Cornell University
Student Assembly

Resolution 78: Approval of the Infrastructure Fund Commission's Recommendations

Abstract: This resolution provides for the disbursement of roughly $53,000 across the four project applications submitted to the Student Assembly Infrastructure Fund Commission.

Sponsored by: Nicholas Maggard '26

Type of Action: Internal Policy

Originally Presented: 05/02/2024

Current Status: Placed on the Consent Calendar

Whereas, the Student Assembly Infrastructure Fund Commission has received four applications for the allocation of the roughly $53,000 in the Fund's Disbursement Account.

Whereas, the $20,000 proposed allocation to Cornell University Sustainable Design will fund the creation of an alpha prototype, and partially a beta prototype, of modernized bus shelters on the Cornell Ithaca campus.

Whereas, the $13,650 proposed allocation to the Office of Student Government Relations will fund heat lamps at bus shelters to provide comfortable places to wait for buses in cold environments.

Whereas, the remaining-balance-allocation will fund features that enhance the Cornell Ithaca campus.

Be it therefore resolved, the sum of twenty thousand dollars ($20,000) be transferred from the Infrastructure Fund Disbursement Account to Cornell University Sustainable Design for the manufacture of their prototype bus shelter.

Be it further resolved, the sum of thirteen thousand six hundred and fifty dollars ($13,650) be transferred from the Infrastructure Fund Disbursement Account to the Student Assembly Office of Student Government Relations for the implementation of heating lamps at bus shelters.

Be it further resolved, the remaining balance of the Infrastructure Fund Disbursement Account be earmarked for the implementation of benches, trees, bike racks, and other features to be selected jointly between the SAIFC Chair, the Undergraduate Student-Elected Trustee, the President of the Student Assembly, and the Office of the University Architect. Such funds shall not be rolled back into the investment account.

Be it further resolved, the Office of Student Government Relations, within seven (7) days following passage of this resolution, shall be required to submit to the SAIFC Chair, further information regarding their application. Failure to submit adequate information will result in their allocation being re-allocated to the Triphammer Cooperative project, plus an additional $1,350 from the remaining-balance-allocation.

Be it further resolved, Cornell University Sustainable Design shall be required to submit a report within sixty (60) days following the transfer of funds on how SAIFC funds are being used. This report shall be provided to the SAIFC Chair elected by the 2024-2025 Student Assembly. Should such office be vacant, the report will be provided to President of the Student Assembly.

Be it finally resolved, this resolution shall take effect upon approval of the Dean of Students.

Respectfully Submitted,

Nicholas Maggard ’26

Parliamentarian of the Student Assembly

Chair, Infrastructure Fund Commission

Cornell University
Student Assembly

Submission of Student Assembly Infrastructure Fund Commission Applications

SAIFC Commissioners,

The Student Assembly Infrastructure Fund Commission has received the following applications for funding:

- Application 1:
  - Franklin Berry (Triphammer Cooperative)
- Application 2:
  - Flora Meng (Cornell University Sustainable Design Sustainable Mobility Team)
- Application 3:
  - David Suarez (Office of Student Government Relations)
- Application 4:
  - James Paul Swenson (Student Assembly)

Pursuant to Appendix C of the Student Assembly Charter, I've attached the applications as well as all provided supplemental materials provided. The SAIFC will be meeting Friday, April 26th at 3pm to consider these applications. The Commission's selections will be voted on at the final meeting of the Student Assembly on May 2nd.

Nicholas Maggard
Chair, Infrastructure Fund Commission

Cornell University
Student Assembly

Applicant 1: Franklin Berry (*Triphammer Cooperative*)

Applicant Name: Franklin Berry

Applicant Organization: Triphammer Cooperative

Requested Funding Amount: $65,000.00

Current Status: Pending Commission Vote

Project Idea:

I'm applying for funding to complete a water mitigation project in the Triphammer Cooperative's basement. This project has an estimated cost of $65,000, as quoted by Cornell Facility managers. Specifically it will cost $15,000 for a ground study around the house to identify the infrastructure weaknesses. Then after those are identified it would cost an estimated $50,000 to seal and mitigate the basement.

Triphammer Cooperative Address: 150 Triphammer Rd, Ithaca, NY 14850

Impact on Undergraduate Students: This would make the basement more consistently usable for Triphammer residents and hopefully more tenable to hold events for the broader student body. It would also reduce health risks to the undergraduate student body and increase the longevity of the building which has served as on-campus cooperative housing for over fifty years.

Problem / Beneficiary:

Problem: The basement consistently floods when it rains. This funding would allow for the basement to be properly sealed and mitigate the flooding. The flooding of course makes the basement unusable during the rain and leads to sanitation problems, including certain mold growth putting students health in jeopardy.

Beneficiary: The main beneficiary would be the residents of Triphammer which are made up of undergraduate students who are selected into the house through a lottery system. The secondary beneficiary would be the general student body because it would enable Triphammer to host social and educational events for the general student body.

Motivation:

I wanted to help the communities I have been apart of using Student Assembly resources and advertise the Student Assembly to them and the opportunities it provides. To my knowledge, I also knew that the fund wasn't being accessed yet this year for a larger project and that the deadline for accessing this years round of funding was coming up. I wanted to put it to good use.

Applicant 2: Flora Meng (*Cornell University Sustainable Design Sustainable Mobility Team*)

Applicant Name: Flora Meng

Applicant Organization: Cornell University Sustainable Design Sustainable Mobility Team

Requested Funding Amount: $30,000

Current Status: Pending Commission Vote

Project Idea:

The Sustainable Mobility Team of Cornell University Sustainable Design (CUSD) would like to replace the bus shelter at the Rockefeller Hall Stop with a new sustainable, accessible, and aesthetic design. This new bus shelter will provide better notice to both waiting passengers and bus drivers by providing clearer signals about when a bus is coming in and if there are passengers waiting inside the shelter so that neither side will miss the other and have a poor service experience. Considering the Routes 30, 32, 90, and four other main bus routes served at this stop, we expect the better function of this new design to benefit a large group of people. Meanwhile, the new design continues the principles of accessibility, making sure that people with disabilities can use the shelter easily. The new shelter will provide enough space to hold wheelchairs, baby carts, and so on while giving places to bikers. Last but not least, the new design is more modern in aesthetics, which makes it more harmonious with the surroundings around Rockefeller Hall Stop and provides more enjoyment for the bigger Cornell Community and whoever walks past by.

We will use the funds provided by SAIF for material costs of our first full-scale prototypes, the Alpha and Beta Prototype. We are currently building a pre-Alpha Prototype with limited funding from CUSD's allocated annual funds. The Alpha prototype will be completed in fall 2024, consisting of a full-scale mock up in the intended construction material. The Beta Prototype will follow after the Alpha Prototyping phase is complete. The Beta Prototype will be a full scale, on-site installation of the bus shelter for regular use. Altogether, we are requesting a total of $30,000 from SAIF to complete the Alpha and Beta Prototype phases.

Problem / Beneficiary:

At a large scope, the shelter redefines the experience of taking public transportation by improving the usability of the bus network and beautifying the otherwise mundane structures that are bus shelters. This encourages the use of inherently sustainable systems like TCAT, helping to sustain the TCAT bus network in the long term and simplifying commutes to and from campus for students, faculty, and staff alike in the short term.

In terms of immediate sustainability gains, the shelter is entirely modular, and it deploys healthy materials throughout to maintain the mission of environmentally friendly design. We aim to use sustainably sourced hemp composite material to produce our triangular building modules. With the design of our architectural and mechanical team, this new material will not only generate less environmental impact but also allow more aesthetics while giving sturdy support for the whole construction. The materials used will be less toxic to the immediate occupants of the shelter and reduce the long-term carbon footprint of the shelter due to the ease of maintenance inherent in the modular nature of the shelter. When the bus shelter is eventually deployed in additional locations, its modularity allows for different design configurations to best match (a) the quantity of user demand and (b) the environmental conditions of the location.

Secondly, the conventional bus shelters do not provide enough visibility to bus drivers or the passengers waiting inside of the shelter. In our field survey, our team observed that people do not like to wait inside the shelter. For some, this is because they are afraid that bus drivers will not be able to see whoever is in the shelter easily, while for others, there is a fear of not making it to the bus if they remain inside of the shelter. Some shelters are not right next to where the bus stops, and if people are not paying attention to the road, missing the bus can be highly possible. Therefore, in our new bus shelter design, we incorporate a comprehensive lighting scheme which makes long-overdue UI/UX updates to bus infrastructure. When the bus is 5 minutes away, the shelter lights up with a dim, calm blue color. As the bus gets closer minute by minute, the intensity of the light increases, and at 1 minute to arrival, the shelter indicates to passerby and users the bus is arriving with an incorporated audio system. We arrived at this system requirement through user feedback and surveys disseminated to Cornell students.

In general, we expect any users of the TCAT bus system, ranging from students, faculties and staff, locals, and visitors, to benefit from this new design. The environment will also benefit from the use of healthier, more sustainable materials.

Motivation:

The group behind the design and implementation of the bus shelter is CUSD's Sustainable Mobility Team, a student organization within the Systems Engineering department that has focused on public transportation in the Ithaca area ever since its founding several years ago. The team is fortunate to have the support of faculty advisor Sirietta Simoncini, a professor in the Systems Engineering department who is dedicated to leveraging solutions for complex social challenges. Team members hail from a variety of backgrounds, including Urban Planning, Engineering, Architecture, Computer Science, and Environment and Sustainability, but share a common care for sustainability and a passion for making public transportation better in our communities. Our willingness to serve the Cornell and Ithaca communities and our individual skill sets motivate us to create deeply thought-out solutions for the problems that face our communities and the environment.

CUSD SUSTAINABLE MOBILITY SHELTER

Fall 2023 Mid-Year Report

FACULTY ADVISOR: Sirietta Simoncini (ss2583)

SHELTER DESIGN	SHELTER MASTERPLAN
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CUSD Sustainable Mobility Shelter
Disclaimer of Warranties

The following report may be shared with external parties and organizations. Since this project is done by students and not a professional firm, the team has to formally notify the external parties and organizations of the following statement:

CUSD (and the CUSD Sustainable Mobility Shelter) is not a professional engineering firm. Therefore, all the deliverables that we produce are only meant to be suggestions or guidelines, which can be used by external parties and organizations at their own discretion. Moreover, before any of the materials provided by CUSD can be implemented, they must get the required validations and approvals (such as PE stamp) of external licensed professionals, which cannot be provided by CUSD. With all the above said, we are also stating that:

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Best Regards,
CUSD Mobility Team Shelter

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CUSD Sustainable Mobility Shelter

Project Overview

The Sustainable Mobility project, under the Cornell University Sustainable Design (CUSD) program and sponsored by Siri Simoncini, aims to revolutionize Tompkins Country's transit network. Utilizing a blend of design thinking and systems engineering, the team focuses on empathetic fieldwork, user-centric design, and system engineering tools and processes.

Team Composition

This diverse team comprises architects, planners, mechanical and aerospace engineers (MAE), electrical and computer engineers (ECE), systems engineers, and other disciplines across both undergraduate and graduate studies. The team operates with two primary sub-teams: Shelter Design and Shelter Masterplan.

- **Shelter Design**: Concentrates on crafting the intricate system for the new bus shelter concept.
- **Shelter Masterplan**: Engages in change management and strategizing for the new bus shelter concept, along with the associated routes.

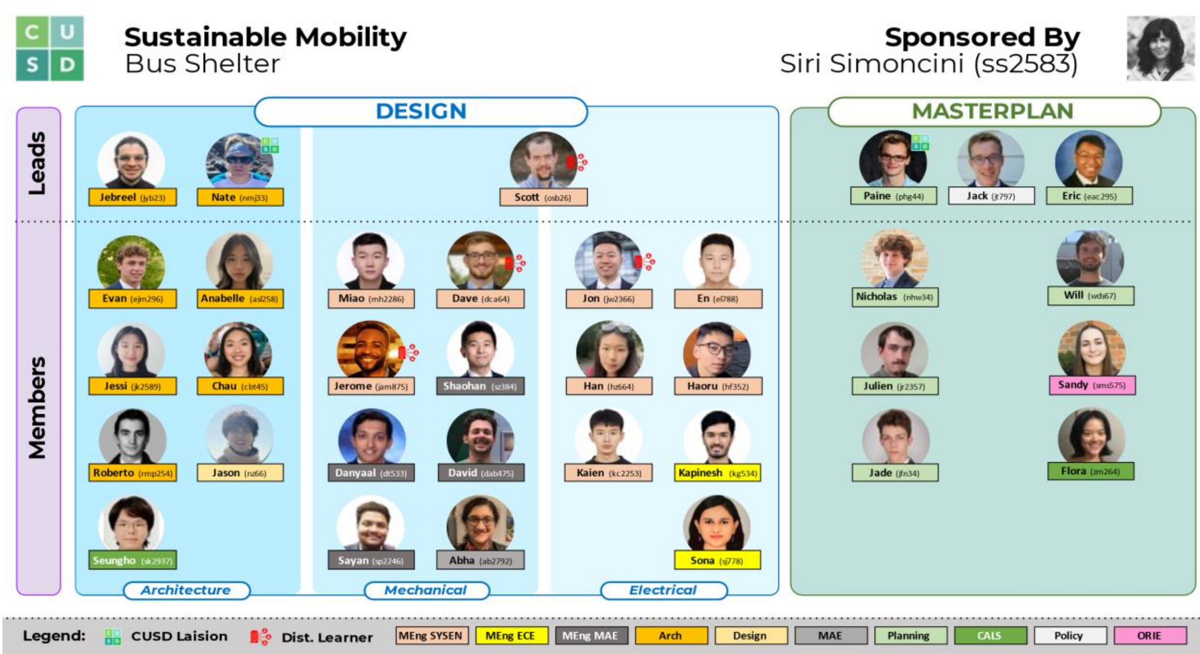

Figure 01: CUSD Sustainable Mobility Shelter – Family Tree

The organization chart, or the "family tree" (refer to Figure 01), delineates the roles, majors, locations, and leadership positions of team members. This structure facilitates task allocation between the sub-teams and manages the diverse skill sets and backgrounds of the large team, both on and off-campus.

Stakeholders

The primary stakeholder, Tompkins Consolidated Area Transit (TCAT), has replaced the previous partnership with Light Green Machines (LGM), a local startup. While working with LGM, the team focused on developing a bus shelter integrated with LGM's small hybrid bus and exploring business cases for LGM's operations.

However, with the shift to TCAT, the team has redirected its efforts:

- **Shelter Design:** Now focuses on integrating TCAT's bus proximity API into the bus shelter, emphasizing sustainable materials, innovative architectural design, and effective communication of complex information.
- **Shelter Masterplan:** Aims to identify optimal locations, Downtown Ithaca or Cornell University's campus, for the innovative bus shelter.

This shift aligns the project's goals with TCAT's requirements, emphasizing groundbreaking architectural and engineering achievements within the transit network.

Shelter Design

Introduction

Under the guidance of TCAT, the Shelter Design team refined its mission and vision for the bus shelter project. The focus now includes showcasing innovative architecture to revitalize interest in bus transit careers and attract new applicants. Additionally, the team aims to integrate a unique bus proximity API system for customer information while maintaining a commitment to sustainability through the use of eco-friendly materials and technologies, aligning with TCAT's goals.

- **Mission:** Revolutionize the concept of bus shelters by creating a transformative platform that reinvents how we communicate complex information, pioneers novel multifunctional building components that seamlessly integrate mechanical, structural, and electrical functionalities, and redefines the landscape and architecture of the conventional bus shelter.

- **Vision:** Upon encountering our bus shelter, our customers will be captivated by the seamless visual representation of the once intricate bus systems and ignited by the

> promise of a sustainable architectural marvel. Our shelter, ingeniously designed to seamlessly assimilate with its natural surroundings, harnesses the beauty of biomimicry, and boasts materials engineered to endure the harshest of natural extremes from the frosty terrain of Alaska to the balmy landscapes of Florida. We aim to leave an indelible impression that fuels inspiration for the future of sustainable architecture, design, and engineering.

Previously, the team debated two architectural concepts: the hub/spoke exoskeleton and the modular puzzle-piece. Despite prior work on both, the team made an executive decision to pursue the modular puzzle-piece concept to align with TCAT's emphasis on innovation and to avoid doubling of work in the development phase.

The project's focus transitioned from the conceptual phase to development phase. Fall 2023 aimed to deliver a comprehensive 'Alpha' design, incorporating electrical, mechanical, and structural systems closely aligned with the chosen puzzle-piece concept. The team set ambitious objectives (see Figure 02) divided among four sub-teams: Architectural, Mechanical, Electrical, and Systems. These objectives created urgency, aiming to transition into prototyping by Spring 2024 and meet Siri Simoncini's milestones for design definition and prototype construction in 2024.

F1	***Architectural***
F1.1	Determine Theoretical Site
F1.2	Determine Overall Package/Footprint of the Shelter
F1.3	Determine Scale, Quantity, Orientation - Puzzle-Piece Elements
F1.4	Determine Foundational Connection Method
F1.5	Determine Electrical Input Location / Control Module Integration
~~F1.6~~	~~Determine Seat Design~~
F1.7	Determine Skin Method
F1.8	Develop Renders for Theoretical Site
F1.9	Develop Video Pitch Showing Functionality in Theoretical Site

F2	***Mechanical***
F2.1	Design Electro-Mechanical Joinery for Puzzle Elements/Cover
F2.2	Test POC of the Electro-Mechanical Joinery
F2.3	Select Material and Manufacturing Method for Puzzle Elements
F2.4	Analyze Structural Robustness of the System to Environment
~~F2.5~~	~~Analyze Structural Robustness of the Seat Design~~
F2.6	Research Skin Element Materials/Methods from Suppliers
F2.7	Design Skin Attach Method Integrating into Puzzle Elements
F2.8	Select Material and Manufacturing Method for Skin Element(s)
F2.9	Design Lighting Attach Method Integrating into Puzzle Elements

F3	***Electrical***
F3.1	Research TCAT Data Extraction / Imports
F3.2	Research TCAT Data Fields (GPS, Lines, etc.) Available
F3.3	Construct a Data Structure with Test Data Mimicing TCAT Data
F3.4	Determine Visual Communication Design from Data Structure
F3.5	Design the Logic Circuit for Visual Communication
F3.6	Establish Connection to TCAT Data
F3.7	Test POC of the Logic Circuit with TCAT
F3.8	Design the Electronic Hardware for the Control Module
F3.9	Design the Lighting Hardware for the Puzzle Elements

F4	***Systems***
F4.1	Refine System Requirements from Potential Customers
F4.2	Refine System Functions from Potential Customers
F4.3	Establish Functional / State Diagrams for the Shelter
F4.4	Establish Architectural Definiton (Comp/Func) of Bus Shelter
F4.5	Flowdown Component Requirements for Mech/Elec Design
F4.6	Flowdown Interface Requirements for Mech/Elec Design
F4.7	Refine System FMEA to Identify Risks / Resulting Requirements
F4.8	Establish Test Suite/Cases for Alpha Testing
F4.9	Acquire Funding for Alpha Prototype for Shelter Design

Figure 02: Shelter Design Objectives for Fall 2023

Architectural Progress

Shelter Footprint

The initial phase of the design process involved establishing the size parameters for the shelter, drawing from both local shelter measurements and insights provided by TCAT. To gather comprehensive data, each team member conducted measurements on one to two shelters situated across the campus. Synthesizing this collective information enabled us to derive average dimensions for nearby bus shelters. Utilizing this data as control ranges, we developed a grasshopper script. This script served as a pivotal tool, allowing us to precisely adjust and refine the shelter's size while staying within the predetermined constraints. Figure 03 demonstrates a visualization at scale, utilizing accurate parameters.

