Backup Buddy:

Wireless Backup Camera

Group 10

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Motivation

- More than 18,000 backup-related injuries occur in the US (200 being fatal)

- Driver visibility is limited during backup

- Average reaction time is 215ms, too slow for proper response

- Our design aims to improve driver awareness and safety

Goals and Objectives

- Providing a live, wide angle video stream of the rear of the vehicle

- Provide alerts and data to indicate obstructions that are behind the car

- Create an easy to install hardware assembly

- Mobile application that interfaces with the system and offers configuration options.
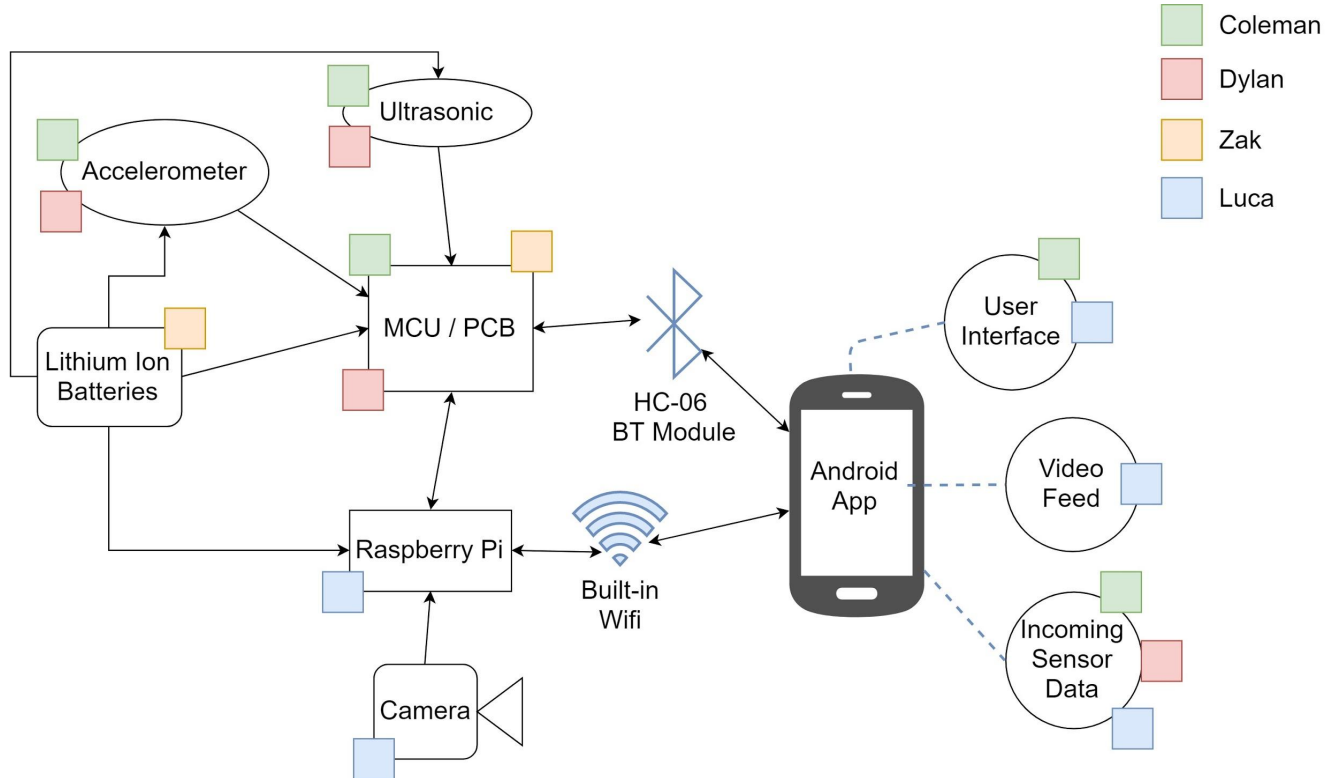
Hardware Requirement Specifications

| 1	The system will require no more than 12V from its power source
2	The system will weigh less than 10 pounds
3	The face of the system will take up a space no larger than 16in x 10in
4	The system will be able to accommodate up to 2A of current draw under load
5	The size of the PCB shall be no larger than 2.5in x 5in

Software Requirement Specifications

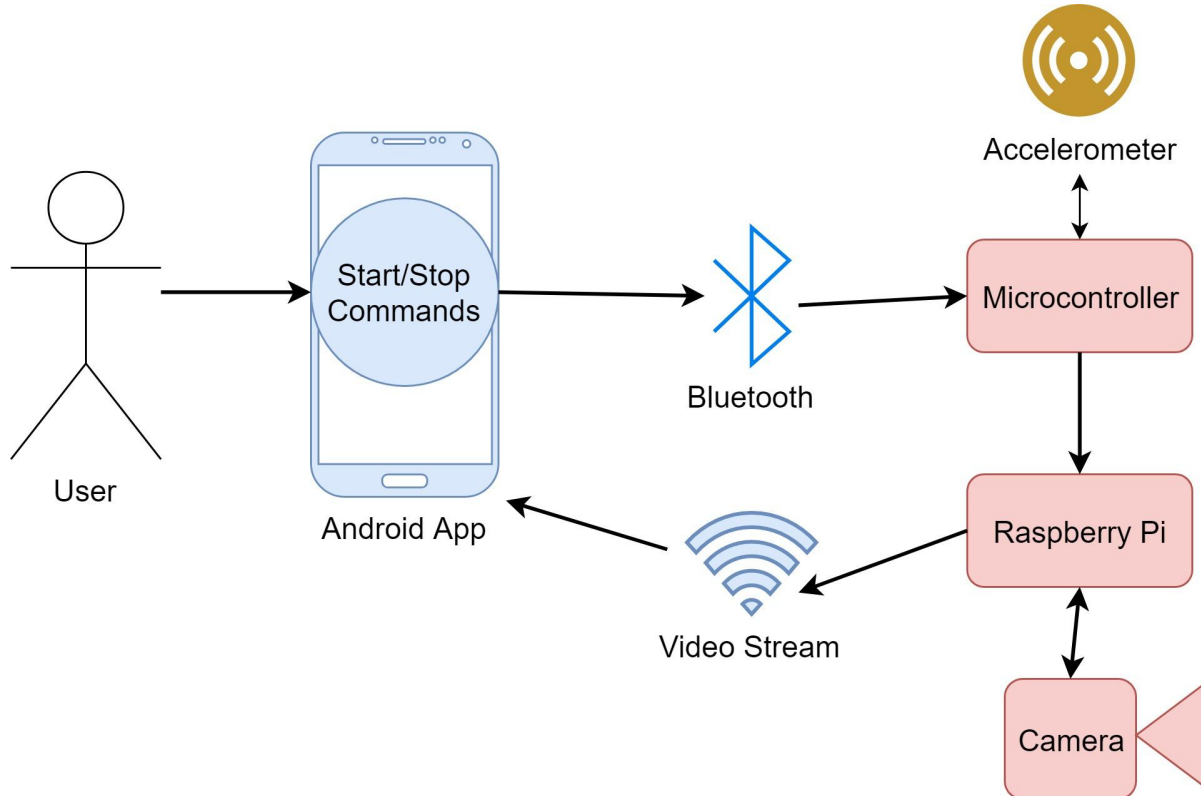| 1	The Android application will provide a visual graphic to indicate an obstruction the car is approaching
2	The Android application will provide an audible tone, with increasing speed as the car becomes closer to an obstruction
3	The system will alert the driver when obstructions that are behind the vehicle are within 5 feet and the size of 1 cubic foot or larger
4	Using an accelerometer the system will detect when the car is in motion, and if not in use will arm the security state of the app
5	The video feed of the rear facing camera will have a framerate of at least 15 fps at any given time

