# PATENT SPECIFICATION

**Patent No. US 11,842,XXX B2**

**Polar Navigation Beacon System for Cold Environment Autonomous Mobile Robots**

**Filed: March 15, 2021**

**Issued: January 11, 2024**

**Assignee: Polar Dynamics Robotics, Inc., Wilmington, Delaware**

**Inventors: Chen, Marcus; Barrett, James; Frost, Elena**

## ABSTRACT

A navigation beacon system for autonomous mobile robots operating in extreme cold environments, comprising a network of temperature-hardened radio frequency beacons that maintain positional accuracy in sub-zero conditions. The system utilizes proprietary cold-resistant signal processing hardware and thermal management systems to ensure reliable navigation in environments between -40 C and +25 C.

## BACKGROUND

[0001] Autonomous mobile robots (AMRs) operating in cold storage and industrial freezer environments face unique challenges in maintaining accurate navigation due to signal degradation, hardware limitations, and environmental interference. Traditional navigation systems often fail or provide unreliable positioning data in extreme cold conditions.

[0002] Existing solutions typically rely on standard RF beacons or visual SLAM systems that become unreliable below -10 C due to component limitations and signal propagation issues in cold, dense air environments.

## SUMMARY OF THE INVENTION

[0003] The present invention provides a cold-environment navigation beacon system comprising:
- Temperature-hardened beacon hardware with proprietary thermal management
- Cold-resistant signal processing circuits
- Distributed mesh network architecture
- Self-calibrating position correction algorithms

-       Redundant signal pathways for mission-critical reliability

## DETAILED DESCRIPTION

[0004] The beacon system includes the following core components:

### Beacon Hardware

[0005] Each navigation beacon comprises:

-       Thermally isolated RF transmitter module

-       Proprietary cold-resistant power management system

-       Temperature-compensated oscillator (TCO)

-       Ruggedized polycarbonate housing rated to -50 C

-       Redundant power supply with cold-weather battery backup

### Signal Processing

[0006] The system processes positioning data through:

-       Multi-channel RF signal analysis

-       Temperature-adjusted signal strength compensation

-       Dynamic frequency adjustment based on environmental conditions

-       Proprietary IceNav(TM) positioning algorithms

### Network Architecture

[0007] The beacon network features:

-       Mesh topology with minimum 3x redundant coverage

-       Self-healing network reconfiguration

-       Distributed processing nodes

-       Secure encrypted communication protocols

## CLAIMS

What is claimed is:

A navigation beacon system for cold environment autonomous mobile robots comprising:

a) A plurality of temperature-hardened radio frequency beacons;

b) Cold-resistant signal processing hardware;

c) Thermal management systems maintaining operation between -40 C and +25 C;

d) Position calculation algorithms compensating for cold-weather signal propagation;

e) Redundant mesh network architecture.

The system of claim 1, wherein each beacon includes:

a) Thermally isolated RF transmitter;

b) Temperature-compensated oscillator;

c) Cold-resistant power management;

d) Ruggedized housing rated to -50 C.

The system of claim 1, further comprising:

a) Dynamic frequency adjustment based on environmental conditions;

b) Self-healing network reconfiguration;

c) Encrypted communication protocols.

## DRAWINGS

[0008] FIG. 1 illustrates the beacon hardware architecture

[0009] FIG. 2 shows the network topology diagram

[0010] FIG. 3 depicts the signal processing flow

[0011] FIG. 4 presents thermal management system components

## TECHNICAL FIELD

[0012] The invention relates to navigation systems for autonomous mobile robots, specifically addressing the challenges of maintaining reliable positioning in extreme cold environments such as industrial freezers and cold storage facilities.

## INDUSTRIAL APPLICABILITY

[0013] This invention has direct application in:

- Cold chain logistics

- Pharmaceutical manufacturing

- Food processing facilities

- Industrial cold storage

- Temperature-controlled warehouses

## PRIOR ART REFERENCES

[0014] US Patent 10,XXX,XXX

[0015] US Patent Application 2020/XXXXXXX

[0016] EP Patent 3,XXX,XXX

The foregoing description is provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed.

**Date of Patent: January 11, 2024**

/Marcus Chen/

Marcus Chen

Chief Technology Officer

Polar Dynamics Robotics, Inc.

/James Barrett/

Dr. James Barrett

Chief Robotics Officer

Polar Dynamics Robotics, Inc.

/Elena Frost/

Dr. Elena Frost

Chief Executive Officer

Polar Dynamics Robotics, Inc.