Black Box

Milestone 1

Team LOST: Shahed Bader, Atticus Cameron, Anjali Dhamsania, Bebo Harraz, Nicole Kwok, Vladimir Leung, William Mah, Nicholas Ruei, Julia Zhiteneva

Overview

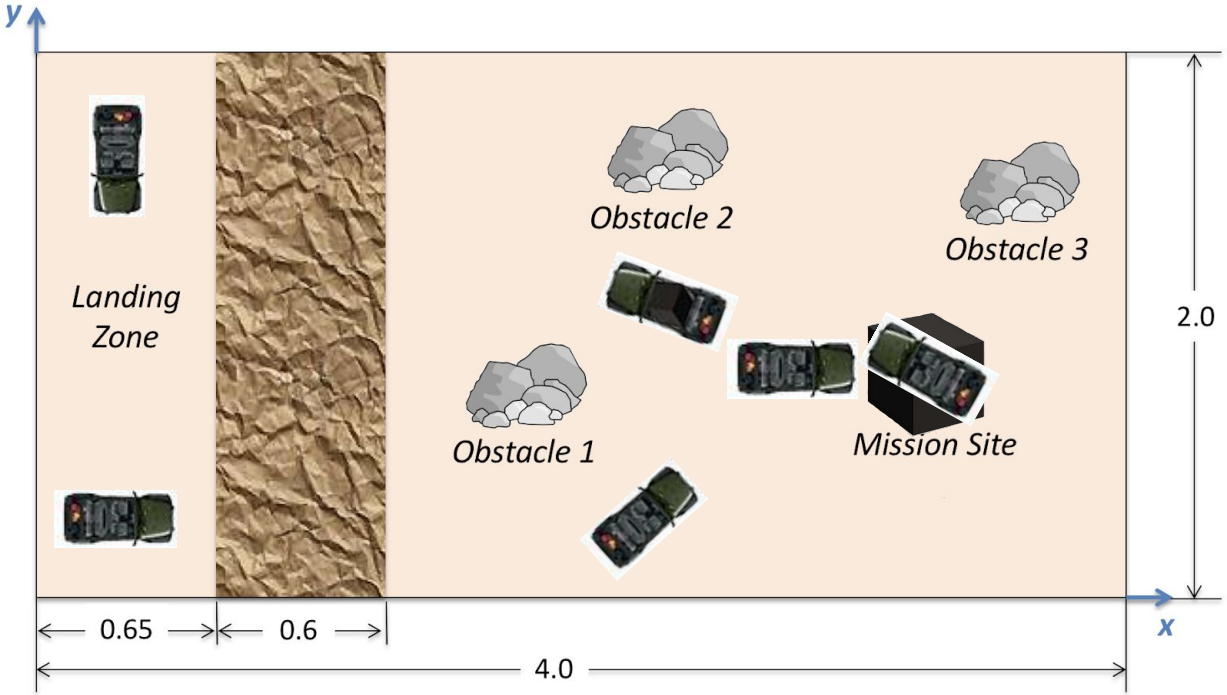
- Mission Objectives
- Team Organization
- Gantt Chart
- Design Concept & Calculations
  - Subsystems: structure, propulsion, drivetrain, steering, power, mission performance, navigation, sensors, communication, controls, and programming
- Expected Bill of Materials
- Expected Mass Chart
- Anticipated Problems + Solutions

Mission Objectives

- Navigate to within 250 mm of the black box locator beacon
- Measure and transmit the coordinates of the black box

<u>Advanced Objectives</u>

- Acquire the black box by lifting it entirely off of the sand
- Deliver the black box to the landing zone



