THE SMART COOLER

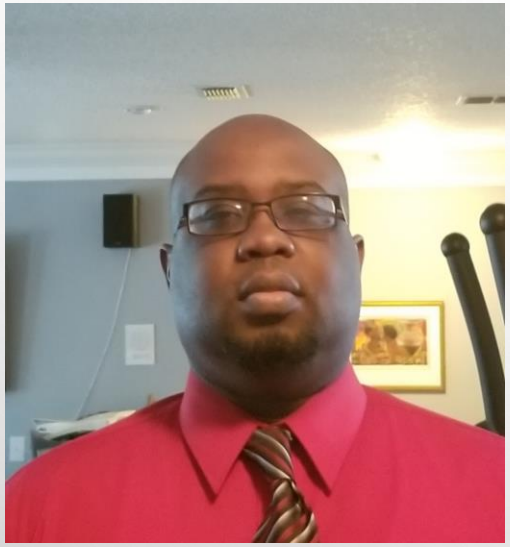
CLARENCE SCOTT

REUBEN TAVERAS

SENIOR DESIGN PROJECT SPRING 2022

TEAM MEMBERS

- CLARENCE SCOTT



- ELECTRICAL ENGINEERING TECH
- ELECTRICAL/ELECTRONIC SYSTEMS
- LRU REPAIR TECHNICIAN
- EXPECTED GRADUATION DATE SPRING 2022

- REUBEN TAVERAS

- ELECTRICAL ENGINEERING TECH
- ELECTRICAL/ELECTRONIC SYSTEMS
- UCF CODING BOOTCAMP
- EXPECTED GRADUATION DATE FALL 2022

TABLE OF CONTENT

MOTIVATION

- IMPROVE ON ORIGINAL STYROFOAM COOLER DESIGN WHICH WAS INTRODUCED BY COLEMAN IN 1957 [1]
- SUPPLEMENT AND IMPROVE SOCIAL GATHERINGS BY PROVIDING
  - SPEAKERS
  - ACCESSIBLE POWER SOURCES
  - LIGHTING OPTIONS
  - LOCKING FOOD STORAGE
- TAKEN TO THE BEACH, CAMPING, PARTY, ETC WHEREVER SOCIAL GATHERINGS HAPPEN
- HAVE SUFFICIENT BATTERY POWER TO OPERATE FOR AN EXTENDED PERIOD OF TIME

SIMILAR PRODUCTS

The Coolest Cooler [3]

THE COOLEST COOLER

- OVER 62,000 BAKERS PLEDGED $13,000,000 [3]
- CONSIDERED ONE OF KICKSTARTER'S BIGGEST SUCCESSES
- ALSO CONSIDERED ONE OF KICKSTARTER'S BIGGEST FAILURES BECAUSE OF TARIFFS IMPOSED TO US FROM CHINA [2]

SIMILAR PRODUCTS

INFINITE Smart Cooler [4]

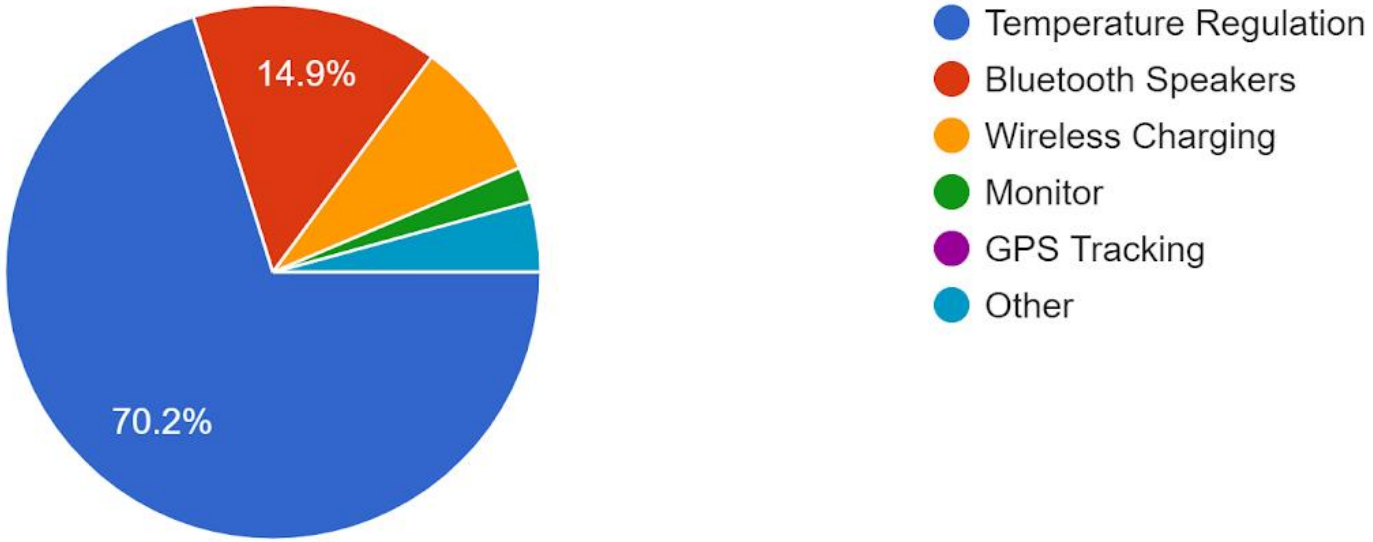
INFINITE SMART COOLER

- INDIEGOGO CAMPAIGN WITH 581 BACKERS [4]
- FEATURES
  - BLENDER
  - CAMERA
  - MULTIFUNCTIONAL UTENSILS
- DOES NOT FEATURE
  - LOCKING MECHANISM

SMART COOLER SURVEY

What feature would you be most excited to have?

47 responses



OTHER WANTED FEATURES

- WHEELS CAPABLE OF HANDLING ROUGH TERRAIN
- TEMPERATURE MONITORING THROUGH MOBILE APP
- REMOVABLE FREEZER BLOCKS
- NOTIFICATION WHEN ICE MELTS
- MAINTAIN DIFFERENCE TEMPERATURES FOR DIFFERENT COMPARTMENTS
- GPS TRACKING AND WAY TO CONTRACT EMERGENCY SERVICES
- SCREEN TO PLAY GAMES
- LED LIGHT INSIDE

DESIGN ENGINEERING REQUIREMENTS

HIGH-LEVEL REQUIREMENTS

- TEMPERATURE MONITORING FOR RANGE MINIMUM OF 0 DEGREES CELSIUS (TEMPERATURE OF ICE) ACCURATE TO WITHIN 1 DEGREE CELSIUS
- MINIMUM ACTIVE OPERATION OF ALL SYSTEMS FOR 12 HOURS.
- MULTIPLE EXTERIOR CHARGING INPUT OPTIONS
- MOBILE APP FUNCTIONALITY
- TOUCHSCREEN GUI
- MAX EMPTY WEIGHT OF 40 LBS
- CONTAINS 1.5 CUBIC FEET OF STORAGE VOLUME

MID-LEVEL REQUIREMENTS

- WIRELESS/WIRED CHARGING OPTIONS AT 5V, 1 TO 3A
- GPS TRACKING WITH ACCURACY WITHIN 3 METERS.
- RFID KEYLESS ENTRY LOCKING MECHANISM.
- BLUETOOTH SPEAKERS ALLOWING FOR A MINIMUM OF 87DB.
- SOLAR PANEL INTEGRATION MAY PROVIDE 12V, 1.5A CHARGING POWER TO BATTERY.

LOW-LEVEL REQUIREMENTS

- CUP HOLDERS WITH A STANDARD MINIMUM 2” DIAMETER.*
- WHEELS CAPABLE OF HANDLING RUGGED TERRAIN.*
- INTERIOR LED ACTIVATED WHEN LIGHTING CONDITIONS OUTSIDE ARE DARK.
- FLASHLIGHT HOLDER.
- BOTTLE OPENER.

*DENOTES FEATURES THAT ARE COVERED BY THE SHELL OF THE COOLER

DESIGN ENGINEERING SPECIFICATIONS

- SHELL
- MICROCONTROLLER
- SPEAKERS
- TEMPERATURE SENSORS
- LIGHT SENSOR
- POWER INPUT VOLTAGE REGULATOR
- POWER OUTPUT VOLTAGE REGULATOR
- BATTERY
- SOLAR PANEL
- USB CHARGING CONNECTION
- WIRELESS CHARGING PAD
- GPS MODULE
- RFID READER
- TOUCH SCREEN DISPLAY

Module	Specific Components	Engineering Specification	Justification and Verification	Responsibility
Shell	Coleman 100qt	Should have cup holders, wheels, and be large enough to support multiple compartments, at least 1.5 cubic feet of space.. Exterior walls should be at least 2' thick. Maximum allowable empty weight of 40 lbs.	Justification: Anyone should be able to move or load the Smart Cooler. Verification: Smart Cooler should be lightweight, have large carrying capacity, and wheels to help with transportation and loading.	Clarence
Control	Microcontroller: Raspberry Pi 4	Controller will provide SPI (Serial Peripheral Interface) used for communicating with other boards or modules. At least 20 GPIO pins needed, with alt functionality for SPI and serial communication. Bluetooth will connect with app at a range of 15m, and microcontroller will operate between 3.5-5.5V.	Justification: The Pi 4 can handle the input and output traffic, and communicate with the other modules. While connecting to the HDMI touch screen or mobile app. Verification: The microcontroller will be able to handle the six primary inputs, and four primary outputs, and communicate with the other modules. The microcontroller has 27 GPIO pins total with up to 6 alternate functions.	Team

Module	Specific Components	Engineering Specification	Justification and Verification	Responsibility
Mobile Application	Apple or Android Smartphone	Bluetooth will communicate with microcontroller at a range of 15m. Application will monitor temperature of each compartment, ability to activate locking and interior LED, ability to change settings (GPS enable, locking mechanism enable, LED light enable, speaker enable), and able to save profiles.	Justification: Providing Android and iPhone support allows for the majority of users to use the app. The app communicating with the microcontroller allows for remote monitoring and setting of the cooler. Verification: Testing will ensure the microcontroller is communicating with the mobile application using an Apple or Android Smartphone.	Reuben
Entertainment	Pyle Marine Speakers	Speakers should be no deeper than 2”. Speakers should operate between 50-200W for a dB rating of 87 dB.	Justification: Narrow footprint so that they can be placed in the walls of the Smart Cooler. Speakers must be heard when near the cooler. Verification: Speakers should be able to be heard at least 5 meters away.	Clarence

Module	Specific Components	Engineering Specification	Justification and Verification	Responsibility
Amplifier	Amp: TPA3116 DAMGOO	Provide at least 200W for Speaker operation. Use class D amplifier for maximum efficiency.	Justification: Exceed minimum Wattage needs for both Speakers. Verification: Speakers should properly operate with the wattage provided from the AMP.	Clarence
Sensors	Temperature: DS18B20 Waterproof Temperature Sensors	Monitor Temperature in compartments to an accuracy of ± 1.0°C in real time, minimum range of at least 0°C	Justification: The temperature sensor will tell when the compartment is too warm and when ice needs to be replaced. Verification: Monitor the temperature with a separate thermometer in the compartments.	Reuben

Module	Specific Components	Engineering Specification	Justification and Verification	Responsibility
Interior LED	Exterior Light: Photo-sensitve Sensor Alitove Led Strip Lights	Exterior light sensor will change output voltage in low light conditions in real time. LED light strip will provide illumination when light sensor detects it is dark outside.	Justification: Interior lights are needed for operation after dark. Verification: Will test and confirm that output voltage changes when ambient light is low. Light strip will activate when dark outside or manually.	Reuben
Power Input Control Module	Voltage Regulator 12V input power socket	Shall provide the cooler multiple charging options to accept 120V AC and 12VDC.	Justification: Allow for battery charging from Solar Panel, outlet plug, or automobile barrel jack. Verification: A digital multimeter will be used to confirm that the module is supplying the correct voltages when both inputs are used to pass.	Team

