

KNIGHTSCOPE

PatrolKnight

Standards & Regulations

Risk assessment and mobile robot safety

MRSD Team E
Sam Dong · Po-Ting Ko · Leo Xu
Pin-Wen Wang · Joshua Tsai

Introduction

Our two standards

ISO 12100:2010

- How to identify hazards, assess risks, and choose protective measures.

ANSI/RIA R15.08-1-2020

- Safety requirements for industrial mobile robot design and testing.



Standard 1: ISO 12100:2010

#1 Description: What is it about?

- Purpose: Identify hazards, assess risks, and choose measures to reduce them.
- When to use it: Consider normal use, like setup, operation, maintenance, and even misuse.
- What to document: Record the hazards, protective measures, test results, and remaining risks.

Standard 1: ISO 12100:2010

#1 Description: Products and markets

- Applicable products: Machinery broadly, including production equipment and automated material-handling systems.
- Applicable markets: Used by machinery designers and manufacturers across industries.
- How it supports other standards: Provides the basic method. Machine-specific standards add detailed requirements.







Standard 1: ISO 12100:2010

#1 Main prescriptions: Risk assessment

Required step	What the designer must do
Define limits	Define intended use, operating conditions, people, and lifecycle limits.
Identify hazards	Identify hazards during operation, setup, maintenance, and likely misuse.
Estimate and evaluate risk	Estimate severity and probability. Decide whether more risk reduction is needed.
Reduce and reassess	Apply measures, check their effectiveness, and document remaining risks.

Standard 1: ISO 12100:2010

#1 Main prescriptions: Estimating risk

- Severity of harm: Assess the possible injury, including the highest foreseeable severity.
- Probability of harm: Consider exposure, the hazardous event, and the chance to avoid harm.
- Evaluate the result: Decide whether the estimated risk needs further reduction. Record the reasoning.

