

# VEHICLE IMMOBILIZING DEVICE

**CLIENT & TECHNICAL ADVISOR:**

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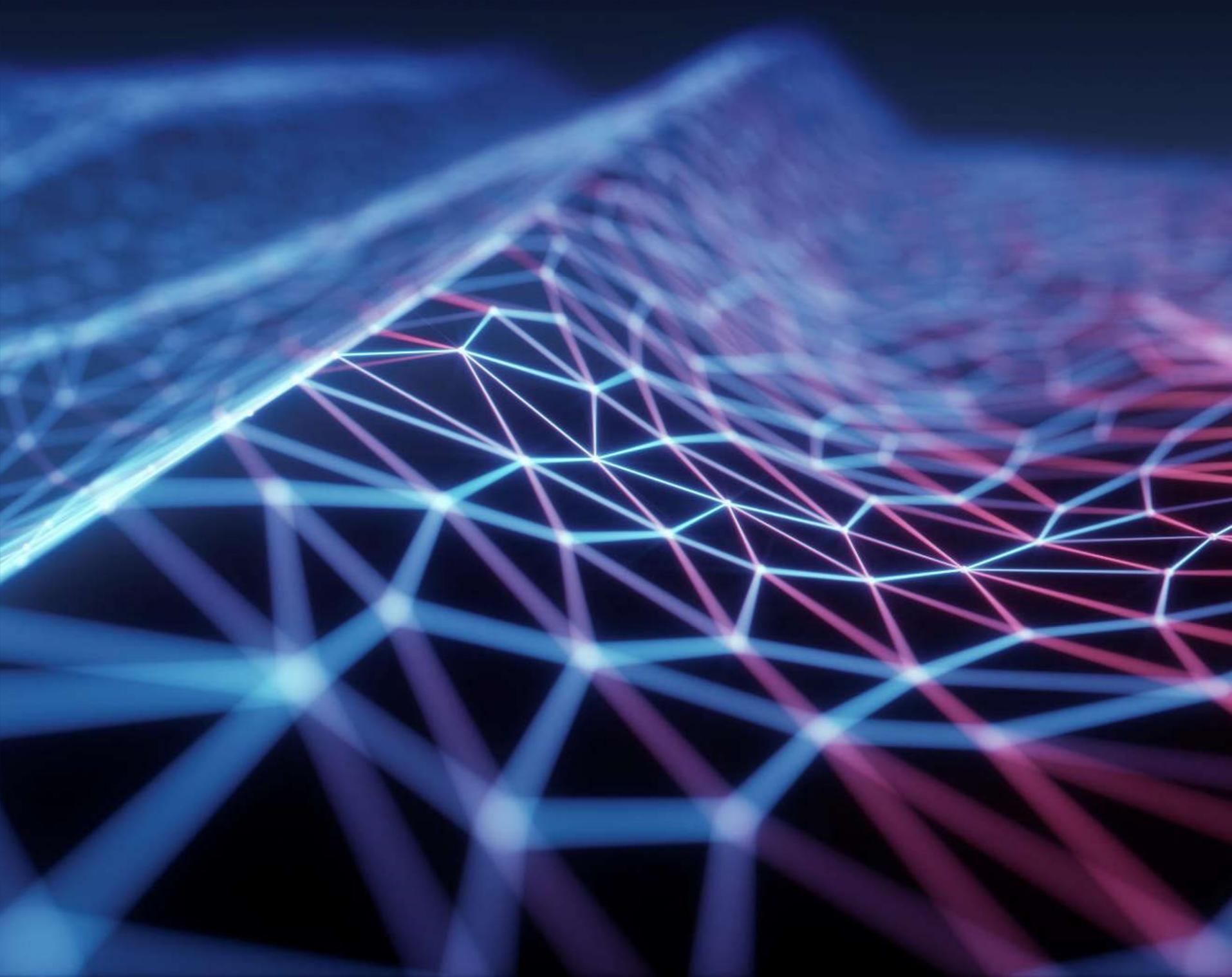
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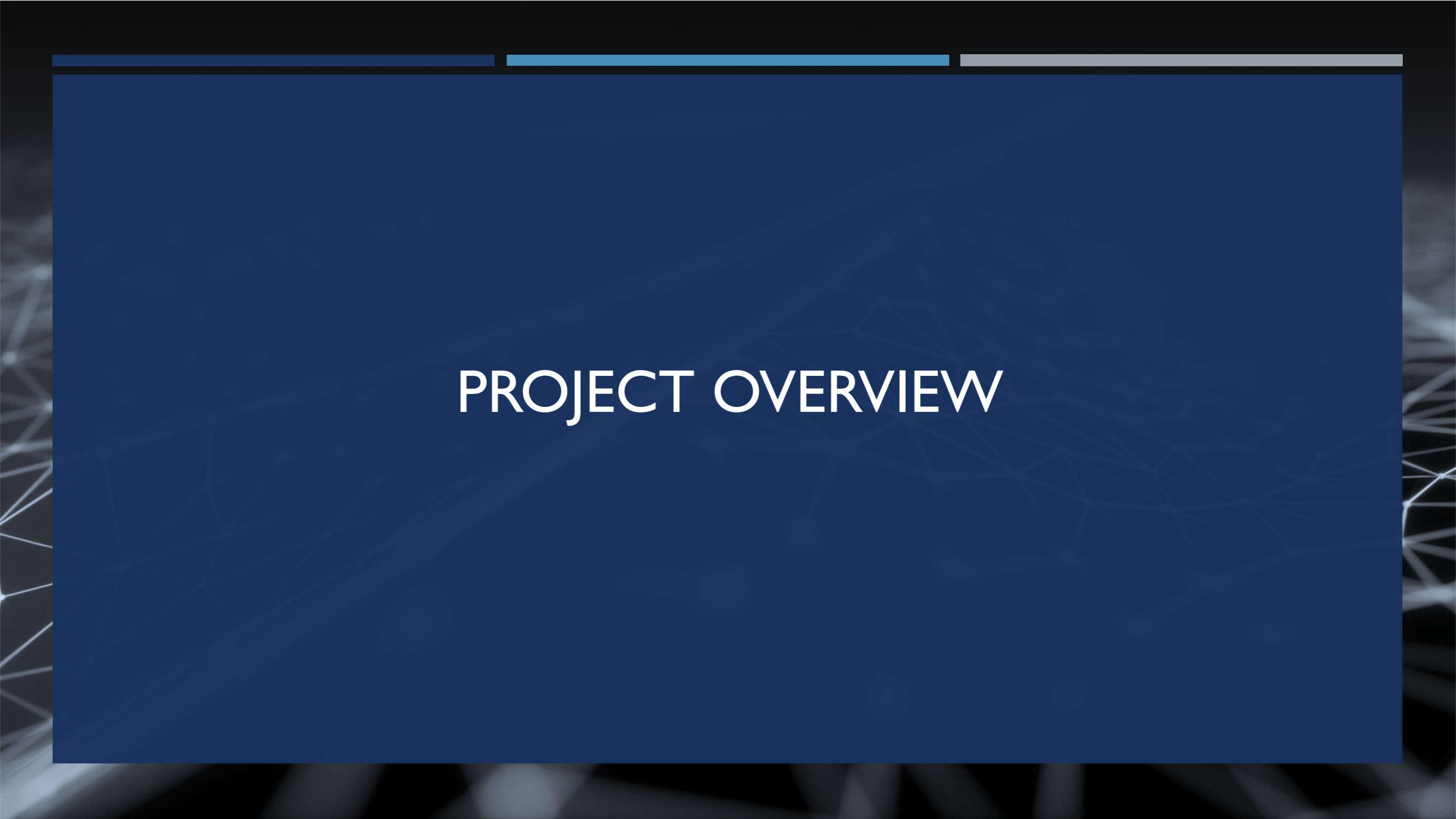


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# PROJECT OVERVIEW



## PROJECT OVERVIEW – BACKGROUND

- In 2015, over 140,000 accidents each causing over \$2000 in damage were reported within Alberta
- Vehicles leaving the scene makes resolution difficult leading to complicated insurance claims
- Initial target end-user: vehicle fleet management companies

## PROJECT OVERVIEW – GOAL



# PROJECT OVERVIEW – GOAL



## Other Goals:

- Tamper-proof
- Secure
- Reliable
- Long-lasting



## BACKGROUND INFORMATION

# BACKGROUND INFORMATION

## How Modern Cars Work: An overview

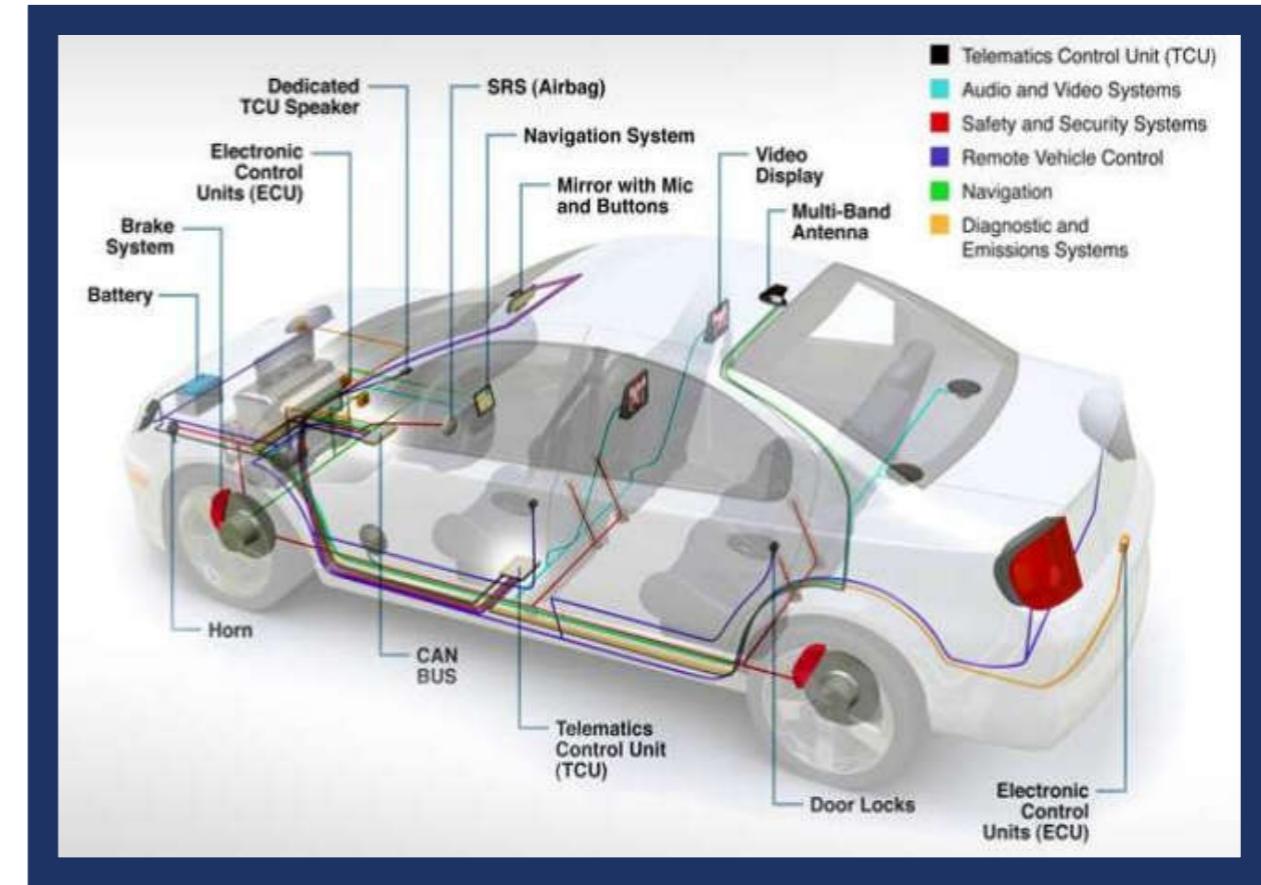


- “Computers with Wheels”
- Electrically controlled, mechanically actuated

# BACKGROUND INFORMATION

## How Modern Cars Work:

Typical ECUs found  
within a car

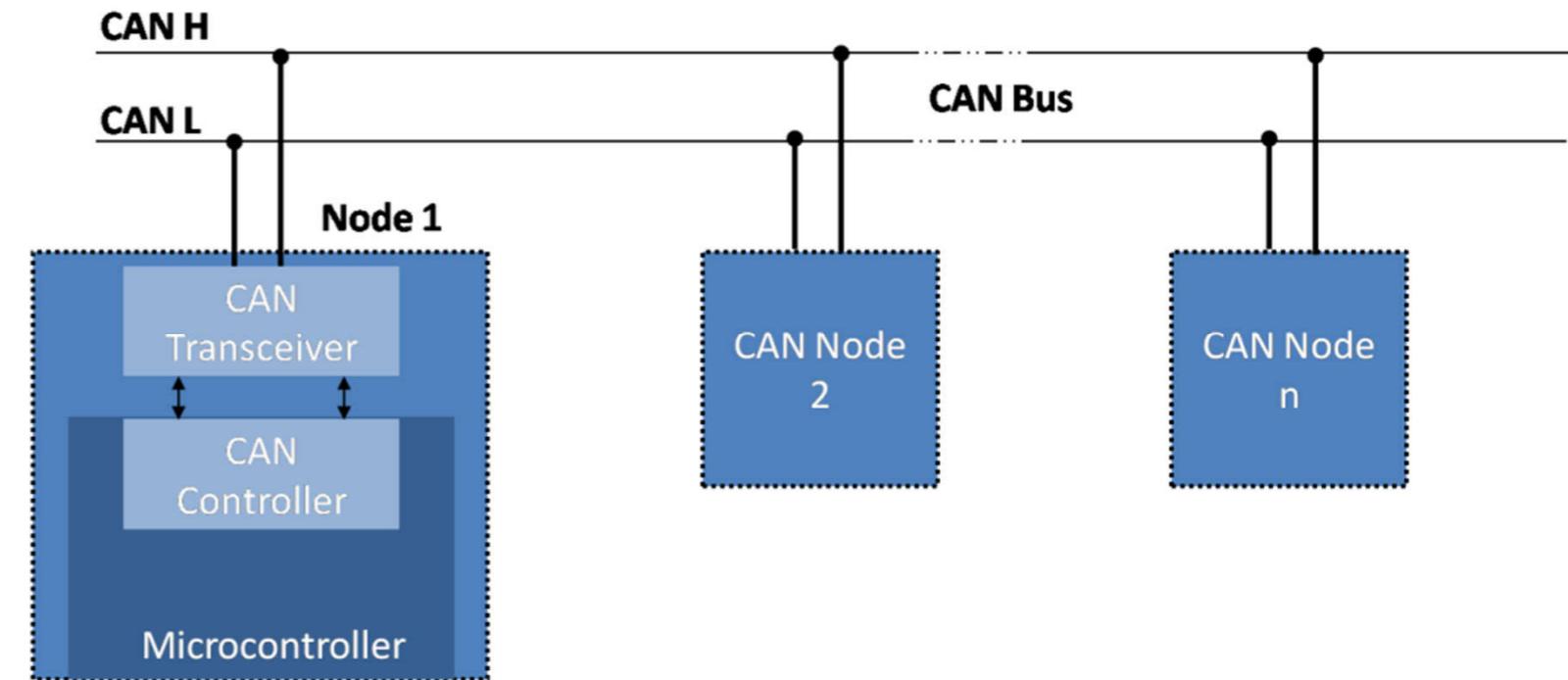


- Transmission Control Unit
- Engine Control Unit
- Powertrain Control Module
- Door Control Unit
- Brake Control Module (ABS)
- Battery Management System
- Electronic Power-Steering Control Unit (PSCU)
- Speed Control Unit

# BACKGROUND INFORMATION

## How Modern Cars Work:

How do ECUs Talk to each other?



