



MEMORANDUM

To: Kimberly Lemieux
CC: ECET Capstone Faculty, Camosun College
From: Cameron Gillingham, Tella Osler, Aaron Huinink
Date: September 20th 2024
Subject: FLoRa Communications Proposal

SUMMARY

Outside the bounds of cellular service, there are a lack of affordable communication choices for the average outdoors recreationalist. Expensive satellite subscription devices are a safety essential for seasoned and technical outdoors people, but for casual hikers this can be a prohibitively expensive option. We aim to provide an inexpensive means of communication with the ease of scanning a QR code on your own smartphone. In 2022 a fatality occurred on the Kludahk trail in Jordan River. This tragedy highlights the importance having accessible communication in remote areas.

Our prototype LoRa (Long Range) radio mesh network will be released December 13th, 2024 as a first step towards a future implementation on the 48 km Kludahk trail outside of Jordan River, BC. LoRa is the perfect long range digital radio transmission choice for this low-noise, backcountry environment. It operates on the unlicensed 915MHz band and has low power requirements, allowing for off-grid, solar powered applications. Users will connect to our web application via Wi-Fi access points at LoRa mesh network nodes along the trail and will be able to post public messages on the user-friendly interface. It is our goal to develop the trail's LoRa network in the future to include cellular integration with emergency services.

The node hardware prototype *Petal v0.0* will be released October 1st 2024 and the user interface software beta *AVAlink* will be released October 28th 2024. We request you accept the proposal and provide us with feedback in a timely fashion so we can remain on target for our scheduled milestones.



CONTENTS

Memorandum.....	1
Summary.....	1
Background.....	4
Current Solutions	4
Petal Radio & AVAlink Network	4
Target Market	4
Moving Forward	5
Technical Overview.....	5
Theory of Operation	5
Scope	6
Deliverables	6
Features.....	6
Not Covered	6
Methods	7
Hardware	7
Software/Firmware	7
Parts & Materials	8
Management Overview.....	8
Our Team.....	8
Logistics	9
Suppliers.....	9
Manufacturers	9
Transportation	9
Storage	9
Facilities.....	9
Financial Overview.....	10
Major Costs	10
Labour	10
Parts	11
Minor Costs	12



Manufacturing	12
Shipping	12
Capital.....	12
Assumptions	12
Conclusion.....	13
Appendices	14
Appendix A: References	15
Appendix B: Requirements Specification.....	16
Appendix C: Schedule Milestones.....	21

BACKGROUND

British Columbia boasts a massive outdoor playground that attracts thousands of wilderness enthusiasts, recreators, and tourists every year [1]. Backcountry recreation is a chance to escape cellular service and the constant barrage of notifications, emails, and breaking news, but it is also inherently risky. When an emergency arises, contacting rescue services as soon as possible is essential to prevent serious injury or death.

Current Solutions

The current technologies for emergency backcountry communication rely on expensive subscription-based satellite devices like the Garmin InReach and SPOT X. These start at \$150 USD [2] and go up to more than \$800 USD [3]. They also require a monthly satellite subscription to operate which is another \$15-\$50 expense incurred by each user per month, depending on the device and the plan [4]. These devices make practical and fiscal sense for hard-core outdoor enthusiasts who spend a lot of time in the backcountry. For most people, though, an expensive GPS satellite messaging device is not feasible.

Petal Radio & AVAlink Network

LoRa (Long-Range) digital radio is a recent innovation that enables a robust text-based communication protocol [5]. FLoRa Communications is designing a LoRa-capable digital radio (*Petal*) and a full-stack

repeater network solution called AVAlink. Instead of requiring users to have an expensive satellite device, our repeaters will host a browser-based web application so that anyone with a smartphone can access the network. Solar panels and battery banks will power each repeater, making them available year-round. Users will send messages via a public chat which will be transmitted along the mesh network and accessible by other users. In the future, repeaters will form a LoRa mesh network that connects to the emergency response infrastructure in the area, like search and rescue and 911.



Figure 1: AVAlink logo.

