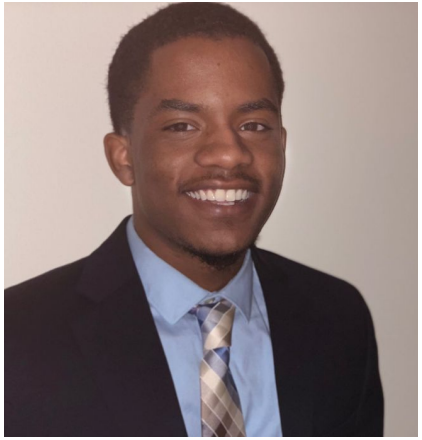
LoadOut: FPR

SDP21 Team 12

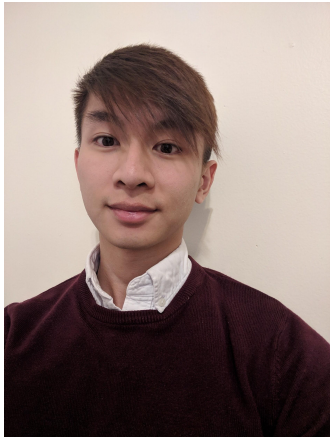
The LoadOut Team

Neyissa Exilus
CompE
Budget Management Lead
User Interface Lead



Smeel Milien
CompE
Online Presence Lead
Processing Lead

Joshua Teixeira
CompE
Team Coordinator
RFID Lead



Wilson Tran
CompE
Altium Lead
Sensing Lead

MOTIVATION

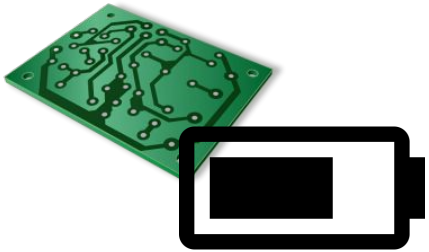
Ever went on a trip and realized mid-way that you forgot to pack something in your luggage? A charger, battery, or maybe a toothbrush? Ever wonder what happens to your luggage and valuables once you check your bag? Traveling can be stressful when you forget to pack certain essentials or when your items are damaged and you have no proof for an insurance claim.

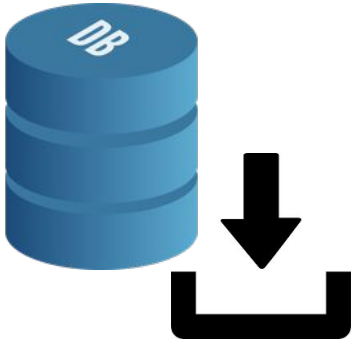
PROBLEM STATEMENT

People have trouble remembering what they need to pack for specific events. A person may have one list of items they need to pack each time they go home for the weekend, and a another list for when they are just leaving their home. LoadOut will provide the ability to make persistent interchangeable lists and will passively update what items the person has packed, and notify the user if an item is missing.

Additionally, LoadOut can provide functionality for monitoring metadata of the bag's journey, such as recording intrusions and substantial drops that could have damaged objects.

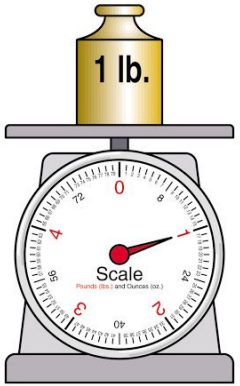
System Specifications





PHYSICAL SPECIFICATIONS

- No more than 4lbs
- Device should be resilient to outside RFID interference
- Final prototype suitcase will be easy to store and pack



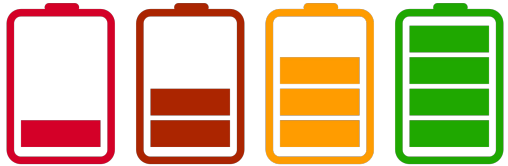
SOFTWARE SPECIFICATIONS

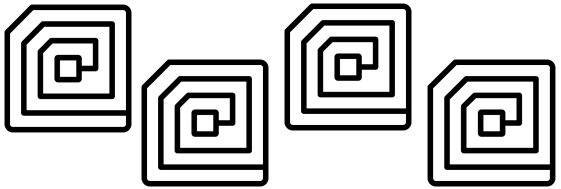
- User should be able to dynamically add/remove items from database and check if an item is in the bag when it is in close range

- Device should be capable of recording and storing information about the status of the items and bag while out of wireless range of the user
  - An interaction log will be recorded onto a SD card

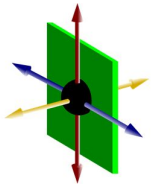
HARDWARE SPECIFICATIONS

- Must have at least 12 hours of battery life
- Must be capable of tracking ~20 items without substantial error
- LoadOut should work in the presence of metals and liquids
- Device should be able to determine if the container has been opened, and if so, if anything has been disturbed

