The Wildfire Supplier

BY THE NAVIGATION SENSATION

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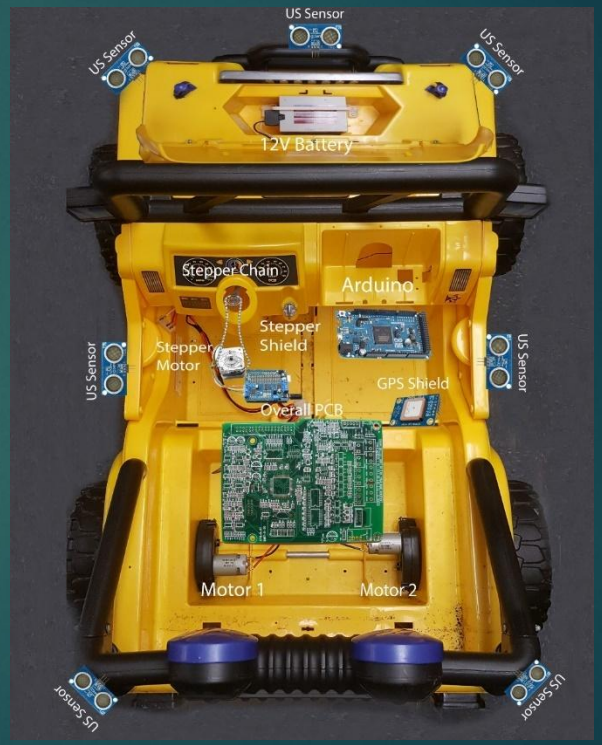
Introduction

- Project Description
  - An Autonomous vehicle that can provide needed supplies to areas that would be inaccessible otherwise
  - Ability to avoid obstacles such as:
    - Path Blockages
    - Ledge detection
    - Fire
- Utilizes GPS and Magnetometer to find destination and calculate a desired heading angle



Market Requirements:

- Must travel 2km (1km each direction)
- Must travel with direction to and be accurate within 10 meters of GPS Point
- Must travel at 1.5km/h
- Must carry payload 15kg
- Must ascend 15% grade
- Must avoid blockages

BOM

Part #	Part Name	Description	Qty	Units	Unit Cost	Cost
AT91SAM3X8E	Arduino Due	Microcontroller	1	Each		
H4807-9993	Chassis + Motors	Powered Toy Car with Motors	1	Each	$15	$15
74777	Battery	12V, 9.5Ah battery for Power Wheel Vehicle	1	Each	$60	$60
42STH38-1684B / 36JX60K51	Nema 17 Motor	Bipolar Stepper Motor	1	Each	$44	$44
HC-SR04	Cytron Technologies Ultrasonic Sensor	A sensor that uses sonar to determine distance to an object	8	Each	$3.95	$31.60
28509	PAM-7Q Parallax GPS Module	GPS Receiver	1	Each	$49.99	$49.99
HMC5883L	Honeywell 3-Axis Digital Compass IC	Magnetometer - Measures the earth's magnetic field	1	Each	$9.95	$9.95
FQP30N06L-ND	Logic Level Power MOSFET	N-Channel MOSFETs for use in motor control	16	Each	$1.12	$15.97
IXTY32P05T	P-Channel Power MOSFET	P-Channel MOSFETs for use in motor control	8	Each	$1.95	$15.60
FQP27P06	P-Channel QFET MOSFET	P-Channel MOSFETs for use in motor control	10	10 Pack	$15.99	$15.99
BC2301-ND	NTC Thermistor	Sensor to measure Temperature	2	Each	$0.69	$1.38
	Wood		1	Each	$7.49	$7.49

