URI GRADUATE STUDENT ASSOCIATION

RHODYREACH

RhodyReach: Smart Food Access and Robotic Restocking Infrastructure

ELECOMP Capstone Design Project 2026-2027

Sponsoring Company:

University of Rhode Island Graduate Student Association (GSA)

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Kingston, Rhode Island 02881
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Company Overview:

The University of Rhode Island Graduate Student Association (GSA) is the representative body for URI graduate students, advocating for graduate student interests and supporting student life through programming, funding, and campus partnerships. Through collaborations with Rhody Outpost, the Feinstein Hunger Center, and other campus organizations, the GSA works to address food insecurity and improve access to essential resources across the URI community.

Project Abstract: RhodyReach is a first-stage physical AI infrastructure project for campus food access. The near-term mission is concrete: build a completed food-recovery application, prototype smart Giving and Taking Boxes, and create a low-cost sensor/data pathway that supports Rhody Outpost and GSA food access points before full smart-box deployment is affordable. The long-term technical vision is larger: a URI campus where smart service locations can be identified, monitored, refilled, and eventually served by autonomous robotic delivery agents that move food and essential supplies where students need them.

The URI Graduate Student Association will serve as product owner and sponsor, with Justin Watkins acting as the primary technical director and project contact for Phase I. Rhody Outpost, URI Dining and Catering, the Feinstein Hunger Center, URI IT and Facilities, and GSA technical leadership provide the campus operating context. Dr. Stegagno's lab and the Intelligent Control and Robotics Laboratory are positioned as collaborative robotics partners for consultation and future development rather than as formal technical directors at this stage.

Robotics is a Phase I design constraint, not a future add-on. The capstone does not promise a full autonomous fleet in one year. Instead, students will design the boxes, data model, access points, site study, and service interfaces so the next phase can integrate a mobile robot without redesigning the whole system.

THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO

Box geometry, modular refill bays, removable totes, service-door access, fiducial markers, machine-readable identity, telemetry states, refill/pickup missions, and campus deployment constraints will be documented with future robotic interaction in mind.

Technical Director(s):

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Collaborative Robotics Consultation / Future Development Partner:
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University of Rhode Island Department of Electrical and Computer Engineering
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Project Motivation:

Physical AI systems - machines that perceive, reason, navigate, and act in shared environments - move engineering beyond software on a screen. RhodyReach gives students a manageable first-stage version of that challenge: build the application, sensing, access-control, and deployment infrastructure that future autonomous restocking agents would need. The technical challenge is not only a robot; it is the surrounding platform that makes robots useful, safe, and accountable in a real campus setting.

Food recovery provides an immediate and measurable use case. URI events create time-sensitive food opportunities, while Rhody Outpost and GSA food access efforts need better ways to see stock levels, pickup needs, refill needs, and student-facing availability. Phase I turns those needs into a working campus application, instrumented prototype boxes, and an exploratory sensor pilot for existing manual Rhody Outpost or GSA food access locations.

Phase I is intentionally bounded for a two-student core team: one Electrical Engineering student and one Computer Engineering student. An additional Computer Engineering student may be added if needed, especially for production application, backend services, geospatial site model, notifications, operations workflow, mission task logic, and simulation support. The core project should remain achievable without assuming that add-on role. The Electrical Engineering student focuses on sensing, power, locking, interlocks, instrumentation, embedded firmware, and prototype reliability alongside being willing to help with application and/or computer engineering tasks as needed. The Computer Engineering student focuses on IoT communication, device identity, APIs, and hardware/software integration interfacing between sensors and application capability for full stack application development.

No autonomous fleet is required during this capstone year. The project ends with the application complete, box prototypes operational, an exploratory manual-site sensor pathway tested or specified, candidate sites ranked, and a robot-ready interface package prepared for future development. Students gain an industry-relevant portfolio spanning full-stack product development, embedded systems, IoT, geospatial operations, smart infrastructure, and physical AI readiness.

Anticipated Best Outcome:

At the final demonstration, the team will present a closed-loop, robot-ready Phase I system: a host publishes a time-bounded food opportunity; students discover it through the application; an administrator can view events, sites, and operational tasks; prototype boxes report inventory/capacity states; an exploratory manual-site sensor kit or specification shows how existing Rhody Outpost locations can be instrumented; and the platform produces robot-ready refill or pickup tasks for future integration.

