VCU College of Engineering

CS 25-301

Community Fridges Usage Data Acquisition

Final Design Report

Prepared for

Taylor Scott

RVA Community Fridges

By

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Under the supervision of

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Executive Summary

In Richmond, Virginia 20.3% of city residents experience some level of food insecurity, which is much higher than the 14.3% of citizens across America who share that experience [3]. RVA Community Fridges is a 501(c)(3) backed mutual aid group that aims to address food insecurity by creating space for community members to support each other out of abundance.

Providing and maintaining public refrigerators, pantries, and food to fill them is a costly mission that requires significant coordination between hundreds of community members. RVA Community Fridges (RVACF) currently follows a manual process of collecting usage data on fridges, where community members might post a picture of the inside of a fridge to the RVACF Discord server. This makes it difficult to articulate credible general usage data in grants, as well as creates challenges for community members to perform responsive maintenance on refrigerators.

In this VCU CS Senior Capstone Project, students aim to serve RVACF by engineering a solution to automate data usage monitoring in a manner that is useful to community members and organization leaders. An ideal solution strikes the perfect balance of being cost effective, robust to the elements, discreet, requiring low maintenance, and as informative as possible about the current condition of a community refrigerator.

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Section A. Problem Statement

RVACF's challenge of refrigerator telemetry, or data collection and transmission, is anything but trivial. There are numerous design considerations that must be accounted for from cost to robustness. Since other community fridge programs exist throughout the United States, the first question the team asked was, "What are other organizations doing to tackle this issue?" The team reached out to these other programs across the nation, and found that strategies for data collection were limited to online form completion by community volunteers, indicating that no well-fitted, pre-existing solution exists. The next question that must be answered is, "What *kind* of solution is most appropriate?", to which the natural answer is an internet-of-things (IoT) device. The IoT domain is the industry's first choice for any problem requiring cost-effective computing solutions for collecting sensor data. [4]

Design of a Telemetry Device

The first and primary problem that must be addressed by this Capstone project is to *design and implement a device that collects data relevant to the stakeholders.* This problem can be further broken down into subproblems, outlined below.

Who are the stakeholders?

The stakeholders in this project include any individual or organization which could stand to benefit from the data collected by the proposed telemetry device. This includes, first and foremost, the project sponsor Taylor Scott at RVACF, and all community volunteers involved in that particular organization. Secondarily, community fridge organizations across the nation may also benefit from our proposed solution. Indirectly, yet perhaps most importantly, anyone who is affected by food insecurity stands to benefit from this project.

What data is relevant to collect?

The primary purpose of this project is to collect data that may secure funding for RVACF. The data collected will be presented to larger organizations that may provide grants to address food insecurity, and typically the most critical data to be provided are either *volume of food* served by RVACF or *number of people* served by RVACF. A solution for data collection must provide one or both of these types of information. It may be trivial to add additional sensors to an IoT package to collect data that secondarily helps community volunteers identify issues with refrigerators (such as an out-of-temp refrigerator), resulting in a more focused maintenance effort of community fridges. Any data collected can be used for multiple purposes, beyond those listed in this document.

How can cost be minimized?

There are numerous cost-effective IoT solutions that can be combined into a single telemetry device, however the single biggest cost to consider is *recurring costs*. An ideal solution should have a minimal recurring cost. RVACF's fridges are positioned outdoors, on property owned and maintained by small-businesses who support the cause. In most (if not all) cases, these small-businesses allow RVACF to place these refrigerators on their property *for free*. An important cost consideration for our team is *the cost of data transmission,* as this is typically a recurring expense, so minimizing this cost is another problem for the Capstone team to solve.

Subsequent Problems

After a telemetry device has been implemented, the team will implement auxiliary solutions so the devices can be most useful to RVACF and community volunteers. A pipeline for the data must be constructed. How/where will the data be stored? How should the data be presented to stakeholders? How can the team integrate the data into software already in use by the organization, such as the organization's website or Discord server?