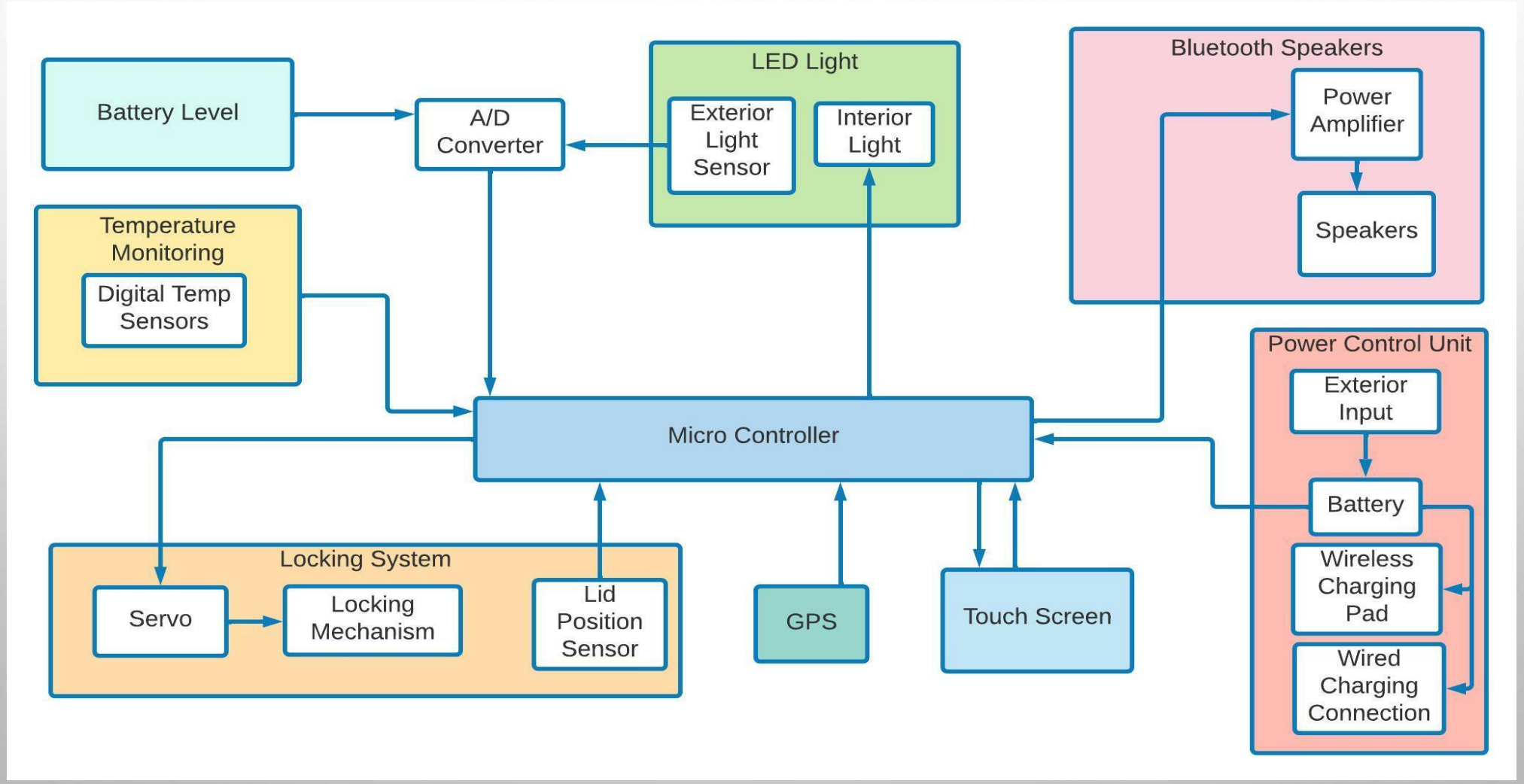
Module	Specific Components	Engineering Specification	Justification and Verification	Responsibility
Battery	Battery: LiFePO4	Provide 12V to the Smart Cooler modules. Battery shall maintain active operation for at least 12 hours. To be charged by charging module.	Justification: Needed to power systems when outside power is not available. Verification: A digital multimeter will be used to confirm that the battery is supplying the correct voltages to pass.	Team
Solar Panel	Solar Panel: Eco-Worthy 12V 10W	12-20V output voltage, at least 1.5A current output, at least 14.4W power output, at least 9.6Ah output	Justification: The solar panel will provide power to the battery during daylight hours and assist with charging for night time operation. Verification: A digital multimeter will be used to confirm that the module is supplying the correct voltages when both inputs are used to pass.	Clarence

Module	Specific Components	Engineering Specification	Justification and Verification	Responsibility
Power Output Control Module	Voltage Regulator	Convert stored energy in the battery into voltages required for operation, 5V and 12V.	Justification: The Voltage Regulator will ensure that the voltages supplied by the batteries are the correct voltages to ensure the modules of the Smart Cooler operate properly without damaging components. Verification: A digital multimeter will be used to confirm that the voltage regulator is allowing the correct voltages to pass.	Team
USB Charging	Exterior USB Charger: Damavo YM1218 USB C and USB A Charger socket	Should operate using either 5V or 12V input voltage. Will output 5V 2.1A for USB A & 5V 3A for USB C	Justification: The charger will allow wired charging of devices. Verification: Plug will be tested with several USB devices	Clarence

Module	Specific Component	Engineering Spec	Justification	Responsibility
GPS Module	BN-880 GPS Module	Module will accurately track location to within 3 meters.	Justification: Allow the user to mark the Smart Cooler and possible camp site. Verification: Google Maps will be used to confirm the accuracy of the GPS location.	Team
Charging Module	Qi Wireless Charging Transmitter	Output at 5W at a minimum of 100 KHz Provide 5V and 1A of charging power to devices.	Justification: Allows the user to charge other mobile devices in a timely manner. Verification: Capable of charging modern Smart devices especially cell phones.	Clarence

Module	Specific Components	Engineering Specification	Justification and Verification	Responsibility
Lock	Locking Mechanism Sensor: Reed Switch Servo: SG90	Close and lock the Smart Cooler using the APP touch screen or RFID Keyless entry. Provide 180 degree rotation to position lock in place.	Justification: Secure the lid so that it can not be opened on accident, unauthorized people, or animals. Verification: The lock should engage and disengage when signalled by the Touch screen, Mobile app, and RFID keyless entry.	Team
Touch Screen	Sunfounder 7 inch	Shall support touchscreen functions and at least Wide SVGA resolution.	Justification: Allows the user to interact with the Micro controller and control the operation of the cooler. Verification: Touching screen interacts with GUI and sets or configures features on cooler.	Clarence

BLOCK DIAGRAM



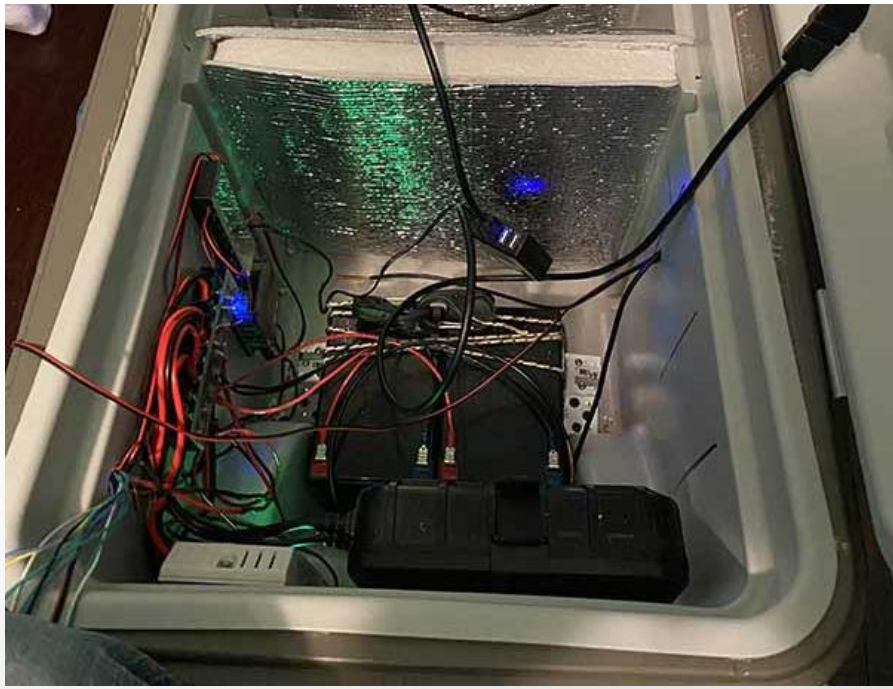
POWER BUDGET

Component	Model	Voltage	Amp	Watts
Microcontroller	Raspberry Pi 4	5V	3A	15W
Temperature Sensor	DS18B20	5V	1mA	5mW
Wireless Charging	Qi Wireless Charging Transmitter	5V	1A x 2 = 2A	10W
Wired USB Charging	YM1236 Dual USB Charger	5V	2.1A	10.5W
Solar Panel	Eco-Worthy	12V	0.833A	10W
Servo	Micro SG90	5V	360mA	1.8W
RFID	RC522	3.3V	26mA	85.8mW
GPS Module	BN-880	5V	50mA	250mW
Touch Screen	Sunfounder 7”	5V	480mA	2.4W
Amp Board	DAMGOO	5-27V	>3A	Up to 200W
LED Light Strip	Alitove WS2812B RGB LEDs	5V	4.05A	20.25W
Analog to Digital Converter	MCP3008	5V	500uA	2.5mW
Total			15.1A	260.3W

MAIN FEATURES AND FUNCTIONS

- POWER SYSTEM
- MICROCONTROLLER
- AUTOMATED LIGHTING
- GPS
- LOCKING MECHANISM
- SPEAKERS

POWER SYSTEM



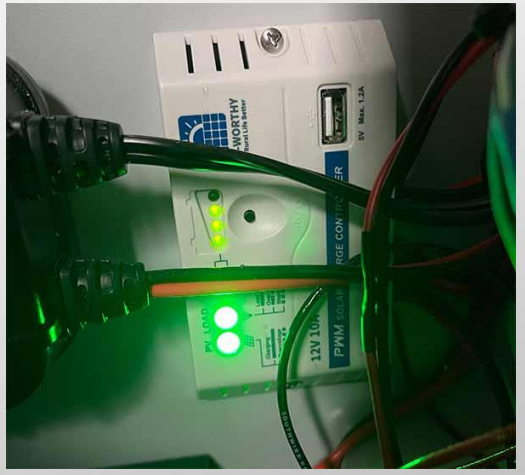
- SEVERAL OPTIONS FOR CHARGING THE SYSTEM
  - 120V AC WALL PLUG
  - 12V DC CAR CIGARETTE LIGHTER
  - 12V SOLAR PANEL
- CAN BE USED TO CHARGE MOBILE DEVICES
  - WIRELESSLY
  - USING USB A OR C

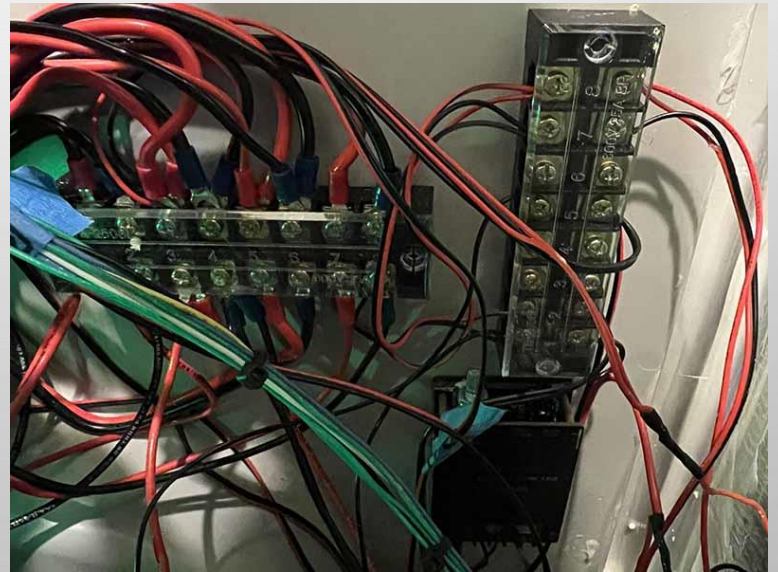
WALL PLUG SYSTEM CHARGING

- THE LITHIUM BATTERIES IN THE SYSTEM REQUIRE SPECIAL CHARGERS THAT ADJUST CURRENT BASED ON THE BATTERIES LEVEL OF CHARGE
- CHARGER WAS USED AND MODIFIED TO ACCOMMODATE 120V AC WALL PLUG

SOLAR PANEL AND CAR CIGARETTE LIGHTER SYSTEM CHARGING

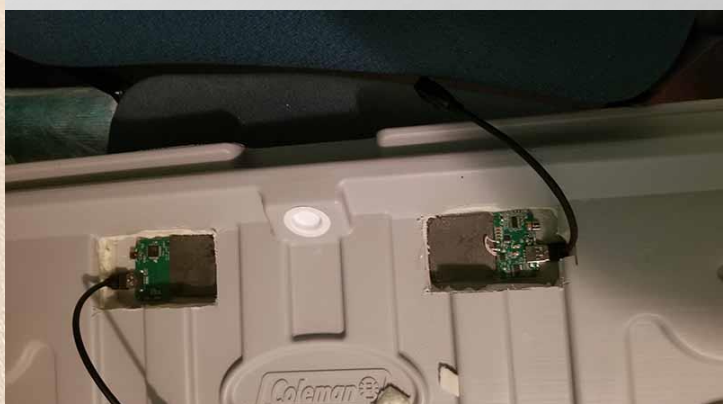
- SOLAR PANEL PROVIDED DISTRIBUTION BOX
- SOLAR PANEL AND CIGARETTE LIGHTER BOTH PROVIDE 12V DC
- TERMINAL BLOCKS WERE USED TO PATCH THE CIGARETTE LIGHTER INTO THE DISTRIBUTION BOX PROVIDED BY THE SOLAR PANEL





MOBILE DEVICE CHARGING

- WIRED CHARGING FUNCTION ACCOMPLISHED USING A USB PLUG THAT SUPPORTS USB A AND C
- WIRELESS CHARGING ACCOMPLISHED THROUGH MOUNTING WIRELESS CHARGING MODULES IN THE COOLER LID



MICROCONTROLLER

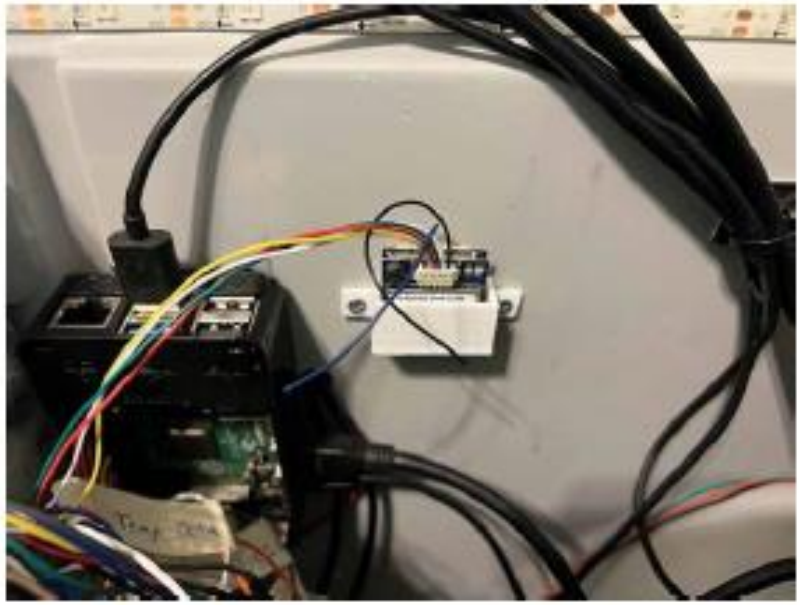
- RASPBERRY PI
- POWERS 3.3V DEVICES
  - A/D CONVERTER
  - LIGHT SENSOR
  - BATTERY LEVEL INDICATOR
  - RFID
- GPIO SWITCHING FOR 5V AND 12V DEVICES
  - GPS
  - LED LIGHTS
  - SERVO
  - SPEAKERS