Target Market

FLoRa aims to provide an affordable alternative to anyone accessing BC's great outdoors. While most hard-core outdoors enthusiasts own an emergency transponder like a Garmin InReach, casual recreators do not. This product targets established outdoor tourism/recreation organizations who see a large volume of casual and seasoned outdoor visitors and who want to add a layer of redundancy to their safety communication systems that patrons can access in the event of an emergency.

We will also provide contracting services to these organizations to evaluate their communication needs, design a network, and deploy our products in their region. We are already in talks with the Kludahk Outdoors Club to do a trial of our product on the Kludahk Trail.

Moving Forward

The future of the prototype we present in December will be *Petal v1.0* and *AVALink v2.0*. In future iterations, we will bring cost-reduction and manufacturability improvements to the *Petal* and improved features to the *AVALink* suite of firmware and software. The hardware will move away from expensive specialty modules and implement its own RF circuitry for the LoRa and Wi-Fi functions. This will reduce the cost per board, and it will also eliminate the board's reliance on specialty RF modules by using widely available parts instead. We will upgrade the firmware to allow network administrators to update devices over the air, and we will add features to the web application to improve user experience.

TECHNICAL OVERVIEW

When first exposed to LoRa as students we envisioned the possibility of utilizing this platform for an emergency network of sorts. We now plan to leverage the advantages of this impressive technology to make our early ideas a reality.

Theory of Operation

LoRa provides low-cost and robust text-based digital radio. The power efficiency and small form factor of the transceivers [6] is perfect for outdoor solar powered communications, and multiple LoRa nodes can be connected to form a mesh network that extends coverage [7].

The most popular LoRa mesh network solutions today, like Meshtastic, require each user to have their own LoRa device to connect to the network. They are highly customizable but also highly complex. Node setup requires flashing firmware onto the device using a command line or web-based flasher tool. Each user must have some knowledge of LoRa and other digital radio concepts to set up their devices, and the user interfaces must be pre-installed on the user's phone. The less technically inclined will find it challenging to use the current LoRa mesh network solutions.

We will develop a mesh network that users can access at any time, without needing their own LoRa device or application. They will simply connect to a Wi-Fi access point provided by the node, scan a QR code to open the web application served by the node, and they can



Figure 2: LoRa Mesh network topology from [7].



send messages to the local mesh chat. In future releases, they will also be able to contact emergency service.

Scope

Deliverables

In this prototyping stage, FLoRa Communications will deliver both hardware and software products according to our requirement specifications (**Error! Reference source not found.**).

Petal v0 will incorporate a LoRa transceiver, a microprocessor and Wi-Fi module, a 3.3V power supply, antenna connections that effectively transmit the LoRa packets, and a bespoke enclosure.

AVAlink v1 will provide a browser-based user interface that allows users to send text messages (chats) from one device to another. The chats will be displayed across the network in real time with an identifier for the sending device and a timestamp. The firmware will monitor the battery voltage and initiate low power disconnects to preserve the battery. It will also use a multiple access strategy to deal with the hidden-node problem [8] and prevent packet collisions while also ensuring predictable latency across the mesh network.

We will also provide documentation for each product, including a user manual for the software/firmware and recommendations for sizing solar panels and batteries for the hardware.

Features

The *Petal* enclosure should have an ingress protection rating of at least IPX4 which protects it from rain in an outdoor setting. The *AVAlink* software should have an SOS mode which directly connects to local emergency services and minimizes network latency at the expense of power efficiency.

Not Covered

The prototype will not include integration with specific emergency services or the solar power and battery requirements for an actual network deployment since this will depend on the location of the installation. We will also use specialty third-party modules for the Wi-Fi and LoRa functions to reduce our development time. These will be replaced with more widely available and manufacturable parts in *Petal v1*.

Methods

Hardware

We will have our first PCB prototype (v0.0) based on our base hardware design (Figure 3) developed in Altium Designer and sent to JLCPCB for manufacturing by October 1st. We will develop a hardware testing schema by that date as well. Based on our testing data, we will revise the PCB and submit an updated v0.1 with appropriate change documentation by October 29th, along with the first version of the enclosure. We will have a final prototype revision (v0.2) and enclosure submitted for manufacturing by November 19th.