The Problem Domain: Internet-of-Things

Integrating physical objects (such as refrigerators) into the internet has been a concept since as early as 1982, when programmers at Carnegie Mellon University connected a Coke machine to the network in order to report inventory, and whether recently stocked drinks were cold yet [4]. It has since evolved into its own field, leading to the commercial industry that we know today – featuring products like smart light bulbs, thermostats, and of course, refrigerators.

There are numerous academic papers that have been written about designing IoT refrigerators using DIY electronics [7] [8] [9], which indicates that similar efforts have been undertaken with generally successful results. The key difference between the work done in these papers and this VCU Senior Capstone is the data transmission component, since one of the team's objectives is to design a solution that is independent of local WiFi networks in order to abstain from dependence on local businesses for the operation of these devices as much as possible.

Section B. Engineering Design Requirements

At present, RVACF has no automated system for tracking fridge usage across its network. All information on food pickups and fridge conditions is gathered manually by volunteers, who report updates via the community Discord. This reliance on manual reporting creates gaps in communication, especially regarding fridge maintenance, where issues may go unnoticed until the next food drop-off. An automated system to notify community members of fridge status would significantly improve volunteer coordination and fridge maintenance, ensuring that faulty fridges are addressed promptly. Additionally, tracking fridge usage would provide valuable insights into how the RVACF network is serving the community and support efforts to expand its impact.

B.1 Project Goals (i.e. Client Needs)

- To design a fast and convenient way to track usage data of fridges across the RVACF network
- To provide a more convenient way of detecting fridge maintenance issues
- To create an accurate method for measuring the capacity of fridges for community volunteers
- To establish a system for monitoring fridge cleanliness and ensuring regular sanitary maintenance

B.2 Design Objectives

- Low power consumption of Raspberry Pi modules will ensure that fridges can still work at their optimal functionality
- The design will ensure that cost of operations can be replicated if needed
- The design will prioritize low recurring data transmission costs to ensure consistent operation and minimize the risk of service interruptions due to insufficient funding
- The design will ensure accurate measurements of fridge utilization
- The design will minimize the need for human intervention and frequent maintenance of data transmission devices
- The design will be scalable, enabling the efficient collection of extensive usage data across all fridges in the RVACF network

B.3 Design Specifications and Constraints

Design Concern 1 — Consumption

Specification 1: The power drawn for devices in the fridge must not exceed 15% of the overall fridge manufactured power.

Design Objective: Ensures the fridge can still work at its optimal performance and effectively preserves the content without disruption.

Design Concern 2 — Expenditures

Specification 1: The maximum budget allocated for any single fridge must not exceed $150.

Design Objective: Ensures the cost of operations can be replicated if needed.

Specification 2: The monthly budget for the AWS services must not exceed $25.

Design Objective: Keeping a low recurring fee minimizes the chances of fridge data transmission being stopped due to funds.

Design Concern 3 — Reliable

Specification 1: The Raspberry Pi module has to transmit data at least once every 6 hours.

Design Objective: Ensures accurate measurements of fridges utilization.

Specification 2: Data transmission from any Raspberry Pi module should be measured to have 100% accuracy, maintaining the integrity of the transmission data for all measurements.

Design Objective: Since data is sensitive to bit error, thorough checks after transmission will ensure correct metrics for fridge utilization.

Design Concern 4 — Robustness

Specification 1: Any modification done to a fridge has to be durable enough to withstand the environmental conditions for at least 1 year.

Design Objective: Ensures Raspberry Pi module will be reliable and won't require frequent repair

Design Concern 5 — Scalable

Specification 1: The design has to be able to be implemented in all 14 fridges, including any fridge that is added to the RVACF.

Design Objective: Ensures for further measurements of utilization.