Figure 03: Shelter Design – Visualization of Shelter at Scale

Triangular Module Detailing

The design specifications for the shelter encompass specific dimensions and layout configurations. Each triangular module measures one meter along all three sides. The shelter is envisioned to comprise around 75 of these modules, but this count remains adaptable, subject to potential adjustments in quantity. Structurally, the arrangement consists of eight rows of modules, evenly distributed with four rows on each side. A notable feature within this design is the hollowed-out interior, anticipated to house the lighting components. A distinctive pattern, shown in Figure 04, emerges within the layout as the triangular modules alternate orientation, flipping within rows and between successive rows, introducing an intriguing visual dynamic to the shelter's facade.

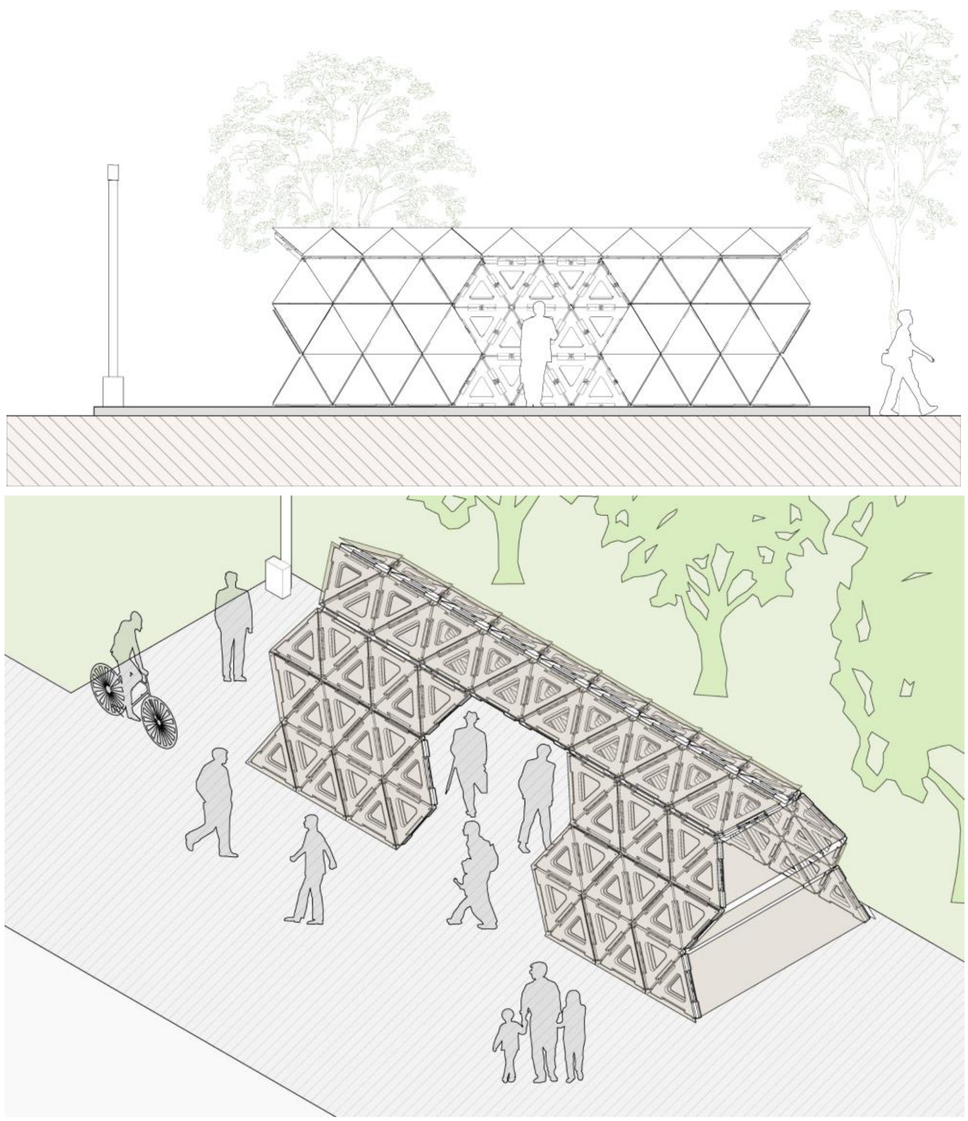

Figure 04: Shelter Design – Distinctive Pattern of Use of the Triangular Modules

Foundation Connection Method

The architecture team embarked on addressing the critical aspect of ensuring the shelter's stability, recognizing the necessity of a robust connection between the shelter and its foundations. Brainstorming sessions within the mechanical team were initiated to conceptualize a sturdy foundation and devise preliminary ideas for an effective connector. While the initial concept for this connector is briefly introduced here, comprehensive details regarding this connector's design and functionality can be found in the mechanical section of this report.

Skin Materials and Method

Throughout preceding semesters, the team engaged in deliberations regarding the optimal material for the shelter's exterior skin. However, this semester marked a definitive decision to transition from considering soft, pliable materials like flexible plastic or fabric to a sturdier, less flexible option. Delving into potential materials such as polycarbonate, glass, or Corning's gorilla glass, the team crafted triangular segments intended to encase the shelter's structure securely. These skin modules were meticulously designed to overlay the shelter framework, employing bolt holes on the surface of each module to ensure a secure fit. Implementing a strategic offset of 2 cm between the skin and the underlying triangular module was a deliberate choice. This offset, shown in Figure 05, serves a dual purpose: to prevent the skin pieces from abutting each other due to the structural angles between modules and to create a barrier against rain penetration into the interstitial spaces. The variance in the offset for each skin piece will be achieved by employing varying quantities of spacers, offering a flexible and adaptable approach to maintain the shelter's integrity and weather resistance.

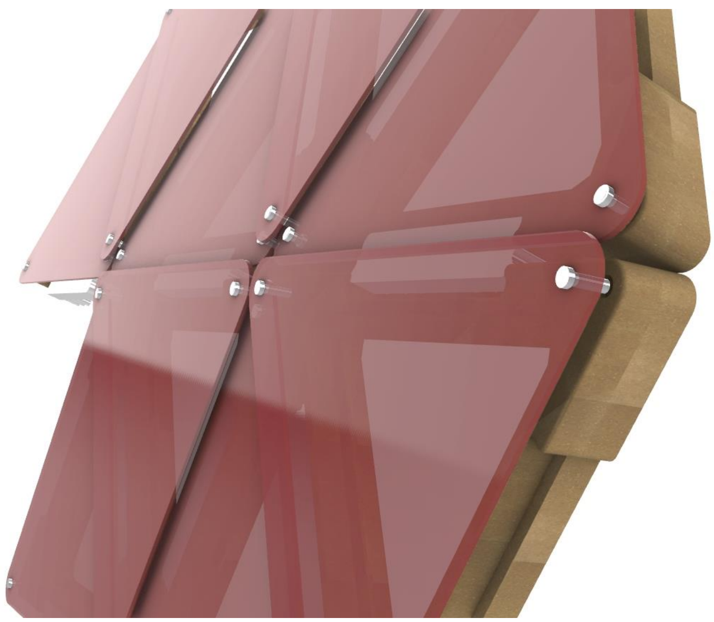

Figure 05: Shelter Design – Offset Between Skin Panels

Lighting Interaction

The lighting interaction embedded within the shelter design serves a dual purpose of assisting both bus drivers and shelter occupants. It functions as a signaling mechanism for bus drivers to determine shelter occupancy and notifies waiting occupants about approaching buses, simultaneously providing adequate lighting (Figure 06).

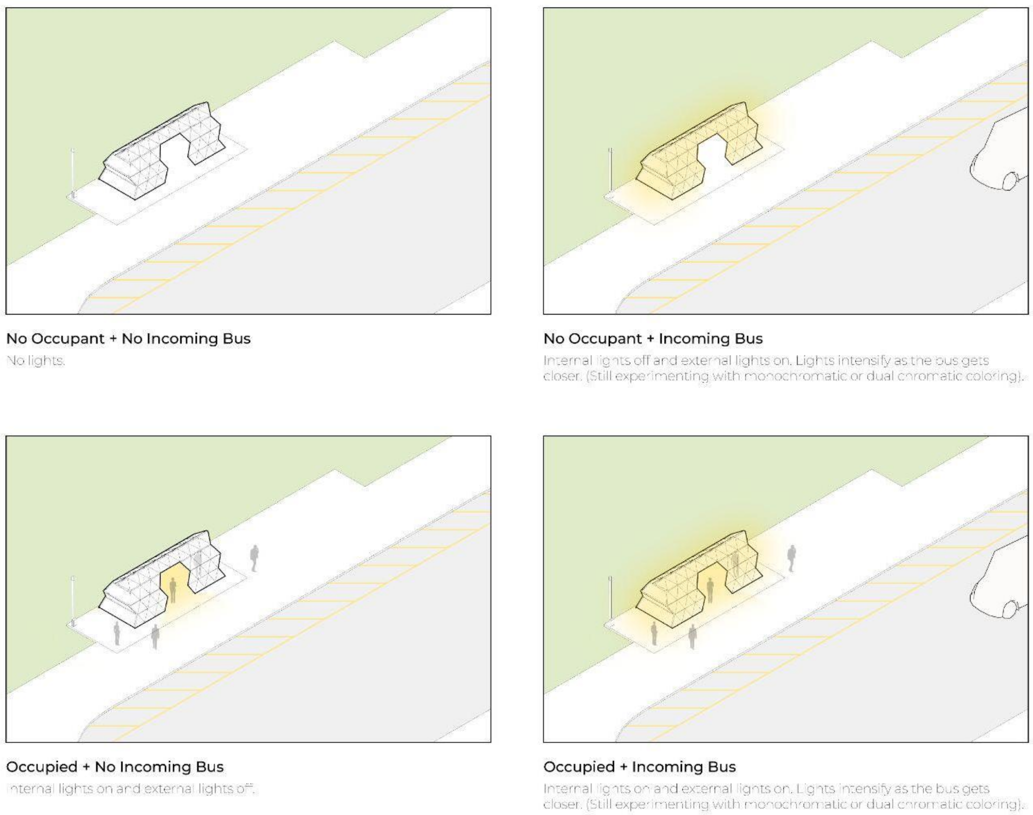

Figure 06: Shelter Design – Visual Communication Design of the Shelter

The intricate lighting interactions are as follows: Firstly, when the shelter is unoccupied and there's no incoming bus, the lights remain off. Secondly, in the absence of occupants but with an approaching bus, the internal lights switch off while external lights illuminate, intensifying gradually as the bus nears (the team is exploring monochromatic or dual chromatic color schemes). Thirdly, when the shelter is occupied without an incoming bus, the internal lights are on while external lights are off. Lastly, in the presence of occupants and an incoming bus, both internal and external lights are activated. Like the previous scenario, the lights intensify as the bus approaches, with ongoing experimentation on color schemes for optimal effectiveness forthcoming. This sequence of lighting interactions aims to provide essential cues to both bus drivers and shelter occupants, enhancing the overall functionality and user experience of the shelter. Figure 07 diagrams the arrangement of LED components, and additional details on technical assembly of the lighting are provided within the mechanical section.

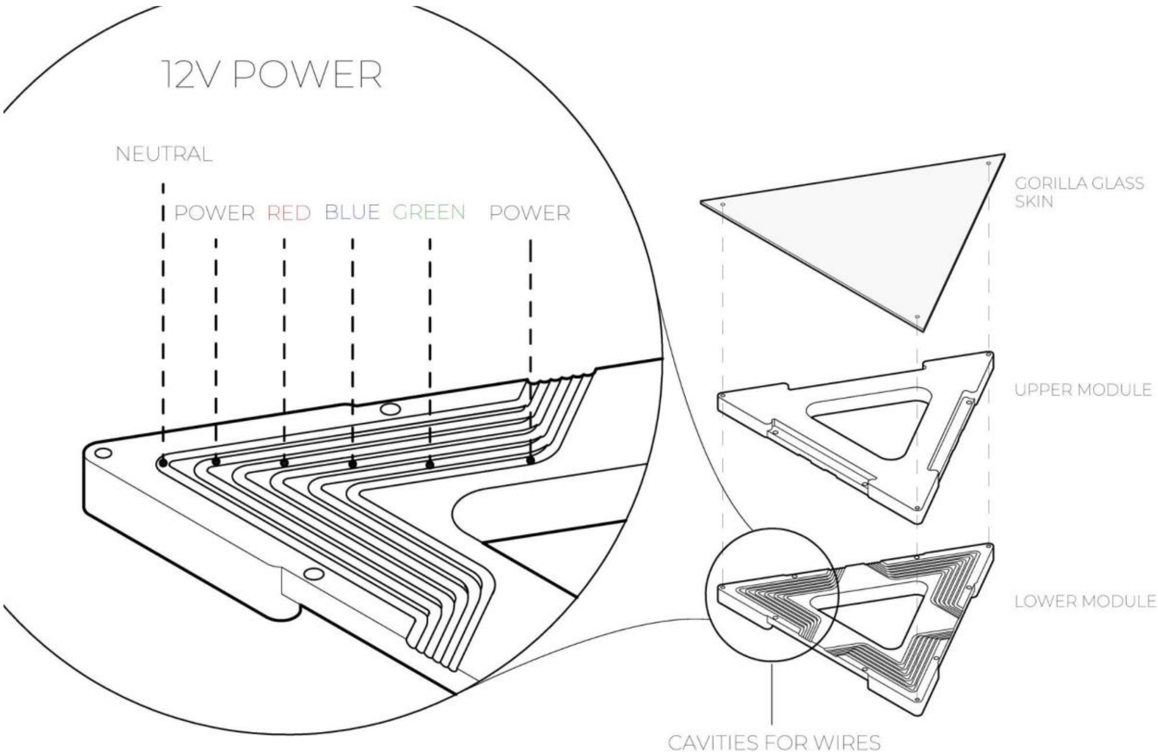

Figure 07: Shelter Design – Integration of LED Circuits into Triangular Modules

Architectural - Next Steps

In the upcoming semester, the team envisions developing a comprehensive video pitch to showcase the theoretical site functionality, providing a tangible visualization of the shelter's intended operation and features. Looking ahead, a multifaceted plan includes several pivotal tasks. These tasks encompass constructing a full-scale model of select triangular modules alongside a smaller-scale model encapsulating the entire shelter design. Moreover, the team aims to rigorously test the electrical systems, conduct thorough structural analyses, and perform calculations to validate the structural integrity. Efforts will be dedicated to resolving intricate connection details between modules and the skin, addressing the insertion of a "wedge" within the hinge mechanism or connector assembly, and sourcing materials from potential suppliers essential for shelter construction. Simultaneously, the team is poised to explore avenues for securing funding and grants crucial for project realization. Additionally, there is a concerted effort to engage engineering and architecture firms willing to endorse the project upon completion, ensuring its credibility and reliability in the professional domain.

Mechanical Progress

Define Problem

The architecture team's directive to move to a modular puzzle-piece concept set the stage for the team's challenge: translating architectural concepts, depicted in Figure 08, into tangible structural, mechanical, and electrical designs.

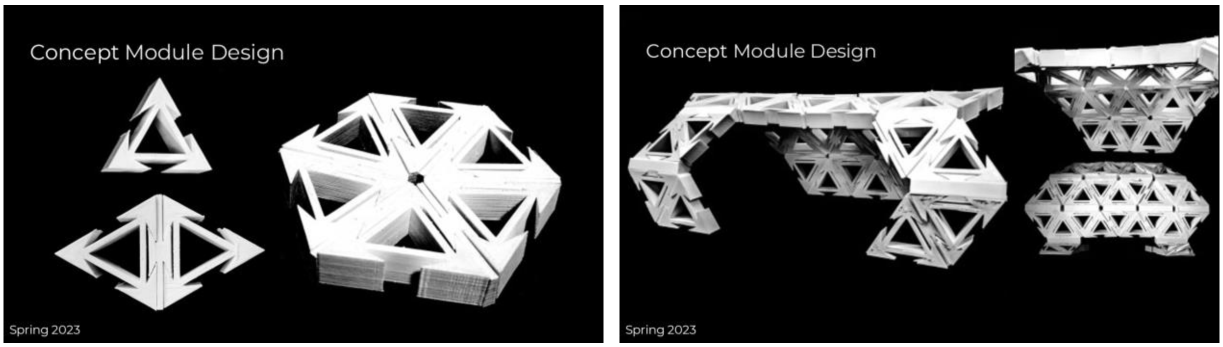

Figure 08: Shelter Design – Architectural Vision (Spring 2023)

Addressing this, the primary hurdle emerged—how to constrain a movable puzzle piece in the z-direction while adhering to the aesthetics and simplicity of a puzzle or Lego piece. Additionally, a second major challenge surfaced—creating a structural framework to supply electricity to individual LED lights within each triangular module without any visible wiring, requiring seamless electrical connections between modules without intricate, time-consuming wiring. Moreover, the team grappled with devising an innovative and sustainable manufacturing, assembly, and servicing approach. Design constraints included removing sharp corners for enhanced manufacturability, opting for a sustainable, cost-effective material—preferably organic over metallic—and facilitating individual module removal without dismantling the entire structure for servicing. Amidst these challenges, robustness against environmental elements took precedence, given exposure to New York weather variations—concerns centered around wind, rain, snow, and sunlight. Balancing design innovation with durability became a critical aspect of the project's success in the face of these multifaceted challenges.