BOM

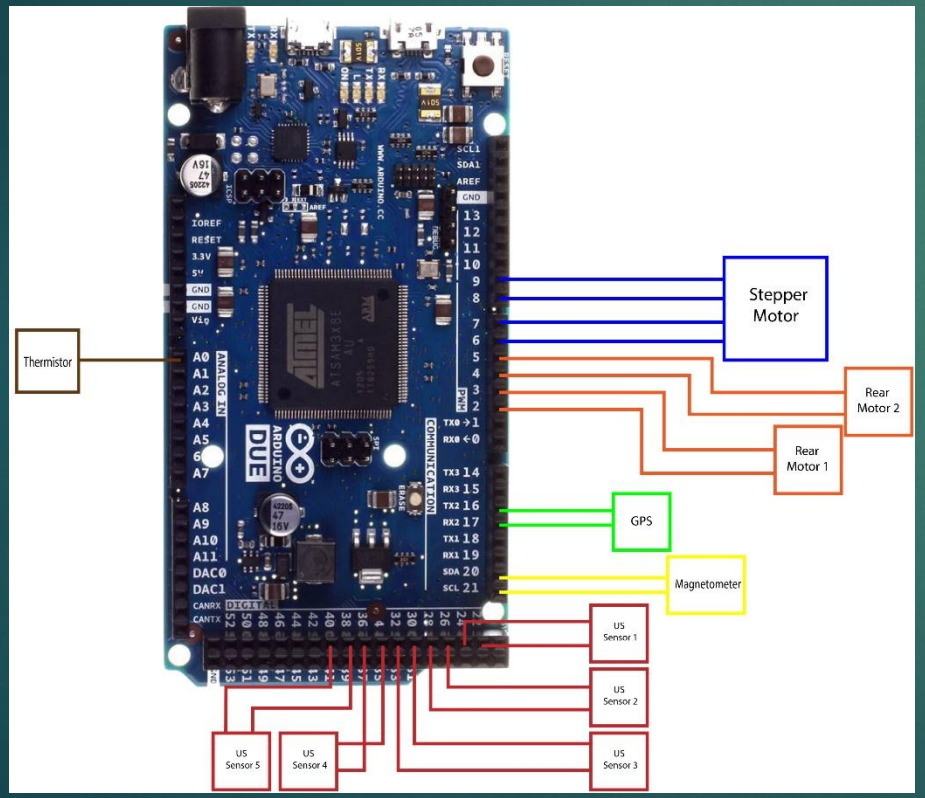
Part #	Part Name	Description	Qty	Units	Unit Cost	Cost
TRM4420_0		Chain for the motor to drive the steering shaft - made for selected sprockets	1	Meter	$5.95	$5.95
TRM4136_0		Sprocket for steering - shaft and back-up	2	Each	$2.80	$5.60
TRM4135_0		Sprocket for the motor shaft	1	Each	$1.85	$1.85
L298N	Motor Drive Controller Board Module	Motor Control IC for Stepper Motor	1	Each	$6.99	$6.99
	Elegoo Multicolored Dupont Wire	Arduino Wires	120	120 Pack	$8.86	$8.86
Total						**$296.22**

Our Prototype

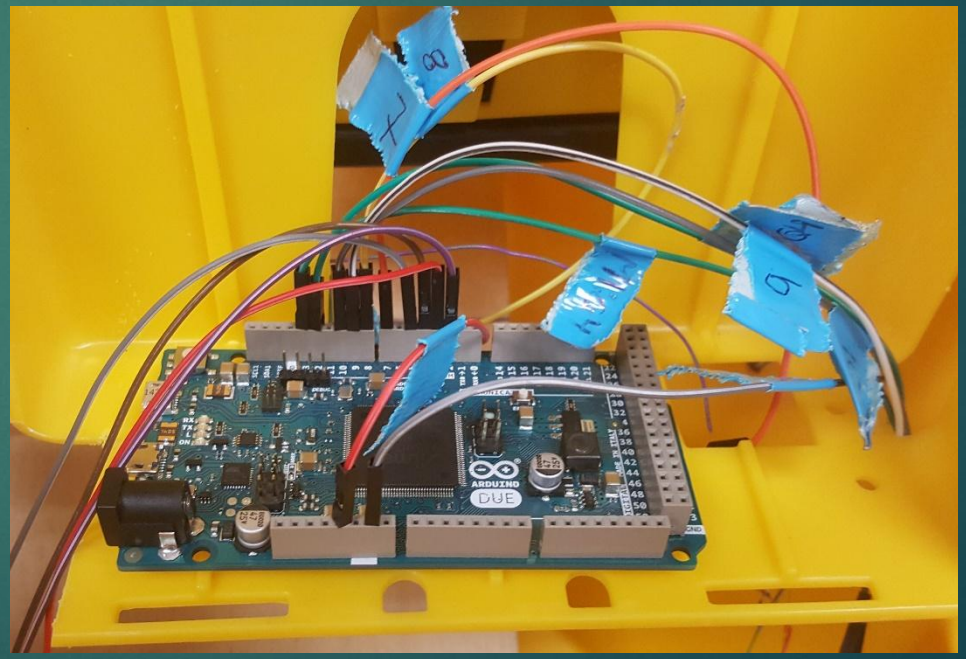
- Size:
  - Length: 115cm
  - Width: 82cm
  - Depth: 52cm
- Weight: 20.2kg
- Number of US sensors: 5
- Bipolar Stepper Motor
- Rear DC Motors
- Battery: 12V, 9.5Ah
  - Power control switch