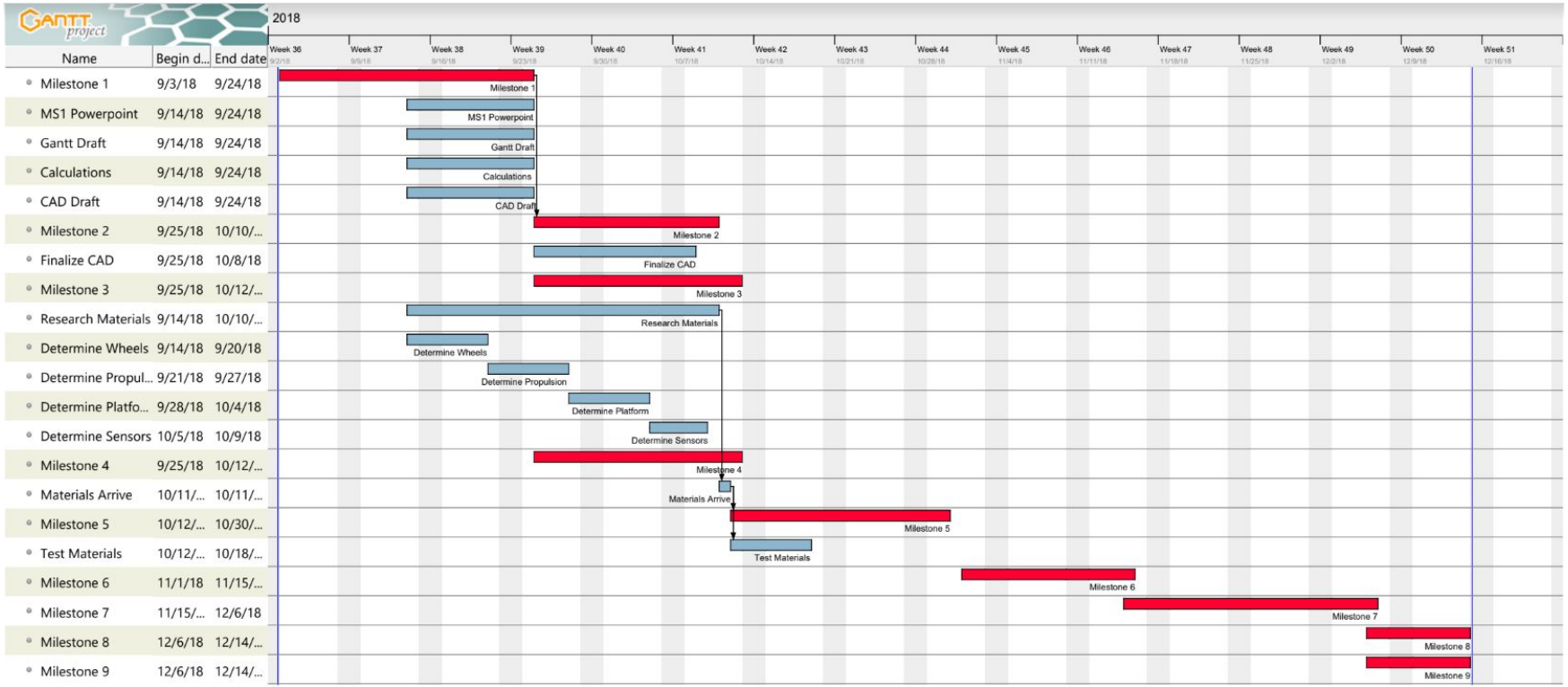
Team Organization: Roles

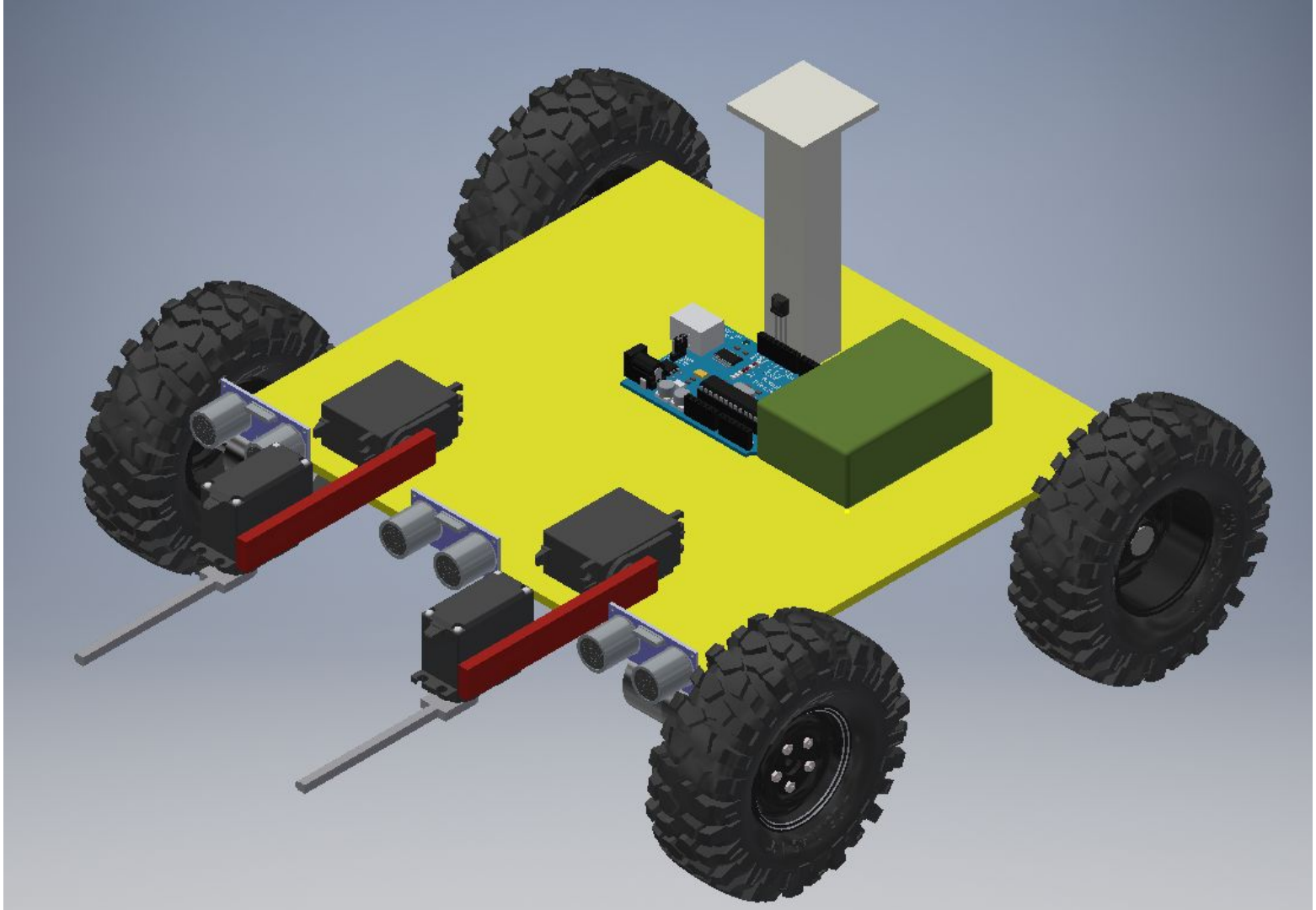
- Team Leaders: Bahaa Harraz, Vladimir Leung
- Programming: Bahaa Harraz
- Circuitry: Vladimir Leung, Anjali Dhamsania
- Design/CAD: Nicole Kwok, Atticus Cameron
- Structure/Building: Nicholas Ruei, William Mah
- Mission Performance: Julia Zhiteneva, Shahed Bader