### CAN BUS (Controller Area Network)

- Two-wire differential communication protocol
- Fabric that connects ECUs
- Messages within the network are manufacturer dependent

# BACKGROUND INFORMATION

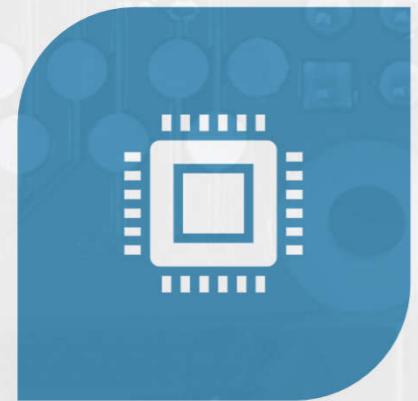
## How Modern Cars Work: OBD-II Port (On-Board Diagnostics)

- All cars produced after 1996 in North America come with an 16-pin interface called an OBD-II port
- Mechanics use this to diagnose problems within a car
- Standardized amongst all manufacturers
- Connected to the CAN bus of a car



# TECHNICAL DESIGN DETAILS

## TECHNICAL DESIGN DETAILS – MODULES



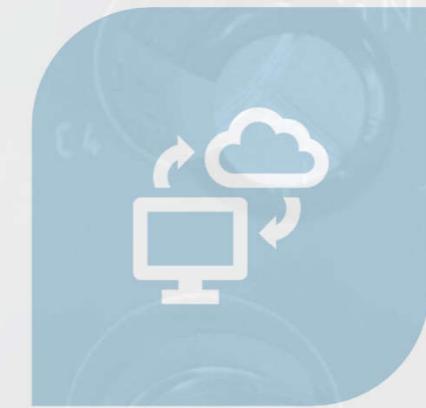
### DETECTION

*Detects front-end collisions*



### IMMOBILIZATION

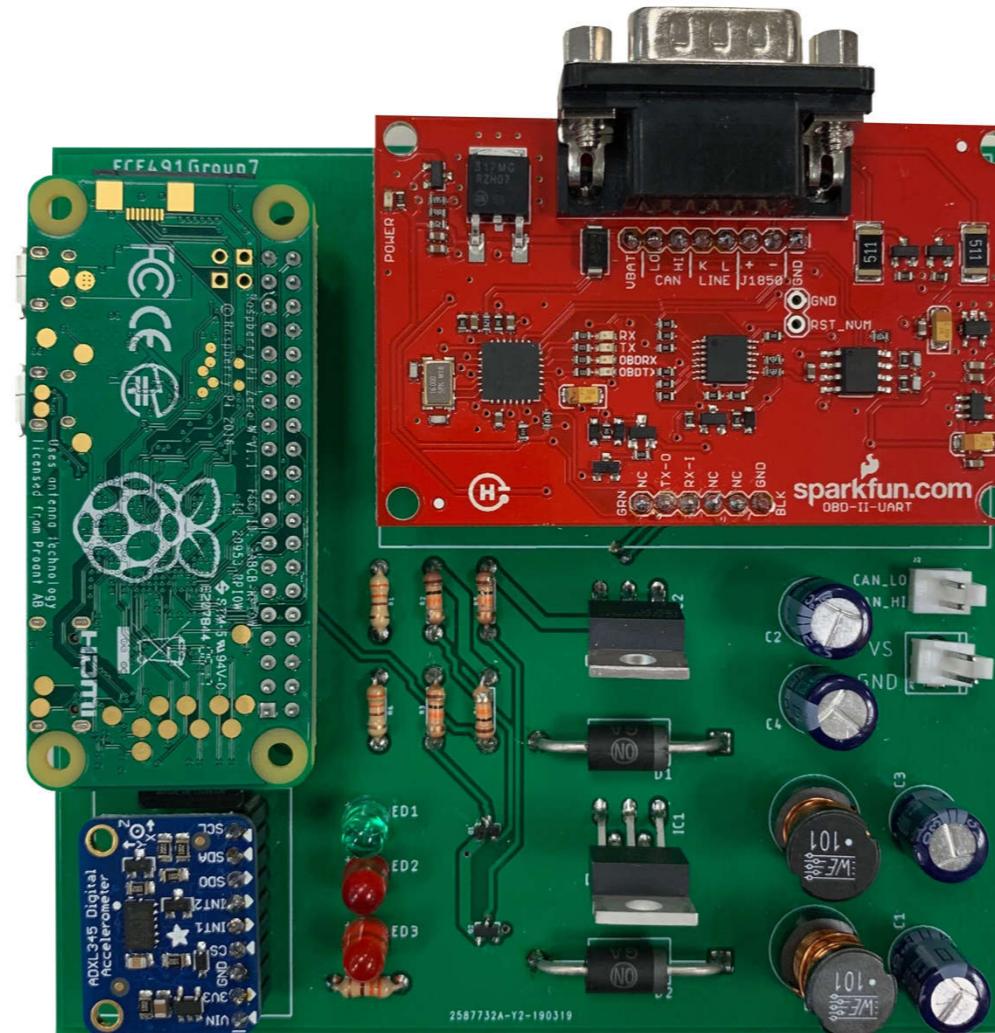
*Immobilizes the vehicle  
after the accident*



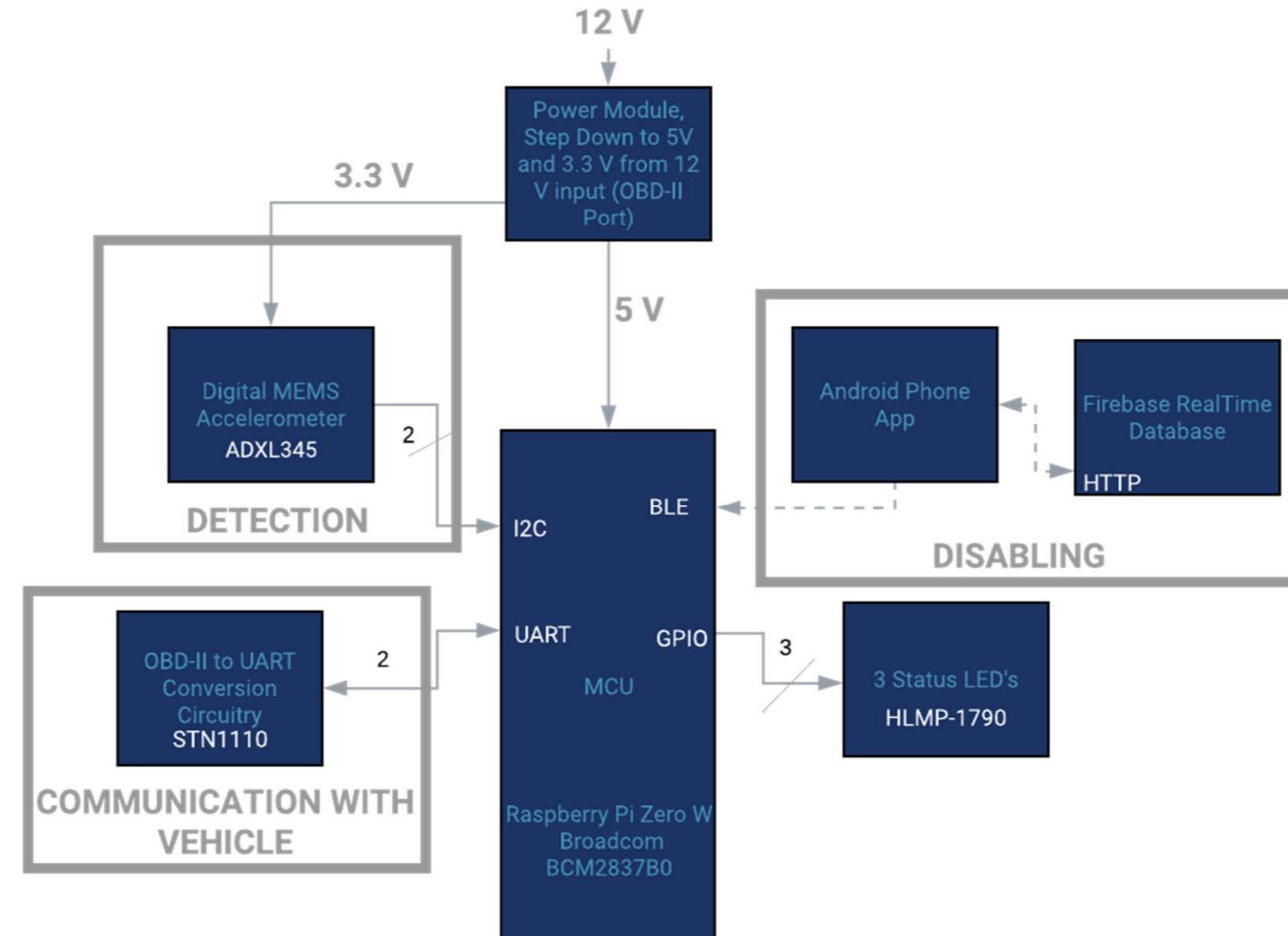
### DISABLER

*Safely re-mobilizes the  
vehicle (by authorized  
personnel)*

# TECHNICAL DESIGN DETAILS – PROOF OF CONCEPT



# TECHNICAL DESIGN DETAILS – HIGH LEVEL BLOCK DIAGRAM

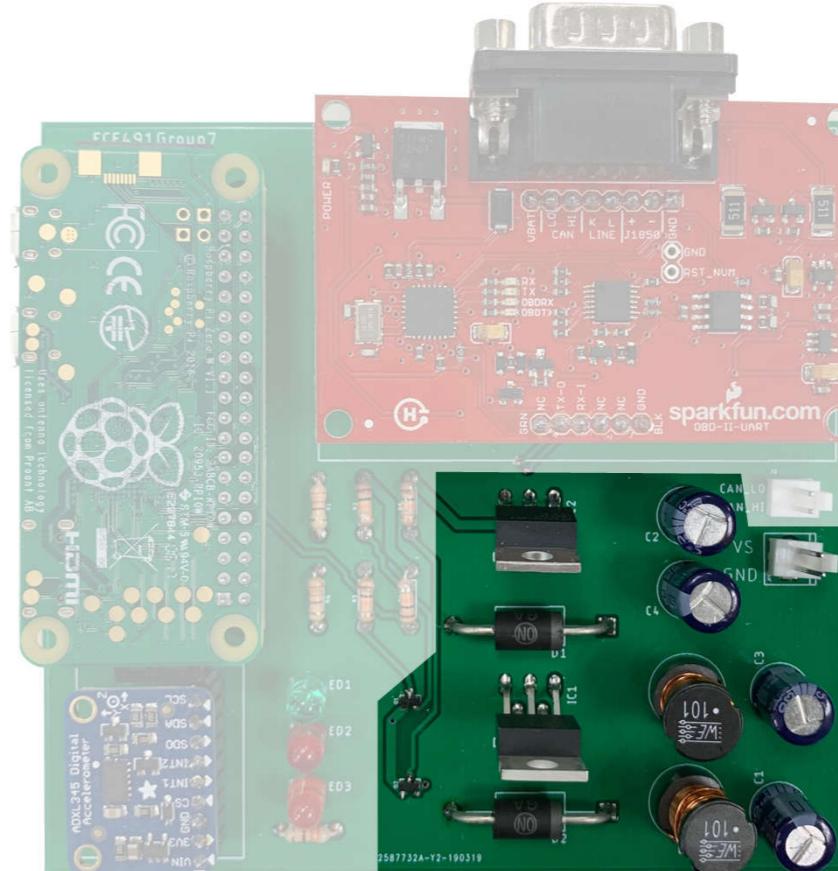


UART - Universal Asynchronous Receiver/Transmitter, I2C - Inter-Integrated Circuit, GPIO - General Purpose Input/Output Pin, BLE - Bluetooth Low Energy 4.2, OBDII - On-Board Diagnostics Port within a Car, DB9 - Serial 9-pin Connector

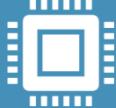
# TECHNICAL DESIGN DETAILS

## Power

- Takes 12V from:
  - car battery via the OBD-II port
  - external power supply for testing
- Steps down 12V to 5V and 3.3V for device components



# TECHNICAL DESIGN DETAILS



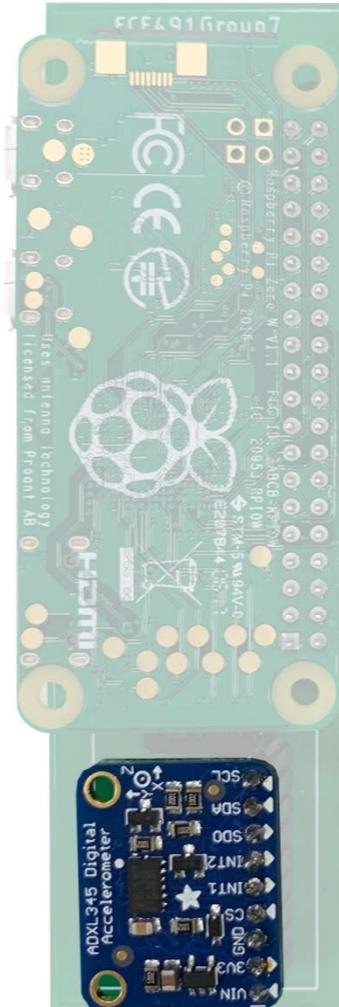
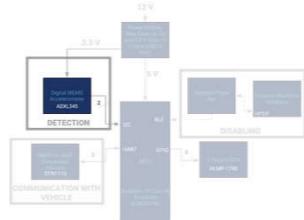
# Detection