B.4 Codes and Standards

Codes

- *FCC Part 15.247 : Frequency Hopping Spread Spectrum (FHSS)*
- *FCC Part 15.247 - Digital Modulation*
- *FCC Part 15.249 : All Other Transmission in the 900MHz Range*
- *UL 60335-2-24: Refrigerating Appliances*

Standards

- *TS009-1.2.1 Certification Protocol*
- *TS001-1.0.4 LoRaWAN® L2 1.0.4 Specification*
- *TS011-1.0.1 Relay*

Section C. Scope of Work

The scope of this capstone project includes designing and implementing a system that monitors community fridges across Richmond, transmitting usage and temperature data from 14 individual fridges to an AWS cloud environment. This project involved integrating IoT devices like door sensors and fridge thermometers to track fridge data. The solution provided daily insights on food availability and fridge usage patterns, supporting better management of resources by the RVACF organization and providing them with data to use for additional funding. We also built a simple, user-friendly visualization of the fridge usage data of the RVACF website so community members can view the most recent data upload. We also built a Discord bot to handle fridge queries and to send temperature alerts. We also built an admin dashboard that offers an intuitive UI for organizational leaders to easily access complete fridge data. Some tasks that fall outside of our scope include fridge repair and food distribution to fridges. Our team followed an agile development approach, with weekly advisor meetings, weekly team meetings, and sponsor meetings as needed. Available funds include the initial $1000 budget given to all Capstone teams and grant money from Dr. John Jones.

C.1 Deliverables

Promised Deliverables:

- Functional IoT system for daily fridge monitoring including door sensors and temperature sensors
- AWS environment with a database for storing usage statistics
- Updated RVACF website for data visualization
- Discord bot handling queries and temperature alerts
- Admin dashboard visualizing complete fridge usage data
- Detailed documentation on the Raspberry Pi modules, including installation instructions for future fridges

Potential Obstacles:

- Installing sensors and other devices require physical presence at fridges. Team members need to efficiently communicate with each other to determine availability for installation, especially if installation requires another person with a technical background other than computer science
- Securing the devices and sensors in the fridge is a top concern. The team must devise effective methods to conceal, secure, or position the sensors in a way that prevents tampering or interference by users, while still allowing the devices to function accurately

C.2 Milestones

Project Timeline

- **August 2024**: Initial solutions brainstorming, assigning team roles
- **September 2024**: Meeting project sponsor, LoRa research, setting up LoRa devices
- **October 2024**: LoRa research, building LoRa device, LoRa testing, RVACF Volunteer Meetings
- **November 2024**: More LoRa testing on communication range, determine LoRa device to be inadequate for project purposes, brainstorm new ideas for data transmission, research Raspberry Pis
- **December 2024**: Raspberry Pi + sensor research over break, GSM research
- **January 2025:** Research Raspberry Pi devices, magnetic door sensors, temperature sensors, how to connect the pieces together, start building Discord bot
- **February 2025:** create AWS environment, build Raspberry Pi modules, research other methods for door usage (light sensor, motion sensor), add query functionality to Discord bot
- **March 2025**: Continue building AWS environment, continue building Raspberry Pi modules, test module in a real fridge, add temperature alert functionality to Discord bot, start updating RVACF site
- **April 2025**: Capstone Expo preparation, continue work on RVACF site and Discord bot

Hard Deadlines (Fall Semester):

- **September 6**: Team Contract
- **October 4**: Sternheimer Proof of Concept
- **October 11**: Project Proposal
- **November 15**: Fall Design Poster
- **December 9**: Preliminary Design Report

Hard Deadlines (Spring Semester):

- **January 31:** Team Contract Update
- **March 7:** Weekly Status Reports
- **March 28:** Expo Abstract
- **April 18:** Exit Survey
- **April 25:** Participation as a Team
- **April 25:** Capstone Expo
- **May 9:** Final Design Report

C.3 Resources

- Raspberry Pi 4B
- Hologram SIM
- USB 4G LTE Router/Modem

- DS18B20 Temperature Sensor Kit
- PIR Motion Sensor
- USB-C Power Adapter
- Micro-SD Card

Section D. Concept Generation

Working the Problem Backwards
For our capstone project, the design problem will mainly be solved by working the problem backwards. We start by asking the sponsor “What problem do you have?” and “What would an ideal solution look like for you?”, and start from the ideal solution, answering the “How?” questions until we have a thorough, well constructed solution.