Breakdown / Explore Options

To tackle the two major problems at hand, the team initiated a brainstorming session utilizing the System Engineering method known as Concept Fragments. This approach involves dissecting the problem into its individual elements, fostering a multitude of options at the individual level, and pulling together options in hybrid fashion to address bigger problems. Specifically targeting the creation of a constrained Z-direction puzzle piece connection and the routing of electricity devoid of visible wires or individual connectors, the team engaged in intensive brainstorming.

Various strategies and potential solutions were explored and documented as concept fragments, offering a glimpse into the multitude of innovative ideas generated, although the summarized fragments are illustrated in Figure 09, it is not an exhaustive list.

Puzzle Piece Style Connection (Constrained in Z-Direction)		No Visible Wires with No Individual Wire Connectors
Latches on the Side of Each Module		Contact Pads by Screw/Connection Points
Flanges Between Triangle and Connector		Wireless Energy Transmission (Tesla Coil)
Dovetail Joint with Standard Bolt		Mold Wires into Triangular Modules
Hidden Dowel with Magnets		Incorporate Breadboard Style Connector in Triangular Modules
Hidden Screw with Magnets		Inductive Charging Embedded in Triangular Modules
Hidden Dowel with Bolt Driven Wedge		Laser-Based Electrical Transfer
		Conductive Rods Embedded into Modules

Figure 09: Shelter Design – Concept Fragments

Subsequently, post the concept fragment brainstorming phase, team members ventured into individual exploration sessions. Each member took these concept fragments, amalgamating them in distinct ways to craft system-level concepts for the triangular module and connector assembly. This approach empowered the team to fuse disparate fragments creatively, thereby conceiving unique concepts that could be evaluated comprehensively.

The efficacy of the concept fragment methodology lay in its ability to provide a focused approach to deconstructing individual problems within a larger set of challenges. It offered a systematic means to generate diverse options and approaches to fulfill specific functional needs, steering away from the conventional starting point of a blank canvas. Ultimately, the power of this methodology materialized in the synthesis of elements from various problems, leading to the creation of distinctive concepts ripe for evaluation and refinement.

Brainstorm / Select Concept

After developing concept fragments, the team ventured into crafting 15 distinct concepts aimed at resolving the identified problems. To facilitate evaluation, the team then formulated 5 primary design criteria essential for gauging the efficacy of these concepts against the intended objectives. These ranked criteria in order of priority encompassed structural rigidity, particularly in the Z-direction, resilience to environmental elements, aesthetic alignment with the architectural vision, manufacturability at scale, flexibility in integrating LED and architectural skin concepts, and the safety concerning electricity transfer. Utilizing these criteria as a yardstick, the team meticulously evaluated the top five concepts. The evaluation aimed to assess the relative performance of each concept concerning the original design shared in Spring 2023. The outcomes of this evaluative process were condensed into a Pugh Selection Matrix, showcased in Figure 10.

Weighted Selection Matrix

	Criteria	Importance Weighting	Percent Contribution	Concepts: 0 - Datum	3	4	12	13	15 (Concept Chosen)
1	Structural Rigidity (All Directions)	10	22.2%	0	5	3	7	10	10
2	Ability to Electricify All Modules Safely	5	11.1%	0	10	10	5	5	7
3	Manufacturability (Medium Volume, Not 3D Printed)	7	15.6%	0	5	3	7	10	5
4	Environmental Robustness	9	20.0%	0	7	3	10	5	7
5	Flexibility in Design for LED / Skin	6	13.3%	0	0	5	10	7	10
6	Aesthetics	8	17.8%	10	7	7	3	5	10
	Total Importance Weight	45	100%						
	Total Score			80	254	214	318	322	373
	Performance vs. Datum			Datum	218%	168%	298%	303%	366%
	Rank			6	4	5	3	2	1

Concept Scoring	
10	Best Performance
7	Somewhat Better Performance
5	Middle of Road
3	Somewhat Poorer Performance
0	Worst Performance

Architecture - Connector is Puzzle Piece Style Interface with Thick "Heavy" Triangle Modules with Dovetail Interface

Figure 10: Shelter Design – Pugh Matrix / Weighted Decision Matrix

Upon completion of the matrix assessment, Concept #15 emerged as the preferred solution—a hybrid amalgamation derived from multiple iterations. This concept, depicted in Figure 11, featured a dovetail puzzle-style interface with standard bolt connections and robust, thick triangular modules housing concealed wires.

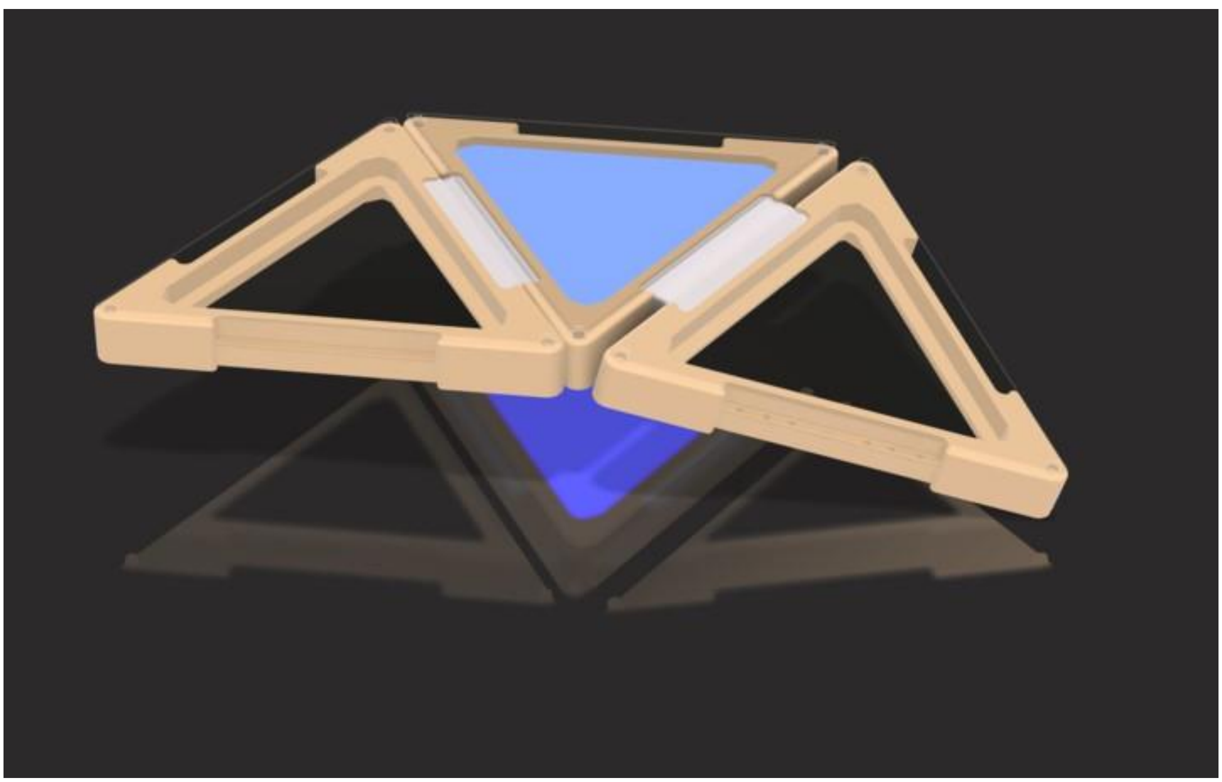

Figure 11: Shelter Design – Selected Concept Architecture (Concept #15)

The selection of Concept #15 was substantiated by its structural integrity via the dovetail interface, its alignment with the project's architectural vision, and its adaptability in integrating LEDs and the architectural skin. Nonetheless, a lingering challenge pertained to devising solutions for accommodating varied angles between connector pieces.

Despite this, the team arrived at a tentative architectural blueprint approved by the architecture team, laying the groundwork to delineate primary and secondary components for detailed design. The team split tasks to delve deeper into the intricacies of the design, concentrating on component specifics, serviceability/assemblability, and manufacturability considerations to advance the project toward its detailed design phase.

Design the Primary Components

Despite the selection of the architectural design, the team encountered several lingering concerns around the primary components of the triangular module and connector assembly. Challenges persisted in housing the theoretical electrical system, ensuring the requisite rigidity of connector pieces, accommodating multiple angles within the connectors, and establishing a robust assembly. Furthermore, refining the visualization of fixtures for the glass skin atop the panels remained essential based on inputs from the architectural team.

To address these complexities, the team opted for refined designs within Fusion 360. The modular panels underwent a structural alteration, being split into halves to accommodate internal electrical systems. These halves were securely fastened using bolts, simultaneously securing the glass skin above the panels.

In response to feedback from mechanical and electrical teams, the internal design of the panel halves was tailored to accommodate six wires—four designated for the external RGB lighting system and two for internal LED illumination. The wire layout was optimized to conform to the triangular panel shape, allowing clearance near the dovetail sections for connector pin connections. Additionally, alterations were made to the output points' orientation, shifting from vertical to horizontal for enhanced connectivity between the panel and the connector.

The connector underwent a redesign, now fitting directly into the dovetail at the panel's bottom. A securing plate was introduced over two pins penetrating the top half of the panel to firmly affix the connector. Addressing the need for multiple angles, the connector was bifurcated with an angle-locking joint incorporated between the halves and within the connector structure. To reinforce the structural integrity of the connectors, custom wood wedges were introduced between the halves, tailored to specific angles. These wedges aimed to prevent bending under loads and safeguard the entire structure from buckling. The resultant design of the primary components is shown in Figure 12.

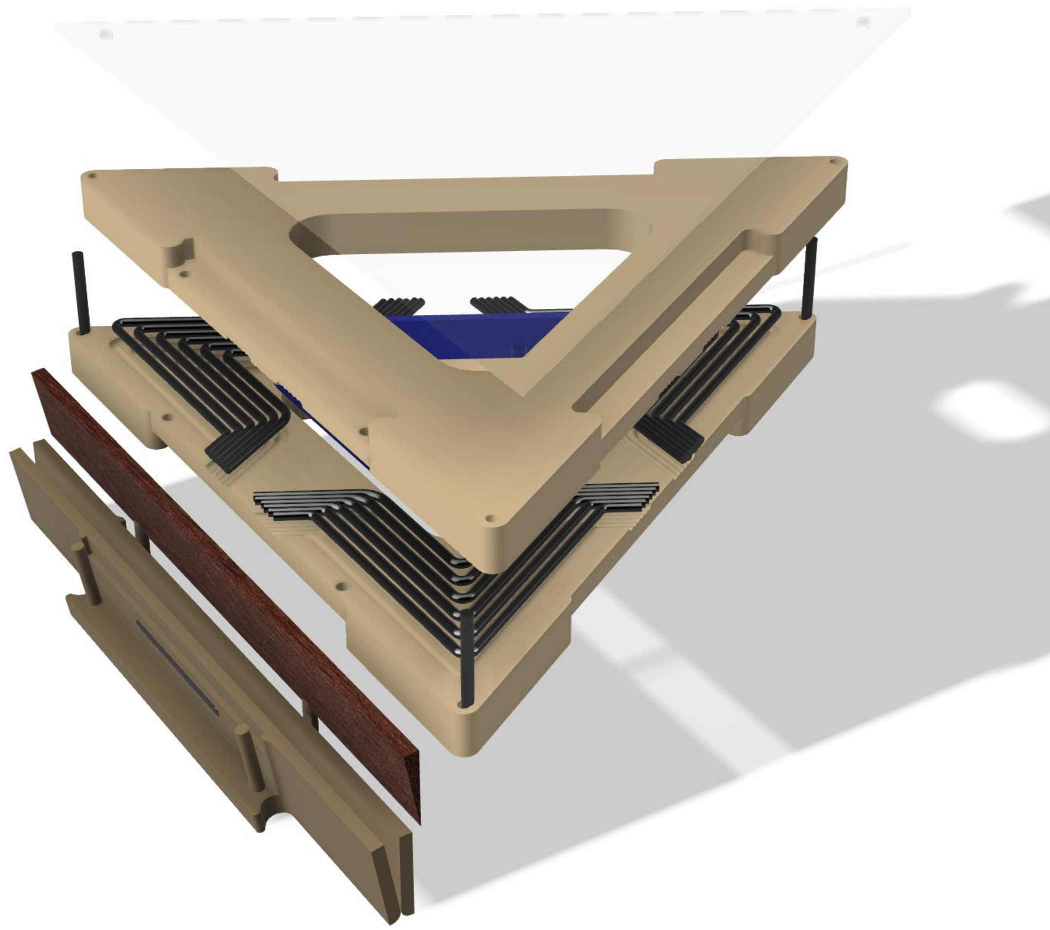

Figure 12: Shelter Design – Design of Triangular Module and Connector Assembly

Develop the Secondary Components

The team grappled with the challenge of establishing a sturdy foundation for the shelter without resorting to conventional materials like concrete, aligning with sustainability goals. An innovative idea surfaced—utilizing a complex gravel setup. The proposal involved evenly spaced columns descending from the shelter to the base of the gravel pit, featuring broad plates extending laterally beneath the gravel. However, linking the triangular modules with secondary components to these columns posed a significant challenge.

An initial concept for the foundational mount emerged from Fusion 360 and depicted in Figure 13—a block with a groove for the module to slot into, secured by a screw-on cap. Though rudimentary, this concept serves as a foundational starting point for future explorations into the shelter's foundations.

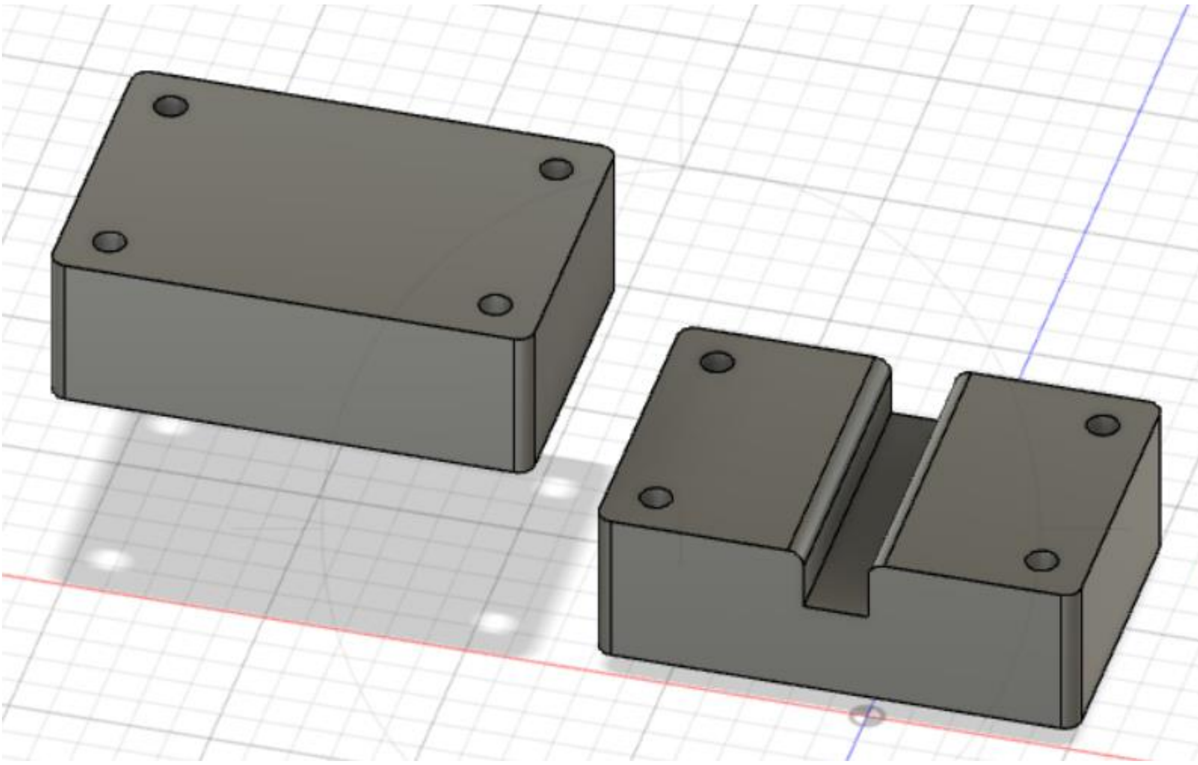

Figure 13: Shelter Design – Design of Foundation Mount

Design for Assemblability and Serviceability

The team commenced exploring the skin-to-module connection by determining the size and coverage of each skin unit and its relation to the modules. A critical consideration was the skin's assemblability and serviceability in case of damage to the module. Initial prototypes assessed the skin covering multiple modules, but concerns arose about the complexity of replacing larger segments if minor damage occurred.

Upon analysis, the team concluded that a more optimal solution involved individual connections for each triangle module to the skin, ensuring simple panel removal. This approach standardized the skin panels, with only the angle of their attachment to the module requiring alteration. Bolts were selected as the connecting medium at varying heights to facilitate individual access to each module. This adaptable assembly method enables easy detachment and maintenance without interference from neighboring modules, facilitating repairs and upgrades to the technical components. Furthermore, the alternating heights of the panels contributed to structural stability by distributing connections across different levels, enhancing the overall structure's resilience against diverse forces.

The team opted for a nyloc nut for the skin-to-module connection, considering its mechanical and functional advantages. The nyloc nut's nylon insert plays a pivotal role, preventing vibrational loosening by acting as a prevailing locking mechanism. This feature is crucial in scenarios with mechanical stresses or vibrations, ensuring the connection remains secure. Moreover, the self-locking nature of the nylon insert enhances the system's reliability, eliminating the need for secondary locking devices or adhesives, streamlining the assembly process, and reducing potential errors. This simplicity in design and assembly streamlines manufacturing processes, contributing to increased efficiency. The resultant design for the skin to module connection is shown in Figure 14.

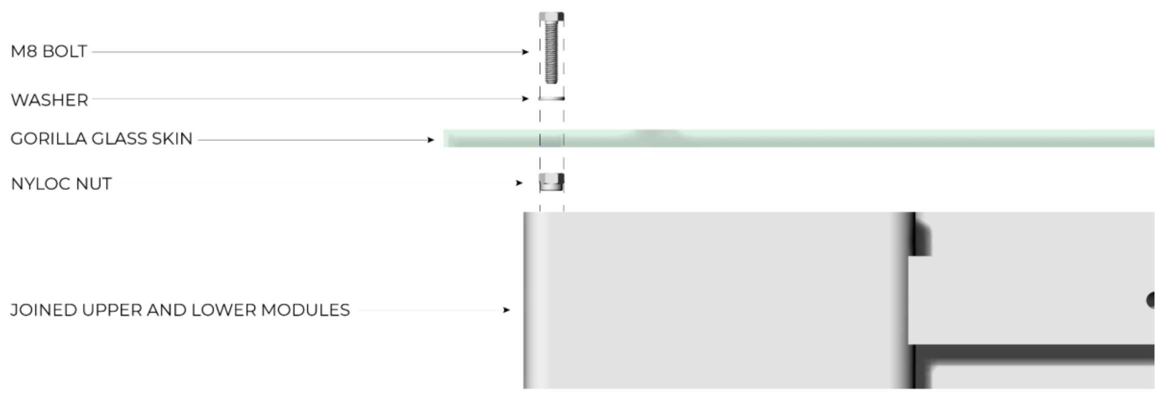

Figure 14: Shelter Design – Skin Attachment (Assemblability / Serviceability)

Design for Manufacturability

The team, dedicated to Cornell University Sustainable Design (CUSD), extensively researched manufacturing materials and methods to align with sustainability principles across the skin, triangular module, and connector assembly components.