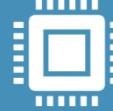
# Immobilization



# Disabler



# TECHNICAL DESIGN DETAILS



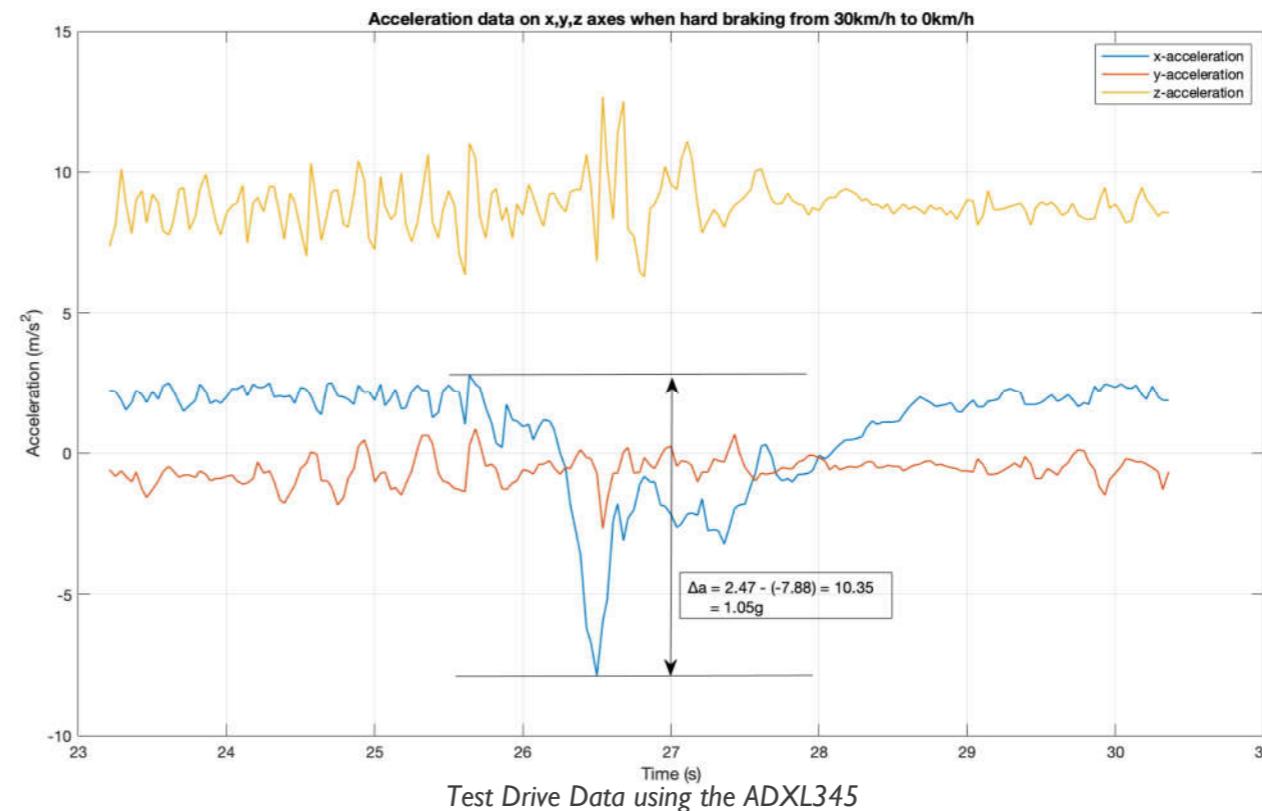
Detection



Immobilization

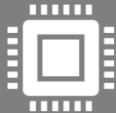


Disabler

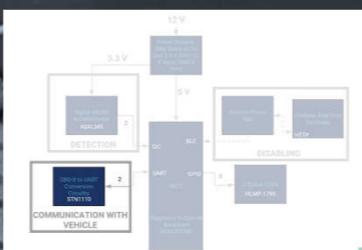


- MEMS digital accelerometer is used to detect large spikes in acceleration (3G over a 0.5 second window)
- X-axis or Y-axis used, Z-axis not used on purpose

# TECHNICAL DESIGN DETAILS



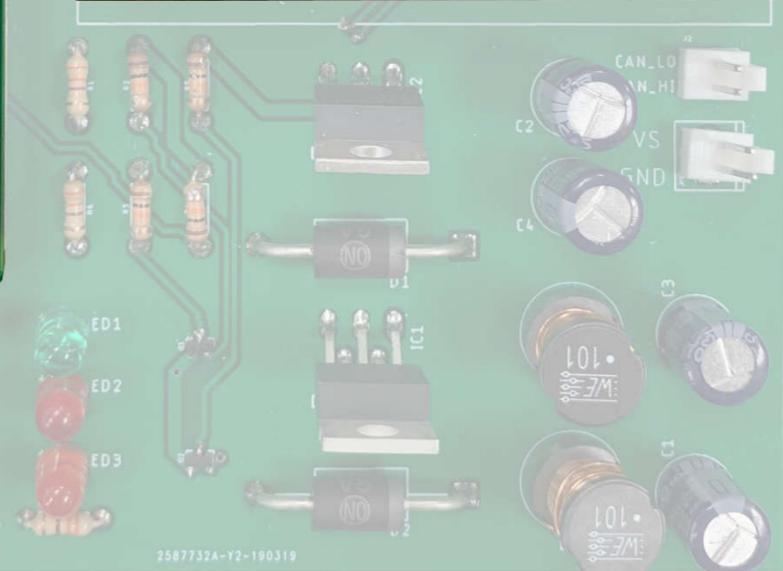
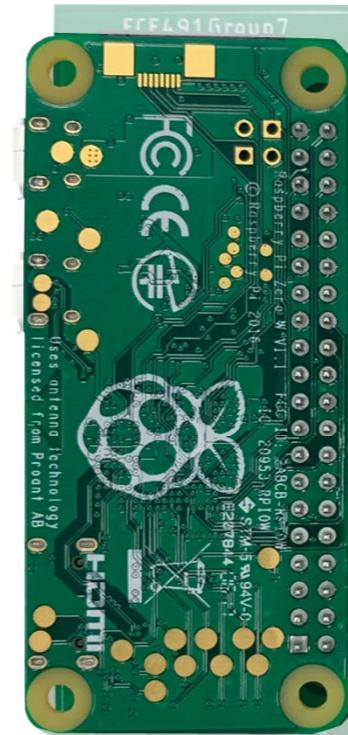
Detection



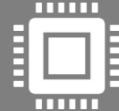
Immobilization



Disabler



# TECHNICAL DESIGN DETAILS



Detection

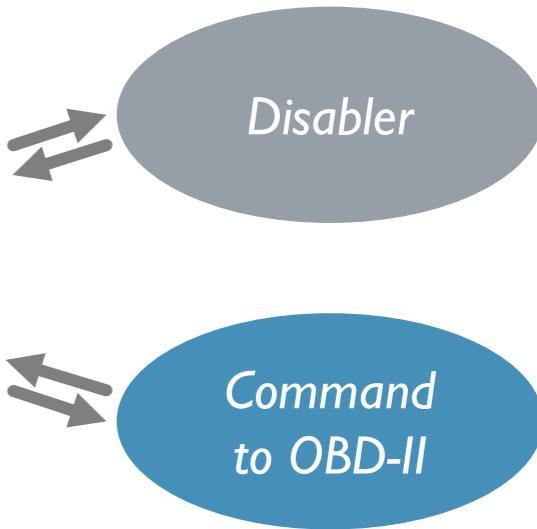


Immobilization



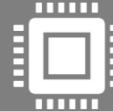
Disabler

Acceleration



- Checks speed for safety purposes (<5km/h)
- Continuously sends immobilization packets
- Preferred method: brake actuation
- Alternate methods: transmission, engine shutoff, cut fuel, DoS attack