Overall Block Diagram

Mounting Enclosure

Ultrasonic Sensors

License Plate Placement Here

PCB

2.1"

Raspberry Pi

3.3"

2.5"

Camera
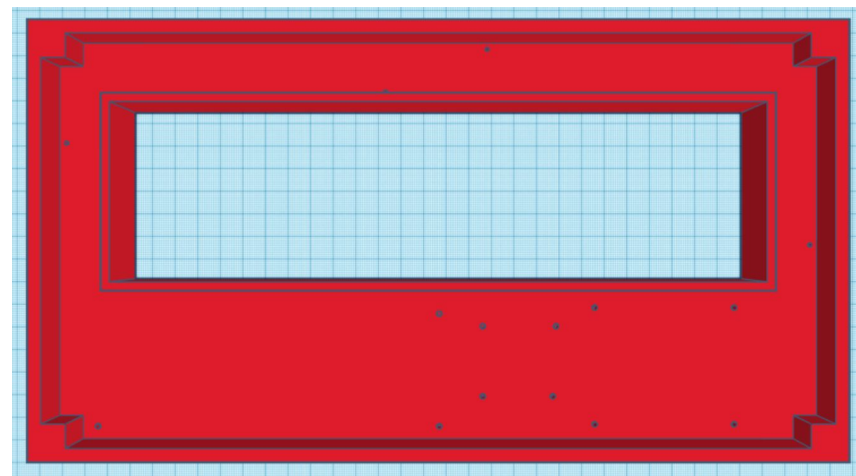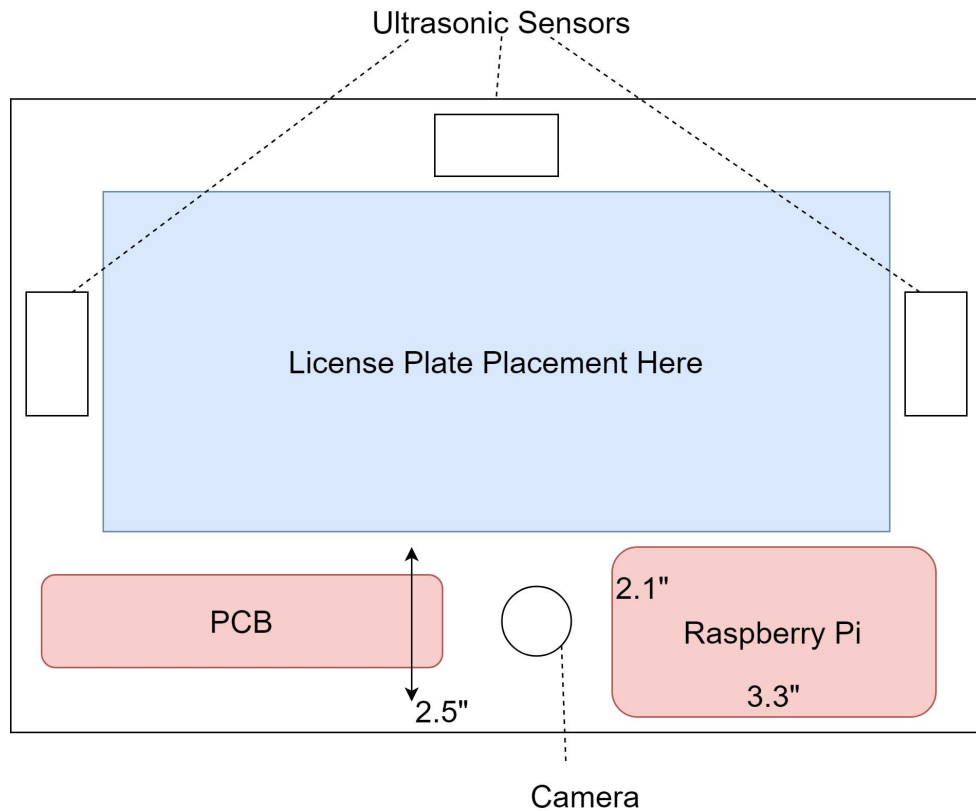
Use Case Diagram

Microcontroller - MSP430-FR5969

Spec	**MSP430-FR5969**	MSP430-G2553	ATmega328P
Clock Speed	1-16MHz	1-16MHz	1-20MHz
GPIO Pins	40	16	23
Storage	64KB (FRAM)	16KB (Flash)	32KB (Flash)
Cost	$3.86	$2.20	$2.01
LPM Power Consumption	0.72 μW	0.90μW	1.35μW

Wireless Technology Selected

Spec	Bluetooth	Wi-Fi	ZigBee
Transfer rate	3 Mbps	300Mbps	250 kbit/s
Power consumption	5-50ma	50-180mA	5-25ma
Range	25m	50m	10-100m

