Team 8: NeverLost

Preliminary Design Review

October 1, 2021 - 4pm

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Evaluators: Professor Burleson, Professor Pishro-Nik

University of Massachusetts Amherst

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Meet the Team!

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Project Motivation

- **~2,000 people** get lost hiking per year
- SAR begin with little to no information
  - Can take months, days
- Limited Access to Emergency Services

Problem Statement

Many hikers need ***means of communication with emergency services*** *but* ***do not have access to cell service****. If a hiker is lost or injured, a search and rescue mission may begin with almost no information, days after the emergency begins.*

Our NeverLost survival beacons will provide ***checkpoints along hiking trails*** *that would allow search and rescue teams to begin with* ***exact coordinates within minutes of their emergency.*** *Our beacons would be accessible to everyone, especially injured hikers that may not be able to walk to the trailhead, but could reach our closest beacon to send a signal for help.*

Existing Solution - Personal Locator Beacons (PLB) [1]

- Sends a one way S.O.S satellite signal at 406MHz
- Long multi-year battery life
- Works in remote areas
- No subscription fee but must be registered with FCC
- Low power homing beacon transmits at 121.5 MHz (aircraft emergency)
- $300+

Existing Solutions - Satellite Messengers [2]

- Two-way communication
- Emergency/non emergency messaging
- GPS navigation
- Works best with a unobstructed view of the sky
- Additional features - sync with fitness watch, maps, weather reports, texting
- $300+
- Subscription

Existing Solution - Hikers Log

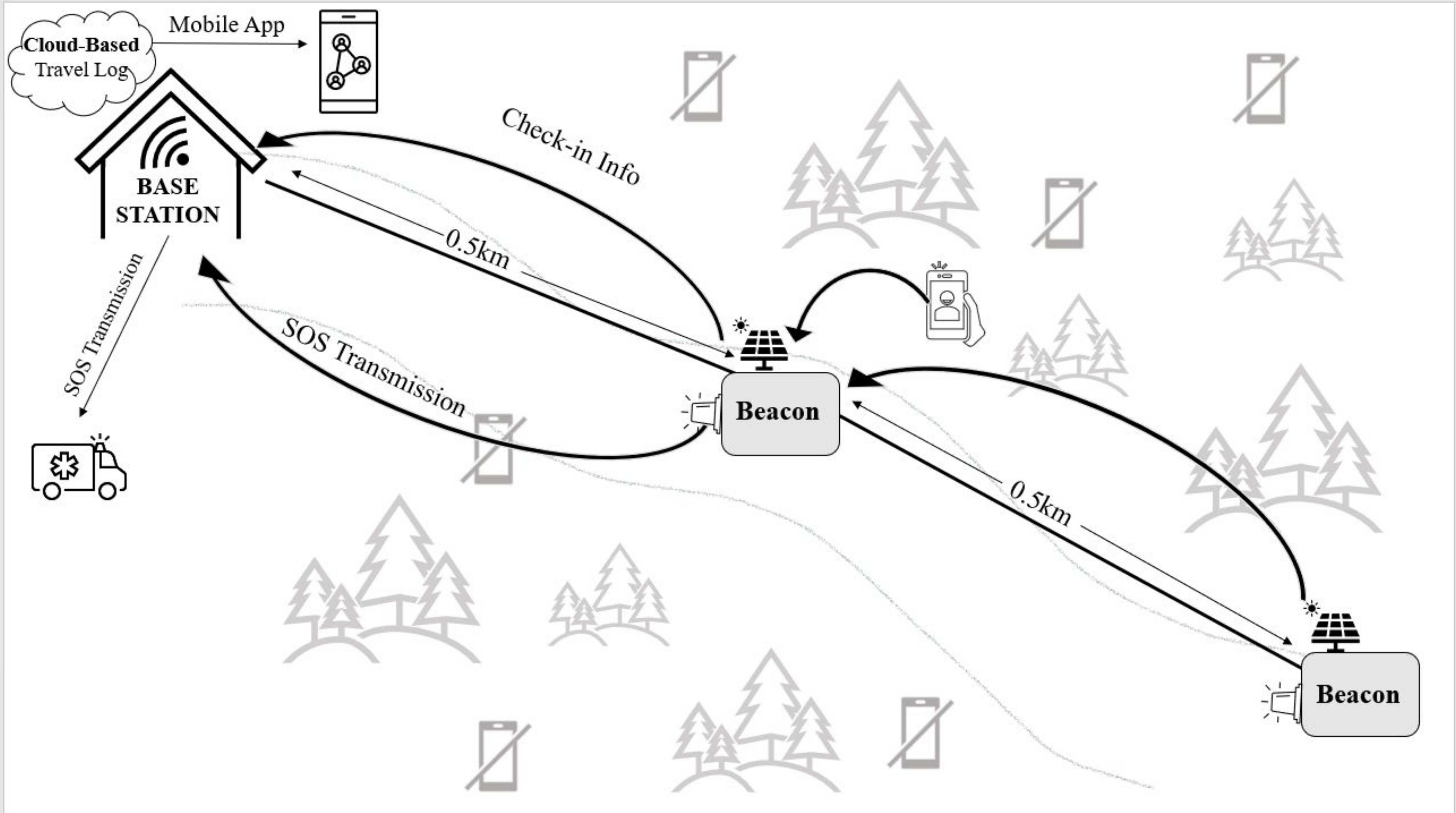
- Notebooks stored along trails where hikers can write their name and a short message
- Paper logs are easily ruined by weather conditions
- These logs are not actively used in SAR efforts

