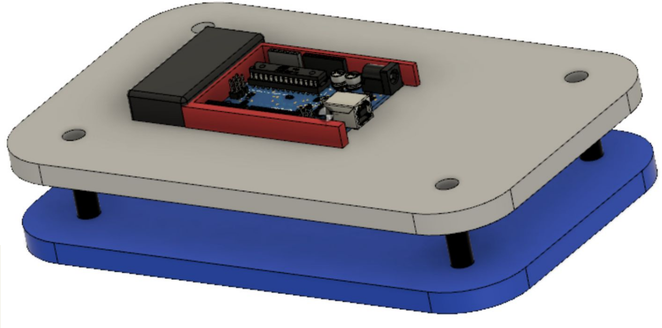
Crash Site Milestone 2

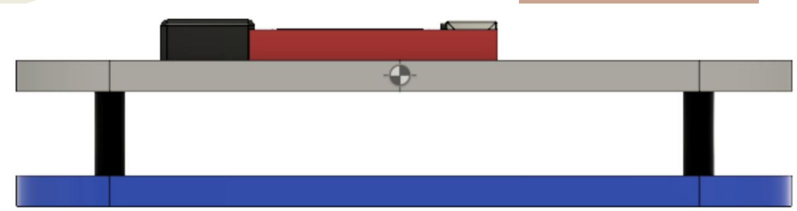
Team Johnny Crash

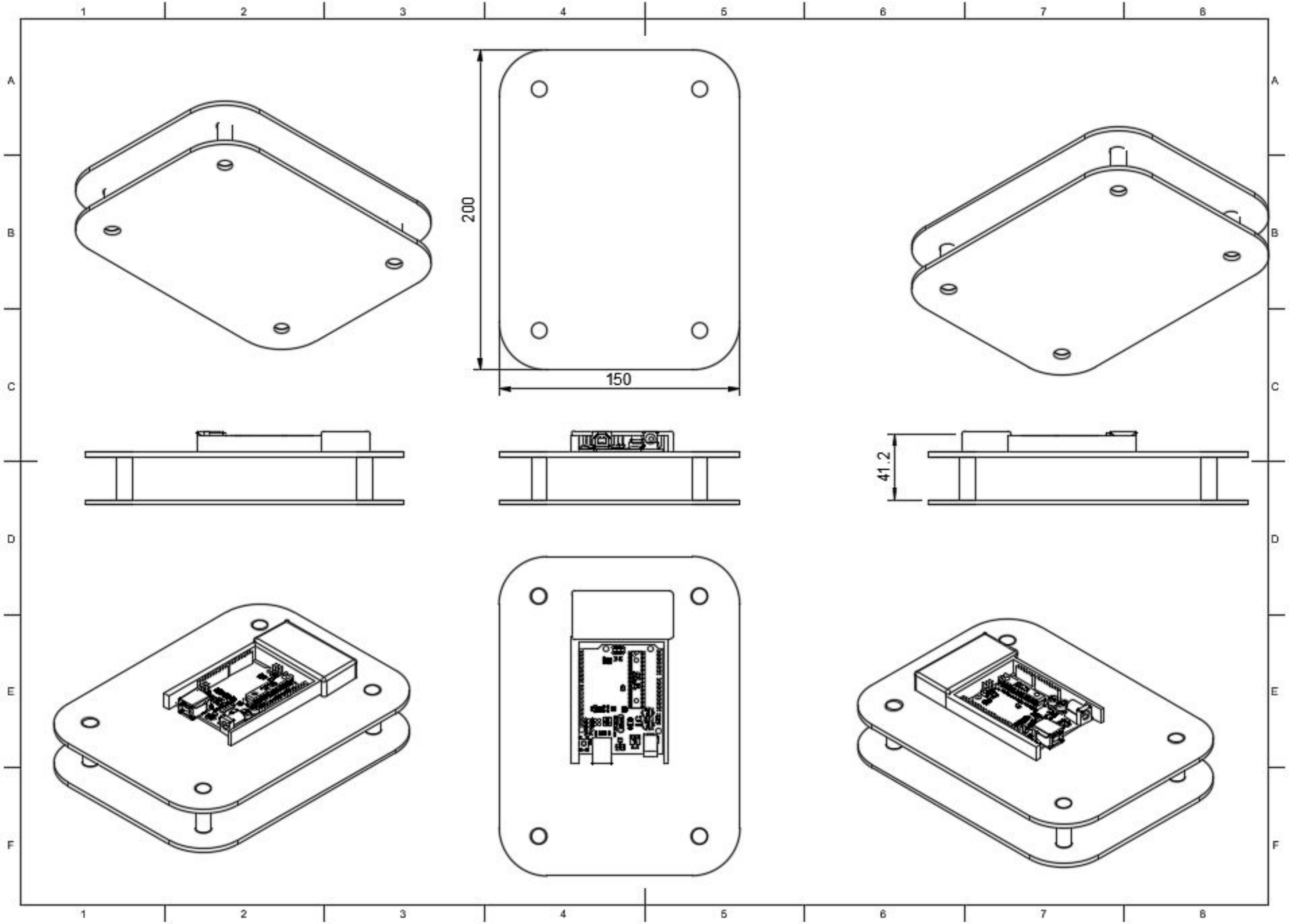
ENES100 Section 0502

Chassis

- Total width must be <250mm to pass on the side between wall and obstacles
- Rectangular, laser-cut
  - plywood (top)
  - acrylic (bottom)
- Filleted edges to prevent OTV from getting stuck
- Chassis dimensions: 150x200x47mm
- Chassis estimated mass of 233.5 g
- OTV estimated mass of 1185.6 g