Pros: There will exist a big picture plan from start to finish, many aspects of the problem will be known before the implementation phase begins.
Cons: It’s hard to quantify solutions to subproblems that we don’t yet know exist. There is always the possibility of expectations from the sponsor that were lost in communication, requiring a revisiting of the design problem.

Adapting Existing Solutions

Adapting existing solutions involves analyzing similar problems and their respective solutions, then modifying or combining those approaches to fit the unique requirements of our capstone project. This approach leverages the knowledge and resources already available to streamline development while tailoring the solution to our project’s needs.

Pros: This method is time-efficient as it builds on proven solutions, reduces the need for extensive trial and error, and minimizes risks associated with untested designs. Existing solutions can provide a reliable foundation for innovation.
Cons: There may be constraints in adapting solutions to a new context, leading to potential inefficiencies or unforeseen compatibility issues. The reliance on previous designs might also limit creative thinking and result in a less innovative solution.

Trial and Error
Trial and error involves iteratively testing potential solutions, evaluating their effectiveness, and refining them until a satisfactory outcome is achieved. This method emphasizes practical experimentation and learning through direct feedback.

Pros: This approach fosters creativity and can uncover unexpected, innovative solutions. It is especially useful for addressing ambiguous problems where theoretical approaches may not yield practical results.
Cons: Trial and error can be time-consuming and resource-intensive, as it often involves discarding ineffective solutions. Additionally, without a structured process, there’s a risk of failing to converge on a viable outcome within the project timeline.

Section E. Concept Evaluation and Selection

Due to the limited solution space, with main factors decreasing the size of the space including factors like: cost of the final design, needs of the community the team is serving, and limitation of available infrastructure at the site of the refrigerators, a highly quantified method of concept evaluation such as using matrices is not necessary. Instead when researching solutions to subproblems that our design helps to solve, we chose to perform an elimination process whenever multiple solutions existed by selecting the solution according to the following criteria, ordered by priority.

1. Does the proposed solution fulfill one or more of the requirements of the subproblem?
2. Which solution has a lower cost to the sponsor, since they are a nonprofit organization with limited resources?
3. Which solution fulfills the highest number of subproblems that we face currently?
4. Which solution will be the easiest to replicate and implement after the Capstone team has moved on from the project?

For any scenario where there existed a tradeoff between two of these criteria, the criteria with a higher priority was selected, while also focusing on the bigger picture of the project. For example, in a situation "which solution fulfills the highest number of subproblems" competed with "which solution has a lower cost to the sponsor, for any two solutions that solve the same set of subproblems, the solution with the lower cost was chosen.

Section F. Design Methodology

Instructions for this Section

Use this section to describe any underlying physical principles and mathematical equations that govern the design. Provide details of any computer-aided modeling techniques used to evaluate the design including the software used, prescribed boundary conditions, and assumptions. Include a detailed description of any experimental testing methods including required testing equipment, test set-up layout, data acquisition and instrumentation, and testing procedures. If one or more prototypes is to be produced and tested, provide a detailed description of how each will be evaluated.

There are no specific underlying physical principles and mathematical equations that govern the design. Testing will be done incrementally as each component of the final design is implemented. The prototypes and final design will be evaluated by installing the device on a real fridge, and making sure that data collection is occurring.

F.1 Validation Procedure

The final design will be validated by the client through community meetings, feedback directly from the sponsor (Taylor Scott). Initial prototypes should be available at the beginning of January, with a final product ready by mid-March. Feedback from the client will be captured through Google Forms sent to the community via a community Discord server, as well as meeting with the community over Zoom for face-to-face feedback. Feedback may also be gathered by the community by adding a QR code at the fridge that links to a Google Form for feedback.

Section G. Results and Design Details

G.1 Modeling Results

For our model, we designed an IoT-based refrigerator telemetry system concept. The initial focus was on using LoRa communication to send sensor data over long ranges, but the devices encountered technical challenges and did not perform as expected. As a preliminary step, we set up basic hardware using ESP32 Heltec LoRa microcontrollers and simulated sensor placement to mimic a real refrigerator environment. This phase helped identify key limitations in device configuration and communication, highlighting the need for further testing and troubleshooting.