- A completed mobile-responsive campus food-recovery application with host sign-up, event creation, scheduled activation/expiration, live map/feed, opt-in alerts, administrator moderation, and audit history.
- A secure backend and geospatial campus model containing event locations, candidate box sites, manual Rhody Outpost sensing sites, route constraints, power/network/accessibility factors, robot approach assumptions, box states, and documented APIs.
- A Giving Box prototype with capacity and tamper sensing, a removable service tote, separated public/service access, machine-readable identity, fiducial pose marker, and service-ready state for future pickup automation.
- A Taking Box prototype with inventory sensing, secure dispensing, modular refill bay, service interlocks, manual override, robot-readable state, and dashboard telemetry for future refill automation.
- An exploratory sensor/data-collection pathway for existing manual Rhody Outpost or GSA food access locations, allowing lower-cost stock, capacity, service, and refill data collection before full smart-box deployment.
- A verified handoff package: application source code, interface-control document, ranked site study, test results, schematics, firmware, sensor-pilot documentation, security/privacy requirements, and a Phase II robotics integration plan.

Demonstration acceptance: a host creates a time-bounded posting; students discover it on the map; a Giving Box reaches a pickup threshold; a Taking Box reaches a refill threshold; a manual Rhody Outpost sensing site reports or simulates inventory status; the platform creates robot-ready service tasks; and the box/platform state confirms closure.

Project Details:

Overall system concept

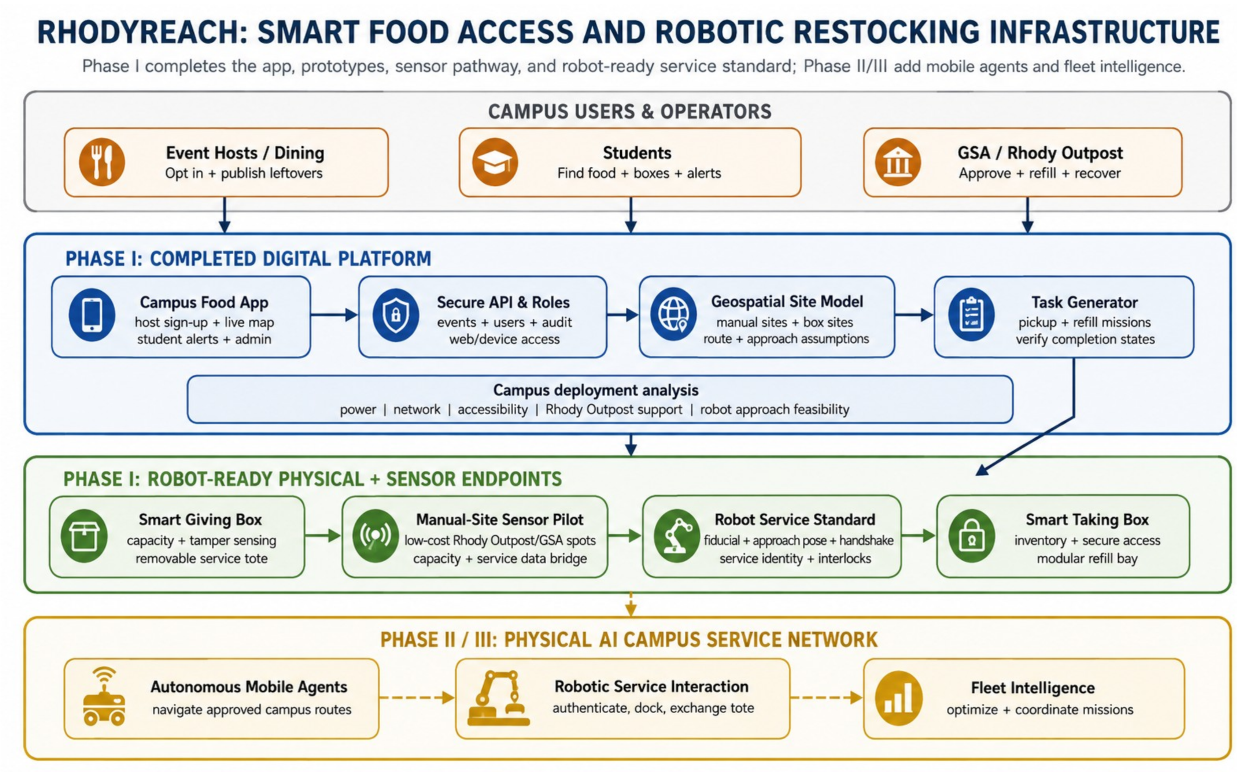
RhodyReach is organized as a physical AI stack rather than disconnected prototypes. The application layer handles event food recovery, student discovery, administration, and task generation. The smart-box layer creates robot-compatible giving and taking endpoints. The exploratory manual-site sensing layer gives Rhody Outpost and GSA a lower-cost data-collection bridge before full smart-box deployment. The future robotics layer converts these sites and states into service missions for supervised mobile agents.