Our Goal

To develop a dependable system that allows hikers to access emergency services. In addition, we intend to devise a check-in system to track hikers progression in order to provide hikers' friends and families peace of mind.

Our Solution

- Low power beacon system utilizes manual button press to contact help in case of emergency
- Beacons along trail communicate with base station to relay precise beacon coordinates to SAR without relying on extra gear or cell phone signal
- Smartphone app check-in system tracks hiker’s progress through cloud based travel log


Cloud-Based
Travel Log
Mobile App
BASE
STATION
Check-in Info
0.5km
SOS Transmission
SOS Transmission
Beacon
0.5km
Beacon

System Specifications

Beacon System

- Small Scale Implementation
  - *Beacons separated by minimum 0.5 km*
  - We will produce 2 beacons and 1 base station
- SOS transmitted to emergency services in *5 minutes or less*

Mobile Application

- Hiker's location updated in app within *30 mins of check-in*

Power Systems

- Low Power Consumption allows for *2 months battery life* without relying on solar
  - To manage power, will implement scheduled transmit and receive times
- Implementation of *2W* solar system

Production Costs

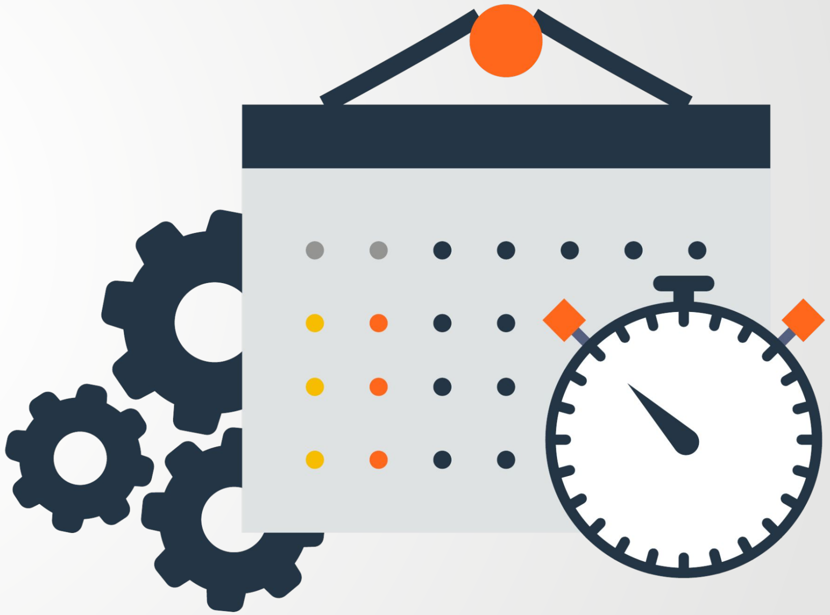
- Cost Per Beacon: ~$110 -- **UPDATE**
- Cost Per Base Station: ~$100 -- **UPDATE**

Transmit and Receive Schedule

To ensure power needs are met we will implement schedule for beacon communication

- Every 5 minutes beacon pair will turn on
- Each pair helps to send data upstream toward base station