Arduino Pin Out

Theoretical Pinout

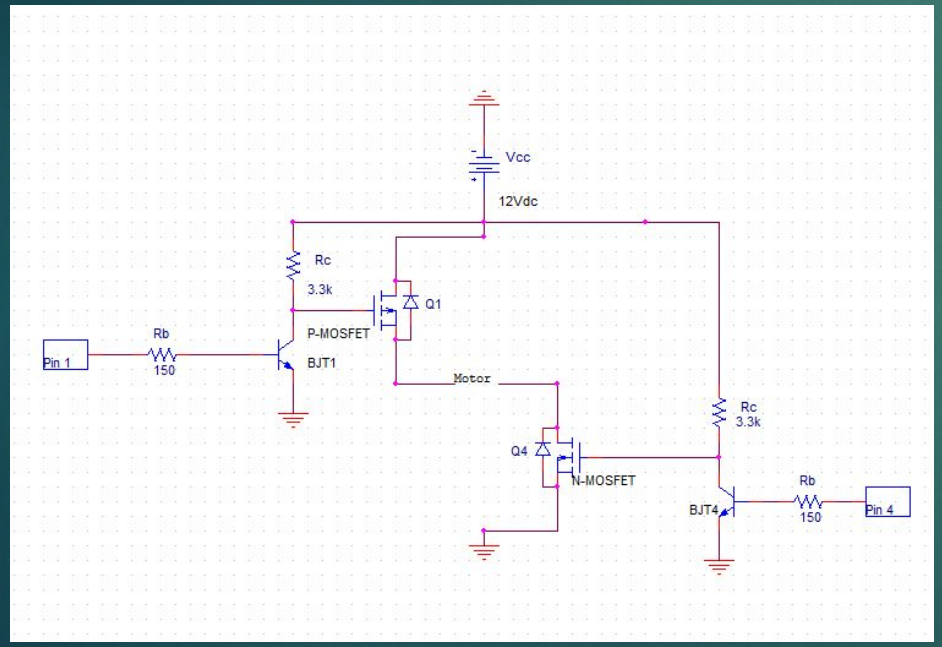


Mounted Arduino

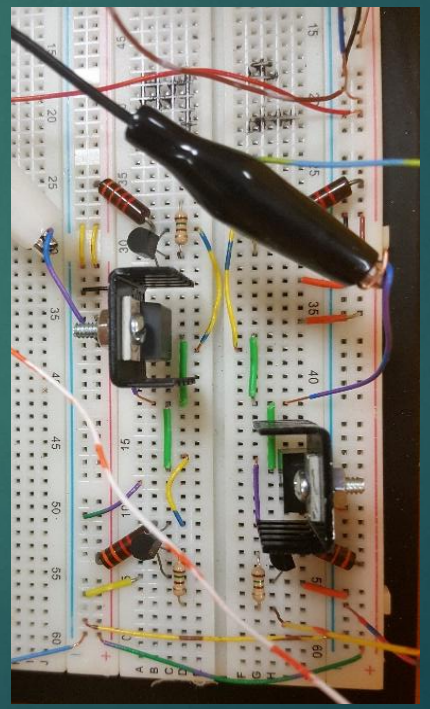


Motor Control

Half H-Bridge Sketch



Half H-Bridge Circuit

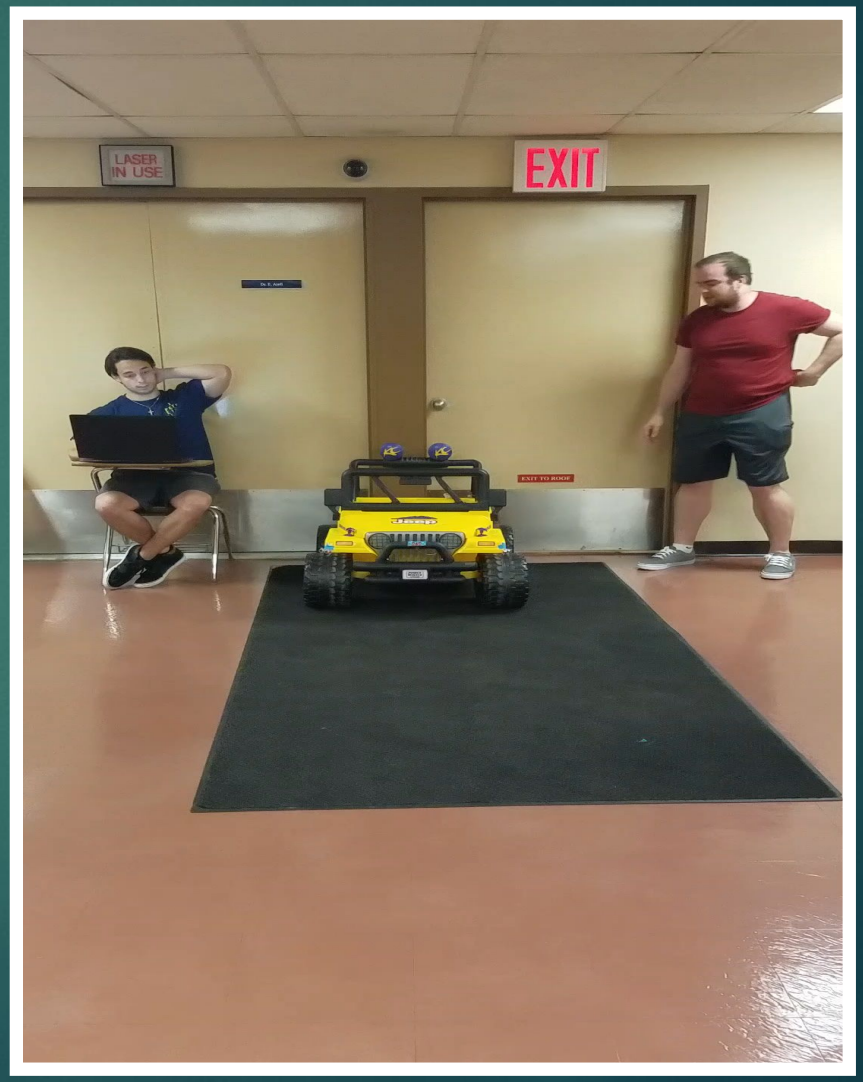


Stepper

- Motor had to be parallel to steering shaft
  - Calculated angle of shaft and cut board according to measurements