Phase I completes the foundation: production application, two instrumented box prototypes, an exploratory manual-site sensor pathway, deployment analysis, a robot-compatible service standard, and a lightweight mission/task simulator. It does not build a production mobile robot, outdoor autonomy, or a campus fleet.

Continuation pathway

- Phase II - single-agent pilot: integrate one laboratory mobile platform, localize and navigate an approved indoor route, authenticate with one prototype box, perform a supervised tote/service interaction, and report completion using the Phase I app/API interface.
- Phase III - campus service network: expand from prototype boxes and manual sensor sites to multiple smart service locations, indoor/outdoor transitions, charging, fleet scheduling, exception recovery, and multi-agent coordination.

Block Diagram:



Blue and green layers are implemented in Phase I. Gold paths define the Phase II/III physical AI expansion from robot-ready infrastructure to autonomous mobile agents and fleet intelligence.

Hardware/Electrical Tasks:

- Under GSA technical direction, define a robot-box interface-control document covering service geometry, approach pose, payload envelope, authentication, interlocks, manual override, and failure states, with Dr. Stegagno's lab consulted as a collaborative robotics partner where available.
- Survey candidate campus locations for surface and slope, doors/elevators, aisle width, turning and approach space, pedestrian traffic, weather exposure, power, network coverage, accessibility, safe human service access, and feasibility for future robot approach.
- Design the Giving Box around a removable sealed tote and robot-service face while separating public donation access from operator or future robot retrieval.
- Design the Taking Box around a modular refill bay, secure student dispensing, service-door interlocks, manual override, and low-complexity robot interaction.
- Evaluate and characterize load cells, inventory/capacity sensing, door and lock position, tote presence,

obstruction/tamper sensing, ambient conditions, and simplified sensor kits for existing manual Rhody Outpost or GSA food access sites.
- Design the low-voltage power architecture, protection, backup/safe-shutdown behavior, service wiring, and health monitoring.
- Implement robot-facing identifiers and state signals: machine-readable ID, fiducial marker, service-ready state, authenticated handshake, and verification that a tote or bay was serviced.
- Produce robust prototypes, schematics, labeled harnesses, calibration and reliability procedures, test fixtures, and measured results at representative deployment conditions.

Firmware/Software/Computer Tasks:

- Complete a production-quality responsive application for event hosts, students, administrators, GSA operators, and Rhody Outpost-supporting workflows, with accessible mobile-first interaction and deployable documentation.
- Implement host sign-up, event lifecycle rules, scheduled activation/expiration, live map/feed, moderation, audit history, automatic closure, and opt-in notifications.
- Build the secure API and data model for events, users/roles, candidate sites, manual sensor sites, robot approach assumptions, route constraints, box telemetry, service tasks, and future missions.
- Create a geospatial campus deployment model and site-scoring workflow that records power, network, accessibility, weather, pedestrian/path constraints, Rhody Outpost adjacency, and approach-zone feasibility.
- Develop embedded firmware for sensing, calibration, lock/service control, safe states, watchdogs, offline buffering, device identity, and secure provisioning.
- Connect boxes and exploratory manual-site sensors through MQTT and/or HTTPS; display telemetry; and generate refill, pickup, fault, obstruction, tamper, and maintenance tasks.
- Implement a lightweight mission/task generator and robot-readiness simulator with assignment, lifecycle/state transitions, authentication assumptions, exception handling, and verified completion.
- Use Git-based collaboration, issue tracking, code review, unit/integration/system testing, continuous integration, containerized deployment, logging, and technical documentation.