Standard 1: ISO 12100:2010

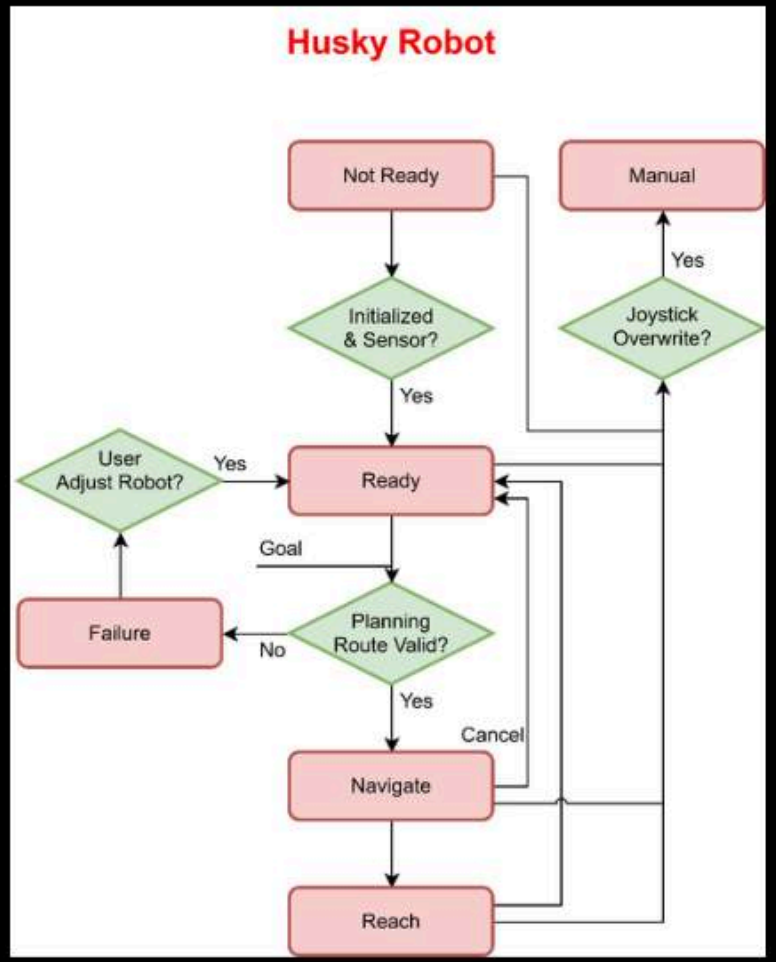
#1 Main prescriptions: Reducing risk

- 1 Inherently safe design: Remove hazards through design, such as avoiding sharp edges and improving stability.
- 2 Safeguarding and complementary measures: Add guards, protective sensing, stopping functions, or other protective measures.
- 3 Information for use: Explain operating limits and remaining risks. Provide instructions and training.