  - Placed board in vehicle at the complement of the shaft angle
- Calculated Torque Required: 3.6 N-m
- Stepper sizing: NEMA-17 Bipolar stepper
  - 12V Recommended Voltage, 1.7A Rated Current
  - Motor Torque: 2.94 N-m
  - 0.067° Step Angle
- Torque of motor was stepped up with gear ratio (10:18)

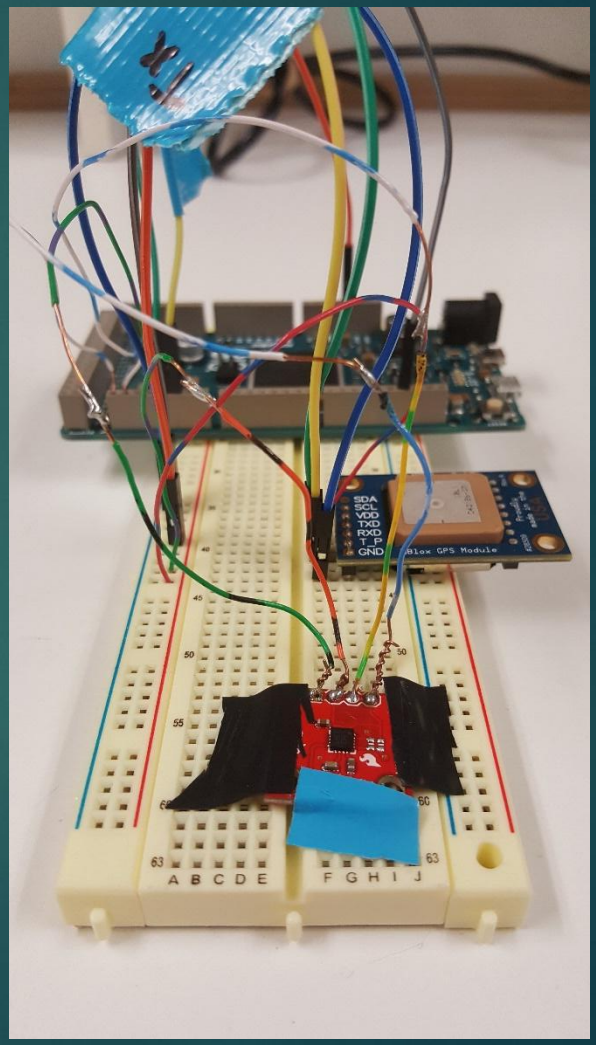
Stepper (Continued)