Composition of Team:

Required two-student core team: 1 Electrical Engineering student and 1 Computer Engineering student.

Electrical Engineering	Computer Engineering
Owns smart-box electronics, sensing, power, lock/actuator hardware, service interlocks, wiring, prototype reliability, and physical deployment constraints.	Shares: embedded firmware, IoT communications, device identity/security, box state machines, API/device integration, and the robot-compatible service handshake.
Shares: embedded firmware, IoT communications, device identity/security, box state machines, API/device integration, and the robot-	Software-platform buildout: production application, backend services, geospatial site model, notifications, operations dashboard,

Electrical Engineering	Computer Engineering
compatible service handshake.	mission task logic, and simulator.

Both students contribute to systems architecture, campus deployment analysis, physical AI requirements, cybersecurity, verification, field testing, stakeholder demonstrations, and final integration.

Skills Required:

No prior autonomous robotics experience is required. The project is structured so each student owns a manageable subsystem while learning how full-stack software, embedded devices, electromechanical interfaces, geospatial data, and physical AI fit together.

Electrical Engineering	Computer Engineering
• Analog/digital circuit design • Sensors and load-cell interfaces • Power conversion and protection • Locks, interlocks, and service states • Schematics, PCB, soldering • Enclosure instrumentation and deployment testing Capability to also help on: • C/C++ embedded programming • I2C, SPI, UART, Wi-Fi • MQTT/HTTP and IoT architecture • Secure device identity and provisioning • State machines and	• C/C++ embedded programming • I2C, SPI, UART, Wi-Fi • MQTT/HTTP and IoT architecture • Secure device identity and provisioning • State machines and handshakes • Hardware/software integration and test automation • TypeScript/JavaScript or Python • Web UI and REST APIs • SQL/PostgreSQL/PostGIS or equivalent geospatial data model • Authentication and notifications • Cloud/Docker/CI workflows

Electrical Engineering	Computer Engineering
handshakes • Hardware/software integration and test automation	• Campus operations, geospatial missions, and simulation

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

The best outcome gives GSA and Rhody Outpost-supporting partners a functioning campus service while giving URI a reusable physical AI testbed. The key economic advantage is architectural reuse: the application, instrumented endpoints, manual-site sensing path, site data, service geometry, APIs, and mission logic are established before the more expensive step of building mobile robotic restocking systems.

- Captures more value from food and supplies that have already been purchased or donated, reducing avoidable waste.
- Replaces routine full/empty checks with targeted pickup and refill tasks, reducing volunteer and operator travel.
- Creates evidence for grants, sponsorships, site selection, program evaluation, and future robotics investment.
- Produces reusable software, electronics, interface standards, campus site data, test fixtures, and deployment documentation.
- Strengthens URI recruitment and public visibility by showing that advanced engineering can directly improve student life.

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

RhodyReach is an industry-relevant physical AI platform expressed through a practical food access project. Its architecture maps directly to challenges in autonomous mobile robots, last-mile delivery, warehouse and hospital logistics, smart infrastructure, assistive systems, and civic robotics: sensing distributed demand, maintaining a geospatial world model, standardizing service endpoints, verifying state changes, and safely coordinating human and robotic operators.

For students, this is not a collection of isolated classroom exercises. The team will build one closed-loop system for real stakeholders and leave with a portfolio spanning product engineering, embedded electronics, full-stack development, cybersecurity, IoT, geospatial computing, robot interaction standards, mission orchestration, verification, and interdisciplinary technical leadership. Phase II can then add a real mobile agent; Phase III can study fleet coordination and campus-scale autonomy.

RhodyReach positions URI not merely as a user of future robotics, but as a place that designs, deploys, and governs physical AI for public benefit. Build food access and data infrastructure in Phase I; use that infrastructure to support future robotic restocking, pickup, and smart campus service systems.

Appendix A: AI Use Policy – RhodyReach: Smart Food Access and Robotic Restocking Infrastructure

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 the 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.
  - 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.