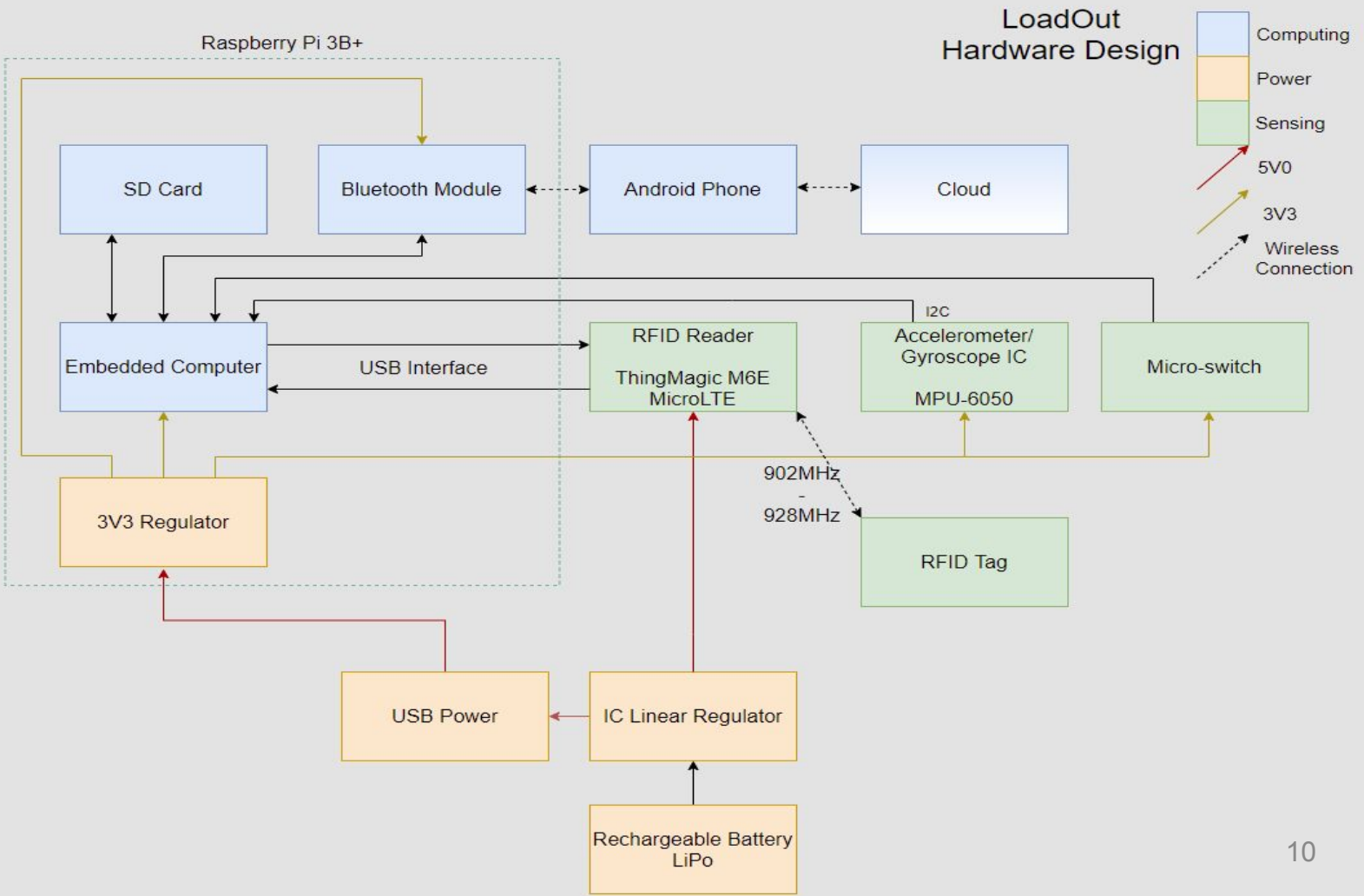




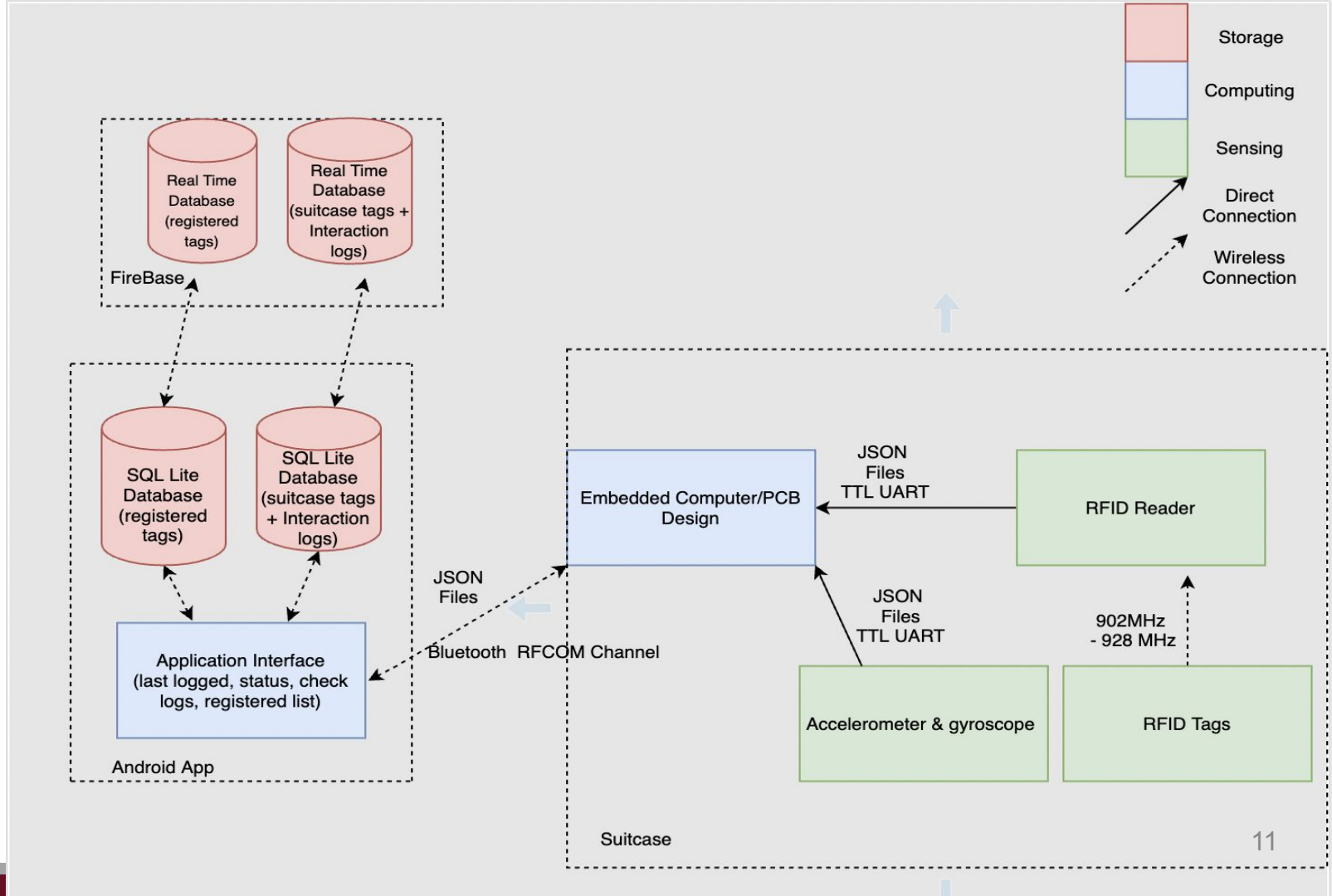
Documentation



FINAL HARDWARE DESIGN FLOWCHART:



FINAL SOFTWARE DESIGN FLOWCHART:



LIST OF HARDWARE AND SOFTWARE

RFID Module (Josh):

- Hardware
  - Micro-LTE RFID Developer Kit
  - Raspberry Pi
- Software
  - Mercury API
  - Netbeans Java IDE
  - Altium

Sensing Module (Wilson):

- Hardware
  - MPU-6050 on Breakout board
  - Microswitch
  - Raspberry Pi 4
- Software
  - Python 3 (Thonny IDE on Raspberry PI OS)
  - Altium Designer 21

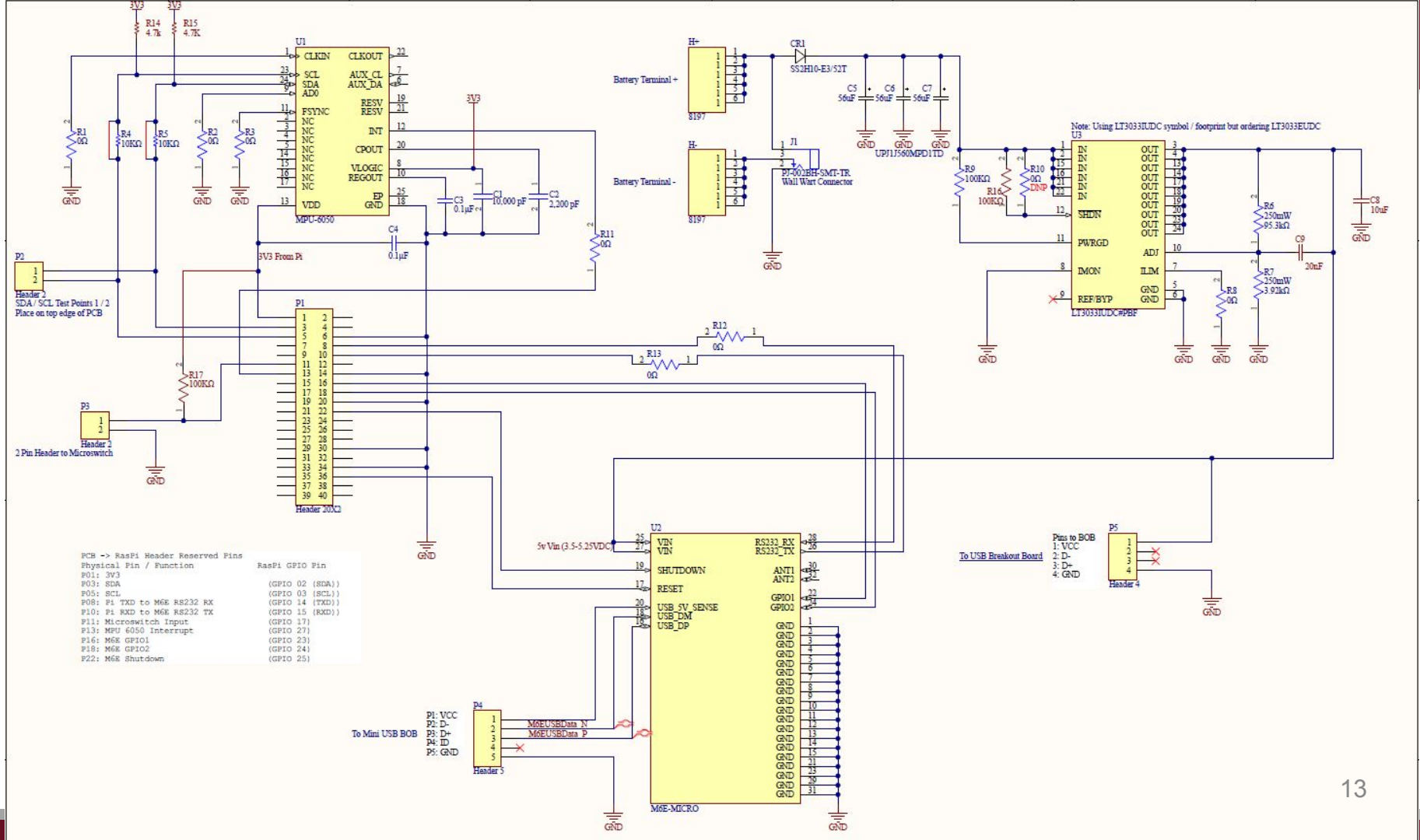
Processing Module (Smeel):