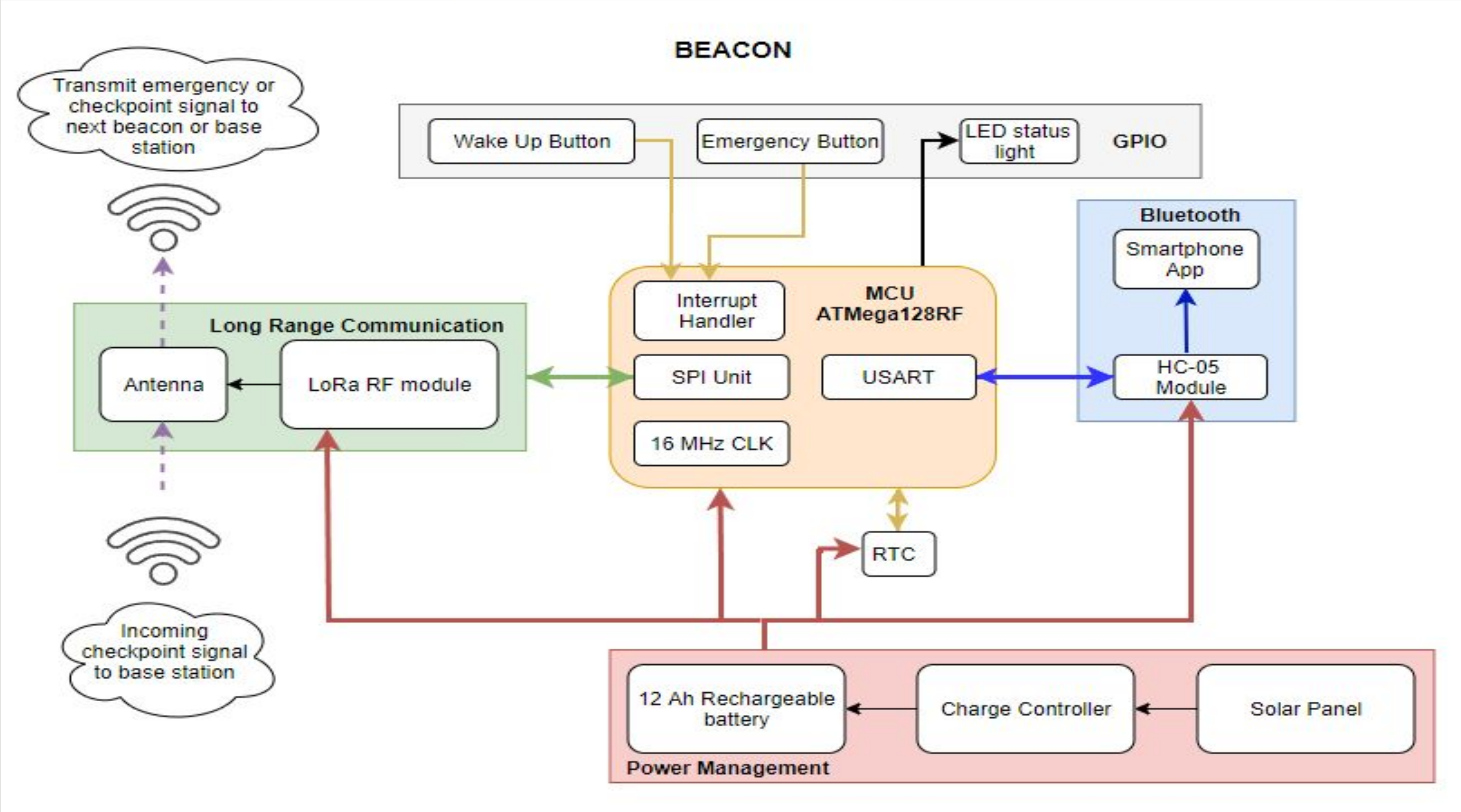
- When a beacon is not scheduled to transmit or receive it will be in low powered sleep mode
- Schedule will follow real time clock



