SUB-ZERO OPERATIONAL LIMITS TECHNICAL REPORT

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Polar Dynamics Robotics, Inc.

Document Reference: TR-2023-142

Date: December 15, 2023

Classification: Confidential

1. EXECUTIVE SUMMARY

This technical report documents the operational limitations and perfor

parameters of Polar Dynamics Robotics' autonomous mobile robots (A

sub-zero environments. Testing was conducted at our primary R&D fa
Minneapolis, Minnesota, between June 2023 and November 2023, us
units equipped with BlueCore(TM) Technology Platform version 4.2.

2. SCOPE AND METHODOLOGY

1. Test Environment Parameters

- Temperature Range: +5 C to -40 C
- Humidity Range: 15% to 85% RH
- Floor Conditions: Varied (concrete, epoxy-coated, metal plate)
- Testing Duration: 2,500 cumulative hours

2. Test Units

- Model: PDR-3000 Cold Series

- Quantity: 5 production units

- Serial Numbers: PDR3K-2023-0458 through PDR3K-2023-0462

- Software Version: BlueCore(TM) 4.2.16

3. OPERATIONAL TEMPERATURE LIMITS

1. Standard Operating Range

- Continuous Operation: -30 C to +5 C

Maximum Duration: 12 hours continuous

- Recovery Period Required: 30 minutes at room temperature

2. Extended Operating Range

- Limited Operation: -40 C to -31 C

- Maximum Duration: 4 hours

- Recovery Period Required: 60 minutes at room temperature

- Requires activation of Enhanced Thermal Management Protocol

4. PERFORMANCE METRICS

1. Navigation Accuracy

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Standard Range: 15mm at -30 C

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Extended Range: 25mm at -40 C

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Path Deviation: <1% at all temperatures

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Obstacle Detection: 99.99% reliability maintained

2. Battery Performance

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Operating Time at -30 C: 8 hours

Operating Time at -40 C: 6 hours

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Charging Time (Cold): 2.5 hours

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Charging Temperature Requirements: >0 C

5. SYSTEM LIMITATIONS

1. Hardware Constraints

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Maximum Payload: 1,200kg at -30 C; 900kg at -40 C

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Maximum Speed: 2.0 m/s at -30 C; 1.5 m/s at -40 C

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Minimum Turn Radius: 1.8m

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Maximum Incline: 5% grade

2. Environmental Constraints

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Maximum Humidity: 85% RH

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Maximum Ice Accumulation: 2mm

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Minimum Floor Friction Coefficient: 0.4

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Maximum Allowable Floor Variation: 10mm

6. SAFETY SYSTEMS

1. Emergency Protocols

- Automatic shutdown at -41 C
- Battery thermal protection engagement at -35 C
- Emergency stop effective to -45 C
- Fail-safe braking system operational to -50 C

2. Warning Systems

- Visual indicators: Operational to -45 C
- Audible alarms: Operational to -40 C

- Wireless communication: Maintained to -40 C
- Remote monitoring: Continuous through all ranges

7. MAINTENANCE REQUIREMENTS

1. Regular Maintenance Intervals

- Daily visual inspection
- Weekly sensor calibration
- Monthly battery conditioning
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Quarterly full system diagnostic

2. Cold-Specific Maintenance

- Desiccant replacement: Every 500 hours
- Thermal paste reapplication: Every 2,000 hours
- Seal inspection: Monthly
- Condensation check: Daily

8. CERTIFICATION AND COMPLIANCE

1. Testing Standards Met

ISO 13849-1:2015 Safety of machinery

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IEC 60068-2-1 Cold testing

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IP65 Environmental protection

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CE Marking requirements

2. Regulatory Compliance

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ANSI/RIA R15.08-1-2020

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EN 1525:1997

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9. LIMITATIONS OF LIABILITY

This report represents testing conducted under controlled conditions. performance may vary based on specific environmental conditions, us and maintenance adherence. Polar Dynamics Robotics, Inc. makes n express or implied, regarding the performance of its products beyond explicitly stated in the standard warranty terms and conditions.

10. CERTIFICATION

The undersigned hereby certify that the tests described in this report w

conducted in accordance with Polar Dynamics Robotics' standard test
and that the results accurately reflect the observed performance of the
units.

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Polar Dynamics Robotics, Inc.

Date: December 15, 2023

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