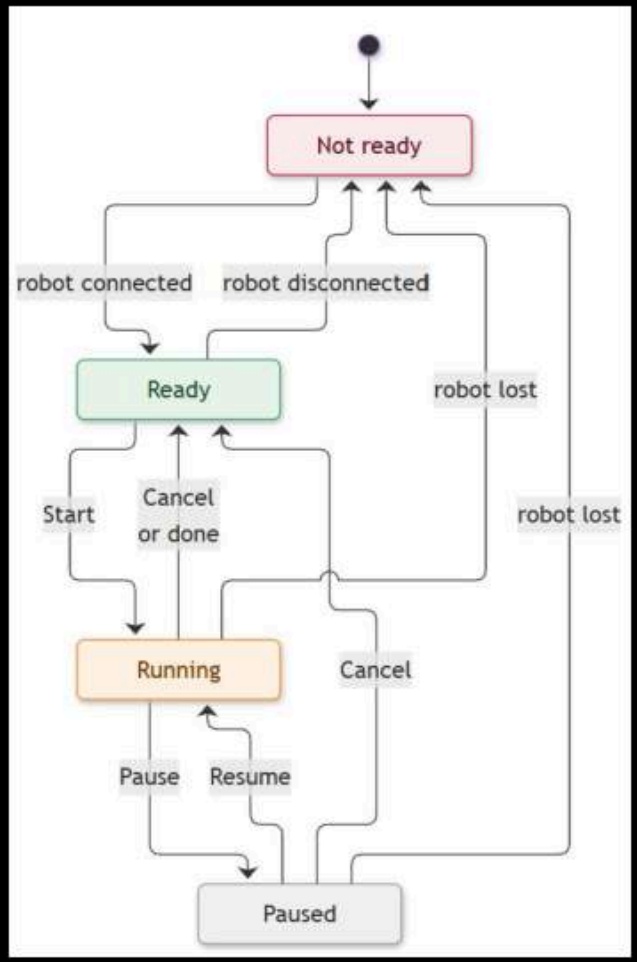
Standard 1: ISO 12100:2010

#1 Application: PatrolKnight

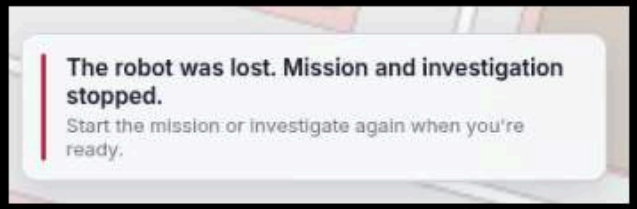
Robot State Machine

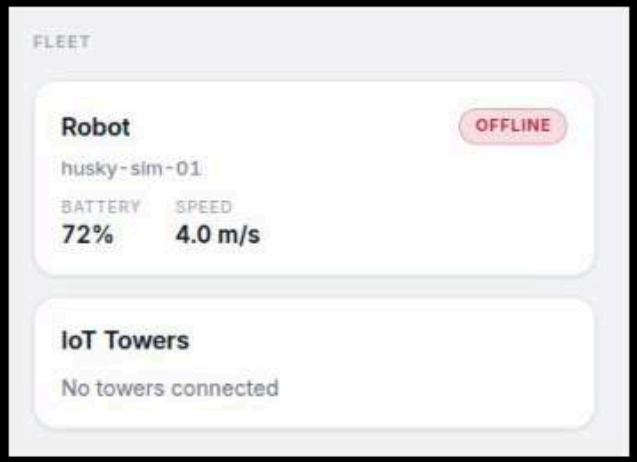


Mission Manager



Communication Failure





Standard 2: ANSI/RIA R15.08-1-2020

#2 Description: What is it about?

Safety requirements for Industrial Mobile Robots (IMRs)

- Purpose: Reduce hazards from mobile robots operating near people.
- What Part 1 covers: Robot design, safety functions, and specified operating conditions.
- Main areas: Risk assessment, robot design, safety tests, and operating instructions.

Standard 2: ANSI/RIA R15.08-1-2020

#2 Description: Products and markets

- Applicable products: Autonomous ground-based industrial mobile robots, including robots with attachments.
- Applicable markets: Manufacturing, laboratories, warehousing, distribution and logistics.
- Operating scope: Mainly industrial workplaces where people have training to interact with the robot.







Standard 2: ANSI/RIA R15.08-1-2020

#2 Main prescriptions: Stopping

Area	Requirement
Protective stop	Stop hazardous motion when a protective condition triggers. Define which motion stops.
Emergency stop	Provide where it reduces risk. Follow the referenced electrical safety requirements.
Measured stopping distance	Measure at rated load and speed under specified conditions. Document the test method.

Standard 2: ANSI/RIA R15.08-1-2020

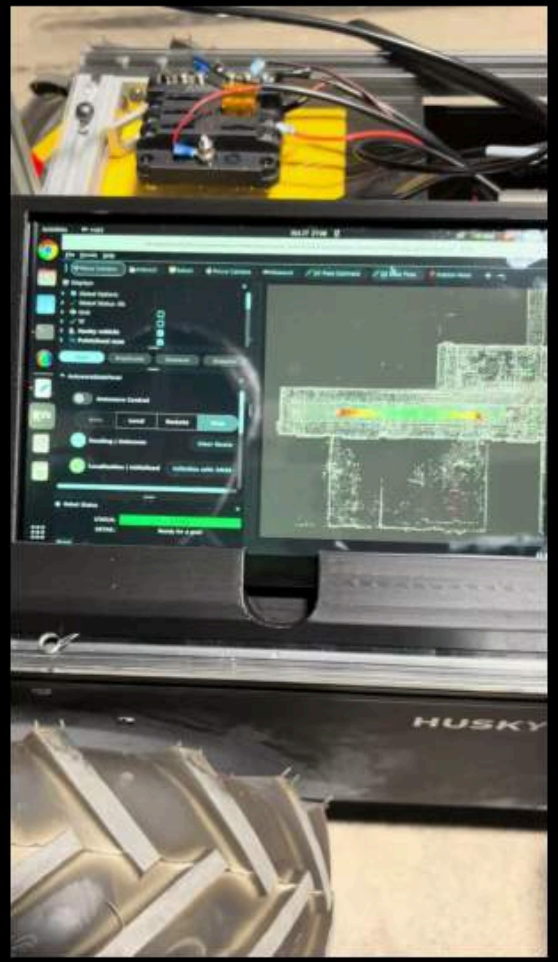
#2 Main prescriptions: Sensing and control

Area	Requirement
Detection coverage	Check the full robot envelope, sensor blind spots and expected pedestrian postures.
Safety controls	Use risk assessment to set the required control-system safety performance.
Verification and documentation	Test detection and stopping. Record sensor limits and the results for each safety function.