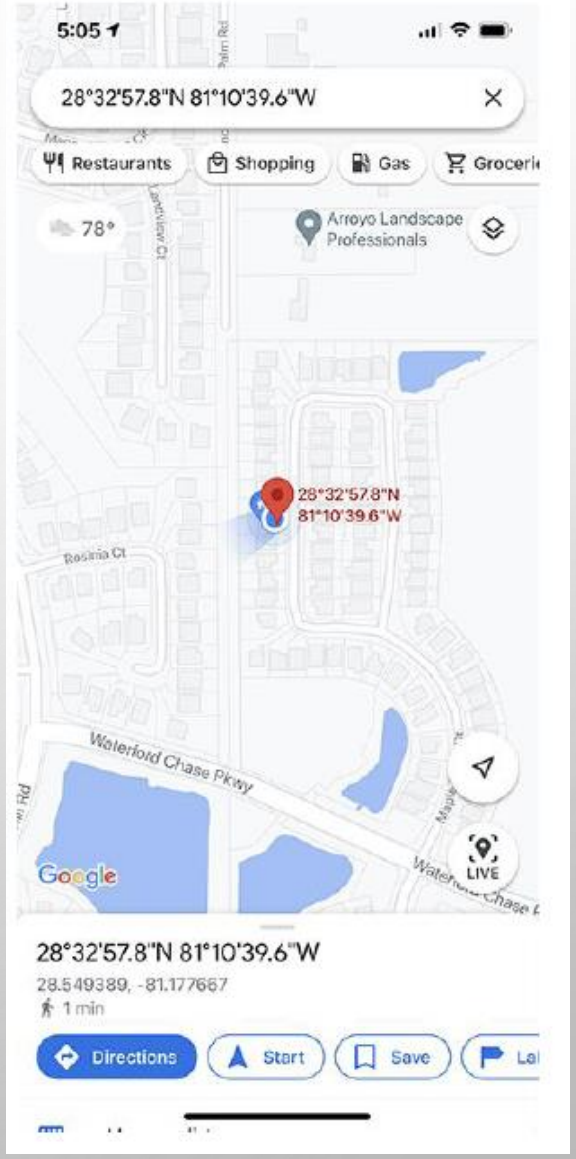
LED LIGHTS

- WS2812B LED LIGHT STRIP
- 73 LED LIGHTS USED
- CAN BE PROGRAMMED TO ANY COLOR USING RPI_WA281X LIBRARY, BUT SELECTED COLORS WERE:
  - RED
  - BLUE
  - WHITE
  - RAINBOW
- AUTO FEATURE
  - LIGHTS TURN ON IN LOW LIGHT ENVIRONMENT

GPS MODULE

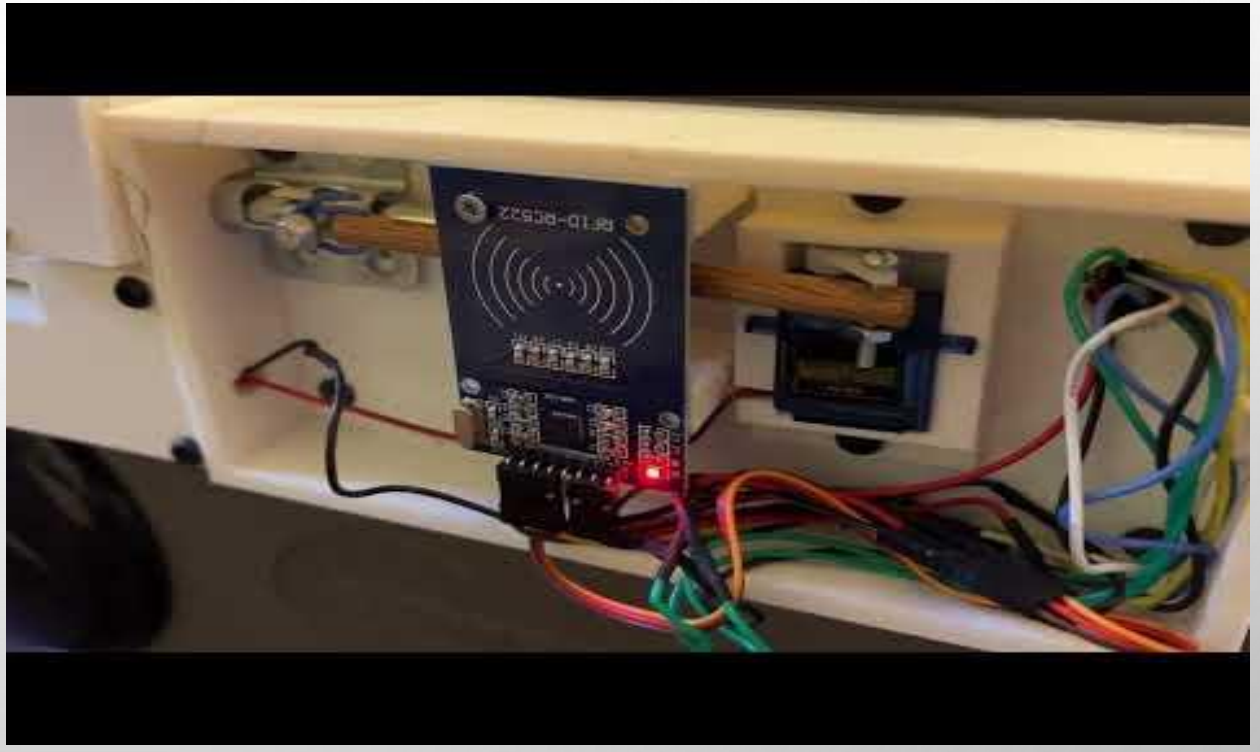
- USES GPSD LIBRARY
- WHEN ENABLED, RECEIVES LAT AND LONG COORDINATES
- WILL SAVE LAST LOCATION OF COOLER AND SHOW ON GOOGLE MAPS





LOCKING MECHANISM

- USES SG90 SERVO AND MC522 RFID
- SERVO CONNECTED TO DOWEL, WHICH IS CONNECTED TO SLIDING LOCK
- DOOR POSITION SENSOR
- AUTO LOCK FEATURE