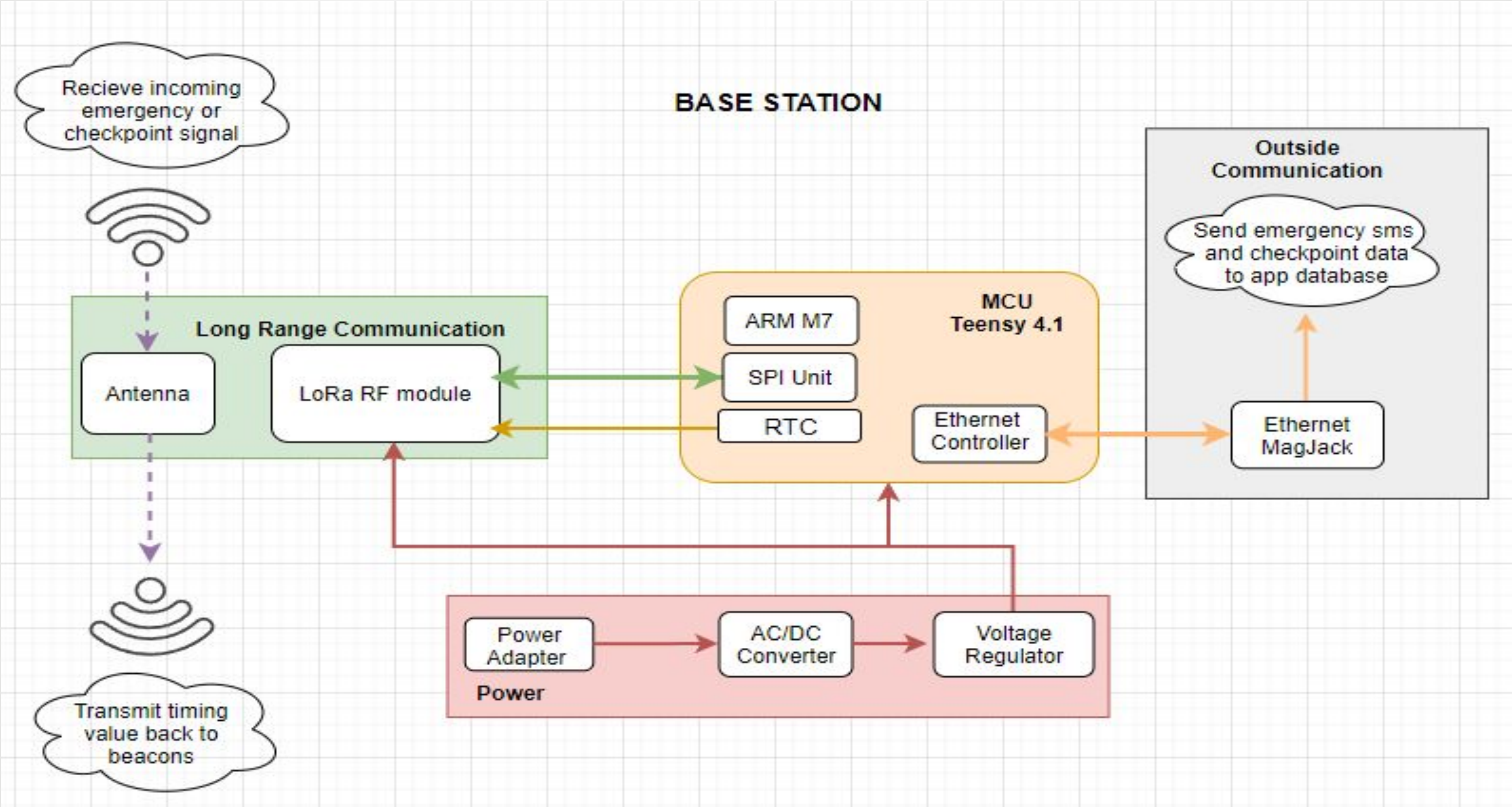
What Sets Our Design Apart

- Location precision using static beacon coordinates
- Public access - no cost to consumer or monthly fee
- Does not require an external device to signal for help
- Low power, long duration, solar