Bluetooth Module - HC-06

Component	HC-06	HC-05	HM-10	RN-42
Transfer rate	2 Mbps	2 Mbps	6 kbps	240 kbps
Power consumption	40 / 8ma	40ma / 8ma	50ma / 8.5ma 800ua	30ma / 3ma
Range	10m	10m	3m	20m
Price	$3.50	$3.50	$8.99	$15.73
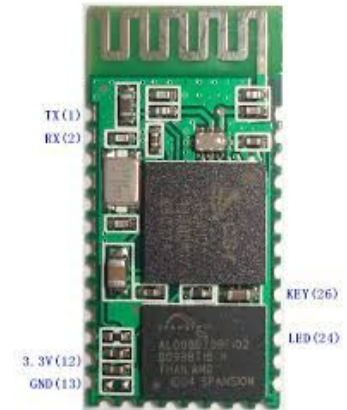
Microcomputer For Streaming Video

Component	Raspberry Pi 3B+	Banana Pi	TI-DaVinci (TMS320DM6446)
Transfer rate	300 Mbps	600 Mbps	100Mbps
Power Consumption	600ma - 2.4A	600ma - 2A	5V - 2A
CPU	ARM 1.4GHz Quad Core	ARM 1.2 GHz Quad Core	600 MHz Quad Core 32bit
Ram	1 GB	1 GB	16KB
Size	85mm x 56mm	92mm x 60mm	Chip
Price	$39.99	$54.99	$46.32 (chip only)

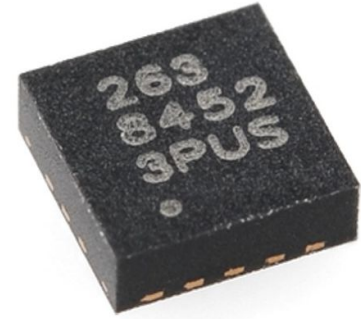# Camera Selection - OV5647 Wide Angle

Component	Omnivision 5647 (Wide angle Lens)	Raspberry Pi Camera	Omnivision 5647 With IR
Field of view	160	62	69.9
Power Consumption	96ma	120ma	120ma
Size	36mm x 36mm	25mm x 23mm	36mm x 36mm
Price	$26.99	$25	$74.89

Accelerometer - MMA8452Q

Component	MMA8452Q	ADXL335	TDK ICM-20948
Output Data Rates	1.56Hz to 800Hz	0.5 to 1600Hz/550Hz	400kHz to 7MHz
Digital Resolution	8-bits or 12-bits	None	16-Bit
Programming Interface	i2C	None	SPI or I2C
Cost	$2.95	$2.05	$5.10

Ultrasonic Sensor - HY-SR05

Component	HY-SR05	HC-SR04	SU04
Range	2cm - 4m	2cm - 4m	40cm-4.5m
Field of View	15 degrees	15 degrees	60 degrees
Programming Interface	UART	UART	I2C, UART
Pins	5	4	4
Size	45mm x 21mm	45mm x 21mm	19mm x 21mm
Cost	$3.95	$3.49	$14.99
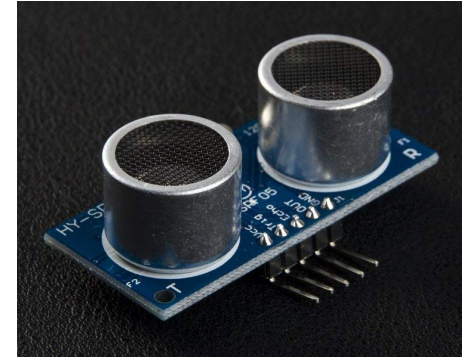
Power Options

| Specs	Battery	Brake Lights	Solar Panel (Always On)
Battery Life	12hr (active) - 11 months (low power)	Indefinite	Unreliable
Start Up Time	20 seconds	1-2min	20 seconds
Easy to install?	Yes	No	Yes

Battery Selection

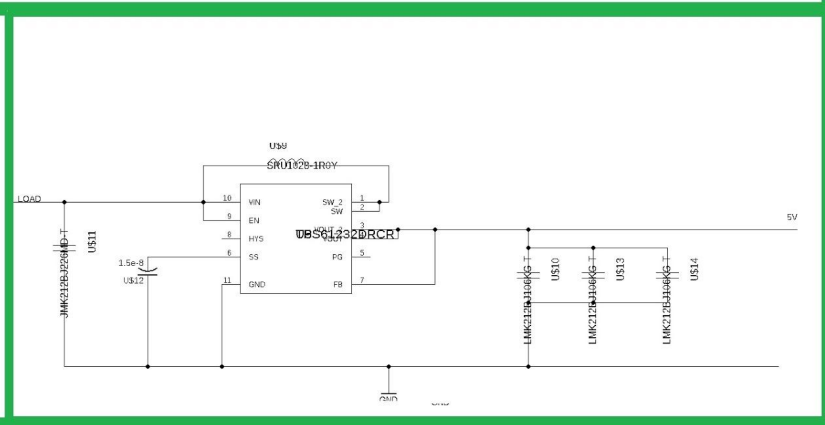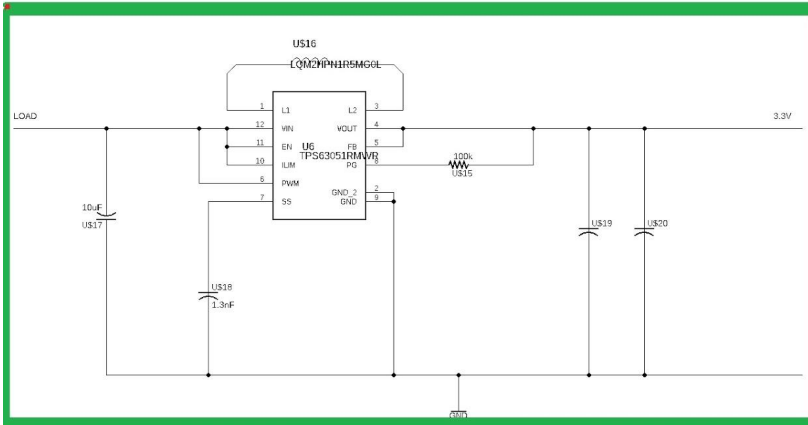| Specs	**LG MJ1 (Li-Ion)**	**Tenergy 10706 (NiMH)**	**SparkFun PRT - 09100 (Alkaline)**
Self-discharge/day	0.1%	1%	<0.01%
mAh	3400-3500	1800-2000	500-2300
Voltage per cell	2.5 - 4.2	1.2 - 0.9	0.9-1.5
Cost per cell	$7	3.48	0.50
Weight	49 g	30 g	23 g
Size	65mm x 18mm	42.5mm x 17mm	53mm x 14mm
Max charge current	3.5 A	1 A	NA
Max discharge current	10 A	9 A	1A

