

# CSS: CAR SENTRY SYSTEM

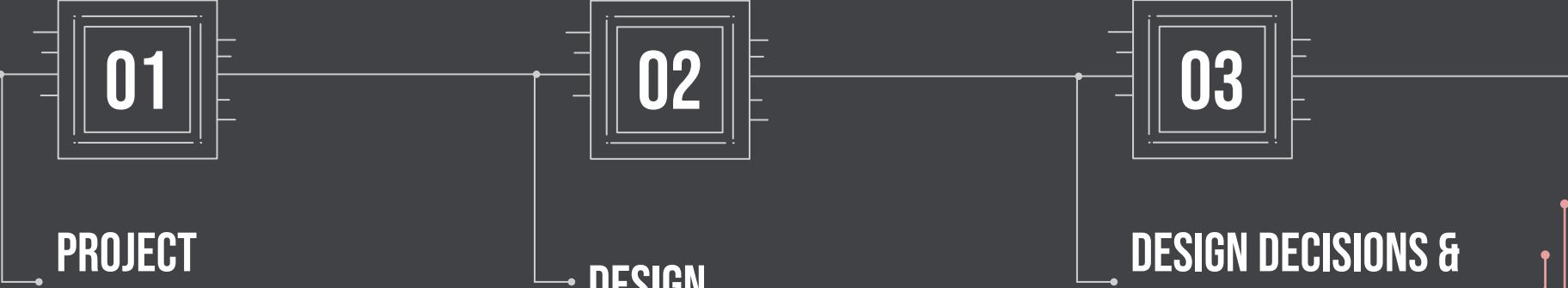
Group 38

Qrizelle Crisostomo, CpE  
Ricardo Nunes Alcobia, CpE  
Ari Pantoja, EE  
Robert Zarrella, EE





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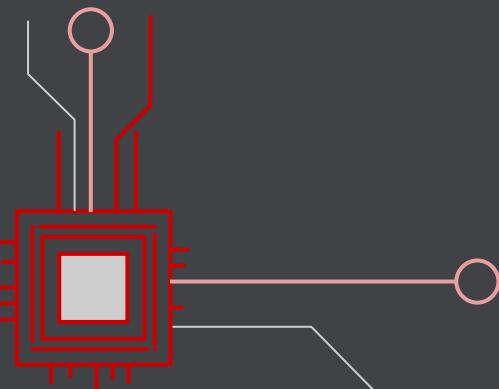
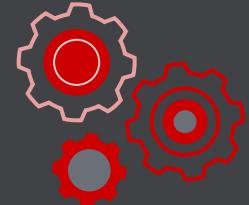
- **QUESTIONS?**

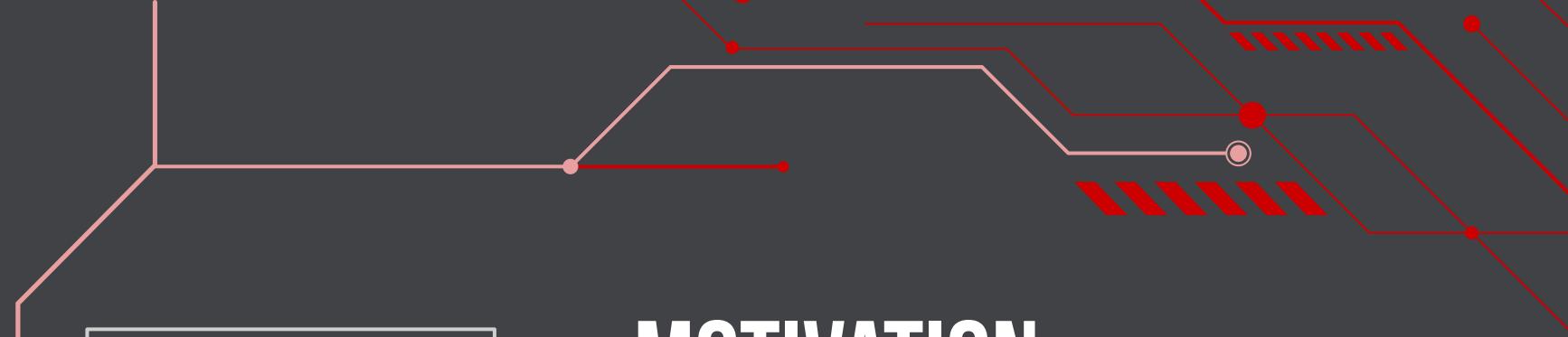
Open Question &  
Answer Session



# 01

# PROJECT OVERVIEW





# MOTIVATION

- Driving is a dangerous activity
  - Hit & Run/Reckless Driving
- Difficulty in Memorization
- Wide range of applications
  - Parking
  - Tolls
  - Grounds Management



# GOALS AND OBJECTIVES



## GOAL:

Produce a low-cost, portable license plate scanner for the average day-to-day driver

## OBJECTIVES:

- Scan license plate information for enclosed, 4-wheel civilian vehicles
- Plug-and-Play functionality
- Lightweight & Portable Design
- Crash Survivability
- Prevent Obstruction in Driver View
- Build to IEEE/IEC/UL Standards
- Modular codebase
- Accessible and Convenient to Users (Mobile Application)





# SPECIFICATIONS

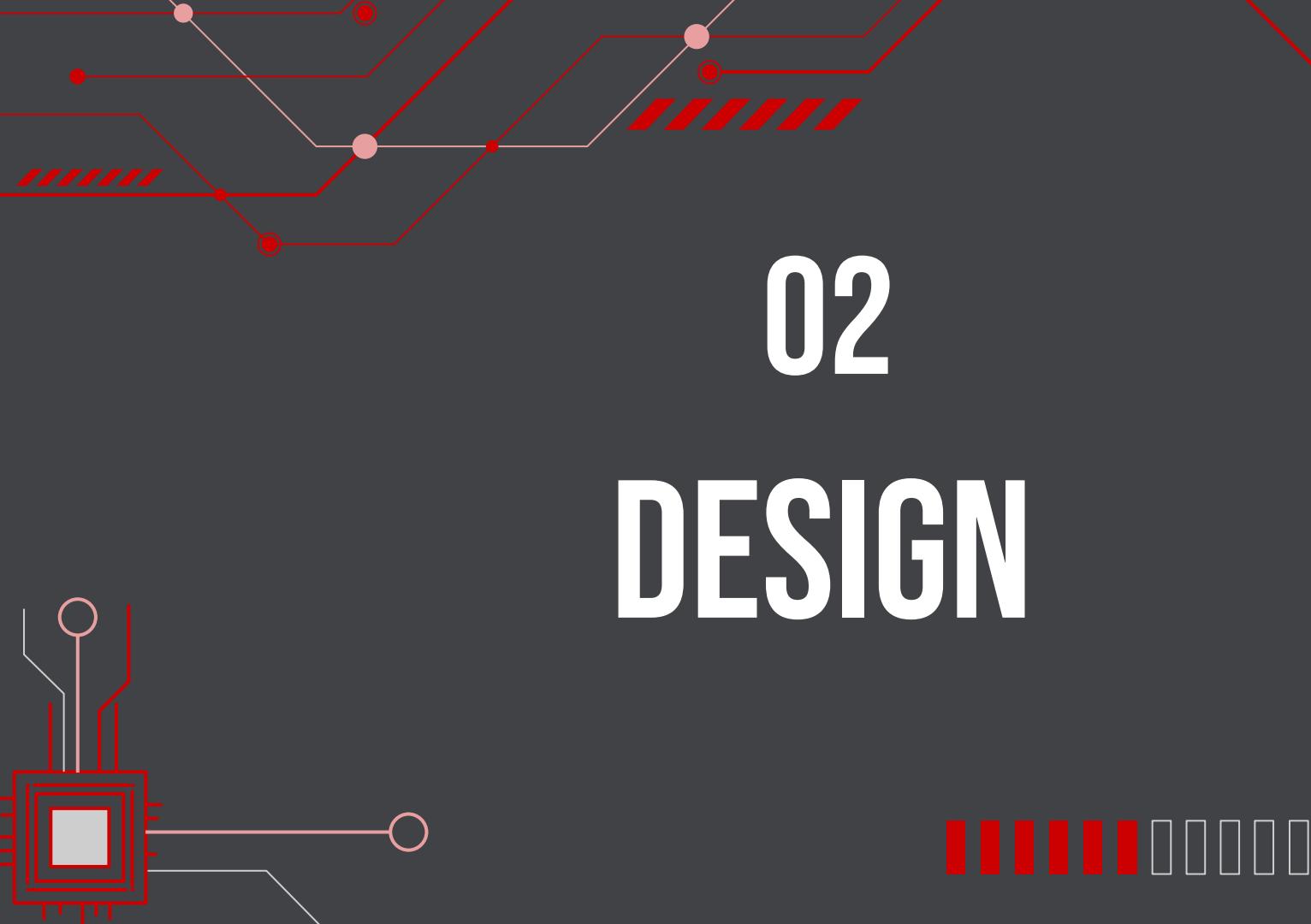
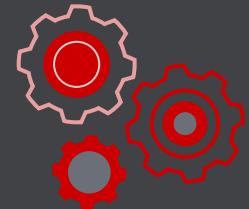
Demonstrable

Component	Parameter	Design Specification
Battery	Discharge Life	3-5 days (Avg. 40-60 mins/day)
Camera	Resolution	1080p with accuracy of $\geq 90\%$
Camera	Frame Rate	Process video feed $\geq 20$ fps
System	Dimensions	Will not exceed 5"x4"x4"
System	Weight	< 2lb
Enclosure	Survivability	Readable storage after 2-story drop