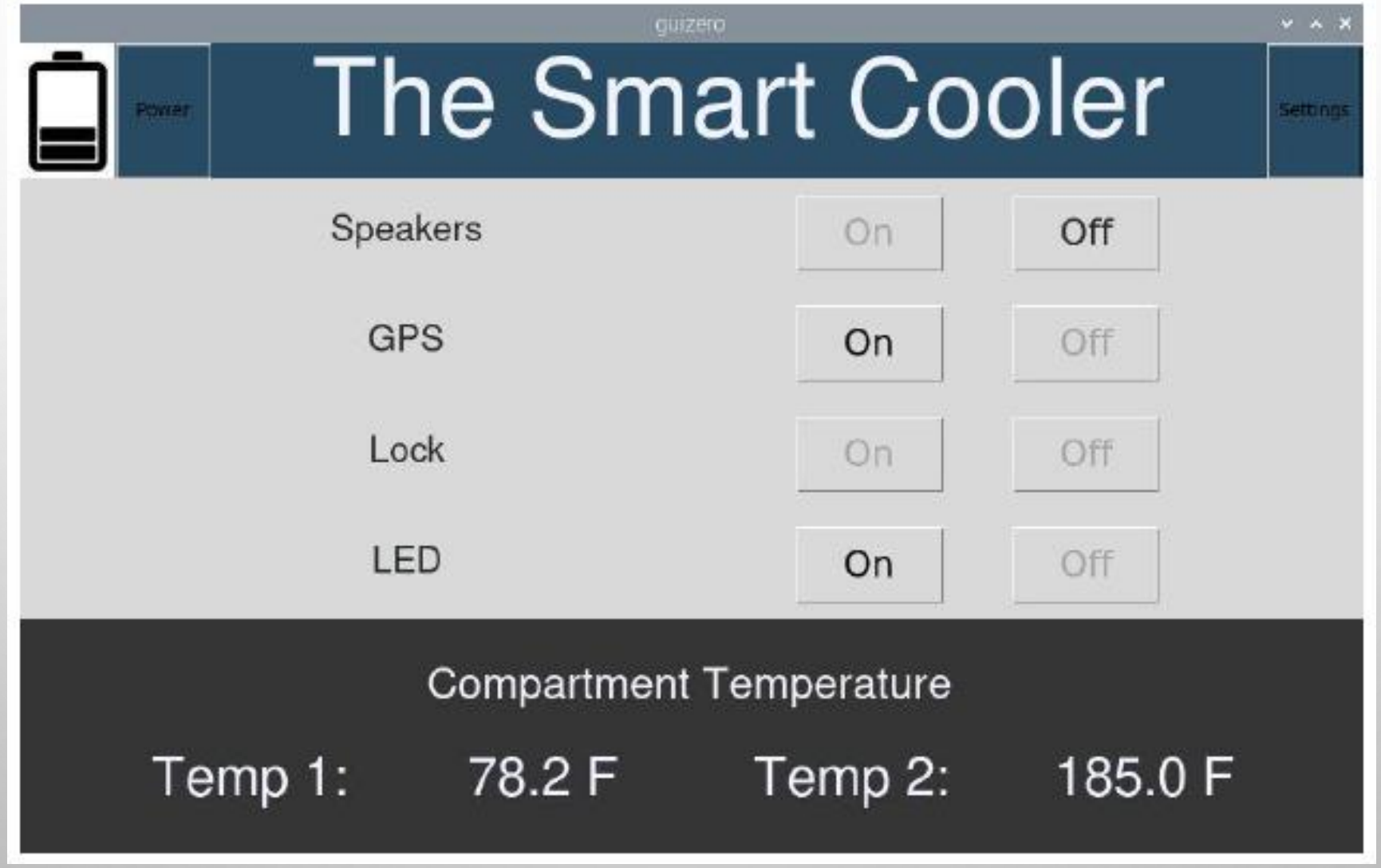
SPEAKERS

- RECESSED INTO THE WALLS
- 100W SPEAKERS
- USES AMPLIFIER

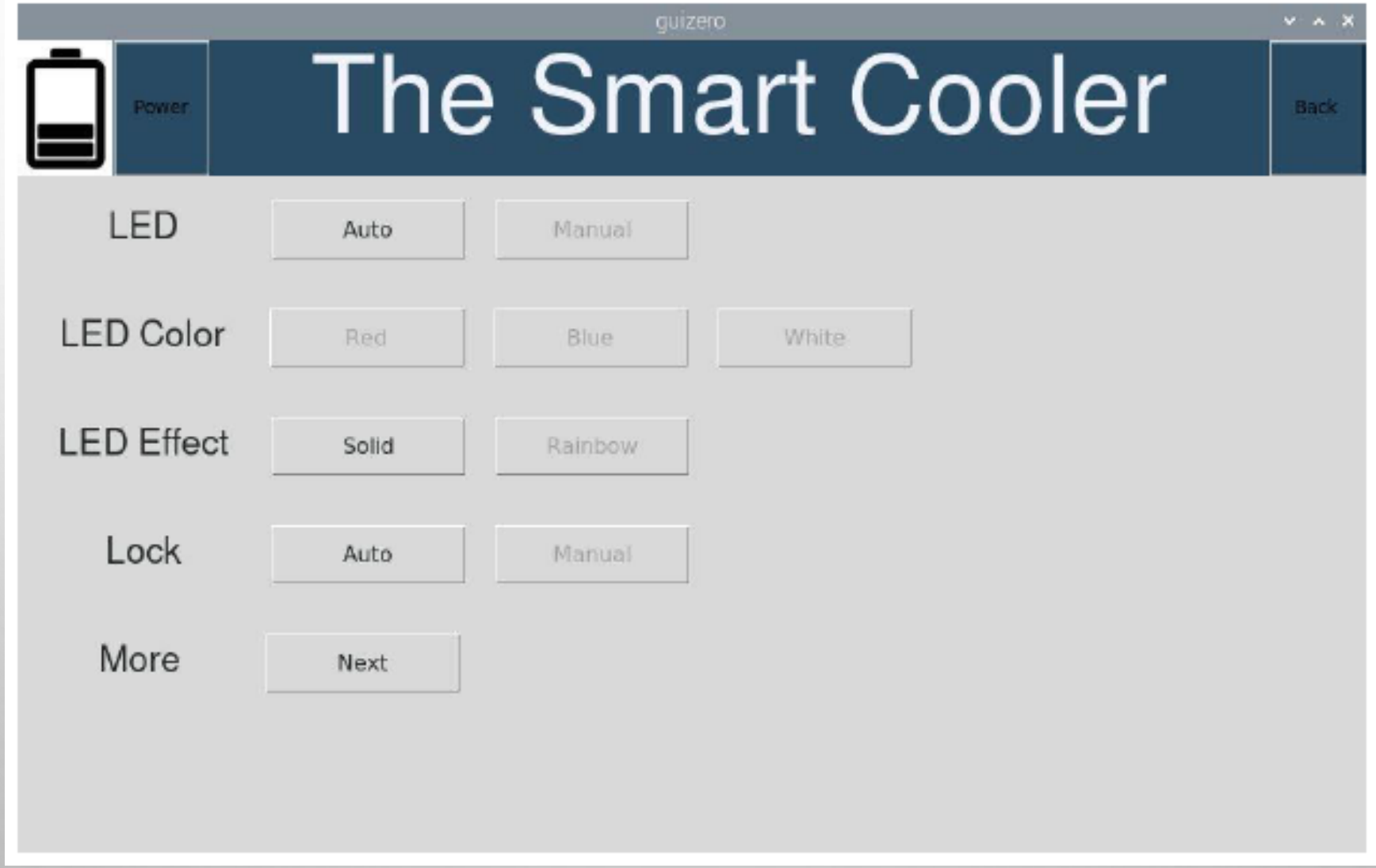
TOUCHSCREEN

- DISPLAYS GUI ON STARTUP
- CAN CONTROL FEATURES:
  - SPEAKERS
  - GPS
  - LOCK
  - LED LIGHTS

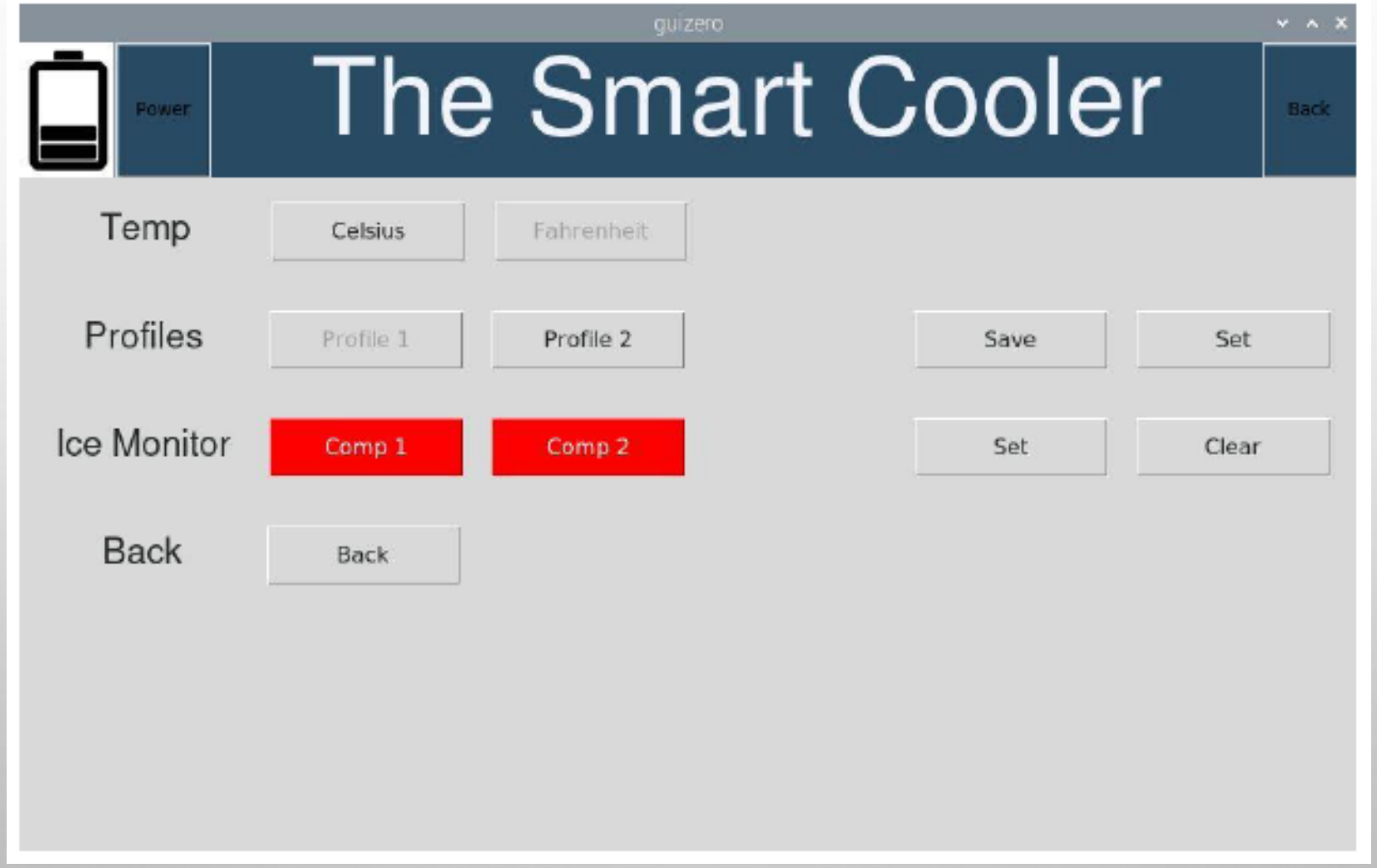
TOUCHSCREEN GUI MAIN SCREEN



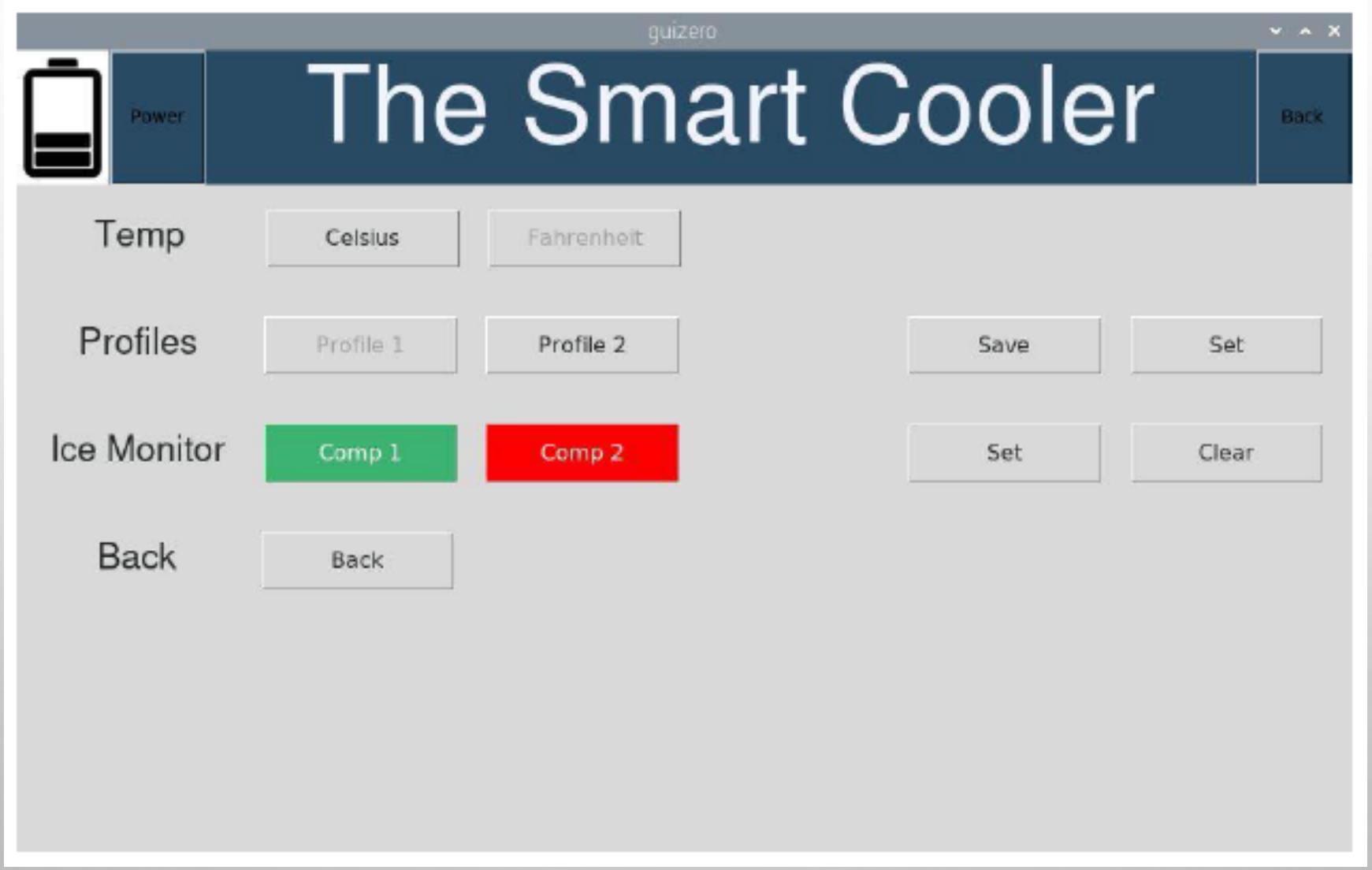
TOUCHSCREEN GUI SETTINGS SCREEN



TOUCHSCREEN GUI MORE SETTINGS SCREEN



TOUCHSCREEN GUI ICE NOTIFICATION

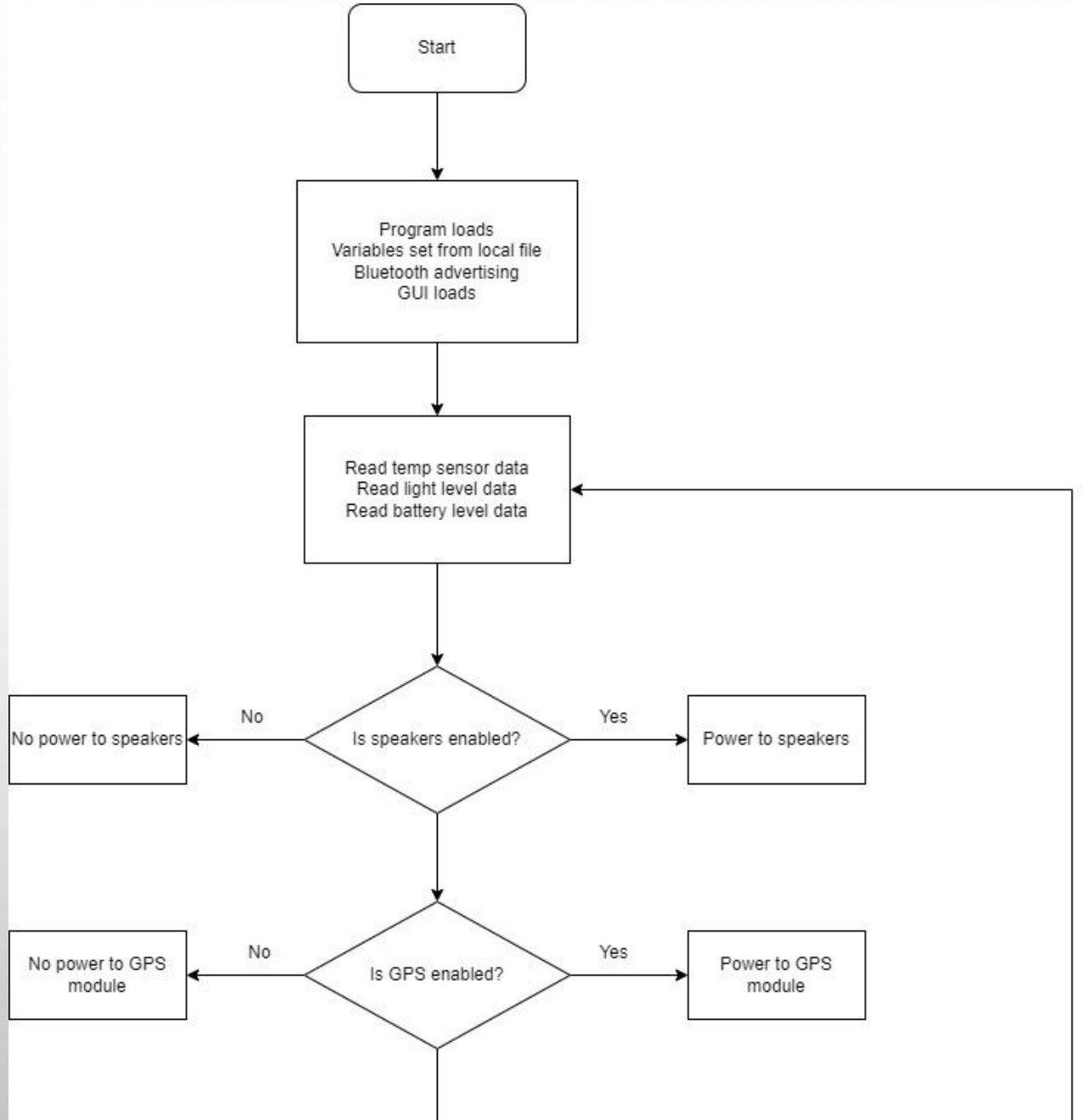


TOUCHSCREEN GUI ICE NOTIFICATION

SOFTWARE

- RASPBERRY PI
  - PYTHON
  - THREADING
    - MAIN LOOP
    - GUI
    - BLUETOOTH
    - RFID
    - LED LIGHTS
- MOBILE APP
  - USES REACT NATIVE (JAVASCRIPT)
  - DEPLOYED FOR BOTH ANDROID AND IPHONE
  - TO DEVELOP FOR IPHONE, A MACBOOK WAS USED