Standard 2: ANSI/RIA R15.08-1-2020

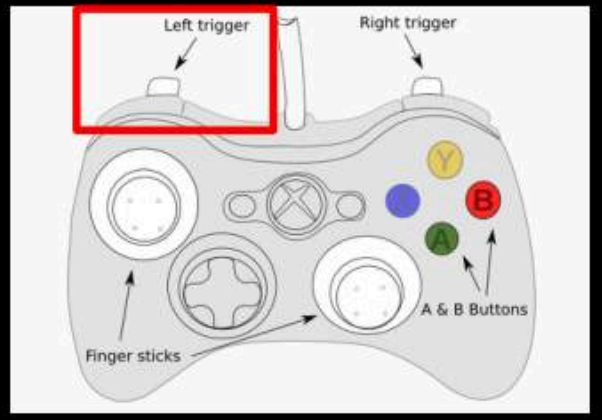
#2 Application: PatrolKnight

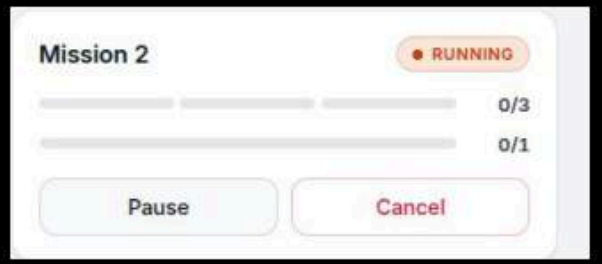
Human Approaching



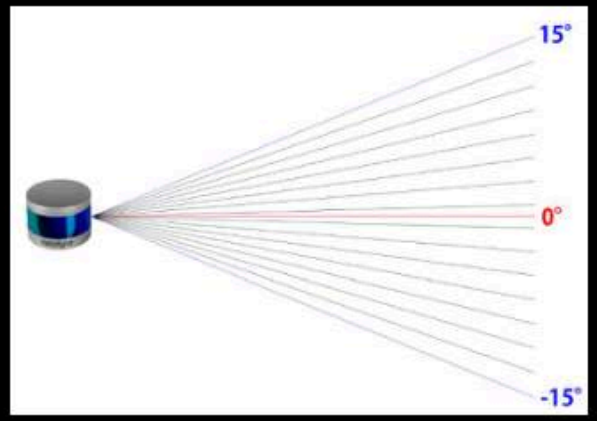
Emergency Stop







Sensor Detection Coverage







Standard 2: ANSI/RIA R15.08-1-2020

#2 Application: Safety tests

Test	Proposed pass condition	Record
Intrusion while moving	Stops before hazardous contact within validated limits	Detection latency and stopping distance
Emergency stop	Hazardous motion stops, reset / restart follows defined policy	Stop response and restart sequence
Link or localization fault	Defined safe response within justified time bound	Fault timestamp and motion trace
Sensor blind-spot challenge	Detects the test piece or operating limits exclude the hazard	Test-piece geometry and coverage

Standard 2: ANSI/RIA R15.08-1-2020

#2 Application: Investigation example

- Hazard: A pedestrian steps out from a blind corner while the robot approaches the investigation point.
- Proposed response: Set a safe approach speed, detect the pedestrian, and stop. Define when motion can resume.
- Required evidence: Test detection and stopping for the actual corner, payload, and allowed operating conditions.

Conclusion

What we will apply to PatrolKnight

- ISO 12100: Use a risk assessment to explain why each protective measure is needed.
- R15.08-1: Use mobile robot requirements to design and test stopping, sensing, and safety controls.
- PatrolKnight’s next step: Confirm what is implemented, complete missing safety functions, and test the robot.

References

Sources and questions

ANSI/RIA R15.08-1-2020

Industrial Mobile Robots – Safety Requirements
Part 1: Requirements for the Industrial Mobile Robot
Focus: Clauses 1, 4–7 and Annex D

ISO 12100:2010

Safety of machinery – General principles for design
Risk assessment and risk reduction
Focus: Clauses 4–7