

# MULTI-ROBOT COORDINATION SYSTEM DESIGN DOCUMENT

## CONFIDENTIAL AND PROPRIETARY

Polar Dynamics Robotics, Inc.

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### 1. DOCUMENT CONTROL

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2 Document ID: PDR-MRCS-2024-001

Classification: Restricted Technical Documentation

Department Owner: Engineering/Robotics Division

Technical Approval: Dr. James Barrett, Chief Robotics Officer

### 2. SYSTEM OVERVIEW

1 The Multi-Robot Coordination System ("MRCS") implements Company's proprietary IceNav(TM) platform for coordinating multiple autonomous mobile robots ("AMRs") in temperature-controlled environments ranging from -40 C to +25 C.

2 Core Components:

- Centralized Control Module (CCM)
- Distributed Navigation Nodes (DNNs)
- Inter-Robot Communication Protocol (ICP)
- Thermal Management Subsystem (TMS)
- Emergency Override System (EOS)

### 3. TECHNICAL SPECIFICATIONS

1 Communication Architecture

- Primary Protocol: IEEE 802.11ax with proprietary encryption
- Backup Protocol: Low-frequency mesh network
- Maximum Supported Nodes: 128 AMRs per control sector

- Latency Requirements: <50ms round-trip
- Bandwidth: 100Mbps minimum per node

## 2 Navigation Parameters

- Positioning Accuracy: 5cm in static conditions
- Path Planning Resolution: 2cm grid mapping
- Update Frequency: 10Hz minimum
- Collision Avoidance Buffer: 0.5m minimum
- Maximum Operating Speed: 2.0 m/s

## 4. SAFETY AND COMPLIANCE

### 1 Safety Classifications

- IEC 61508 SIL 2 Compliance
- ISO 13849-1 Performance Level D
- IP65 Environmental Protection Rating
- UL 1740 Robot Safety Requirements

### 2 Emergency Protocols

- Distributed Emergency Stop (E-Stop) System
- Redundant Safety Controllers
- Fail-Safe State Implementation
- Thermal Monitoring and Shutdown Procedures

## 5. PROPRIETARY FEATURES

### 1 IceNav(TM) Cold Environment Adaptations

- Patent-pending thermal compensation algorithms
- Cold-resistant sensor arrays
- Heated critical components management
- Anti-icing navigation protocols

### 2 Multi-Robot Coordination

- Dynamic task allocation

- Adaptive path optimization
- Load balancing algorithms
- Conflict resolution protocols

## **6. INTEGRATION REQUIREMENTS**

### **1 Facility Requirements**

- Minimum WiFi Coverage: -75dBm throughout operating area
- Power Infrastructure: 480V 3-phase
- Emergency Power Backup: UPS system rated for 30 minutes
- Network Infrastructure: Dedicated VLAN with QoS

### **2 Software Integration**

- REST API Version: 2.0
- Authentication: OAuth 2.0
- Data Format: JSON/Protocol Buffers
- Logging: ELK Stack Compatible

## **7. PERFORMANCE METRICS**

### **1 System Performance**

- Maximum Fleet Size: 128 units
- Minimum Path Planning Time: 100ms
- Position Update Rate: 10Hz
- Battery Life: 12 hours continuous operation

### **2 Environmental Parameters**

- Operating Temperature: -40 C to +25 C
- Humidity: 10% to 95% non-condensing
- Floor Surface: Concrete/epoxy/steel
- Lighting: 50-1000 lux

## **8. INTELLECTUAL PROPERTY NOTICE**

1 This document describes technology protected by one or more of the following patents and patent

applications:

- US Patent No. 11,123,456
- US Patent Application No. 17/123,456
- PCT Application No. PCT/US2023/012345

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