# TECHNICAL DESIGN DETAILS



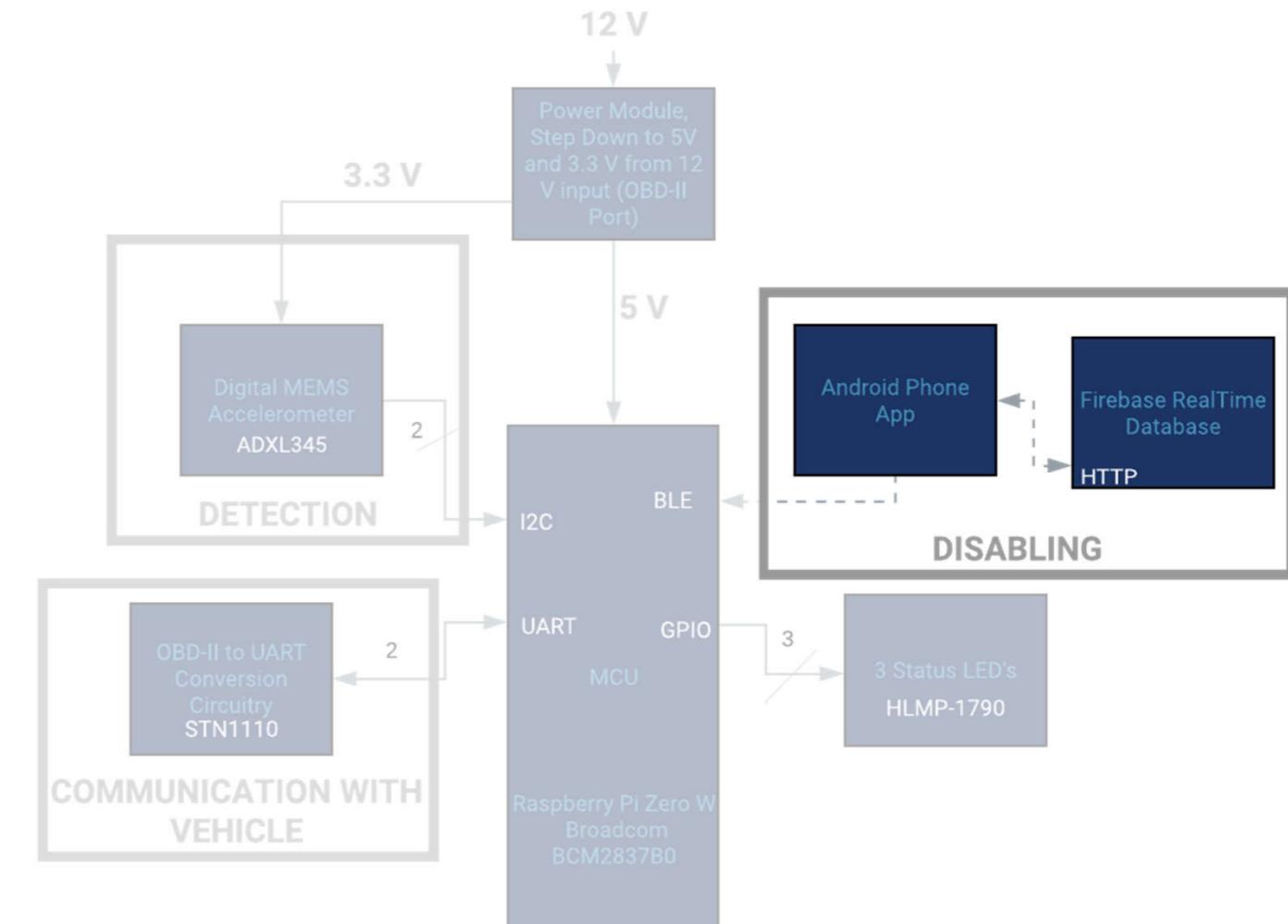
Detection



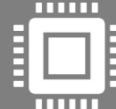
Immobilization



Disabler



# TECHNICAL DESIGN DETAILS



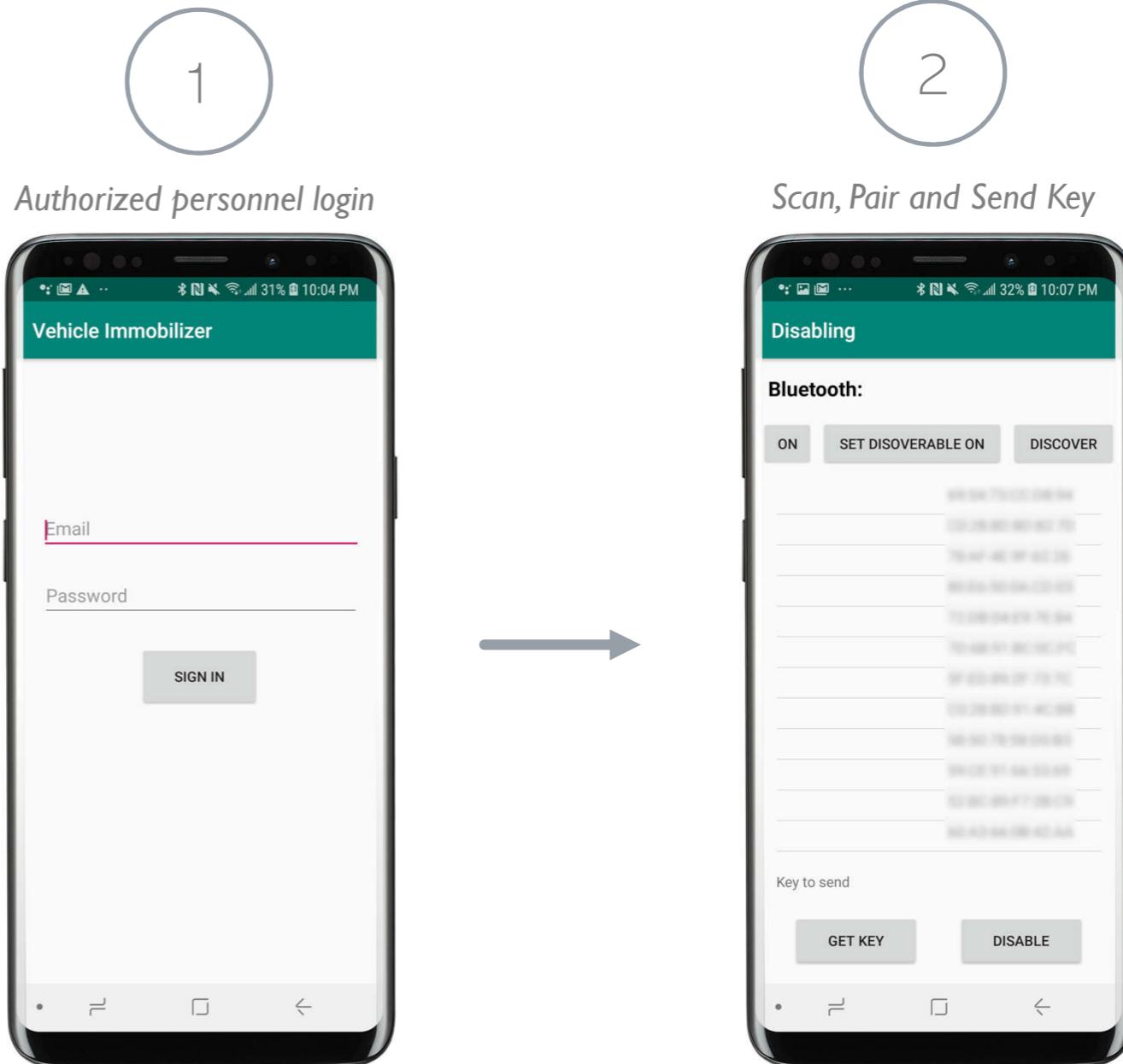
Detection



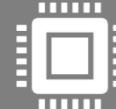
Immobilization



Disabler



# TECHNICAL DESIGN DETAILS



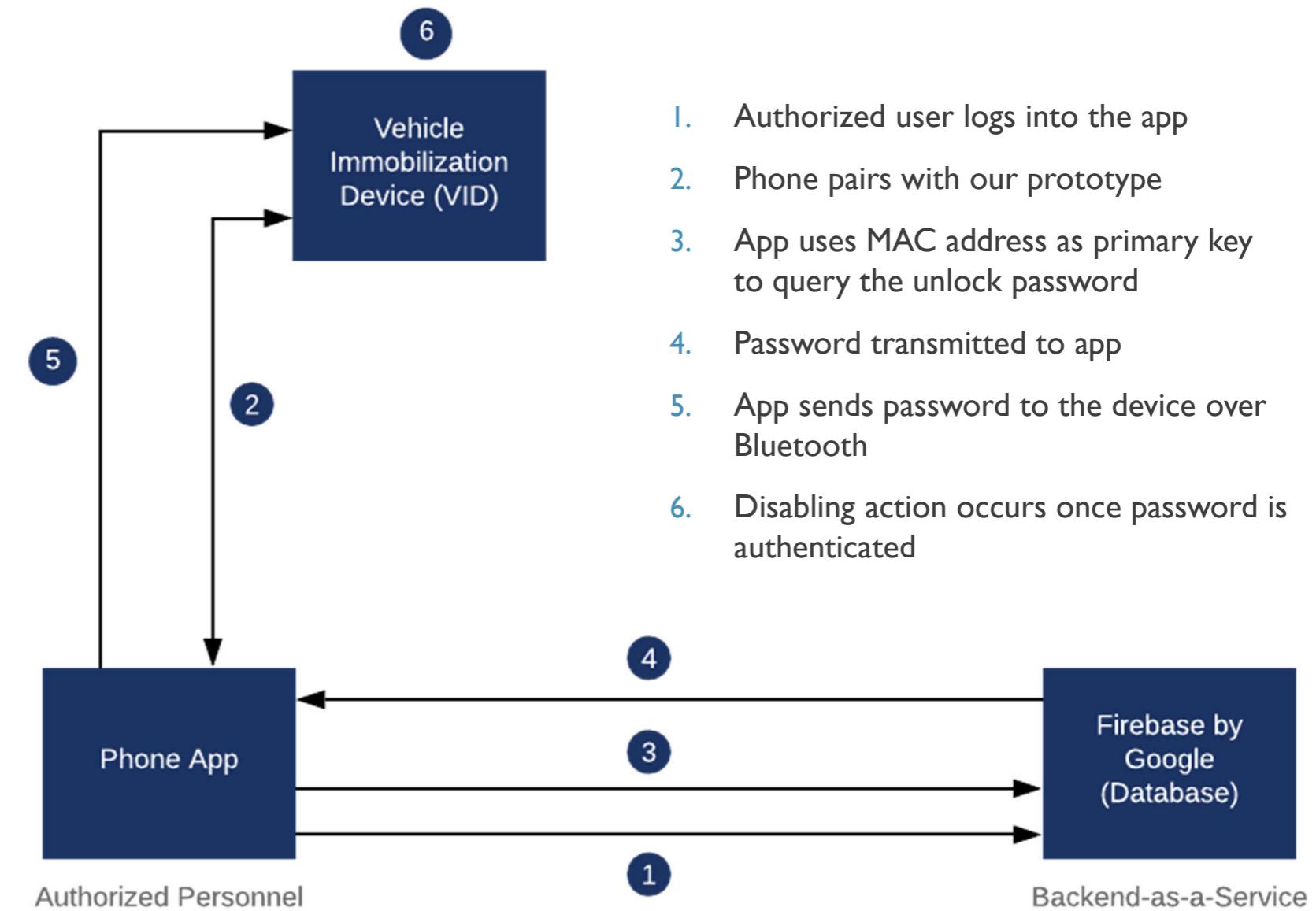
Detection



Immobilization

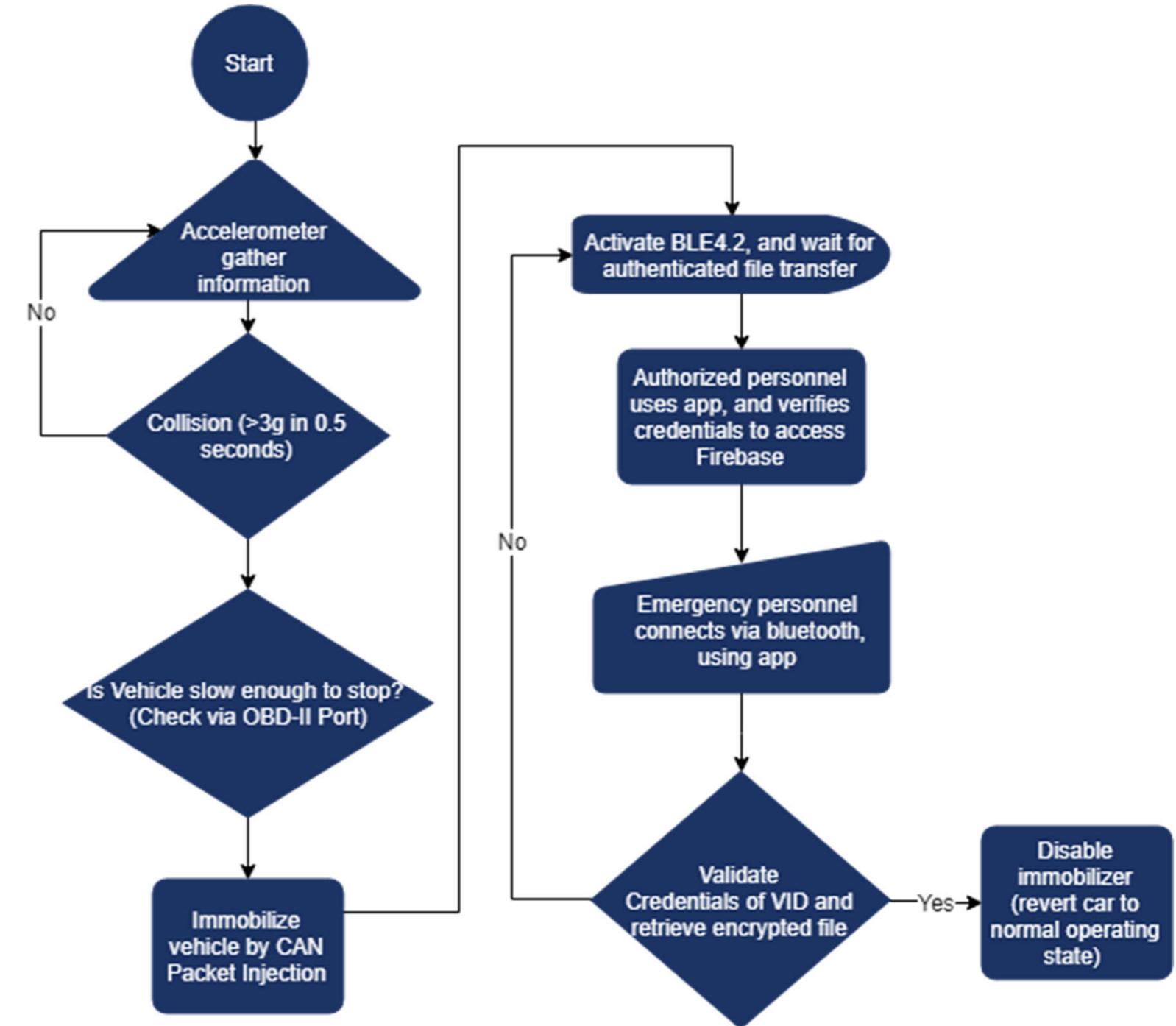


Disabler



# TECHNICAL DESIGN DETAILS

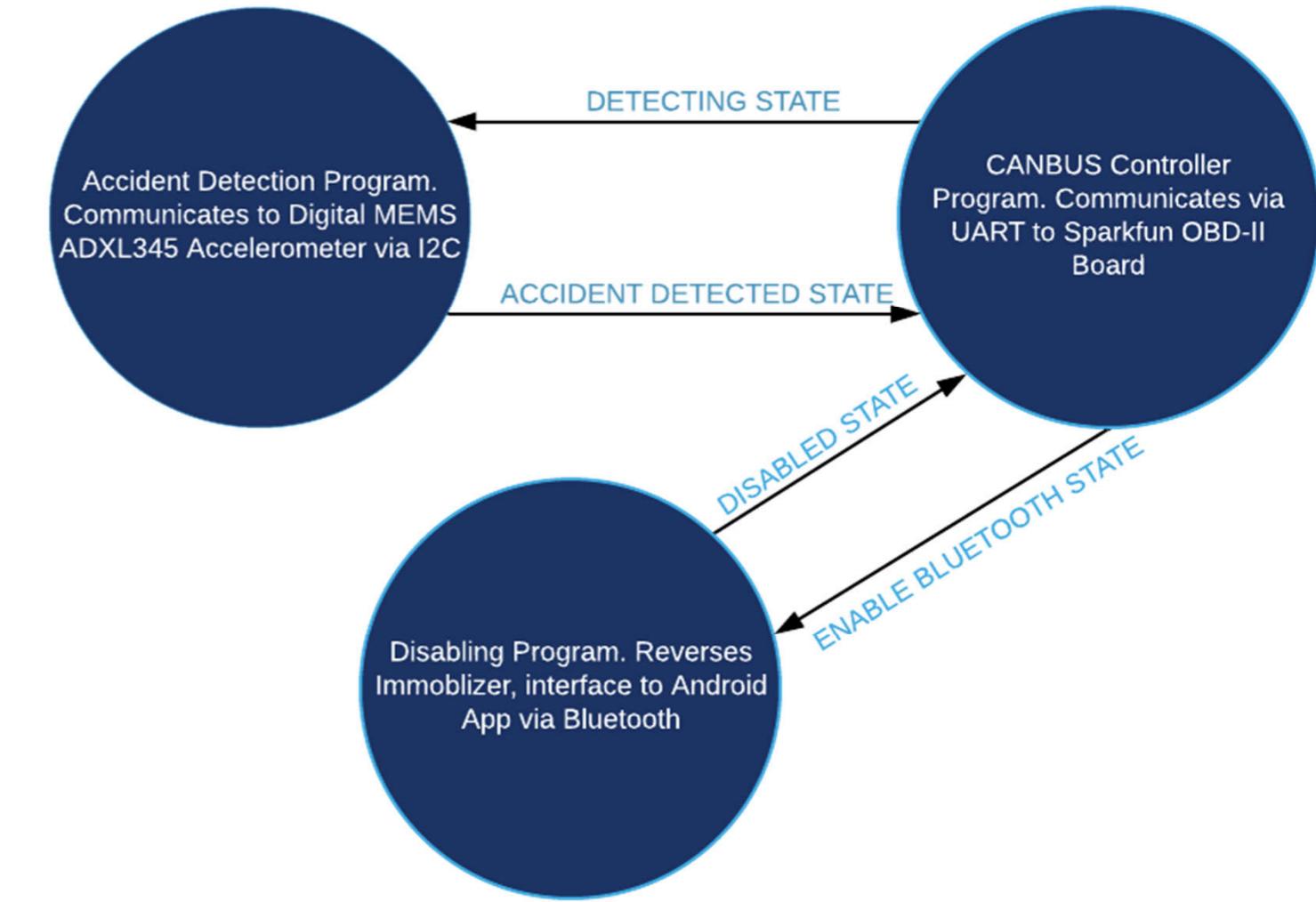
## Software Process Device Flowchart



# TECHNICAL DESIGN DETAILS

## Software Process

## State Machine Diagram



1. Detecting State
2. Accident Detected State
3. Enable Bluetooth State
4. Disabled State

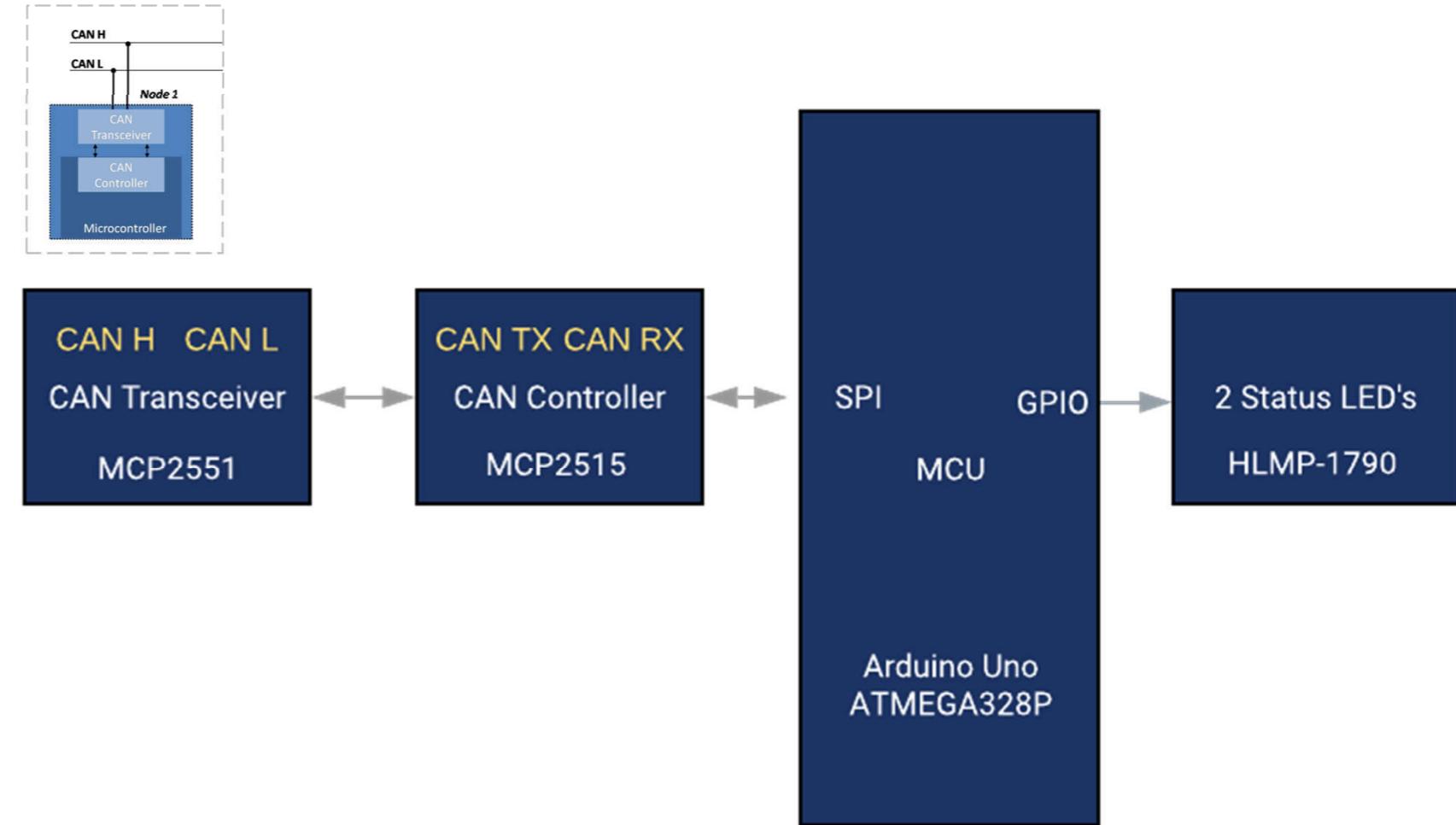


