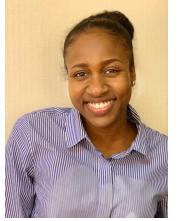
LoadOut: FPR

SDP21 Team 12



ECE - SDP2020

The LoadOut Team





Neyissa ExilusSmeel MilienCompECompEBudget Management LeadOnline Presence LeadUser Interface LeadProcessing Lead

Joshua Teixeira CompE Team Coordinator RFID Lead



Wilson Tran CompE Altium Lead Sensing Lead

MOTIVATION

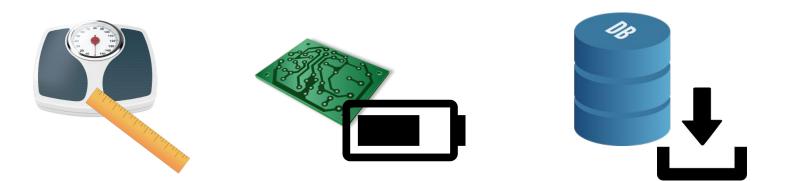
Ever went on a trip and realized mid-way that you forgot to pack something in your luggage? A charger, battery, or maybe a toothbrush? Ever wonder what happens to your luggage and valuables once you check your bag? Traveling can be stressful when you forget to pack certain essentials or when your items 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

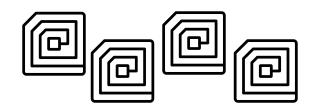
- User should be able to dynamically add/remove items from database and check if an item is in the bag when it is in close range
- Device should be capable of recording and storing information about the status of the items and bag while out of wireless range of the user
 - An interaction log will be 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