- Hardware
  - Raspberry Pi
- Software
  - Python
  - Android Studio

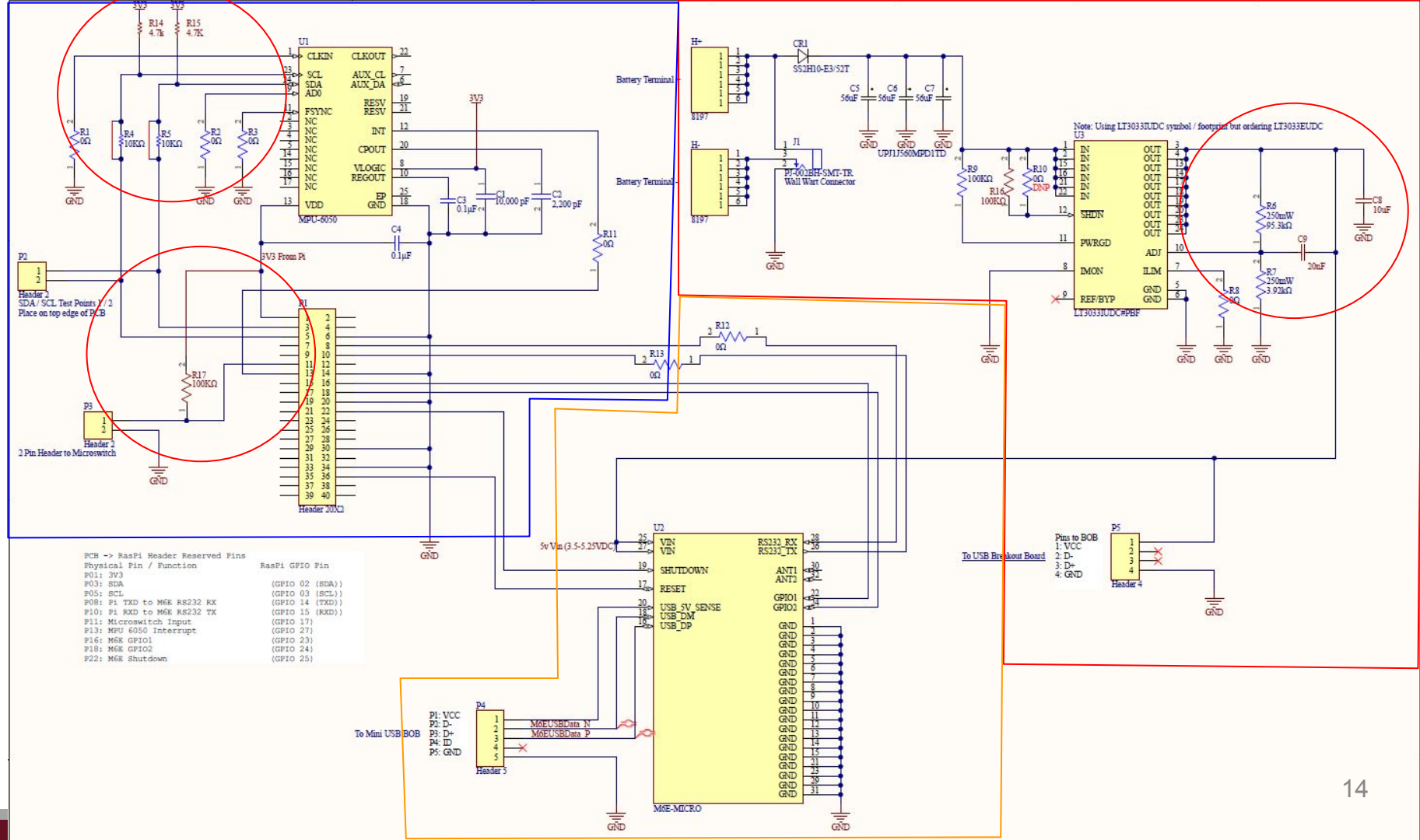
User Interface Module (Neyissa):

- Hardware
  - Phone (user owns)
- Software
  - Android Studio
  - Firebase

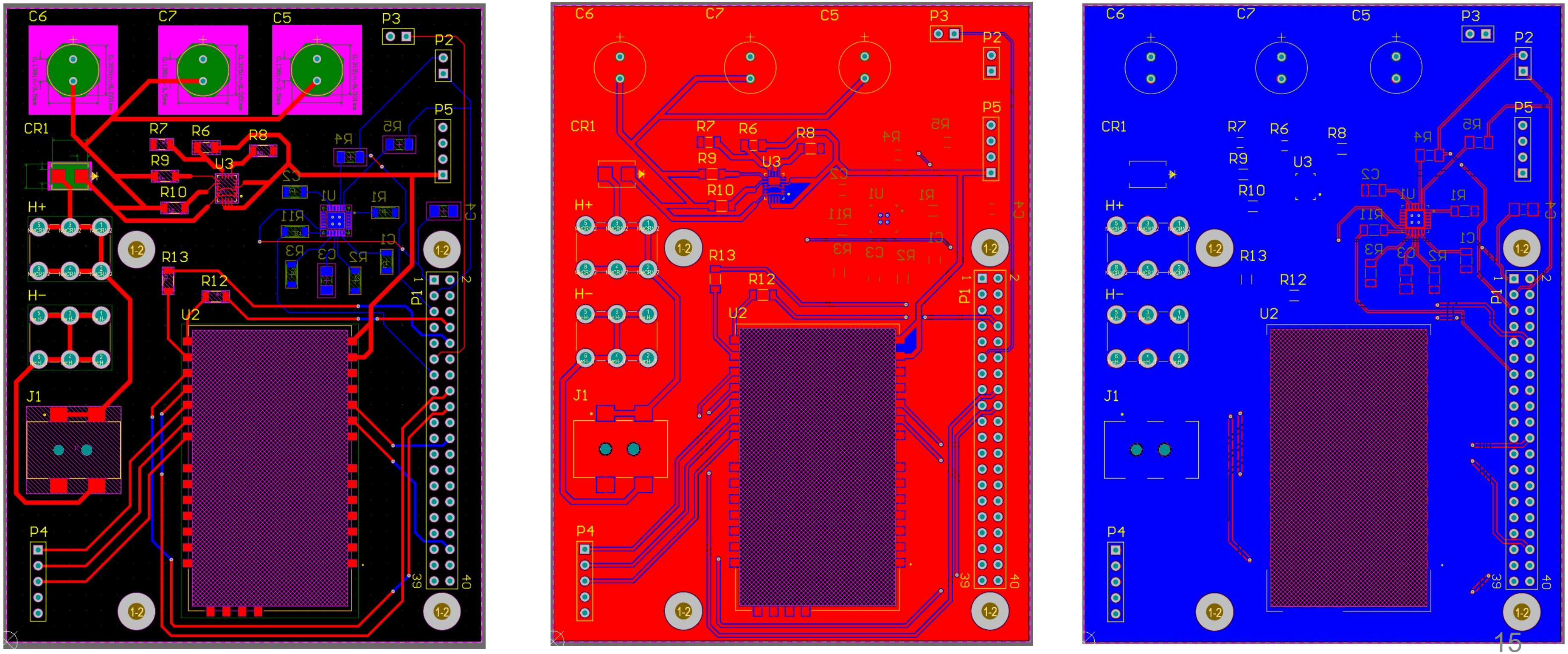
PCB SCHEMATIC



PCB SCHEMATIC



PCB LAYOUT



BATTERY

- Battery selection informed by system needs and MDR research
- Two main states: packing, and packed

Power Consumption over 12 Hr Simulated Period				
		Packing Hour	**11 Hours**	**Total**
	Watts	Watt-Hours	Watt-Hours	Watt-Hours
Reader Idle	0.008	0.008	0.088	
Raspberry Pi	1.300	1.300	14.300	
Each Read Event	2.400	0.120	0.067	
Number of Reads		180 reads	100 reads	
Subtotal Power		1.428	14.455	
			Total Needed	**15.883**
			Our Battery	**16.28**

% Time in "Active State"	RF Strength (db)	RFID Power Consumption (watts)	RasPi Power Consumption (watts)	Sum (watts)	Wh to last 12hrs
5	27	0.232	1.0150	1.2470	14.964
5	23	0.182	1.0150	1.1970	14.364
5	10	0.157	1.0150	1.1720	14.064
10	27	0.407	1.0300	1.4370	17.244
10	23	0.307	1.0300	1.3370	16.044
10	10	0.257	1.0300	1.2870	15.444

2,200 mAh,
7.4V battery

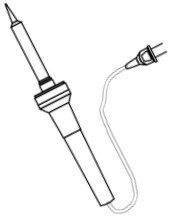
COST ESTIMATES

Items	Cost for QTY 1	Cost for QTY 1000
ThingMagic M6E Micro LTE UHF RFID Reader	$243.00	$201.89
Antenna	$96.04	$84.51
Development Board	$792.00	$0.79
RFID Tags	$5.64	$3.04
Capacitors	$2.89	$0.36
Resistors	$0.72	$0.16
Diodes	$0.49	$0.20
Headers and Connecters	$12.11	$1.57
ICs	$14.93	$6.95
Battery	$15.95	$10.05
Total	**$1,183.77**	**$309.53**

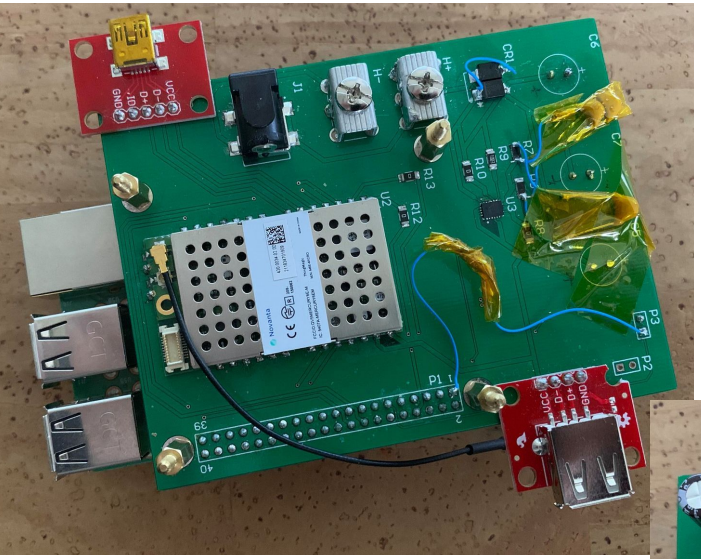
Loaned Items	Savings
Antenna	$96.04
Development Board	$792.00
RFID Tags	$5.64
Total	**$893.67**