# VERIFICATION

# VERIFICATION

## ECU Simulator

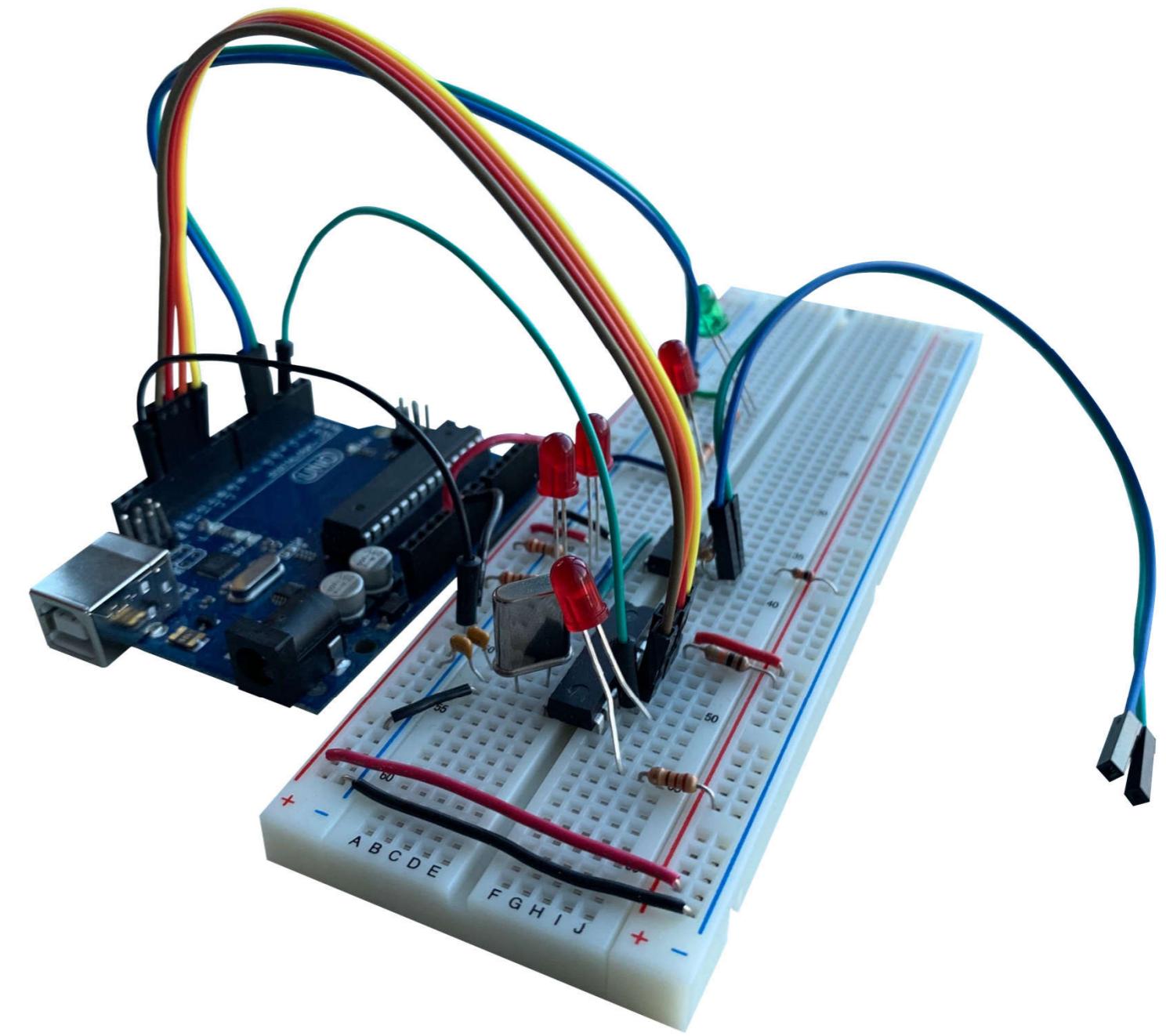
### Block Diagram



- Acts as a CAN bus node (ECU)
- Simulates standard OBD-II queries sent over CAN bus
- Receives specific CAN packets interpreted as braking or transmission

# VERIFICATION

ECU Simulator  
Implementation



## VERIFICATION

Video Demo

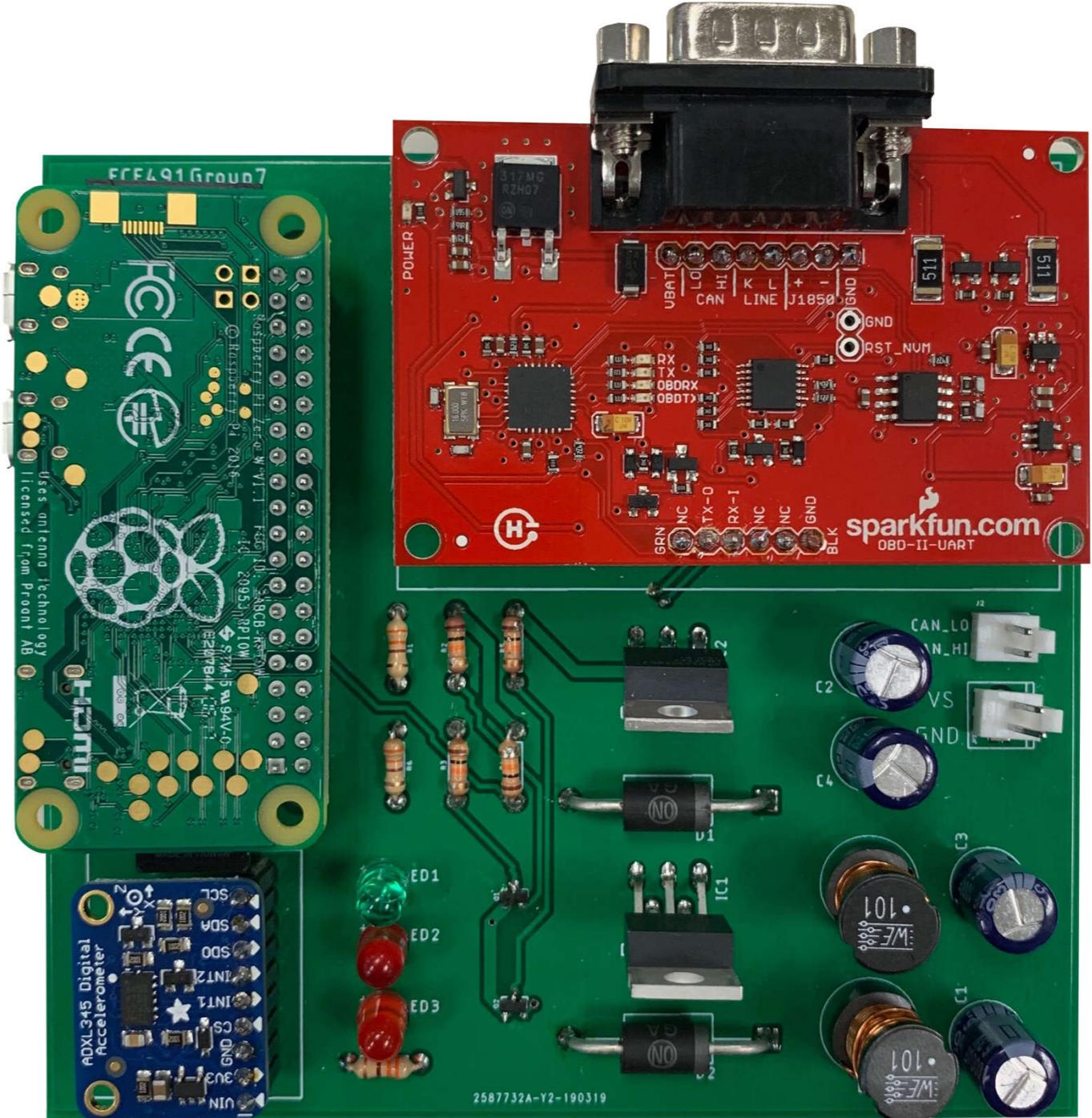




PRODUCT DESIGN

# PRODUCT DESIGN

Proof-of-concept



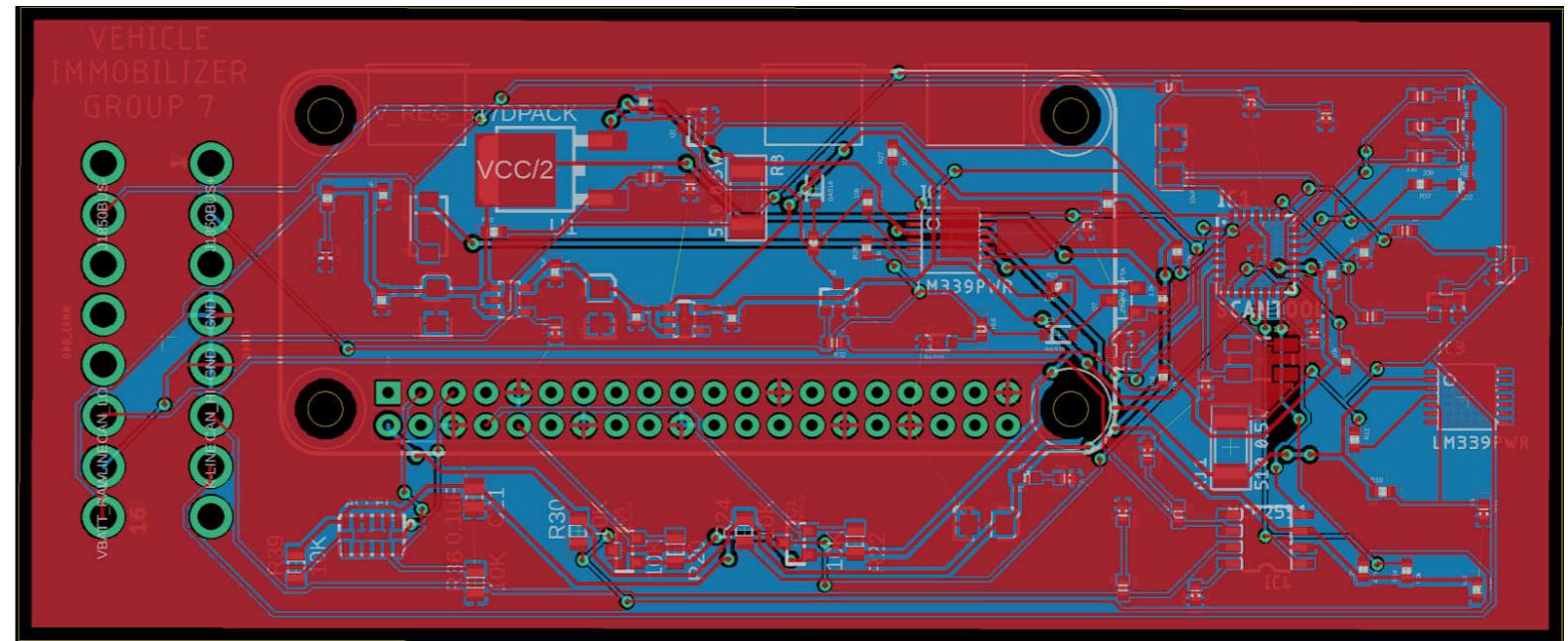
# PRODUCT DESIGN

Dongle Form Factor



# PRODUCT DESIGN

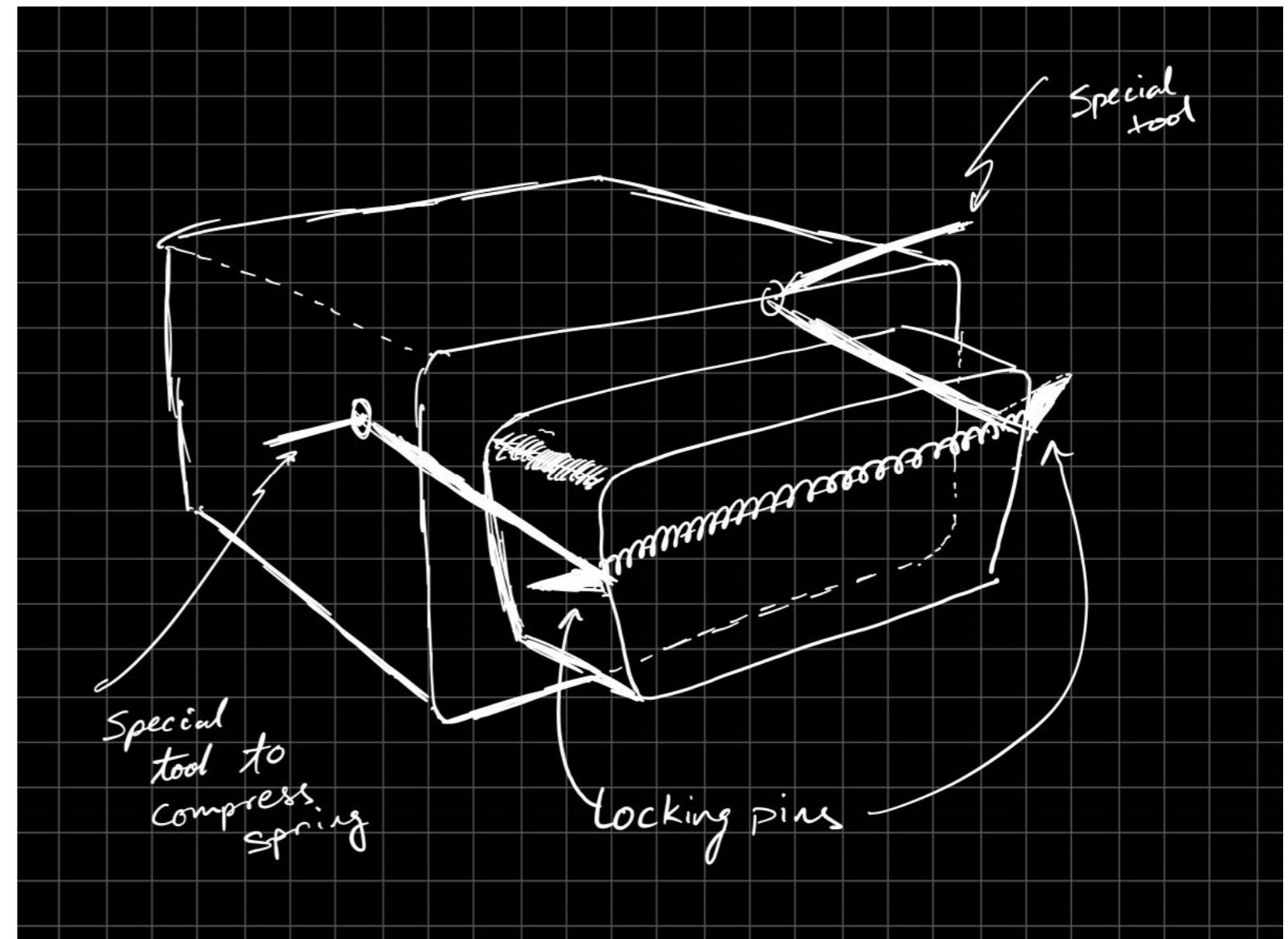
# PCB Layout



- Dimensions: ~128mm x ~60mm
  - Smaller form factor

# PRODUCT DESIGN

## Locking Mechanism



# FUTURE CONSIDERATIONS

## **Low Power Mode**

*Design and build a power management solution that features a low power mode to minimize power consumption*