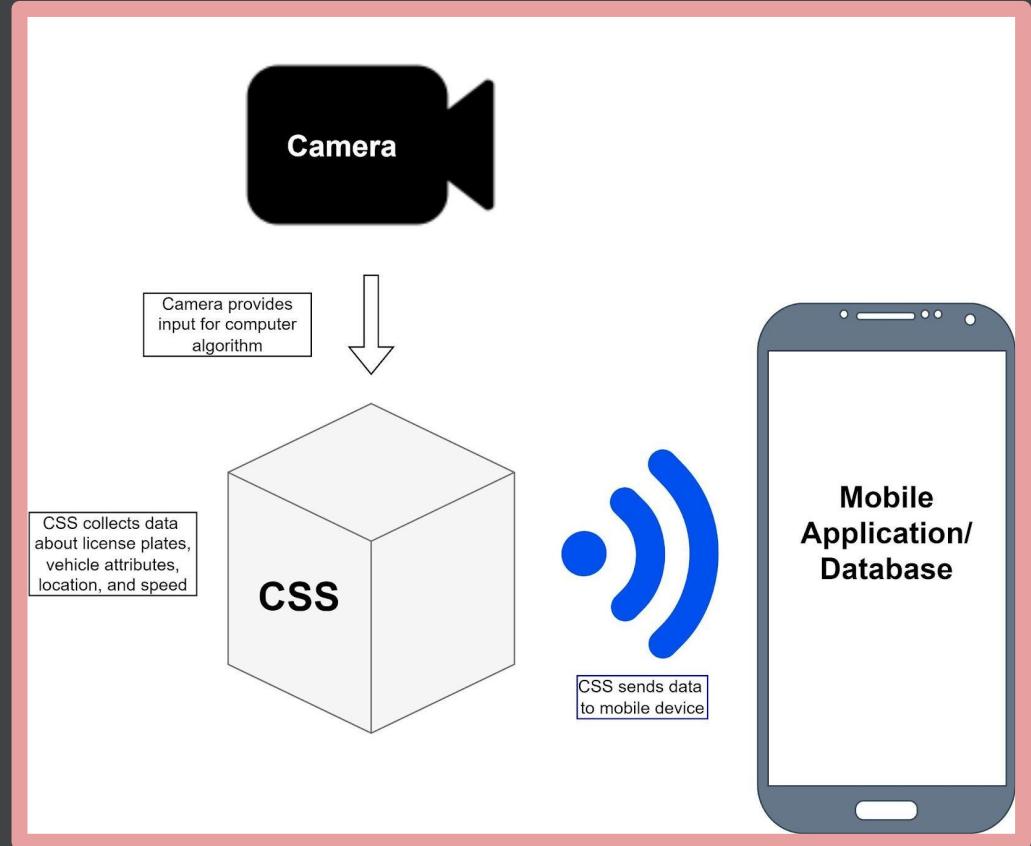


# 02

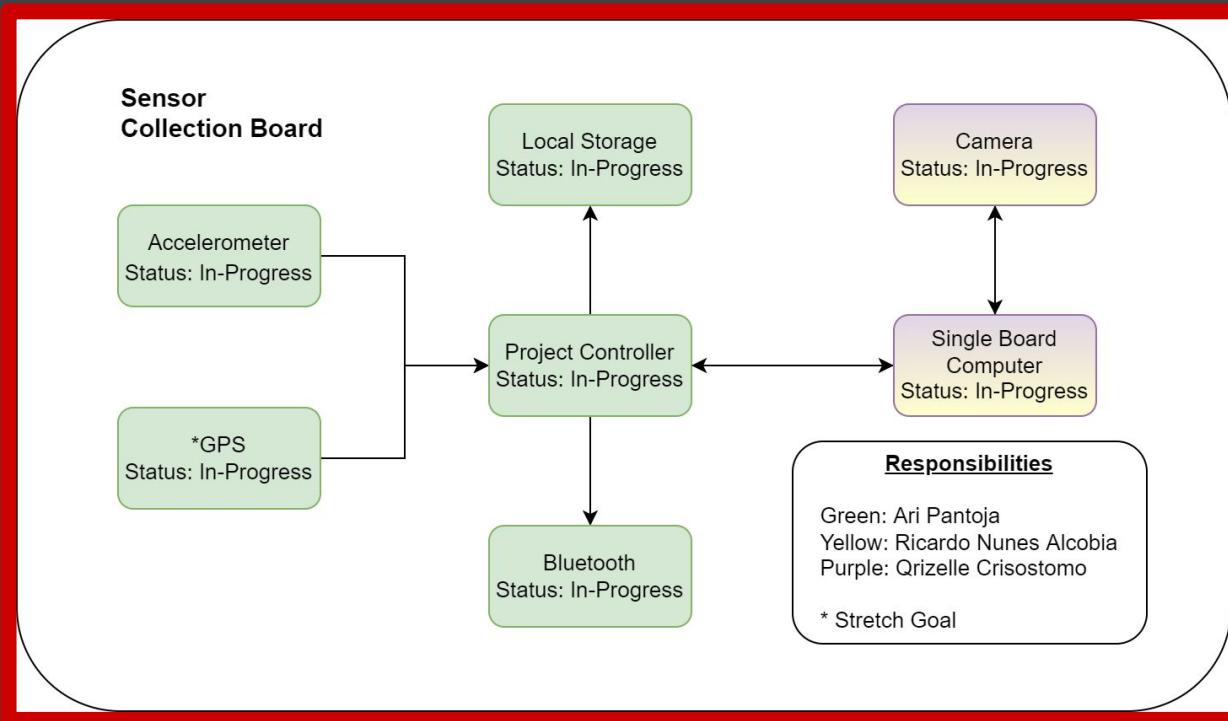
# DESIGN



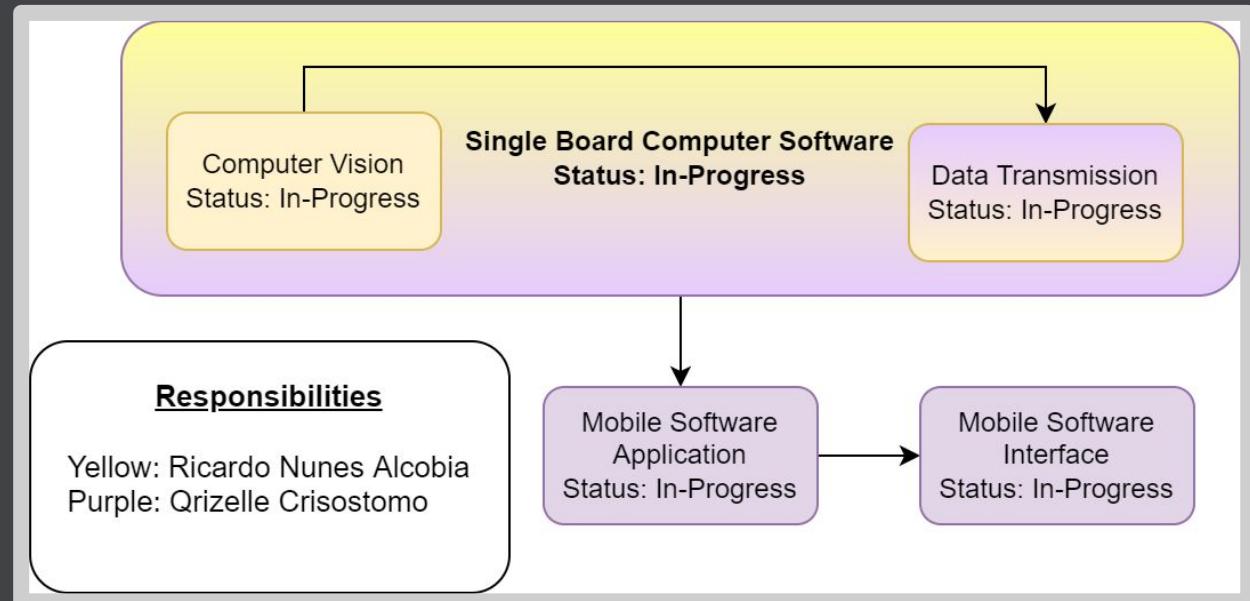
# HIGH-LEVEL OVERVIEW



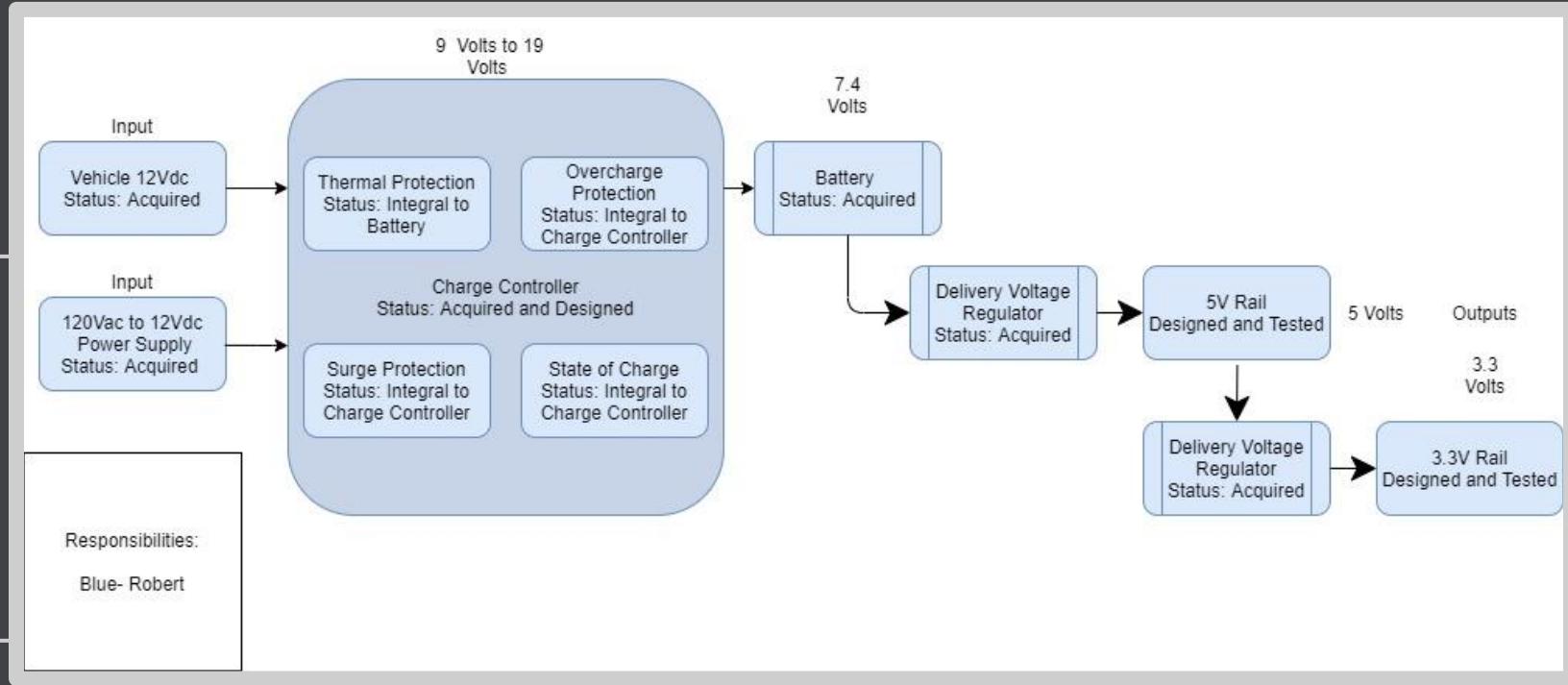
# ELECTRONICS BLOCK DIAGRAM

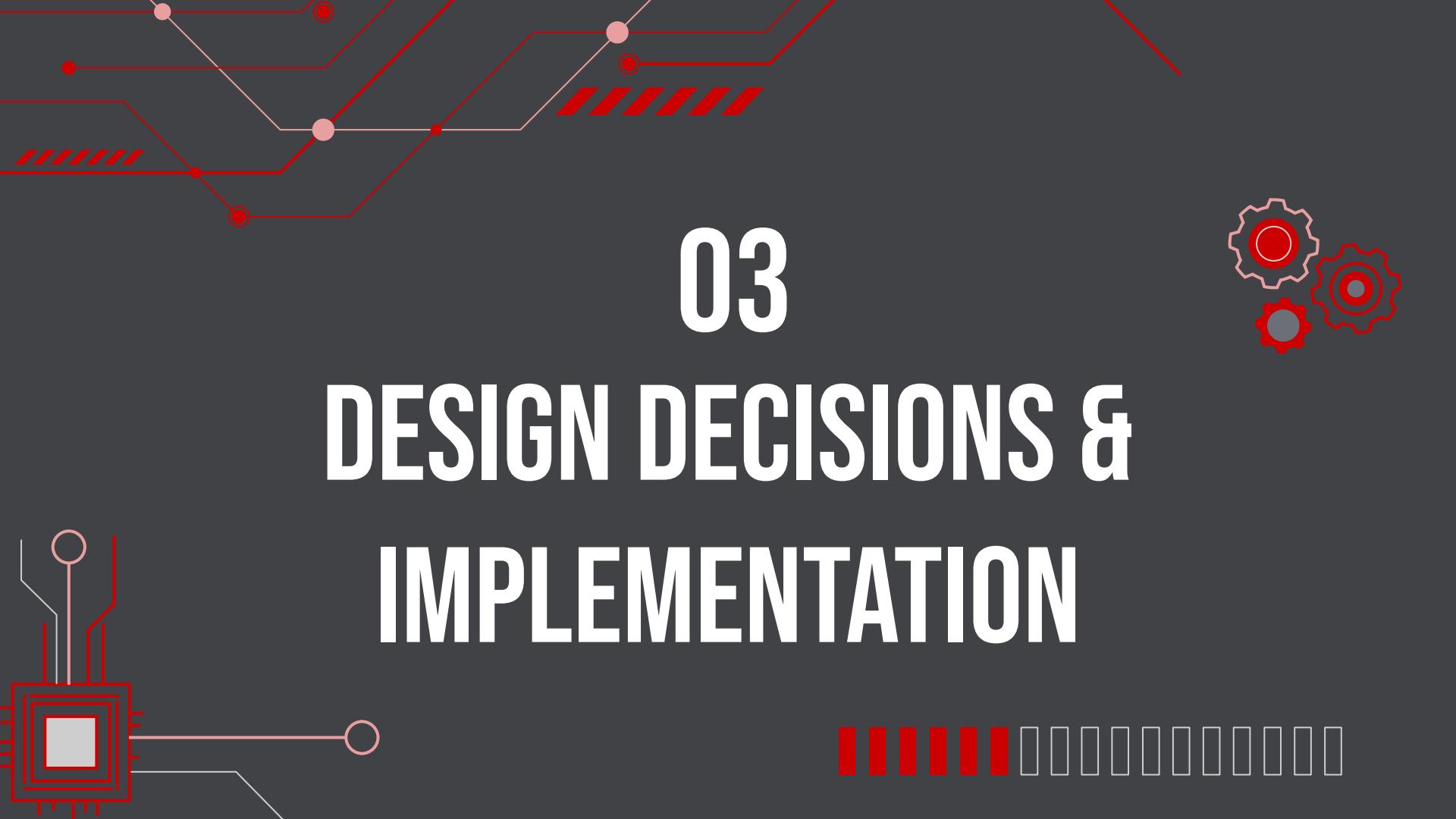


# SOFTWARE BLOCK DIAGRAM



# POWER BLOCK DIAGRAM

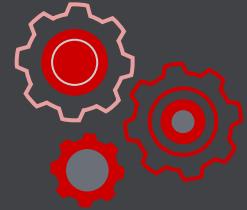




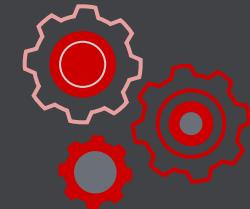
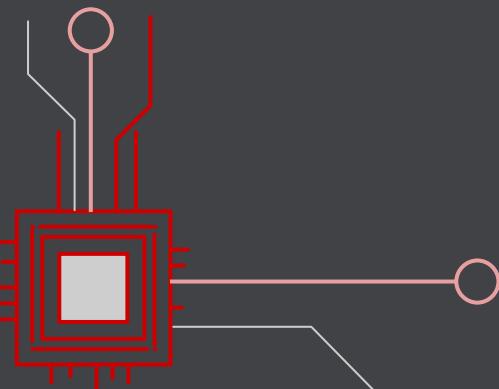
# 03

# DESIGN DECISIONS &

# IMPLEMENTATION



# HARDWARE



# SBC ANALYSIS

## PROCESSING POWER

Single Board Computer	CPU Clock Frequency (MHz)	GPU Clock Frequency (MHz)
Arduino Nano 33 BLE Sense	64 MHz	N/A
Asus Tinker Board S	1800 MHz	600 MHz
NVIDIA Jetson Nano	1430 MHz	640 MHz
Raspberry Pi 4 Model B	1500 MHz	N/A

## ENERGY CONSUMPTION

Single Board Computer	Operating Voltage (V)	DC Current Min - Max (mA)	Power Consumption Min - Max (mW)
Arduino Nano 33 BLE Sense	3.3V	15 - 330 mA	49.5 - 1089 mW
Asus Tinker Board S	5 V	500 - 1000 mA	2500 - 5000 mW
NVIDIA Jetson Nano	5 V	1000 - 2000 mA	5000 - 10000 mW
Raspberry Pi 4 Model B	5 V	540 - 1280 mA	2700 - 6400 mW

## MEMORY SIZE

Single Board Computer	Memory (GB)
Arduino Nano 33 BLE Sense	0.001 GB FLASH   0.000256 GB SRAM
Asus Tinker Board S	2GB Dual Channel DDR3
NVIDIA Jetson Nano	2 GB LPDDR4