RASPBERRY PI PYTHON FLOWCHART



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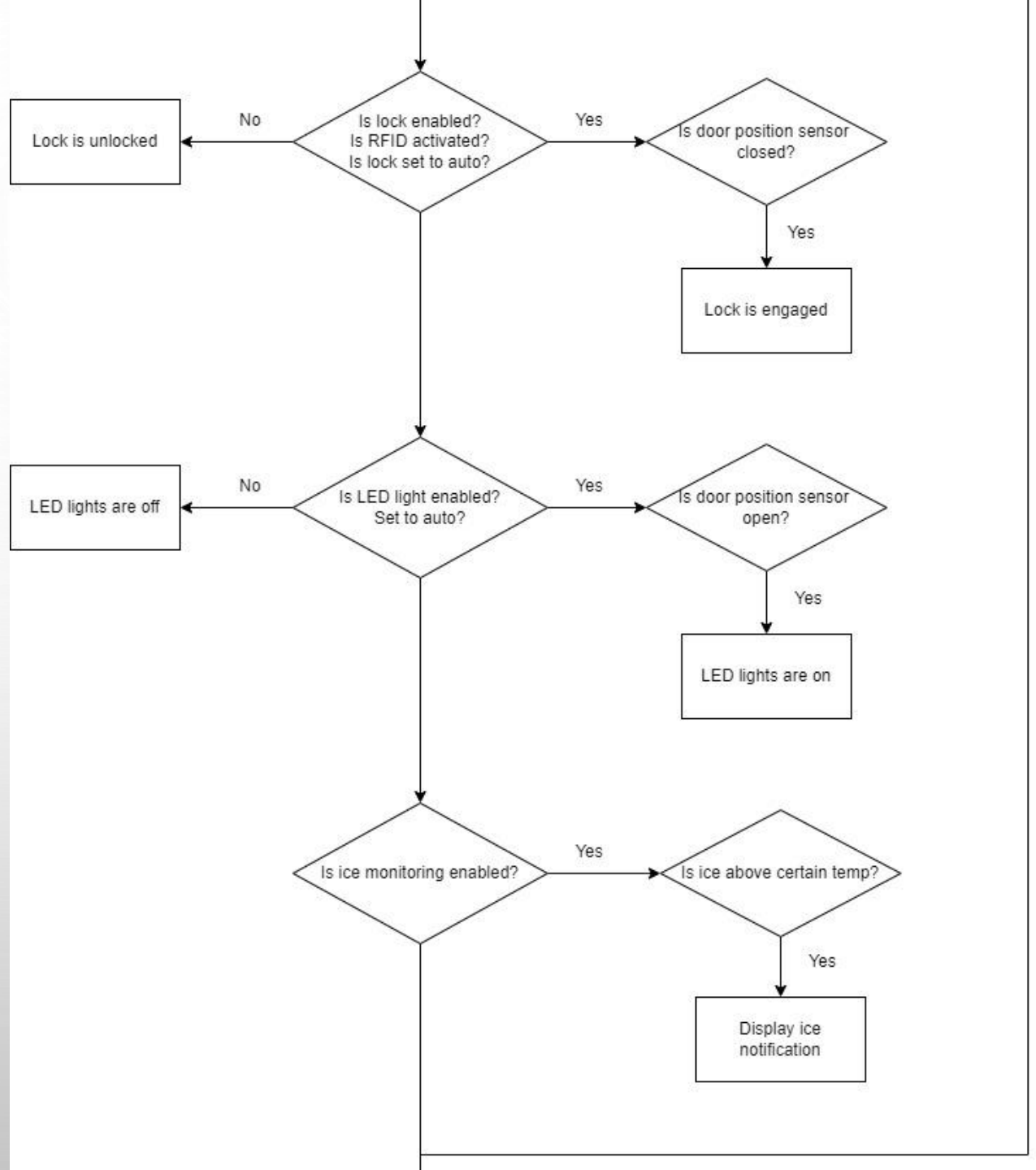
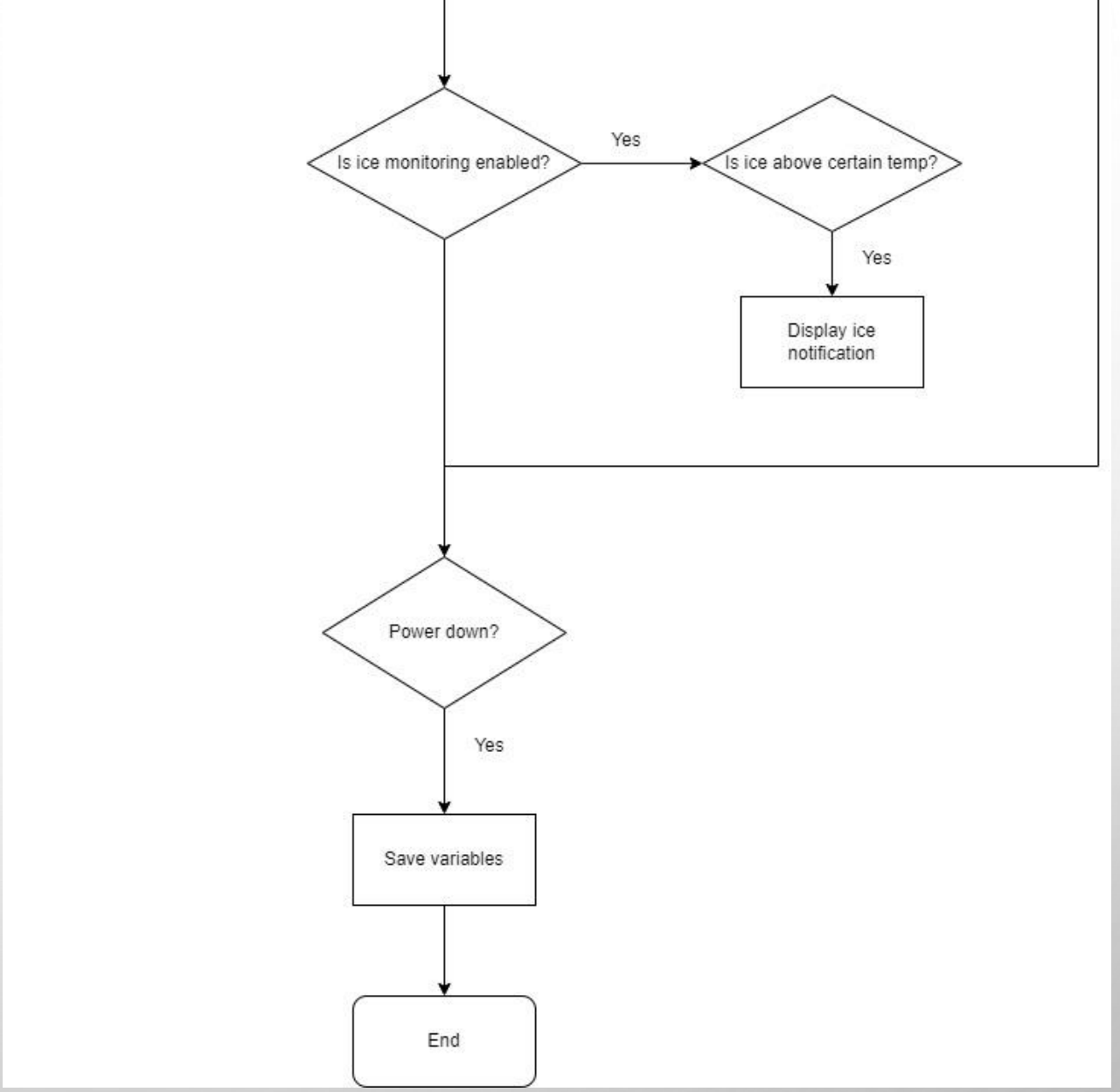
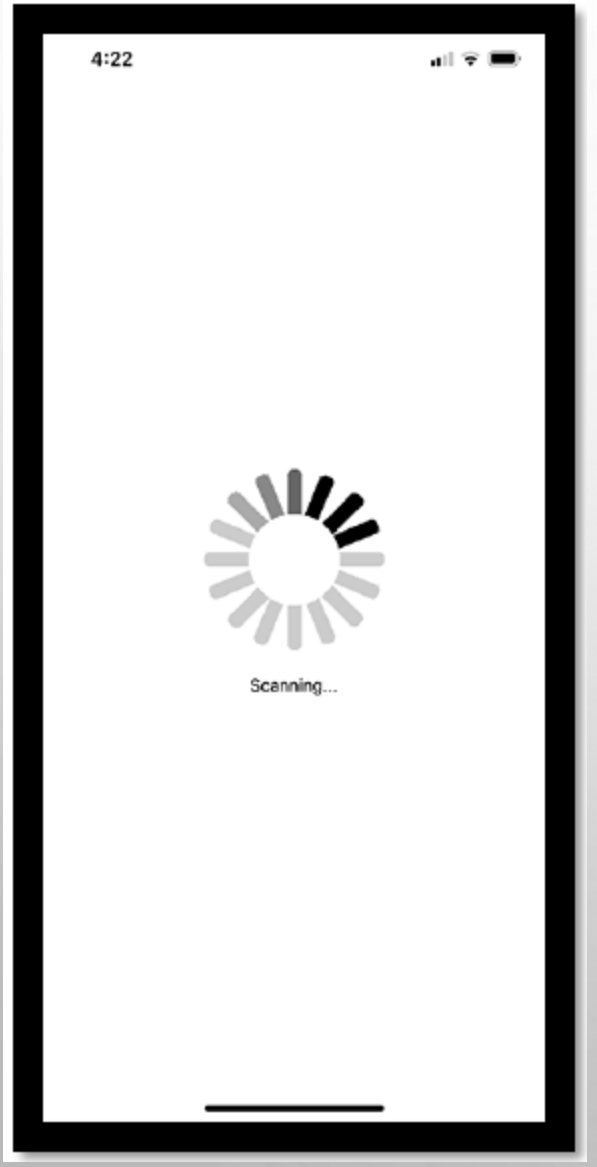
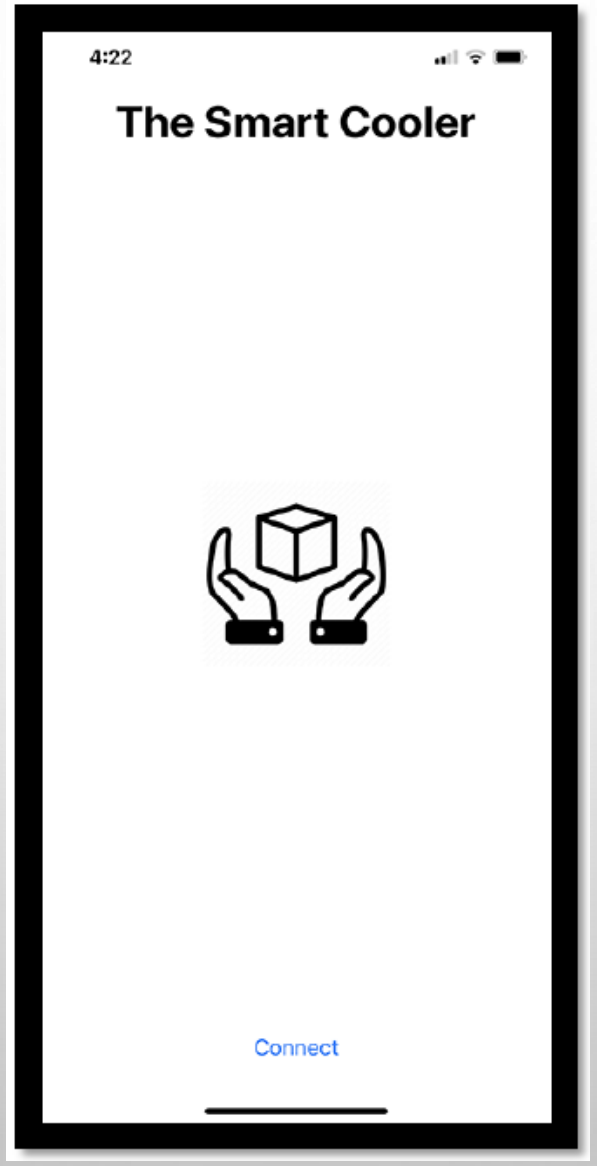