## **Proprietary CAN Packet Structures**

*Query Vehicle Identification Number (VIN) to identify vehicle make & model to for correct immobilization packet structure*

## **Improved Accident Detection**

*Retrieval of additional data from CAN bus for redundancy checks (i.e. airbag deployment status) & multi-directional collisions*

## **Enhanced Security for Disabling**

*Implement a more secure authentication software solution (i.e. SHA-256 Authentication)*

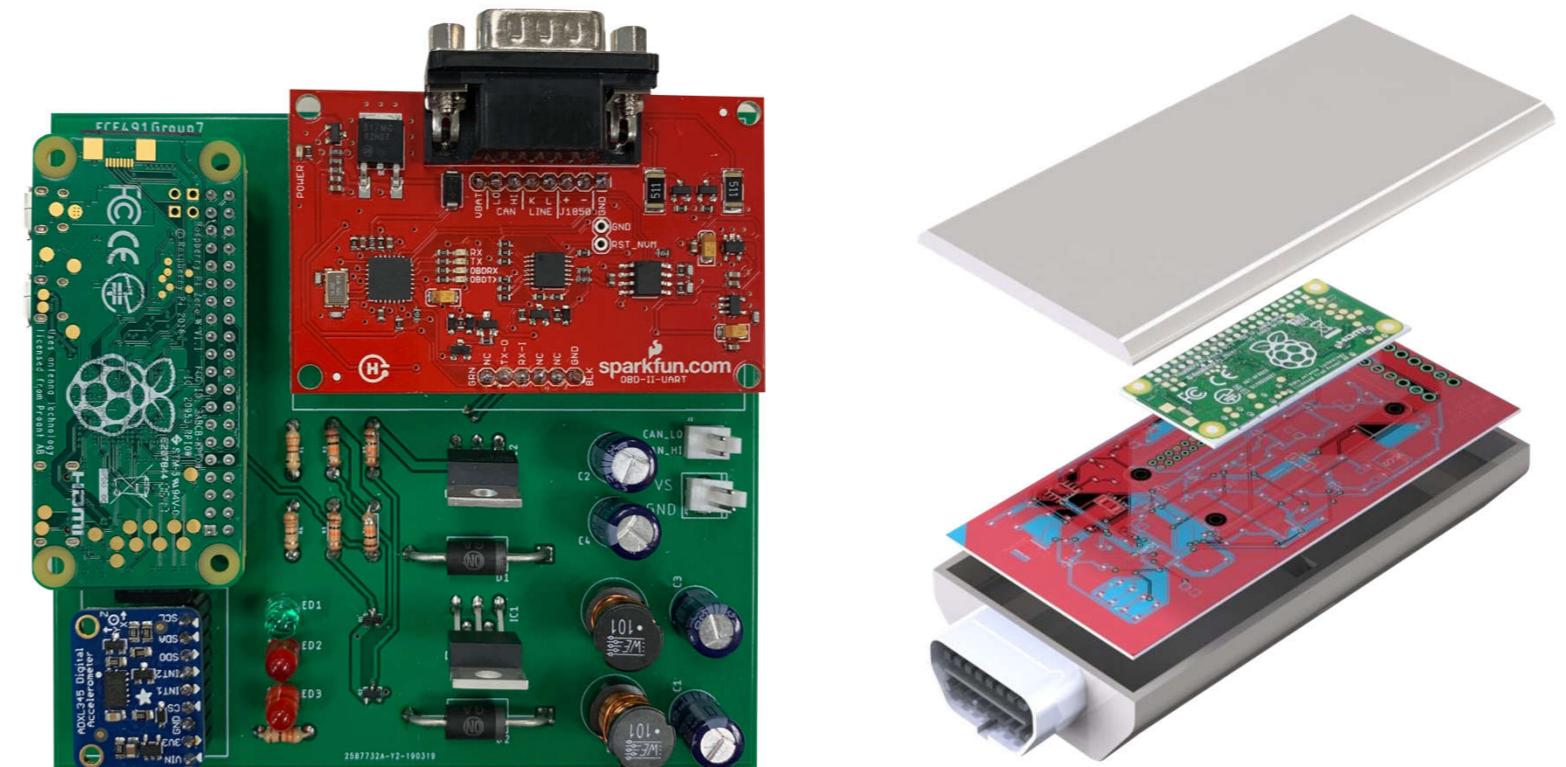
## **Location**

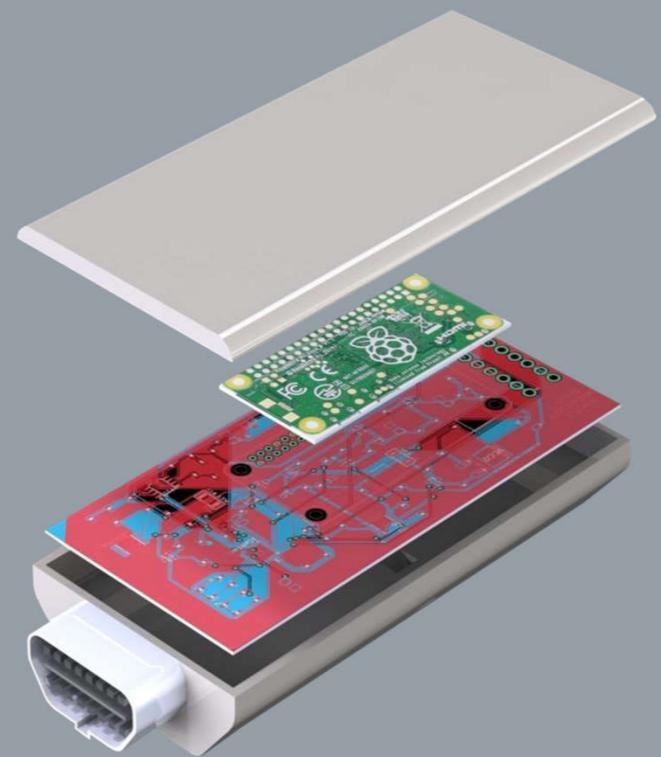
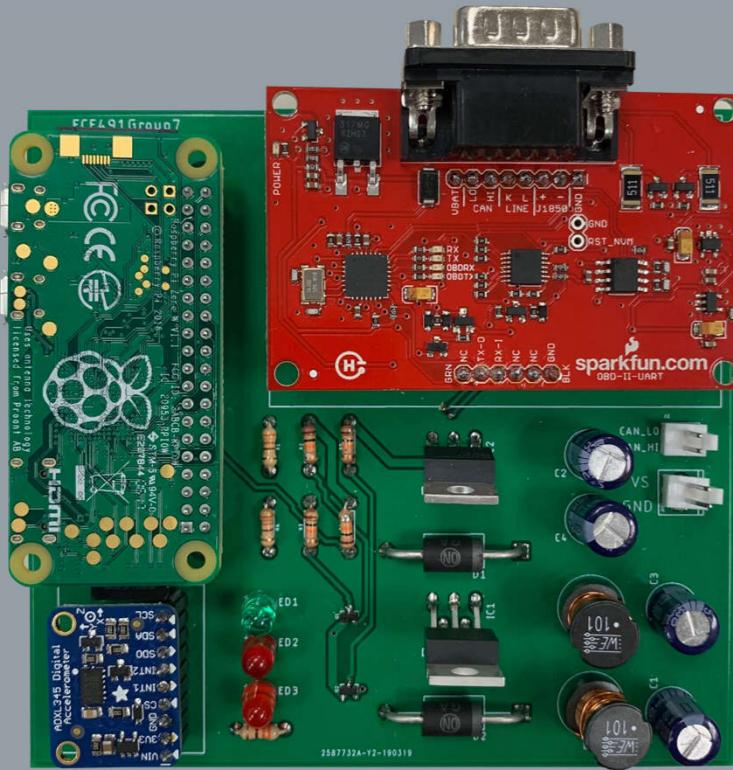
*Store the coordinates of the scene of accident and send them to emergency personnel by adding a GPS module*

# SUMMARY

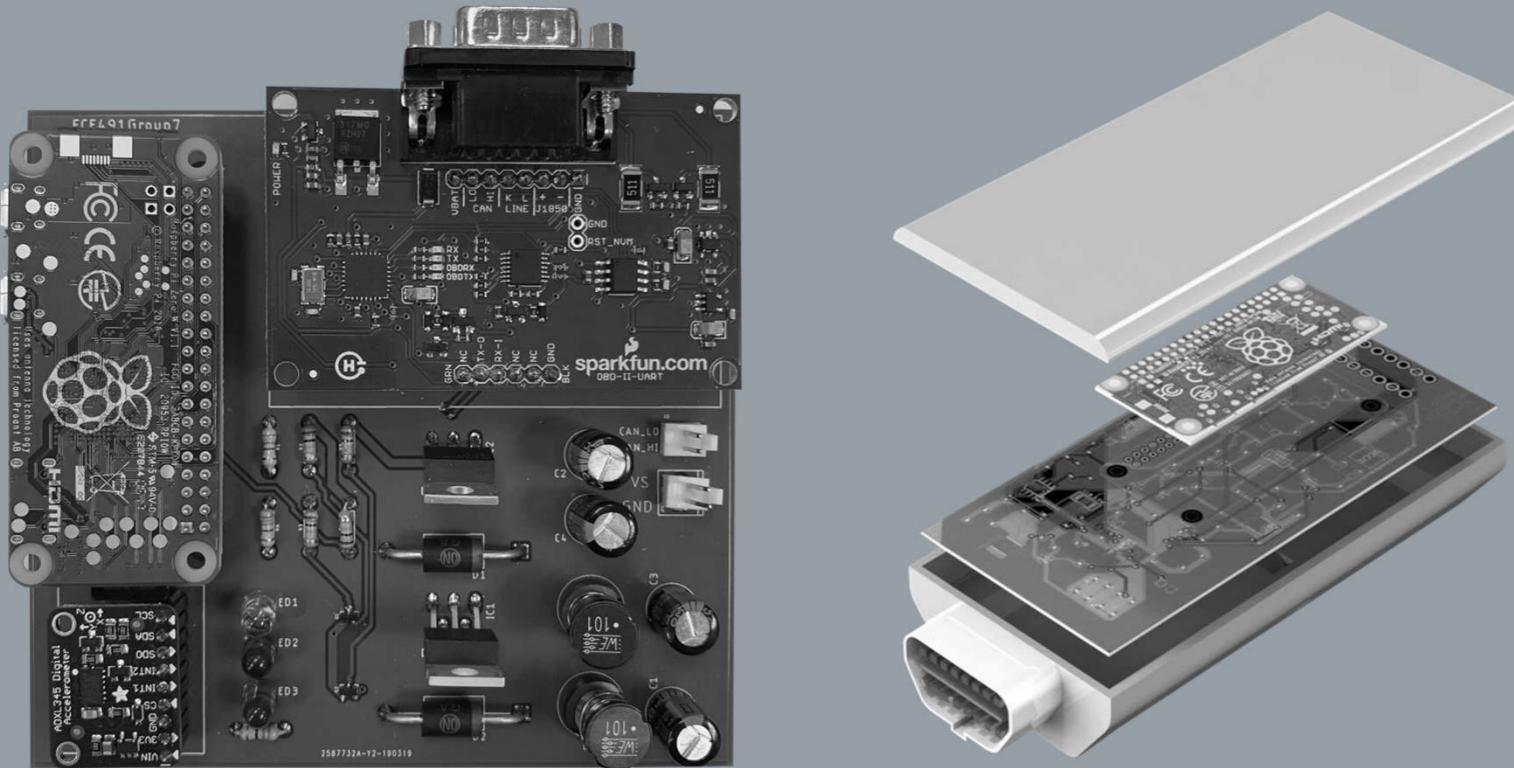
## Goals

- Accurate collision detection
- Immobilize the vehicle in a reversible manner.
- Secure re-mobilization of vehicle by authorized personnel