Raspberry Pi 4 Model B	2 GB LPDDR4

## COST ANALYSIS

Single Board Computer	Board Price (\$)	Percentage of System Cost (%)
Arduino Nano 33 BLE Sense	\$22.50	4.5%
Asus Tinker Board S	\$199.99	40%
NVIDIA Jetson Nano	\$62.84	12.6%
Raspberry Pi 4 Model B	\$83.95	16.9%



# SINGLE-BOARD COMPUTER (SBC)

## FEATURES

Powerful GPU in a compact form factor

## OVERALL VALUE

Great Value Proposition



## WEALTH OF KNOWLEDGE

Extensive Developer Community and Resources

## COSTS

Cheaper than comparable alternatives

# JETSON NANO

# SPECIFICATIONS

	ATmega2560	MSP430BT5190	MSP430FR698x	MSP430F249
<b>Architecture</b>	8-bit RISC	16-bit RISC	16-bit RISC	16-bit RISC
<b>Clock Speed</b>	16 MHz	25 MHz	16 MHz	16 MHz
<b>Voltage Range</b>	2.7V – 5.5V	1.8V – 3.6V	1.8V – 3.6V	1.8V – 3.6V
<b>Active Power Mode</b>	500 µA	230 µA/MHz	100 µA/MHz	270 µA/MHz
<b>Standby Power Mode</b>	11.85 mA	1.2 µA	0.4 µA	0.3 µA
<b>Wake Time from Sleep/LP Mode</b>	Unknown	< 5 µs	6 µs	< 1 µs
<b>Non-Volatile Memory (kB)</b>	256	256	128	60
<b>RAM (kB)</b>	8	16	2	2
<b>UART</b>	4	0	2	2
<b>I2C</b>	1	4	2	2
<b>SPI</b>	1	4	4	2
<b>Bluetooth Version</b>	N/A	2.1	N/A	N/A

# PROJECT CONTROLLER ANALYSIS

Part	Communication Scheme
Accelerometer	I2C
SD Card	SPI*
Bluetooth	UART, I2C, or SPI*
GPS (Stretch Goal)	UART
Single Board Computer	SPI