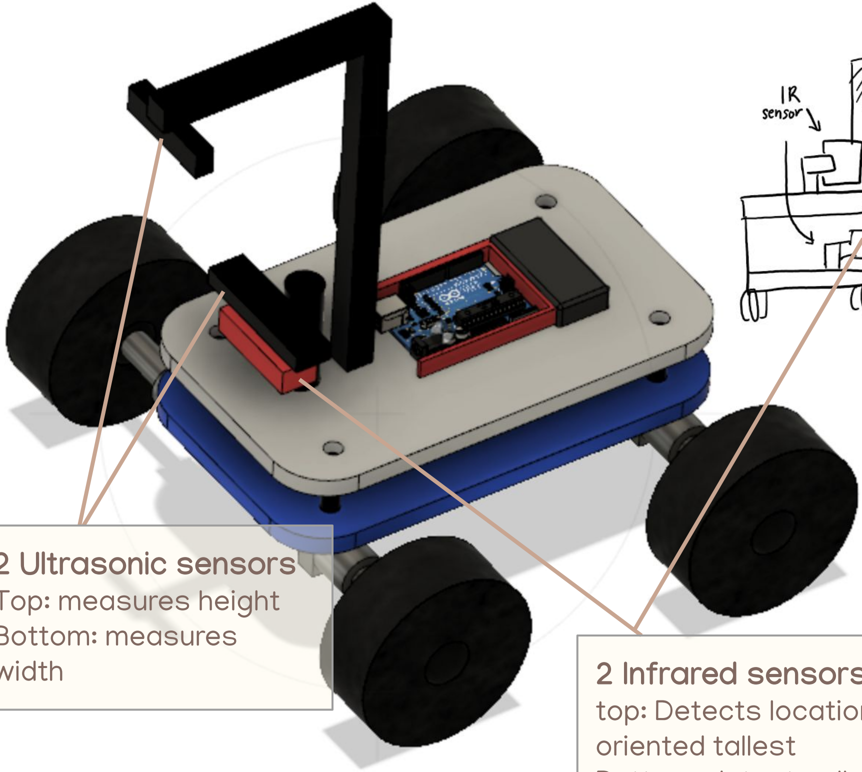


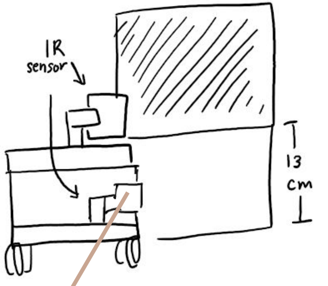


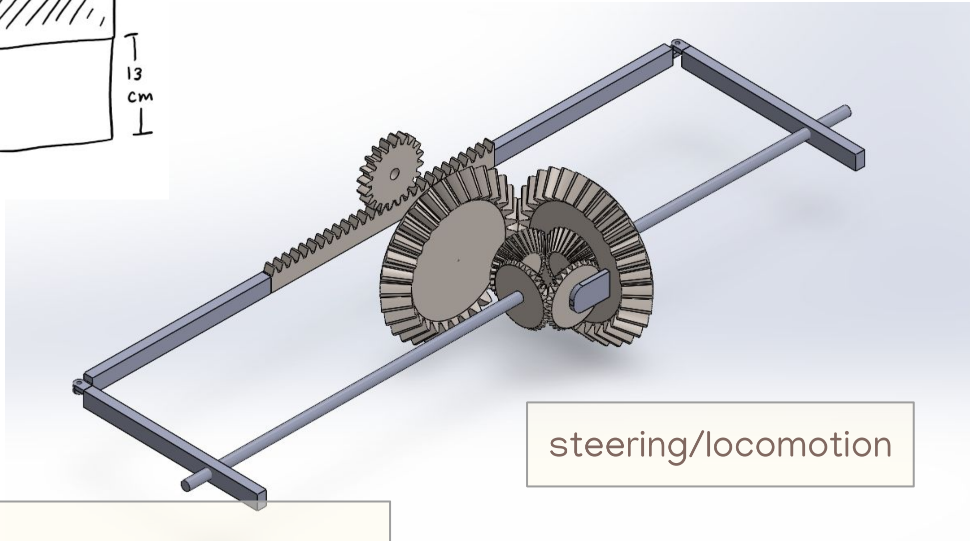


1
2
3
4
5
6
7
8
A
B
C
D
E
F
200
150
41.2

CAD Model







2 Ultrasonic sensors
Top: measures height
Bottom: measures width

2 Infrared sensors
top: Detects location of missing part if box is oriented tallest
Bottom: detects all sides at minimum height

