

# **FAULT DETECTION SYSTEM ARCHITECTURE**

**Document ID: PDR-TECH-FD-2023-001**

**Version: 3.1**

**Last Updated: December 15, 2023**

**Classification: CONFIDENTIAL**

## **1. OVERVIEW AND SCOPE**

1. This Fault Detection System Architecture document ("Architecture Document") describes the proprietary fault detection and diagnostic system implemented in Polar Dynamics Robotics, Inc.'s ("Company") IceNav(TM)-enabled autonomous mobile robots ("AMRs") and related control systems.
2. This Architecture Document is considered Confidential Information as defined in the Company's Master Confidentiality Agreement and is subject to all applicable protections and restrictions therein.

## **2. DEFINITIONS**

1. "Critical Operating Parameters" means the set of system variables monitored by the Fault Detection System, including but not limited to:
  - a) Thermal management system performance metrics
  - b) Motor controller feedback signals
  - c) Navigation sensor data integrity
  - d) Battery management system parameters
  - e) Environmental condition measurements
2. "Fault Detection System" or "FDS" means the Company's proprietary system for real-time monitoring, detection, and diagnosis of operational anomalies in AMR systems.
3. "IceNav(TM) Platform" means the Company's proprietary navigation and control software platform designed for cold-environment operation.

## **3. SYSTEM ARCHITECTURE**

### **1. Core Components**

The FDS consists of the following integrated subsystems:

- a) Sensor Interface Layer
- b) Data Acquisition Module
- c) Analysis Engine
- d) Response Management System
- e) Logging and Reporting Module

## 2. Operational Framework

The FDS operates within a multi-tiered architecture:

### 2.1. Tier 1: Real-time Monitoring

- Continuous sampling of Critical Operating Parameters
- Primary fault detection algorithms
- Immediate response triggering

### 2.2. Tier 2: Diagnostic Processing

- Pattern recognition and analysis
- Historical data correlation
- Predictive fault modeling

### 2.3. Tier 3: System Management

- Fleet-wide data aggregation
- Performance optimization
- Maintenance scheduling

## 4. FAULT DETECTION PROTOCOLS

1. The FDS shall employ the following detection protocols:

### 1.1. Primary Detection

- Real-time parameter monitoring
- Threshold violation detection
- Signal analysis and validation

### 1.2. Secondary Detection

- Cross-correlation analysis

- Trend detection
- Statistical anomaly identification

## 2. Response Classification

Detected faults shall be classified according to the following severity levels:

Level 1: Advisory

Level 2: Warning

Level 3: Critical

Level 4: Emergency Shutdown

## 5. PROPRIETARY TECHNOLOGIES

1. The FDS incorporates the following proprietary technologies:

- a) ThermalGuard(TM) monitoring system
- b) CryoSense(TM) sensor array
- c) FrostLogic(TM) decision engine
- d) PolarShield(TM) protection protocols

2. All technologies listed in Section 5.1 are protected under U.S. Patents [REDACTED] and related international filings.

## 6. COMPLIANCE AND CERTIFICATION

1. The FDS architecture complies with:

- a) ISO 13849-1 Safety of machinery
- b) IEC 61508 Functional Safety
- c) ANSI/RIA R15.06 Robot Safety
- d) FDA 21 CFR Part 11 (where applicable)

## 7. IMPLEMENTATION AND MAINTENANCE

1. Implementation Requirements

The FDS shall be implemented according to Company Standard Operating Procedure PDR-SOP-2023-142.

## 2. Maintenance Protocol

Regular system maintenance shall be performed according to the following schedule:

- a) Daily: Automated system checks
- b) Weekly: Diagnostic review
- c) Monthly: Performance analysis
- d) Quarterly: Full system audit

## 8. LEGAL NOTICES

### 1. Proprietary Rights

This Architecture Document and all technologies described herein are proprietary to Polar Dynamics Robotics, Inc. and are protected by applicable intellectual property laws.

### 2. Confidentiality

This document contains trade secrets and confidential information of the Company. Unauthorized disclosure, reproduction, or use is strictly prohibited.

## 9. DOCUMENT CONTROL

- 1. This Architecture Document shall be reviewed and updated annually or as required by significant system modifications.
- 2. All revisions must be approved by the Chief Technology Officer and Chief Robotics Officer.

## AUTHORIZATION

APPROVED AND ADOPTED this 15th day of December, 2023.

POLAR DYNAMICS ROBOTICS, INC.

**By: \_**

Marcus Chen

Chief Technology Officer

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