\* - can use the same pin for both connected in an SPI daisy-chain configuration



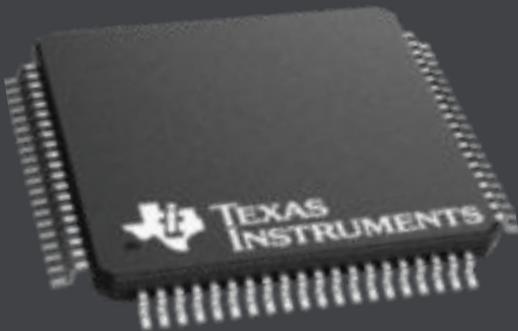
# METHOD OF COMMUNICATION

# PROJECT CONTROLLER

## TI MSP430FR6989

### CONVENIENCE

Familiar and  
Previously  
Acquired



### CAPABLE

Enough channels  
to run all  
communications

# ACCELEROMETER

## MEMSIC MXC4005XC-B

### IMPACT SURVIVAL

Maximum  
Acceleration  
200,000g

### TINY FOOTPRINT

6 solder pads  
0.25mm wide each  
underneath chip

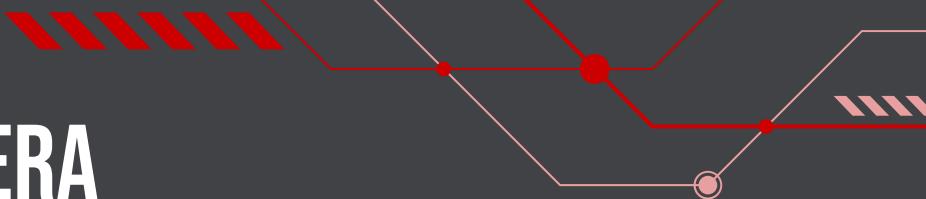


### INTERRUPTS

Shake Detection

### SOLUTION

Breakout board  
will plug directly  
into PCB



# CAMERA

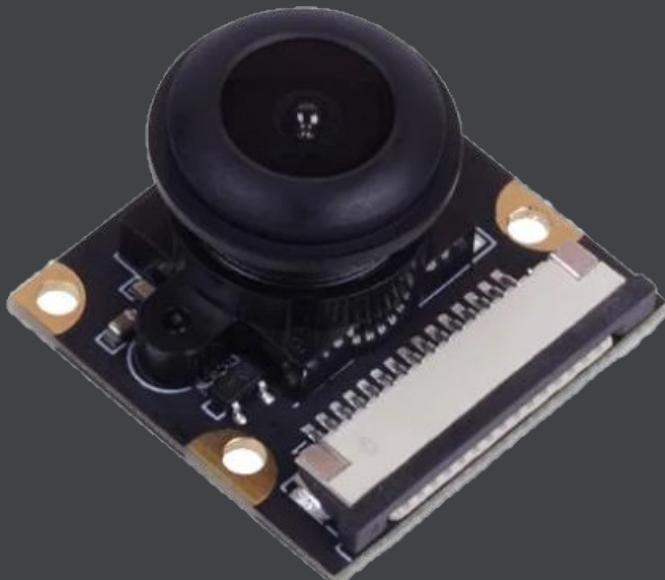
## SEEED STUDIO 114992262

### 8 MEGAPIXELS

Exceeds 1080p  
Requirements

### 130° FIELD OF VIEW

Allows for little  
distortion



### MADE FOR US

Designed  
specifically to  
interface with  
Jetson

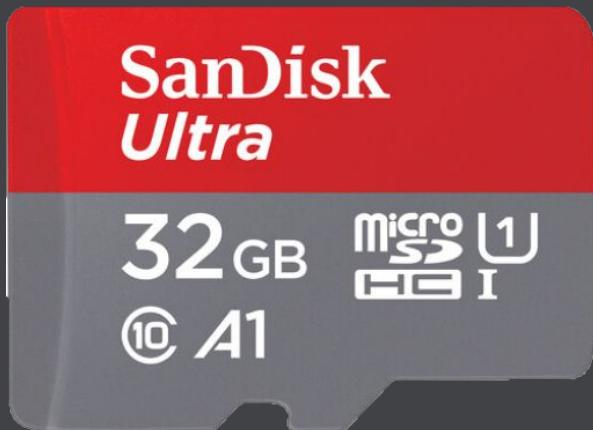
# STORAGE UNIT

## MORE PERMANENT

Less risk of data loss than BT

## PORTABILITY

Can be removed and read in any device that can access uSD Card



## MICRO SD CARD

## RELIABLE

Shown to consistently store .txt files

## EASILY ACCESSIBLE

Large variety of uSD Card compatible with FatFs Library

# BLUETOOTH

## RAYTAC MDBT42Q-P192

### AVAILABILITY

Readily available on  
many online  
retailers

### USER SUPPORT

Plenty of examples  
to work with



### BLUETOOTH 5.0

Fits our Bluetooth  
5.0 requirement

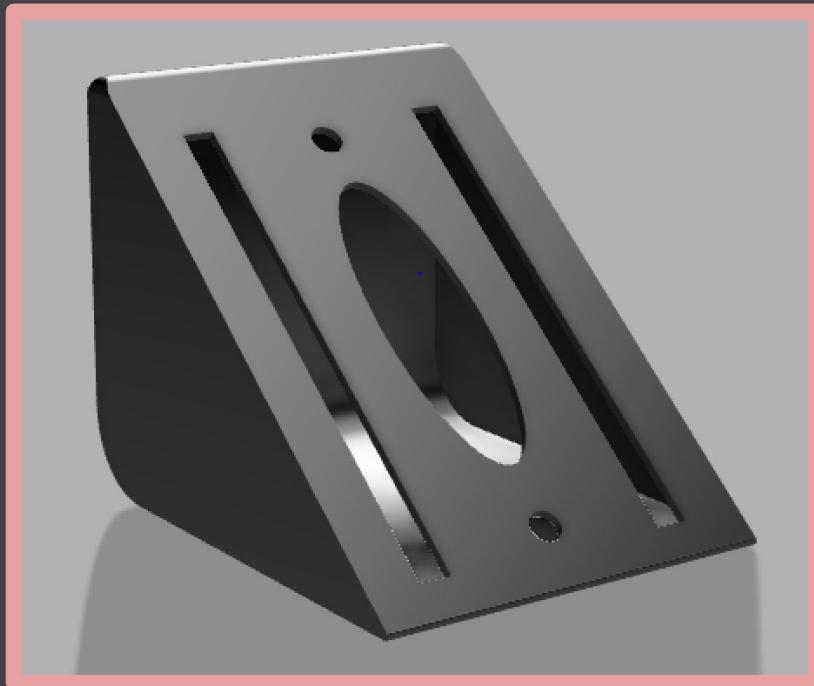
### EASILY PROGRAMMABLE

J-Link via Nordic  
Dev Kit

# ENCLOSURE

**3D PRINTED**  
ABS Filament for  
added strength

**ACETONE VAPOR  
POLISHING**  
Added strength and  