steering/locomotion

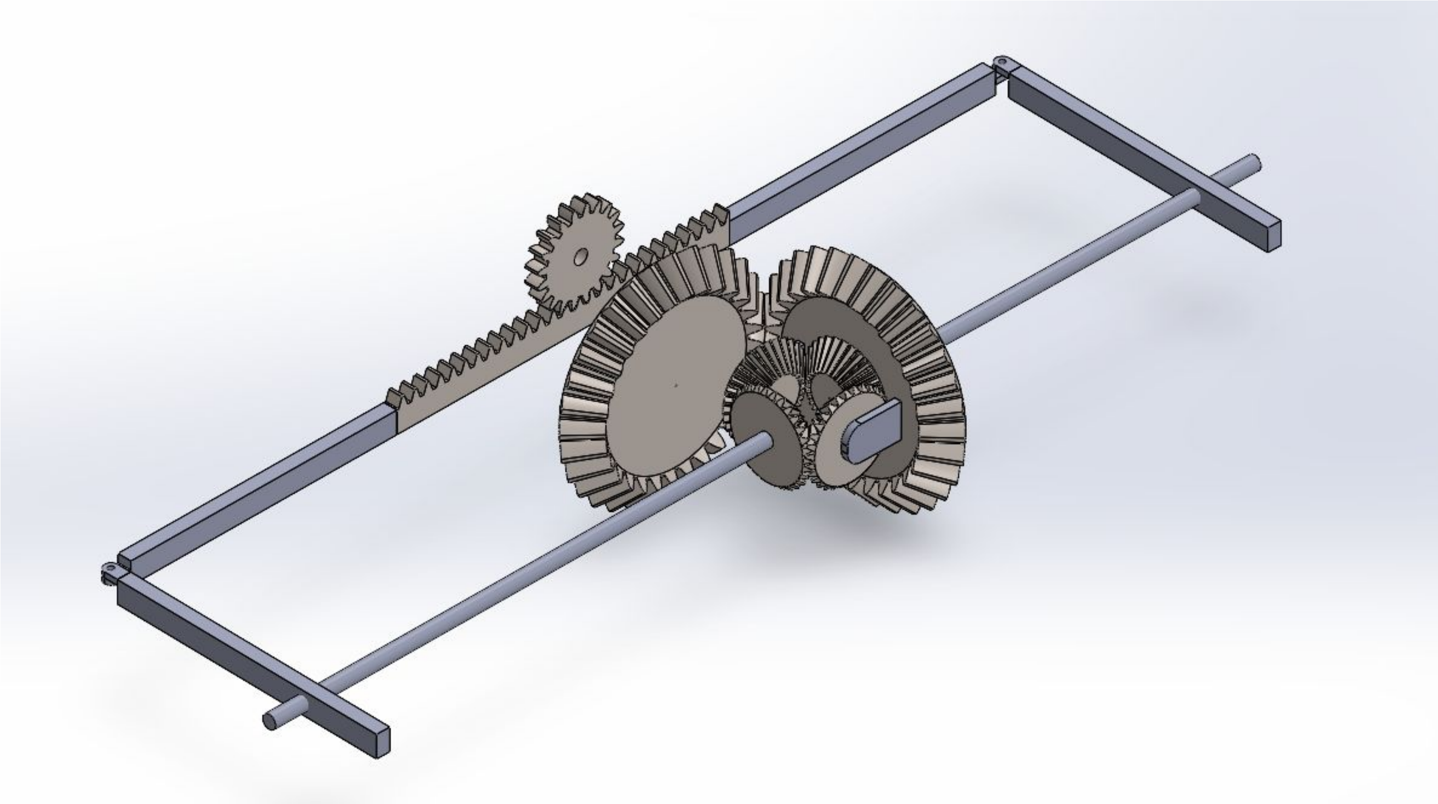
Propulsion

Requirements:

- Moving the vehicle around the crash site to survey which side is abnormal
- Moving past the obstacles and getting over the log
- Completing the mission and course under 5 minutes

Challenges:

- Finding suitable mechanical elements for the OTV that would allow the vehicle to complete the requirements



Calculations for Motors

For steady, flat driving:

$F_{RR} = (0.01)(24.5N) = 0.245N$
$\tau = (0.245N)(4.9cm) = 1.2005N\text{–}cm$
$1.2005N\text{–}cm / 2$ motors = $0.6003N\text{–}cm$

$m = 2.5$ kg
$r = 4.9$ cm
$C_{RR} = 0.01$

To get over log:

$\theta \approx 60^\circ$
$m = 1.0$ kg (over 1 axle)
$r = 4.9$ cm
$C_{RR} = 0.001$

$$F_{TF} = mg\cos\theta = (1\text{ kg})(9.81 m/s^2)(\sin 60^\circ) = 8.50\text{ N}$$

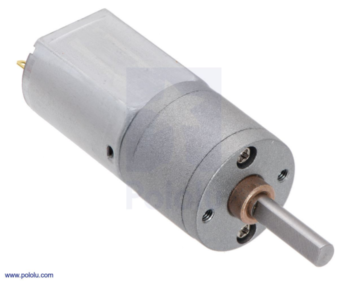
$$F_{RR} = mg\sin\theta C_{RR} = (1\text{ kg})(9.81 m/s^2)(\cos 60^\circ)(0.001) = 0.0049\text{ N}$$