Initially, for the skin, glass was favored over plastics due to its resilience against discoloration in direct sunlight. However, a more durable solution was sought, leading to collaboration with Corning, a reputable local supplier. The team explored the use of 2mm thick gorilla glass, commonly employed in watch and phone faces. This glass material also offered options for frosting or etching, aligning with architectural preferences.

Regarding the triangular module, organic materials were considered, prioritizing suitability over excessive mechanical strength. Research led the team to investigate hemp composites utilized in the automotive industry, aiming to employ these composites for molding the module's two halves. Further exploration is underway, with a focus on companies like Flexform Technologies, known for manufacturing similar components for the automotive sector.

In addressing the connector assembly, the team encountered a two-fold challenge. Prioritizing structural integrity for forces traversing through the connector, materials such as Aluminum or stainless steel were recommended. Following an extensive feedback session with Professor Fabien Royer, the team incorporated wood into the connector assembly as a wedge. This decision was influenced by wood's commendable compressive strength, ease of on-site modifications during assembly, and cost-effectiveness.

Prototype / Test Concept

The team's initial focus was on creating a prototype for the electrical system, serving as a foundational concept for subsequent mechanical designs. The first prototype took shape as a basic breadboard circuit, simulating the concept of "rails" designated for various types of connections required for power or signal transfer among modules. This approach aimed to ensure consistent production of modules that could seamlessly connect, irrespective of their orientation. The successful demonstration of this concept was evident as depicted in Figure 15, where the illuminated LEDs validated their functionality. Further prototyping remains necessary to refine the integration of RGB LEDs into the system.

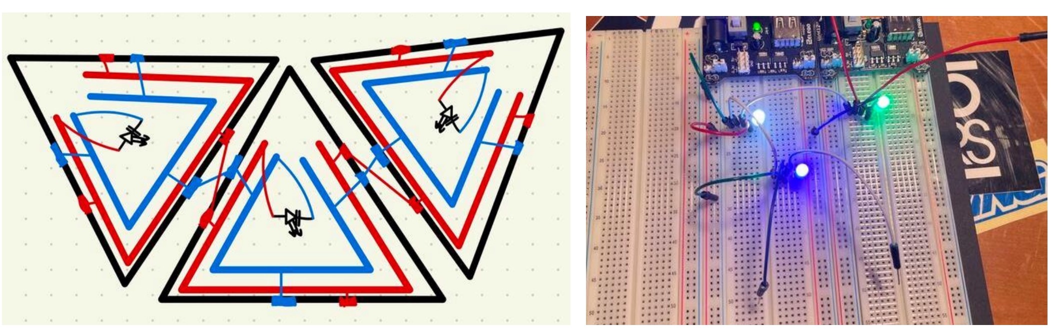

Figure 15: Shelter Design – Proof of Concept (Breadboard Style Connections for LED)

Mechanical – Next Steps

Transitioning into the upcoming semester, the mechanical team aims to seamlessly collaborate with the electrical team, forming a unified engineering front to integrate both electrical and mechanical components effectively. A key challenge currently faced involves integrating wires or printed circuit boards (PCBs) into the mold design, alongside configuring multiple angles within the connector assembly. Specifically, the team is tasked with establishing connections for six different traces between each triangular module and the connector assembly, while also accommodating one or two LED strips within a standardized fitting or harness. Moreover, a critical concern lies in setting and securing five to six different angles in the architectural structure without introducing additional part numbers or complexities.

The team is exploring alternative approaches for powering the LEDs, drawing inspiration from examples like the TIZIO lamp. However, this exploration requires substantial prototyping and testing resources, presenting a dilemma regarding its viability and resource allocation. The team's focus on resolving electrical challenges has somewhat diverted attention from pressing mechanical issues, particularly angle locking mechanisms. With a shift in resources towards addressing electrical complexities, the team anticipates dedicating more effort to tackling the outstanding structural and mechanical challenges. The aim is to embark on an analysis-led design approach, prioritizing a comprehensive resolution to these open issues.

Electrical Progress

Connecting to TCAT Bus Proximity API

The electrical team initially encountered challenges with the available bus proximity APIs, facing limitations in accessibility and real-time information provision. After exploring options like the Transitland website's free download API, incompatible with their software, and a subscribe-based API unable to offer real-time data via their preferred platform, the team sought an alternative solution. They coordinated with the TCAT IT department to explore viable alternatives and were introduced to "Swiftly," a third-party bus data provider. Following consultations and assistance from TCAT, the team engaged with Swiftly's technical support to secure an API key compatible with their preferred programming environment, utilizing vscode with Python. This API enables the retrieval of real-time bus predictions specifically tied to the shelter ID, updating at the very worst every 30 seconds. Below is Figure 16 depicting the successful connection to TCATs Bus Proximity API and the output for the Rockefeller Hall stop for each bus in transit (time from shelter in seconds, time from shelter in minutes, bus usage, bus route).

```
Route ID: 32
Stop ID: 1525
Stop Name: Rockefeller Hall
Prediction: {'time': 1701623684, 'sec': 1366, 'min': 22, 'departure': True, 'occupancyStatus': 'EMPTY', 'vehicleId': '1807', 'tripId': 't4B0-b232B-slD'}
Route ID: 90
Stop ID: 1525
Stop Name: Rockefeller Hall
Prediction: {'time': 1701622770, 'sec': 452, 'min': 7, 'occupancyStatus': 'EMPTY', 'vehicleId': '1109', 'tripId': 't479-b2333-slD'}
Route ID: 90
Stop ID: 1525
Stop Name: Rockefeller Hall
Prediction: {'time': 1701624409, 'sec': 2091, 'min': 34, 'scheduleBased': True, 'vehicleId': 'block_9013_schedBasedVehicle', 'tripId': 't4BF-b2335-slD'}
```

Figure 16: Shelter Design – Successful TCAT API Connection (Rockefeller Hall)

Selecting / Analyzing Electronic Hardware

The team conducted a thorough analysis encompassing 75 to 150 LEDs configured in a parallel circuit, resulting in a recommendation to pursue either 12V or 24V LED strips for the project. The evaluation highlighted distinct characteristics of each voltage option: the 24V strips enabling longer runs, up to 7 meters, albeit posing challenges with sharp turns, while the 12V strips afford the flexibility for sharper turns but typically limit runs to approximately 5 meters.

The analysis indicated that voltage drop, while a consideration, wouldn't significantly impact the system, given the consistent voltage across LEDs in a parallel setup, each facing an approximate 3V voltage drop. However, the critical aspect for the parallel circuit centers on the current rating of the LED strips. Anticipating an increase in current for every LED integrated into the system, the team recommended LED strips falling within the range of 14 to 28 mA ratings to effectively accommodate the structural requirements.

Electrical – Next Steps

This past semester posed significant challenges for the electrical team due to various constraints stemming from work and academic schedules. Despite these hurdles, the team managed to establish an API connection, providing valuable insights for LED architecture decisions. However, progress fell short of implementing a logic circuit.

Heading into the upcoming semester, the primary focus for the team revolves around constructing a logic circuit that aligns with the visual communication design guidelines outlined in the systems section. This entails creating an electronic control module capable of interfacing with the bus proximity API via Swiftly. The aim is to utilize this API data to regulate a circuit responsible for communicating bus proximity and occupancy through speakers and lights.

Recognizing the paramount importance of electrical design in the Spring 2024 semester, the team intends to seek additional electrical resources. They plan to diligently simulate the logic circuit using Proteus, a tool facilitating API connections and circuit simulations. Subsequently, the team aims to concentrate on prototyping the entire electrical system independently from the mechanical components. Small-scale testing on a breadboard level will be employed, simulating bus proximity and occupancy at a designated campus bus shelter stop. This approach allows for evaluating API functionality with arriving buses and sensor use concurrently, verifying the system's operation.

Systems Progress

Business or Mission Analysis Process

The project on Sustainable Mobility has been ongoing for over four years in collaboration with the primary stakeholder, Light Green Machines (LGM), originally aimed at creating an electronic hub for hybrid buses to charge at stops and accommodate other devices like bikes and electronics. However, due to a shift in stakeholders from LGM to the Tompkins Consolidated Area Transit (TCAT), the team revisited the project's initial mission analysis at the onset of the semester.

The team followed the Business or Mission Analysis Process outlined by the International Council on Systems Engineering (INCOSE) handbook. The purpose of this process is to define the business or mission problem or opportunity, characterize the solution space and determine potential solution classes that could address a problem or take advantage of an opportunity. Therefore, to understand TCAT's perspective, they conducted a Voice of the Customer (VOC) session, revealing several key insights:

TCAT emphasized the need for an innovative and technologically advanced bus shelter to attract employees and customers, signaling revitalization in the industry. They prioritized customer safety by suggesting integration with emergency services, offering shelter to larger groups, ensuring shelter lighting when occupied, and aiming to deter loitering. Moreover, TCAT questioned the necessity of seats in the bus shelter, considering the potential for increased loitering and reduced shelter capacity. They also expressed interest in communicating bus proximity data uniquely through the shelter via an API integration.

Additionally, the team acknowledged previous empathy field studies, finding that the user perspective, particularly the need for timely bus arrival information, remained consistent. A common scenario among Cornell's population involved waiting in harsh weather conditions without timely information about bus arrivals. One such example that was used to convey this message:

> *"Imagine it's the middle of winter and you just parked in the A-Lot. It's super cold and you don't want to get out of your warm car, and you are in the back of the parking lot.*

You want to time when you come to the bus shelter but if you wait until the bus arrives you are too late. You also are wearing gloves so getting to the app on your phone to tell you how far the bus is would be a bit of work. You wish the bus shelter would give you some kind of sign that the bus is nearing the shelter, so you know exactly when to make the trek to reduce time in the elements."

To capture TCAT and user requirements, the team constructed a context diagram (see Figure 17) to better understand the solution space and outline interfaces with various stakeholders, including homeless populations, emergency services, facilities services, transit services, as well as unexpected interfaces like users' bikes, electronics, and animals.

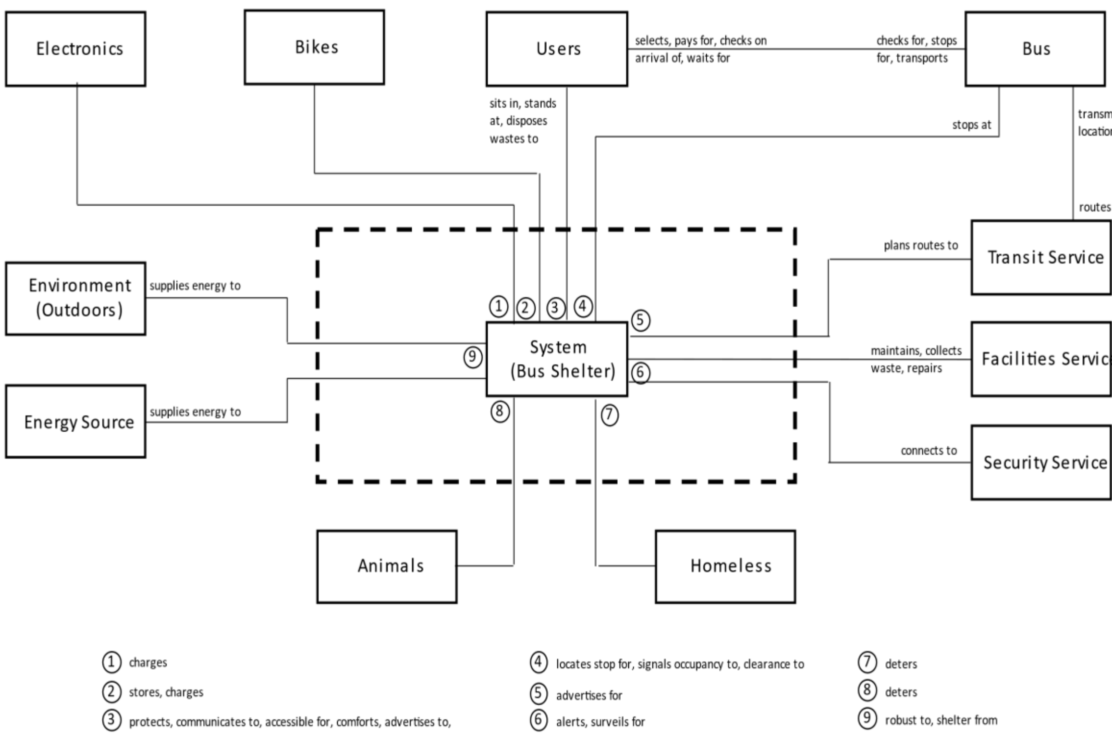

Figure 17: Shelter Design – Context Diagram

Subsequently, the team ventured into developing use cases and refining them from an extensive list to a more manageable minimum viable product. To show the relationships, the team constructed use case diagrams representing user, bus, and environmental interactions with the shelter (see Figures 18, 19, and 20). The team used these diagrams to start a conversation on the intent of the shelter and to identify the minimum viable product (purple) and additional features (blue) desired by customers and the transit service. Through this, the team identified crucial interactions between users and the bus, such as the driver's need to assess shelter occupancy before stopping.

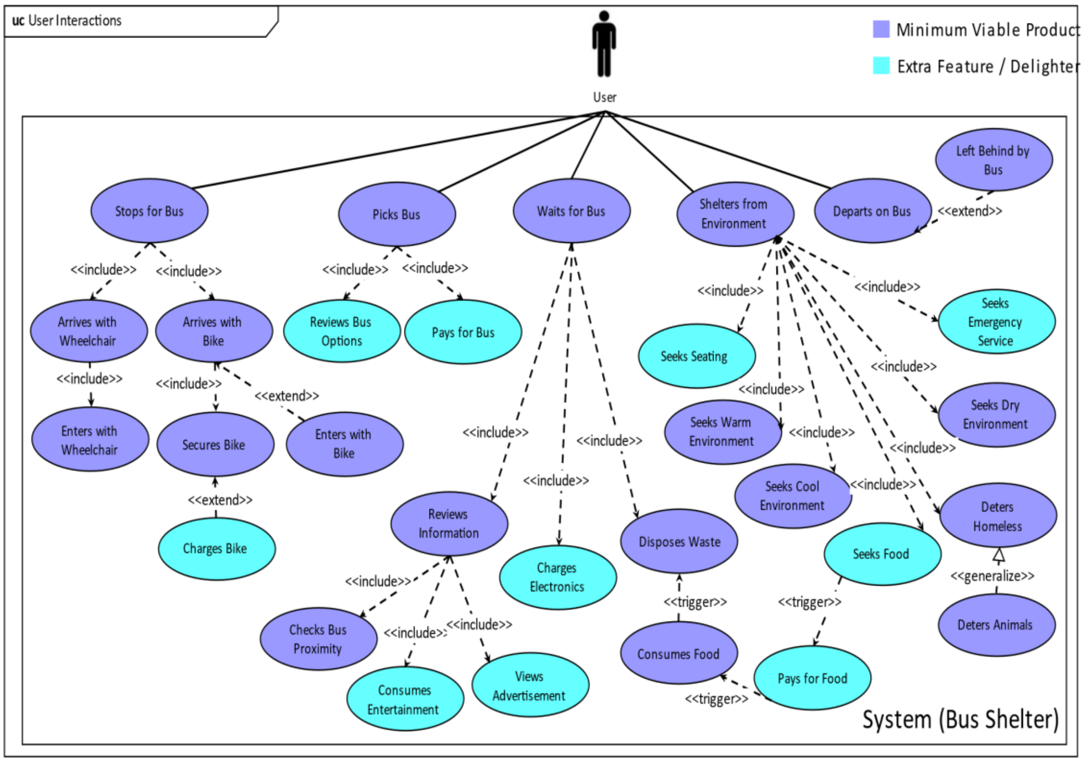

Figure 18: Shelter Design – Use Case Diagram (User Interactions)

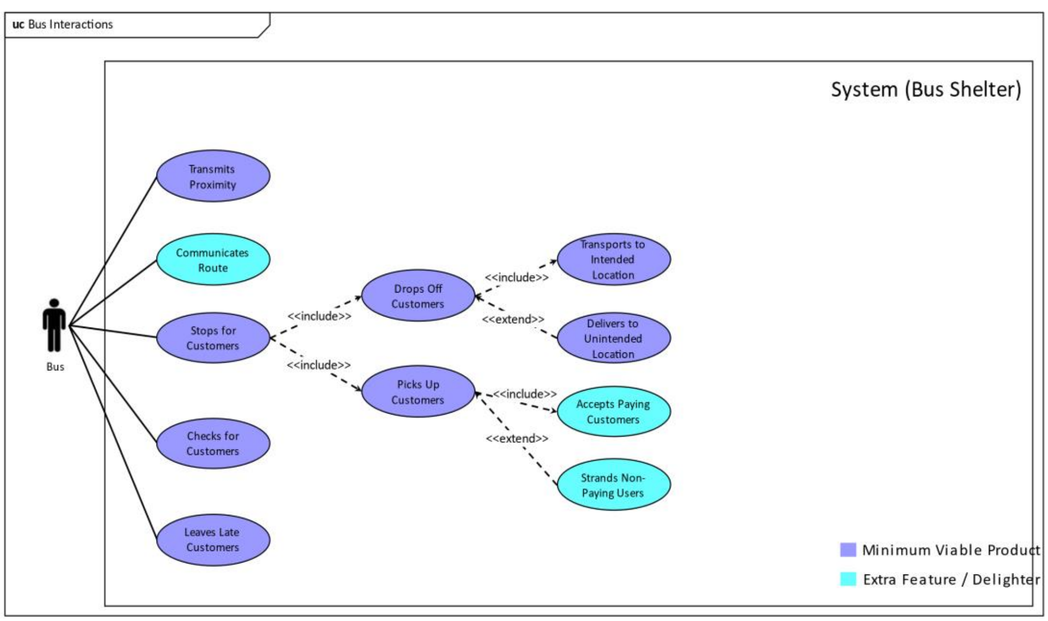

Figure 19: Shelter Design – Use Case Diagram (Bus Interactions)

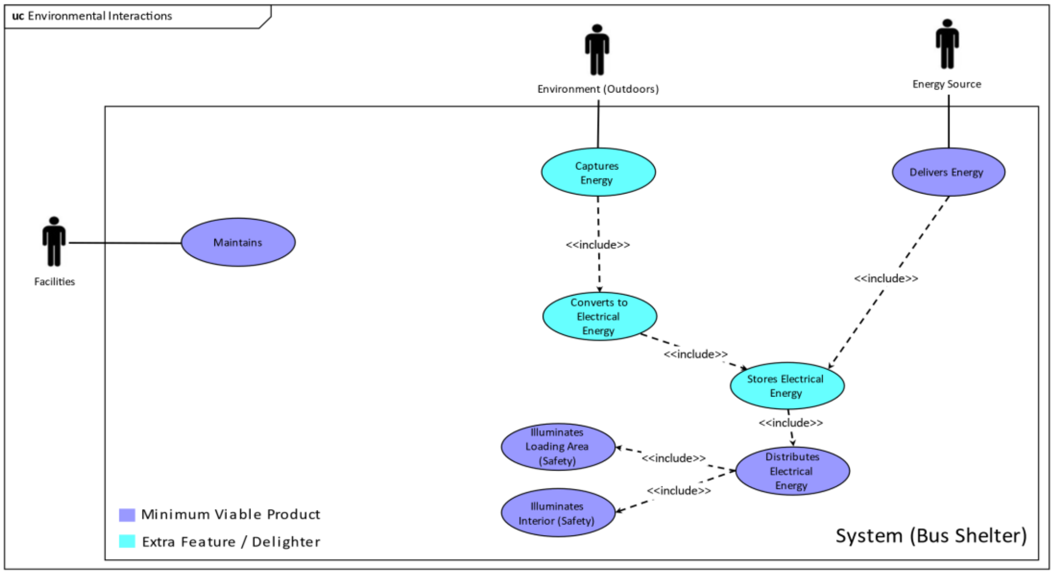

Figure 20: Shelter Design – Use Case Diagram (Environmental Interactions)

Transitioning to SysML modeling using CAMEO, the team faced collaboration challenges but found advantages in connecting functional and logical architectures. Their draft SysML use case diagram (see Figure 21) exemplifies their efforts to establish digital thread traceability among various artifacts and trim down the use cases.