Type	Orders	Item Costs	Tariffs	Shipping	Total	Sum Check
DigiKey	2020-10-02	$347.94	$1.14	$4.99	$354.07	$354.07
JLCPCB	2021-02-03	$18.70		$11.20	$29.90	$29.90
DigiKey	2021-03-05	$67.08	$0.26	$6.99	$74.33	$74.33
Mouser	2021-03-05	$27.64		$7.99	$35.63	$35.63
Totals		$461.36	$1.40	$31.17	$493.93	$493.93

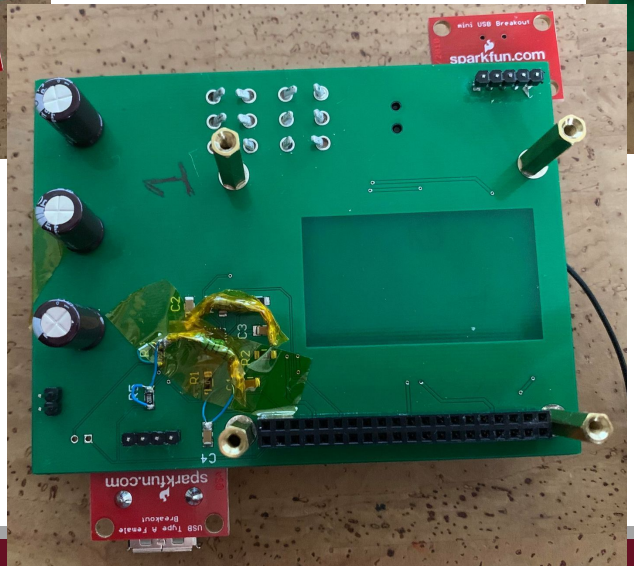
CUSTOM PCB



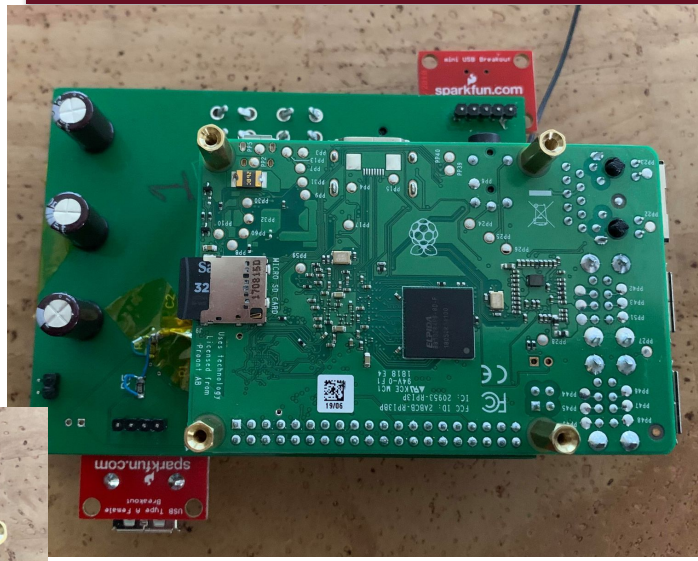
CUSTOM PCB INTEGRATED



Above: Top of PCB/Pi Assembly



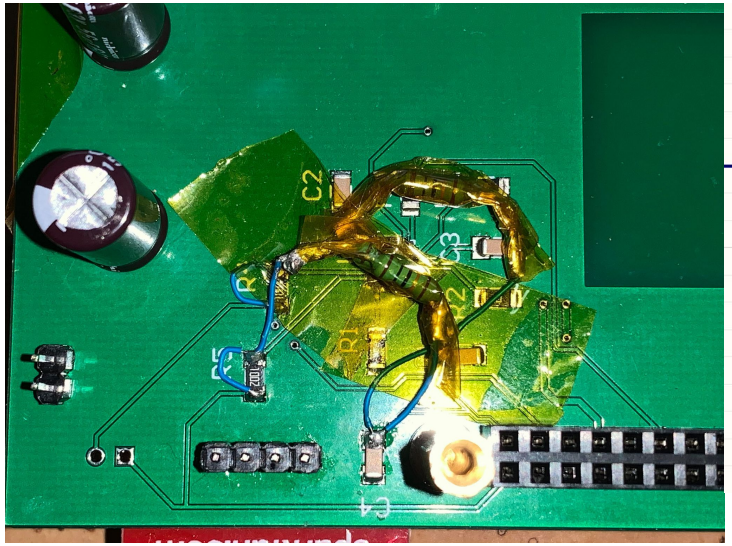
Right: Bottom of PCB

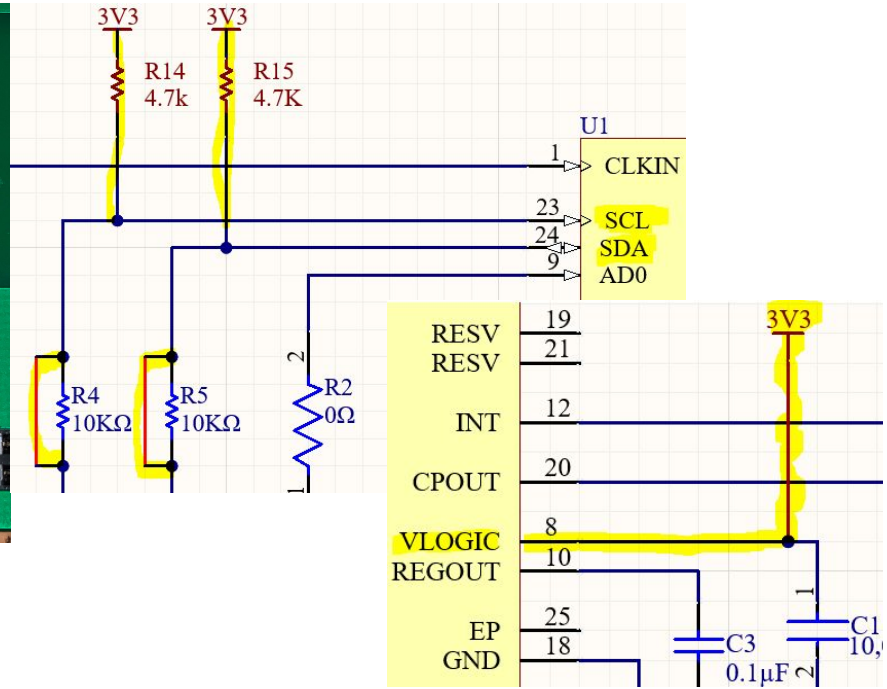


Above: Bottom of PCB/Pi Assembly

PCB REWORK

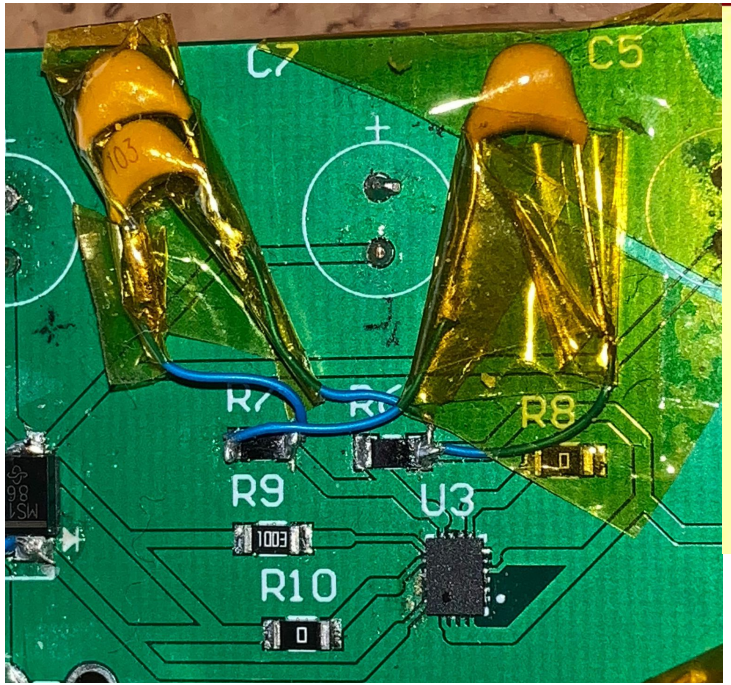
- MPU6050 required pull-up resistors on SDA and SCL
- Also needed 3V3 connection to VLOGIC

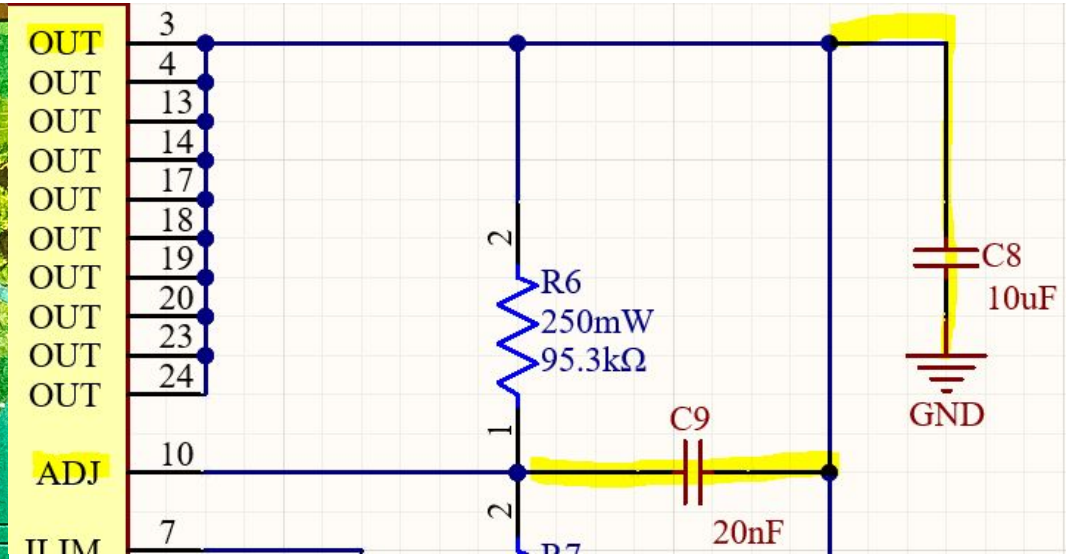




PCB REWORK (contd.)