temperature tolerance



**PCB SLIDE  
SHELVING**  
PCB will slide and lock  
into place

**HIGH GRADE  
SUCTION CUPS**  
Affixed to Windshield

# BATTERY

## MAKERFOCUS 9065115

### LITHIUM POLYMER

Low Self-Discharge  
Resilient to High  
Temperatures

### PROTECTION CIRCUIT MODULE

Thermal Protection  
Overcurrent Protection  
Short-Circuit Protection



### HIGH CAPACITY

10,000 mAh  
74 Wh = 5.6 Hrs of  
CSS operation

### STANDARD ADHERENCE

IEEE 1725-2021  
IEC/UL 62133

# 5 VOLT REGULATOR

## TEXAS INSTRUMENTS LM3150

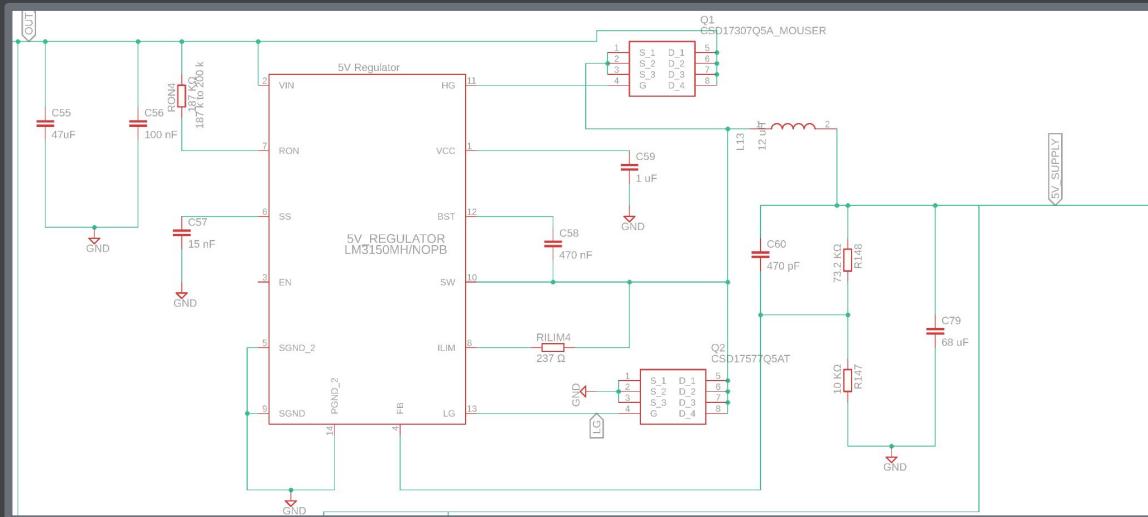
### HIGH EFFICIENCY

96.3%

Drives high efficiency external MOSFETs

### OVERCURRENT PROTECTION

Feedback network monitors current



### LOW COST

Only 61% cost of comparably efficient topologies

### ADDITIONAL PROTECTION

Short Circuit  
Soft Start  
Thermal

# 3.3 VOLT REGULATOR

## TEXAS INSTRUMENTS TLV62568

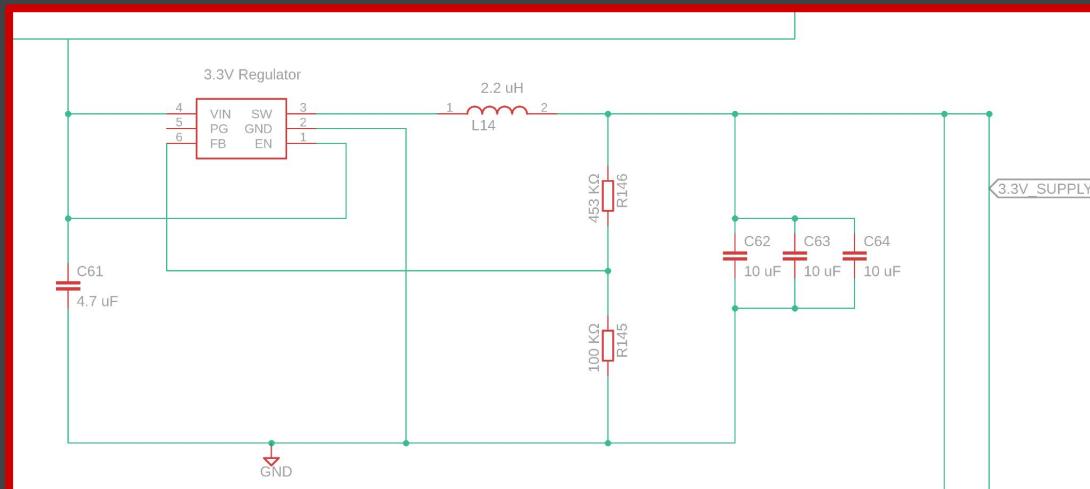
### HIGH EFFICIENCY

96.26 %

With Minimal  
PCB Area and Cost

### OVERCURRENT PROTECTION

Integral current  
detection with auto  
shut-off and restart



### SOFT START

Limits dV/dT to  
protect sensitive  
downstream  
devices

### DYNAMIC FREQUENCY

Provides additional  
efficiency under  
low load

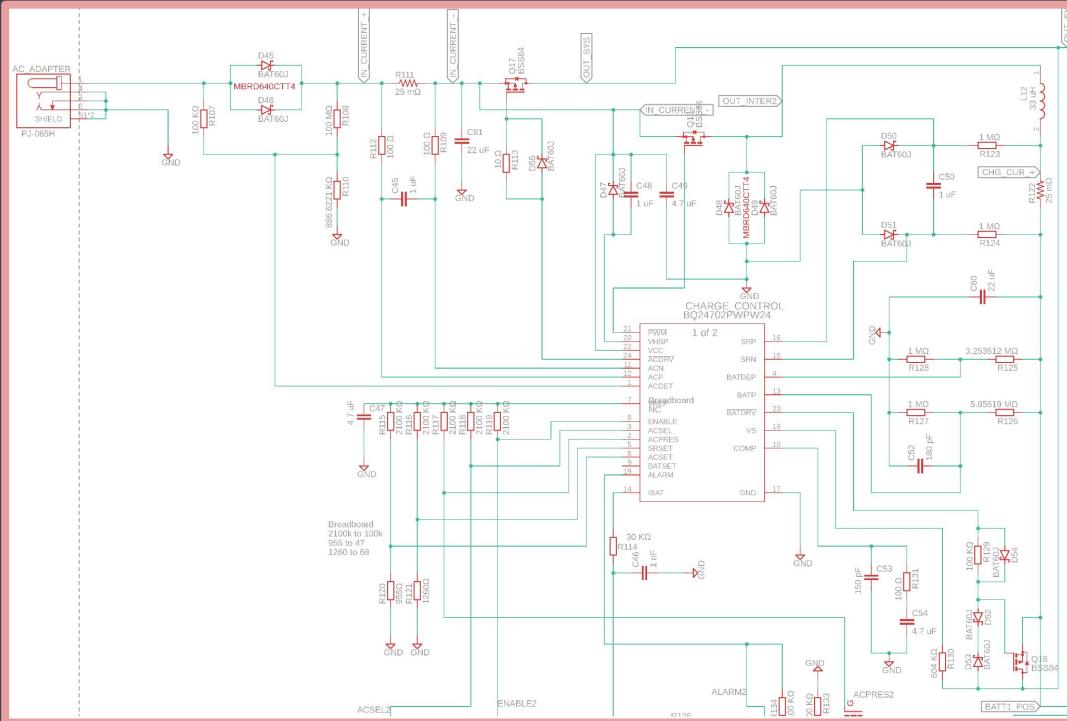
# CHARGE CONTROLLER

# HIGH EFFICIENCY

Low quiescent power consumption when on battery power

# CONCURRENT LOAD/CHARGE

Provides system power from AC while simultaneously charging the batteries



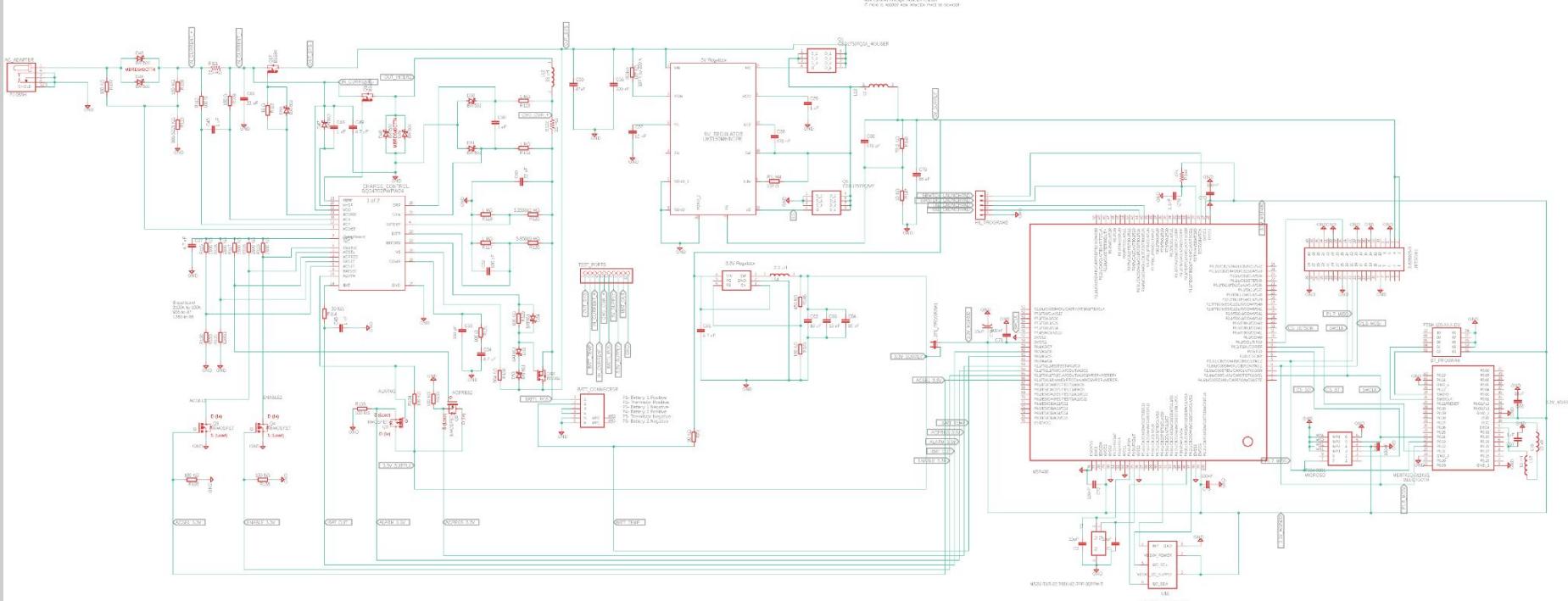
# DYNAMIC SOURCE SWITCHING

Seamlessly changes from AC supply to battery supply without interruption

**PROTECTION**  
Overcurrent  