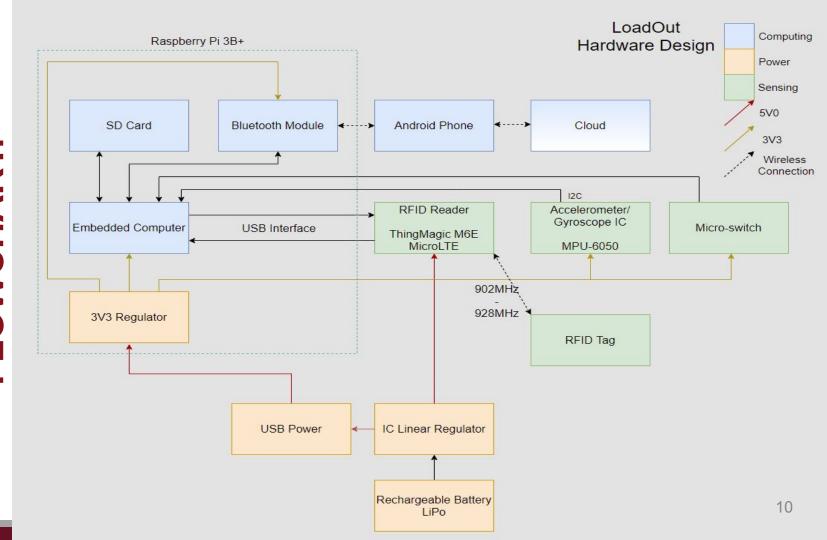




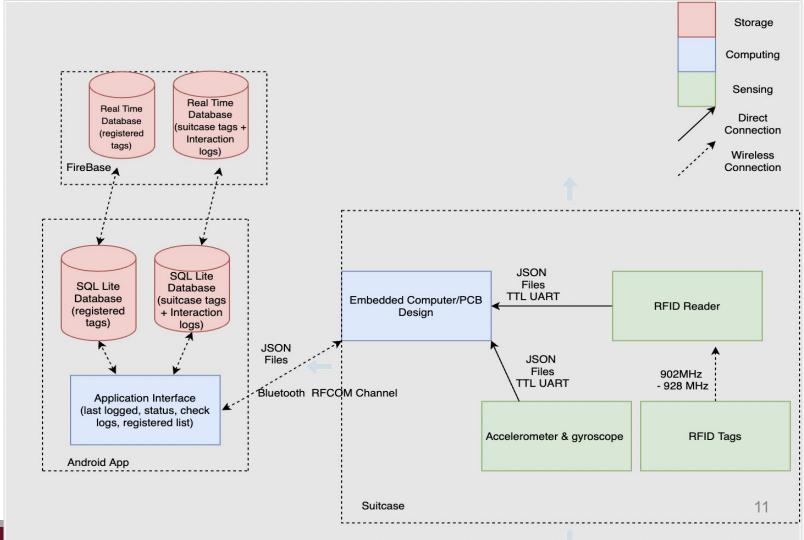
Documentation



DESIGN ARDWARE Ŷ 4 T OWCI ш FINAL



ESIGN Ë Ш **OFTWARI** LOWCHAI 3 L FINAI



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):

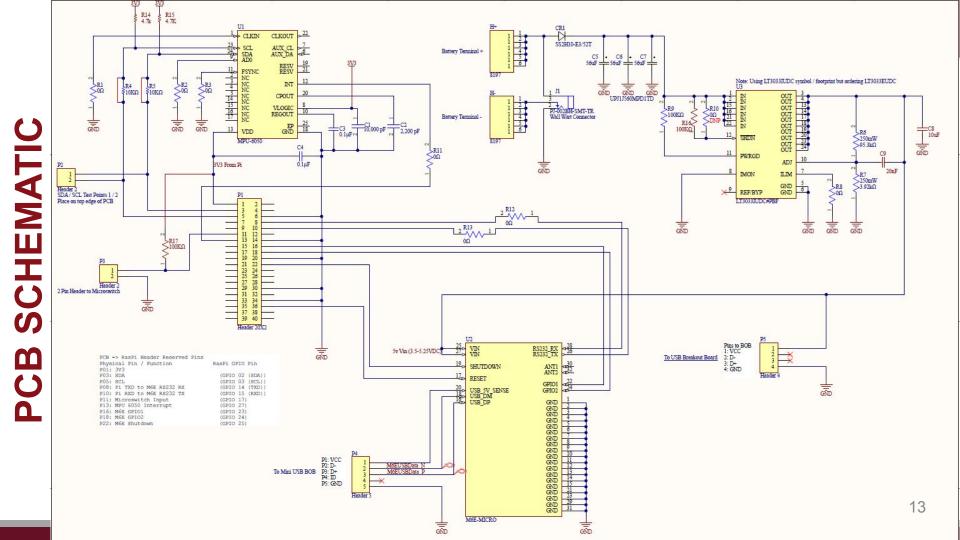
- Hardware
 - MPU-6050 on Breakout board
 - Microswitch
 - Raspberry Pi 4
- Software
 - Python 3 (Thonny IDE on Raspberry PI OS)
 - Altium Designer 21

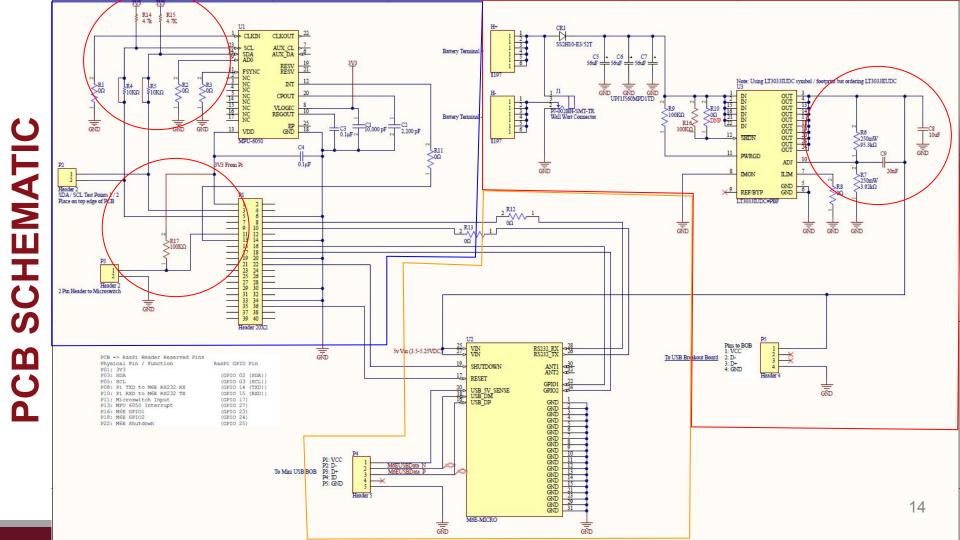
Processing Module (Smeel):