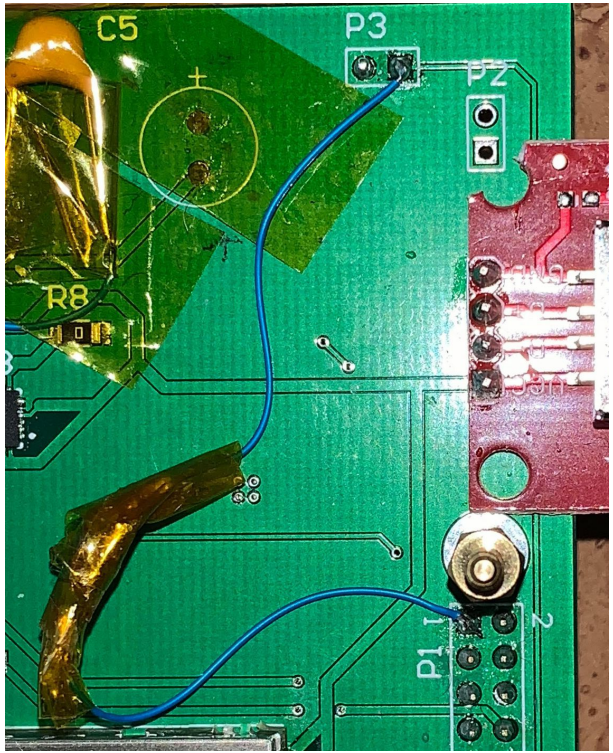
- LT3033 required additional capacitance between OUT and GND
- Also needed a cap between ADJ and OUT

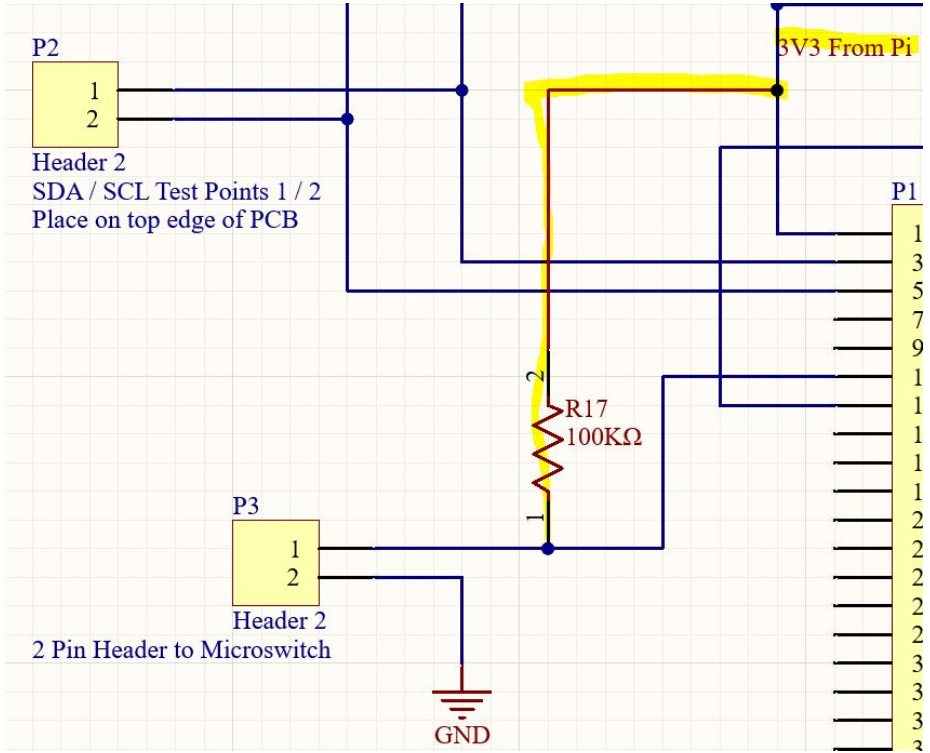




PCB REWORK (contd.)

- Input switch required a resistor to 3V3
  - Eliminated indeterminate behavior





PCB FUNCTIONALITY

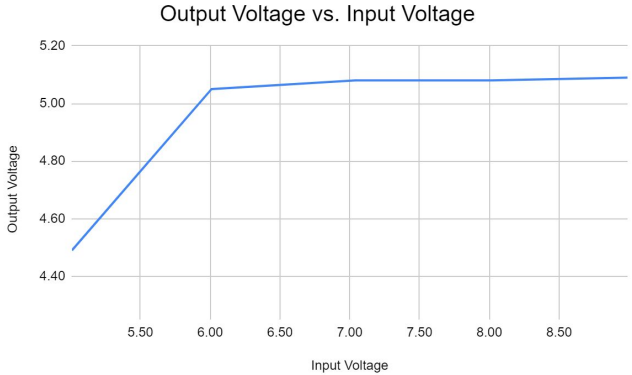
- PCB Functions:
  - Power and facilitate M6E and communication to Pi
  - Power and facilitate Raspberry Pi and communication to MPU6050

State Of Charge vs. Lipoly Pack Voltage

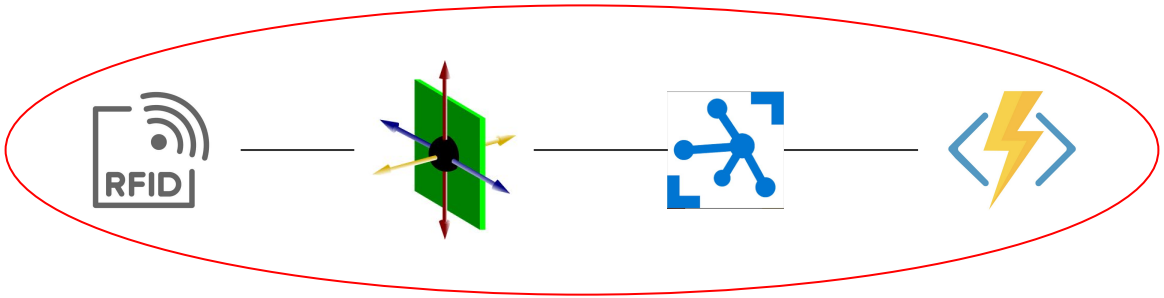
% Capacity	1S Cell	2S Pack	3S Pack	4S Pack	5S Pack
100	4.20	8.40	12.60	16.80	21.00
95	4.15	8.30	12.45	16.60	20.75
90	4.11	8.22	12.33	16.45	20.56
85	4.08	8.16	12.25	16.33	20.41
80	4.02	8.05	12.07	16.09	20.11
75	3.98	7.97	11.95	15.93	19.92
70	3.95	7.91	11.86	15.81	19.77
65	3.91	7.83	11.74	15.66	19.57
60	3.87	7.75	11.62	15.50	19.37
55	3.85	7.71	11.56	15.42	19.27
50	3.84	7.67	11.51	15.34	19.18
45	3.82	7.63	11.45	15.26	19.08
40	3.80	7.59	11.39	15.18	18.98
35	3.79	7.57	11.36	15.14	18.93
30	3.77	7.53	11.30	15.06	18.83
25	3.75	7.49	11.24	14.99	18.73
20	3.73	7.45	11.18	14.91	18.63
15	3.71	7.41	11.12	14.83	18.54