- Motor controlled through Dual h-bridge motor control board
  - Board Logic Voltage: 5V
  - Drive Voltage: 5V - 35V
  - Max Current 2A Continuous
  - Max Power: 25W

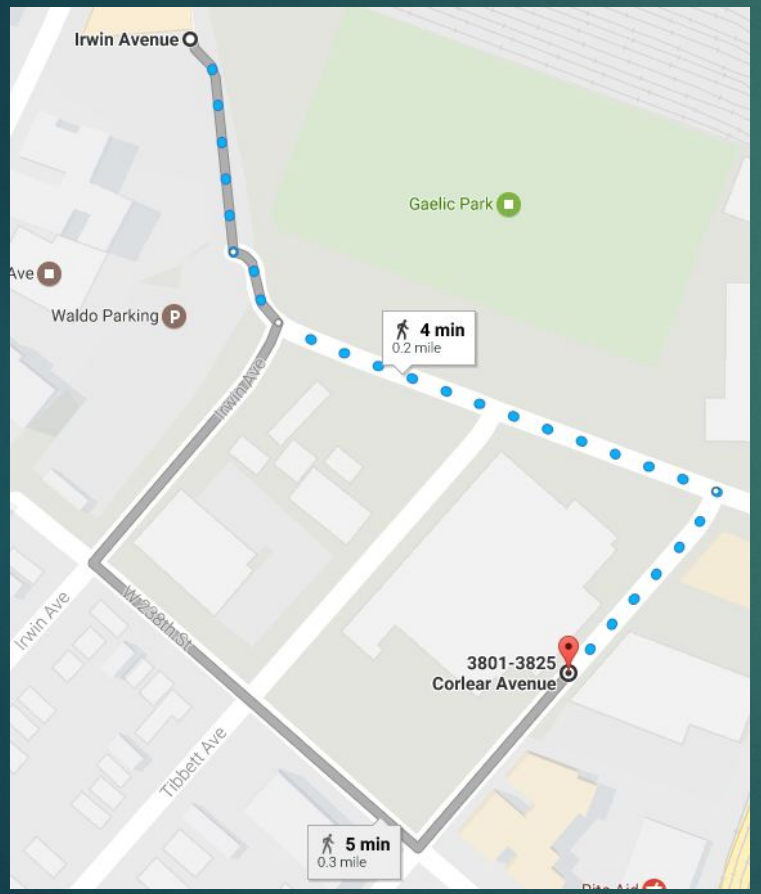


Pathfinding

- GPS
  - Obtains current coordinates
  - Obtain the distance between current fix & destination
- Magnetometer
  - Obtains vehicles direction (in comparison to magnetic north)
- Together these combine to determine if we are on course to reach destination



Pathfinding Test




```
 Current Position:
Lat:
40.88817

Long:
-73.90271

Destination Position:
DestLat:
40.88816

DestLong:
-73.90274
```

