



Project Ambient

Harvesting Power and Extending Label Lifetimes

ELECOMP Capstone Design Project 2026-2027

Sponsoring Company:

Zebra Technologies Corporation

116 The American Road
Morris Plains, NJ 07950 USA
<http://www.zebra.com>

Company Overview:

Zebra Technologies Corporation and its subsidiaries provide enterprise asset intelligence solutions in the automatic identification and data capture solutions industry worldwide. The company designs, manufactures, and sells printers, which produce labels, wristbands, tickets, receipts, and plastic cards; dye-sublimation thermal card printers, which produce images which are used for personal identification, access control, and financial transactions; RFID printers that encode data into passive RFID transponders; accessories and options for our printers, including vehicle mounts and battery chargers; stock and customized thermal labels, receipts, ribbons, plastic cards, and RFID tags for printers; and temperature-monitoring labels primarily used in vaccine distribution. It also provides various maintenance, technical support, repair, and managed and professional services; real-time location systems and services; and tags, sensors, excimers, middleware software, and application software; as well as physical inventory management solutions, and rugged tablets and enterprise-grade mobile computing products and accessories. In addition, the company offers barcode scanners, RFID readers, industrial machine vision cameras, and fixed industrial scanners, workforce management solutions, workflow execution and task management solutions, and prescriptive analytics solutions, as well as communications and collaboration solutions. It also provides cloud-based software subscriptions and robotics automation solutions. The company serves retail and e-commerce, manufacturing, transportation and logistics, healthcare, public sector, and other industries through direct sales and a network of channel partners.



Technical Director(s):

Zareena Al-Shehab

Research Engineer

zareena.alshehab@zebra.com

<https://www.linkedin.com/in/zareena-al-shehab/>

Joe Moreira

Engineering Fellow

JMoreira@zebra.com

Project Motivation:

Project Ambient aims to fundamentally overcome the limitations of traditional, single-use labels, which create costly and inefficient relabeling cycles for assets with multi-year lifespans. This initiative is developing a truly autonomous "print-and-place" smart label engineered to survive on an asset for its entire lifecycle without maintenance. The core of this innovation lies in pairing an integrated energy harvester, designed to scavenge ambient power from sources like light or radio waves, with an ultra-low-power Bluetooth Low Energy (BLE) radio for efficient and ubiquitous data communication. To ensure continuous operation even in the absence of an immediate energy source, the system incorporates an advanced thin-film battery for energy storage, providing a reliable power buffer for the electronics. All components are encased in a physically robust package, ensuring both the printed information and the embedded electronics can withstand years of exposure to harsh industrial or outdoor environments, thus delivering constant data visibility and active tracking capabilities with zero manual intervention.



Anticipated Best Outcome:

A working label prototype that sustains a constant wireless report interval over realistic, variable ambient energy conditions.

Project Details:

Battery "Free" Operation: The label pairs an energy harvester, that can be optionally buffered with a thin-film, non-lithium battery, with a low-power radio so it reports on a consistent schedule without ever needing a battery swap.

Radio Selection: BLE offers immediate compatibility with infrastructure already deployed in the field; Sub-GHz radios likely offer better range and power efficiency. The project resolves these trade-offs with real power budget data. There are many avenues to consider!

Display Integration: Determine if an e-paper display is a suitable alternative to traditional face stocks by analyzing its effect on the device's power profile.

Form Factor Discipline: Every component (harvester, buffer, radio, antenna, FCP) is constrained by a strict sub-1.25mm thickness budget.

An ideal outcome would include a working prototype demonstrating reliable, battery-free wireless reporting over a suitable test period, with a data-backed recommendation on radio type and power architecture.

Composition of Team:

3 Electrical Engineers



Skills Required:

Adaptable, quick learner, highly curious.

Interest in, or experience with, circuit design

Interest in, or experience with, RF/wireless communication and IoT

AI Usage:

The AI Use Policy for this project is defined in Appendix A at the end of this proposal. The Technical Directors have completed the checklist in Appendix A to indicate which AI uses are permitted on this project. Any item left unchecked is not allowed.

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

A validated no-maintenance label removes a recurring cost currently borne by both customer and company: battery service on active tags. It builds on R&D the company already has depth in, advanced label coatings and RF design, positioning this as a new class of multimodal sensors rather than an incremental update to an existing offering.

Broader Implications of the Best Outcome on the Company's Industry:

A proven "forever" asset tracking label shifts the industry away from service contracts for battery swaps, most relevant to industries with large reusable asset pools: logistics, kegging, industrial pallet pools, manufacturing equipment. It also aligns with the broader industry move towards energy-harvesting IoT devices.



Appendix A: AI Use Policy – Project Ambient

Allowed

- Students may use AI tools for
 - ☒ brainstorming support
 - ☒ concept development
 - ☒ literature and publicly available documentation review
 - ☐ software development
 - ☐ debugging
 - ☐ data analysis
 - ☐ test development
 - ☒ non-proprietary paragraph editing
 - ☐ non-proprietary single-slide formatting
 - ☐ preparation of project deliverables
 - ☐ note taking or transcription of meetings
 - ☐ Others: _____

Not Allowed

- Using AI in violation of university policies, applicable laws, or course-specific rules identified by capstone instruction team and project-specific rules identified by the technical directors.
- Entering proprietary, confidential, personally identifiable, security-sensitive, or otherwise restricted information into an AI system without authorization.



- Submitting AI-assisted work without understanding, reviewing, verifying, and appropriately disclosing its use.
- Submitting entire documents or presentations to an AI system for editing or formatting.
- Any unchecked items from the allowed list above.

Requirements

- If any use is allowed, AI tools may only be used to enhance, but not replace, students' technical reasoning, engineering judgment, and understanding. Students must be able to explain, justify, and defend all submitted designs, code, analyses, test results, documentation, and conclusions.
- During the first two weeks of the project, the student team shall work with the Technical Directors to: identify any proprietary or confidential information that may be involved in the project; determine what information may or may not be shared with AI systems; identify the AI tools, models, accounts, and configurations approved for project use; and document any project-specific restrictions or approval requirements.
- Students shall transparently document the uses of AI using the URI CYPHER AI Usage Marking guidelines (<https://web.uri.edu/cypher/ai-marking/>). A workshop is planned for September to familiarize students with these guidelines.
- Students retain full professional responsibility for all design decisions, analyses, implementations, testing, documentation, presentations, and final deliverables, regardless of whether AI tools contributed to the work.