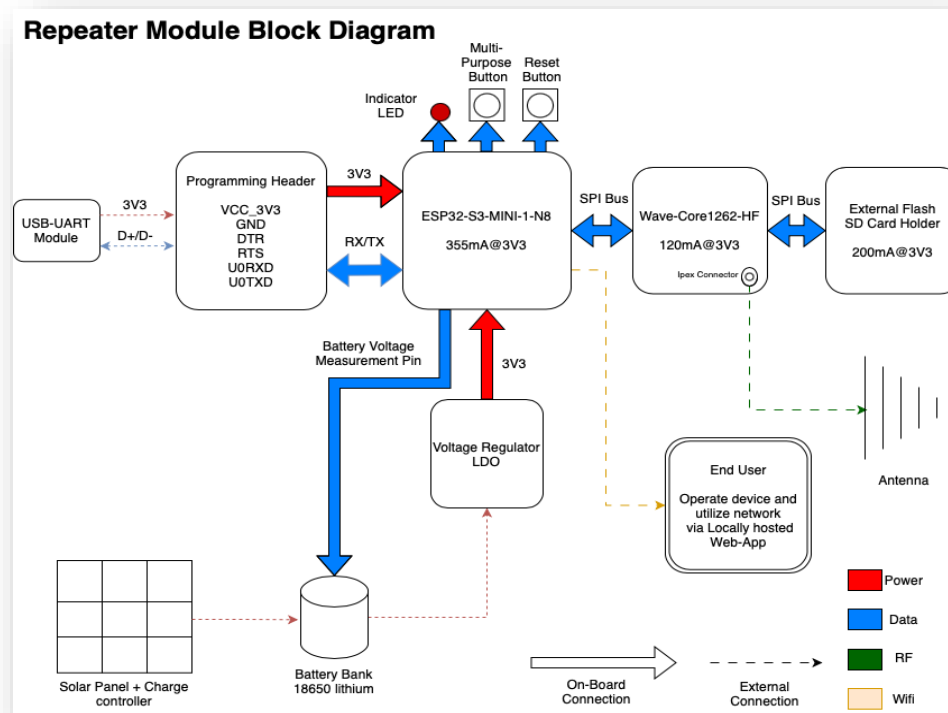


Figure 3: Petal v0.0 hardware block diagram and power usage estimate.

Software/Firmware

The user web interface will be built using Microsoft's Blazor framework. Blazor apps can be compiled down to a static Web Assembly (.wasm) file which can be run on all modern browsers [9]. Using Web Assembly means that the client's smartphone and web browser does the computing required render and interact with the web application, not the server. The demands on the *Petal's* microprocessor are greatly reduced by this framework since it only needs to serve the initial .wasm file and provide an API for the mesh network. This will optimize user experience and reduce the *Petal's* power consumption.



The firmware will be written in the Rust programming language because of its speed and memory safety guarantees. The firmware will include the mesh network API, .wasm file server, and Wi-Fi access point configuration.

The beta release of *AVAlink* is slated for October 28th with testing to conclude on November 11th. The first production release of *AVAlink v1.0* will be December 13th at the Capstone Symposium.

Parts & Materials

Version 0 of *Petal* will use prefabricated modules for the LoRa transceiver, microprocessor, and Wi-Fi to expedite the prototyping process and avoid the complexities of designing a radio frequency (RF) PCB. For the LoRa transceiver, we will use the WAVE-20855-HF Core1262 module which uses a Semtech 1262 transceiver. It comes with the receiver balun, transmitter harmonic filters, RF switch, impedance matching circuits, and a temperature compensated crystal oscillator pre-installed. For the processor and Wi-Fi, we will use the ESP32-S3-MINI-1 system on chip (SoC), which contains an ESP32-S3 dual-core microprocessor, peripherals with breakout pins, and a Wi-Fi module with in-built antenna.