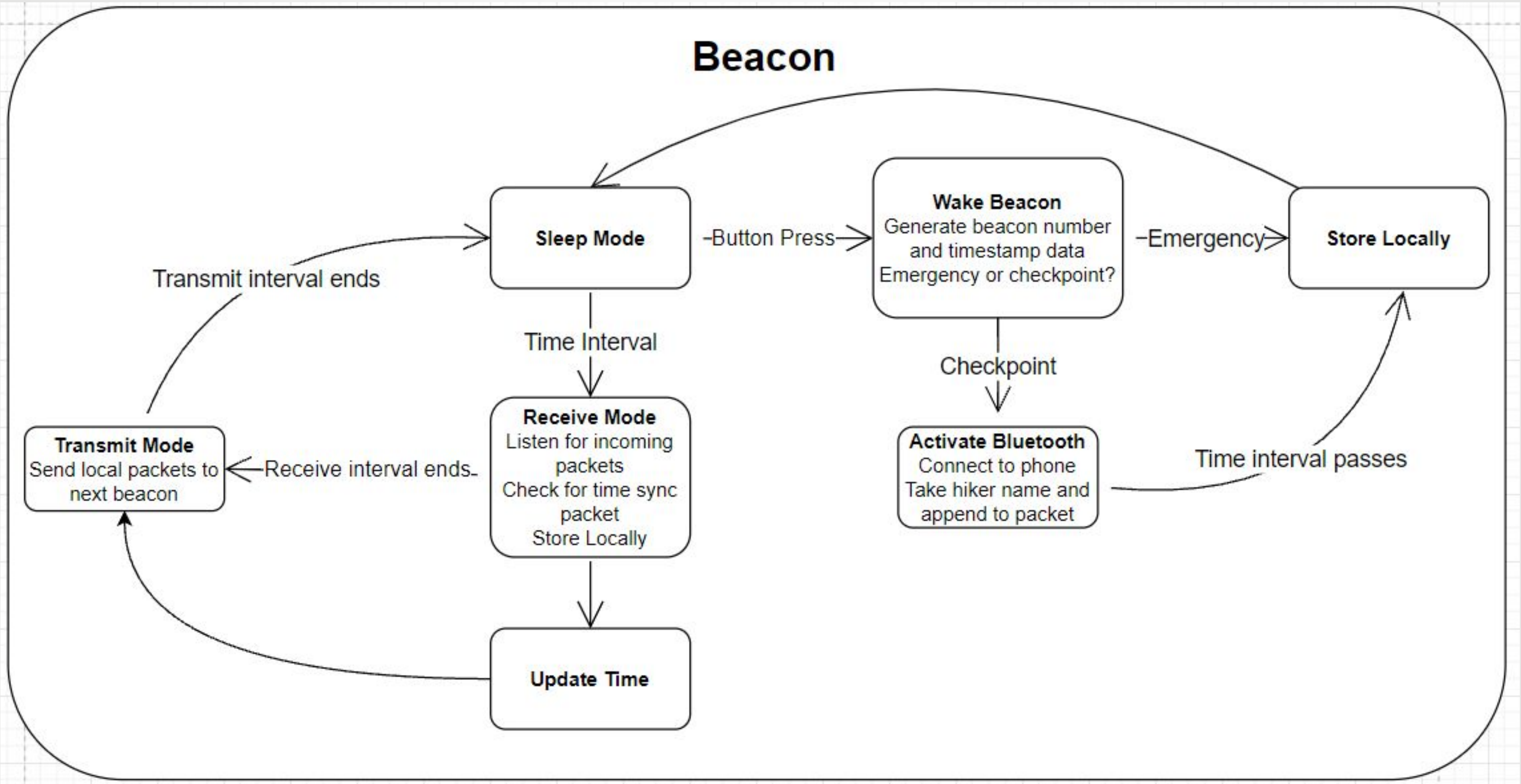
Hardware Block Diagram - Beacon



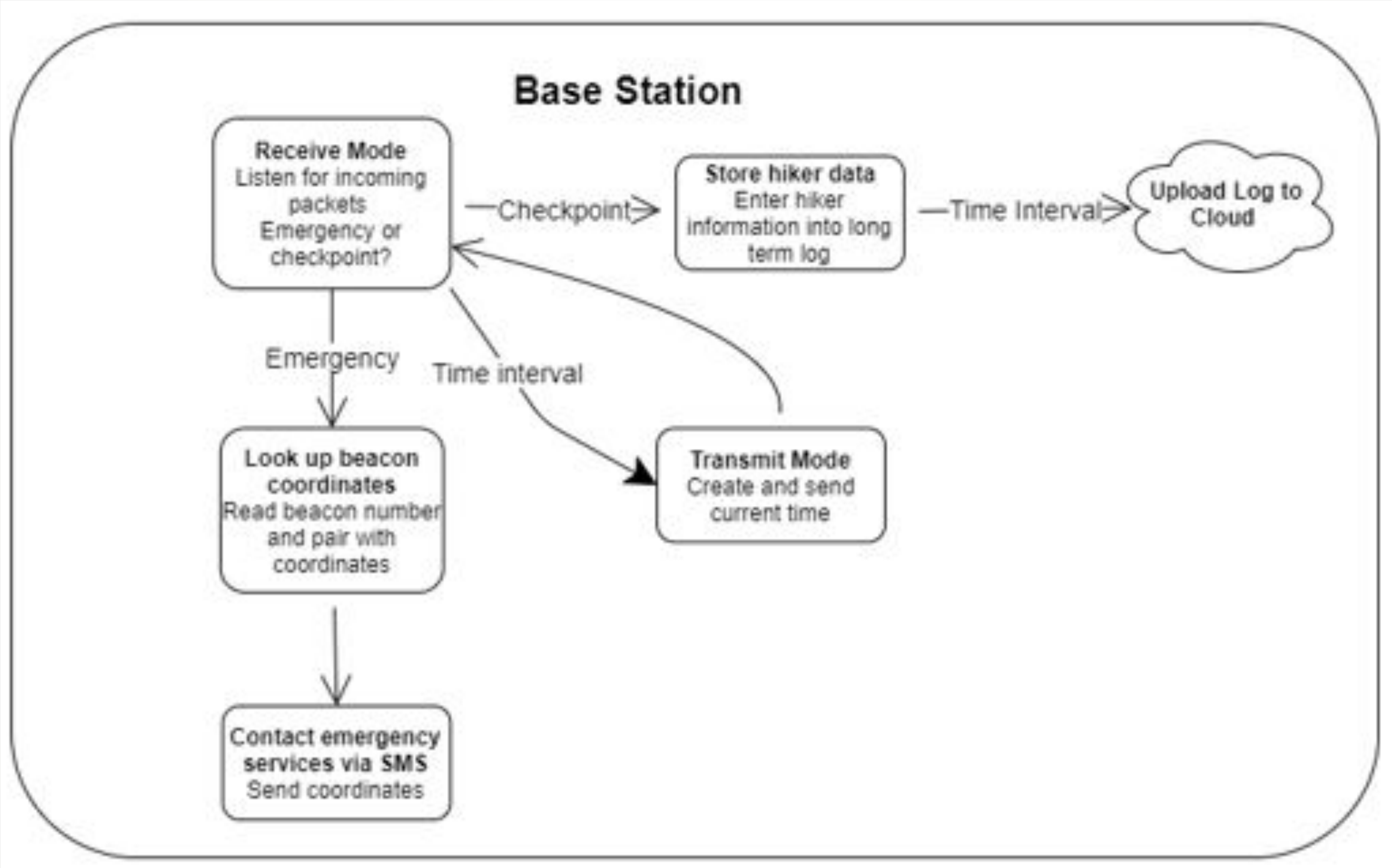
Hardware Block Diagram - Base Station



Software Diagram: Beacon



Software Diagram: Base Station



Mobile Application

- **Primary Functionality:** Hiker check-in capability via short-range Bluetooth
- **Secondary Functionality:** Allows approved users to track hiker’s progress along trail
  - Hikers profile updated with every check-in
  - Check-ins sent to Base Station → Base Station updates user profile in application using Internet Connection

Significant Custom Hardware Design

Beacon PCB will contain:

- Microcontroller **-** Atmega128RFA
- Bluetooth - HC-05 module