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

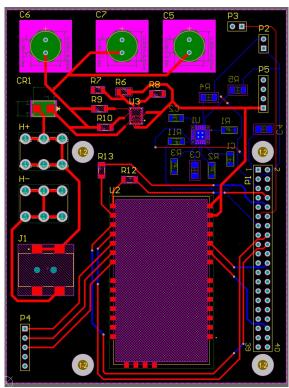
User Interface Module (Neyissa):

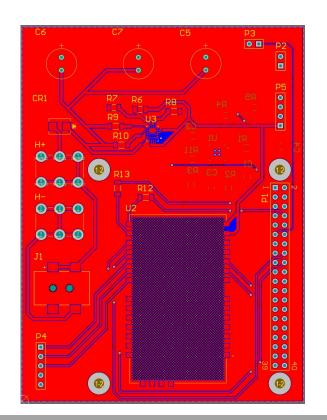
- Hardware
 - Phone (user owns)
- Software
 - Android Studio
 - Firebase

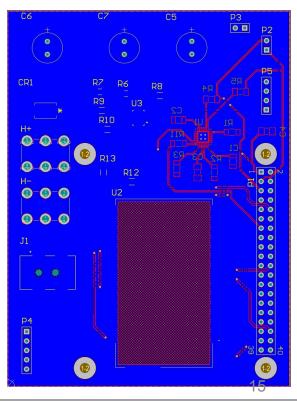




PCB LAYOUT







BATTERY

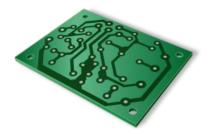
- Battery selection informed by system needs and MDR research
- Two main states: packing, and packed

Ρον	wer Consumption	over 12 Hr Simul	ated Period		% Time in		RFID Power Consumption	RasPi Power Consumption		Wh to last
		Packing Hour	11 Hours	Total	"Active State"	RF Strength (db)		(watts)		12hrs
		Facking nour	TT HOUIS	TOLAT	5					1
	Watts	Watt-Hours	Watt-Hours	Watt-Hours	5					
	vvalio	Wall-Hours	vall-riours	vall-riours	5	10	0.157	1.0150	1.1720	14.064
Reader Idle	0.008	0.008	0.088		10	27	0.407	1.0300	1.4370	17.244
	0.000	0.000	0.000		10	23	0.307	1.0300	1.3370	16.044
Raspberry Pi	1.300	1.300	14.300		10	10	0.257	1.0300	1.2870	15.444
					10 10 10		and 10 110 115	140:1		
Each Read Event	2.400	0.120	0.067		1					
Number of Reads		180 reads	100 reads		R		ing Max			
					le		1			mAh,
Subtotal Power		1.428	14.455						7.4V k	oattery
			Total Needed	15.883			T LING			
			Our Battery	16.28						16

COST ESTIMATES

Items			Cost for QTY 1	Cost for QTY 1	000			
ThingMagic M6	E Micro LTE UH	IF RFID Reader	\$243.00	\$20	1.89			
<u>Antenna</u>			\$96.04	\$8	4.51			
Development E	Board		\$792.00	\$	0.79			
RFID Tags			\$5.64	. \$	3.04			
Capacitors			\$2.89	\$	0.36			
Resistors			\$0.72	\$	0.16			
<u>Diodes</u>			\$0.49	\$	0.20	Loaned Iter	ns	Savings
Headers and Co	nnecters		\$12.11	\$	1.57	Antenna		\$96.04
<u>ICs</u>			\$14.93	\$	6.95	Developm	ent Board	\$792.00
Battery			\$15.95	\$1	0.05	RFID Tags		\$5.64
Total			\$1,183.77	\$30	9.53	Total		\$893.67
Туре	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	17

