

EXECUTIVE PROJECT SUMMARY

CHAINGUARD RESEARCH REPORT

PROJECT TOPIC	ChainGuard: IoT Cold Chain Integrity Monitor for Pharma Logistics		
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INTRODUCTION

This report outlines the development of ChainGuard, an IoT Cold Chain Integrity Monitor designed primarily for pharmaceutical logistics, food logistics, and the chemical industry. The system provides continuous monitoring of critical variables like temperature and humidity directly inside transport boxes, eliminating the thermal blind spots associated with traditional, truck-fixed hardware.

CONTEXT & PROBLEM

Current cold chain monitoring relies on slow, inflexible sensors fixed to truck walls, which fail to maintain accurate measurements across the entire cargo. This inefficiency leads to undetected spoilage and financial waste. The industry needs to shift from isolated, proprietary, and battery-dependent loggers to a flexible, sustainable, and integrated system that provides real-time, box-level visibility.

METHODOLOGY & ARCHITECTURE

The solution employs a Seeed Studio XIAO nRF52840 microcontroller, Si7021 temperature/humidity sensors, and an Adafruit PCF8523 RTC, all powered sustainably by two 50F supercapacitors (rechargeable via wireless induction). Sensors record data every 60 seconds and store it in internal flash while the device rests in an ultra-low power Deep Sleep mode. Upon arrival, data is transmitted via Bluetooth (BLE) to a Raspberry Pi Gateway and forwarded to a Firestore Cloud dashboard.

CONCLUSIONS & RESULTS

Extensive testing demonstrated a highly precise accuracy margin of $\pm 0.2^{\circ}C$. The prototype successfully achieved 10 hours of continuous operational autonomy on a single charge of the supercapacitors. The entire prototype was developed within a 100-euro budget. While the 10-hour autonomy provided valuable data and proved the concept, further power optimization is required to hit the initial 24-hour target.

KEY BENEFITS & RECOMMENDATIONS

Based on the prototype's success, we highlight the following strategic benefits and recommendations for logistics adoption:

- Zero Maintenance:** The supercapacitor architecture supports infinite recharge cycles, eliminating battery replacements and electronic waste.
- Labor Efficiency:** Automating data collection via BLE removes the need for manual logging by operators.
- Waste Mitigation:** Box-level monitoring allows companies to isolate specifically affected cargo rather than discarding entire shipments.
- Targeted Deployment:** Prioritize deployment for biological samples and high-value pharmaceuticals according to partner requirements (e.g., INSA and Transaire).