G.2 Experimental Results

We experimented with the LoRa devices primarily to test their ability to send and receive data packets over various distances. However, the devices faced challenges in successful communication.

Key Observations:

- **Packet Transmission Failures**: LoRa devices did not reliably transmit or receive data, likely due to misconfigurations or hardware/software incompatibilities.
- **Range Limitations**: Despite adjustments to transmission power and settings, consistent communication could not be established even at short ranges. The LoRa devices reached a max of 300 feet.

The unsuccessful results prompted the need for further investigation into the hardware setup, proper configuration of LoRa protocols, and external factors such as interference.

G.3 Prototyping and Testing Results

Our prototyping and testing phase focused on integrating the LoRa devices with a conceptual sensor-based system. While temperature and humidity sensors were considered for data collection, experiments were not performed due to technical difficulties with the communication modules.

Testing results:

- **LoRa Communication Issues**: Data packets were not successfully sent or received.
- **Time Constraints**: Troubleshooting required more time than was available in the project timeline.
- **Sensor Testing**: Without reliable data transmission, further testing with temperature sensors could not be conducted.

Despite these setbacks, the prototyping process provided valuable insights into potential design improvements and emphasized the importance of robust hardware validation.

G.4. Final Design Details/Specifications

The final design focuses on using a GSM-based communication system to address the challenges faced with LoRa devices. The specifications below outline the intended features for a functional refrigerator telemetry system:

1. **Sensors (Planned):**
    - **Temperature Sensor**: To monitor internal refrigerator temperatures (e.g., DHT22).
    - **Humidity Sensor**: To measure humidity levels inside the fridge.
2. **Communication:**
    - **GSM Network**: Transmits sensor data to AWS for cloud-based storage using cellular data.
3. **Intended Features (Conceptual):**
    - **Fridge Monitoring**: Temperature and humidity data logged at regular intervals (e.g., every 6 hours).
    - **Data Transmission**: Reliable data transmission over GSM to ensure accessibility from remote servers.
    - **Visualization**: Data stored in a cloud-based platform, accessible via a web dashboard and Discord bot.
    - **Alerts**: Potential to implement alerts to RVACF Discord server for temperature deviations to notify volunteers of defective fridges.

Section H. Societal Impacts of Design

H.1 Societal Impacts

The project has the potential to significantly improve food accessibility for food-insecure communities in Richmond and beyond. By enabling RVA Community Fridges (RVACF) to automate usage monitoring, the organization can better track demand and usage trends. This data can enhance RVACF's ability to advocate for support, ensuring that resources are allocated efficiently to high-need areas. Additionally, improved fridge maintenance means safer and fresher food for community members. Automating these processes also promotes sustainability in mutual aid efforts, empowering community members to collaborate more effectively and fostering a stronger sense of solidarity in tackling food insecurity.

H.2 Political/Regulatory Impacts

As the project enhances data collection and reporting, it can strengthen RVACF's credibility when seeking local, state, or federal grants. Detailed, data-driven insights on food insecurity can also inform policymakers, helping to shape effective food assistance programs and regulations in underserved communities. Additionally, RVACF operates public fridges in compliance with health and safety standards; our solution could help ensure regulatory adherence by monitoring temperature and food safety conditions, reducing potential risks and liabilities.

H.3 Economic Impacts

Automating fridge monitoring reduces the manual labor and time required for data collection, allowing RVACF volunteers to focus on other critical tasks. More reliable data can also improve RVACF's ability to secure grants, donations, and partnerships, providing greater financial stability and potential for expansion. By optimizing fridge maintenance and reducing food spoilage, the solution supports cost-efficient operations. In the broader community, improved food access may alleviate economic strain on food-insecure individuals and families, enabling them to redirect limited income toward other essential expenses.

H.4 Environmental Impacts

The project contributes to environmental sustainability by reducing food waste. With better data on fridge capacity and usage, RVACF can optimize food deliveries and avoid overstocking, which often leads to spoilage. Monitoring fridge temperatures ensures food safety while reducing energy waste caused by malfunctioning or inefficient refrigerators. As the project expands, it could encourage a more widespread culture of responsible food sharing and waste reduction across communities.