CUSTOM PCB

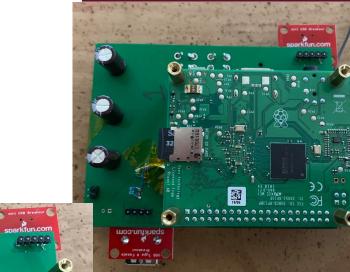






CUSTOM PCB INTEGRATED

UMassAmherst



Above: Bottom of PCB/Pi Assembly



Above: Top of PCB/Pi Assembly

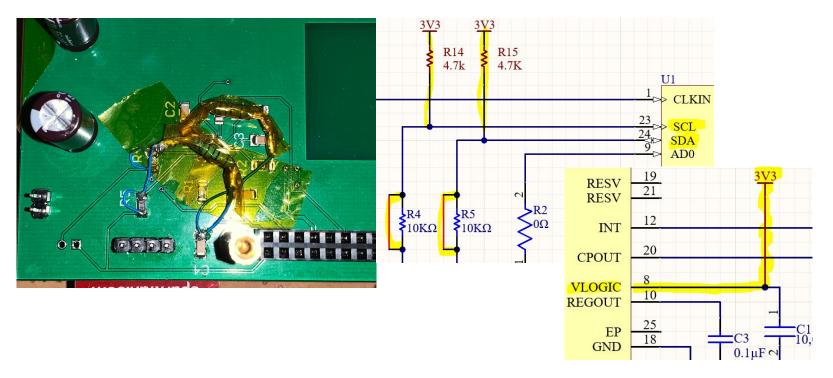
Right: Bottom of PCB



PCB REWORK

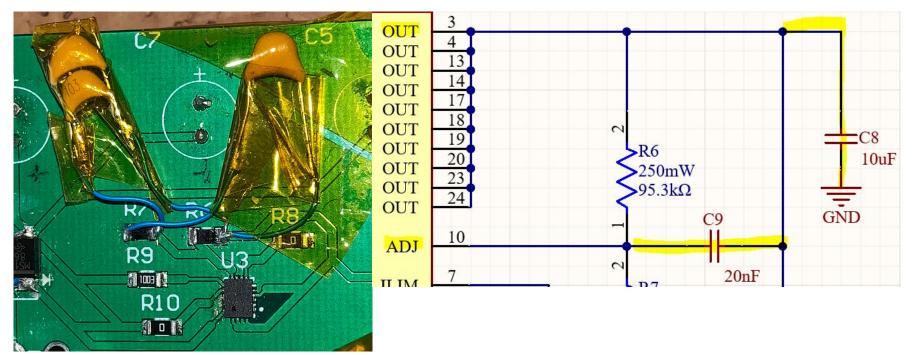
UMassAmherst

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



PCB REWORK (contd.)

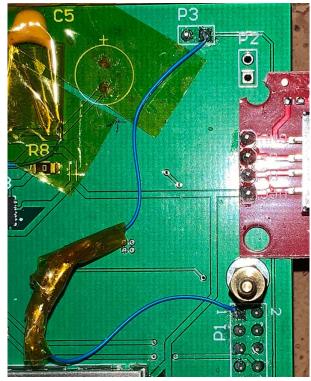
- UMassAmherst
- LT3033 required additional capacitance between OUT and GND
- Also needed a cap between ADJ and OUT

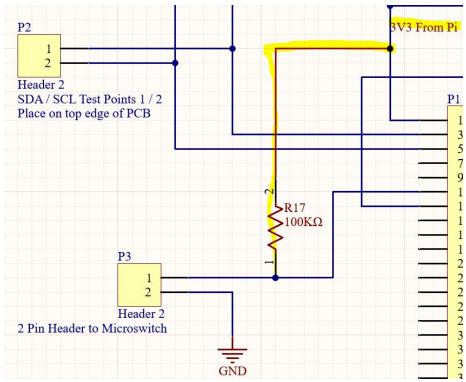


PCB REWORK (contd.)