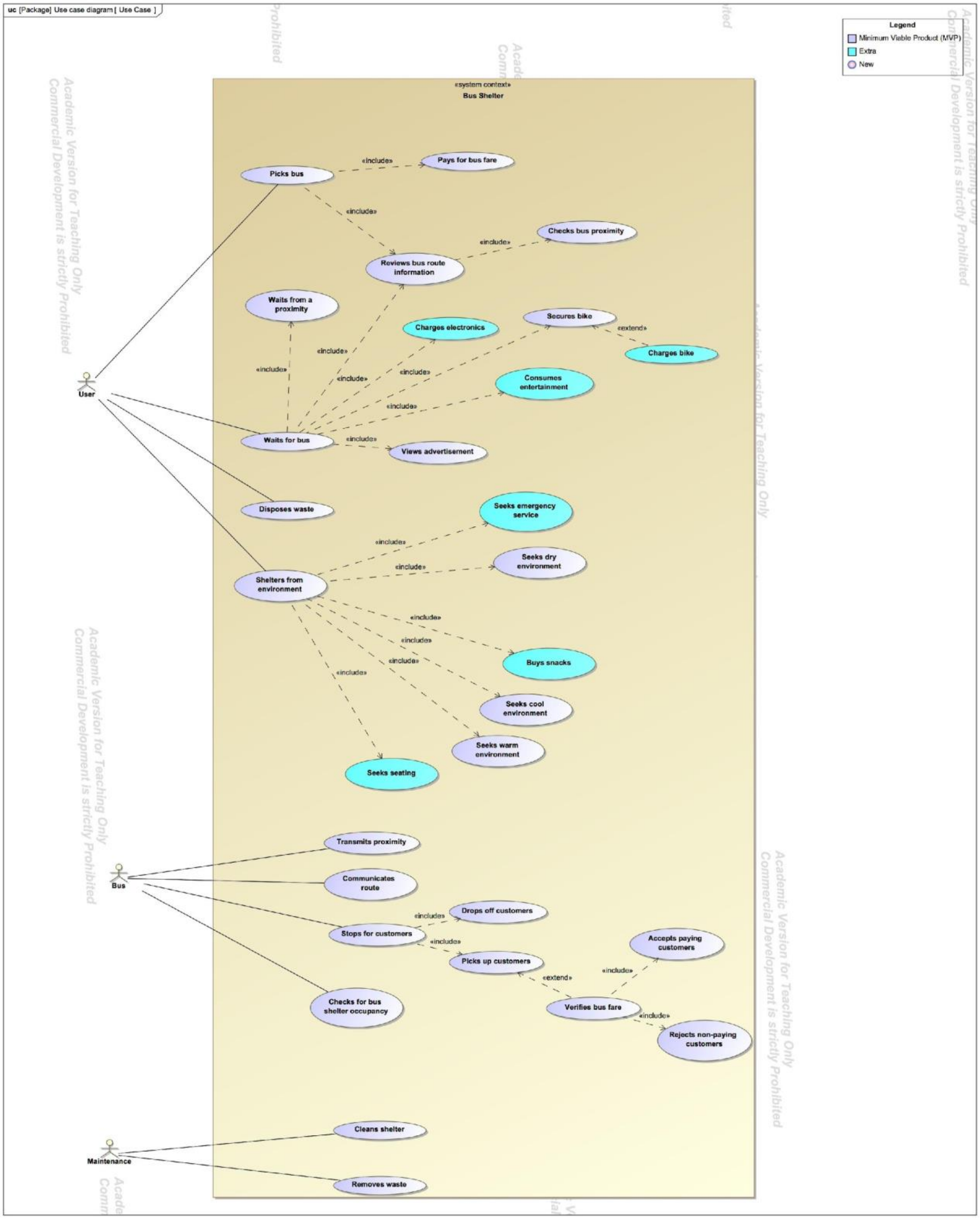

Figure 21: Shelter Design – Use Case Diagram (SysML)

Having completed the context and use case diagrams, the team gained a comprehensive understanding of the problem space. The next step involved breaking down stakeholder needs and requirements to further advance the project.

Stakeholder Needs and Requirements Definition Process

Following a significant redefinition and rescope of the problem space after four years of directional shifts, the team embarked on the Stakeholder Needs and Requirements Definition Process. This process, according to the INCOSE handbook, aimed to establish stakeholder requirements for a system capable of meeting user and other stakeholder needs within a specific environment.

The team's initial step involved dissecting the functional aspects of the bus shelter. They utilized an IDEF0 diagram to outline the shelter's fundamental functions along with its inputs, outputs, resources, and controls. They started with the A0 diagram (see Figure 22), which highlighted the core function of sheltering users.

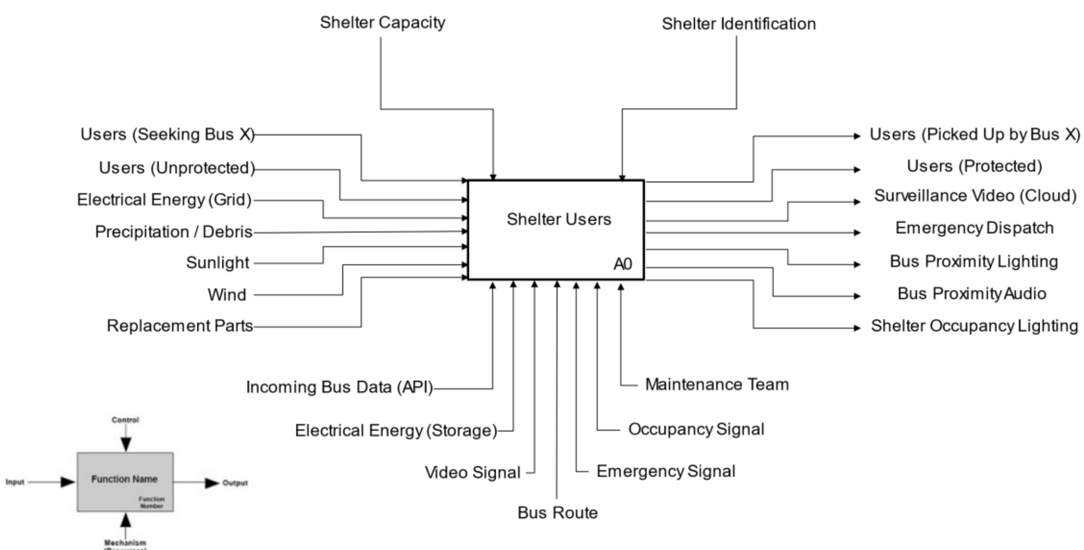

Figure 22: Shelter Design – IDEF0 Diagram (A0 Diagram)

Through this diagram, the team delved into sub-functions, understanding the necessity for lighting and audio to communicate bus proximity and explored the resources required to achieve the desired outputs. Notably, they emphasized the significance of easily replaceable components to facilitate modular repair without disassembling the entire structure. Subsequently, sub-functions were detailed in Figure 23 using the same IDEF0 format.

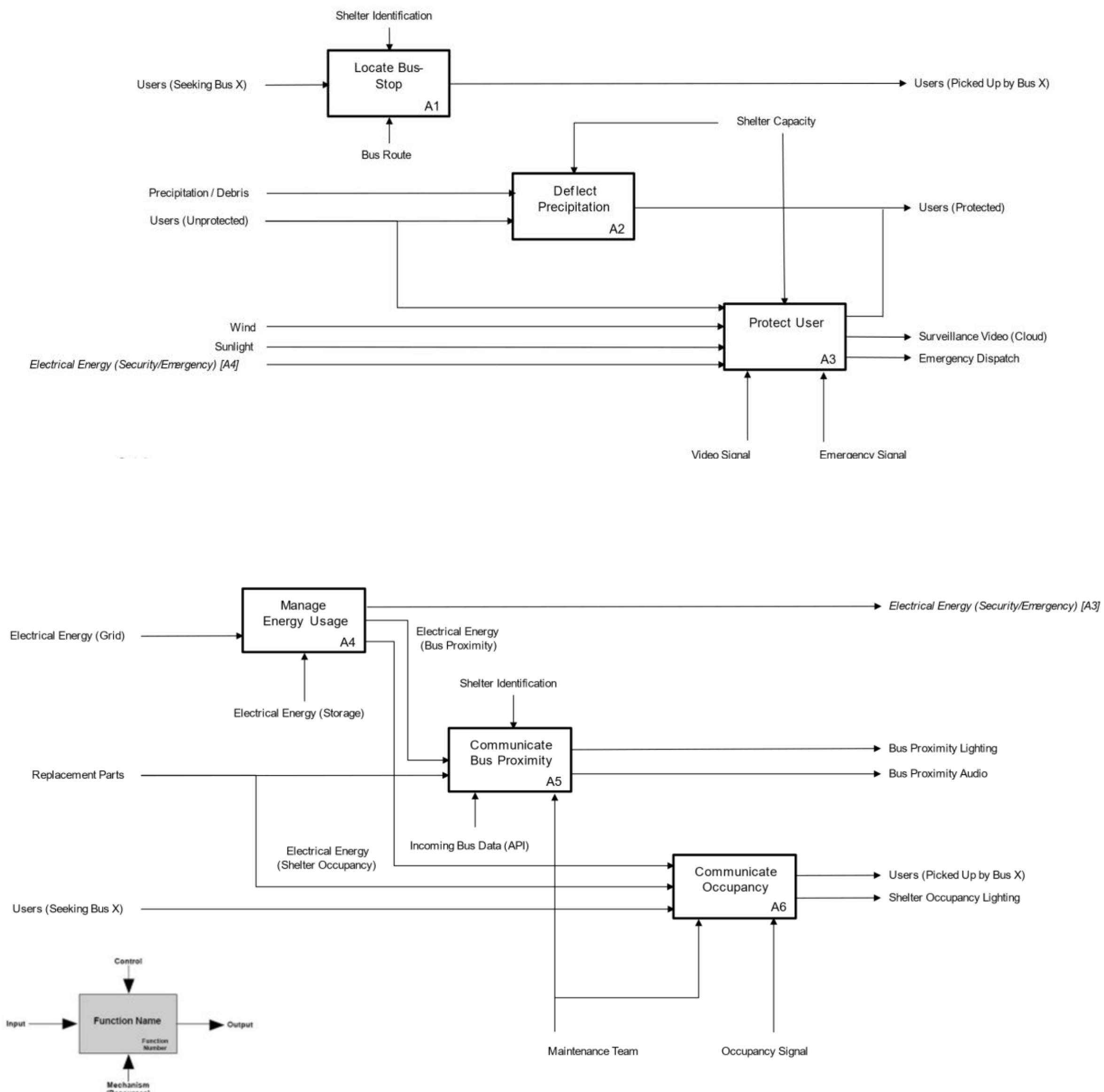

Figure 23: Shelter Design – IDEF0 Diagram (A1-A6 Diagrams)

Using this IDEF0, the team identified three primary sub-functions essential for any bus shelter to qualify as a shelter: locating a bus stop, providing covering, and protecting the user. Additionally, they pinpointed two unique sub-functions—communicating bus proximity and occupancy—that distinguished this shelter from conventional ones. Lastly, the team identified a sub-function of managing energy usage to support the communication aspect. These functions aligned with the stakeholder's desire for innovation, aiming to draw attention by conveying complex information uniquely.

Transitioning to SysML near the end of semester (still work in progress), the team refined the functional architecture (see Figure 24), consolidating functions like communication, adding temperature regulation (reduce wind chill), and reworking various others.

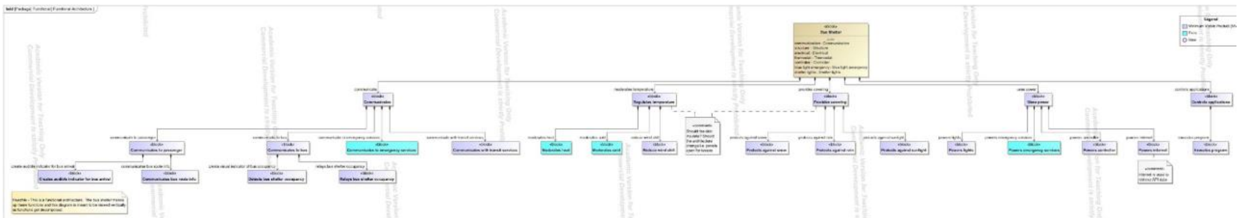

Figure 24: Shelter Design – Functional Diagram (SysML)

This functional diagram delineated major shelter functions, illustrating the breakdown between minimum viable product (MVP) and extra features, facilitating potential expansion based on customer verification. It aided in identifying function gaps and establishing alignment for each major function's composition. These SysML diagrams made it simple to translate functions into logical architecture and then decompose them further through activity diagrams to define the design.

Having completed the Stakeholder Needs and Requirements Definition Process, the team discerned the system's functional requirements, recognizing both the fundamental needs of a bus shelter and its distinguishing characteristics. Now, the focus shifted towards articulating specific requirements, readying them for communication to the broader design and architecture teams. These requirements would be expressed as 'shall' statements, forming the basis for defining the system comprehensively.

System Requirements Definition Process

In steering the mechanical and electrical teams toward developing the system and component designs, the team engaged in crafting system-level requirements through the System Requirements Definition Process, aligning with the INCOSE handbook's guidelines aimed at translating user-oriented needs into a technical framework.

Initially, the team scrutinized the highest priority use cases dictated by the functional and use case diagrams. Subsequently, they disentangled the user's perspective of the system into technical requirements, employing a Use Case Behavioral Diagram (UCBD).

From an amalgamation of 18 distinct use cases, the team constructed 9 UCBDs. These diagrams functioned as scenarios, illustrating the roles' actions within specific situations, effectively transforming system actions into shall statements that formed the crux of the system requirements. The script-like methodology utilized in the UCBDs followed a sequence of initial conditions, role actions, and concluding end conditions, incorporating notes and assumptions where necessary. Two influential UCBDs, pivotal in shaping the system requirements, are depicted in Figure 25.

UC.01 / UC.33 / UC.34 - User stops for the bus at the bus shelter / Bus picks up customers at the bus shelter / Bus transports		
Initial Conditions		
Bus en route to shelter		
User running late to bus shelter - about 300 feet away		
Environment is foggy and dark		
User	**System (Bus Shelter)**	**Bus**
		Bus transmits signal that it is 1 minute away from the bus shelter
User approaches bus shelter from a distance away		
	The shelter shall determine bus proximity to the shelter to a delta of **proximity_sensitivity** seconds	
	The shelter shall communicate bus proximity using both visible and audible signals	
	The shelter's proximity signal shall be visible from all directions	
	The shelter's proximity signal shall be visible from **signal_visibility_distance** in all weather conditions	
	The shelter's proximity signal shall be audible from all directions	
	The shelter's proximity signal shall be audible from **signal_audibility_distance** in all weather conditions	
	The shelter's proximity signal shall be at max brightness when the bus arrives at the shelter	
	The shelter's proximity signal shall be at max loudness when the bus arrives at the shelter	
	The shelter shall sync bus proximity with transit API at least once every **refresh rate_seconds**	
User speeds up to arrive at bus shelter on time		
User arrives at the shelter		
		Bus arrives at the shelter
User boards the bus at the shelter		
		Bus transports to intended location
End Conditions		
Bus arrives at shelter and takes customer to intended location		
User notified of proximity and makes the stop on time		
Notes		

UC.31 - Bus stops for customers at the bus shelter / Bus shelter illuminates the interior of shelter for safety		
Initial Conditions		
Bus en route to shelter		
User waiting for bus		
Environment is dark		
User	**System (Bus Shelter)**	**Bus**
User arrives at the shelter early		
User stands inside the shelter		
	The shelter shall sense occupancy inside the structure to within **occupancy_sensitivity** accuracy	
	The shelter's occupancy signal shall be visble to the bus driver when the bus arrives at the shelter	
	The shelter shall maintain a **min_lumen_level** inside the structure when occupied	
		The bus arrives at the shelter
		The bus driver checks for occupants
		The bus driver stops for occupants after seeing signal
		The bus driver waits for occupants to enter bus
User exits shelter		
User enters bus		
End Conditions		
Bus leaving shelter		
User leaves with bus		
Notes		

Figure 25: Shelter Design – Use Case Behavioral Diagrams (2 of 9 Completed)

Drawing insights from these UCBDs and collaborating closely with the Architecture team, the team delineated an originating requirements list comprising 51 items. Each requirement was accompanied by its rationale and allocation to specific functions. Additionally, the Architecture team contributed 3 interface requirements based on their analysis. These foundational requirements were swiftly conveyed to the engineering teams as they commenced their mechanical and electrical design. These requirements were bounded by various constants managed by the systems group, ensuring control and constraint within the system. A comprehensive view of the full requirements list and the governing constants defining the system is depicted in Figures 26 and 27.