Schematic - Power
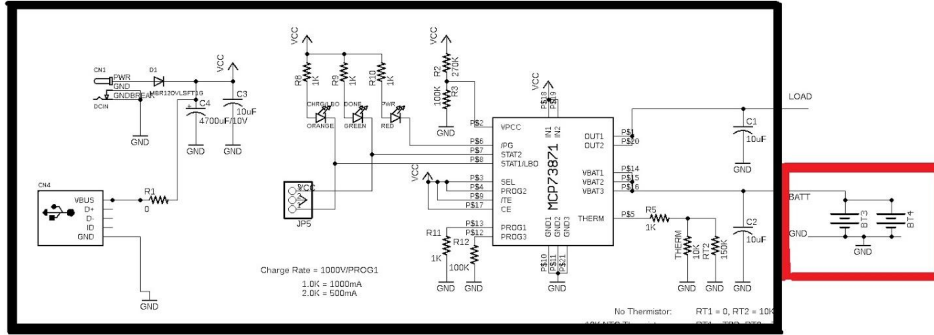
Battery

Voltage Regulator

Charge controller

Charge Controller - MCP73871

Component	MCP73871	Microchip MCP73831	TI BQ24650
Input Voltage	0V - 6V	3.75V-6V	5-28V
Battery status indicator	3 states	3 states	3 states
Max. battery charge current	1 A	500 mA	20 A
External components required	9	5	27
Price	$1.84	$0.61	$4.43

Charge Controller - MCP73871
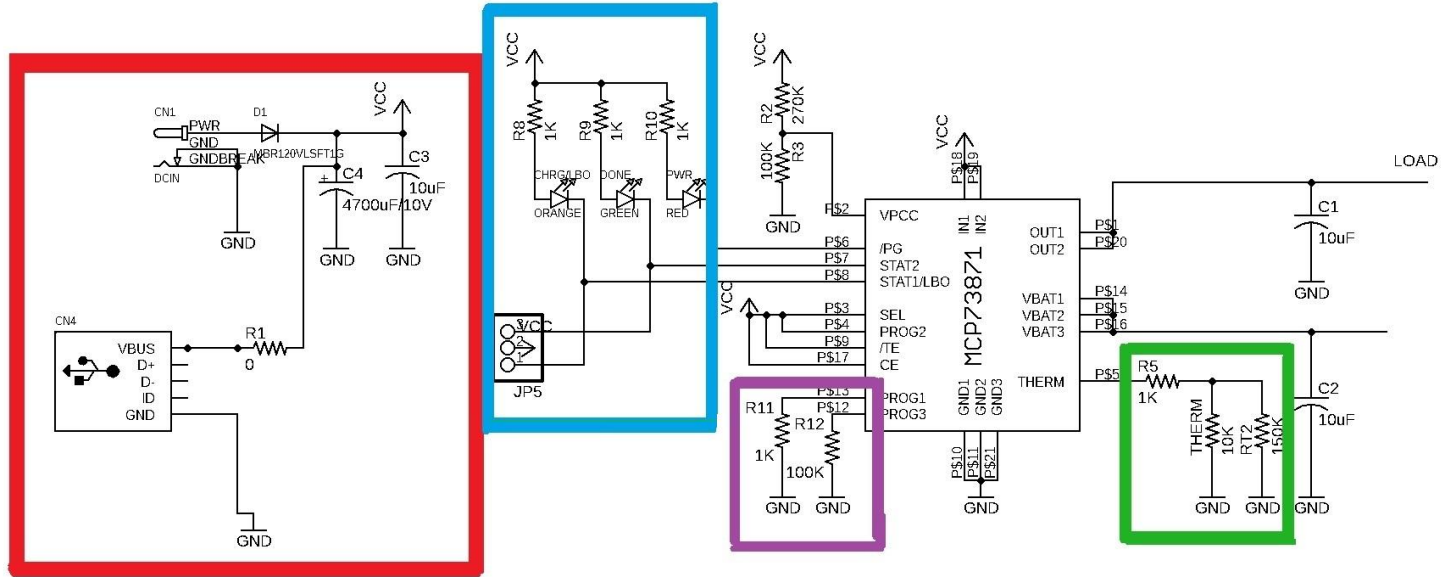
USB+DC input/Over-voltage protection

Temperature sensing

LEDs with charging status

Charge current regulation

Voltage Regulator - 3.3V - TPS 63051

Specs	TPS63051	TPS64203	MCP1700
Voltage input range	2.5V - 5.5V	1.8V - 6.5V	2.3V - 6V
Voltage output	3.3V	1.2V - 6.5V	1.2V - 5V
Max. current	1A	3A	250mA
Operating Temp.	-40°C - 85°C	-30°C - 65°C	-40°C - 125°C
Efficiency	90%-95%	80%-85%	79%-91%
Switching frequency	2.5 MHz	800 kHz	NA/ LDO Linear Regulator
Price	$1.66 from T.I.	$1.36 from T.I.	$0.37 from Microchip

Voltage Regulator - 5V - TPS 61232

Specs	TPS61232	TPS61253A	MIC29301
Voltage input range	2.3V - 5.5V	2.3V - 5.5V	-20V - 60V
Voltage output	5V	5V	5V
Max. current	2.1A	1.5A	5A
Operating Temp.	-40°C - 85°C	-40°C - 85°C	-40°C - 125°C
Efficiency	Up to 94%	Up to 95%	60%-84%
Switching frequency	2 MHz	3.5 MHz	NA/LDO Linear Regulator
Price	$1.66	$1.18	$4.31