UMassAmherst

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





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PCB FUNCTIONALITY

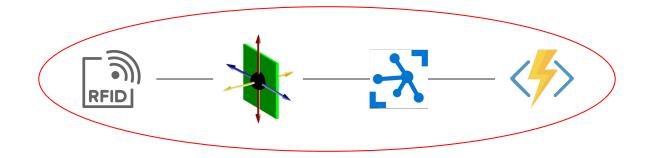
PCB Functions:

- Power and facilitate M6E and communication to Pi
- Power and facilitate Raspberry Pi and communication to MPU6050

State Of Charge vs. Lipoly Pack Voltage

2						_									
% Capacity	1S Cell	2S Pack	3S Pack	4S Pack	5S Pack										
100	4.20	8.40	12.60	16.80	21.00	Voltage R	Regulation								
95	4.15	8.30	12.45	16.60	20.75	Charac		O	utput V	oltage	vs. Inpu	it Volta	ge		
90	4.11	8.22	12.33	16.45	20.56	Cilarac	lensucs	5.20							
85	4.08	8.16	12.25	16.33	20.41		0								
80	4.02	8.05	12.07	16.09	20.11		Output	5.00							
75	3.98	7.97	11.95	15.93	19.92	Input Voltage	Voltage		1						
70	3.95	7.91	11.86	15.81	19.77	5.01	4.49	014.80 Oltage	/						
65	3.91	7.83	11.74	15.66	19.57	J.01	4.49	t Colt							
60	3.87	7.75	11.62	15.50	19.37	6.01	5.05	ndtno 4.60							
55	3.85	7.71	11.56	15.42	19.27			0							
50	3.84	7.67	11.51	15.34	19.18	7.04	5.08	4.40							
45	3.82	7.63	11.45	15.26	19.08	8.02	5.08	4.40							
40	3.80	7.59	11.39	15.18	18.98	0.02	5.00	5	5.50	6.00	6.50	7.00	7.50	8.00	8,50
35	3.79	7.57	11.36	15.14	18.93	8.99	5.09	0	0.00	6.00				8.00	6.50
30	3.77	7.53	11.30	15.06	18.83						1	nput Voltage	e		
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										

FINAL SYSTEM PERFORMANCE

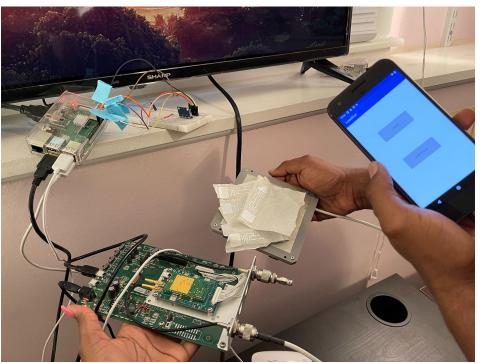


RECALL CDR PROTOTYPE

Development Board

Bread Board

• Beta version of app



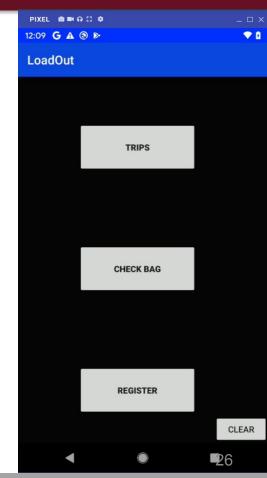




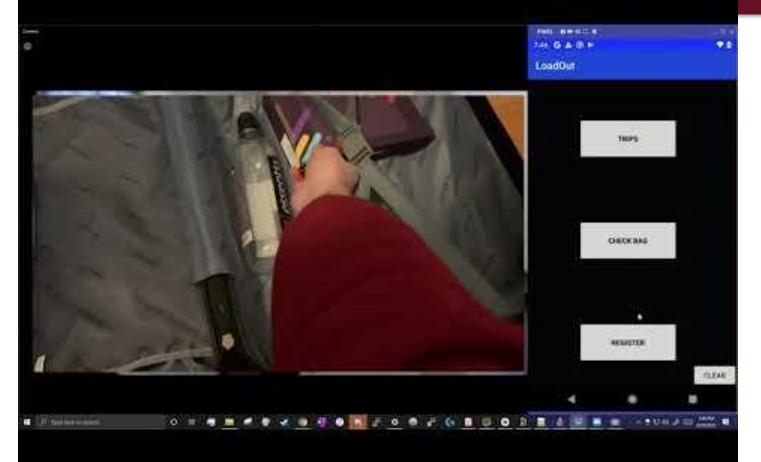


Metallic Shielding

Rigid PCB and Battery Housing



sAmherst



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



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

LAIRD S9028PCL weighs .8lbs https://www.lairdconnect.com/documentation/datasheet-s902-series