- LoRa RF Communication - SX1276 Transceiver
- LED status light
- Input buttons

Base Station PCB contain:

- Development board - Teensy 4.1
- Ethernet Controller
- Lora RF Communication - SX1276 Transceiver

Microcontroller

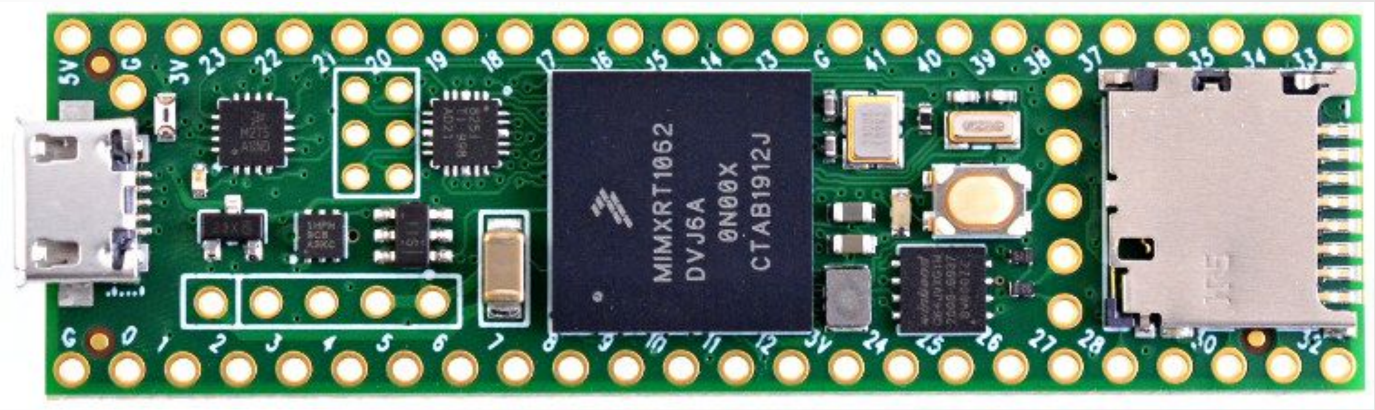
ATmega128RF [3]

- Low Power AVR 8-Bit Microcontroller
- 16 Mhz clock
- 128KB of Flash Memory
- Multiple serial communication interfaces I2C,SPI,USART
- Familiar with AVR devices and Microchip Studio

Development Board

Teensy 4.1 [4]

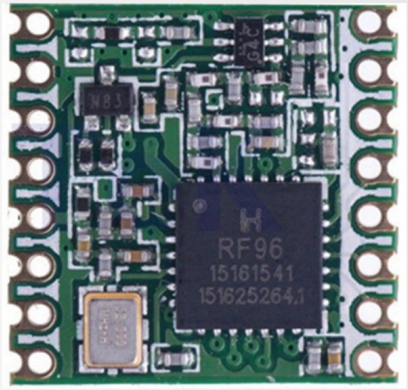
- ARM M7 600MHz CPU
- 793KB Flash, 1024KB RAM
- Ethernet Controller on board
- Arduino IDE compatible



Modules

SX1276 915MHz [5]