Undervoltage  
Thermal  
Short Circuit

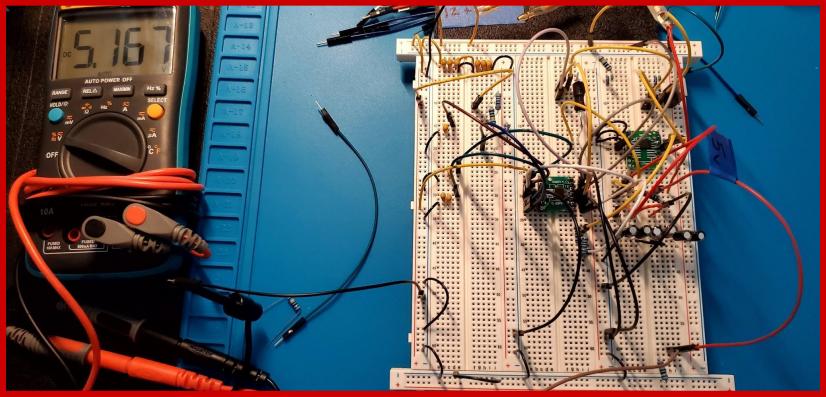
# TEXAS INSTRUMENTS BQ24702

# INTEGRATED SCHEMATIC

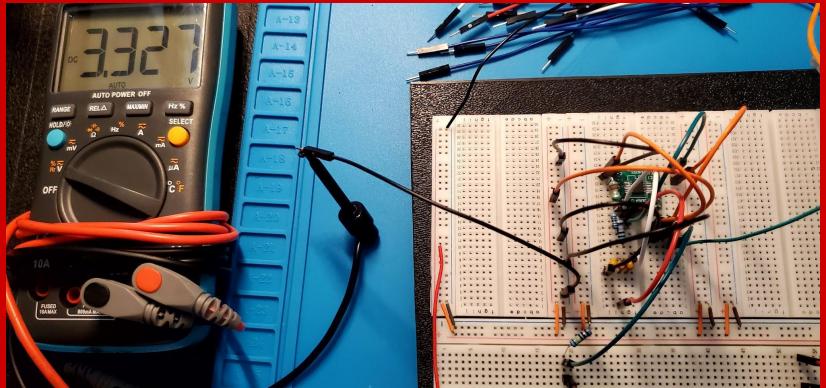


# PCB PROTOTYPING

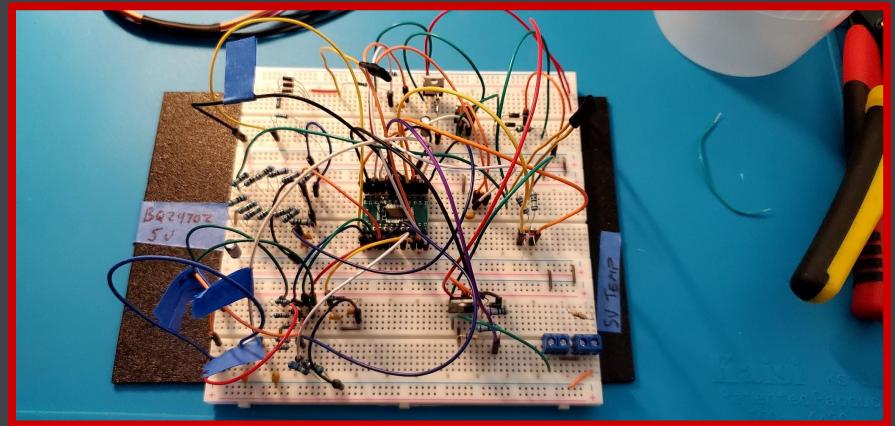
5 VOLT RAIL



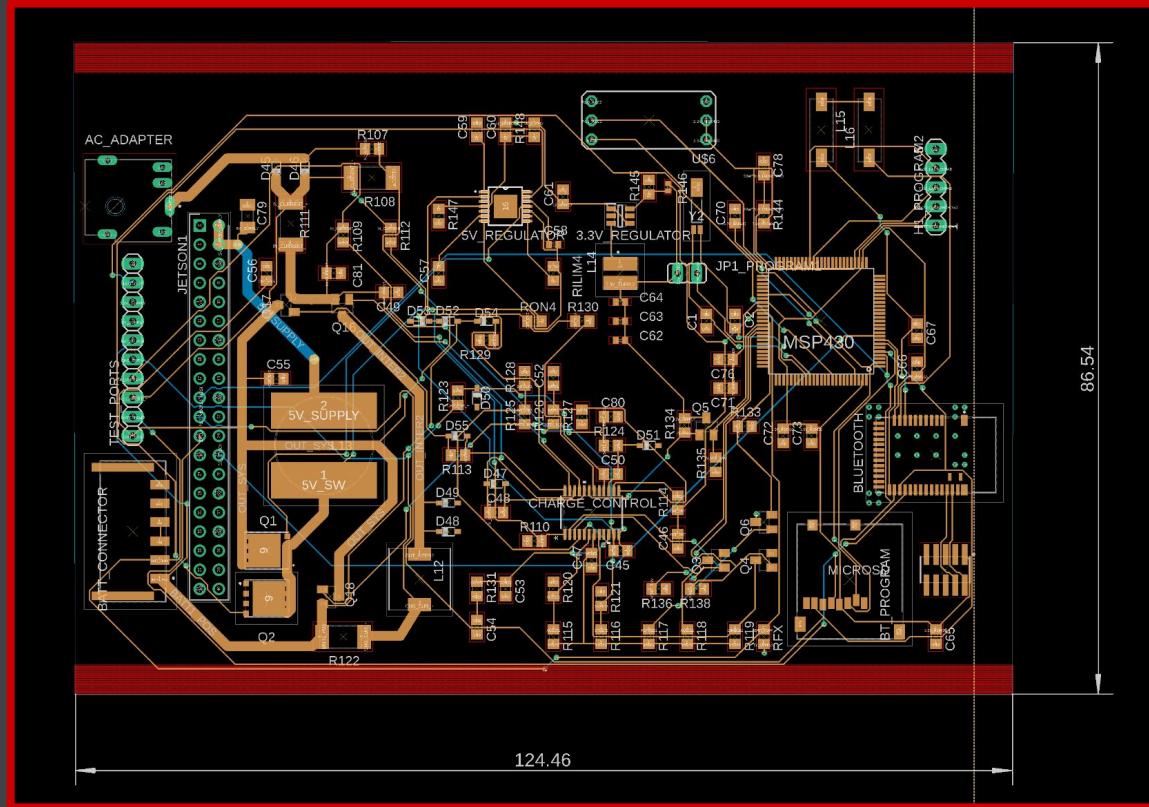
3.3 VOLT RAIL



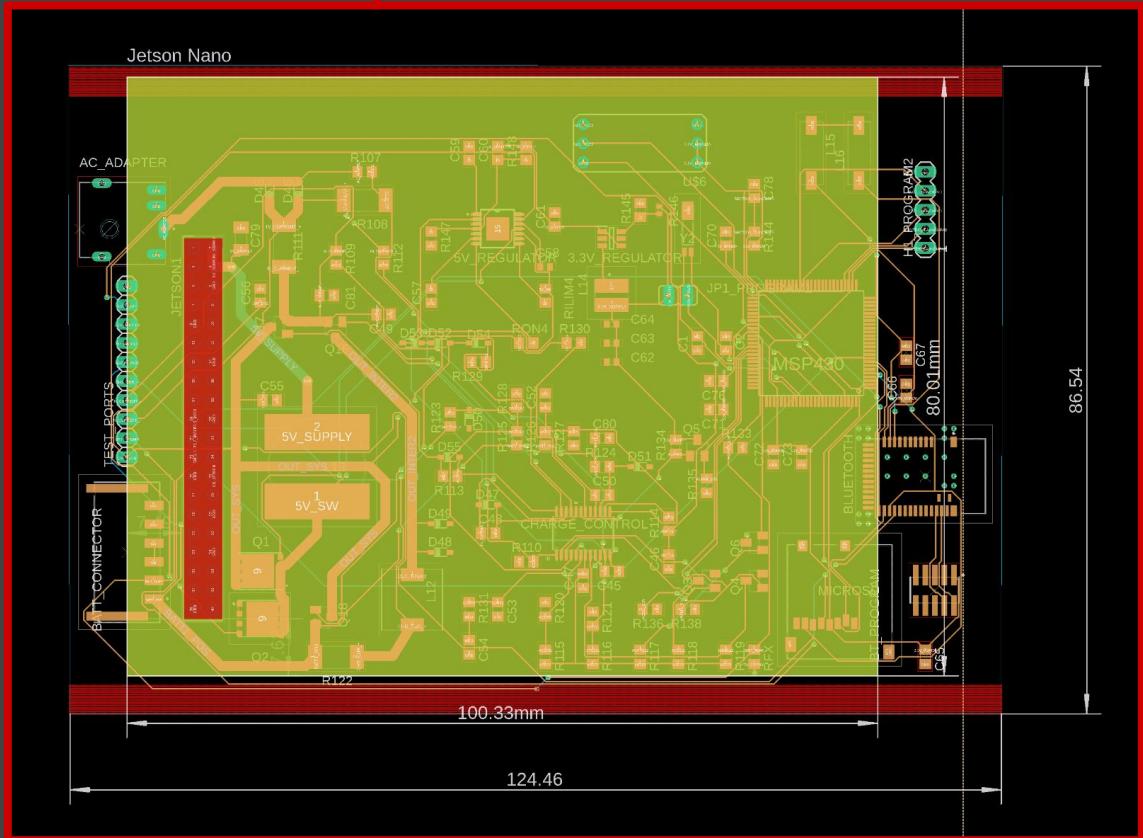
CHARGE CONTROLLER



# PCB LAYOUT

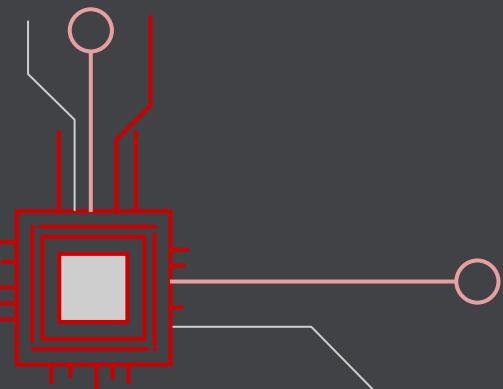
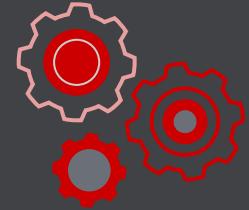


# PCB LAYOUT WITH NVIDIA JETSON NANO

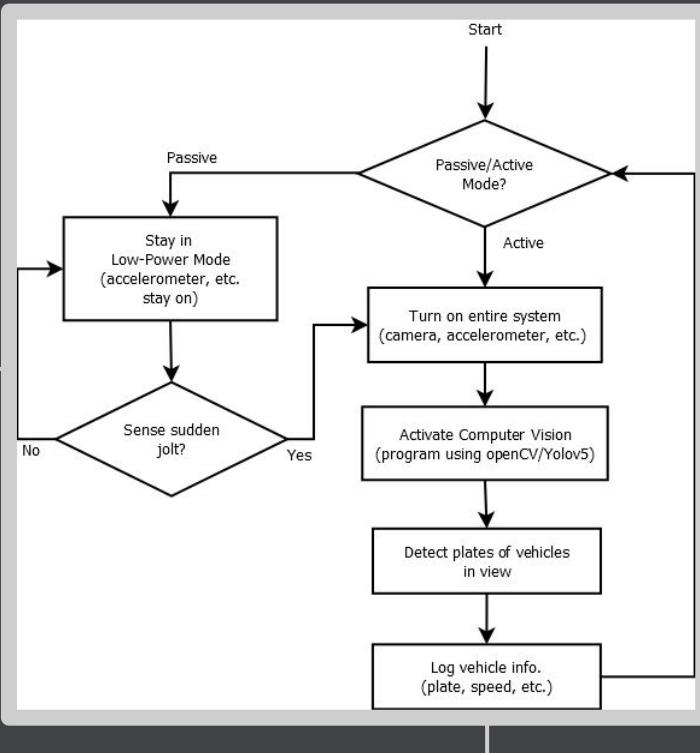


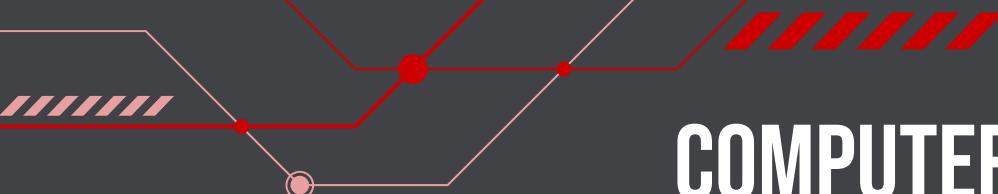


# SOFTWARE/FIRMWARE



# SINGLE BOARD COMPUTER SOFTWARE FLOW





# COMPUTER VISION

## OPENALPR

Easy to get up and running

Used for testing purposes

## OPENCV

Powerful pretrained algorithms

## OPTICAL CHARACTER RECOGNITION (OCR)

To recognize characters

## OBJECT DETECTION

Identify and isolate license plate area

## TENSORRT

Used for training  
Optimized for Nvidia GPUs

## EDGE DETECTION

To isolate characters

# GRAPHICAL USER INTERFACE & FEATURES



Users are able to create their own accounts and access License Plate data.

**Stretch Goal:** Optional attributes can be stored, such as color, make, and model.

# MOBILE APPLICATION DEVELOPMENT

- Progressive Web Application (PWA)
- FERN Stack

# FERN STACK

**FIREBASE**  
Robust and  
scalable database  
system



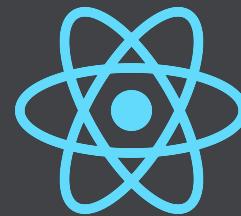
## EXPRESS

Framework for  
APIs

Tried and true technology stack.  
Facilitates faster development



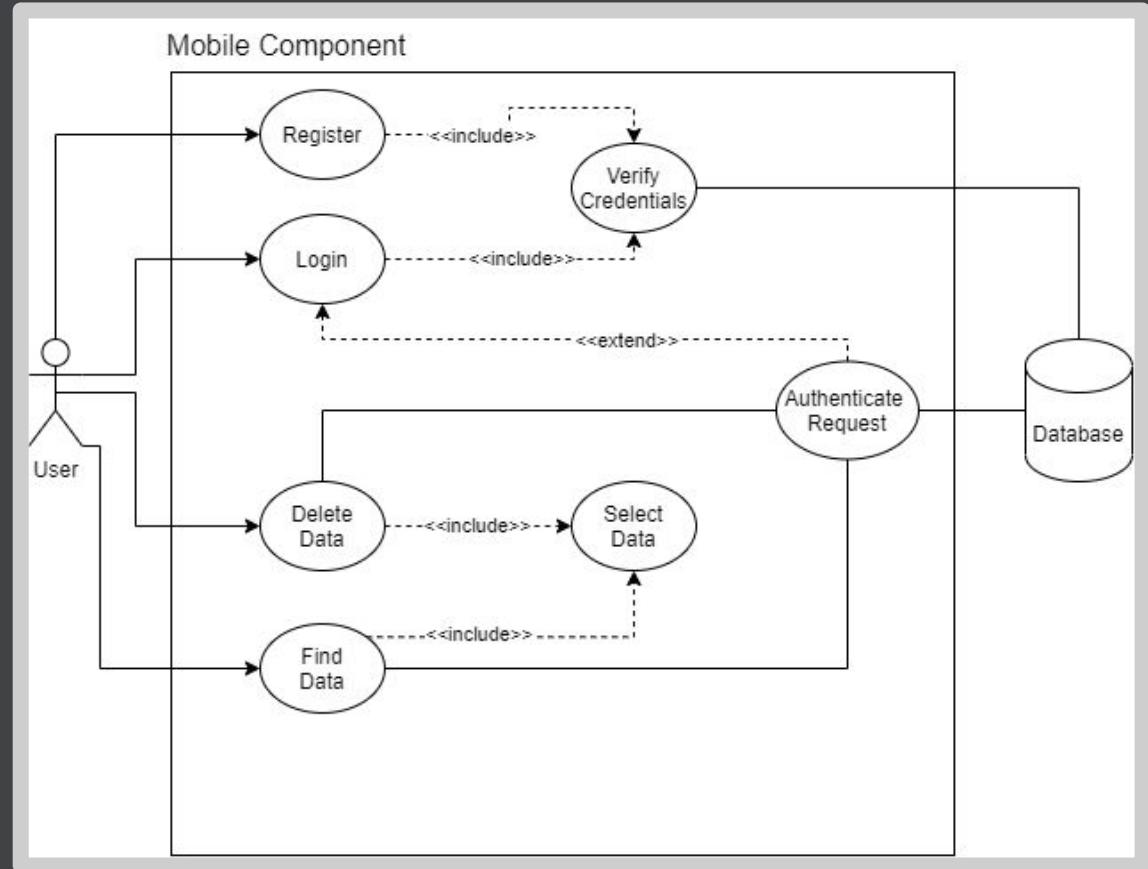
**REACT**  
Team members have  
experience with  
REACT frontend dev.