Voltage Regulation Characteristics

Input Voltage	Output Voltage
5.01	4.49
6.01	5.05
7.04	5.08
8.02	5.08
8.99	5.09

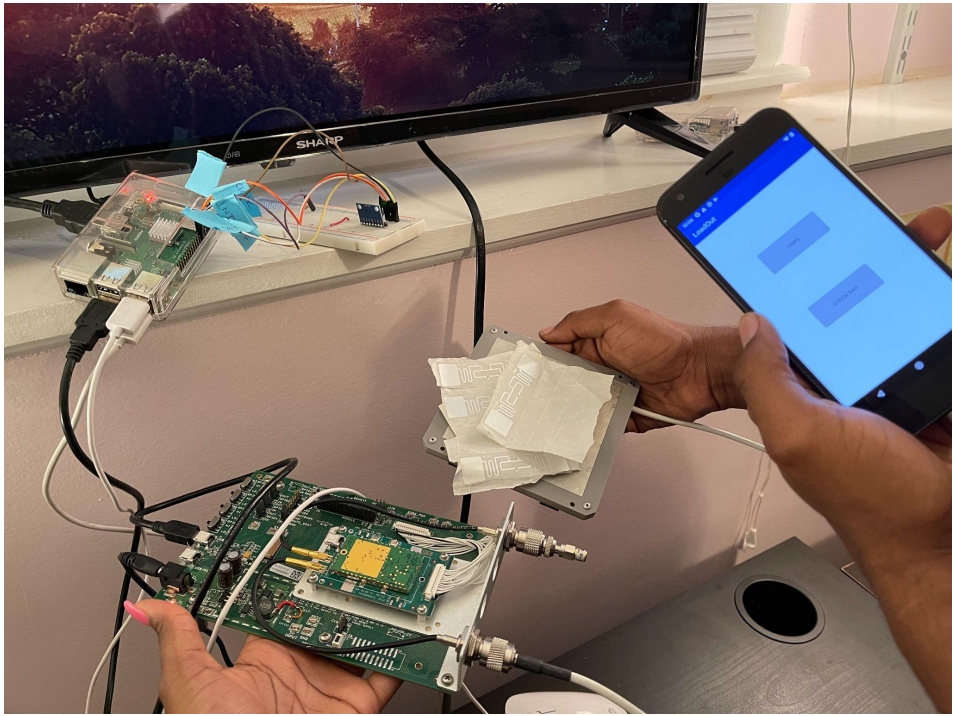


FINAL SYSTEM PERFORMANCE



RECALL CDR PROTOTYPE

- Development Board
- Bread Board
- Beta version of app

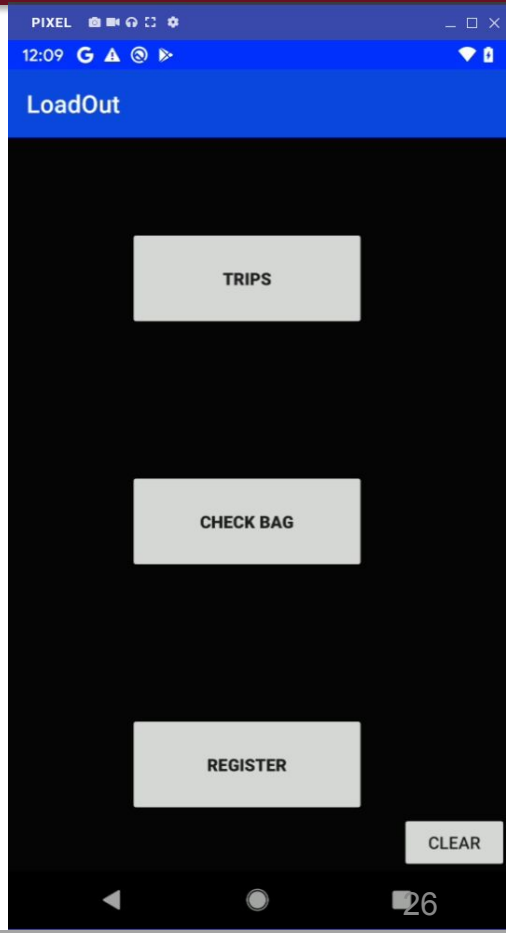


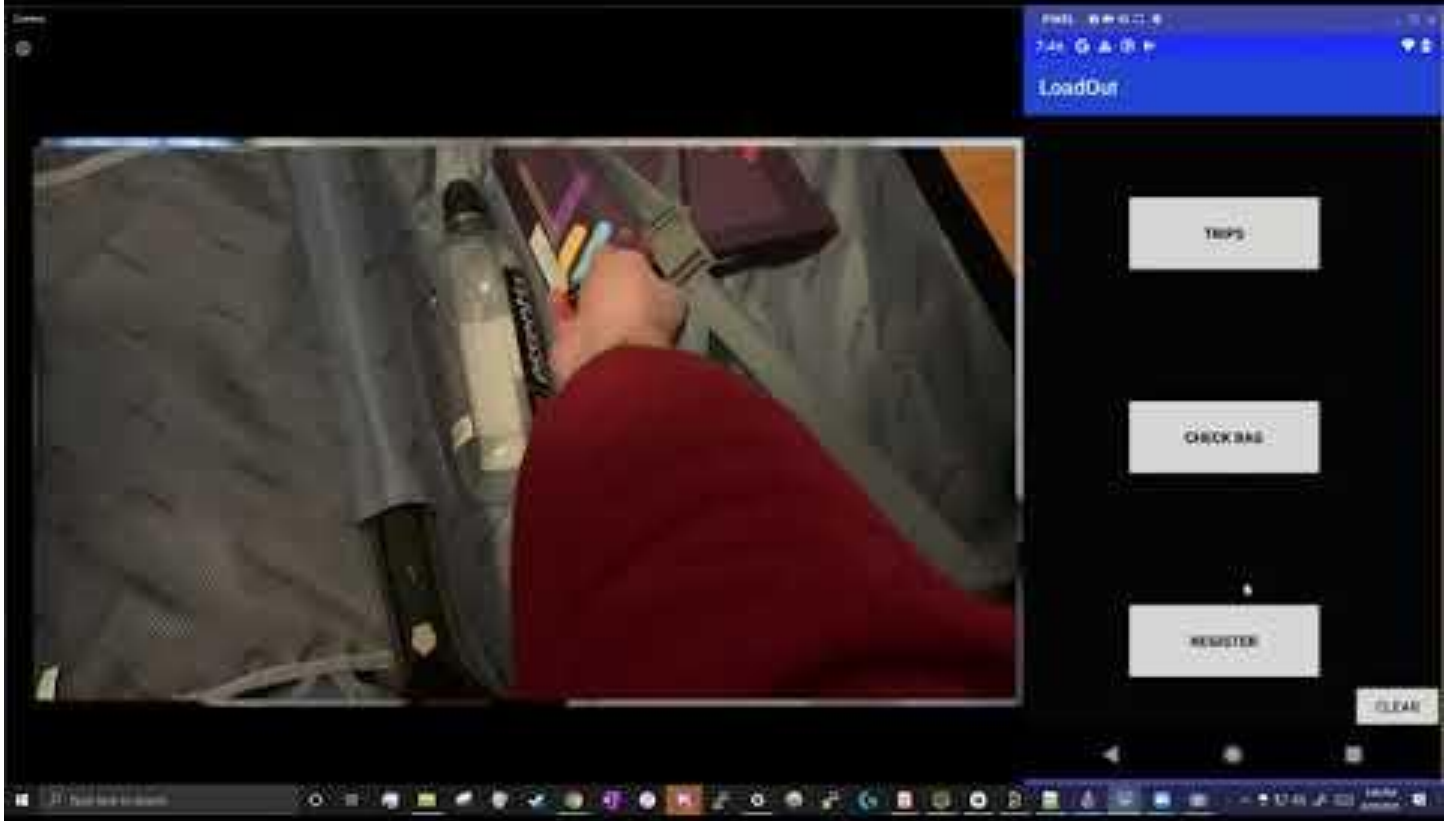
FINAL SYSTEM

Antenna

Metallic Shielding

Rigid PCB and Battery Housing




LoadOut
TRIPS
CHECK BAG
REGISTER
CLEAR

FPR DEMO

- Please watch “Demo Camera” to see the LoadOut device, and this screen to see the Android App

SPEC: WEIGHT

- Must be less than 4 lbs
  - As a total, LoadOut weighs 1.56 lbs, well within the 4lb specification

LAIRD S9028PCL weighs .8lbs

https://www.lairdconnect.com/documentation/datasheet-s902-series

LoadOut Assembly + Battery and cables weighs 12.1 oz or 0.76 lbs

SPEC: SUFFICIENT RFID SHIELDING

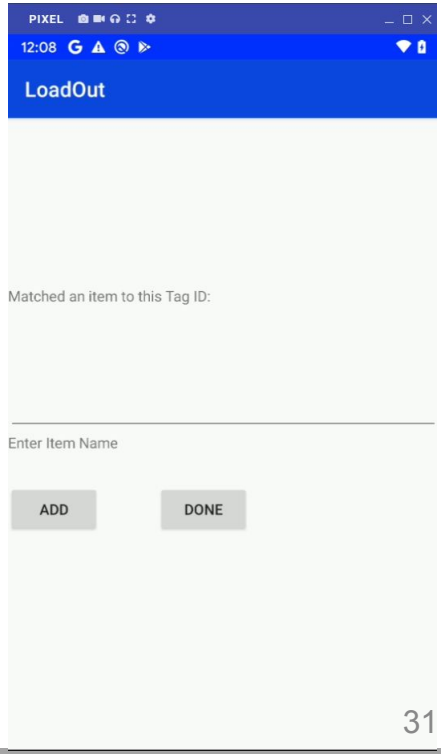
- Resilient to outside RFID interference
  - The LoadOut bag is shielded nearly completely by metal foil