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

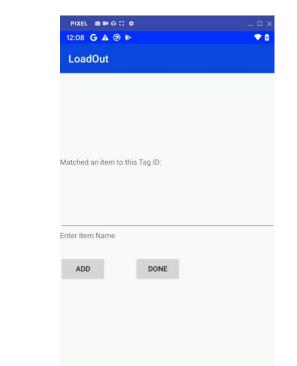
Appears physically no

different than a normal

hardshell suitcase

- Unobstructive
- Easy registration of items





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

📕 🍋 🔍	Open Datak		vser for SQLite -	altime Database Rules Backups Usage
		✓ Databas	se Structure	Frototype and test end-to-end with the Local Emulator Suite, now with Firebase Authentication Get started Fordation of the second started Fordation of the second started Fordation of the second started started Fordation of the second started
	I logged_items_table 📀 🔁 😼 😼 🖷 🕒			sdp-foad-out-default-rtdb → Items_table laptop: "£2004078410801901140A4D7" parts: "£2804078410802161140A508"
			hoes: "£2094078418892151140A586" toothpaste: "£2084078418892561140A586" 	
Filter	Filter	Filter		
		Filter 2021-04-07T09:29:07.886-0400		toothpaste: "E2004078410802561140A558"
Filter E2004078410B01901140A4D7	laptop			- toothpaste: 'E2094078410802561140A558" ⊖- Logged_ltems_table - laptop: "(\"Phase\": 67, \"RSSI\": -36, \"Readcount\": 17, \"EP"
Filter E2004078410B01901140A4D7	laptop shirt	2021-04-07T09:29:07.886-0400		<pre>toothpaste: "E2004078410802561140A558" =-Logged.items_table laptop: '(\"Phase\": 67, \"RSSI\": -36, \"Readcount\": 17, \"EP" pants: '(\"Phase\": 171, \"RSSI\": -32, \"Readcount\": 17, \"E" shirt: ''\"Phase\": 104, \"RSSI\": -32, \"Readcount\": 17, \"E"</pre>

SPEC: STORAGE USE / INTERACTION LOGS

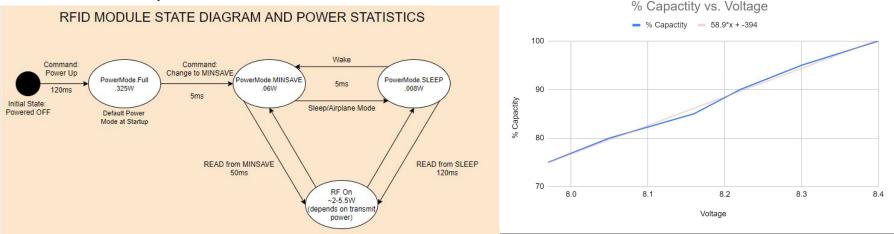
- Should record logs locally while outside of Bluetooth transmission range of the user's phone
 - LoadOut stores untransmitted files locally, divided into individual directories for reads and switch/mishandling logs
 - Max Read Files: 4 MB
 - Max Log files: 3 MB
 - Est. Max Total: 7 MB