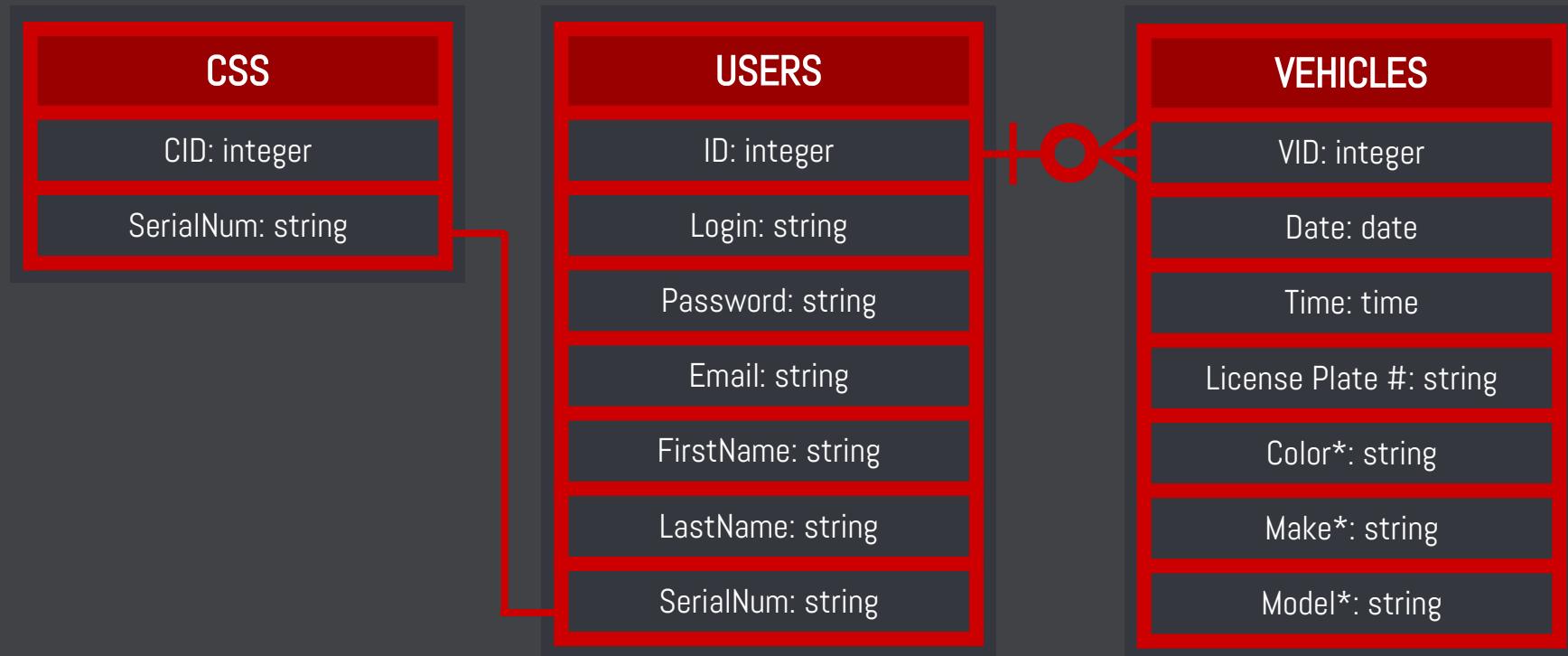
## NODE.JS

Backend  
environment

# MOBILE APPLICATION USE CASE DIAGRAM

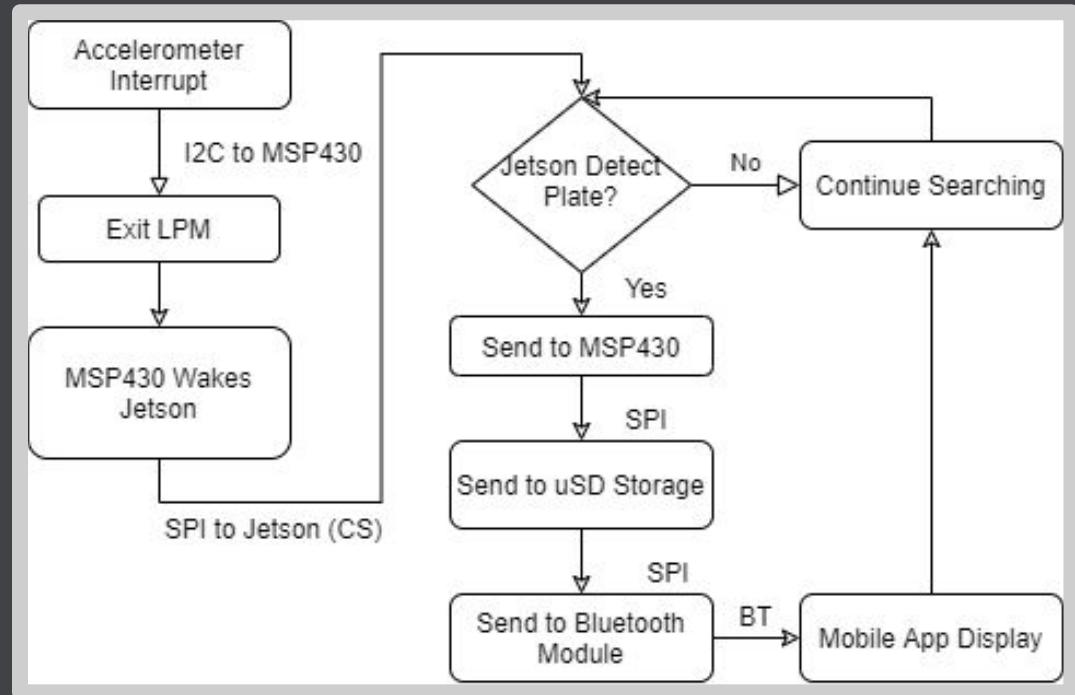


# ENTITY RELATIONSHIP DIAGRAM

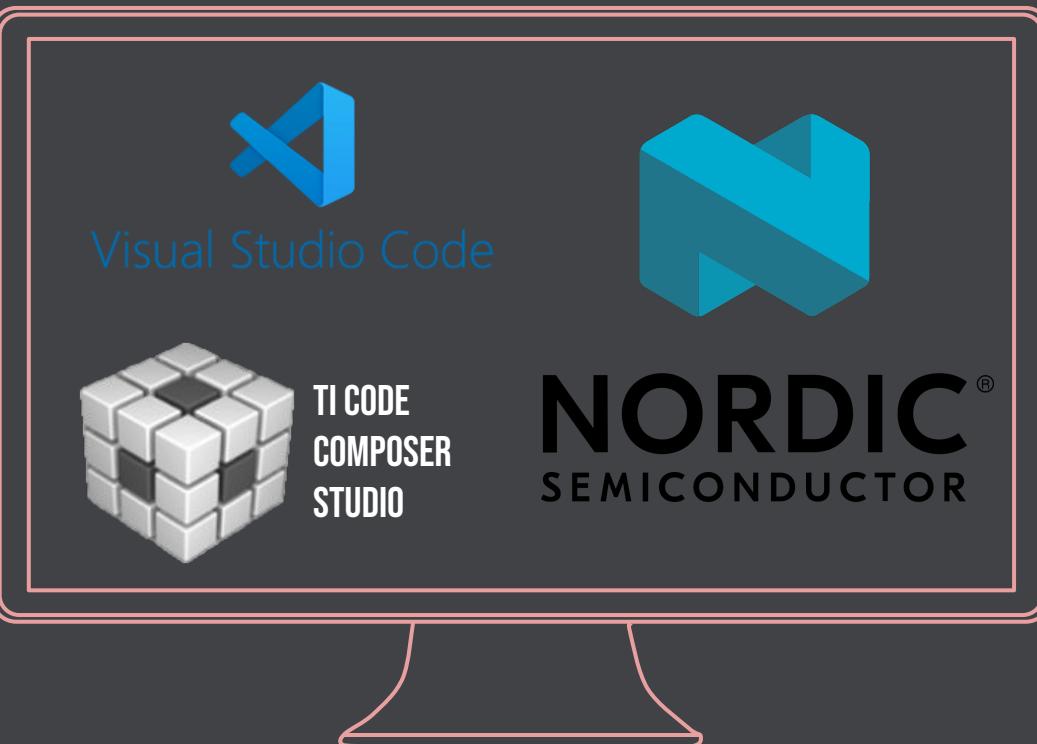


\* Stretch Goal

# FIRMWARE DATAFLOW



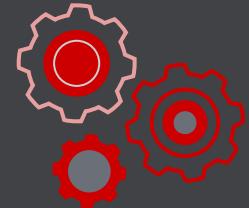
# FIRMWARE DEVELOPMENT

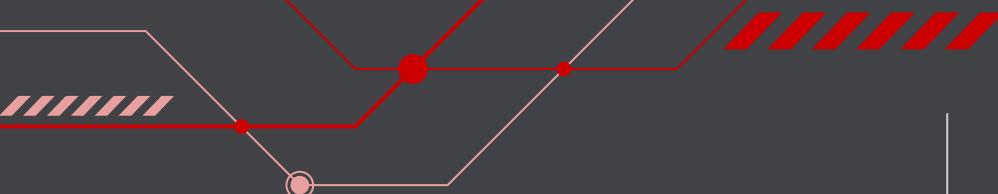




04

# EXPERIENCE





# SUCCESSES

- Getting the Nano to read a license plate
- MSP430FR6989 writing .txt files to uSD card on breadboard
- Raytac BT module programmable
- Breadboarding sensitive switching circuits

# CHALLENGES

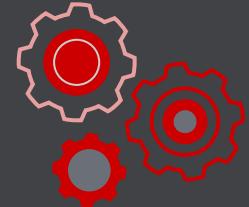
- Tackling CV/ML
- Data transmission across all components
- Specced some parts too small to solder by hand
- Nordic Software Bugs