One side of the LoadOut suitcase, shielding behind the lining

SPEC: EASE OF USE

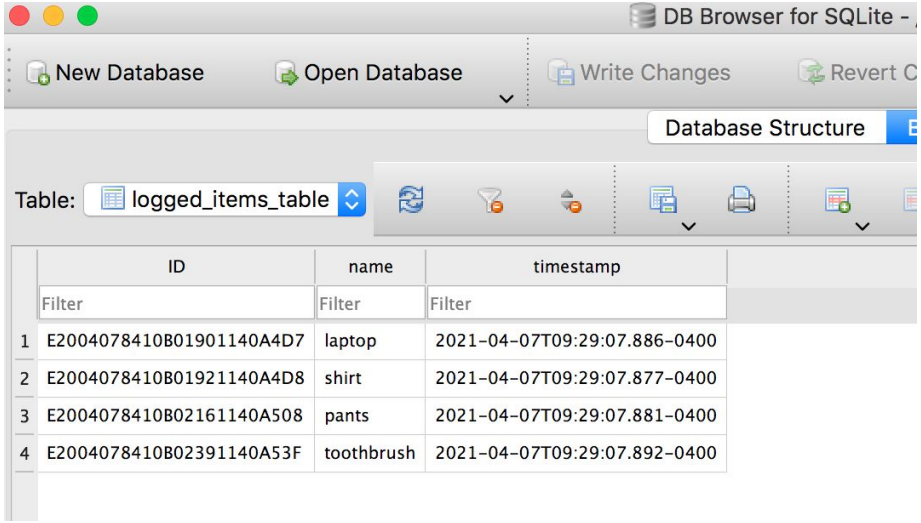
- Should not make packing the suitcase difficult
  - Unobstructive
  - Easy registration of items

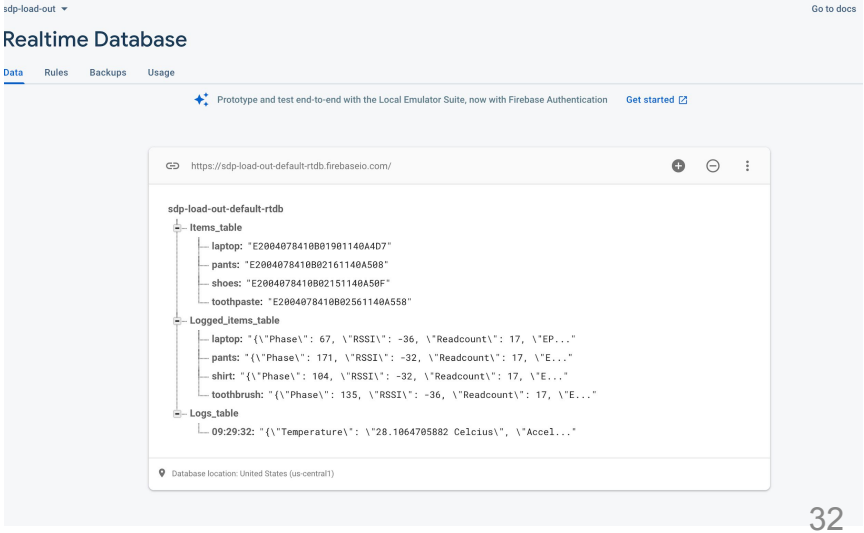
Appears physically no different than a normal hardshell suitcase



SPEC: DATABASE AND APP FUNCTION

- User should be able to add/remove items from database and check if an item is in the bag when it is in close range

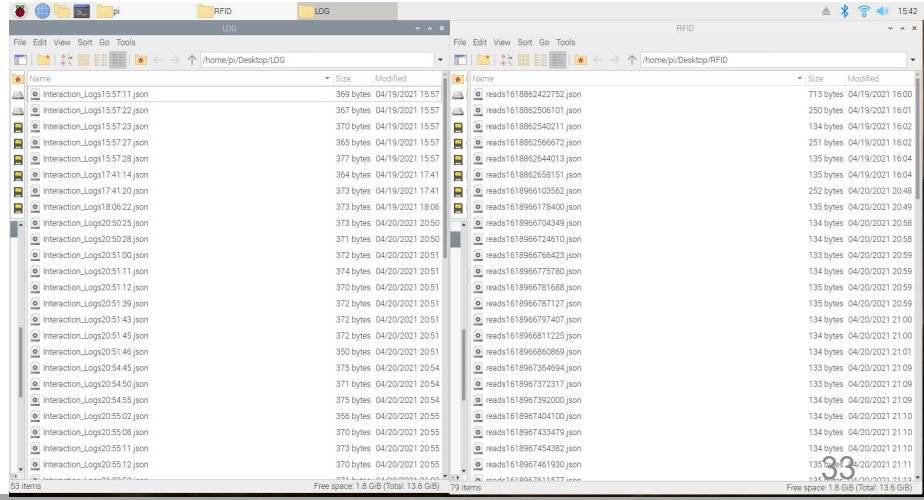




SPEC: STORAGE USE / INTERACTION LOGS

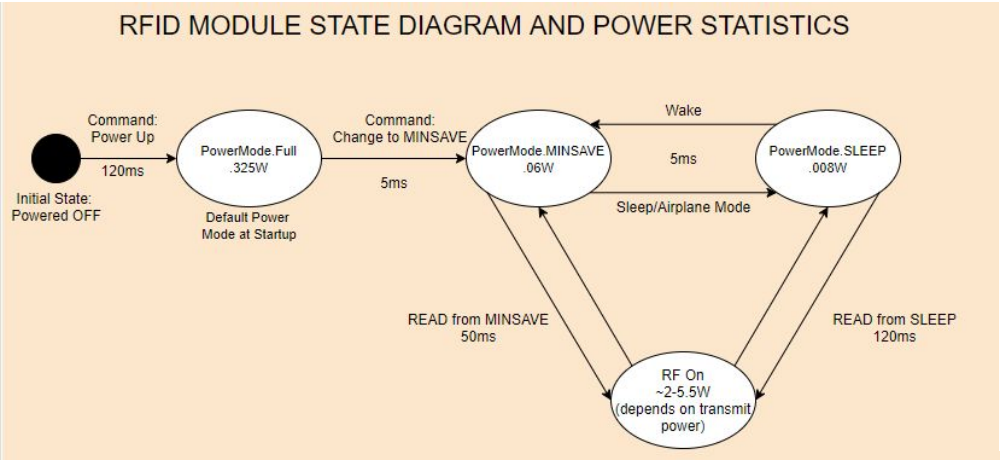
- Should record logs locally while outside of Bluetooth transmission range of the user's phone
  - LoadOut stores untransmitted files locally, divided into individual directories for reads and switch/mishandling logs

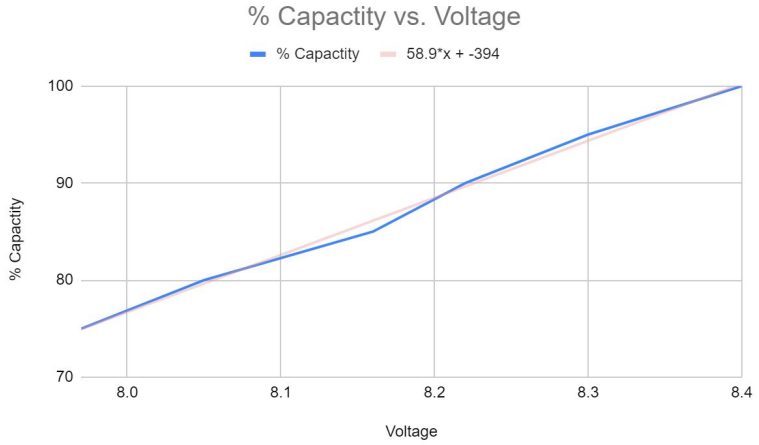
  - Max Read Files: 4 MB
  - Max Log files: 3 MB
  - Est. Max Total: 7 MB



SPEC: POWER USAGE

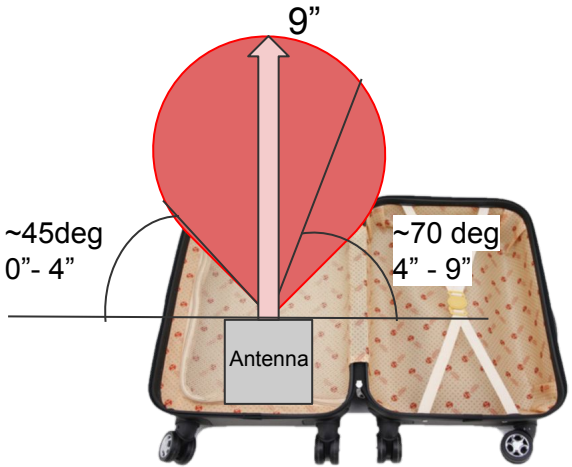
- Must have at least 12 hours of battery life
  - In 1hr “packing” stress test battery voltage drop indicated an about 7% drop in capacity
  - Extrapolating, this means we have >14 hours of battery life, within specifications