Team Organization: Meeting Arrangements and Communication

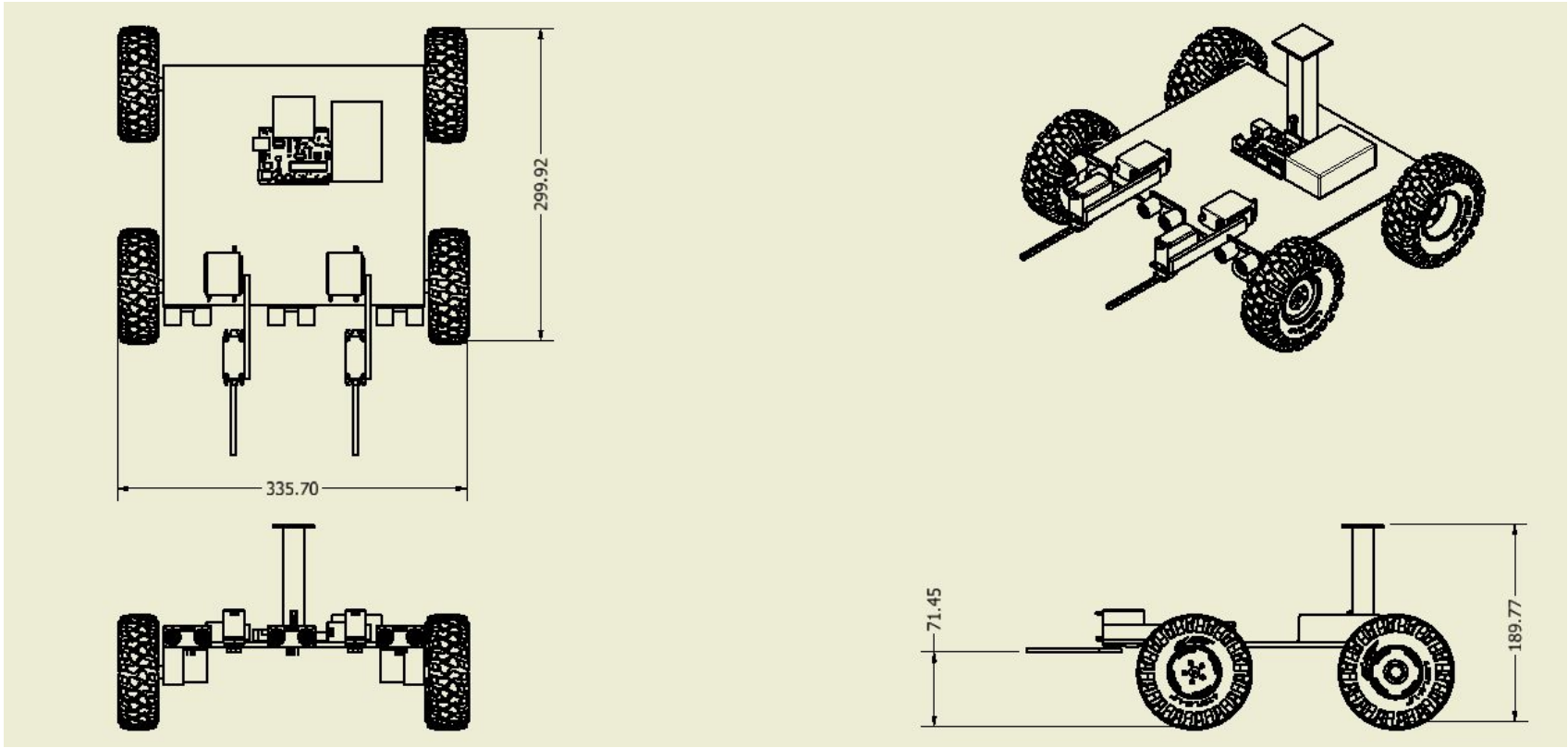
- Meeting Times:
  - Fridays 10-12
  - Second meeting after class on Wednesday
- Team GroupMe
- Advance notification of absences
- Place all purchase receipts into a shared folder
- Decision Making:
  - All decisions are arguable
  - In event of a disagreement, the majority opinion takes precedence
  - If a group member is absent, decisions are made by remaining members

Gantt Chart


2018
Week 36
Week 37
Week 38
Week 39
Week 40
Week 41
Week 42
Week 43
Week 44
Week 45
Week 46
Week 47
Week 48
Week 49
Week 50
Week 51
Name
Begin d...
End date
Milestone 1 9/3/18 9/24/18
MS1 Powerpoint 9/14/18 9/24/18
Gantt Draft 9/14/18 9/24/18
Calculations 9/14/18 9/24/18
CAD Draft 9/14/18 9/24/18
Milestone 2 9/25/18 10/10/...
Finalize CAD 9/25/18 10/8/18
Milestone 3 9/25/18 10/12/...
Research Materials 9/14/18 10/10/...
Determine Wheels 9/14/18 9/20/18
Determine Propul... 9/21/18 9/27/18
Determine Platfo... 9/28/18 10/4/18
Determine Sensors 10/5/18 10/9/18
Milestone 4 9/25/18 10/12/...
Materials Arrive 10/11/... 10/11/...
Milestone 5 10/12/... 10/30/...
Test Materials 10/12/... 10/18/...
Milestone 6 11/1/18 11/15/...
Milestone 7 11/15/... 12/6/18
Milestone 8 12/6/18 12/14/...
Milestone 9 12/6/18 12/14/...



Dimensions



Calculations at 0 Degrees

F_N = normal force
F_g = Force of gravity = (2.50)(9.81) = 24.5 N
C_{RR} = coefficient of rolling resistance
F_{RR} = force of rolling resistance
F_{sf} = force of static friction
TE = tractive effort
τ = torque
ω = angular velocity
r = radius of the wheels = 5.00 cm
w = width of the wheels = 3.60 cm
d = diameter of the wheels = 10.0 cm
μ = Coefficient of static friction = 0.700

$$F_N = \frac{F_g}{4} = \frac{2.50(9.81)}{4}$$
$$= 6.13\ N\ on\ each\ wheel$$

$$C_{RR} = \left[3.33\ x\ \left(\frac{6.13}{3.60(10.0)^2}\right)\right]^{1/3} = .384$$