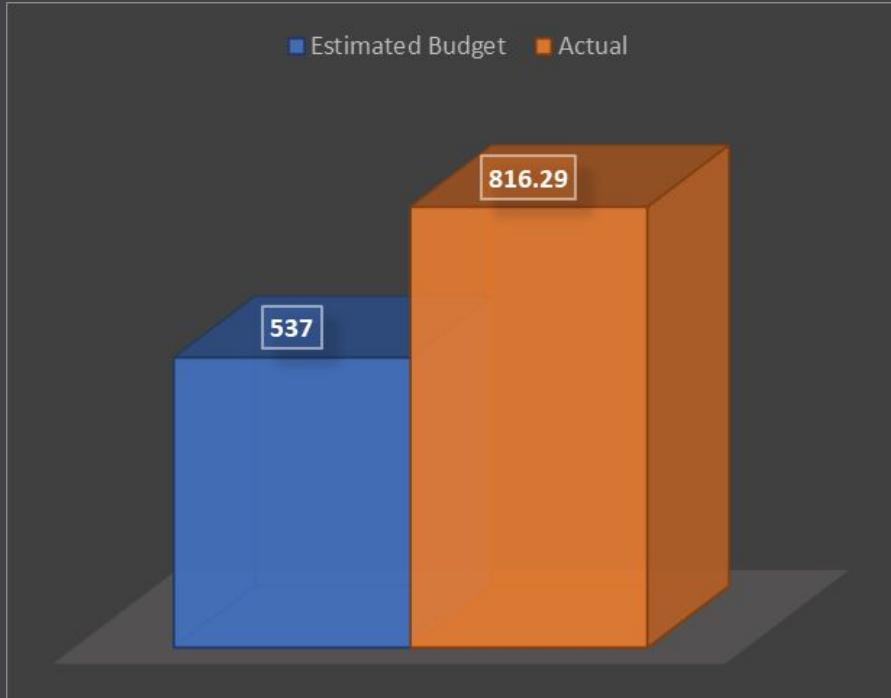


05

# ADMINISTRATION



# BUDGET & FINANCING



BOUGHT TWO JETSON NANO DEV.  
KITS FOR TESTING

MISC COMPONENTS WERE  
ANOTHER MAJOR EXPENSE

PCB ORDER APPROX. \$130



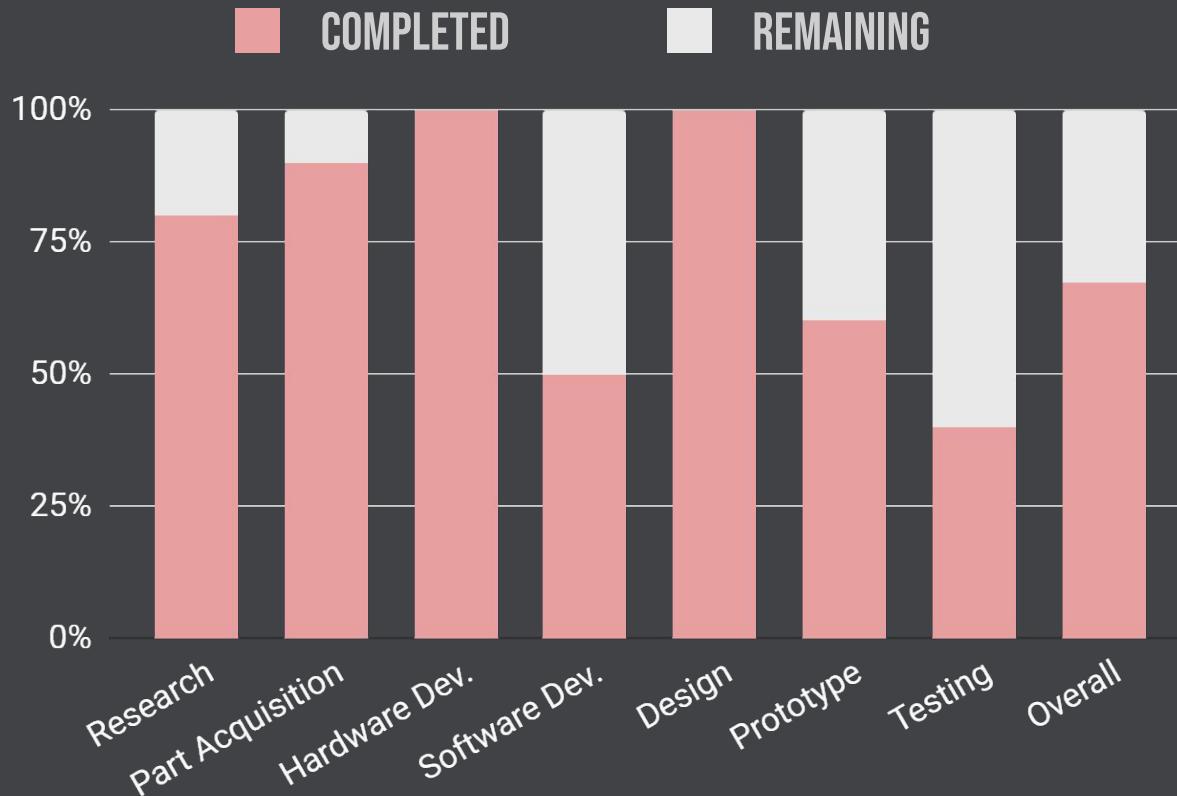
# COST OF COMPONENTS

Item	Price	Quantity	Shipping Cost	FL Tax	Total
MSP430FR6989	\$10.10	2	-	1.07	\$29.50
NVIDIA Jetson Nano	\$59.00	1	-	1.065	\$62.84
5V 4A Power Supply	\$12.59	2	-	1.065	\$26.82
2.5 to 2.1mm Adapter	\$8.96	2	-	1.065	\$19.08
4GB NVIDIA Jetson Nano	\$169.95	1	-	1.065	\$181.00
GY-521 MPU-6050 MPU6050 Module 3 Axis analog gyro sensors	\$2.64	1	-	1.00	\$2.64
WAVGAT Micro SD Storage Expansion Board	\$1.83	1	-	1.00	\$1.83
Accelerometer & uSD expansion	\$3.25	1	-	1.00	\$3.25
10000mAh LiPo Batteries	\$12.00	2	-	1.00	\$24.00
Cooling Unit	\$24.38	2	\$1.50	1.00	\$50.26
uSD Module	\$0.20	1	\$1.80	1.00	\$2.00
GPS Module	\$2.60	1	\$1.65	1.00	\$4.25
Camera Module	\$19.90	1	-	1.07	\$21.29
Accelerometers	\$1.49	2	-	1.07	\$3.19
Mouse Shipping	\$7.99	1	-	1.00	\$7.99
10000mAh LiPo Battery	\$13.82	2	\$0.99	1.07	\$30.56
BL651/BL652 Breakout PCB	\$8.00	2	\$9.98	1.065	\$27.02

# WORK DISTRIBUTION

	ROLES	RESPONSIBILITY
QRIZELLE C.	Lead Mobile Developer	Computer Vision and Mobile Application
RICARDO N.	Lead Computer Vision Developer	Computer Vision and Mobile Application
ARI P.	Lead Firmware Developer	Hardware (PCB) and Firmware Development
ROBERT Z.	Lead Power Systems Engineer	Hardware (PCB) and Schematic Integration

# PROGRESS



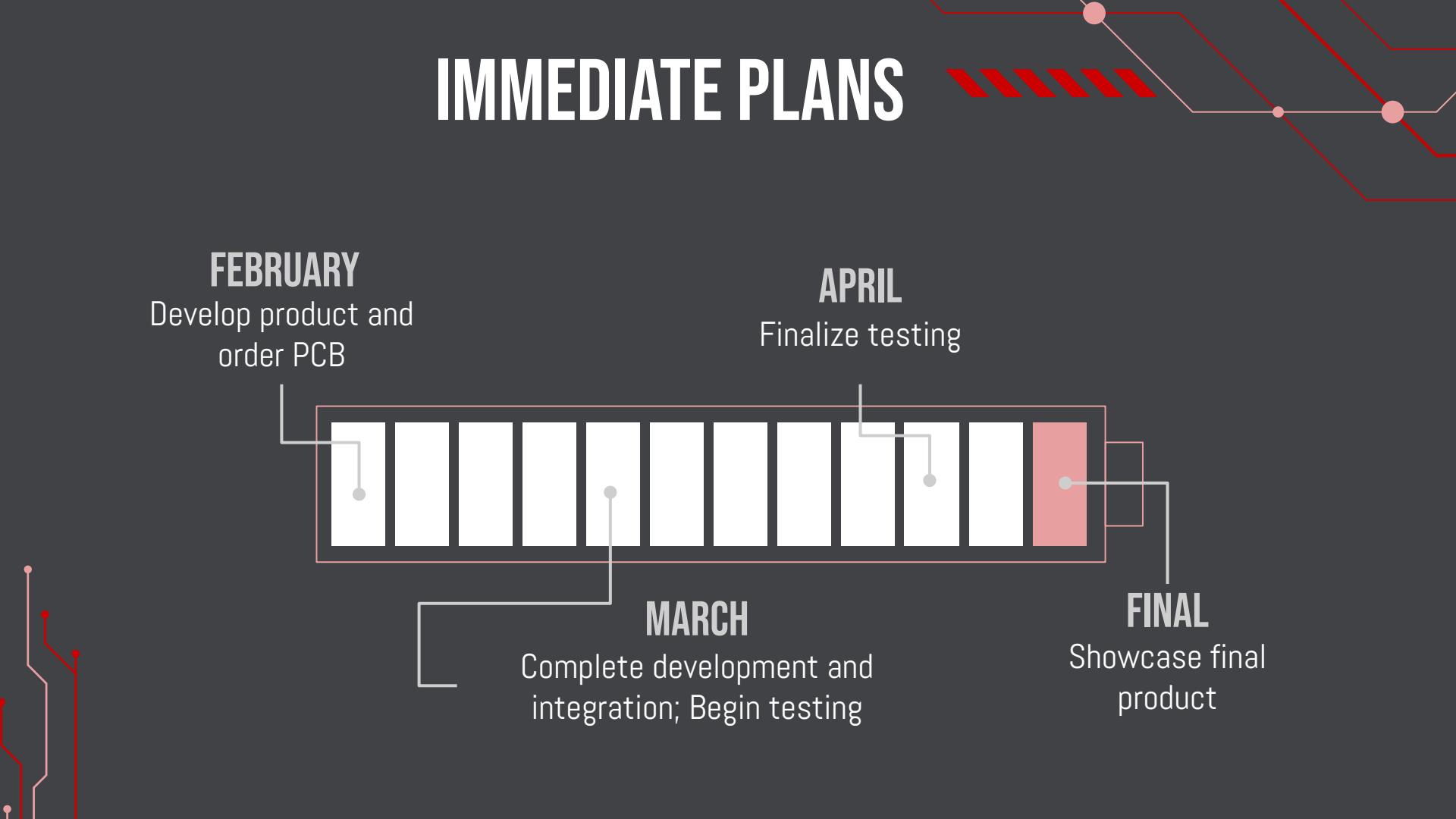
# IMMEDIATE PLANS

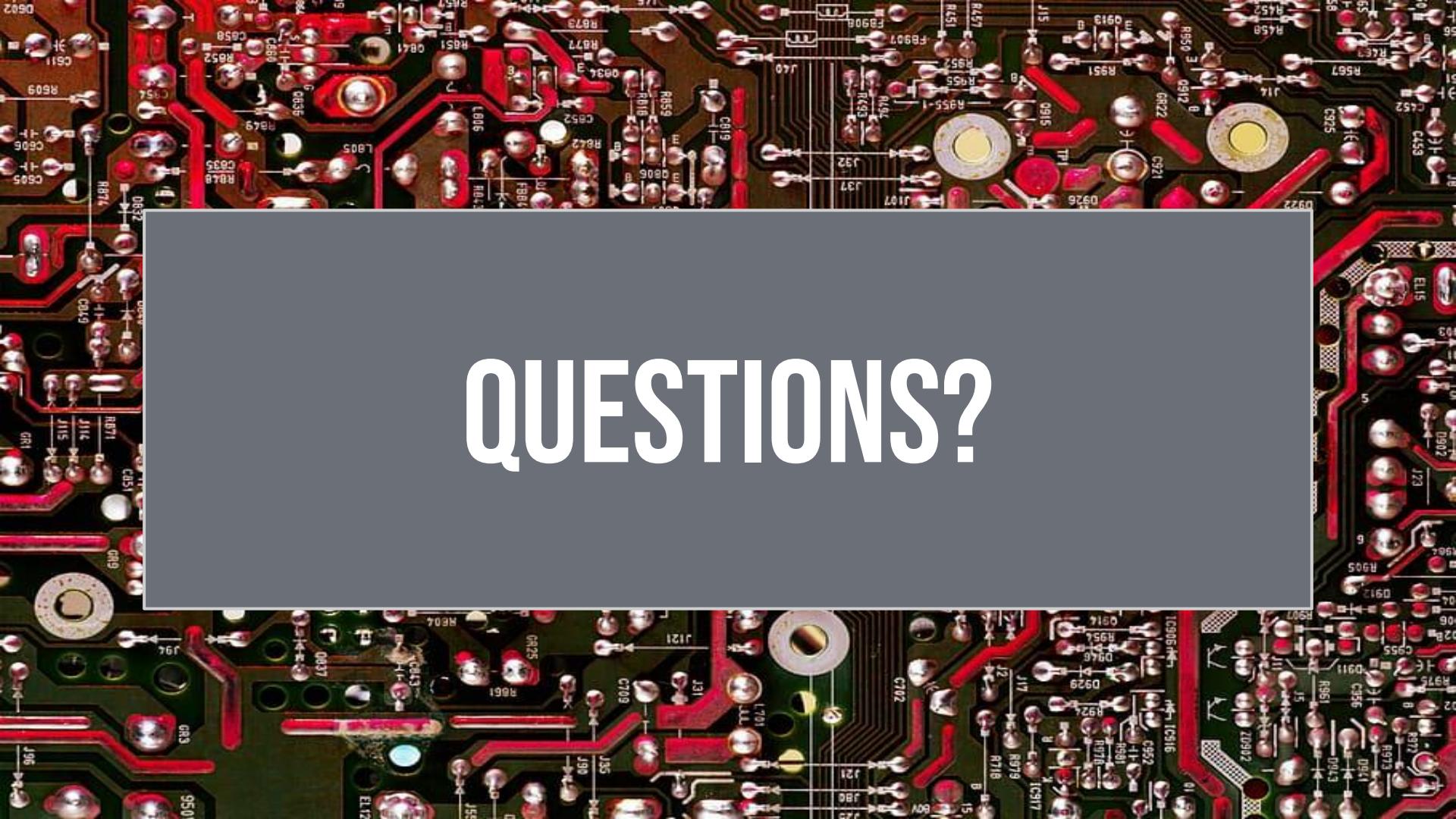
**FEBRUARY**  
Develop product and  
order PCB

**APRIL**  
Finalize testing

**MARCH**  
Complete development and  
integration; Begin testing

**FINAL**  
Showcase final  
product





# QUESTIONS?