Mobile Robot Safety Standards -- Is there a need?

Jerry Fox
Senior Engineer
The Boeing Company

With input from the National Institute of Standards and Technology

October 14th – 16th, 2013 ~ Indianapolis, Indiana USA

Agenda

- Introduction—
  - Tremendous growth in automation
  - Drivers and Enablers
- Examples of moving systems/robots -- non-industrial & industrial
- Definition of Industrial Robot
- Applications
- Existing Safety Standards – Robots and Movement Systems
- Special safety issues related to moving robots
- Gaps in Existing Standards
- Conclusions and Recommendations
Grown in Automation / Robots

**Drivers**
- Competition
- Labor and Workforce reduction
- Space utilization
- Flexibility – order change
- Quality
- Speed
- Ergonomic
- Throughput

**Enablers**
- Computing Technology
- Robot Controllers
- Vision – Sensors → Accuracy
- Guidance Systems
- Advanced Safety Systems
- Manipulators
- Acceptance – *Tipping Point*
- Updated Safety Standards take advantage of technology → Collaborative

Mobile Automation Examples
Automated Guided Vehicle Applications

*Industrial robot – automatically controlled, reprogrammable multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications

*Automated guided vehicle (AGV) – mobile platform following a predetermined path indicated by markers or external guidance commands, typically in the factory
Mobile Robot Applications

Railcar Unloading

Aerospace Drilling

Lumber Bar Coding

Mobile Robot Applications (cont.)

Order Picking

Aerospace Drilling

Southwest Research Institute’s mobile tracking

Palletizing
Applicable Standards

Robots

ANSI/RIA R15.06-2012

AGV’s

ANSI/ITSDF -2012

American National Standards Institute/Robot Industries Association/Industrial Truck Standards Development Foundation

Mobile Robot Challenges/Gaps

- AGV standards assume fixed loads during movement
- Robot safety standards “assume” a fixed robot system
- Traditional robot applications characterized by:
  - Contained and fenced
  - Dedicated to very repetitive processes
  - High volume, short cycle times
  - Minimal manual intervention
- How to handle the environment without fences, gates, interlocks
- How to handle concepts such as safeguarded space, restricted space, and operating space in a mobile environment?
- Safety sensing and navigation with truly autonomous systems
Mobile Robot Safeguarding

- Present applications are safe
- Safeguarding based on existing standards
- Safeguarding using traditional methods
  - Physical barriers, gates, interlocks
  - Light curtains, area scanners, etc.
- Locking robots during platform moves
- Manually moving robots

Gaps – Competing Safety Protocols

- Robot standards prohibit motion while AGV standards allow it
- AGV’s allow automatic restart in emergency braking situations while only “Collaborative” robots may do so
- B56.5 does not discuss “other onboard systems”, such as a robot, providing e-stop control functions
- Neither standard address dual controls
Gaps – Human detection

- Human is near mobile manipulator carrying a part that extends into the path of the robot or AGV beyond expected reach of human
- A robot that is paused/stopped is not required to detect presence of humans except to prevent automatic start/restart – requires deliberate human action
- B56.5 calls for specific size and shape of test pieces
- Robot standard calls for detection of humans or parts of humans
- Both safety standards mandate proper safety when humans are near, but neither provides language for detecting all classifications of human hazards nor all circumstances

Gaps – Velocity Issues

- Velocity of any point on mobile manipulator may be greater than either the robot arm or the mobile base individually
- Summation of velocities when the arm and AGV are moving simultaneously (e.g., for picking/placing objects while moving)
- R15.06 limits velocities of TCP (tool center point) and individual axes but does not address Cartesian motions of linkages as robot moves.
Gaps – Unplanned restart from pause/stop
Error recovery

- Unplanned mobile manipulator restart from pause/stop.
- R15.06 requires deliberate human action to prevent restarting after
  - Safeguarding actuation
  - Change in operating mode
- B56.5 (AGV standard) allows automatic restart.
- B56.5 doesn’t address error recovery for on-board manipulators or
  onboard equipment restarting the AGV.

Gaps – Robot / AGV software safety interlock

- B56.5 is not specific for hardware or software interlocks but
  addresses safe position for transport, implying PLC control
- R15.06 outlines Safety Rated Monitored Stop (software function)
Gaps – Robot / AGV configuration/position updating/verification

- Many robots don’t have joint or TCP (tool center point) information available for external controllers
- B56.5 addresses mandatory emergency control functions:
  - Loss of speed detection
  - Loss of guide path reference
  - Process monitor (watchdog timer)

Conclusions and Recommendations

- Mobile robot systems applications have been safe
- Both Robot and AGV’s safety standards adequately cover their respective areas
- Neither standard covers mobile robots adequately
- Recommend a joint RIA/ITSDF effort for development of a standard for mobile robots
Contact Information

- **Jerry Fox**
  Senior Engineer
- **The Boeing Company**
- P.O. Box 34787 MC 5C-39
  Seattle, WA 98124-1787
  U. S.
- Telephone: 253-657-3353
  email: jerry.g.fox@boeing.com