Index	Requirements	Function Name	Comments
OR.01	The shelter shall have a standing capacity that exceeds minimum shelter capacity	Locate Bus Stop	Rationale: Want to maximize shelter area for a number of people that could be waiting for a bus or in the surrounding area during a storm
OR.02	The shelter shall display the bus stop's identification placard	Locate Bus Stop	Rationale: the shelter needs to physically display as a bus stop for the transit service meaning it needs identification
OR.03	The shelter shall meet an ip rating target rating per the Ingress Protection (IP) standard	Deflect Precipitation	Rationale: Should protect against any debris (rain, water, snow, nuts, etc.) at vertical or tilted angles
OR.04	The shelter shall sense occupancy inside the structure to within occupancy sensitivity accuracy	Communicate Occupancy	Rationale: Don't want to falsely tell bus driver no one is in the shelter and the bus doesn't stop. Must be super accurate with occupancy but can be less accurate for no one in the shelter
OR.05	The shelter's occupancy signal shall be visible to the bus driver when the bus arrives at the shelter	Communicate Occupancy	Rationale: This can be done with see through walls or with lights. The driver just needs to know if someone is in the shelter
OR.06	The shelter's occupancy signal shall communicate no occupancy or occupancy to bus driver	Communicate Occupancy	Rationale: Don't want to falsely tell bus driver no one is in the shelter and the bus doesn't stop. Must be super accurate with occupancy but can be less accurate for no one in the shelter
OR.08	The shelter shall determine bus proximity to the shelter to a delta of proximity sensitivity seconds	Communicate Bus Proximity	Rationale: Want to make sure the signal is accurate enough for users to trust it and know when they see it that they need to get ready for bus to arrive
OR.09	The shelter shall communicate bus proximity using both visible and audible signals	Communicate Bus Proximity	Rationale: Accessible to both deaf / blind users
OR.10	The shelter's proximity signal shall be visible from all directions	Communicate Bus Proximity	Rationale: Shelters tend to be placed in open areas and need to be visible regardless of the direction
OR.11	The shelter's proximity signal shall be visible from signal visibility distance in all weather conditions	Communicate Bus Proximity	Rationale: Lights need to be visible from a certain distance like a parking lot where you need to know if bus is getting ready to arrive...expect you might be at the back of parking lot
OR.12	The shelter's proximity signal shall not exceed max lumen level	Communicate Bus Proximity	Rationale: Light Pollution (Public Domain), How Do We Measure It - In the Middle of the Night?
OR.13	The shelter's proximity signal shall be at max brightness when the bus arrives at the shelter	Communicate Bus Proximity	Rationale: Allows for users to safely be picked up and dropped off especially at night transitioning from shelter to the bus. More light the more safely this can be done (watch for blinding customers though)
OR.14	The shelter's proximity signal shall be audible from all directions	Communicate Bus Proximity	Rationale: Shelters tend to be placed in open areas and need to be audible regardless of the direction
OR.15	The shelter's proximity signal shall be audible from signal audibility distance in all weather conditions	Communicate Bus Proximity	Rationale: Sounds need to be audible from a certain distance like a parking lot where you need to know if bus is getting ready to arrive...expect you might be at the back of parking lot
OR.16	The shelter's proximity signal shall not exceed max decibel level	Communicate Bus Proximity	Rationale: Sound Pollution (Public Domain)
OR.17	The shelter's proximity signal shall be at max loudness when the bus arrives at the shelter	Communicate Bus Proximity	Rationale: Maximize those that may need to here that the bus is arriving soon or that the bus has arrived. Makes sure those in shelter hear and those that may be rushing to the shelter from distant location...should be equal to average
OR.18	The shelter shall sync bus proximity with transit API at least once every refresh rate seconds	Communicate Bus Proximity	Rationale: Want to make sure the proximity signal is refreshed with latest data so as to reset the bus-shelter proximity signal
OR.19	The shelter shall ensure user safety by preventing any electrical shocks	Protect Users	Rationale: Do no want users to get electrocuted on an aspect of the shelter
OR.20	The shelter shall withstand a max snow load covering all surfaces	Protect Users	Rationale: Don't want the structure to collapse under the weight of snow or any other factors
OR.21	The shelter shall maintain a min lumen level inside the structure when occupied	Protect Users	Rationale: For safety purposes...this should be on all the time
OR.22	The shelter shall maintain a min_lumen_level within lumen_boundary_distance outside of the structure when	Protect Users	Rationale: For safety purposes...this should be on when in transit
OR.23	The shelter shall withstand a max sustained wind gust from any direction	Protect Users	Rationale: Don't want the structure to collapse under a windstorm
OR.24	The shelter shall have at least minimum entrances	Protect Users	Rationale: Meet Americans with Disabilities Act (ADA) standards
OR.25	The shelter shall have at least minimum height of any walkway or entrance	Protect Users	Rationale: Meet Americans with Disabilities Act (ADA) standards
OR.26	The shelter shall have at least minimum width of any walkway or entrance	Protect Users	Rationale: Meet Americans with Disabilities Act (ADA) standards
OR.27	The shelter shall be traversable by passengers with disabilities under any conditions	Protect Users	Rationale: Meet Americans with Disabilities Act (ADA) standards, Includes Wheelchairs, crutches, scooters, etc.
OR.28	The shelter shall be certified structurally by a professional engineer for use in public outdoor space	Protect Users	Rationale: Projects was developed by a team of non-structural engineers outside of civil engineering - want signoff by the right authories
OR.29	The shelter shall video record the full interior continuously	Protect Users	Rationale: This is safety protection for the user but also to make sure theives or vandals can be identified
OR.30	The shelter shall video record the bus stop side of the exterior continuously	Protect Users	Rationale: This is safety protection for the user but also to make sure theives or vandals can be identified
OR.31	The shelter shall store video recordings for at least video recording retention period	Protect Users	Rationale: This is safety protection for the user but also to make sure theives or vandals can be identified
OR.32	The shelter shall dispatch emergency personnel to the location immediately when distress is detected	Protect Users	Rationale: this could easily be a call button but what if it was listening for someone to say help or scream and used the video recording or audio recording to automatically dispatch. Be great to have a button but what if I can't get to the
OR.33	The shelter shall dispatch emergency personnel to the location at an accuracy of greater than distress accuracy	Protect Users	Rationale: Don't want to create a boy cried wolf scenario where we get false signals and then when an emergency happens we don't have the response needed
OR.34	The shelter shall provide visible and audible distress signal if emergency services has been dispatched	Protect Users	Rationale: We want to create a distress signal if someone needs help so that others in the area may be able to help and to spook perpetrator. This should also prevent people from just hitting it randomly.
OR.35	The shelter shall contain no sharp edges less than sharp edge angle	Protect Users	Rationale: Do not want users to cut themselves on an aspect of the shelter
OR.36	The shelter shall input one-phase supply voltage from the electrical grid	Manage Energy Usage	Rationale: Don't want to add complexity by bringing in various phases of electrical power, mostly likely use residential voltage regulations
OR.37	The shelter shall operate without supply voltage from the electrical grid for at least battery backup time	Manage Energy Usage	Rationale: Bus still needs to run when the power is out. It should still operate properly without power input
OR.38	The shelter shall be composed of materials that do not change colors when exposed to sunlight	Maintain Shelter	Rationale: We don't want it to appear to lose quality over time. Want to look nice into the future
OR.39	The shelter shall be composed of materials that do not change weight when exposed to moisture	Maintain Shelter	Rationale: Water absorption could cause problem with structural rigidity and the present of water can cause corrosion, erosion, and decay of the structure
OR.40	The shelter shall maintain a mean time between repairs (MTBR) of at least mtbr minimum	Maintain Shelter	Rationale: Don't want to have to replace components consistently and want long life out of the shelter
OR.41	The shelter shall be serviced within max_service_time	Maintain Shelter	Rationale: Want this to be easy to maintain particularly changing light bulbs
OR.42	The shelter shall be composed of materials that can be washed of residue when exposed to spray paint	Maintain Shelter	Rationale: Want this to be made of vandal-proof materials...https://www.windowfilmdepot.com/blog/prevent-graffiti-and-vandalism-
OR.43	The shelter shall be composed of materials that are considered by CUSD or environmental authority as sustainable	Sustain Environment	Rationale: As a sustainable solution, we must use sustainable materials and manufacturing methods
OR.44	The shelter shall minimize power consumption when not in use	Sustain Environment	Rationale: As a sustainable solution, we must minimize power usage and be as efficient as possible
OR.45	The shelter shall minimize the number of unique components used in the design	Sustain Environment	Rationale: Sustain the environment by reducing number of components to be manufactured and energy used to make them
OR.46	The shelter shall reduce wind speeds to less than max wind within shelter anywhere within	Regulate Temperature	Rationale: Not trying to get temperature to certain value, just trying to drop windchill which is basically wind speed. Maybe reduce the wind by XX% or to a certain max wind speed of XX mph
OR.47	The shelter shall store at least bike capacity	Store Bikes	Rationale: Particularly on college campuses want to have bike storage where someone got to that point on bike but needs to go longer distance on bus and want temporary storage
OR.48	The shelter shall collect waste from the users	Collect Waste	Rationale: Anywhere users wait they will want to rid themselves of trash
OR.49	The shelter shall seperate perishable waste from recycleable waste	Collect Waste	Rationale: As a sustainable solution, we have to provide recycling options
OR.50	The shelter shall cost less than benchmark cost	Generate Revenue	Rationale: Want to be at least competitive but doesn't seem to be focused on a cost
OR.51	The shelter shall provide info on bus fares, payment, routes, and schedule	Generate Revenue	Rationale: Information either needs to be physcially displayed or linked to in some way shape or form for every transit service
IR.01	*The shelter base components shall connect at the following angles 0.0, 3.1, 7.6, 14.7, 37.6, 53.8 degrees*	Architectural	Rationale: To contain the catenary arch, the triangle panels need to connect at these angles
IR.02	*The shelter base components shall create a equilateral triangle module with side length at 100 cm*	Architectural	Rationale: To make up the catenary arch and produce the desired architectural effect
IR.03	*The shelter shall be free of any visible wiring*	Architectural	Rationale: visual appearance, vandalism prevention, safety for users

Figure 26: Shelter Design – System Requirements

Constants	Value	Units	Estimate?	Modified Date	Modified By	Due Date	Source
signal visibility distance	300	feet	Y	11/13/2023	Team		This is estimated distance one could walk within 1 minute (announcement from shelter and still make the bus)
signal audibility distance	300	feet	Y	11/13/2023	Team		This is estimated distance one could walk within 1 minute (announcement from shelter and still make the bus)
max lumen level	2640	lumen		11/13/2023	Team		Should this be 2640 Lumens from TCAT from Light Specs Sheet as a component requirement for lights https://www.novea-energies.com/en/your-project/shelter-and-bus-shelter/ or 10-20 lux
max decibel level	85	dB(A)		11/13/2023	Team		https://www.who.int/news-room/questions-and-answers/item/deafness-and-hearing-loss-safe-listening
max_wind_within_shelter	7	mph		11/13/2023	Team		https://en.wikipedia.org/wiki/Beaufort_scale: This is when wind chill starts to be effected https://www.math.wichita.edu/~richardson/windchill.html#:~:text=How%20the%20wind%20chill%20factor,has%20no%20further%20appreciable%20effect.
ip_rating_target	IP32	ip rating		11/13/2023	Team		Protect against 10 mm debris and 15 degree ingress of precipitation
max_snow_load	60	psf	Y	11/13/2023	Team		About 3 feet of wet snow
max_sustained_wind_gust	73	mph		11/13/2023	Team		https://en.wikipedia.org/wiki/Beaufort_scale: This is when hurricane force winds are experienced
min_lumen_level	690	lumen		11/13/2023	Team		Should this be 690 from TCAT Lighting Specs Sheet or should it be in lux
lumen_boundary_distance	10	feet	Y	11/13/2023	Team		Guess it should be 10 feet away even though bus shelters are typically 3 feet away
minimum_shelter_capacity	10	people	Y	11/13/2023	Team		Old -- should it be more or closer to capacity of a bus?
occupancy_sensitivity	95	%	Y	11/13/2023	Team		Best guess...should be very accurate...proposing 95%
proximity sensitivity	60	seconds	Y	11/13/2023	Team		Best guess...should be within a minute either way (typical duration of stop light)
mtbr_minimum	1	year	Y	11/13/2023	Team		Maintenance best guess
supply voltage	110	Volt		11/13/2023	Team		Typical for consumer power usage
max_service_time	60	minutes	Y	11/13/2023	Team		Maintenance best guess
minimum entrances	1	entrance		11/13/2023	Team		ADA standards tab
minimum_height	80	inches		11/13/2023	Team		ADA standards tab
minimum width	32	inches		11/13/2023	Team		ADA standards tab
benchmark_cost	8000	$USD	Y	11/13/2023	Team		Base on cost of other structures...using Alibaba links: https://www.alibaba.com/showroom/smart-bus-shelter-wifi.html but likely can go higher
video_recording_retention_period	30	days	Y	11/13/2023	Team		Longest retention likely to be 30 days
sharp_edge_angle	120	degrees	Y	11/13/2023	Team		Old statement of 120 degrees being safe to touch
bike_capacity	4	bikes	Y	11/13/2023	Team		Old statement of 4 bikes being the right capacity
distress_accuracy	99	%	Y	11/13/2023	Team		Accuracy will be difficult to test but felt like 1 in 100 is accuracy needed
battery_backup_time	3	hours	Y	11/13/2023	Team		Guess that it should run without power for average time power is out
refresh rate_seconds	15	secs	Y	11/13/2023	Team		Feels like the right length of time...anymore feels like overkill?

Figure 27: Shelter Design – Requirement Constants

Concluding the System Requirements Definition Process, the team disseminated system-level requirements to the engineering teams. However, the next phase necessitated the inception of the logical and physical architecture of the system. This step aimed to enable the allocation of requirements to tangible, physical solutions, further advancing the design and development trajectory.

Architecture Definition Process

With the system requirements in place, the team shifted focus towards the intricate task of allocating these requirements and functions to the diverse subsystems and components constituting the system, following the Architecture Definition Process. Defined by the INCOSE handbook, this process aims to generate and evaluate system architecture alternatives, aligning stakeholder concerns with system requirements while presenting these in coherent and consistent views.

Over the past semesters, the architectural form has persisted despite a change in stakeholders. However, the functional aspect of the shelter underwent significant transformation. The primary focus shifted towards conveying complex information in an intuitive manner for users, shaping the shelter's functionality while maintaining its architectural vision. The architectural form and the decision making and integration with engineering is discussed above in the architectural section.

The functional architecture underwent finalization through a mechanical design process. Employing concept fragments, brainstorming techniques, and tools like the Pugh matrix as documented in the mechanical section, the team identified conceptual architectures of the triangular building blocks and their interconnections within the overall structure. This process addressed mechanical constraints from previous semesters (constraining in the z-direction with a puzzle-piece concept) while initiating steps towards meeting the sponsor's vision of seamless assembly and invisible wire design.

Resulting from this amalgamation of physical and functional architecture was the logical architecture diagram (see Figure 28). While still a work in progress, this diagram delineated the breakdown of logical components within the shelter. It served as a guide to identify gaps, align subsystem compositions, and highlight key functionalities such as internet connectivity for bus API integration and the necessity for multiple modes of lights to communicate occupancy and bus proximity.

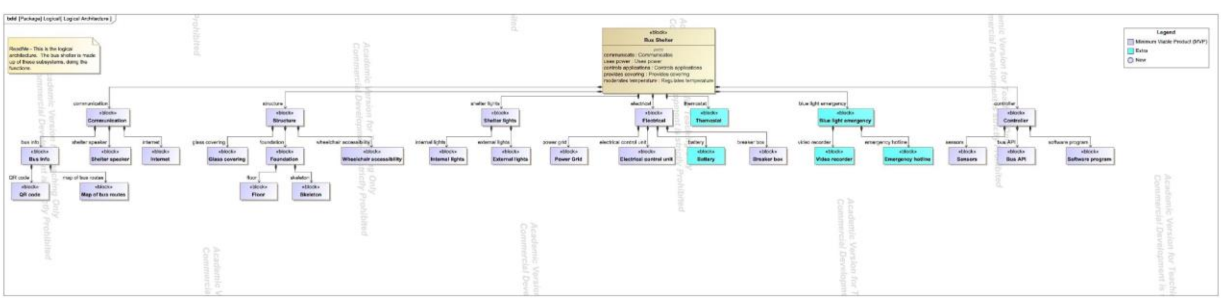

Figure 28: Shelter Design – Logical Diagram (Subsystems / Components using SysML)

Having defined the logical and functional architecture, the team prepared to delve into detailed design work, marking the project's transition from the Concept Stage to the Development Stage according to the INCOSE handbook. This shift in focus would center on integration and design activities at the lower levels of the System Engineering Vee-Diagram, marking a pivotal phase in the project's evolution.

Design Definition Process

Entering the Development Stage, the team split efforts into two primary streams, honing in on detailed design work concerning the mechanical structure and visual communication via the Design Definition Process. The Design Definition Process, in accordance with the INCOSE handbook, aimed to furnish comprehensive data and insights about the system and its components, ensuring implementation aligns with the defined architectural entities.

In the mechanical domain, as detailed previously in the mechanical section, the team concentrated design efforts on aspects crucial to structural integrity, manufacturability, wire visibility, and the connection of triangular building blocks. Special emphasis was placed on accommodating two types of lights—one RGB and one non-RGB LED

Concurrently, the systems team directed their focus toward visual communication, assisting the electrical team in devising design guidelines before crafting electrical circuitry. They utilized Functional Flow Block Diagrams (FFBD) to gain an initial understanding of functions such as Communicating Occupancy, Communicating Proximity, and their resultant Manage Energy Usage, showcased in Figures 29, 30, and 31.