H.5 Global Impacts

While the project focuses on a local solution for food insecurity, its impact can serve as a model for other mutual aid organizations worldwide. By demonstrating a cost-effective, automated approach to managing community fridges, this solution can inspire similar initiatives in other cities or countries facing food insecurity challenges. The use of affordable, scalable technology also means the solution can be adopted in both developed and under-resourced regions, contributing to global efforts to reduce hunger and promote food equity.

H.6 Ethical Considerations

This project raises important ethical considerations, including the responsible collection and usage of data. Efforts must ensure that fridge usage data is anonymized and only used to support RVACF's mission, protecting the dignity and privacy of individuals who rely on community fridges. Furthermore, the project must prioritize accessibility, ensuring the technology does not create barriers for community members, such as increased reliance on internet connectivity or technology unfamiliarity. Additionally, volunteers and stakeholders must be consulted throughout development to ensure the solution aligns with RVACF's values and community-driven approach.

Section I. Cost Analysis

Provide a simple cost analysis of the project that includes a list of all expenditures related to the project. If an experimental test set-up or prototype was developed, provide a Bill of Materials that includes part numbers, vendor names, unit costs, quantity, total costs, delivery times, dates received, etc. Do not forget to include all manufacturing costs incurred throughout the completion of the project. If the design is expected to become a commercial product, provide a production cost estimate including fixed capital, raw materials, manufacturing (including tooling and/or casting), and labor costs to produce and package the device. Note that this type of detailed cost analysis may be listed as a project deliverable.

- Raspberry Pi 4B
- Hologram SIM
- USB 4G LTE Router/Modem
- DS18B20 Temperature Sensor Kit
- PIR Motion Sensor
- USB-C Power Adapter
- Micro-SD Card

FIXED COSTS:

Item	Quantity	Unit Cost	Total Cost
Raspberry Pi 4B	9	$35.00	$315
Hologram SIM	6	$3.00	$18.00
USB 4G LTE Router/Modem	6	$19.99	$119.94
DS18B20 Temperature Sensor Kit	6	$5.99	$35.94
PIR Motion Sensor (x5)	1	$9.78	$9.78
USB-C Power Adapter	4	$16.99	$67.96
Micro-SD Card (x2)	4	$19.99	$79.96

RECURRING COSTS:

Item	Quantity	Cost/Unit
Hologram SIM Card	6	\$1/month, \$0.03/MB
Amazon Web Services	1	Variable, \$5+/month depending on usage

Section J. Conclusions and Recommendations

The evolution of the final design was cultivated through trial and error. Starting from ideas that have been explored through other people's experience to ideas that stemmed from our intuition. Ultimately, this was and remains a learning experience, primarily due to the nature of the project being more computer engineering than computer science.

Our engineering design process started with defining the problem, as stated in *Section A. Problem Statement,* we concluded that it is to design and implement a device that collects data relevant to the stakeholders. Given a task that is unfamiliar and more out of our realm of knowledge, we decided that it would be best if we do research and present viable solutions. The two main solutions that we came up with are LoRa (Long Range) communication and/or a cellular plan that will utilize a SIM card.

After moving forward with the LoRa devices, we ran into obstacles when designing our module. Our inexperience with these devices and the Heltec ecosystem held us captive for much of the Fall semester. After reading documentation and trying different approaches, we contacted an expert to figure out what we were doing wrong. It was only by engaging in multiple conversations with the expert that we had a breakthrough in getting the LoRa devices to communicate with each other. However, after the devices were up and running, we realized that our research limitations were more theoretical than practical. The range distance of the proposed 3km to 5km, turned out to be around 0.965606km in the urban area of Richmond. This raised some concerns, therefore changing our course of action to utilize the SIM cards for all the fridges.

Other than the architecture to communicate data from one fridge to the other, we were utilizing sensors to monitor door usage and to measure internal temperature. To summarize the deliverables of the project, we built a Raspberry Pi module that reads data from our sensors every 6 hours. This information will be uploaded to our database hosted on AWS. The Discord bot will be used to notify RVACF members if the internal temperature goes above the recommended temperature for food safety. The second feature of the bot allows anyone to query data from our AWS database.