$$F_{TE} = F_{TF} + F_{RR} = 8.50\text{ N} + 0.0049\text{ N} = 8.5049\text{ N}$$

$$\tau = F_{TE} r = (8.5049N)(4.9\text{ cm}) = 41.67\text{ N–cm}$$

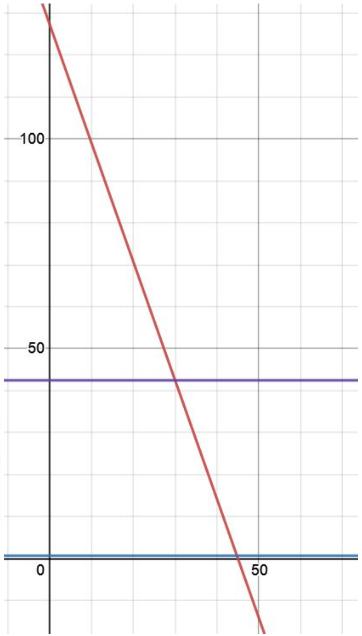
Motor

313:1 Metal Gearmotor 20Dx46L mm 6V CB

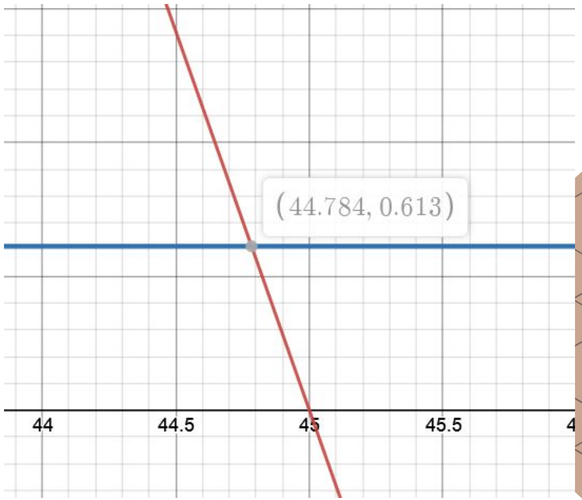


voltage	no-load performance	stall extrapolation
6 V	45 RPM, 150 mA	13 kg·cm (180 oz·in), 2.9 A

Mass: 47 g



τ(N–cm) (x–axis) vs. ω(RPM) (y–axis)



ω = ((44.784 RPM)(2π rad)) / 60s = 4.69 rad/s

V = (4.69 rad/s)(0.049m) = 0.230m/s

Torque to overcome log (purple) and flat driving torque (blue line) shown. Flat driving torque results in reasonable linear velocity of 0.234m/s.

Other Elements

Stepper Motor

Stepper Motor: Bipolar, 200 Steps/Rev, 35×36mm, 2.7V, 1 A/Phase

- For steering
- Voltage rating: 2.7 V
- Mass: 180 g

Wheels

1:10 RC Rock Crawler 1.9 Inch Rubber Tires 98MM for Axial SCX10 Tamiya CC01 D90 TF2

- Tire Diameter: 98 mm
- Material: Rubber and plastic (rim)
- Mass: 266.5 g

Power

Requirements

- The battery must last long enough to power the vehicle fully for 10 minutes, must also not be lithium or lead acid.

Challenges

- Considering all the different components and finding a battery that can power the system and also has a capacity to last long enough without charging

6-Cell AA 7.2V Battery Pack with SM-2P Plug 2000mAh Ni-MH High Capacity

Consumption and Run Time:

- Motors: 300mA
- Stepper motor: 1000mA
- Arduino: 50mA
- Other components: 1134mA
- Total: 2484 mA

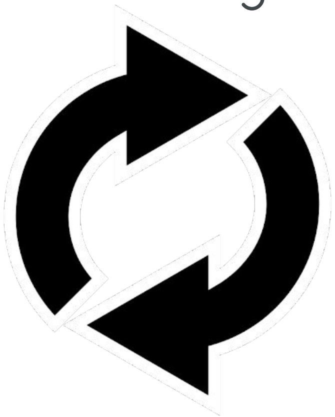
Capacity of battery: 2000mAh
Capacity = (Current)(Time)
2000 mAh = (2484 mA)(T)
T = 0.81 hrs (estimated time battery can power OTV before recharging)