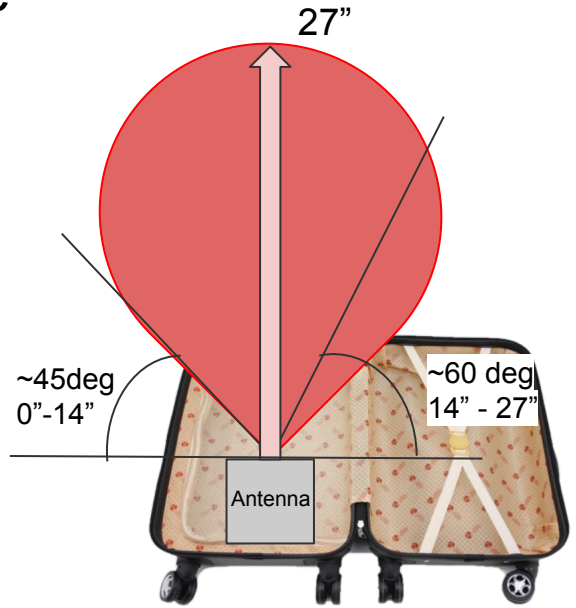


SPEC: ITEM TRACKING

- Maximum possible detection distance



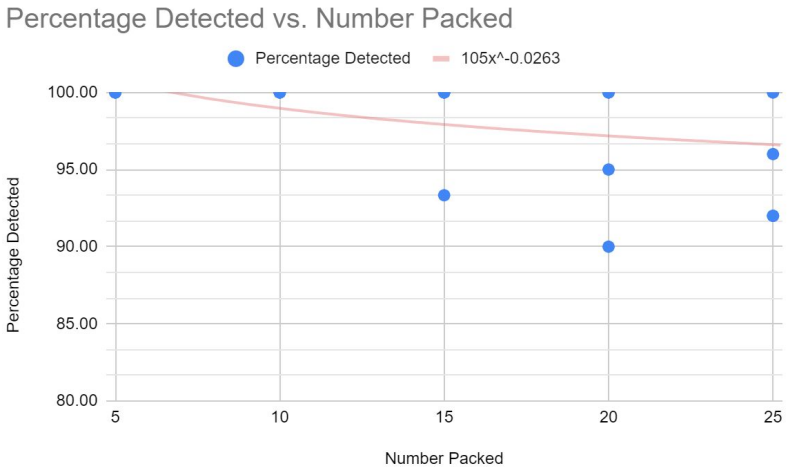
Register Mode Read Range and Angle



Normal Read Mode Range and Angle

SPEC: ITEM TRACKING (contd.)

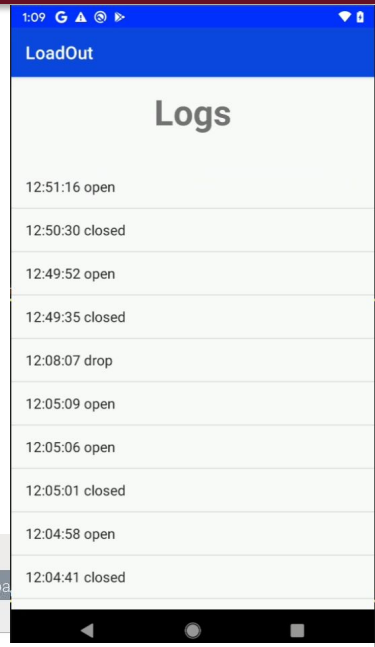
- Must be capable of tracking ~20 items without substantial error,
- Should work in the presence of metals and liquids



Trial	Number Packed	Number Detected	Percentage Detected
1	5	5	100.00
2	5	5	100.00
3	5	5	100.00
4	5	5	100.00
5	5	5	100.00
6	10	10	100.00
7	10	10	100.00
8	10	10	100.00
9	10	10	100.00
10	10	10	100.00
11	15	15	100.00
12	15	15	100.00
13	15	15	100.00
14	15	14	93.33
15	15	15	100.00
16	20	20	100.00
17	20	20	100.00
18	20	18	90.00
19	20	19	95.00
20	20	20	100.00

SPEC: SENSING SUITE

- Should be able to determine if the suitcase has been opened, and if so, if anything has been disturbed



Old Logs | *Interaction_Logs21:0... | Sensing Suite Old Ver... | [Thonny - /home/pi/... | Interaction_Logs19:2...

Interaction_Logs19:29:32.json - Mousepad

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```
{
 "logEvent": [
  {
   "detection": "drop",
   "time": "19:29:32",
   "magnitude": "23.2461572265625 (2.37060546875g)",
   "Gyroscope": "{'x': -7.893129770992366, 'y': -0.25190839694656486, 'z': 0.7709923664122137}",
   "Accelerometer": "{'x': 0.3495302734375, 'y': 0.49077880859374995, 'z': -10.172288574218749}",
   "Temperature": "31.071176470588235 Celcius"
  }
 ]
}
```

*Interaction_Logs21:09:47.json - Mousepa

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```
{
 "logEvent": [
  {
   "detection": "open",
   "time": "21:09:47",
   "magnitude": "10.8354384765625 (1.10498046875g)",
   "Gyroscope": "{'x': -4.633587786259542, 'y': -0.26717557251908397, 'z': 0.6106870229007634}",
   "Accelerometer": "{'x': 0.48838476562499994, 'y': 0.0, 'z': -10.21538134765625}",
   "Temperature": "29.377058823529413 Celcius"
  }
 ]
}
```

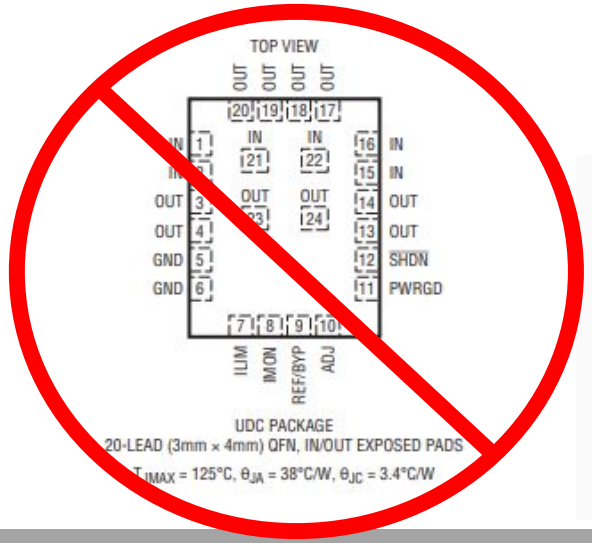
SPECIFICATIONS SUMMARY

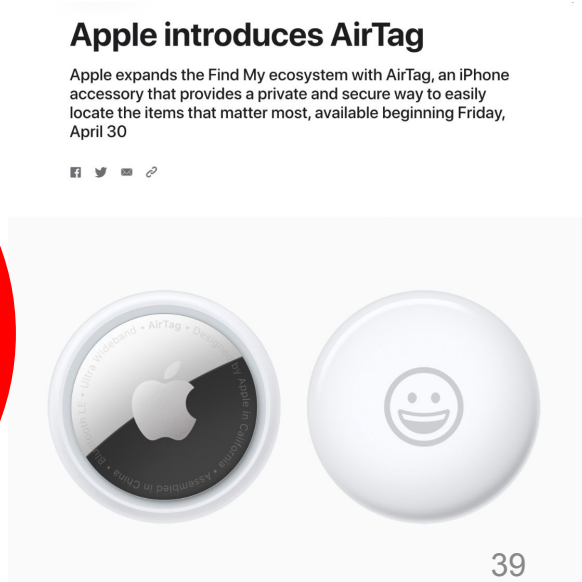
Specification	Result	
LoadOut is <4Lbs	LoadOut is 1.6 lbs, most of that is the antenna	✓
Resilient to outside RFID interference	LoadOut is contained within a near Faraday cage	✓
LoadOut should not make packing the suitcase difficult	LoadOut is conveniently located behind the lining of the suitcase lid	✓
The user should be able to dynamically add/remove items from database and check if an item is in the bag when it is in close range	LoadOut registered items list and other other save on SQLite and Realtime Database. LoadOut reads the bag when close to phone	✓
LoadOut should be able of recording logs locally while outside of Bluetooth transmission range of the user's phone	LoadOut saves untransmitted logs locally, and can transmit them to the user's phone when a connection is reestablished	✓
Must have at least 12 hours of battery life	LoadOut has an at minimum usable battery life of 12h20m	✓
Must be capable of tracking ~20 items without substantial error	LoadOut reads and displays that ~20 items are in the bag	✓
LoadOut should work in the presence of metals and liquids	LoadOut still detects tags in the presence of water bottles and reasonable metallic objects such as a laptop	✓
Device should be able to determine if the container has been opened, and if so, if anything has been disturbed	LoadOut generates logs whenever the bag is opened or violently disturbed	✓

CLOSING

- Apple Air Tags: problem recognized in industry

- Retrospect





Thank you!

HIDDEN SLIDE: BACKUP DEMO VIDEO

FPR BACKUP VIDEO LINK: https://youtu.be/YMn7glPR2tE