👅 🛑 🛑 👅 🛛	pi	RFID	LOG				🔺 🎗 🛜 🌒 15.42
						RFID	× ^ X
File Edit View Sort	Go Tools				File	Edit View Sort Go Tools	
🗂 i 🖬 i 👯 🔛 I	🗄 🔜 I 🐱 🔶 1	home/pi/Desktop/LOG		*		📑 🍀 🇱 📗 🛛 🖿 (home/pi/Desktop/RFI	· ·
Name			▼ Size Modi	fied		Name	 Size Modified
Interaction_Log	s15:57:11.json		369 bytes 04/1	9/2021 15:57	8	 reads1618862422752.json 	713 bytes 04/19/2021 16:00
Interaction_Log	s15:57:22.json		367 bytes 04/1	9/2021 15:57	8	 reads1618862506101.json 	250 bytes 04/19/2021 16:01
Interaction_Log	s15:57:23.json		370 bytes 04/1	9/2021 15:57		 reads1618862540211.json 	134 bytes 04/19/2021 16:02
Interaction_Log	s15:57:27.json		365 bytes 04/1	9/2021 15:57		 reads1618862566672.jscn 	251 bytes 04/19/2021 16:02
📔 🧕 Interaction_Log	s15:57:28.json		377 bytes 04/1	9/2021 15:57		reads1618862644013.json	135 bytes 04/19/2021 16:04
📔 🧕 Interaction_Log	s17:41:14.json		364 bytes 04/1	9/2021 17:41		 reads1618862658151.json 	135 bytes 04/19/2021 16:04
📔 🧕 Interaction_Log	s17:41:20.json		373 bytes 04/1	9/2021 17:41		 reads1618966103562.json 	252 bytes 04/20/2021 20:48
📔 🧕 Interaction_Log	s18:06:22.json		373 bytes 04/1	9/2021 18:06		o reads1618966178400.json	135 bytes 04/20/2021 20:49
Interaction_Log	s20:50:25.json		373 bytes 04/2	0/2021 20:50	-	 reads1618966704349.json 	134 bytes 04/20/2021 20:58
Interaction_Log	s20:50:28.json		371 bytes 04/2	0/2021 20:50		 reads1618956724610.json 	134 bytes 04/20/2021 20:58
Interaction_Log	s20:51:00.json		372 bytes 04/2	0/2021 20:51		 reads1618956766423.json 	133 bytes 04/20/2021 20:59
Interaction_Log	s20:51:11.json		374 bytes 04/2	0/2021 20:51		 reads1618966775780.json 	134 bytes 04/20/2021 20:59
o Interaction_Log	s20:51:12.json		370 bytes 04/2	0/2021 20.51		 reads1618966781688.json 	135 bytes 04/20/2021 20:59
 Interaction_Log 	s20:51:39.json		372 bytes 04/2	0/2021 20:51		 reads1618966787127.json 	135 bytes 04/20/2021 20:59
Interaction_Log	s20:51:43.json		372 bytes 04/2	0/2021 20:51		 reads1618966797407.json 	134 bytes 04/20/2021 21:00
Interaction_Log	s20:51:45.json		372 bytes 04/2	0/2021 20:51		 reads1618966811225.json 	134 bytes 04/20/2021 21:00
 Interaction_Log 	s20:51:46.json		350 bytes 04/2	0/2021 20:51	- 1	o reads1618966860869.json	134 bytes 04/20/2021 21:01
 Interaction_Log 	s20:54:45.json		375 bytes 04/2	0/2021 20:54	- 1	o reads1618967364694.json	133 bytes 04/20/2021 21:09
Interaction_Log	s20:54:50.json		371 bytes 04/2	0/2021 20:54	- 1	 reads1618967372317.json 	133 bytes 04/20/2021 21:09
Interaction_Log	s20:54:55.json		375 bytes 04/2	0/2021 20:54	1.1	 reads1618967392000.json 	134 bytes 04/20/2021 21:09
Interaction_Log	s20:55:02.json		356 bytes 04/2	0/2021 20:55		 reads1618967404100.json 	134 bytes 04/20/2021 21:10
Interaction_Log	s20:55:08.json		370 bytes 04/2	0/2021 20:55		 reads1618967433479.json 	134 bytes 04/20/2021 21:10
Interaction_Log	s20:55:11.json		373 bytes 04/2	0/2021 20.55		 reads1618967454382.json 	134 bytes 04/20/2021 21:10
Interaction_Log	s20:55:12.json		370 bytes 04/2	0/2021 20:55		 reads1618967461930 json 	135 24/20/2021 21:11
o 53 items	.01.00.00.1		Free space: 1.8 GiB (To	tal: 13.6 GiB)	10 79 ite	a. mode1619067611577.icon. MS	Free space: 1.8 GiB (Total: 13.6 GiB)