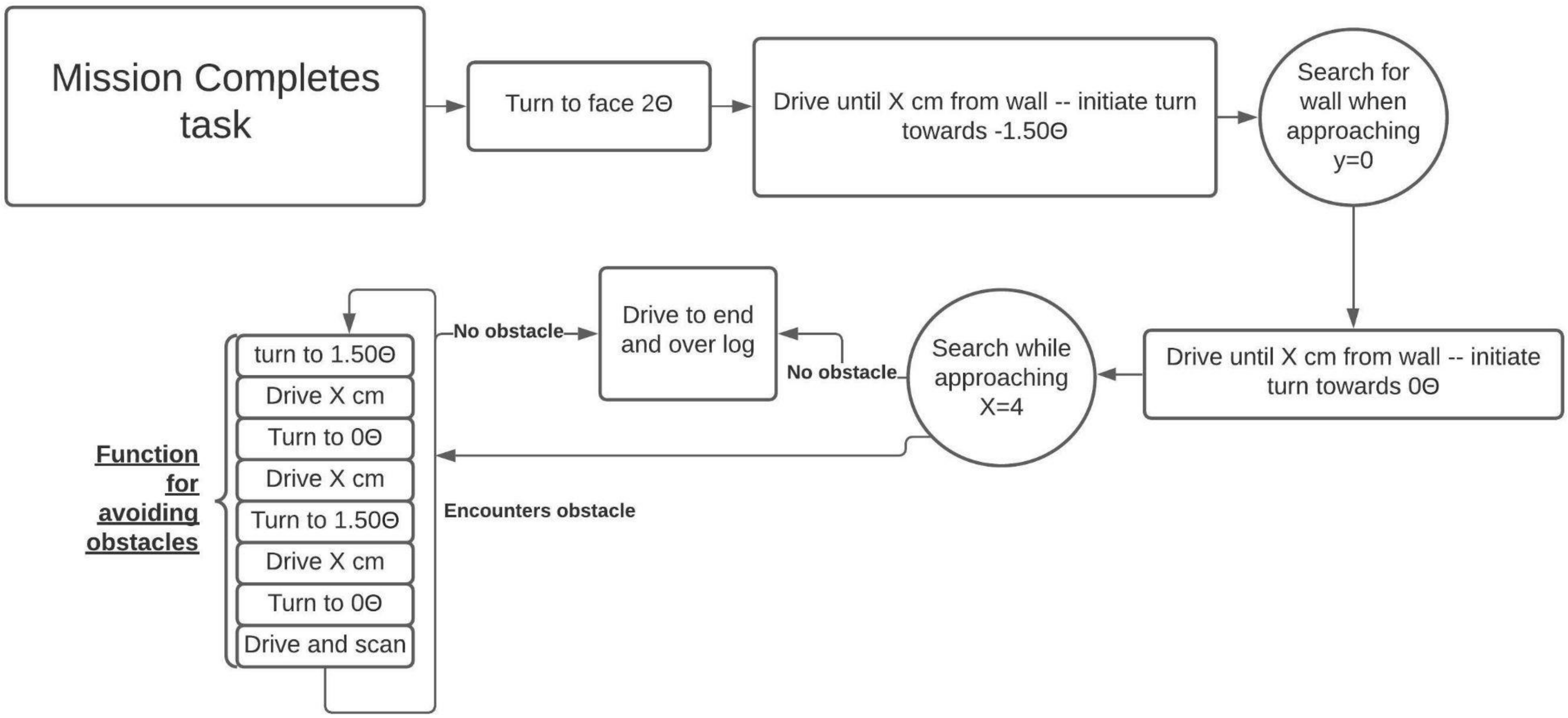
Navigation (sensor)

- **Requirements:** We must reach the end of the arena without collision into the obstacles or walls.
- Programming the OTV to be self operational throughout the entire mission
- **Challenges:** Writing a program well enough for the OTV to be able to independently navigate the course. Including differentiating walls from obstacles and the log or limbo bar.
- **Justification for design choice:** We plan on making our OTV of a certain width to navigate between the wall of the arena and the obstacles.
- We will have one singular ultrasonic sensor located at the front of the OTV to identify the walls, obstacles log.

Navigation (coding)

- Multiple functions for turning- can be easily called at any time
- Loops allow sensor inputs to be constantly monitored and processes like turning and obstacle avoidance to be repeated as needed
- Theta inputs from vision system will be used to aid in orienting robot and will be crucial with turning functions
- Flowchart demonstrates ideal logic path as robot navigates to end zone




Mission Completes task
Turn to face 2Θ
Drive until X cm from wall -- initiate turn towards -1.50Θ
Search for wall when approaching y=0
Drive until X cm from wall -- initiate turn towards 0Θ
Search while approaching X=4
No obstacle
Drive to end and over log
No obstacle
Encounters obstacle
turn to 1.50Θ
Drive X cm
Turn to 0Θ
Drive X cm
Turn to 1.50Θ
Drive X cm
Turn to 0Θ
Drive and scan
Function for avoiding obstacles

OTV Mission

Mission Requirements and Challenges:

- After navigating to the site, we must first find out which side contains the abnormal panel. From there, we must figure out the width and height of the side along with placing an aruco marker on the side with the abnormality.

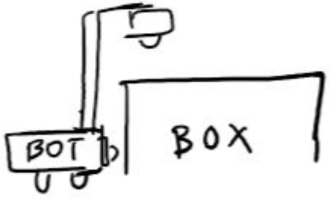
Justification:

- height ultrasonic sensor: simple design with little to no chance of error.
- width ultrasonic sensor: efficient design, combining with navigation to limit the number of pins we will occupy.
- infrared sensors: needed to identify the abnormal side.
- pole: plastic to act as a light but sturdy way to support the ultrasonic sensor that we use for height.

Apparatus: Ultrasonic

ULTRASONIC SENSOR 1

- used for height measurement.
- placed at height $h > 27$cm, facing straight down (–z)
- use the height of the sensor minus the distance between sensor and top of box to find height



ULTRASONIC SENSOR 2

- used for width measurement
- placed on front side of vehicle on a mount along with infrared sensor (the side we want facing crash site)
- can detect when we reach desired distance from crash site + widths of possible sides

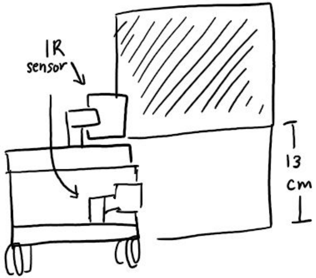
Apparatus: Infrared

INFRARED SENSOR 1

- Placed higher than 13 cm from the ground
- Accounts for the chance the wreckage is placed with its longest side as the height.