$$F_{RR} = C_{RR} \cdot F_N = (.384)(6.13) = 2.35\ N$$

$$F_{sf} = \mu \cdot F_N = (0.700)(6.13) = 4.29\ N$$

$$F_{RR} < TE < F_{sf} \rightarrow \boxed{2.35\ N < TE < 4.29\ N}$$

Calculations at 35 Degrees

- $F_N = \frac{F_g \cos(35)}{4} = \frac{2.50(9.81)\cos(35)}{4} = 5.02\ N\ on\ each\ wheel$
- $C_{RR} = \left[3.33\ x\ \left(\frac{5.02}{3.60(10.0)^2}\right)\right]^{1/3} = 0.359$
- $F_{RR} = C_{RR} \cdot F_N = (.359)(5.02) = 1.80\ N$
- $F_{sf} = \mu \cdot F_N = (0.700)(5.02) = 3.51\ N$
- $F_{RR} < TE < F_{sf} \rightarrow$ $1.80\ N < TE < 3.51\ N$

Calculations

@0	$2.35\ N < TE < 4.29\ N$
@35	$1.80\ N < TE < 3.51\ N$
Combined	$2.35\ N < TE < 3.51\ N$

TORQUE	$\tau = \mathrm{r} \times \mathrm{F}$
@0	$11.75\ N \cdot cm < \tau < 21.45\ N \cdot cm$
@35	$9.00\ N \cdot cm < \tau < 17.55\ N \cdot cm$
Combined:	$11.75\ N \cdot cm < \tau < 17.55\ N \cdot cm$

Selecting a Motor

- Ideal Torque: 13 → 17.5 $N \cdot cm$

Chosen Motor:

No-load speed: 0.200 kRPM

Stall torque: 4.00 kg·cm

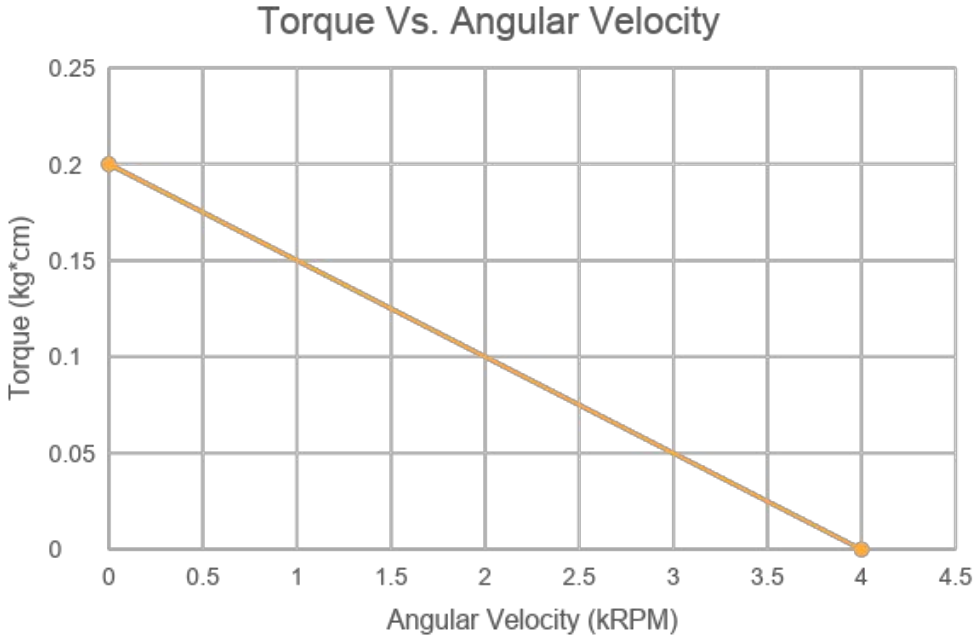
Linear equation:

$$\tau = (-20)\omega + 4.00$$

$$17.0\ N \cdot cm \rightarrow 1.224\ kg \cdot cm$$

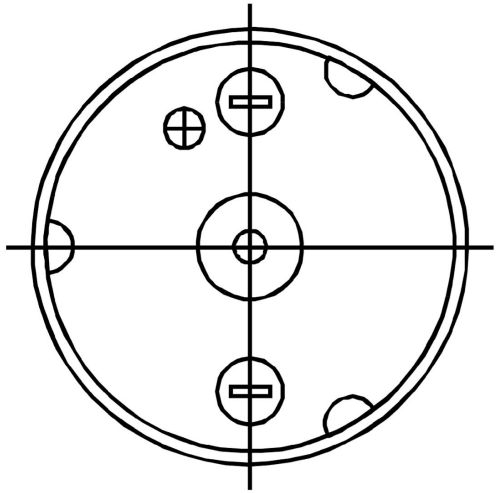
$$1.224\ kg \cdot cm = (-20)\omega + 4.00$$