Calculated GPS Angle

```
Bearing Angle:
1.81604
```

Calculated Magnetometer Angle

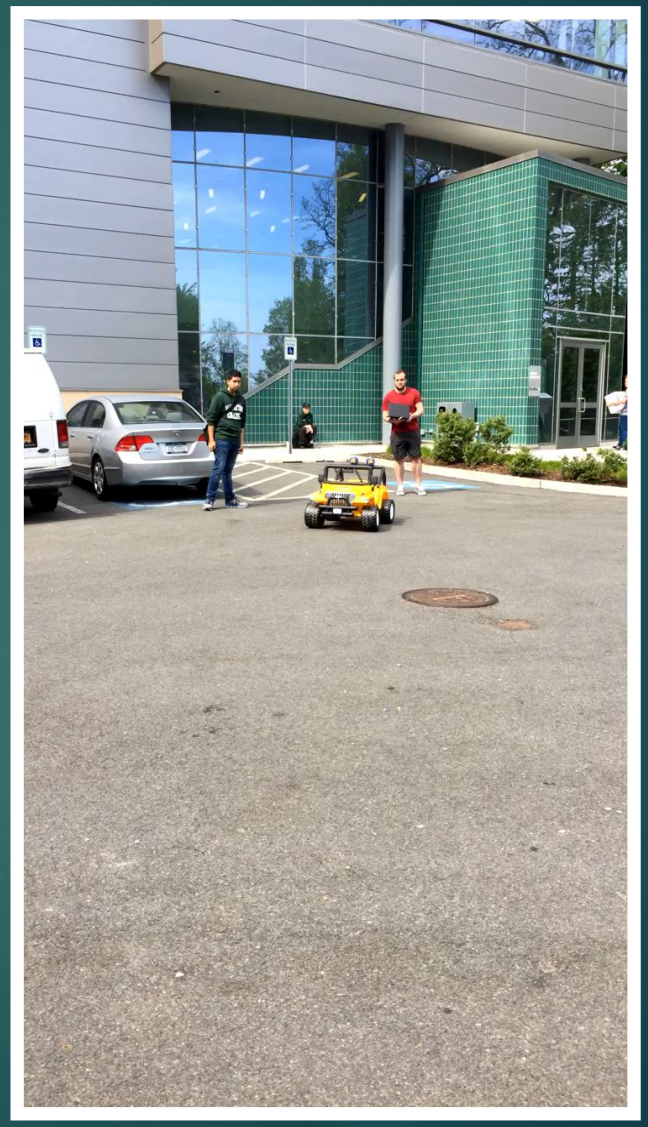
```
Heading (degrees): 127.22800
```

Final needed adjustment

```
Final Heading (degrees): -122.96511
End of 10 iteration program
You are within 10m of your destination
The distance is :
2.73617
```

Object avoidance

- Motor Control
  - Move forward, reverse or brake using a DC motor with an H-bridge configuration
- Steering
  - Turns steering shaft with a stepper motor
- Ultrasonic Sensor
  - Detect objects in vehicles path
- Work together to detect and avoid objects in vehicles path



Ultrasonic Sensor

- Can measure the distance to an object by using sound waves at a specific frequency and listens for that sound wave to bounce back.
- Very accurate, stable and can be used over large ranges.
- $Distance = \frac{speed\ of\ sound\ x\ time\ taken}{2}$, $Speed\ of\ sound = 341 - 344\ m/s$
- Comprised of:
  1. Transmits ultrasonic waves like a speaker
  2. Receives waves like a microphone

Thermistor

- Set in series with a 5% tolerance 10kOhm resistor
- 5V across the Thermistor and Resistor
  - Ambient Temperature is found from Analog voltage read into the Arduino
  - This value changes from the resistance change in the Thermistor
- Change in temperature will effect the accuracy of the US sensors
- Large heat increase will slow the sound wave reverberation

Market Requirements

- Speed test: Distance – 20m

Test	No Load	Load 15.9 kg(35lbs)
1	13.59s	14.25s
2	12.89s	13.33s
3	13.21s	14.10s
4	12.90s	13.26s
5	13.32s	14.15s
6	12.94s	13.28s
Average	13.14s	13.73s
Speed	0.66m/s → 2.37km/h	0.69m/s → 2.47km/h

Market Requirements

Incline Test

Load Test: 15kg

Design issues - Hardware

- H bridge configuration
  - Originally we had 4 N-channel FETs for each bridge
    - This required a lot of extra voltage to turn the top FETs
    - Not a viable solution to have an extra battery just to switch FETs on
  - Then changed to 2 P-channel and 2 N-channel FETs
    - This did not need the extra battery to drive the top FETs
    - Also allowed us to use only two pins from the arduinos
    - Smokeshow
  - 2 P-channel and 2 N-channel FETs → 4 PWM pins + EN switch
    - Isolated each FET and allowed safer operation

Design issues - Software

- Integrating the GPS and Magnetometer Modules
  - Needed to averaged values read in from each module
  - Amended the GPS code to regularly read in the current position
- Receiving False positives when Controlling Motors with Ultrasonic Sensors
  - Tested in Indoor & Outdoor Environments
  - We've constrained the range of operation of the sensors to better suit our needs

Future Improvements

- Wheels are poorly mounted
  - Need to be improved for off-road conditions
  - Plastic Slips on most surfaces
- Turning
  - Stepper Motor cannot handle the load
  - Axle needs to be mounted properly
- US sensors return false positives
  - Lack accuracy in the multi-sensor triggering algorithm
  - Thermistor would be integrated
- Axle limits need to be hardware reactive
  - Limit switches
    - Provide closed loop feedback to the current stepper position

Thank-you