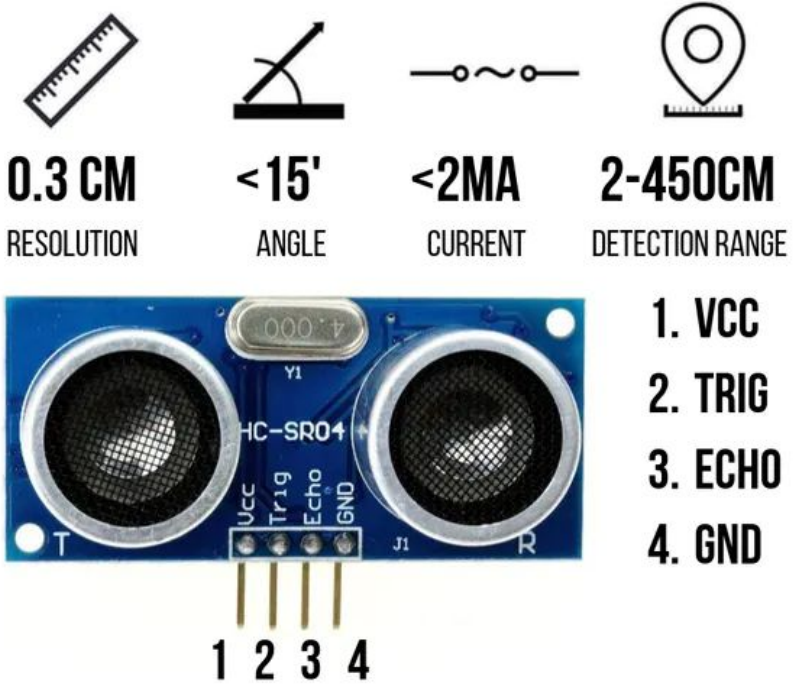
INFRARED SENSOR 2

- Placed at a point from (0,13) cm from the ground.
- Will always be able to scan a side of the wreckage.



Sensor Range & Resolution

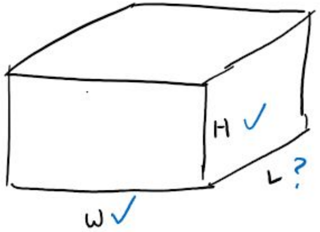
Ultrasonic



Infrared

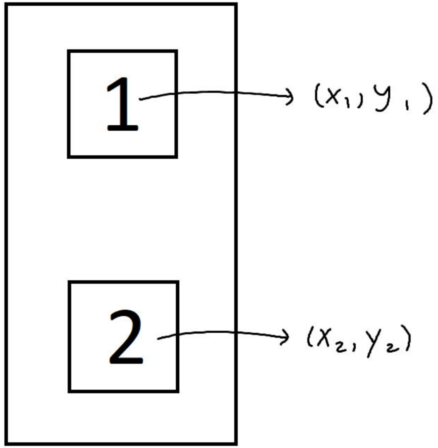
- 5 mm optimal range
- 30 mm max range
- outputs a value representing the reflectivity of given surface

What about length?

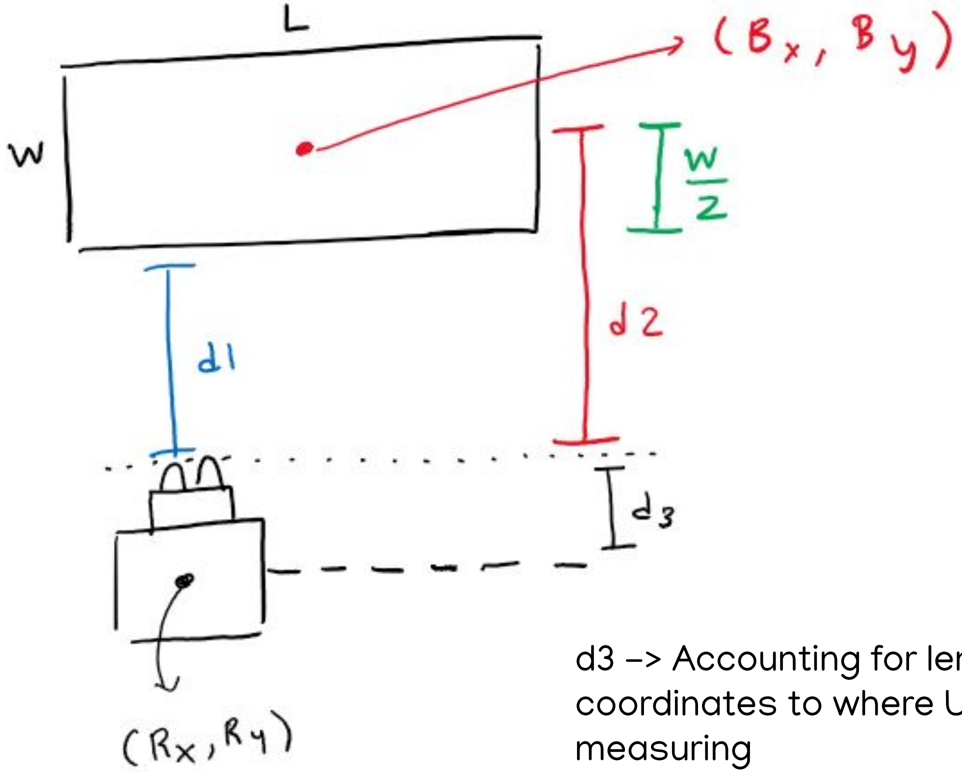


- We only measure the width and the height, not length.
- Volume of the box is a constant. (V = W * L * H)
- Determining W and H is enough to find L.
- Dimensions:
    - 26.5 cm
    - 14 cm
    - 19 cm
    - V = 7049 cm^3

