobile arm can deploy or how the robot arm's motion may affect the stability of the combined system during manipulation processes. In addition, OSHA has no standard covering AMRs, and instead refers to the RIA's standard.

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[3] https://www.iamrobotics.com/

[4] https://www.kuka.com/en-us/press/news/2015/12/lbr-iiwa-as-mobile-assistant-for-logistics-tasks

[5] https://www.man-and-machine.staubli.com/en/helmo/

The issues with B56.5 are that it doesn't address the hazards typically present with a mobile mounted industrial robot and that the language of the standard is tailored to vehicles that follow a prescribed path (i.e. AGVs).

Primary Controls

Lastly in a Mobile Manipulator, you have a combined system consisting of a robot controller and an AMR controller, since most systems are an integrated platform. The system architecture and design needs to consider which controller (the AMR or the Robot) is the master controller and which is managing the safety functions of the combined system. This gap needs to be addressed in any revised or new standard.

What's Coming Next

To cover the mobile manipulation use case, and to extend the safety standards to the capabilities of modern AMRs and sensor technology, the industry is working on a new standard. This new standard is R15.08[6], which launched in July of 2016, is now coming to fruition. The first iteration of the standard is expected to be ready for review and public comment starting in June 2019. The committee met in mid-May to review the draft and vote on release for public comment. Stay tuned.

For more information on R15.08:

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Final Note of Caution:

While the safety standards evolve, it is important to complete a risk assessment of your application, your facility and your mobile robot vendor before deploying any automated equipment into your facility. This document outlines the major, worldwide standards which are in play as it relates to AMR safety. However, this article, and this list is not all inclusive. There may be regional, federal, state or local laws which govern facility and safety requirements for equipment which you operate. We recommend that you do a thorough safety and risk assessment before deploying any equipment.

[6] https://www.robotics.org/filesDownload.cfm?dl4=3_Industrial%20Mobile%20Robots%20Safety%20Standard%20Update.pdf