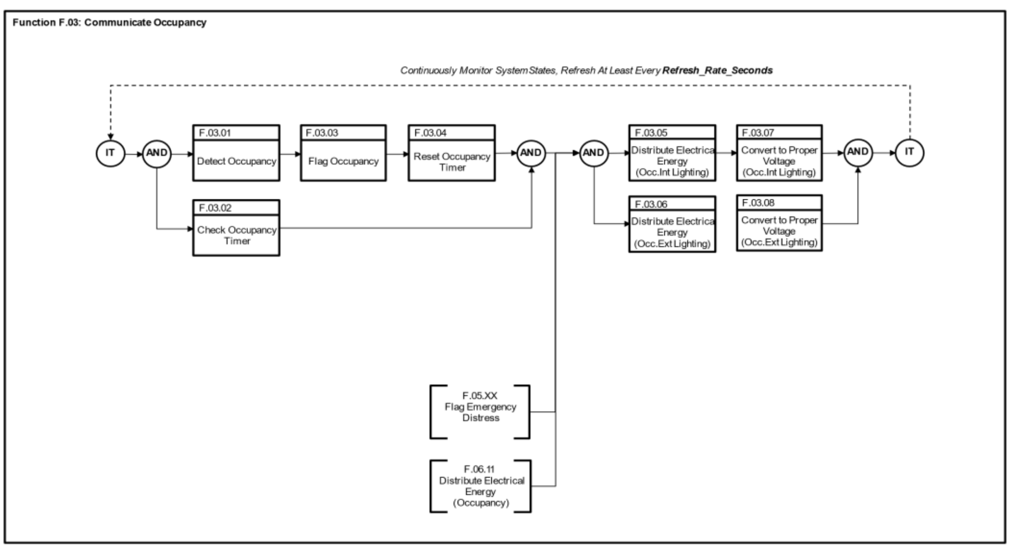

Figure 29: Shelter Design – Functional Flow Block Diagram (Communicate Occupancy)

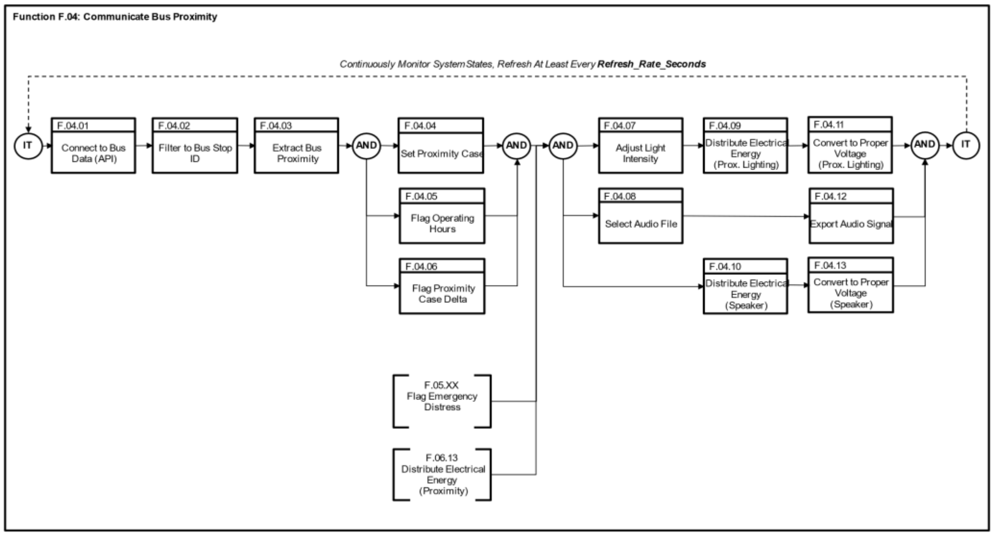

Figure 30: Shelter Design – Functional Flow Block Diagram (Communicate Proximity)

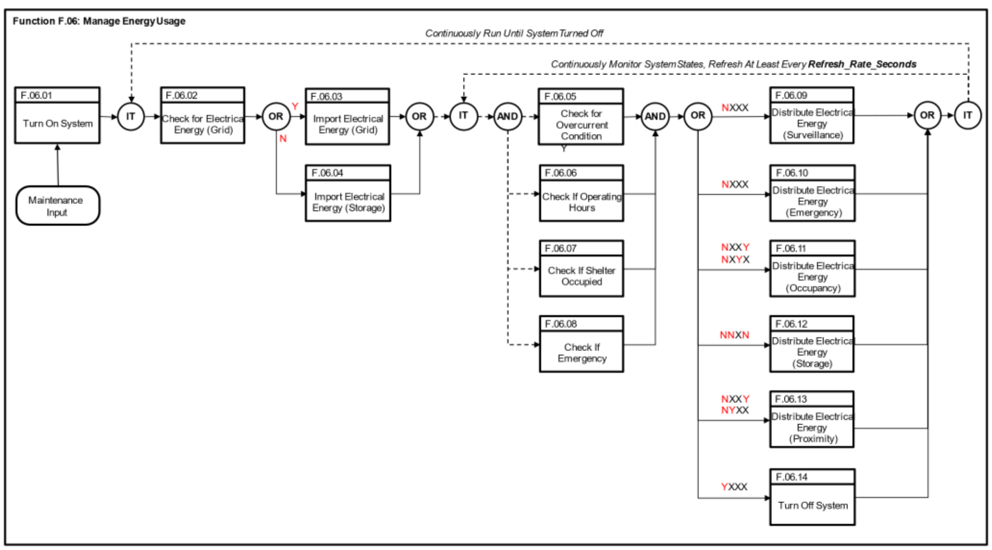

Figure 31: Shelter Design – Functional Flow Block Diagram (Manage Energy Usage)

While these diagrams laid a foundation for communicating the unique functions of proximity and occupancy and their interdependencies, they lacked the detailed sequencing sought by the electrical team. To address this, the team resorted to activity diagrams, illustrating logical flows and sequences based on the defined logical architecture from the Architecture Definition Process. Figures 32 and 33 depict activity diagrams outlining the sequences for these sub-functions.

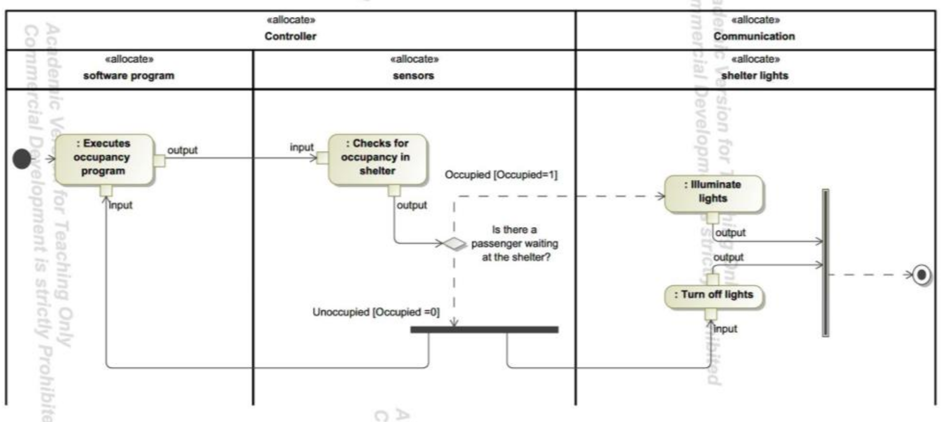

Figure 32: Shelter Design – Activity / Sequence Diagram (Communicate Occupancy)

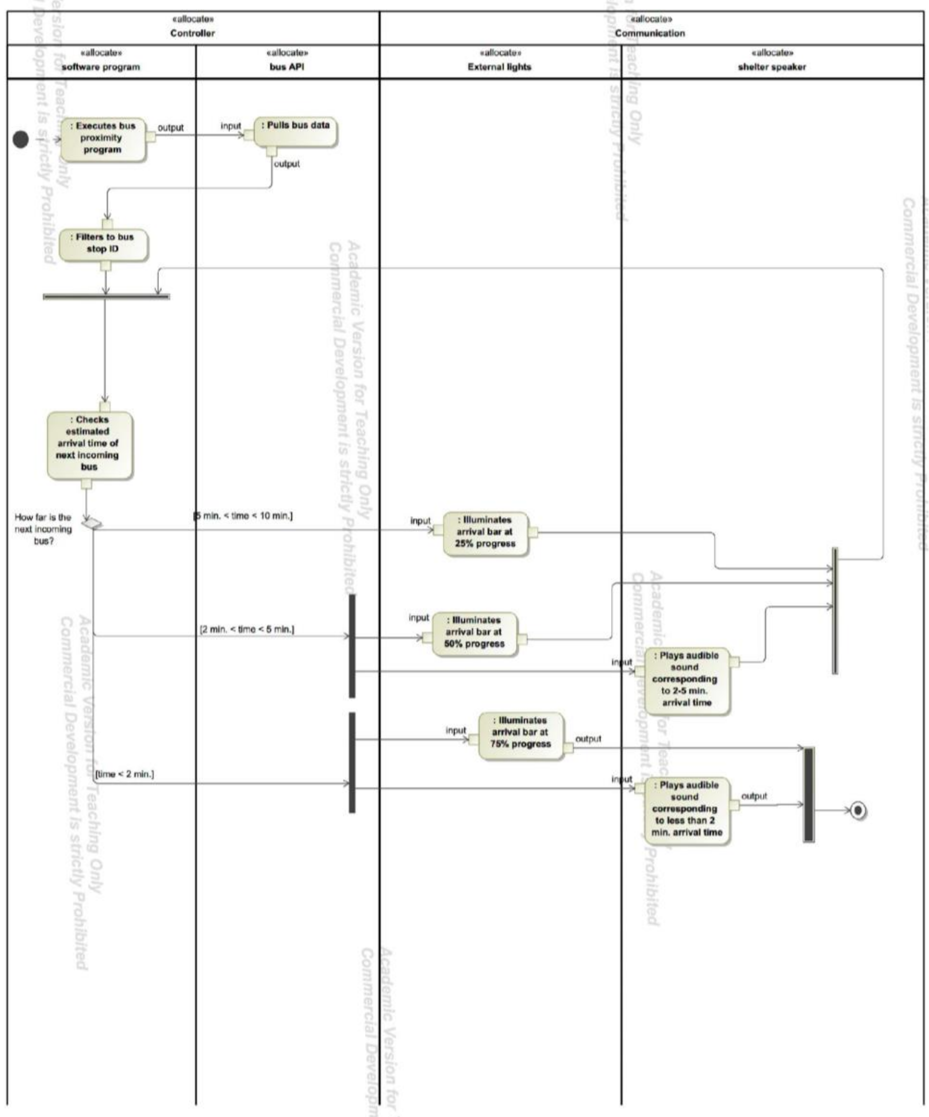

Figure 33: Shelter Design – Activity / Sequence Diagram (Communicate Proximity)

These activity diagrams delineated inter-subsystem activities, logical behavior, and lower-level functional breakdowns. They effectively conveyed the envisioned interactions concerning proximity and occupancy data with speaker and lighting systems, outlining specific system responses in various scenarios. Utilizing this information, the architecture team crafted Figure 34 to convey intentions of communication system to stakeholders during the Design Definition Process.

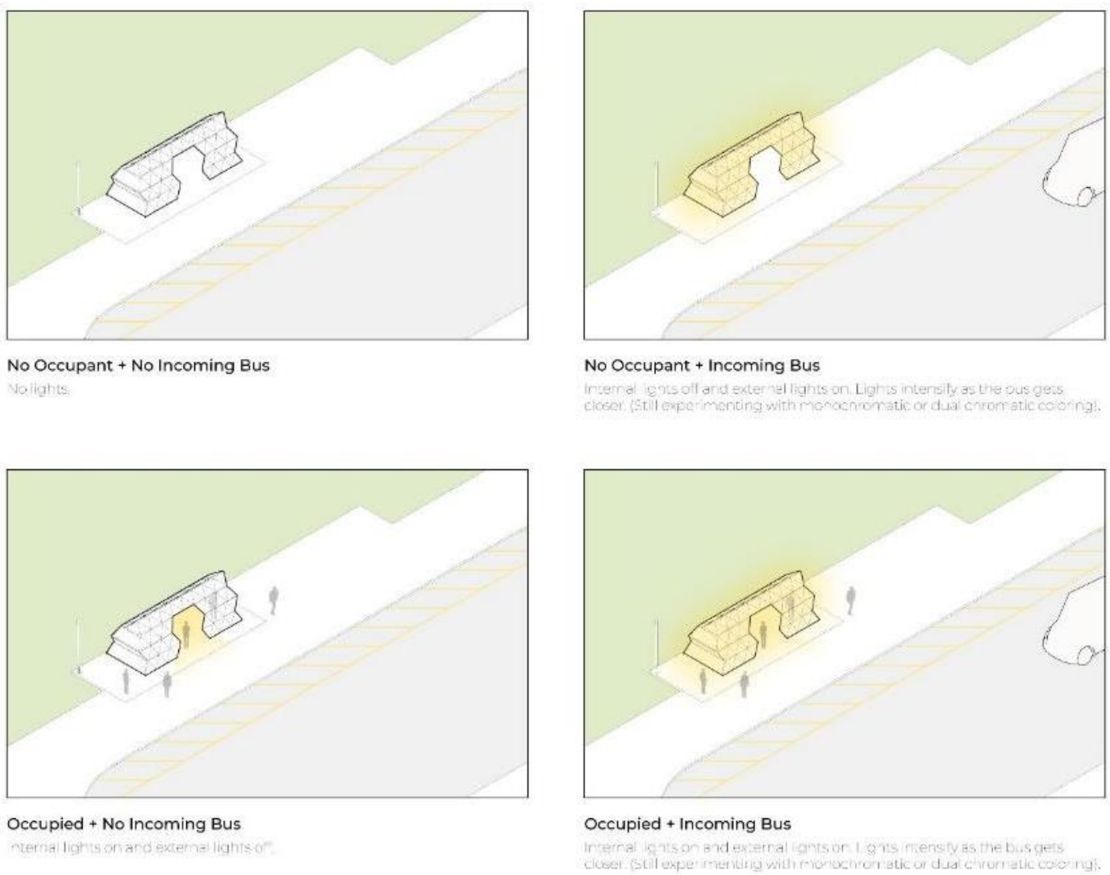

Figure 34: Shelter Design – Visual Communication Design (Simple)

Further work remains in the Design Definition Process, especially in refining detailed design aspects within the mechanical structure and the electrical control system. Design iterations and refinements are anticipated in the next semester, with a significant focus on scrutinizing failure modes and risks via analysis and prototyping within the System Analysis and Implementation Processes.

Systems - Next Steps

The semester marked a pivotal success for the systems facet of the project, despite the substantial shifts in mission, problem statements, and stakeholder dynamics. The team adeptly navigated these changes, efficiently reworking stakeholder needs, requirements, and the architectural framework to align with the updated project trajectory. However, looking ahead, substantial work remains to consolidate and refine the logical architecture while continuing to enhance the detailed design. The forthcoming semester will prominently feature a concerted effort to streamline functions, use cases, requirements, subsystems, and componentry, ensuring a more cohesive system framework.

To expedite progress and ensure seamless integration, the team plans to merge the mechanical and electrical aspects, fostering a harmonized engineering team. This integrated approach will facilitate swifter advancement in design endeavors, with a keen focus on delineating electronic hardware implications on the mechanical framework and the overall system dynamics. Additionally, a significant emphasis will be placed on formulating a comprehensive test plan for the system. This plan aims to drive analysis-led design work, aiding in the identification of potential risks through a meticulous Failure Mode and Effects Analysis (FMEA). These proactive measures are crucial before embarking on the implementation process and the production of drawings and components. Central to the upcoming tasks is the pivotal role of the systems team in facilitating the integration of all system aspects within the overarching vision. Their task involves aligning the engineering design team to ensure a holistic and cohesive system approach that encompasses all elements of the project's envisioned outcome.

Next Steps

The team has now solidified both the physical and functional architecture, marking a pivotal transition from Concept to Development phase, emphasizing a detailed examination of component interfaces and component design. Although primary architectural decisions have been settled, several lingering queries persist around secondary functions, such as bike storage and bus identification placement, requiring further consideration from an architectural standpoint. However, the impending focus for the next semester centers on achieving a comprehensive and finalized electrical and mechanical design, aiming to address all outstanding queries while commencing significant testing and in-depth analysis. The team aspires to construct a scaled prototype using akin materials to conduct a meticulous system check, albeit potentially downscaled, offering an opportunity to scrutinize both mechanical components and electrical logic.

The team's primary emphasis heading into next semester is directed toward small-scale prototyping and testing, essential for evaluating design efficacy and logic functionality. The success of the upcoming semester hinges on the sequential completion of numerous small tasks, enabling the progression toward larger-scale models of components. This proactive approach aligns with the team's strategy to remain aggressive and agile, steering efforts towards realizing a functional prototype. The ultimate objective is to secure funding to initiate production, aiming to deploy at least one full-scale system within a specified location detailed in the Shelter Masterplan section, prominently within the Cornell Campus.

Shelter Masterplan

Introduction

The Shelter Masterplan team has dedicated preceding semesters to collaborating with diverse stakeholders in the City of Ithaca and Tompkins County, laying the groundwork for the integration of a hybrid-electric shuttle bus into Ithaca's transportation grid. Initial efforts were channeled into redeveloping strategies for the Gadabout on-demand paratransit service. Furthermore, the team undertook initiatives to establish a direct shuttle route linking the Ithaca Tompkins County International Airport and Cornell University. However, this semester witnessed a shift in focus toward specific bus stop analysis, a strategic pivot aimed at complementing the ongoing design endeavors of the Shelter Design team. This recalibration in objectives aimed to deepen the understanding of specific bus stop dynamics, aligning seamlessly with the comprehensive design work underway within the Shelter Design team.

Progress

Analysis Method and Assumptions

The team embarked on a comprehensive evaluation of TCAT's extensive network, encompassing numerous routes and hundreds of stops across Tompkins County. This evaluation aimed to assess existing stops and identify potential locations for a new shelter, particularly focusing on stops proximate to or on the Cornell Campus. Eight specific bus stops—A Lot, Baker Flagpole, Collegetown at Oak, Collegetown Schwartz, Collegetown Proposed, Dairy Bar, Kennedy Hall, and Rockefeller Hall—were meticulously analyzed based on a set of eight criteria. These encompassed geographical coordinates, served routes, ownership, presence of existing shelters, ADA accessibility, infrastructure context, nearby geographical features, and areas of interest. To augment the data, site visits were conducted to observe user interaction with shelters and amenities at these stops.