Appendix 1: Project Timeline

Provide a Gantt chart of similarly composed visual timeline showing the start and end dates of all completed tasks and how they are grouped together, overlapped, and linked together. Include all senior design requirements including design reports and Expo materials (i.e. Abstract, Poster, and Presentation). All major milestones should be included in the timeline.

https://lucid.app/lucidspark/dc0b0729-e6e6-43ea-afb0-d64bec602978/edit?viewport_loc=-1281%2C725%2C5030%2C2810%2C0_0&invitationId=inv_37d0a42f-96d2-41b1-a0b4-36e11a0034be

Appendix 2: Team Contract (i.e. Team Organization)

Step 1: Get to Know One Another. Gather Basic Information.

Task: This initial time together is important to form a strong team dynamic and get to know each other more as people outside of class time. Consider ways to develop positive working relationships with others, while remaining open and personal. Learn each other's strengths and discuss good/bad team experiences. This is also a good opportunity to start to better understand each other's communication and working styles.

Team Member Name	***Strengths each member bring to the group***	***Other Info***	***Contact Info***
Ethan Leyden	Communication, leadership experience, programming.	Experience working with large datasets and building NLP models, experience maintaining websites	leydene@vcu.edu 704-500-5351 etleyden@gmail.com
Jermane Jackson	Programming, problem solving	Experience with full stack web development and deployment, most used/favorite language is Python	jacksonja13@vcu.edu
Damian Ashjian	Communication, programming, problem-solving	Experience building interfaces for web apps, strong Java and Python experience	ashjianda@vcu.edu
Khuong Nguyen	Communication, programming	Experience working with SQL and Python for webscraping, intermediate experience with Java and Python	nguyenk20@vcu.edu

Other Stakeholders	***Notes***	***Contact Info***
Dr. Daniel Cranston		*dcranston@vcu.edu*
Taylor Scott		rvafridgeoutreach@gmail.com or vacommunityfridges@gmail.com

Step 2: Team Culture. Clarify the Group's Purpose and Culture Goals.

Task: Discuss how each team member wants to be treated to encourage them to make valuable contributions to the group and how each team member would like to feel recognized for their efforts. Discuss how the team will foster an environment where each team member feels they are accountable for their actions and the way they contribute to the project. These are your Culture Goals (left column). How do the students demonstrate these culture goals? These are your Actions (middle column). Finally, how do students deviate from the team's culture goals? What are ways that other team members can notice when that culture goal is no longer being honored in team dynamics? These are your Warning Signs (right column).

Resources: More information and an example Team Culture can be found in the Biodesign Student Guide "Intentional Teamwork" page (webpage | PDF)

Culture Goals	***Actions***	***Warning Signs***
Keep expectations clear	- Maintain detailed to-do list each week - Track what you've worked on/completed throughout the week	- Vague outline of plans for the week, leaving room for poor performance - No documentation of achievements
Being open-minded	- Take into consideration teammates ideas and feelings - Ask questions when you do not understand concepts	- Teammates withdraw from conversations - Teammates use words like "bad" or "stupid"
Follow through on commitment	- Meet deadlines and fulfill goals/requirements - Communicate with the team when you will be unable to fulfill a commitment that you made	- Student shows up for weekly meeting with no considerable work done - Student has been stuck on the same goal or deliverable for a long time without any follow up or communication

Step 3: Time Commitments, Meeting Structure, and Communication

Task: Discuss the anticipated time commitments for the group project. Consider the following questions (don't answer these questions in the box below):

- What are reasonable time commitments for everyone to invest in this project?
- What other activities and commitments do group members have in their lives?
- How will we communicate with each other?
- When will we meet as a team? Where will we meet? How Often?
- Who will run the meetings? Will there be an assigned team leader or scribe? Does that position rotate or will same person take on that role for the duration of the project?

Required: How often you will meet with your faculty advisor advisor, where you will meet, and how the meetings will be conducted. Who arranges these meetings?
See examples below.