34

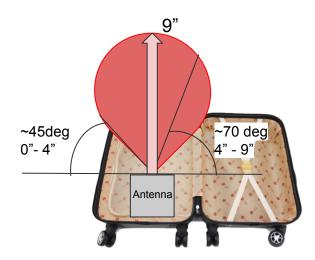
SPEC: POWER USAGE

- 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

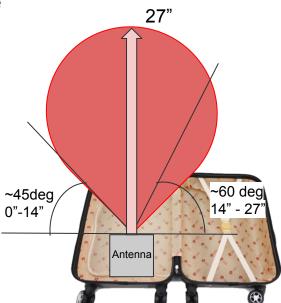


SPEC: ITEM TRACKING

• Maximum possible detection distance

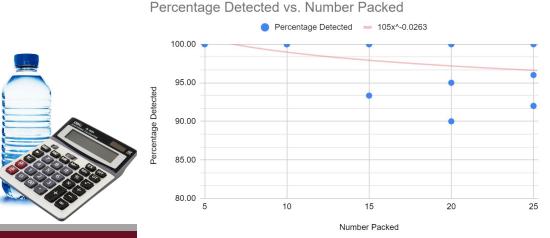


Register Mode Read Range and Angle



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 Th [Thonny - /hor	12:04:58 open				
Interaction_Logs19:29:32.json - Mousepad	*Interaction_Logs21:09:47.json - Mousepa	12:04:41 closed			
File Edit Search View Document Help I 1 { I 2 "logEvent": [3 3 { "detection": "drop", 5 "time": "19:29:32", "magnitude": "23.2461572265625 (2.37060546875g)", 6 "magnitude": "23.2461572265625 (2.37060546875g)", " 7 "Gyroscope": "{'x': -7.893129770992366, 'y': -0.25190839694656486, 'z': 0.7709923664122137]", 8 "Accelerometer": "{'x': 0.3495302734375, 'y': 0.49077880859374995, 'z': 1 -10.172288574218749]", 1 9 "Temperature": "31.071176470588235 Celcius" 1	<pre>File Edit Search View Document Help 1 { 2 "logEvent": [3 { 4 "detection": "open", 5 "time": "21:09:47", 6 "magnitude": "10.8354384765625 (1.10498046875g)", 7 "Gyroscope": "{'x': -4.633587786259542, 'y': -0.267175572515 8 "Accelerometer": "{'x': 0.48838476562499994, 'y': 0.0, 'z': 9 "Temperature": "29.377058823529413 Celcius" 1] 12 2 } </pre>		229007634}",		
12 }			37		

UMassAmherst

Logs

V B

1:09 G 🗛 🛞 🕨

12:51:16 open

12:50:30 closed

12:49:35 closed 12:08:07 drop 12:05:09 open 12:05:06 open 12:05:01 closed

LoadOut

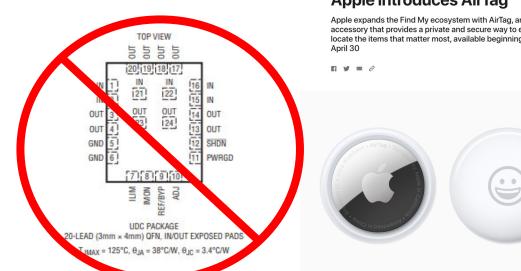
SPECIFICATIONS SUMMARY

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 •



Apple introduces AirTag

Apple expands the Find My ecosystem with AirTag, an iPhone accessory that provides a private and secure way to easily locate the items that matter most, available beginning Friday,

Thank you!

HIDDEN SLIDE: BACKUP DEMO VIDEO

FPR BACKUP VIDEO LINK: <u>https://youtu.be/YMn7gIPR2tE</u>