Although the modules *Petal v0* is using are relatively expensive compared to the circuits they replace, the LoRa and Wi-Fi RF circuits are very difficult to design on our PCB without the luxury of time to do several PCB revisions. *Petal v1*, our future production release, will replace these with circuits designed in-house to reduce the cost of and reliance on third-party modules.

MANAGEMENT OVERVIEW

Our project's success hinges on a careful and coordinated schedule. We have outlined all the milestones we will have to meet as a group in order to have a successful release day at the capstone symposium.

Our Team

Meet the team members of Flora Communications. We are a group of individuals passionate about electronics engineering and bringing this discipline out into the environment we love.

Aaron Huinink



Aaron discovered his passion for electronics while completing his Bachelor of Science at McMaster University. He brings extensive project management experience from his summers managing a tree-planting camp and technical skills from his co-op as a radio technologist with the BC Wildfire Service

Tella Osler



Through biology fieldwork and remote marine research at sea, Tella has a first-hand appreciation for remote communication methods. She has previously worked on both on and off-grid electrical systems, has recently entered the world of HAM radio, and is excited to educate, and be educated by this community.

Cameron Gillingham



After 8 years as an electrician, Cameron followed his passion for musical electronics to Camosun's tech program. In recent years, Cameron has spent much of his time in the backcountry. These experiences have given him insight into the needs Flora Communications hopes to fill.

Logistics

There are many moving parts in an electronics design project, after careful research and consideration we have chosen what we deem to be the most effective methods of completing this project.

Suppliers

We will only use Camosun approved vendors for our parts (i.e. Amazon.ca, Digikey, Abra Electronics, and Mouser).

Manufacturers

We will use JLCPCB for PCB manufacturing and assembly.

Transportation

Our PCBs will be transported using DHL for fast and safe delivery.

Storage

We will use our storage locker at Camosun to safely store project related equipment.

Facilities

We will be developing our prototype using the facilities available to us at Camosun. We have access to a solder reflow station, pick and place machine, oscilloscopes,



multimeters, and vector network analysers. We will also use the British Columbia Natural Resource Ministry’s Radio Shop on Bay Street in Victoria where Aaron did his co-op. They have kindly agreed to let us use their antenna testers, radio equipment, and their workshop if we need.

FINANCIAL OVERVIEW

We have estimated the costs we will incur in the prototyping stage based on our requirement specifications.

Table 1: Overview of expected labour and monetary costs of the prototyping stage.

Cost	Amount	Notes
Labour	1530 hours	No monetary cost associated.
Parts	\$735.00	
Shipping	\$300.00	
Manufacturing	\$120.	
Total	\$1155.00 & 1530 hours	

Major Costs

With a cost of \$735.00 Parts will make up largest portion of our estimated budget. This high cost is partially due to our choice to use specialty R.F. modules to speed up our development.

Labour

A breakdown of the expected 1530 hours expected to complete all of the tasks associated with the prototype releases of release of the *Petal* radio and *AVAlink* software.

Table 2: Labour time cost estimates for the prototyping stage.

Component	Milestone	Hours	Equivalent Work Weeks
Petal	Datasheet	40	1
	Enclosure v0.1	80	2
	Enclosure v0.2	40	1
	User Manual	40	1
	v0.0	240	6
	v0.0 testing	80	2
	v0.1	120	3
	v0.1 testing	80	2
	v0.2	120	3
AVAlink	v1.0 beta	240	6
	v1.0 beta testing	40	1
	v1.0	160	4



	Documentation	40	1
Project Documentation	Budget	10	0.25
	Display	20	0.5
	Standards	10	0.25
	Ethics	10	0.25
	Completion Audit	10	0.25
	Final Presentation	20	0.5
	Formal Report	40	1
	Gantt Chart	5	0.125
	Progress Presentation	5	0.125
	Progress Report	20	0.5
	Proposal	20	0.5
	Proposal Presentation	10	0.25
	Risk Assessment	10	0.25
	Risk Audit	10	0.25
Total		1560	39
Total/Person		520	13

Parts

All parts chosen in our hardware design were selected for power efficiency, part availability, low cost, and ease of design.