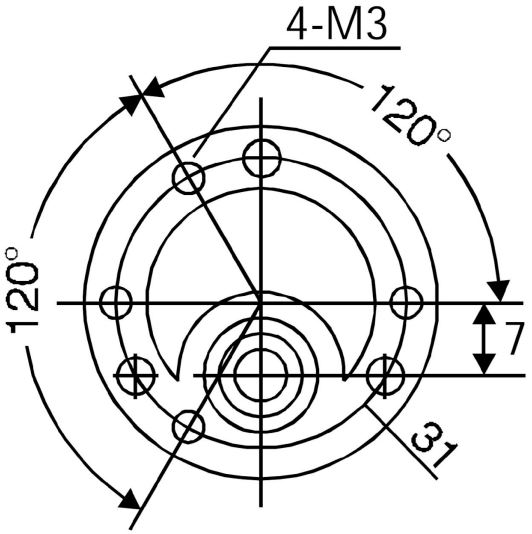
$$\omega = 0.1388\ kRPM = 138.8\ RPM = 14.535\ \frac{rad}{s}$$

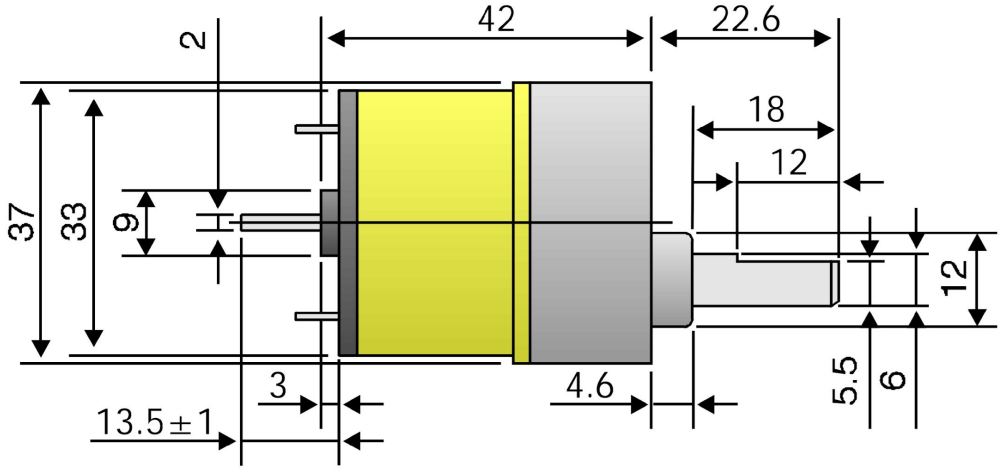


Selected Motor

Voltage = 12vdc
RPM = 200
Reduction = 30:1
Stall Torque = 55.6 oz-in (4 kg-cm)
Outside Diameter = 37mm
Mass = 0.120769 kg







Expected Bill of Materials

Material	Cost (USD)	
APC220	$	26.44
Wheels	$	24.43
Infrared Sensor	$	7.49
Romeo Microcontroller	$	29.98
Ultrasonic Distance Sensor	$	5.38
Fiberglass Base	$	5.00
Control System	$	34.95
Battery	$	29.95
Forklift Motor (2x)	$	45.96
Forklift Arms (2x)	$	5.00
Motors	$	21.95
Total:	$	236.53

Expected Mass Chart

Items	Quantity	Estimated Mass(kg)	Source
APC220	1	0.03	Web
Wheels	4	0.8	Web
Infrared Sensor	1	0.005	Web
Romeo Microcontroller	1	0.06	Web
Ultrasonic Distance Sensor	3	0.009	Web
Base	1	0.366	Actual
Control System	1	0.15	Estimated
Battery	1	0.251	Web
Forklift Motor	4	0.18824084	Web
Forklift Arms	2	0.05	Estimated
Motors	4	0.4831	Web
Total		2.39234084	

Anticipated Problems + Solutions

- Parts breaking
  - Buy new materials when needed
- Disagreement
  - Majority rules, resolve problems in a mature fashion
- If lifting the black box lead to the OSV tilting from the weight
  - Add more counterweights to the back of the OSV
- If forklift arms can’t correctly orient themselves around the black box
  - Write code to allow the OSV to have a greater scope of navigation