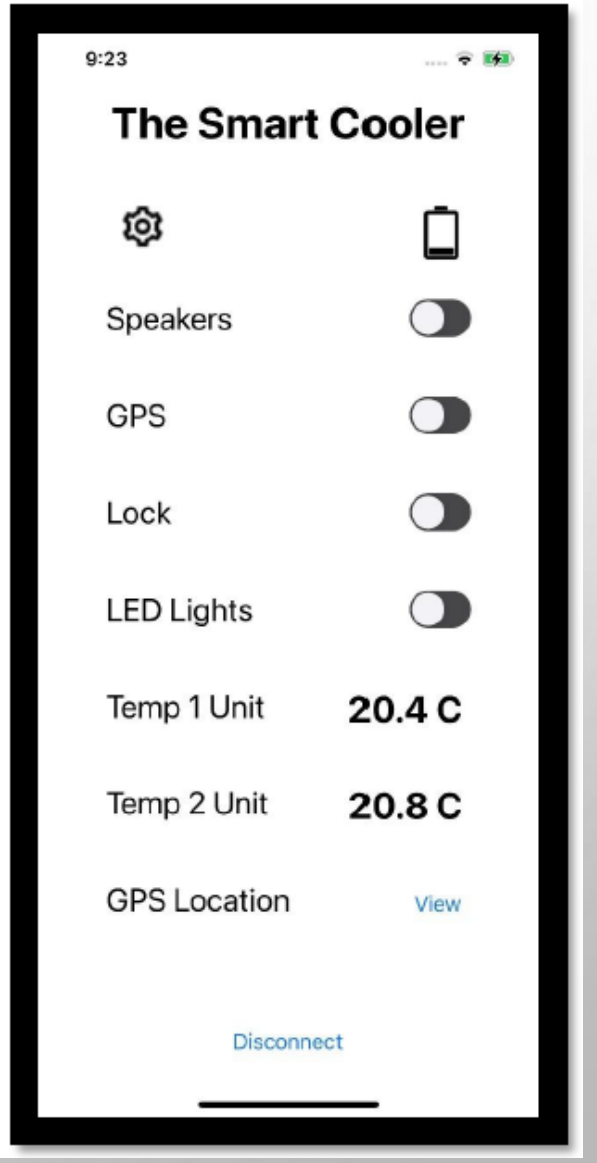
RASPBERRY PI PYTHON FLOWCHART



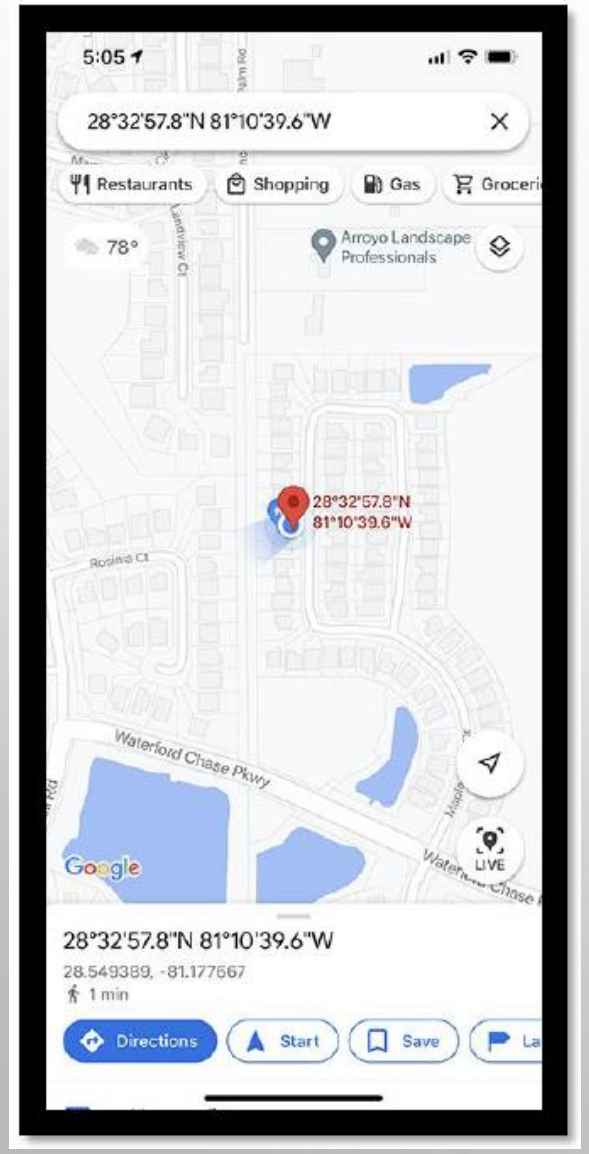
MOBILE APP

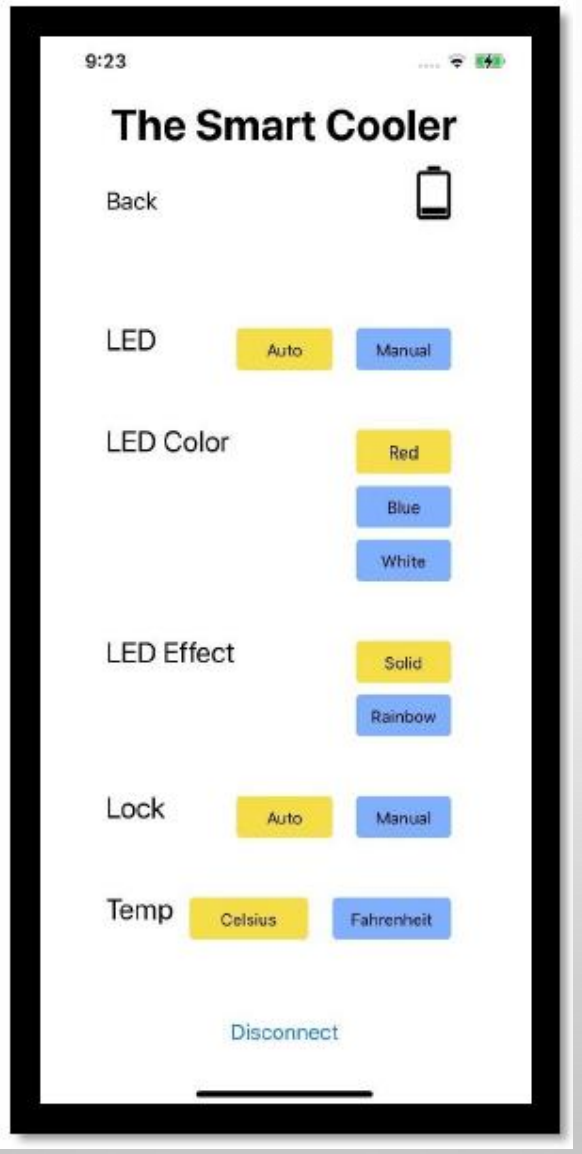

4:22
Scanning...

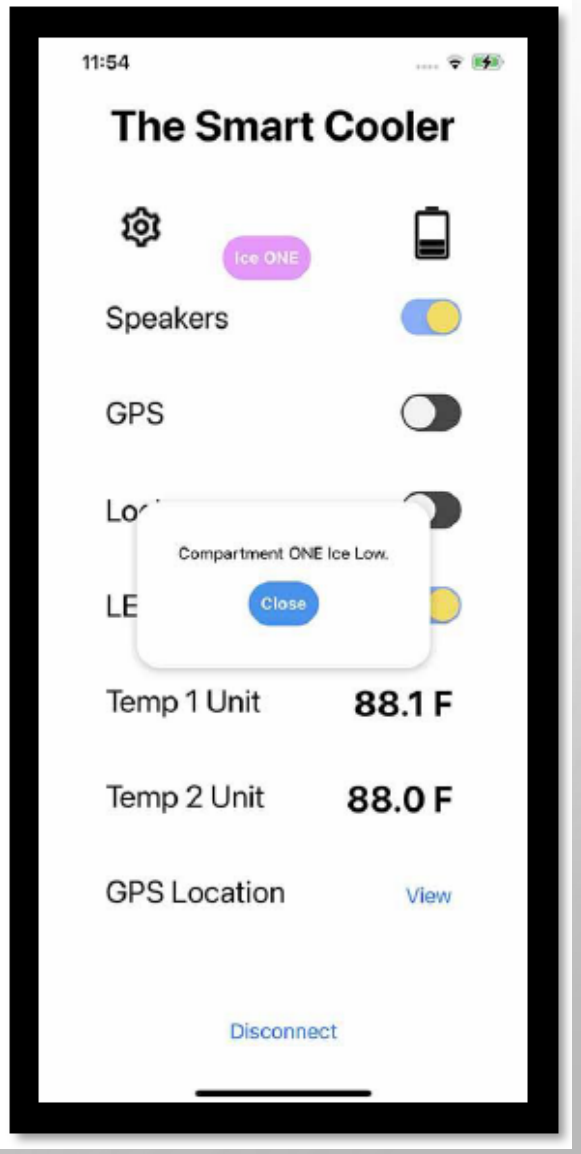

4:22
The Smart Cooler
Connect


9:23
The Smart Cooler
Speakers
GPS
Lock
LED Lights
Temp 1 Unit
20.4 C
Temp 2 Unit
20.8 C
GPS Location
View
Disconnect

MOBILE APP


5:05
28°32'57.8"N 81°10'39.6"W
Restaurants
Shopping
Gas
78°
Arroyo Landscape Professionals
28°32'57.8"N
81°10'39.6"W
Waterford Chase Pkwy
Google
LIVE
28°32'57.8"N 81°10'39.6"W
28.549389, -81.177667
1 min
Directions
Start
Save


9:23
The Smart Cooler
Back
LED
Auto
Manual
LED Color
Red
Blue
White
LED Effect
Solid
Rainbow
Lock
Auto
Manual
Temp
Celsius
Fahrenheit
Disconnect


11:54
The Smart Cooler
Ice ONE
Speakers
GPS
Compartment ONE Ice Low.
Close
Temp 1 Unit
88.1 F
Temp 2 Unit
88.0 F
GPS Location
View
Disconnect

EXPECTED BUDGET

Component	Item	Price	Quantity	Total
Cooler	Coleman 100qt	$69.97	1	$69.97
Micro Controller				
Micro Controller	Raspberry Pi 4	$79.99	1	$79.99
Temperature Regulation				
Temperature Sensor	DHT11	$5.99	2	$11.98
Refrigerator	Thermoelectric Refrigerator	$23.99	2	$47.98

EXPECTED BUDGET

Component	Item	Price	Quantity	Total
Charging Applications	Qi Wireless Charging Transmitter	$26.95	1	$26.95
Solar Panel	ECO-Worthy	$33.00	1	$33.00
Battery	Miadi LFP20AH	$69.99	2	139.98
Wired USB Charging	YM1236 Dual USB Charger	$9.59	1	$9.59
AC Battery Charger	NOCO Genius10	$64.96	1	$64.96
Locking Mechanism				
RFID	RC 522	$5.49	1	$5.49
Servo	Betu 25KG	$18.50	2	$37.00
LED Lights				
LED Light Strip	Flexible LED Strip Lights	$8.79	1	$8.79
Photoresistor	Photocell	$0.95	1	$0.95

EXPECTED BUDGET

Component	Item	Price	Quantity	Total
Cutting Board	FarberWare Plastic Cutting Board	$6.62	1	$6.62
Servo	Betu 25KG	$18.50	1	$18.50
GPS				
GPS Module	BN-880 GPS Module	$18.99	1	$18.99
Inputs				
TouchScreen	Sunfounder 7 inch	$65.99	1	$65.99
Outputs				
Speakers	Low Profile Marine Speakers	$29.99	1	$29.99
Amp board	TPA3116,DAMGOO	$22.99	1	$22.99

EXPECTED BUDGET

Component	Item	Price	Quantity	Total
Analog to Digital Converter	MCP3008	$3.75	1	$3.75
Servo Controller	SunFounder PCA9685	$9.99	1	$9.99
Misc		$100.00	1	$100
Total				$813.45

ACTUAL BUDGET

Modules	Parts	Unit Cost	Quantity	Cost
Structure/Chassis				
Cooler	Coleman 100qt	$69.97	1	$69.97
Micro Controller				
Micro Controller	Raspberry Pi 4	$35.00	1	$35.00
Temperature Regulation				
Temperature Sensor	DS18B20 Waterproof Temp Sensors	$2.20	2	$4.40

ACTUAL BUDGET

Power Control Unit				
Charging Applications	Qi Wireless Charging Transmitter	$26.95	2	$53.90
Solar Panel	ECO-Worthy	$33.00	1	$33.00
Battery	Miadi LFP16AH	$59.99	2	$119.98
Wired USB Charging	YM1236 Dual USB Charger	$9.59	1	$9.59
AC Battery Charger	NOCO Genius10	$64.96	1	$64.96
12V-5V Buck Converter	DROK 5A USB Voltage Regulator	$9.99	1	$9.99
12V-5V Buck Converter	Yipin Hexha DC 5V Converter Module	$14.99	1	$14.99

ACTUAL BUDGET

Locking Mechanism				
RFID	RC 522	$5.49	1	$5.49
Servo	Micro SG90	$5.95	1	$5.95
LED Lights				
LED Light Strip	Alitove WS2812B RGB LED Strip	$23.99	1	$23.99
Photoresistor	Photocell	$0.95	1	$0.95
GPS				
GPS Module	BN-880 GPS Module	$18.99	1	$18.99
Inputs				
TouchScreen	Sunfounder 7 inch	$65.99	1	$65.99

ACTUAL BUDGET

Outputs				
Speakers	Low Profile Marine Speakers	$29.99	1	$29.99
Amp board	TPA3116,DAMGOO	$22.99	1	$22.99
Other Components				
Analog to Digital Converter	MCP3008	$3.75	1	$3.75
Misc				
MOSFET	FQP30N06 N-Channel MOSFET	$0.90	3	$2.70
Lid Position Sensor	Magnetic Reed Switch	$5.00	1	$5.00
Terminal Block	600V 25A Dual Row Screw Terminal	$2.83	2	$5.66
Insulation Shield	3MM Reflective Foam Insulation	$16.88	1	$16.88
Connector Plug	LanHong 2 Pin Connector Plug	$1.20	2	$2.40
Foam Board	1" Thick Polystyrene Foam Board	$20.99	1	$20.99
USB Cable	DTECH Type A to A USB Cable	$6.98	2	$13.96

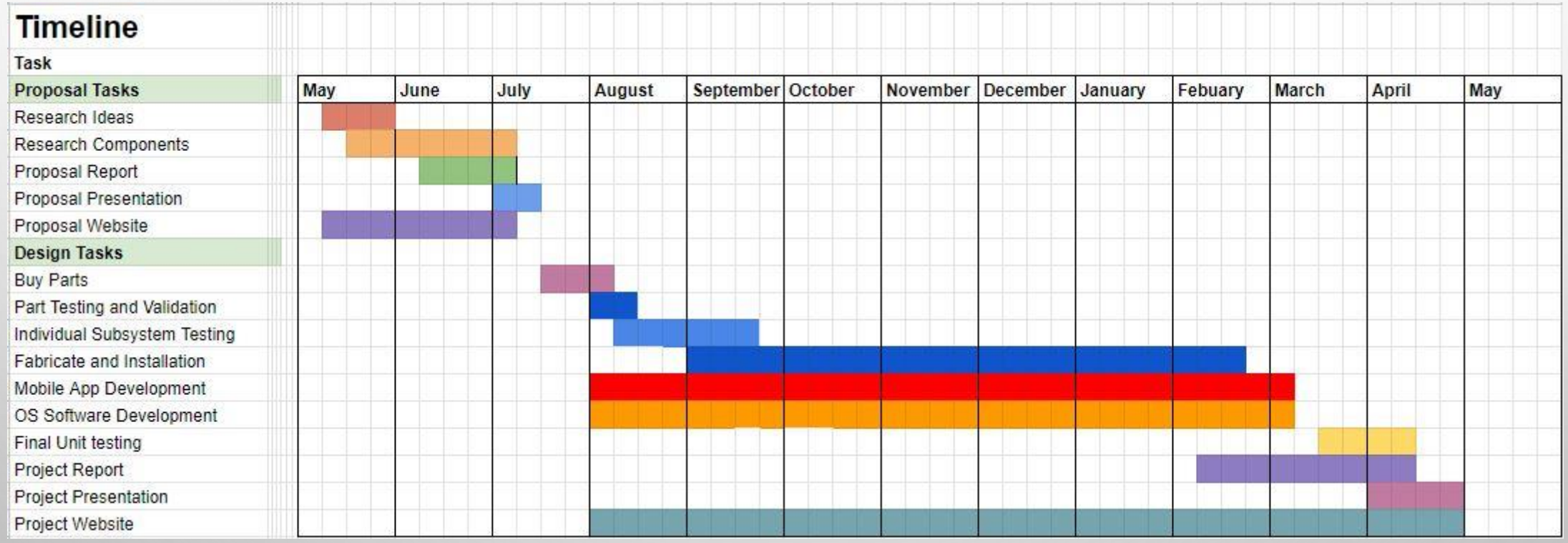
ACTUAL BUDGET

Power Switch	**Magic&Shell Round Rocker Switch**	**$1.75**	**1**	**$1.75**
Drain Plug	Cooler Drain Plug Replacement	$11.99	1	$11.99
Plexiglass	Optix Plexiglass	$34.00	2	$68.00
3d Printing Filament	1.75mm PLA Filament 1kg	$20.00	1	$20.00
Solar Panel Metal Bracket	Armstrong 2' Cross Tee	$1.90	1	$1.90
Sliding Lock	ReliaBilt Zinc Steel Barrel Bolt	$2.68	1	$2.68
Wooden Dowel	Wooden Dowel	$1.50	1	$1.50
Various Screws and Bolts	Various Screws and Bolts	$5.00	1	$5.00
Total				$774.28