Table 3: Monetary costs of parts required for the prototyping stage. The subtotal is based on the assumption that 3 versions of the PCB will be ordered, with 5 PCBs manufactured per revision.

Component	Description	Unit Cost	Qty/Board	Cost/Board	Subtotal
Specialty Parts					
ESP32-S3-MINI-1-N8	Microprocessor SoC & Wi-Fi module	\$4.00	1	\$4.00	\$60.00
WAVE-20855-HF Core1262	LoRa transceiver module	\$17.00	1	\$17.00	\$255.00
RT9013-33GB	Voltage regulator	\$1.00	1	\$1.00	\$15.00
WS2812	RGB LED	\$1.00	1	\$1.00	\$15.00
Antenna	SMA connector, coax, antenna	\$10.00	1	\$10.00	\$150.00
Basic Parts					
Resistors		\$0.05	~50	\$2.50	\$37.50
Capacitors		\$0.05	~30	\$1.50	\$22.50
Inductors		\$0.60	~10	\$6.00	\$90.00
Buttons		\$0.50	~2	\$1.00	\$15.00
Transistors		\$0.50	~10	\$5.00	\$75.00
TOTAL					\$735.00



Minor Costs

It is expected we will incur some minor costs throughout the prototyping and development stages of this project, they are projected as follows.

Manufacturing

PCB manufacturing costs will be about \$40 per order, so \$120 over the prototyping stage. Enclosure manufacturing costs will be covered by FLoRa Communications.

Shipping

We estimate \$300 will be required over the course of the prototyping stage to ship parts and PCBs.

Capital

Camosun College has agreed to fund the prototyping stage.

ASSUMPTIONS

With our design choices we have had to make some assumptions, though unlikely that these will interfere with the success of our development, it is worth noting that they do exist.

Table 4: Operating assumptions ranked according to their expected risk to the project.

Relative Risk to Project	Assumption	Notes
1	Modules will be available throughout the prototyping stage.	The WAVE LoRa module is the most at risk. Vendors do not typically hold large stock of this module, and it has a lead time of 3-4 weeks, but our vendor has assured us they will be available. We will also proactively order the quantity we need for the project ahead of time.
2	Users will have a browser that supports Web Assembly	All modern browsers support Web Assembly on PC and mobile [9], but some niche or outdated browsers do not.
3	Our system will not interfere with existing 915MHz ISM band systems	The power efficiency and large processing gain of LoRa make it robust against interference, but this is always a possibility when using a license-exempt band.



4	The 900-928MHz band will continue to be license-exempt	The 900MHz ISM band is well established and it is highly unlikely that ISED Canada will significantly change the legislation for these frequencies.
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CONCLUSION

With our prototype being released later this year, there will soon be affordable backcountry communication options without requiring users to have advanced technical knowledge or deep pockets. After producing a functional prototype, we will continue to develop our LoRa technology in wilderness safety applications on the Kludahk trail network and integrate it with emergency services.

Please review our timeline and financial overviews and provide feedback prior to our September 30th budget meeting. You may contact our project manager Aaron via email at flora.outdoor.comms@gmail.com.

We at FLoRa Communications are excited to work with you to make the local outdoors a safer place through chatting on the trail. We invite you to join us when we unveil the prototype (Version 0) of *Petal* Radio with the *AVAlink* web interface on December 13th at the 2024 Camosun College Capstone Symposium!

Kindest Regards,

The FLoRa Comms team

Aaron Huinink

Tella Osler

Cameron Gillingham



APPENDICES

Appendix A: References

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Appendix A: References

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- [9] “WebAssembly | Can I use... Support tables for HTML5, CSS3, etc.” Accessed: Sep. 13, 2024. [Online]. Available: <https://caniuse.com/wasm>

Appendix B: Requirements Specification

Table 5: Requirement specifications for the prototype.