MCU Schematic
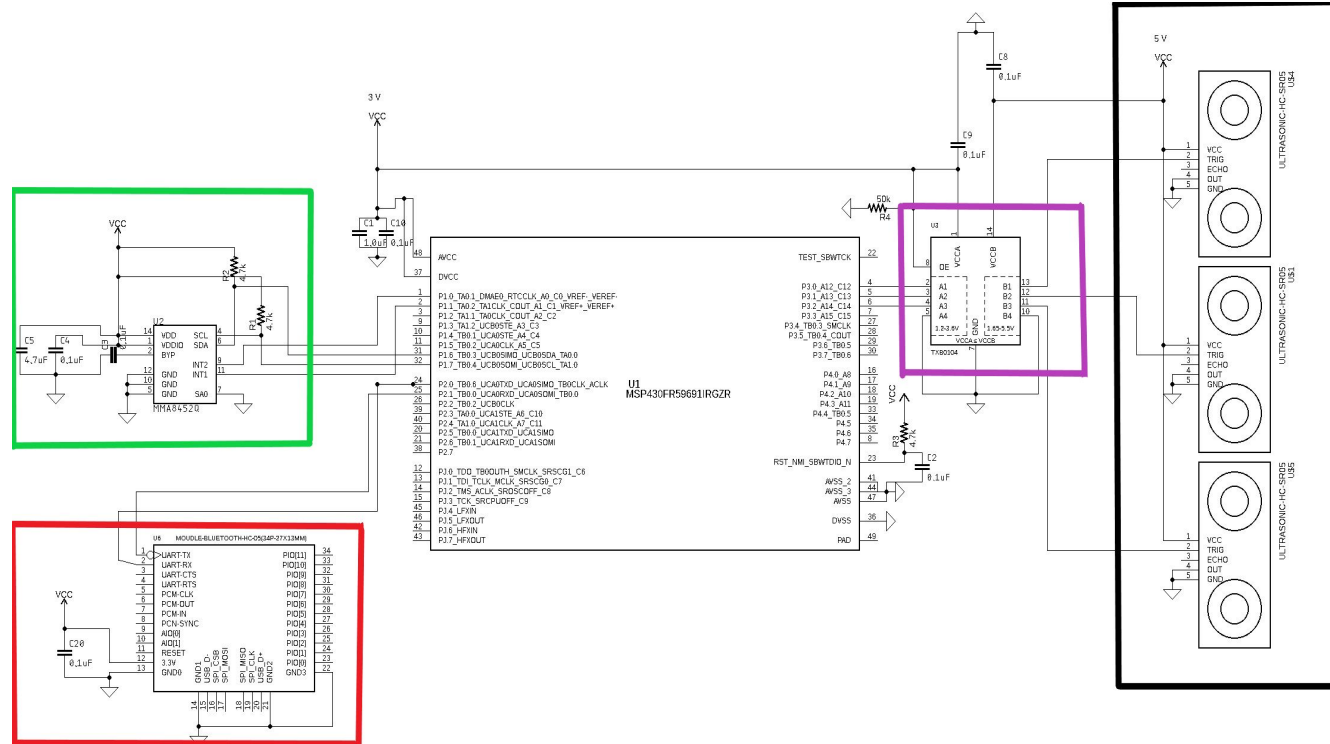
Bluetooth

MMA8452Q
Accelerometer
-i2C

TXB0104
Level Shifter
-GPIO

HC-SR05
Ultrasonic

Logic Level Shifter - TXB0104

Specs	TXB0104	LSF0204	Voltage divider
Bit size	4-bits Bi-directional	4-bits Bi-directional	Any size Uni-directional
Logic Voltage Capability	1.2V - 3.6V port A 1.65V - 5.5V port B	1V - 4.5V port A 1.8V - 5.5V port B	Depends on resistor values
Propagation delay	1-4 nanoseconds	1.5 nanoseconds	NA
Max. logic output current	100mA	64 mA	NA
Clock skew	0.5 nanoseconds	Depends on PCB	NA
Price	$1.25 from T.I.	$0.98 from T.I.	$0.15

Current Consumption Flowchart
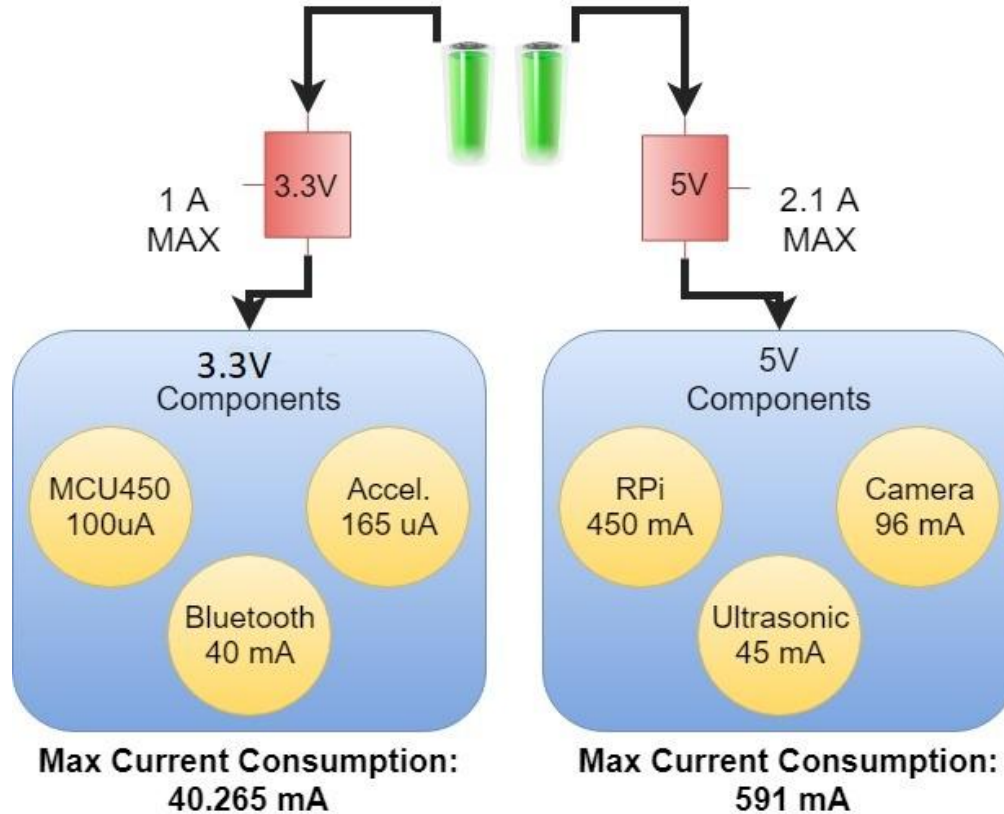
Battery Life

Component	Active mode current draw	Low-power mode current draw
MCU (MSP430FR59691)	100 µA	0.40 µA
Raspberry Pi module	450 mA	150 µA
Ultrasonic Sensors (3)	45 mA	0 mA (off)
Accelerometer	165 µA	6 µA
Bluetooth Module	30 mA	1 mA
Camera	96 mA	20 µA
All components together	599.765 mA	1.158 mA