THANK YOU



## Q&A

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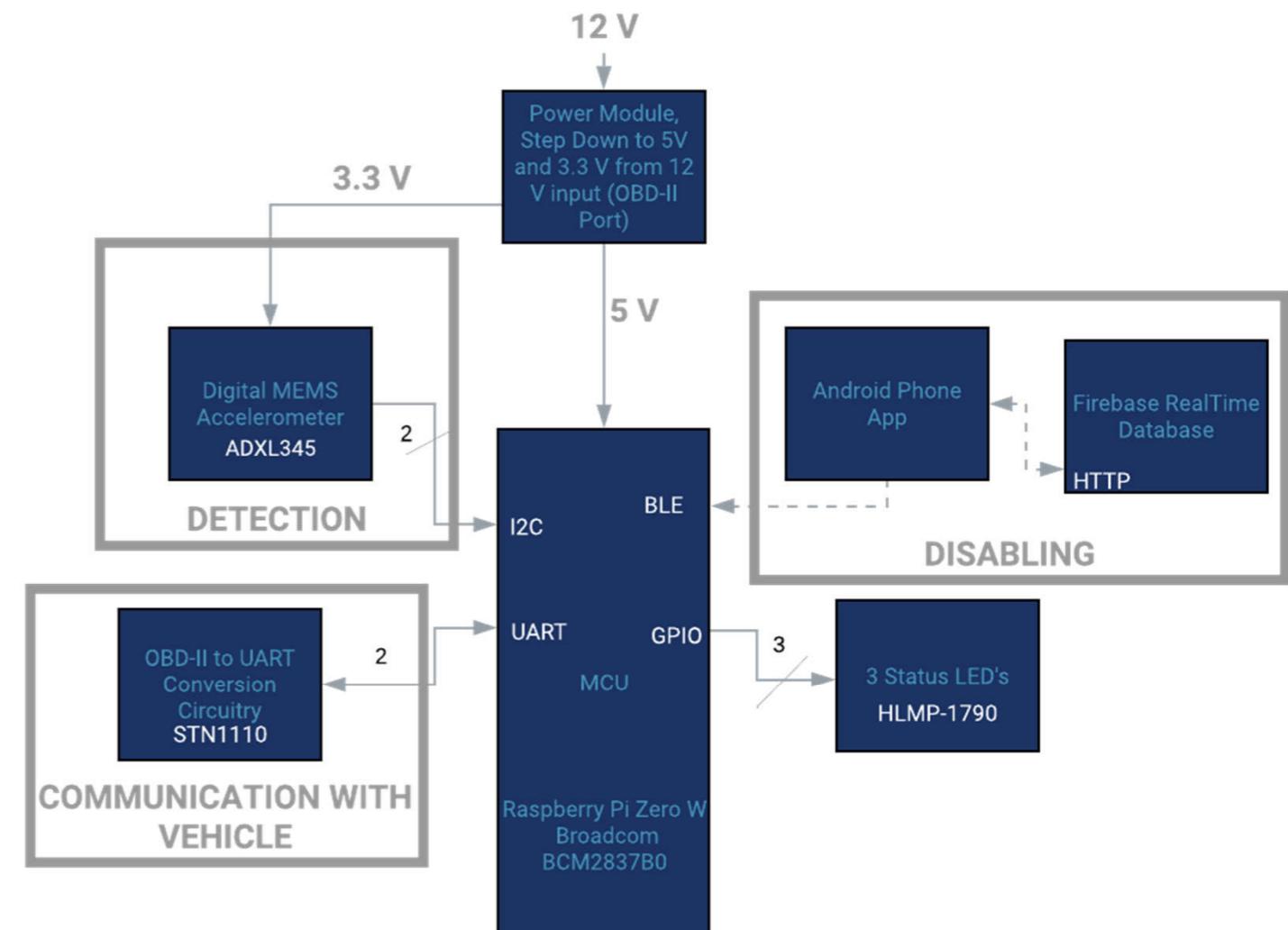
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Redge Santillan  
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# APPENDIX

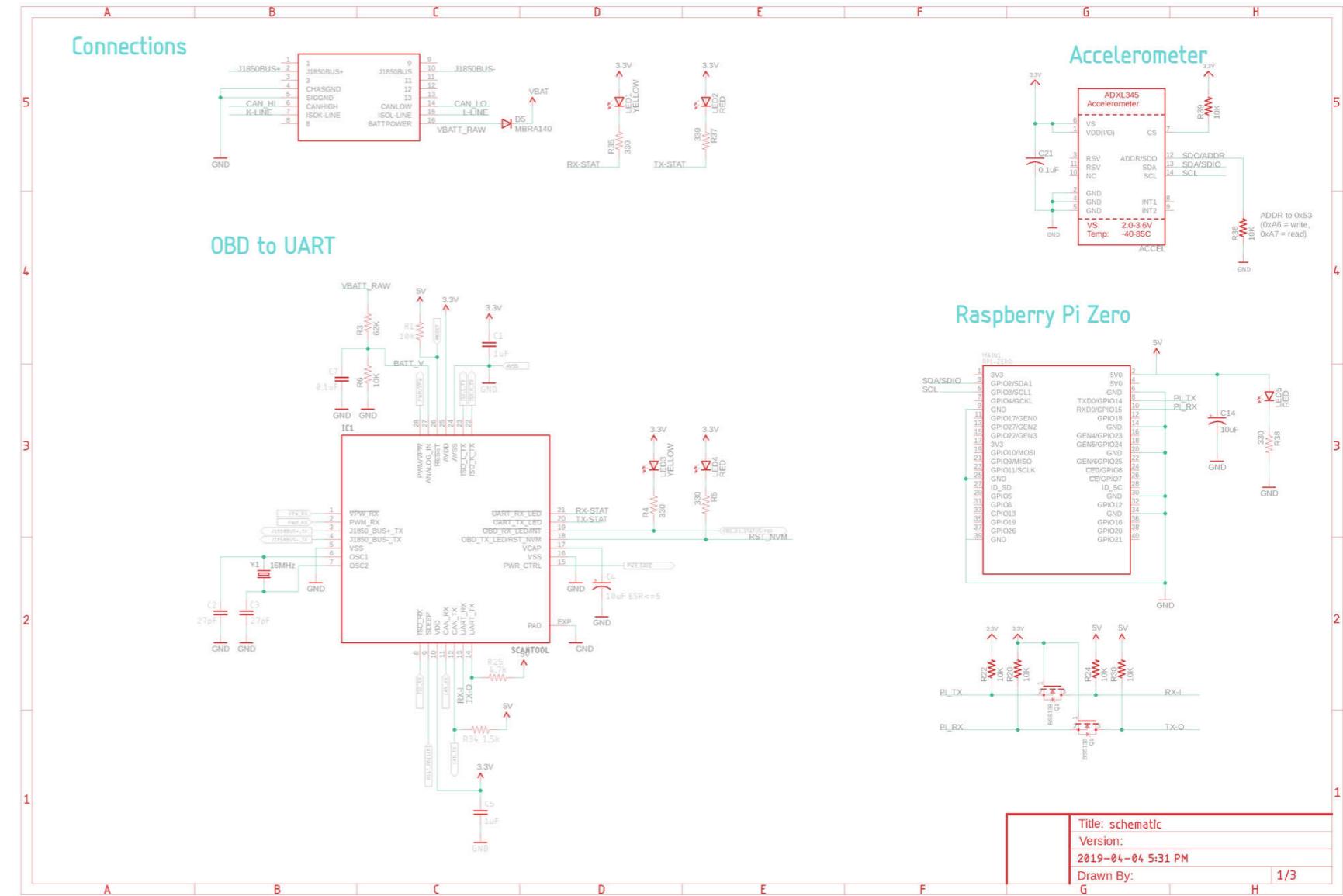
## Full High Level Block Diagram



UART - Universal Asynchronous Receiver/Transmitter, I<sub>2</sub>C - Inter-Integrated Circuit, GPIO - General Purpose Input/Output Pin, BLE - Bluetooth Low Energy 4.2, OBDII - On-Board Diagnostics Port within a Car, DB9 - Serial 9-pin Connector