Meeting Participants	***Frequency Dates and Times / Locations***	***Meeting Goals Responsible Party***
Students Only	*As needed in Discord*	*Give updates on work progress, especially if there are roadblocks to completing deliverables.*
Students Only	*Every Thursday from 6pm-6:50pm, location TBD each week.*	*Actively work on the project, and discuss what the team should be working on individually.*
Students + Faculty advisor	*Every Tuesday from 11am-12pm in East Hall of Engineering Room E4310*	*Update faculty advisor and get answers to our questions. Ethan will recap each meeting in*
Project Sponsor	*As needed during Tuesday meetings, or periodically over email*	*Significant updates on project progress, or for feedback on potential ideas*

Step 4: Determine Individual Roles and Responsibilities

Task: As part of the Capstone Team experience, each member will take on a leadership role, ***in addition to*** contributing to the overall weekly action items for the project. Some common leadership roles for Capstone projects are listed below. Other roles may be assigned with approval of your faculty advisor as deemed fit for the project. For the entirety of the project, you should communicate progress to your advisor specifically with regard to your role.

- **Before meeting with your team**, take some time to ask yourself: what is my "natural" role in this group (strengths)? How can I use this experience to help me grow and develop more?
- **As a group,** discuss the various tasks needed for the project and role preferences. Then assign roles in the table on the next page. Try to create a team dynamic that is fair and equitable, while promoting the strengths of each member.

Common Leadership Roles for Capstone

1. **Project Manager:** Manages all tasks; develops overall schedule for project; writes agendas and runs meetings; reviews and monitors individual action items; creates an environment where team members are respected, take risks and feel safe expressing their ideas.
   Required: On Edusourced, under the Team tab, make sure that this student is assigned the Project Manager role. This is required so that Capstone program staff can easily identify a single contact person, especially for items like Purchasing and Receiving project supplies.
2. **Logistics Manager:** coordinates all internal and external interactions; lead in establishing contact within and outside of organization, following up on communication of commitments, obtaining information for the team; documents meeting minutes; manages facility and resource usage.
3. **Financial Manager:** researches/benchmarks technical purchases and acquisitions; conducts pricing analysis and budget justifications on proposed purchases; carries out team purchase requests; monitors team budget.
4. **Systems Engineer:** analyzes Client initial design specification and leads establishment of product specifications; monitors, coordinates and manages integration of sub-systems in the prototype; develops and recommends system architecture and manages product interfaces.
5. **Test Engineer:** oversees experimental design, test plan, procedures and data analysis; acquires data acquisition equipment and any necessary software; establishes test protocols and schedules; oversees statistical analysis of results; leads presentation of experimental finding and resulting recommendations.
6. **Manufacturing Engineer:** coordinates all fabrication required to meet final prototype requirements; oversees that all engineering drawings meet the requirements of machine shop or vendor; reviews designs to ensure design for manufacturing; determines realistic timing for fabrication and quality; develops schedule for all manufacturing.

Team Member	***Role(s)***	***Responsibilities***
Ethan Leyden	Project Manager	✔ Develops overall schedule for the project ✔ Writes agendas and runs meetings ✔ Reviews and monitors action items ✔ Create an environment where team members are respected and feel safe expressing ideas
Jermane Jackson	Developer	✔ Develops hardware and software needed for the deliverables of the project
Damian Ashjian	Logistics Manager Developer	✔ Sends emails to sponsor/advisor; communicates responses to team ✔ Develops software needed for the deliverables of the project ✔ Oversees group purchases and budget
Khuong Nguyen	Test Engineer	✔ Oversees test plan, procedures, and data analysis ✔ Acquires any necessary software, as well as test protocols and schedules. ✔ Leads presentation of experimental finding and resulting recommendations.

Step 5: Agree to the above team contract

Team Member: Ethan Leyden *Signature: Ethan Leyden*

Team Member: Jermane Jackson *Signature: Jermane A Jackson*

Team Member: Damian Ashjian *Signature: Damian Ashjian*

Team Member: Khuong Nguyen *Signature: Khuong Nguyen*

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