Reference Number	Requirement	Test	Pass/Fail Criteria
1-SW	R1 – The user interface MUST be accessible through a modern web browser without the need for a separate application.	T1.0 – Connect a smartphone with a modern browser to the node and scan the web server QR code. T1.1 – Connect a PC to the node and navigate to the web server page.	C1.0 – UI is rendered and readable on a mobile device. C1.1 – UI is rendered and readable on a PC.
2-SW	R1 – Users MUST be able to send LoRa packets using the web interface to a public forum-like chat that can be viewed from another node. F1 – Users can send chats between specific nodes that are not publicly visible to all nodes.	T1 – Send a message using the UI to another node	C1 – The sent message is shown on all other devices' UIs. FC1 – The sent message is only viewable on the intended receiver's UI.
3-SW	R1 – Chats on UI must have a username or device identifier and a timestamp of when the message was sent.	T1 – Send chat messages from multiple devices over the UI	C1 – The UI renders chat history with usernames in chronological order according to message timestamp
4-SW	R1 – The repeater node MUST monitor battery voltage and disconnect when dropping below the low voltage threshold. The repeater node low-voltage disconnect MUST implement hysteresis	T1 – Supply voltage to the node with a variable power supply and document which voltages result in disconnect and reconnect. The node voltage monitor will be compared to that of the power supply	C1.0 – The reported battery voltage is accurate within 3%. C1.1 – The load disconnects when the battery voltage drops below the low voltage threshold and turns back on when the battery

	to prevent power cycling. F1 – The repeater SHOULD indicate to the rest of the mesh network that it is powering down.	and measured with an external meter.	charges above threshold voltage. The implemented hysteresis prevents power cycling of the device. FC1 – Before the low-voltage disconnect, the device transmits an alert that it is powering down.
5-SW	R1 – The software MUST implement a collision avoidance or multiple access protocol that deals with the hidden-node problem	T1 – Transmit a LoRa packet from two devices to a single receiver at the same time without a connection between the two senders to coordinate between them	C1.0 – Neither message is lost, or corrupted. C1.1 – Messages are displayed in the UI in the correct order based on their timestamp
6-HW	R1 – MUST Design and order a PCB	T1 – Before each revision is submitted for manufacturing, it will be subject to an internal review by the group and an external review by the Capstone Committee.	C1.0 – The PCB design passes an internal review process and review from the Capstone Committee. C1.1 – Each revision passes our hardware testing suite.
7-HW	R1 – MUST have a bespoke enclosure. F1 – SHOULD be protected against rain and moisture ingress	T1.0 – The enclosure will be inspected by professors. T1.1 – Third-party parts like cable glands are IPX4 certified. FT1 – The enclosure is subjected to the standard IPX4 test	C1 – All materials have IPX4 or greater certification from reputable lab FC1 – No water ingress is present after the IPX4 test.
8-HW	R1 – Voltage regulator MUST effectively	T1 – Sweep the input voltage across the	C1.1 – The hardware receives a stable

	provide the required 3.3V to the hardware for a range of typical battery voltages.	range defined by the regulator datasheet and measure the voltage regulator output while it is loaded with the expected full load current the PCB requires.	3.3V +/- 0.1V out across the range of test voltages while under the expected load. C1.2 – The regulator operates as expected according to the manufacturer’s datasheet.
9-HW	R1 – MUST provide recommendations for sizing batteries and solar panels based on expected insolation.	T1 – Use recommendations to size solar and battery power for a mock installation at Camosun College using insolation data for that location.	C1 - Recommended panel wattages and battery Ah meet or exceed node requirements as calculated by our power audit (datasheet specifications, duty cycle, solar insolation modeling)
10-HW	R1 – Antennas MUST be well matched to the driving hardware	T1 – SWR/Impedance testing of antenna and source using VNA (may require tuning to meet these requirements)	C1 – Source impedance is matched to antenna so that VSWR < 2 and return loss < -10 dB
11-HW	R1 – Prototype nodes MUST incorporate an accessible user button at access points for users to initiate the web server. R2 – The Wi-Fi access point MUST time-out after 5 minutes of inactivity to save power.	T1 – Check that the Wi-Fi access point is powered down. Press the user button to initiate the Wi-Fi access point. T2 – Leave the access point for 5 minutes without activity.	C1 – The Wi-Fi access point is available after pressing the user button. C2 – The Wi-Fi access point is disabled after 5 minutes of inactivity.