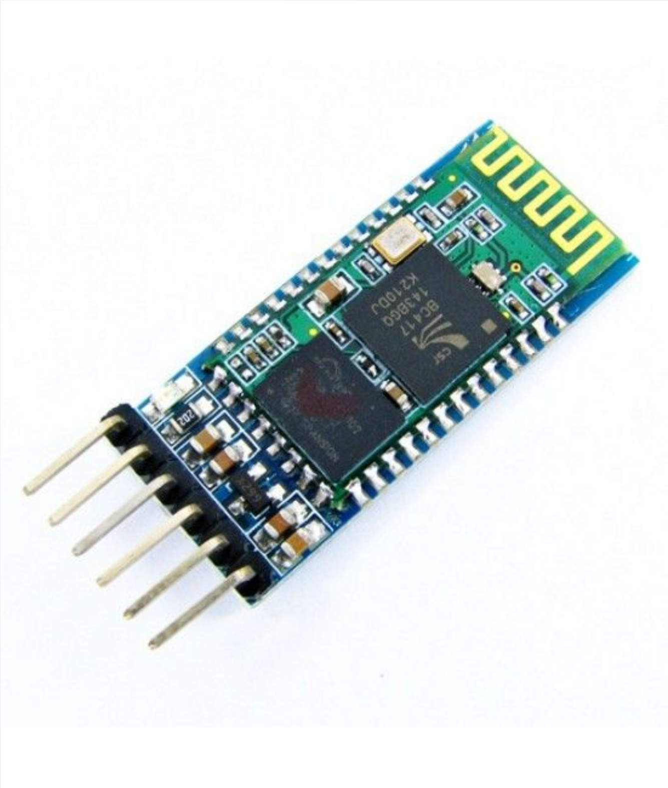
- Low power LoRa based packet radio module
- Handshake between transmitter and receiver
- License-free ISM band 415MHz
- 300uA sleep mode, 120mA transmit, 40mA receive
- ~1km direct sight



Modules

HC-05 [6]

- Serial bluetooth module USART
- 30mA operating current
- 10ft radius
- Compatible with smartphone
- Plenty of projects and documentation for quick prototyping



Modules

Charging System

Voltaic Systems Solar Panel[7]
- 6V, 2W system
- 19% efficiency

Crowd Supply Battery[8]
- 12 Ah, rechargable

Solar Output
- Using 6V, 2W solar system - we can estimate 1.52Wh output per day
- Assumption of 4 hours sunlight per day

Power Specifications

System will be able to last at least 2 months without help of solar

- Maximum current draw is 142 mA when transmitting
- System current is 76 mA when receiving
- System sleep current is 302 uA

Based on sleep scheduling and usage estimates, system will use 5.67Ah per month, 0.19Ah per day

- System will consume 0.6Wh per day

With solar

- We can estimate 1.52Wh output per day
- This power output is almost 3 times our power usage for 1 day and should keep our beacons charged for many months

MDR Deliverables

We will produce 1 prototype beacon, and 1 prototype base station for testing

Long Range Communication

- Send a serial 40 byte message with the LoRa transceiver
- Communicate long range with few obstructions

Short Range Communication and Mobile App

- Communicate data from smartphone to beacon via bluetooth
- Working user interface in app
- Contacting outside world from base station via SMS

Power Systems

- Prototype including all proposed modules to measure power consumption
- Set up working solar charging system
- Confirm min and max power of modules

Verification Plan

Long Range Communication

1. Demonstrate ability to *send and receive 40 byte serial data* via LoRa
2. Measure the maximum accurate range of the LoRa transceiver (*minimum goal 0.5km*)

Short Range Communication and Mobile App

3. Demonstrate communication of data from smartphone user interface to beacon via bluetooth
4. Demonstrate ability to contact outside world from base station via SMS

Power Systems

5. Test the solar cell efficiency by measuring output current - *expect 63mA*
6. Measure min system current *302uA* and max system current *142mA*

Cost Estimate

Item	Cost
Teensy 4.1 x 1	30
AtMega128 x 2	20
LoRa module x 3	15
Bluetooth x 2	20
Solar x 2	60
PCB	230
Battery x 2	70
Antenna x 3	40
Total Estimate	485

Gantt Chart

	Task Name	Start Date	End Date	Members
Hardware				
	Order Modules	4-Oct	6-Oct	ES + L
	Establish Long-Range RF Communication	5-Oct	22-Oct	ES + L
	Emergency Signal Transmission	25-Oct	5-Nov	ES + L
	Power Conservation / Solar Implementation	8-Oct	17-Nov	ES + L
Software				
	Initialize App Development	4-Oct	8-Oct	S+EA
	Functioning Prototype (Sample Data)	6-Oct	22-Oct	S+EA
	Base Station Connection to DB / Cloud	20-Oct	29-Oct	S+L
	Real Time Data to App Users	8-Nov	19-Nov	S+EA
Both				
	Short-Range Bluetooth Communication	18-Oct	29-Oct	ALL
	Network / Application Connectivity	25-Oct	5-Nov	ALL
	Packet Delivery from App to Beacon System	1-Nov	12-Nov	ALL
	Time Sync	15-Nov	26-Nov	ALL