In low power mode: (7000 mAh)/(1.158 mA) = 6044 hours = **251 days**

In active mode: (7000 mAh) / (599.765 mA) = **11.7 hours**

PCB Drawings

1st Gen: 120 mm x 40 mm
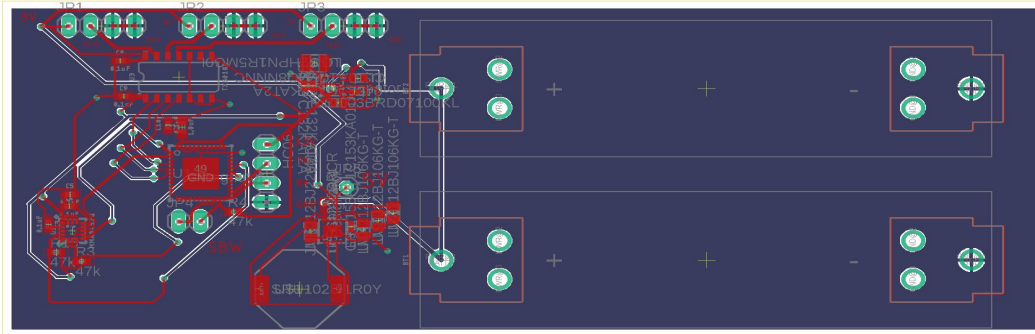
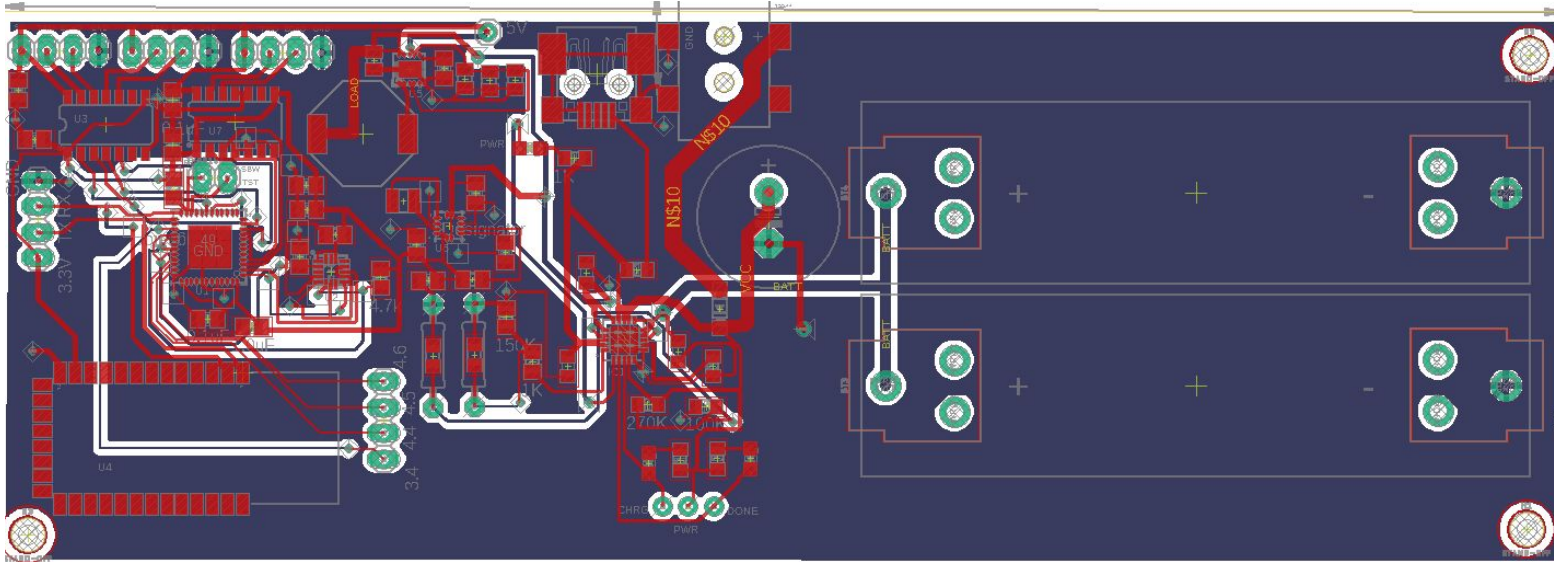2nd Gen: 156 mm x 40 mm
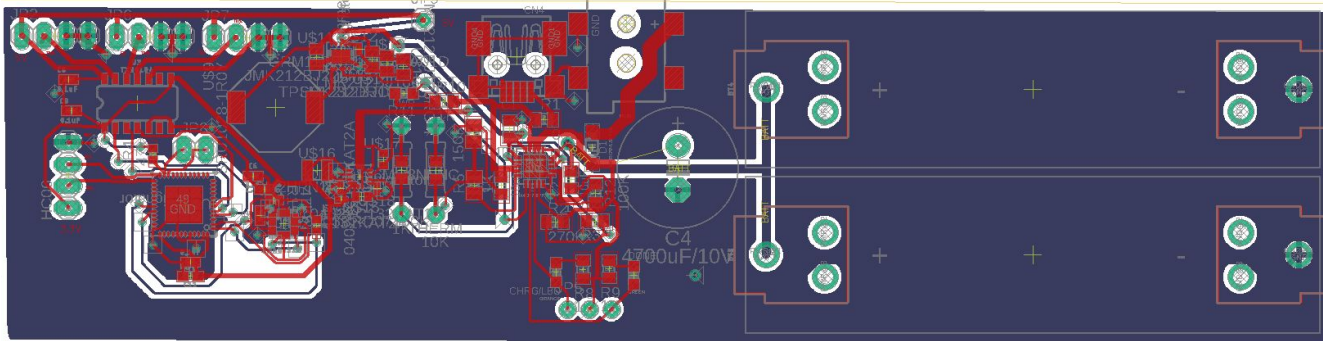
<u>Changes</u>
- Fixed missing pads
- Added charge controller