Control Algorithm Background

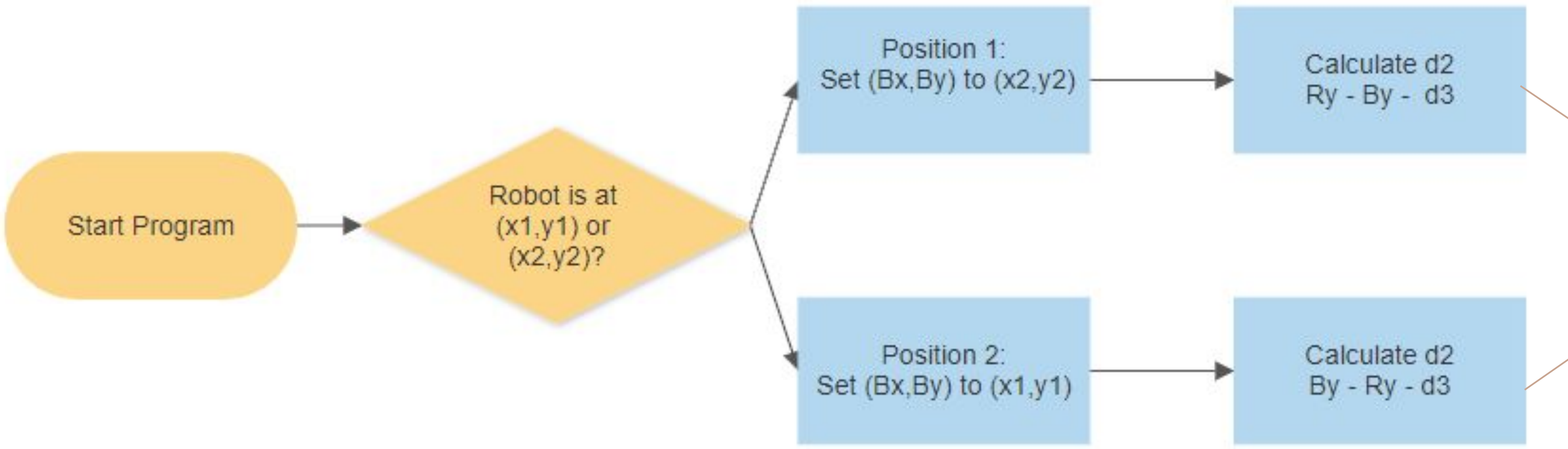


x1 = x2
(x1,x2) and (y1, y2) are known coordinates!

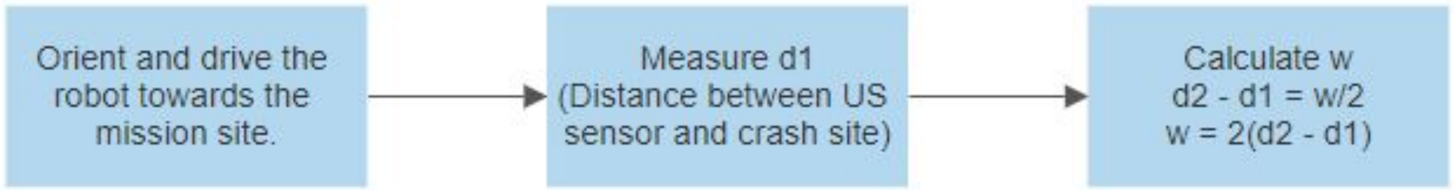


d3 –> Accounting for length from robot coordinates to where US sensor will be measuring