<p>12- SW</p>	<p>R1 – The firmware has multiple modes: Passive: The MPU is sleeping and listening for new messages. It will act as a repeater. Message Available: The MPU is in passive mode, but it has saved new messages for the next user to view Active: The MPU is powered up and advertising the Wi-Fi access point while continuing to act as a LoRa mesh node. Low-Power: The low voltage disconnect has taken the node offline until the battery can be recharged. F1 – An RGB LED indicates the state the hardware is in with different colours (Passive, Message Available, Active, Waiting, Low battery). F2 – An SOS mode that activates across the entire network. It connects directly to emergency services, minimizes network latency at the expense of power efficiency, and disables the low voltage disconnect.</p>	<p>T1.0 & FT1.0 – Send a message from an Active node to a Passive node. T1.1 – Receive a message repeated by a Passive node. T1.2 – Test the current draw in passive mode. FT1.1 – Input a voltage lower than the low-voltage disconnect but larger than the minimum voltage required by the linear voltage regulator.</p>	<p>C1.0 – The message is available when the Passive node is powered up later. C1.1 – The message is received at the active node. C1.2 – The current draw in passive mode is less than the current draw in active mode. FC1.0 – The LED indicates a New Message state. FC1.1 – The LED indicates low voltage.</p>
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Legend

Table 6: A legend describing the syntax used for the reference numbers.

Reference Number	Requirement	Testing	Pass/Fail Criteria
<p>#-(ID):</p> <p>HW: Indicates a hardware requirement</p> <p>SW: Indicates a software requirement</p>	<p><u>R#:</u> A requirement, something the component MUST have, followed by an identification number that begins at 0.</p> <p><u>F#:</u> A feature, something the component SHOULD have, followed by an identification number that begins at 0.</p>	<p><u>T#.#:</u> The test identification number. The number matches the requirement it corresponds to. If multiple tests relate to the same requirement, a second reference number is added with a decimal point.</p> <p><u>FT.#.#:</u> Same as requirement tests but relates to a feature.</p>	<p><u>C#.#.#:</u> The criteria identification number. The number matches the test it corresponds to. If multiple criteria exist for the same test, a second sub-reference number is added. A Pass is required.</p> <p><u>FC.#.#.#:</u> Same as requirement criteria but relates to a feature and is not required to pass.</p>



Appendix C: Schedule Milestones

Table 7: Milestones and their deadlines for the prototype.

Component	Milestone	Date
Petal	v0.0	October 1, 2024
	v0.0 testing	October 15, 2024
	v0.1	October 29, 2024
	Enclosure v0.1	November 1, 2024
	v0.1 testing	November 10, 2024
	v0.2	November 19, 2024
	Datasheet	December 13, 2024
	Enclosure v0.2	December 13, 2024
	User Manual	December 13, 2024
AVALink	v1.0 beta	October 28, 2024
	v1.0 beta testing	November 11, 2024
	v1.0	December 13, 2024
	Documentation	December 13, 2024
Project Documentation	Scope Document	September 9, 2024
	Proposal	September 20, 2024
	Gantt Chart	September 23, 2024
	Budget	September 30, 2024
	Proposal Presentation	October 3, 2024
	Risk Assessment	October 7, 2024
	Test Planning	October 21, 2024
	Progress Report	October 25, 2024
	Progress Presentation	October 31, 2024
	Standards Document	November 4, 2024
	Ethics Document	November 18, 2024
	Web Page	November 22, 2024
	Risk Audit	November 25, 2024
	Completion Audit	December 2, 2024
	Formal Report	December 6, 2024
	Display	December 13, 2024
	Final Presentation	December 13, 2024