# PCB Final Drawing

156 mm x 56mm

Changes

- Changed ultrasonic pins to use trigger and echo on GPIO
- Added a level shifter to accommodate extra ultrasonic to GPIO communication
- Made resistors and capacitors slightly bigger
- Put Bluetooth chip on-board
- Added external pins for GPIO to connect to Raspberry Pi
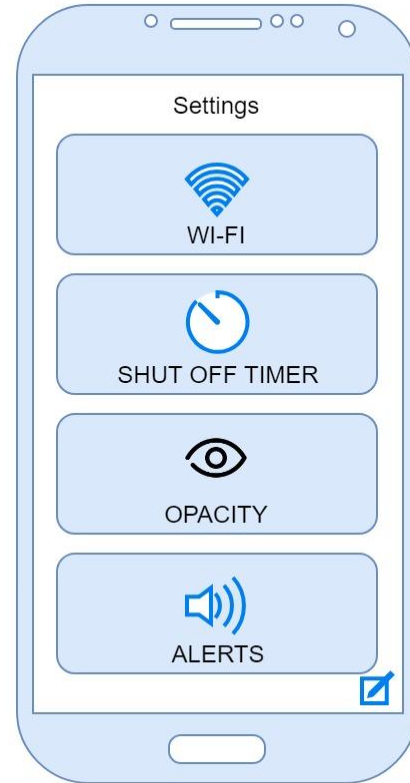
Mobile App Development: Android vs iOS

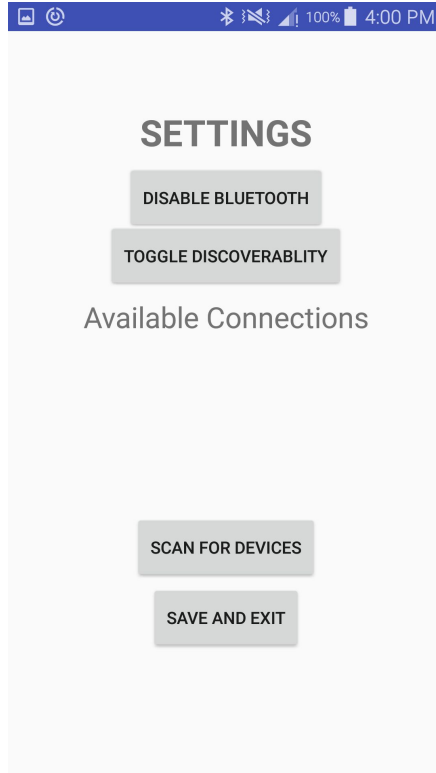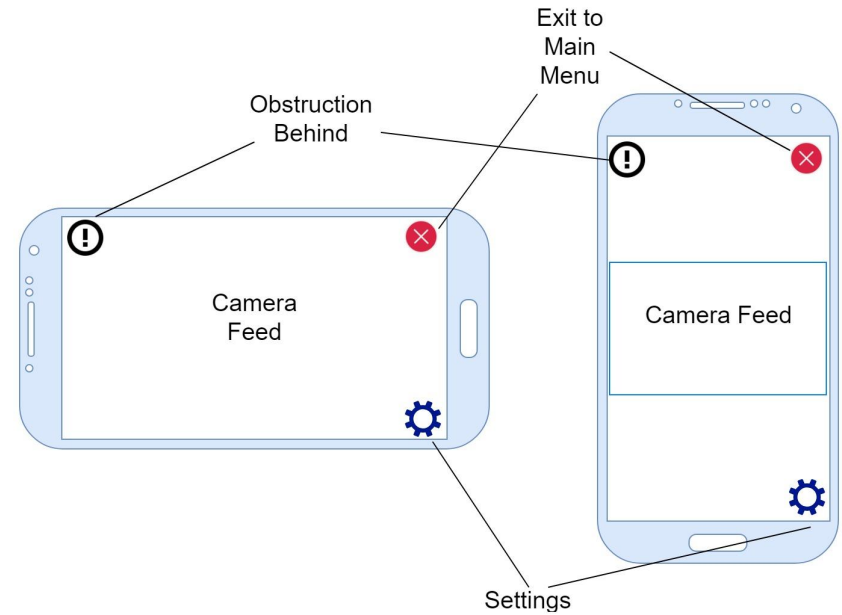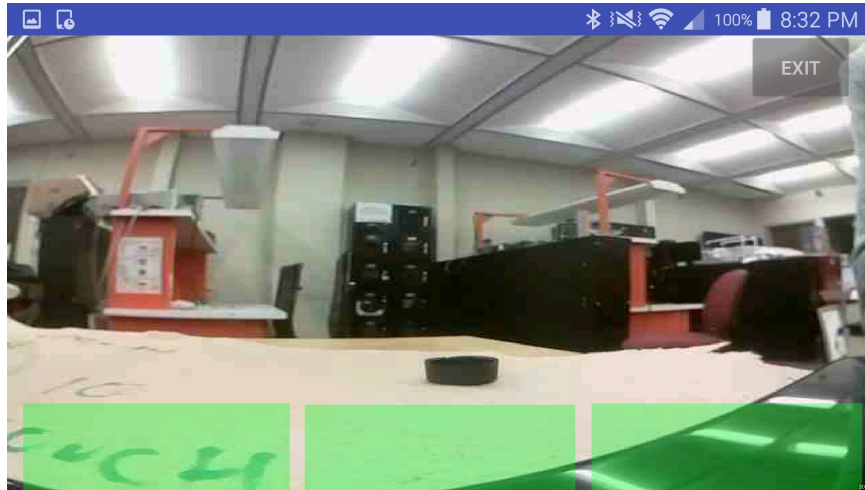| Specs	**Android**	iOS
Programming Language	Java	Swift
Required Hardware/Software	macOS or Windows	macOS specific
Marketshare	More	Less
Documentation/Resources	Abundant	Limited