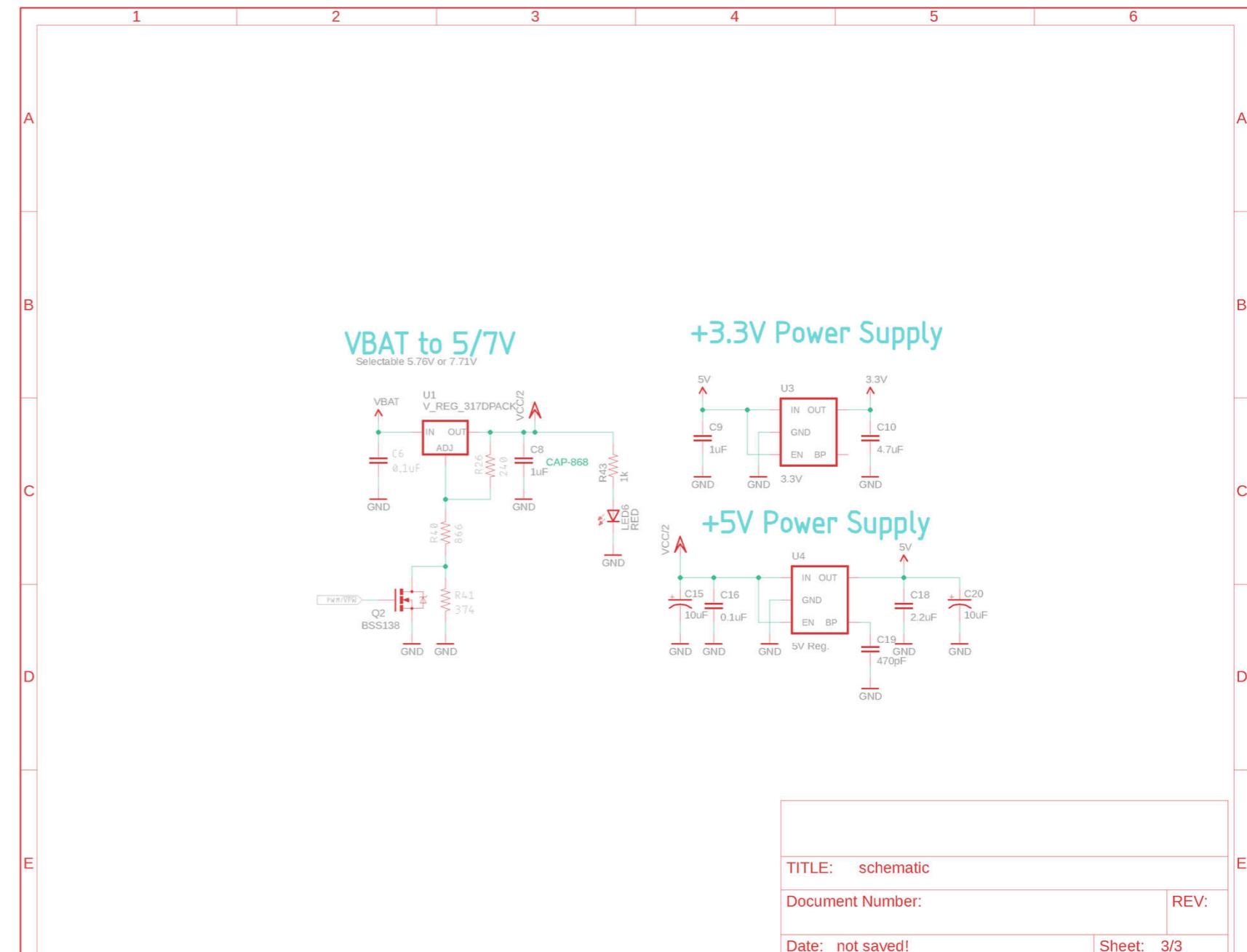
# APPENDIX

## Schematic – Vehicle Immobilization Device (Page 1 of 4)



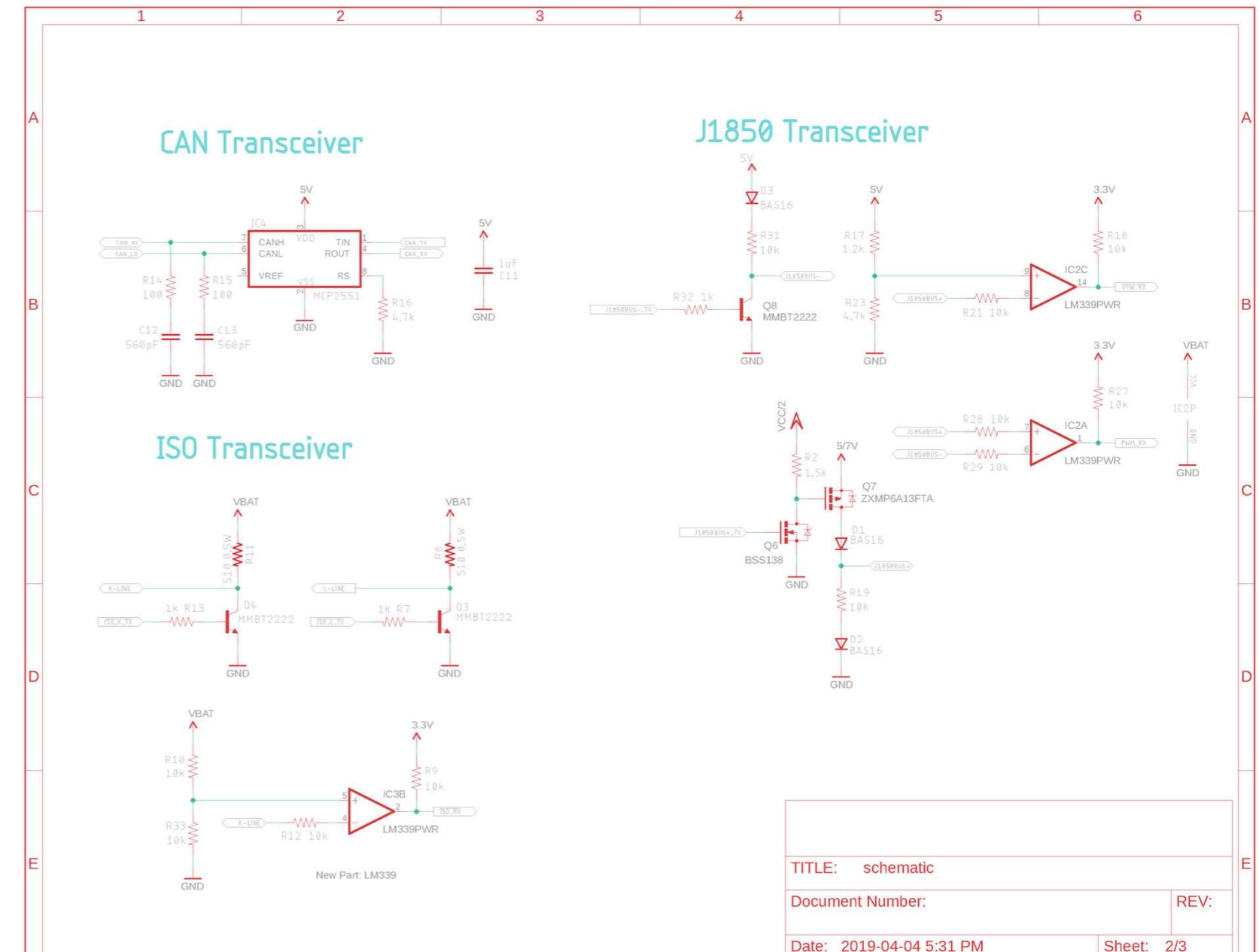
# APPENDIX

## Schematic – Power Module (Page 2 of 4)



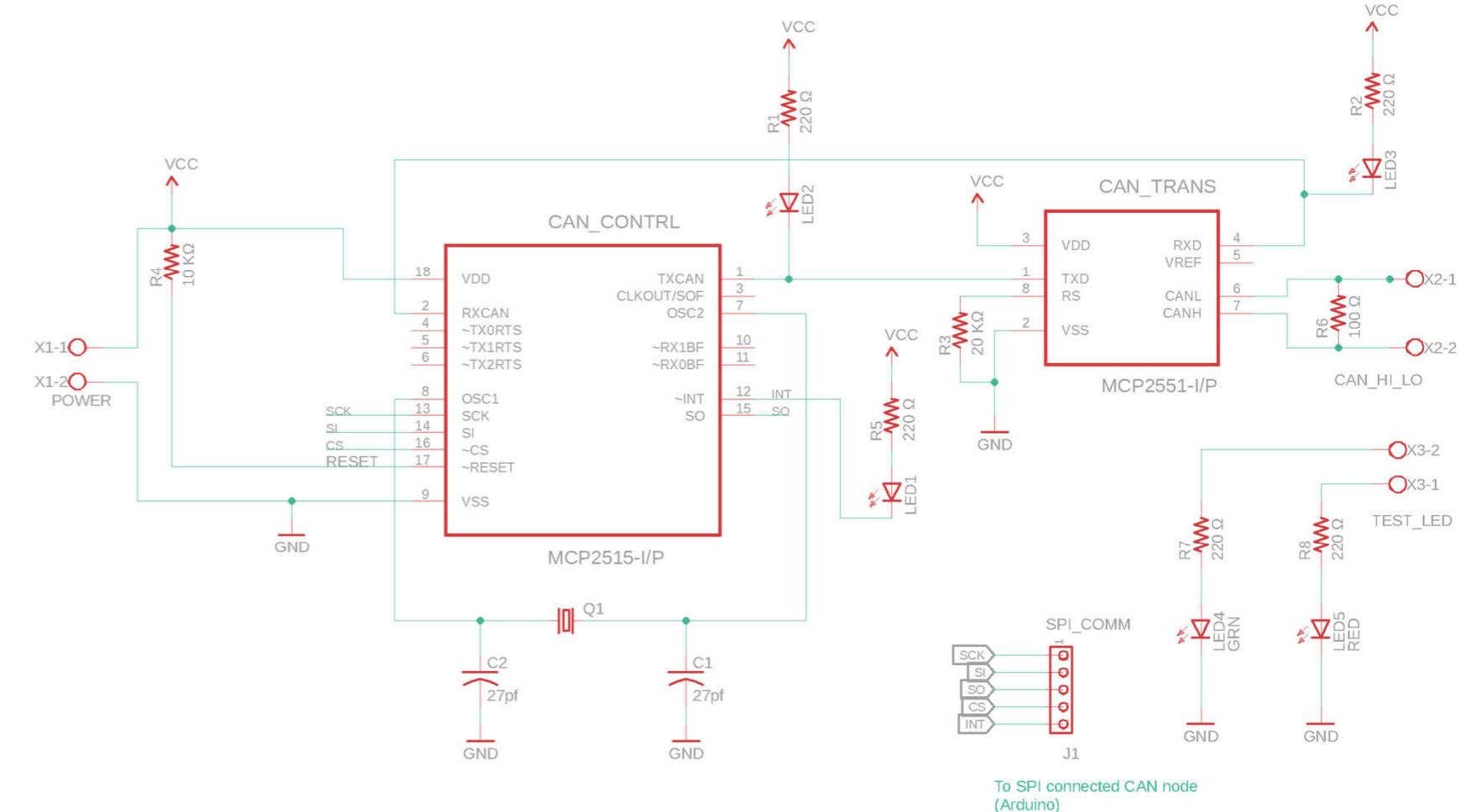
# APPENDIX

## Schematic – OBD-II Transceivers (Page 3 of 4)



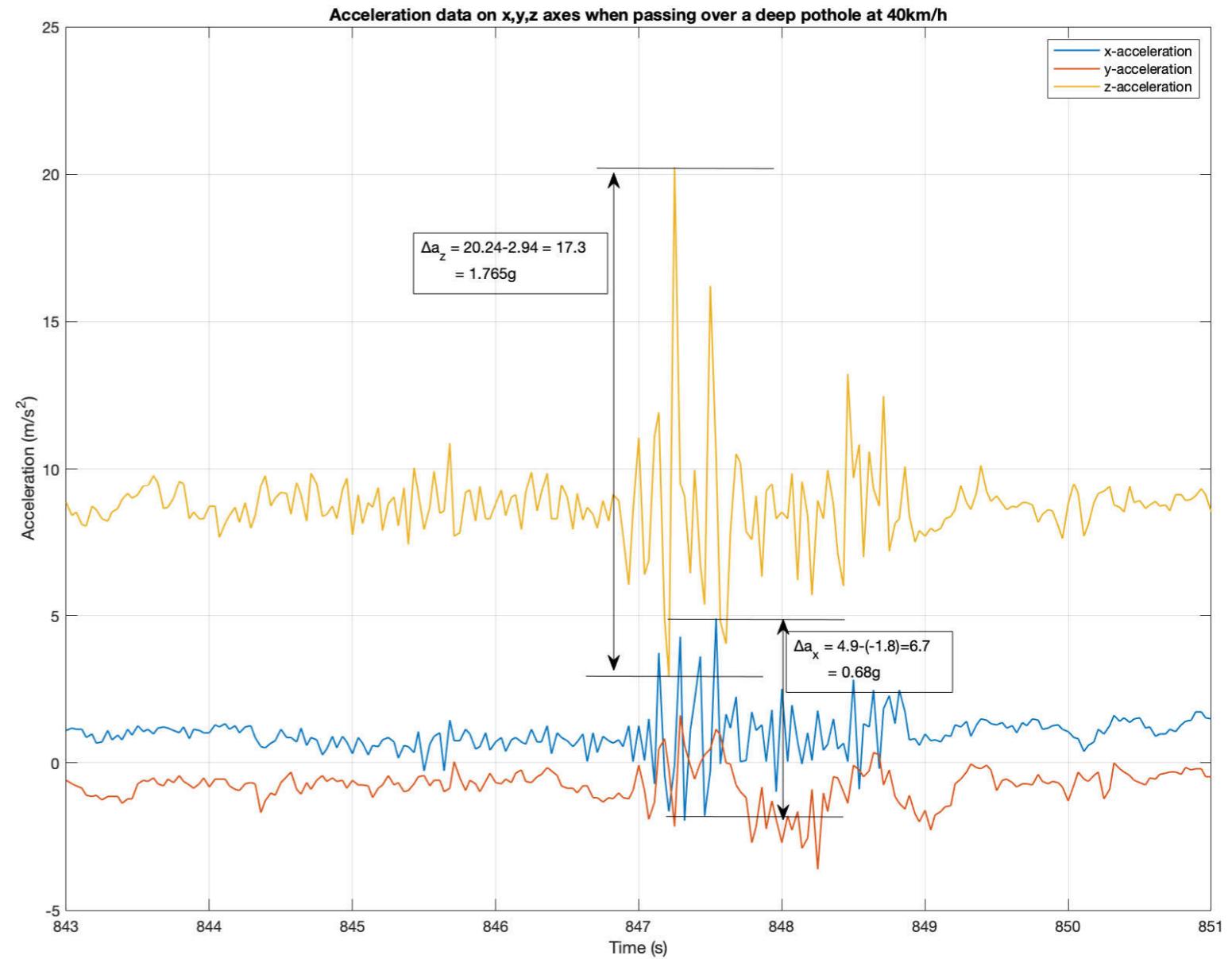
# APPENDIX

## Schematic – ECU Simulator (Page 4 of 4)



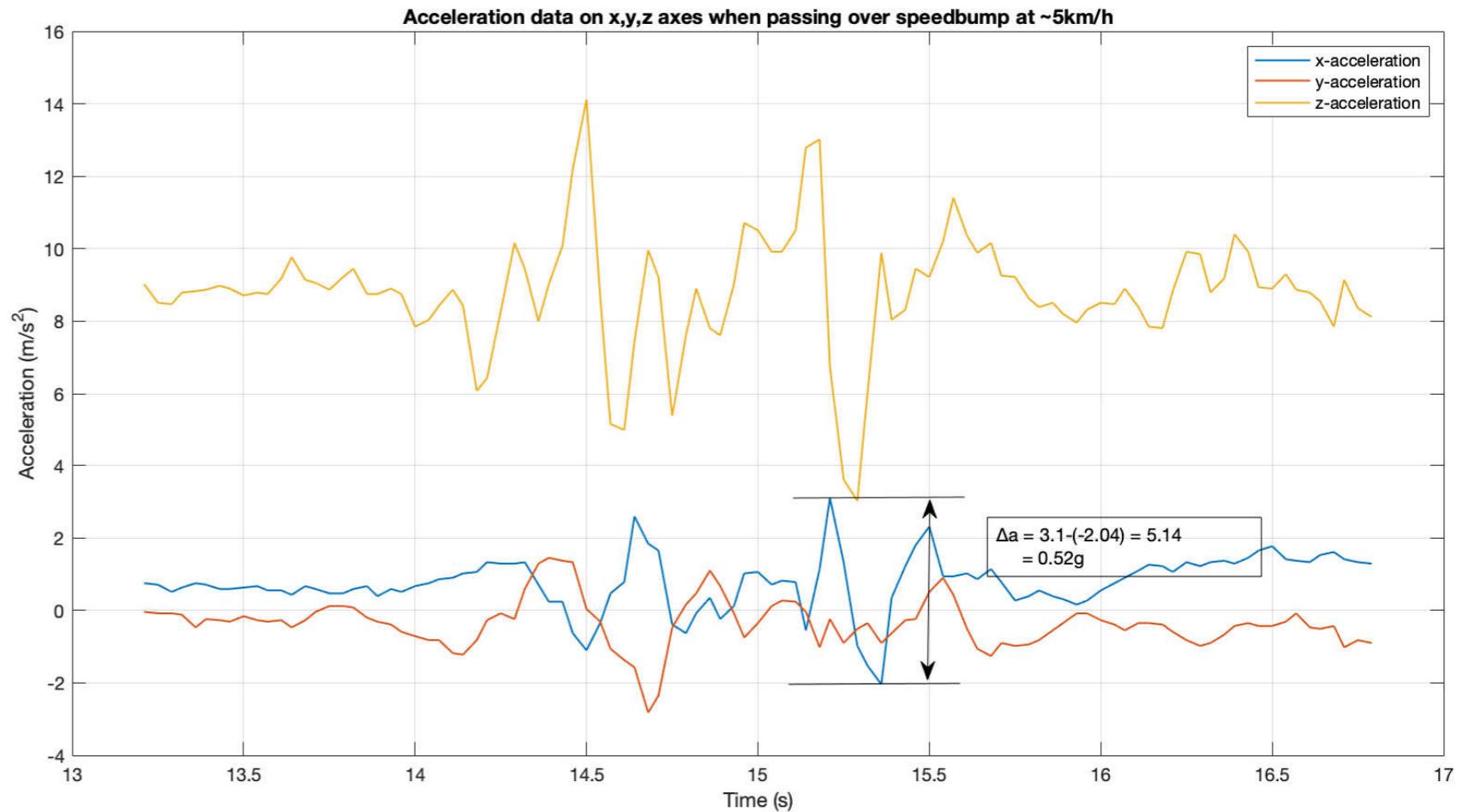
# APPENDIX

Graph (2 of 3) – Pothole at  
40km/h



# APPENDIX

Graph (3 of 3) – Speedbump at 5km/h



# APPENDIX

## Bill of Materials – Product Design

Complete bill of materials					
	Value	Description	Qty	Unit \$	Total \$
Capacitors					\$ 0.39
	1uF	Capacitor	5	\$ 0.0058	\$ 0.03
	2.2uF	Capacitor	1	\$ 0.0200	\$ 0.02
	27pF	Capacitor	2	\$ 0.0090	\$ 0.02
	4.7uF	Capacitor	1	\$ 0.0320	\$ 0.03
	470pF	Capacitor	1	\$ 0.0127	\$ 0.01
	560pF	Capacitor	2	\$ 0.0065	\$ 0.01
	10uF	Capacitor	4	\$ 0.0490	\$ 0.20
	0.1uF	Capacitor	5	\$ 0.0049	\$ 0.02
	10uF	Capacitor	1	\$ 0.0490	\$ 0.05
Diodes					\$ 1.29
	BAS16	Diode	3	\$ 0.20	\$ 0.60
	MBRA140	Diode	1	\$ 0.69	\$ 0.69
STN1110 - OBD II to UART Interpreter, PDIP Package					\$ 7.65
	SCANTOOL	STN1110 - OBD II to UART Interpreter, QFN-28-S	1	\$ 7.65	\$ 7.65
Quad Differential Comparators					\$ 1.16
	LM339PWR	Quad Differential Comparators	2	\$ 0.58	\$ 1.16
CAN Driver					\$ 1.86
	MCP2551	CAN Driver	1	\$ 1.86	\$ 1.86
Header					\$ 2.00
	DNP	Header	1		
		Header	1		
LEDs					\$ 4.38
	RED	LED	3	\$ 0.32	\$ 0.96
	YELLOW	LED	2	\$ 0.39	\$ 0.78
	GREEN	LED	3	\$ 0.88	\$ 2.64
Transistors NPN					\$ 0.66
	MMBT2222	Transistor NPN	3	\$ 0.22	\$ 0.66

	Value	Description	Qty.	Unit \$	Total \$
Resistors					\$ 2.68
	100	Resistor	2	\$ 0.033	\$ 0.07
	240	Resistor	1	\$ 0.033	\$ 0.03
	330	Resistor	4	\$ 0.072	\$ 0.29
	374	Resistor	1	\$ 0.007	\$ 0.01
	866	Resistor	1	\$ 0.072	\$ 0.07
	1.2k	Resistor	1	\$ 0.072	\$ 0.07
	1.5k	Resistor	2	\$ 0.072	\$ 0.14
	10k	Resistor	20	\$ 0.033	\$ 0.66
	1k	Resistor	4	\$ 0.034	\$ 0.13
	4.7k	Resistor	3	\$ 0.072	\$ 0.22
	62K	Resistor	1	\$ 0.072	\$ 0.07
	510 0.5W Resistor		2	\$ 0.460	\$ 0.92
Voltage Regulators					\$ 2.48
		Voltage Regulator	1	\$ 0.83	\$ 0.83
	3.3V	Voltage Regulator	1	\$ 0.73	\$ 0.73
	5V Reg.	Voltage Regulator	1	\$ 0.92	\$ 0.92
ADXL345 - Digital 3-Axis Accelerometer (I2C/SPI)					\$12.32
		ADXL345 - Digital 3-Axis Accelerometer (I2C/SPI)	1	\$ 12.32	\$ 12.32
OBD Connector					\$ 1.11
	Male OBD2		1	\$ 7.99	\$ 7.99
Crystals					\$ 1.32
	16MHz	Crystals	1	\$ 1.32	\$ 1.32
MOSFET					\$ 2.73
	BSS138	MOSFET	4	\$ 0.45	\$ 1.80
	ZXMP6A	MOSFET	1	\$ 0.93	\$ 0.93
Raspberry Pi Zero					\$35.03
	RPI-ZERO	Raspberry Pi Zero W	1	\$ 35.03	\$35.03
					Grand total
					\$75.07