Week6	Week7	Week8	Week9	Week10	Week11	Week12	Week13
10/04 - 10/08	10/11 - 10/15	10/18 - 10/22	10/25 - 10/29	11/01 - 11/05	11/08 - 11/12	11/15 - 11/19	11/22 - 11/26
M T W TH F	M T W TH F	M T W TH F	M T W TH F	M T W TH F	M T W TH F	M T W TH F	M T W TH F

Thank you!

Questions?

Works Cited

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[3]“Atmega128rfa 1 8-bit 4K bytes EEPROM microcontroller with ...,” *microchip.com*. [Online]. Available: https://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-8266-MCU_Wireless-ATmega128RFA1_Datasheet.pdf. [Accessed: Sep-202

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Appendix

Power Consumption Calculations

1	**Power Usage Calc**														
2	Part Description	Sleep Amps	Ah per month	Ah per year	Transmit Amp	Ah per month	Ah per year	Listening	Ah per month	Ah per year	Ah per month	Ah per year	Ah per day		
3	Rf Module	300uA	0.0036	0.0432	120mA	1.44	17.28	40mA	0.48	5.76	1.9236	23.0832	0.06412		
4	Bluetooth/RFID module				30mA	3.6	43.2				3.6	43.2	0.12		
5	MCU	1.6uA	0.0000192	0.0002304	6mA	0.072	0.864	6mA	0.072	0.864	0.1440192	1.7282304	0.00480064	Wh per day	
6	LED				142 mA						5.6676192	68.0114304	0.18892064	0.623438112	0.025976588
7															
8	**Power Calc Timing stuff**														
9	transmit every 5 mins	transmit 5s	60s per hr	0.4hr per day	12hr per month	144hr per year			**Max Power draw**						
10	receive every 5 mins	rx 5s	60s per hr	0.4 hr per day	12hr per month	144hr per year			142mA	3.3V	.469W				
11	sleep mode - else		58mins per hr	23.2hr per day	696hr per mont	8352hr per year									
12	bluetooth - 5 hikers per hr	2mins each	10 min per hour	4hr per day	120hr per mont	1440hr per year									
13															

50			
51	**Solar Output Calc**		
52	solar output Voltage	6	V
53	solar output power	2	W
54	hours sunlight per day	4	hr
55	claimed solar efficiency	19%	
56			
57	Wh per Day w/ assumptions	1.52	Wh
58			

Appendix

Receiver Sensitivity Recalculation

14	**Antenna Range Calc**			
15	transmit 20dBm			dB = 10log(W)
16	receive -148dBm			dB/10 = logW
17	antenna gain 1.2dBi			10^(dB/10) = W
18	lambda 0.328m			
19				
20	**Antenna Sensitivity**	recalc (don't believe the claimed value)		
21	Psens = SNRdB + 10log(kTB) + FdB	-93	dBm	
22	SNR	20	dB	
23	10log(kTB)	-119	dBm	
24	F	6	dB	
25				
26				

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Appendix

Max Range Calculations

27	**Friis Equation**									
28	Pr/Pt = (Ar*At)/(d^2*lambda^2)	>>>	d^2 =[(Ar*At)/lambda^2]*(Pt/Pr)			***this equation uses effective aperture area				
29										
30	Ar	0.011261		d^2 =	7.44E+13					
31	At	0.011261		d =	8627337.697	meters	*** these numbers use full link budget			
32	lambda	0.327868852			8627.337697	km				
33	Pt	0.1	20dBm							
34	Pr	1.58E-18	_148dBm							
35										
36										
37	**Change Pr and Pt to update accuracy of**									
38	Pr = Pt + Dt + Dr + 20log(lambda/(4pi*d))		*** this version of equation is more accepted							
39	d = [lambda/4pi]/10^[(Pr - Pt - Dt - Dr)/20]									
40	Pr	-73	dBm	<-- calculated assuming 300kbps			**% of claimed Pr, Pt**	**Pr [dBm]**	**Pt [dBm]**	**Transmission distance [km]**
41	Pt	20	dBm	^also assumes an extra 20dB of loss			**100%**	-148	20	8627.337697
42	lambda	0.327868852	m				**50%**	-145	17	4330
43	Dt	1.2	dBi				**25%**	-142	14	2170
44	Dr	1.2	dBi				**10%**	-138	10	864
45							**1%**	-128	0	86.4
46	d =	1536.350467	m							
47		1.536350467	km							