Employing Microsoft Excel for data organization, the team collated and categorized the gathered information. Subsequently, this data was visualized and presented via a Story Map created in

ArcGIS ([Link]()). Additional considerations were factored into this evaluation, including rider usage data, existing infrastructure, and the identification of specific focus stops on the Cornell Campus. The team also highlighted the significance of ridership statistics (shown in Figure 35), illustrating bus boardings per stop based on the most recent available data from Spring 2022. Moreover, the presence or absence of existing shelters at various stops, particularly within the Cornell Campus vicinity, was carefully considered in the selection process. This culminated in the identification of a smaller subset of focus stops on the Cornell Campus that were subjected to further scrutiny and evaluation to determine the feasibility of installing new shelters.

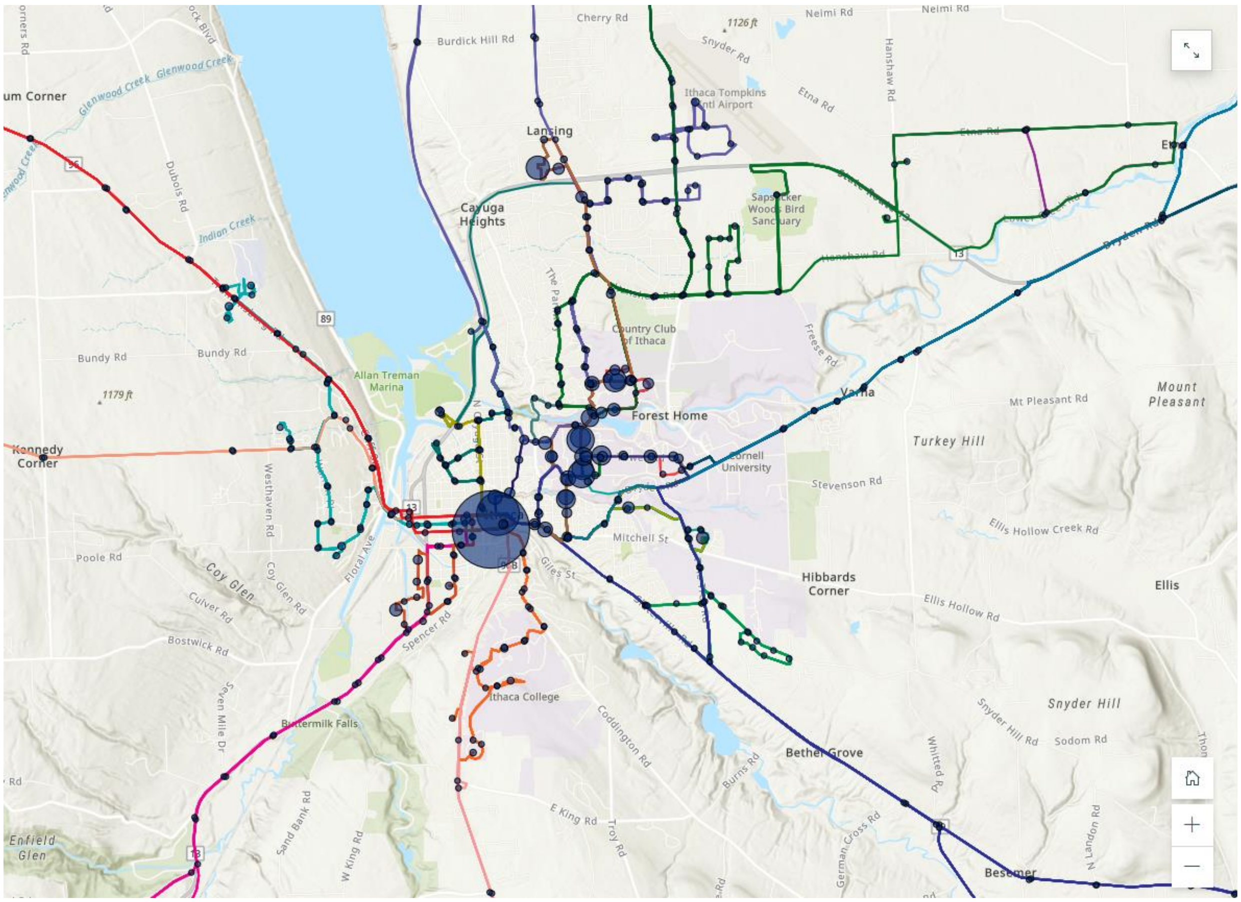

Figure 35: Shelter Masterplan – Ridership Statistics by Stop **(Larger Bubble More Riders)**

Baker Flagpole Evaluation

- Ownership: Cornell
- Existing Shelter: No
- ADA Accessible: Yes

Baker Flagpole (shown in Figure 36) is West Campus' main weekend and night stop, adjacent to Libe Slope and Lyon Hall on Cornell property. It is predominantly used by nighttime and weekend riders on route 92 and weekend riders on route 30. It receives hourly frequencies throughout the night and half-hourly frequencies from 7:00 am till 10:00 pm on weekends. The stop features ADA-accessible 5-foot-wide sidewalks, two midblock crosswalks, bus pullouts, nearby electrical hookups, and ADA-accessible connections to West Campus. It currently lacks any shelters, lighting, or rider amenities, and the crosswalks are missing detectable warning strips. Given the high volume of nighttime riders, this stop would especially benefit from added lighting and shelters. While Libe Slope constrains the northbound stop's footprint - requiring a retaining wall for shelter construction - the southbound stop could fit a shelter.

Figure 36: Shelter Masterplan – Baker Flagpole

Kennedy Hall Evaluation

- Ownership: Cornell
- Existing Shelter: Yes
- ADA Accessible: Yes

Kennedy Hall Stop (shown in Figure 37) is the busiest bus stop near Ag Quad, mainly serving students who have classes around on weekdays. The bus service provided by 12 routes starts from 7 am to 10 pm on weekdays and Saturdays and from 8 am to 7 pm on Sundays. The primary interests of this area include Bus Stop Bagels, Trillium Dining, CALS, and Dyson School. So far, the stop has a concrete-grounded shelter that has five seats, which are fixed to the concrete ground by bolts, and shielded space inside at two sides. The shielded space at each side is potentially enough to accommodate a wheelchair. Thus, the size of this shelter is larger than the majority of on-campus ones. Its seats are at the back of the shelter with enough width for small-sized people to sit and expand their legs with a backpack on. The stop has one lighting but its functionality at night needs more observation. The glass shield at four sides of the shelter leaves gaps at the bottom, enabling ventilation while providing good visibility of the coming buses. Overall, the current shelter at Kennedy Hall stop is functioning decently with riders sitting inside of it. As the land is under the ownership of Cornell University, this shelter has been there for years, and this stop is rather popular, we expect replacing the old shelter to be relatively possible and more helpful for the promotion of the newly designed stop.

Figure 37: Shelter Masterplan – Kennedy Hall

Collegetown at Oak Evaluation

- Ownership: Cornell
- Existing Shelter: No
- ADA Accessible: Yes

Collegetown at Oak (shown in Figure 38) is currently one of the three primary stops in Collegetown. It serves the area closest to the campus, with primary interest spots including Schwartz, CTB, IBC, and many other restaurants. Additionally, it's a popular living area for many upperclassmen students. Since there likely isn't enough room at the current location, we propose relocating the stop to the nearby roundabout, approximately 10 feet away. This change would provide adequate space for a full-sized shelter. We believe that Cornell currently owns the existing stop, but we would need to investigate the ownership of the proposed new location. From our observations, people tend to stand at this stop, likely due to the frequency of the bus routes it serves and the current lack of a bench for seating. Not much room for a bus stop. Mostly cement and IBC uses most of the area outside for seating.

Figure 38: Shelter Masterplan – Collegetown at Oak

Collegetown at Schwartz Evaluation

- Ownership: Cornell
- Existing Shelter: No
- ADA Accessible: Yes

Collegetown at Schwartz (shown in Figure 39) is currently one of the three primary stops in Collegetown. It serves the area closest to the campus, with primary interest spots including Schwartz, CTB, IBC, and many other restaurants. Additionally, it's a popular living area for many upperclassmen students. There is currently no shelter, but there is a small bench. While this stop has enough room for a shelter, we could also relocate this stop to the nearby roundabout, approximately 15 feet away. If not, there is still plenty of room at the current location. We believe that Cornell currently owns the existing stop, but we would need to investigate the ownership of the proposed new location. From our observations, people tend to stand at this stop, likely due to the frequency of the bus routes it serves and the size of the current bench.

Figure 39: Shelter Masterplan – Collegetown at Schwartz

Potential New Collegetown Stop Evaluation

- Ownership: Cornell
- Existing Shelter: No
- ADA Accessible: Yes

This is the location of the proposed new Collegetown at Oak stop (shown in Figure 40). It is currently a roundabout circle with shrubs and cement. This would be able to accommodate a new shelter.

Figure 40: Shelter Masterplan – Potential New Collegetown Stop

Dairy Bar Evaluation

- Ownership: Cornell
- Existing Shelter: Yes
- ADA Accessible: Yes

The Dairy Bar stop (shown in Figure 41) is an important stop on Cornell's eastern side of campus, servicing routes used by students, faculty and staff alike- the routes 20, 21, 32, 37, 40, 43, 51, 52, 65, 67, 81, and 82. The most trafficked route is the 81, with the 82, 32, 37, and 51 being other important urban routes. The stops on both the north and south sides of the street are situated on property owned by Cornell. Both stops appear to be ADA complaint, with curb cuts and bump strips. The geography of the site on the north side of the street comprises a relatively flat area situated on the edge of a slope. Meanwhile, on the south side, there are permeable pavers covering a flat surface next to a gently sloped green area. The shelter on the north side is older, with the pyramid array style of roof, while the shelter on the south side is newer with an open design that does not provide great coverage from the elements. The areas of interest near the stop include Stocking Hall and the Dairy Bar, the botanic gardens, the soon-to-be-opened Atkinson Center, and the athletic fields used for games. Concerns for replacing these shelters should focus on their adequacy for protecting from the elements, as well as providing information for upcoming arrivals and departures, as both sides of the street are lacking these technological enhancements.

Figure 41: Shelter Masterplan – Dairy Bar

A-Lot Evaluation

- Ownership: Cornell
- Existing Shelter: Yes
- ADA Accessible: Yes

The A-Lot (shown in Figure 42) is one of the most important stops in the TCAT system when in use Monday through Friday. The stop is only served by one route, the intra-campus 81 shuttle, but receives frequent service from 5am to 7pm every weekday. The stop is located in an important parking lot for faculty and staff who drive to campus and take the bus to their final destination. The parking lot itself is home to two identical looking bus stops, the lower stop and the upper stop. The 81 will frequently sit at the lower stop before setting out for another loop around campus to the Vet School. Both the existing shelters are spacious and the shelters embed well into the parking lot. The shelters are quite dated, however, with the interiors appearing quite dilapidated. In that sense, a new shelter at both the lower and upper stop, or a single stop in the middle serving the entire A Lot, would be an immense improvement over the current situation.

Figure 42: Shelter Masterplan – A-Lot

Rockefeller Hall Evaluation

- Ownership: Cornell
- Existing Shelter: Yes
- ADA Accessible: Yes

The Rockefeller Hall stop (shown in Figure 43) is one of the main TCAT stops on central campus. The stop serves destinations on and near the Arts Quad, including Baker Lab, Rockefeller Hall, the PSB, Goldwin Smith Hall, Lincoln Hall, and Sibley Hall, among others. There are three nearby cafés: Green Dragon, Temple of Zeus, and Goldie's. The stop is owned by Cornell. In terms of user behavior, riders typically sit and wait for the bus on the small brick wall next to the bus shelter. When both the wall and the shelter are full, people stand around on the sidewalk to wait. The shelter is located below a steep slope to access Rockefeller Hall and the PSB, which may cause accessibility issues that Cornell would need to address. The existing shelter is of the older, pre-NCRE style, and often fills very quickly. A new, larger shelter would certainly be well used by students returning to North Campus, as well as medium-distance commuters. There is also ample space for a larger shelter, with extra space existing between the current shelter and the bike racks.

Figure 43: Shelter Masterplan – Rockefeller Hall

Boldt Hall Evaluation

- Ownership: Cornell
- Existing Shelter: No
- ADA Accessible: Yes

Cornell’s Boldt Hall (shown in Figure 44) is a highly utilized stop for west campus residents. This stop is served by TCAT’s route 10, which runs weekdays 7am-5pm with high frequencies. It also serves route 36. This stop is unused on the weekends. This stop currently doesn’t have a shelter attached to it and has a steep-cross slope. Any shelter would have to be constructed on a concrete pad installed in the grassy strip between the road and the sidewalk. This would require significant leveling or a dynamic shelter to be installed.

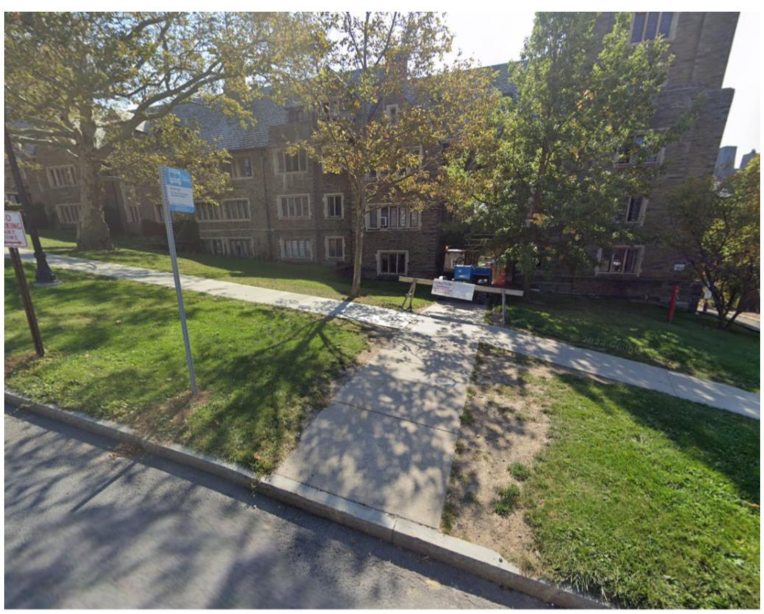

Figure 44: Shelter Masterplan – Boldt Hall

Recommendation for Shelter Location

In the team's assessment, the A-Lot and Rockefeller Hall stops emerge as prime candidates for the installation of new shelter design. The A-Lot stop boasts ample space for construction, offering a substantial improvement over its current dated structures. Meanwhile, at Rockefeller Hall, the existing shelter diverges from the typical design seen along Feeney Way and often leaves passengers exposed to the elements. The team envisions a new shelter at Rockefeller Hall that not only provides protection for waiting passengers but also ensures visibility to bus drivers, facilitating a seamless boarding process. This proposed design aligns with the team's objectives and could serve as a prototype for future shelter installations.

Research Grants for Shelter Construction

The team identified three potential grant programs for securing funding for the shelter construction. Firstly, the FTA Buses and Bus Facilities Grant Program, aimed at government agencies and transit bodies, has historically supported bus-related facilities, including shelters. TCAT, in collaboration with Cornell, could apply for this grant, with applications due annually in April. Secondly, the US Department of Transportation's SMART Program allocates $100 million yearly for technological integration in transportation systems. To qualify, the shelter design would need to include real-time information, with applications due annually in October. Lastly, the New York State Transit State Dedicated Fund (SDF) Program offers capital project funds for government agencies, specifically targeted for system enhancements and innovative capital projects. Allocations are made annually in October as part of the Governor's multi-year Transportation Plan, providing resources that exceed federal and local availability for non-MTA systems.

Next Steps

The team is poised to collaborate with the SYSEN 5740 course "Design Thinking for Complex Systems" and the Ithaca Tompkins International Airport to enhance multimodal transportation to and from the airport and streamline curbside-to-gate operations. Conducting empathy fieldwork with airport users will provide invaluable insights for identifying areas for improvement. Additionally, the team remains committed to sourcing grant opportunities for the Shelter Design team's bus shelter prototype. Regular communication of grant information to relevant partners like TCAT and the design team ensures swift initiation of the testing and construction process by Shelter Design team.

There's a concerted effort to engage with other transit agencies and propose partnerships aimed at enhancing efficiency, sustainability, and equity within their services. Leveraging expertise in ArcGIS, empathy fieldwork, and research, the team aims to extend collaboration beyond the bus shelter and Light Green Machines (LGM) to embrace a broader scope of impactful initiatives. These initiatives are set to kick off immediately after the current semester, ensuring a seamless continuation of ongoing work. Establishing partnerships with transit company stakeholders across the US is prioritized, aiming for collaboration commencement right from the beginning of the upcoming semester to maximize collective impact and effectiveness.

Applicant 3: David Suarez (*Office of Student Government Relations*)

Applicant Name: David Suarez

Applicant Organization: Office of Student Government Relations (OSGR)

Requested Funding Amount: $13,650

Current Status: Pending Commission Vote

Project Idea:

Implementing heating lamps in Bus Shelters across the CU campus

Would entail affixing a heat lamp to roofs of shelters

Currently only focused on stops with a seating area/ roofing

Includes ALL parts of campus (North, West, Central, Vet)

Problem / Beneficiary:

Focus on increasing comfort for students

Providing cozier environment for students

This would benefit all students in an equal manner

Bus Stops are accessible to all

ANY student taking the bus could use/activate the lamps

Motivation:

We were motivated by our own experience here at Cornell's Ithaca Campus as undergraduate students. Having to bear the brunt of snow/rain and low temperatures even under bus stop covers.

Applicant 4: James Paul Swenson (*Student Assembly*)

Applicant Name: James Paul Swenson

Applicant Organization: Student Assembly

Requested Funding Amount: $50,000

Current Status: Pending Commission Vote

Project Idea:

My idea is to increase infrastructure on campus that will improve Cornells beauty and comfortability. I am working with the University Architects to identify areas around campus that need more greenery, benches, hammock groves, bike racks, ect. The impact to undergrads is that they will have more places to sit on and around central campus, and we will focus on specific areas of the residential communities, like West and North Campus.

Problem / Beneficiary:

The problem I am trying to address is a lack of seating outdoors on campus specifically. There are not enough benches and seating areas. Specifically, on and around the slope/central campus and around Bebee Lake. I believe the entire Cornell Community will benefit from an increase in benches. For greenery, Cornell can also get more beautiful. I am a believer that, the more trees, the better.

Motivation:

I was motivated to spend the SAIF fund given this fund does not roll over into next year. I believe these types of infrastructure improve campus life greatly and will make Cornell more comfortable and green. I am working with the University Architects to implement this idea and they will send me the unit prices of each type of item (trees, benches, bushes, chairs, ect.) and I hope to work with this committee to allocate funding and influence where specifically the infrastructure is placed.

I am requesting $50,000 from this fund to emplace more trees, bushes, benches, bike racks, and other types of relevant infrastructure on campus.