TIMELINE

Task	Length (Days)	Start Date	End Date
Buy Parts	19	07/12/2021	07/31/2021
Part Testing and Validation	13	08/01/2021	08/14/2021
Individual Subsystem Testing	44	08/07/2021	09/20/2021
Fabricate and Installation	175	09/01/2021	02/23/2022
Mobile App Development	221	08/01/2021	03/10/2022
OS Software Development	221	08/01/2021	03/10/2022
Final Unit Testing	26	03/20/2022	04/15/2022
Project Report	64	02/10/2022	04/15/2022
Project Presentation	21	04/01/2022	04/22/2022
Project Website	264	08/01/2021	04/22/2022

TIMELINE (VISUAL)



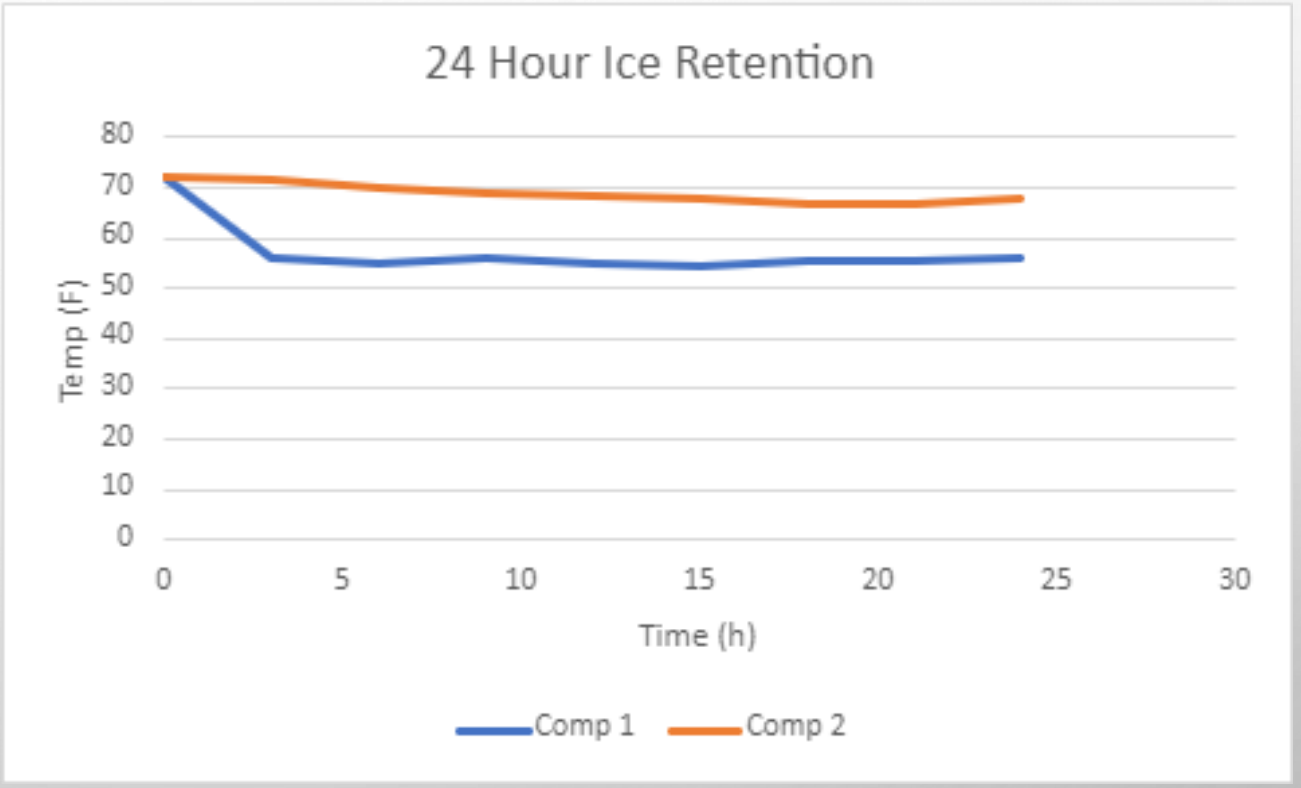
POWER ANALYSIS RESULTS

- POWER BUDGET CALCULATED AS 15.1A
- UPON TESTING, TOTAL AMPS ABOUT 1A
- CURRENT INCREASES WITH EACH ADDITIONAL FEATURE ACTIVATED

Component	Total Current (mA)
Startup, Just Raspberry Pi and touchscreen running.	410
Phone Connected to USB Charger	490
One Wireless Charger Used	550
Second Wireless Charger Used	680
Speakers (Max Volume)	770
LED Lights (White)	920

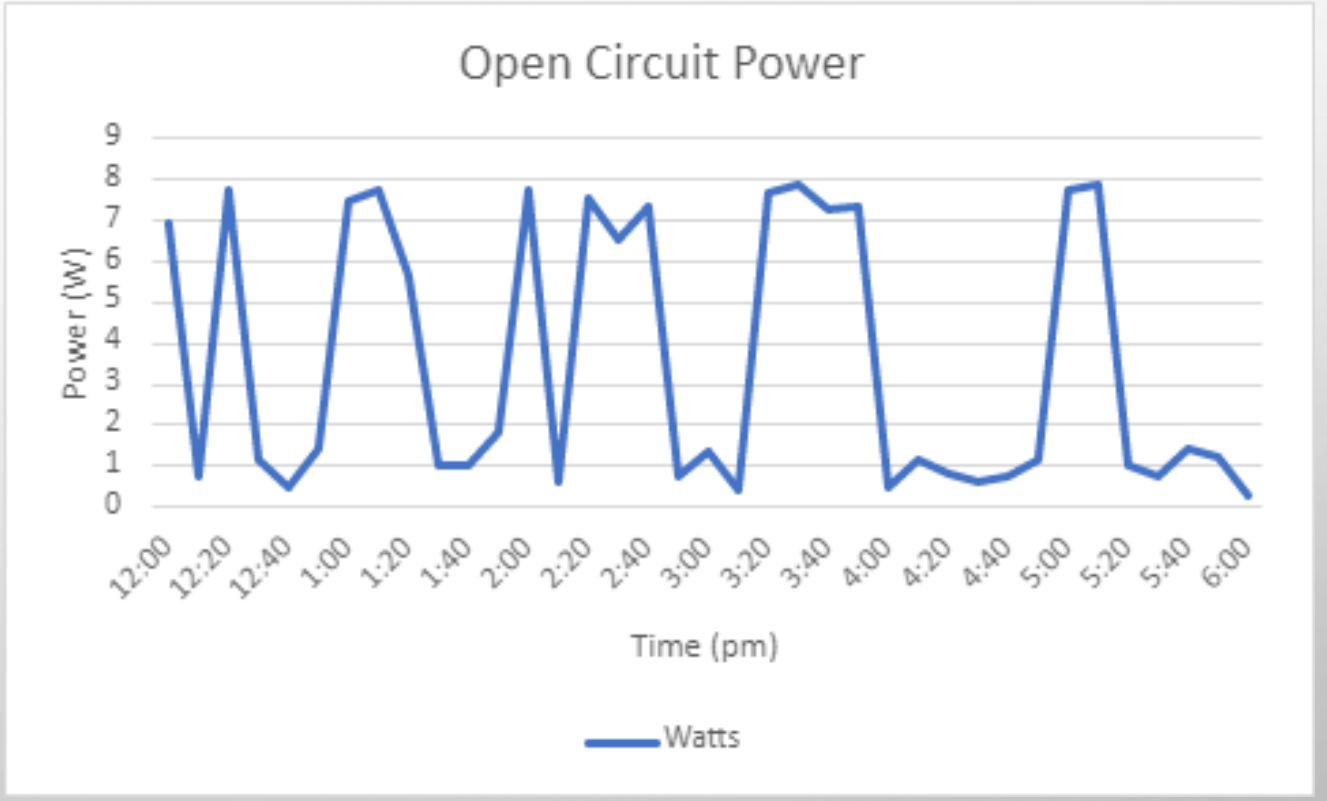
TEMPERATURE MONITORING FOR 24 HOURS

- COMP1 HAS ICE
- COMP2 HAS NO ICE
- TESTED BOTH OUTSIDE AND INSIDE
- COMPARTMENTS DO GOOD JOB OF MAINTAINING TEMPERATURE



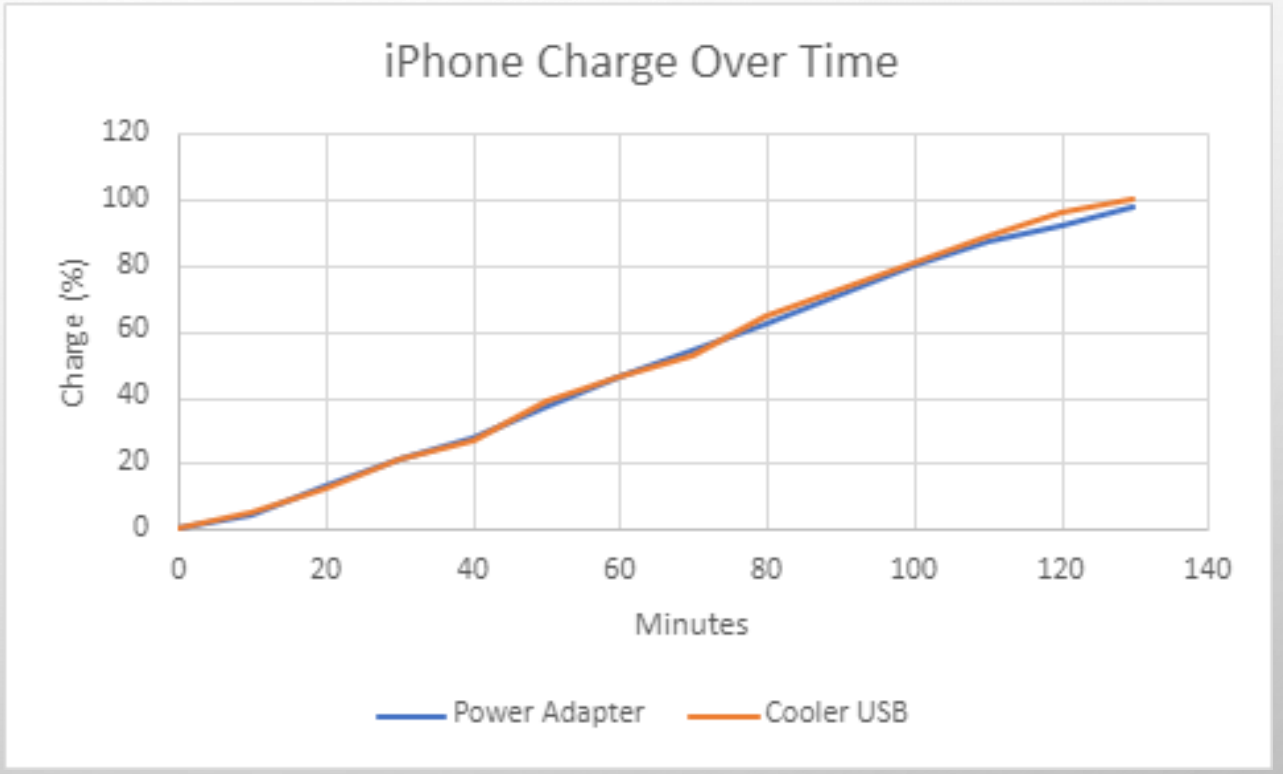
SOLAR PANEL POWER

- SOLAR PANEL WATTAGE TESTED BY MEASURING OPEN CIRCUIT VOLTAGE AND SHORT CIRCUIT CURRENT
- SOLAR PANEL RATED FOR 10W
- MEASURED 7.9W MAX ON PARTLY CLOUDY DAY