Mobile App - Main Menu
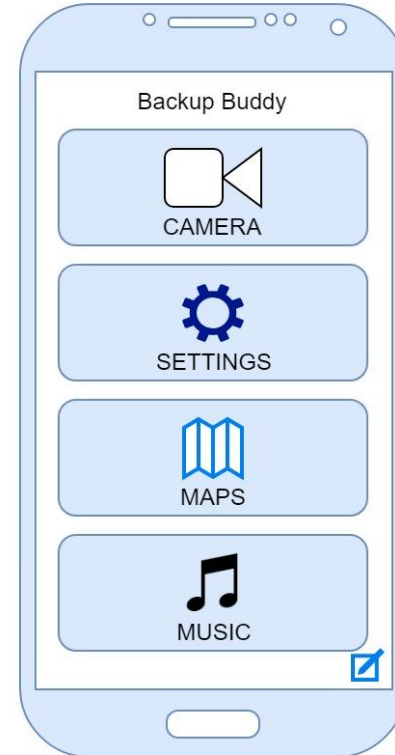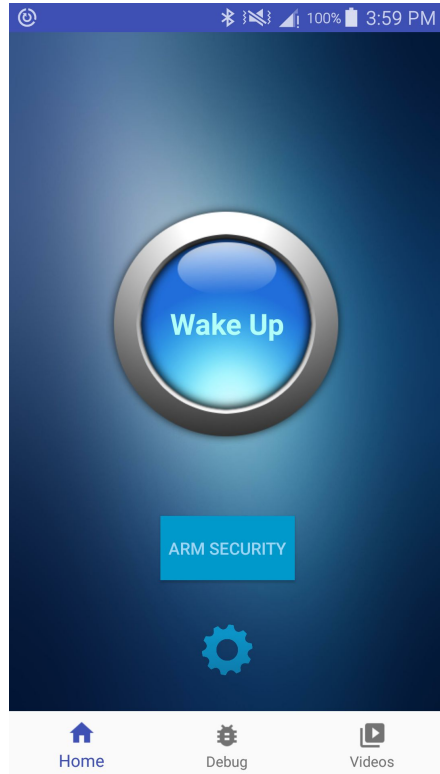
Mobile App - Settings Page

Mobile App - Camera View

Mobile App - Security View
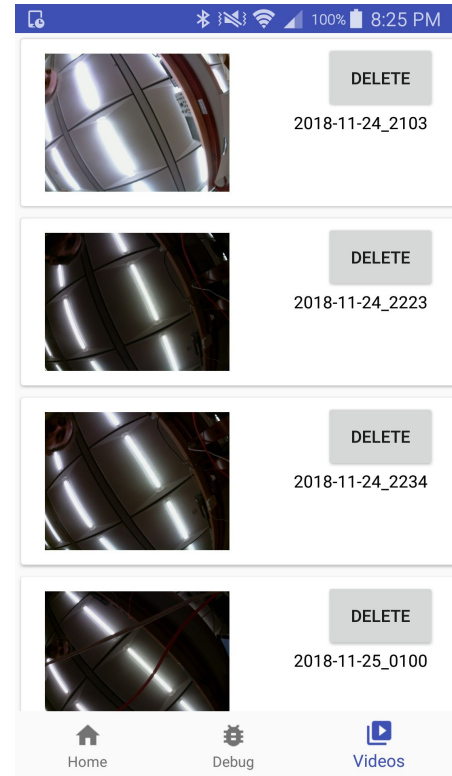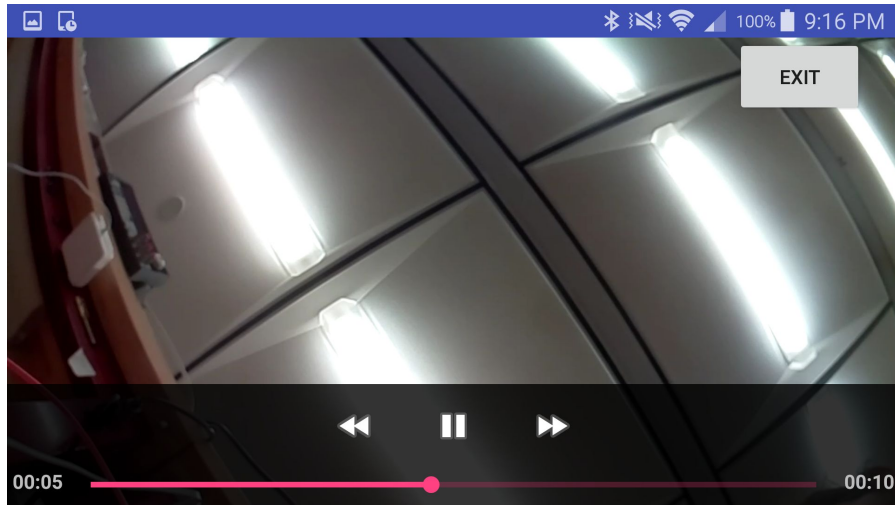
Admin Content

Work Distribution

Member	Embedded Development	Android App	Circuit Design	PCB Design	Raspberry Pi Video	3D Model Design
Dylan	P		S	S		P
Coleman	P	P	S			
Luca		P	S		P	
Zak	S		P	P		

Financing - Major Components

Item	Part Number	QTY	Source	Raw Cost	Used Cost
Ultrasonic Sensors	HC-SR05	4	Amazon	$15.98	$11.97
Accelerometer	MMA8452Q	4	Karlson Robotics	$25.76	$2.95
Microcontroller	MSP430FR5969	4	TI	$34.56	$3.86
BT Module	HC-06	1	Amazon	$8.99	$8.99
Sleepy Pi	Sleepy Pi	1	Spell Foundry	$55.95	$0.00
Camera	Omnivision 5467	2	Amazon	$53.98	$26.39
Raspberry Pi	Pi 3B+	1	Amazon	$35.99	$35.99
TOTAL				**$231.21**	**$90.15**

Financing - PCB & Related

Item	Part Number	QTY	Source	Raw Cost	Used Cost
3.3V Regulator	TPS63051YFFR	5	TI	$0.00	$0.00
5V Regulator	TPS61253YFFR	5	TI	$0.00	$0.00
Lithium Ion Battery	LG INR 18650 MJ1	2	Amazon	$14.98	$14.98
Charge Controller	MCP73871	3	DigiKey	$5.52	$1.84
PCB	Custom	20	PCBWay	$105.00	$5.25
Enclosure	Wood	1	Home Depot	$22.70	$5.67
TOTAL				**$148.20**	**$27.74**

Financing - Totals

Description	Raw Cost	Used Cost
Major Components	$231.21	$90.15
PCB/Secondary Components	$148.20	$27.74
Development	$17.49	$0.00
TOTAL	**$396.90**	**$117.89**
Expected Budget	$500.00	$200.00

Issues & Challenges

- Latency of the video stream was poor
  Solution: Moved to MJPG stream, little to no encoding

- Ultrasonic sensors not working in a single pin mode
  Solution: Updated PCB design to 2 pin model

- Sensor data was larger than 8-bits
  Solution: Break up and send in frames over bluetooth

- Faulted components on the main PCB
  Solution: Power with older model

DEMO