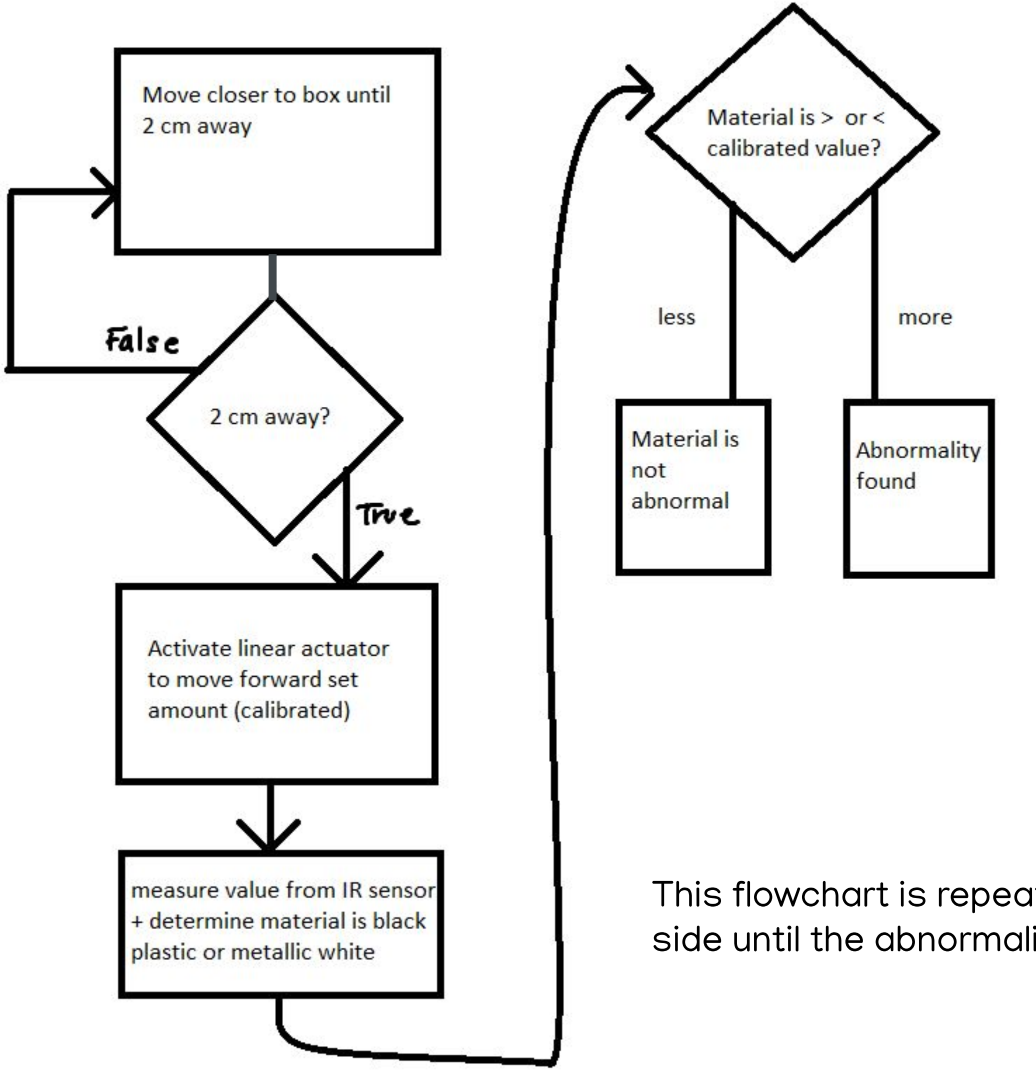
Control Algorithm Flow Chart: Width Pt. I



Control Algorithm Flow Chart: Width Pt 2



Control Algorithm Flowchart: Finding Abnormal Side



This flowchart is repeated for each side until the abnormality is found.

Things to Consider

- Accuracy of the infrared sensor
  - Solution: Calibration
  - Potential Solution: Linear actuator
- The ultrasonic sensor sometimes gives erroneous values (such as 100 cm when there is an object 20 cm away).
  - Solution: Write a function that filters the outliers.

Systems Integration Plan

Mission will collaborate with Structure in order to attach required sensors onto the chassis.

Locomotion and Structure will collaborate to make sure the wheels can rotate properly within the chassis.

Locomotion and Navigation will work together to figure out the needed rolling resistance values to overcome the log.

Mission and Navigation will work together to make sure sensors can be used to achieve both teams' goals.

Risk Analysis

	Risk	Solution
Locomotion Integration Risk: Chosen materials may not be enough to overcome rolling resistance to go over the log	LOW	Identify problem early and figure out better materials
Navigation Integration Risk: Coordinate system might not be accurate enough	MEDIUM	Implement a different coding strategy to alleviate the wrong/missing coordinates
Mission Integration Risk: The pole is too heavy or high so that the OTV may flip over the log when attempting to climb.	HIGH	Change pole material, implement different design to move center of mass.
Structure: Chassis gets stuck on side of wall while maneuvering the obstacles.	MEDIUM	Reevaluate chassis shape, find a different strategy to avoid obstacles besides hugging wall

Pin Assignments

Analog

A0 Ultrasonic Sensor 1
A1 Ultrasonic Sensor 2
A2 Infrared Sensor 1
A3 Infrared Sensor 2
A4 --

Digital (PWM ~)

D0 --
D1 --
D2 --
D3 ~Motor Controller #1
D4 Motor Controller #2
D5 ~Motor Controller #1
D6~Motor Controller #1
D7 Motor Controller #2
D8 Motor Controller #2
D9 ~Motor Controller #1
D10 ~
D11~
D12 Motor Controller #2
D13 --

Preliminary Bill of Materials

Item	Mass (g)	Approval	Quantity	Cost
Arduino Ultrasonic Sensor	2	✅	2	--
Pololu QTR Reflectance Sensors	0.6	❓	2	$2.12
Motor	47	✅	2	$21.95
Stepper Motor	180	❓	1	$17.95
Battery + Charger	125	✅	1	$20.49
Wheels (pack of 4)	266.4	✅	1	$23.90
Motor Controller	50	✅	1	$22.99
Extra material costs (wood, metal, 3d printing)	233.5	✅		
Total	952.1			$133.47

Questions?

Teamwork

How does this design reflect the team's goals and interests?

The design is a result of each subteams' work and collaboration between subteams to make sure all parts of the OTV work together while satisfying the goal for each subteam.

How is the team drawing on individual strengths?

Team members with more experience in a specific aspect of the OTV / mission will be guide the team.

How is the team advancing individual growth?

Each subteam deals with specific problems that they will have to overcome, learning something in the process.