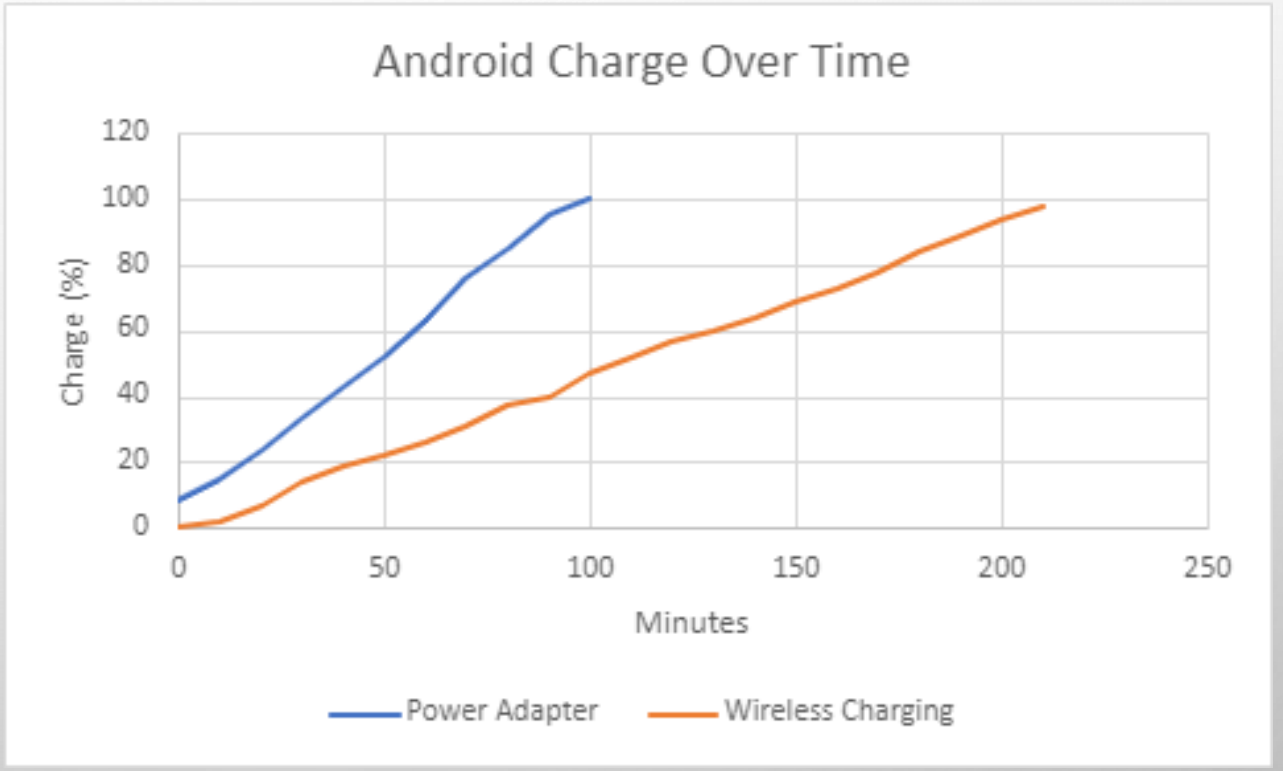
USB DEVICE CHARGING

- COOLER USB RATED FOR 5V 2.1A
- POWER ADAPTER RATED FOR 5.2V 2.4A
- APPROXIMATELY SAME CHARGING RATE



WIRELESS DEVICE CHARGING

- WIRELESS CHARGING PAD RATED 5V 1A
- POWER ADAPTER RATED 5V 2A
- WIRELESS CHARGING MUCH SLOWER



SPEAKER RATING

- SETTING SPEAKERS TO MAX MEASURED 89DB
- SETTING SPEAKERS TO "COMFORTABLE LEVEL" MEASURED 78DB

Distance (feet)	Decibel Rating (dB)
2	78
10	64.8
15	62.3
20	60

OUTDOOR BATTERY TESTING

- THE COOLER WAS POWERED ON AND LEFT OUTSIDE
- THE TEST STARTED AT 4 PM AND ENDED AT 8 PM THE NEXT DAY
- ALL SYSTEMS WERE ON AND RUNNING FOR 28 HOURS

LOCKING MECHANISM AND RFID

- THE PROCEDURE FOR TESTING THE LOCK IS SHOWN IN THE VIDEO
- THE COOLER WAS LOCKED, CONFIRMED THE STATUS WAS SHOWN ON THE TOUCHSCREEN, ATTEMPT MADE TO OPEN THE COOLER, COOLER IS UNLOCKED, STATUS IS CONFIRMED ON THE TOUCHSCREEN, AND FINALLY THE COOLER IS OPENED
- THIS TESTS, THE RFID READER, AND THE LOCKING MECHANISM
- THIS TEST WAS RUN 50 TIMES WITHOUT AN ERROR OR MECHANICAL FAILURE

AUTO LIGHT FEATURE

- THE AUTO LIGHT FEATURE NEEDED TO BE MODIFIED.
- THE FOLLOWING VIDEO SHOWS THE AUTO LIGHT FEATURE BEING ACTIVATED. THE LID IS OPENED, AND THEN THE LIGHTS IN THE ROOM ARE TURNED OFF. THE AUTO LIGHT FEATURE TURNS ON THE LIGHTS, AND THE LIGHTS STAY ON UNTIL THE LID IS CLOSED.
- AN ISSUE THAT OCCURRED WAS THAT THE LIGHTS WOULD TURN OFF WHEN THE LIGHT TURNED ON BECAUSE OF AMBIENT LIGHT AFFECTING SENSOR.

MOBILE APP TESTS

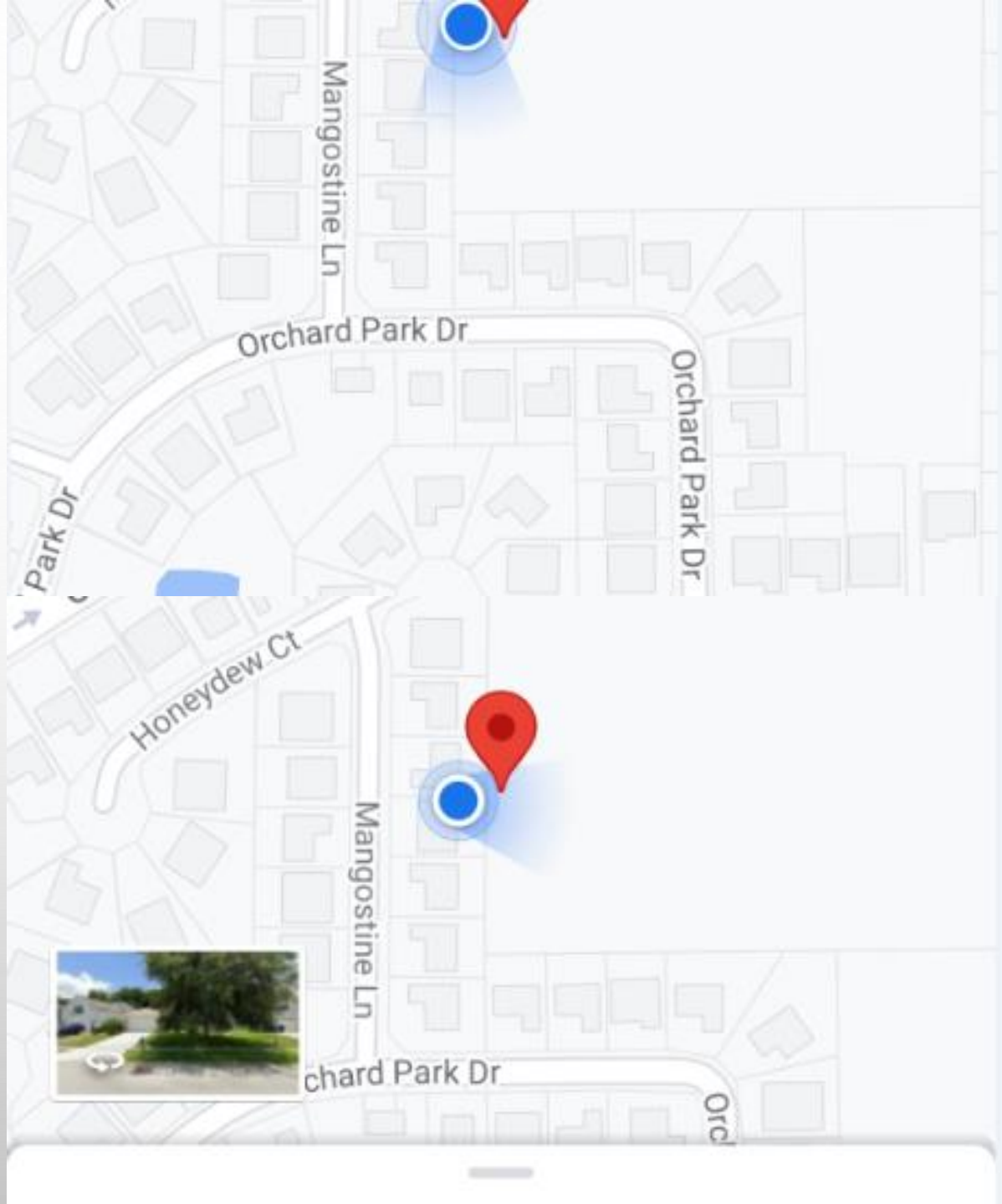
- THE MOBILE APP WAS DEPLOYED AND TESTED ON BOTH THE IPHONE AND ANDROID.
- IN THIS VIDEO, AN ANDROID PHONE IS BEING USED.
- THE VIDEO SHOWS THE APP CONNECTED TO THE COOLER, WHERE THE LED LIGHTS ARE CHANGED FROM BLUE TO WHITE TO RED TO RAINBOW.

MOBILE APP OUTDOOR TEST RESULTS

- CONNECTIVITY WAS TESTED BY OBSERVING THE MAXIMUM DISTANCE THAT THE APP COULD PROPERLY CONTROL THE FUNCTIONS OF THE COOLER
- THE MOBILE APP WAS ABLE TO PROPERLY CONTROL THE COOLER AT A MAXIMUM RANGE OF 25 METERS, OR 75 FEET

GPS TESTING

- WHILE IN THE WOODED AREA THE GPS WAS POWERED ON AND OPERATION WAS CONFIRMED AND UNAFFECTED BY THE TREES AND BRUSH
- THE APP WAS ABLE TO CONNECT WITH GOOGLE SERVERS TO PROVIDE DIRECTIONS TO THE LOCATION



SUCCESS CRITERIA

Success Criteria

Subject	**Success Criteria**
Shell	1) Does the Cooler retain Ice for a minimum of 12 hours? 2) Does the empty weight stay less than 40 lbs? 3) Does the storage volume measure 1.5 cubic feet?
Touch Screen	1) Does the touch screen respond to touch inputs correctly 9/10 times?
Controller	1) Does the microcontroller properly control the system without errors 19/20 times?
App integration	1) Does the App take full control of the system without interference 9/10 times?
Power System	1) Does the system properly power on and off 95% of the time 19/20?
GPS	1) Does the GPS module accurately track the cooler's location 95% of the time?
Locking mechanism	1) Does the lock engage and disengage when signaled by the Touch screen, Mobile app, and RFID keyless entry 9/10 times?

Final Testing Results

Subject	**Success Criteria**	
Shell	1) Does the Cooler retain Ice for a minimum of 12 hours? 2) Does the empty weight stay less than 40 lbs? 3) Does the storage volume measure 1.5 cubic feet?	21 hours 43 lbs 1.2 cubic ft
Touch Screen	1) Does the touch screen respond to touch inputs correctly 9/10 times?	25/25
Controller	1) Does the microcontroller properly control the system without errors 19/20 times?	20/20
App integration	1) Does the App take full control of the system without interference 9/10 times?	20/20
Power System	1) Does the system properly power on and off 95% of the time 19/20?	50/50
GPS	1) Does the GPS module accurately track the cooler's location 95% of the time?	15/15
Locking mechanism	1) Does the lock engage and disengage when signaled by the Touch screen, Mobile app, and RFID keyless entry 9/10 times?	50/50

SUMMARY AND CONCLUSION

- ADDING BATTERY SOURCE TO COOLER OPENS UP POSSIBILITIES
- POWER CONSUMPTION MUCH SMALLER THAN POWER BUDGET
- SUCCESS CRITERIA PASSED
- SLIGHTLY OVER BUDGET
- SUGGESTIONS FOR FUTURE IMPROVEMENTS
  - THERMOELECTRIC TEMPERATURE REGULATION
  - LARGER BATTERIES
  - CONTACT EMERGENCY SERVICES

REFERENCES

[1] LEVINS, CORY. "A COOL INVENTION: THE HISTORY OF THE STYROFOAM COOLER," AIR SEA CONTAINERS. [ONLINE] AVAILABLE AT: HTTPS://WWW.AIRSEACONTAINERS.COM/BLOG/A-COOL-INVENTION-THE-HISTORY-OF-THE-STYROFOAM-COOLER/ (ACCESSED JULY 8, 2021)

[2] K. SCHLOSSER. "COOLEST COOLER SHUTS DOWN AFTER 5-YEAR SAGA, LEAVING 20,000 BACKERS WITHOUT KICKSTARTER REWARD," GEEKWIRE, 12/09/2019. [ONLINE] AVAILABLE AT: HTTPS://WWW.GEEKWIRE.COM/2019/COOLEST-COOLER-SHUTS-5-YEAR-SAGA-LEAVING-20000- BACKERS-WITHOUT-KICKSTARTER-REWARD/ (ACCESSED JUNE 17, 2021)

[3] "INFINITE: WORLD'S MOST VERSATILE, SMART COOLER," INDIEGOGO. [ONLINE] AVAILABLE AT: HTTPS://WWW.INDIEGOGO.COM/PROJECTS/INFINITE-WORLD-S-MOST-VERSATILE-SMART-COOLER#/ (ACCESSED JUNE 17, 2021)

[4] R. GREPPER. "COOLEST COOLER: 21ST CENTURY COOLER THAT'S ACTUALLY COOLER," KICKSTARTER, 03/12/2018. [ONLINE] AVAILABLE AT: HTTPS://WWW.KICKSTARTER.COM/PROJECTS/RYANGREPPER/COOLEST-COOLER-21ST-CENTURY-COOLERTHATS-ACTUALLY (ACCESSED JUNE 17, 2021)

QUESTIONS