

SAFETY SYSTEM TECHNICAL REQUIREMENTS

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Classification: Confidential

1. PURPOSE AND SCOPE

1. This document establishes the mandatory safety system technical requirements for all autonomous mobile robots ("AMRs") manufactured by Polar Dynamics Robotics, Inc. ("Company") under the IceNav(TM) platform designation.
2. These requirements apply to all Series-X and Series-Z AMR models designed for operation in controlled temperature environments ranging from ambient to -40 C.

2. DEFINITIONS

1. "Safety System" means the integrated hardware and software components responsible for ensuring safe AMR operation, including but not limited to emergency stops, collision avoidance systems, thermal monitoring systems, and fail-safe protocols.
2. "Critical Operating Parameters" means the defined operational boundaries within which the AMR must function to maintain safety certification.
3. "Safety Integrity Level (SIL)" refers to the relative level of risk-reduction provided by a safety function as defined in IEC 61508.

3. SYSTEM ARCHITECTURE REQUIREMENTS

1. Primary Safety Controller

- Must utilize redundant microprocessors with independent voting systems
- Minimum SIL-2 certification required
- Real-time operating system with maximum response latency of 10ms
- Independent power supply with minimum 30-minute backup

2. Sensor Systems

- Minimum of three independent LIDAR sensors with 360° coverage
- Redundant temperature monitoring at critical points
- Dual-technology proximity detection (ultrasonic and infrared)
- Minimum sensor sampling rate of 100Hz

4. OPERATIONAL SAFETY REQUIREMENTS

1. Emergency Stop Functions

- Category 0 stop capability per IEC 60204-1
- Maximum stop distance of 300mm at full speed
- Redundant physical e-stop buttons accessible from all sides
- Remote emergency stop capability via secure wireless link

2. Motion Safety

- Maximum speed automatically limited based on environmental conditions
- Dynamic safety zone adjustment based on speed and load
- Automatic deceleration in restricted visibility conditions
- Anti-slip monitoring and traction control

5. ENVIRONMENTAL ADAPTATION SYSTEMS

1. Temperature Management

- Continuous monitoring of critical component temperatures
- Automatic thermal protection engagement at -35°C
- Heat dissipation monitoring with automatic load reduction
- Condensation prevention systems for electronic enclosures

2. Surface Condition Response

- Real-time coefficient of friction calculation
- Automatic adjustment for ice and frost conditions
- Minimum traction threshold monitoring
- Emergency protocols for loss of surface contact

6. COMPLIANCE AND CERTIFICATION

1. Required Standards

- ISO 13849-1:2015 Performance Level D
- IEC 61508 SIL-2 certification
- ANSI/RIA R15.06-2012 compliance
- CE marking requirements for applicable markets

2. Testing Requirements

- Full system validation at -40 C operating temperature
- 1,000-hour continuous operation validation
- EMC testing per IEC 61000-6-2
- Impact resistance testing per IP65 requirements

7. DOCUMENTATION AND VERIFICATION

1. Each safety system implementation must be documented with:

- Complete technical specifications
- Risk assessment documentation
- Test validation reports
- Certification documentation
- Maintenance requirements

2. Version Control

- Safety system software must maintain MISRA-C:2012 compliance
- All changes must follow documented change control procedures
- Version history must be maintained for 7 years

8. MAINTENANCE AND INSPECTION

1. Periodic inspection requirements:

- Daily visual safety system checks
- Weekly sensor calibration verification
- Monthly comprehensive system testing
- Quarterly third-party safety audit

2. Component Replacement

- Safety-critical components must be replaced at 80% of rated life
- Maintenance records must be maintained in secure database
- Only Company-certified components may be used for replacement

9. LEGAL COMPLIANCE

The requirements contained herein represent minimum safety standards. Compliance with these requirements does not guarantee compliance with all applicable laws and regulations. The Company reserves the right to modify these requirements at any time to maintain compliance with evolving safety standards and regulations.

10. AUTHORIZATION

These Safety System Technical Requirements are hereby authorized and approved:

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Dr. Elena Frost

Chief Executive Officer

Polar Dynamics Robotics, Inc.

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Dr. James Barrett

Chief Robotics Officer

Polar Dynamics Robotics, Inc.

Date: