STERIBOT

YOUR GUARDIAN OF PURITY IN THE BATTLE OF GERMS

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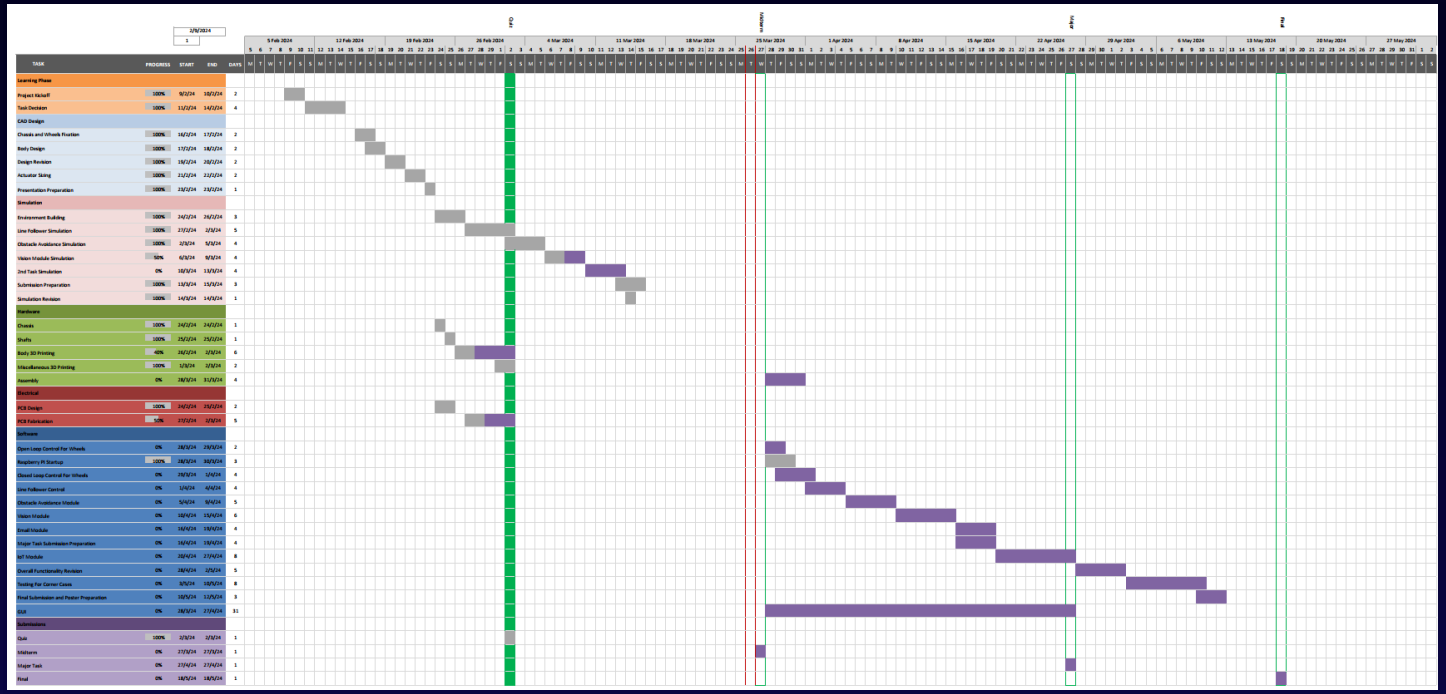
01
Project Plan



TASK	PROGRESS	START	END	DAYS
Learning Phase				
Project Kickoff	100%	9/2/24	10/2/24	2
Task Decision	100%	11/2/24	14/2/24	4
CAD Design				
Chassis and Wheels Fixation	100%	16/2/24	17/2/24	2
Body Design	100%	17/2/24	18/2/24	2
Design Revision	100%	19/2/24	20/2/24	2
Actuator Sizing	100%	21/2/24	22/2/24	2
Presentation Preparation	100%	23/2/24	23/2/24	1
Simulation				
Environment Building	100%	24/2/24	26/2/24	3
Line Follower Simulation	100%	27/2/24	2/3/24	5
Obstacle Avoidance Simulation	100%	2/3/24	5/3/24	4
Vision Module Simulation	50%	6/3/24	9/3/24	4
2nd Task Simulation	0%	10/3/24	13/3/24	4
Submission Preparation	100%	13/3/24	15/3/24	3
Simulation Revision	100%	14/3/24	14/3/24	1
Hardware				
Chassis	100%	24/2/24	24/2/24	1
Shafts	100%	25/2/24	25/2/24	1
Body 3D Printing	40%	26/2/24	2/3/24	6
Miscellaneous 3D Printing	100%	1/3/24	2/3/24	2
Assembly	0%	28/3/24	31/3/24	4
Electrical				
PCB Design	100%	24/2/24	25/2/24	2
PCB Fabrication	50%	27/2/24	2/3/24	5
Software				
Open Loop Control For Wheels	0%	28/3/24	29/3/24	2
Raspberry Pi Startup	100%	28/3/24	30/3/24	3
Closed Loop Control For Wheels	0%	29/3/24	1/4/24	4
Line Follower Control	0%	1/4/24	4/4/24	4
Obstacle Avoidance Module	0%	5/4/24	9/4/24	5
Vision Module	0%	10/4/24	15/4/24	6
Small Module	0%	16/4/24	19/4/24	4
Major Task Submission Preparation	0%	16/4/24	19/4/24	4
IoT Module	0%	20/4/24	27/4/24	8
Overall Functionality Revision	0%	28/4/24	2/5/24	5
Testing For Corner Cases	0%	3/5/24	10/5/24	8
Final Submission and Poster Preparation	0%	10/5/24	12/5/24	3
EGP	0%	28/3/24	27/4/24	31
Submissions				
Quiz	100%	2/3/24	2/3/24	1
Midterm	0%	27/3/24	27/3/24	1
Major Task	0%	27/4/24	27/4/24	1
Final	0%	18/5/24	18/5/24	1

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Project Plan

TASK	PROGRESS	START	END	DAYS
Learning Phase				
Project Kickoff	100%	9/2/24	10/2/24	2
Task Decision	100%	11/2/24	14/2/24	4

01
Project Plan

CAD Design				
Chassis and Wheels Fixation	100%	16/2/24	17/2/24	2
Body Design	100%	17/2/24	18/2/24	2
Design Revision	100%	19/2/24	20/2/24	2
Actuator Sizing	100%	21/2/24	22/2/24	2
Presentation Preparation	100%	23/2/24	23/2/24	1

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Project Plan

Simulation				
Environment Building	100%	24/2/24	26/2/24	3
Line Follower Simulation	100%	27/2/24	2/3/24	5
Obstacle Avoidance Simulation	100%	2/3/24	5/3/24	4
Vision Module Simulation	50%	6/3/24	9/3/24	4
2nd Task Simulation	0%	10/3/24	13/3/24	4
Submission Preparation	100%	13/3/24	15/3/24	3
Simulation Revision	100%	14/3/24	14/3/24	1

01
Project Plan

Hardware				
Chassis	100%	24/2/24	24/2/24	1
Shafts	100%	25/2/24	25/2/24	1
Body 3D Printing	40%	26/2/24	2/3/24	6
Miscellaneous 3D Printing	100%	1/3/24	2/3/24	2
Assembly	0%	17/3/24	20/3/24	4

01
Project Plan

Electrical				
PCB Design	100%	24/2/24	25/2/24	2
PCB Fabrication	50%	27/2/24	2/3/24	5

01
Project Plan

Software				
Open Loop Control For Wheels	0%	21/3/24	25/3/24	5
Raspberry PI Startup	0%	26/3/24	28/3/24	3
Closed Loop Control For Wheels	0%	29/3/24	1/4/24	4
Line Follower Control	0%	1/4/24	4/4/24	4
Obstacle Avoidance Module	0%	5/4/24	9/4/24	5
Vision Module	0%	10/4/24	15/4/24	6
Email Module	0%	16/4/24	19/4/24	4
Major Task Submission Preparation	0%	16/4/24	19/4/24	4
IoT Module	0%	20/4/24	27/4/24	8
Overall Functionality Revision	0%	28/4/24	2/5/24	5
Testing For Corner Cases	0%	3/5/24	10/5/24	8
Final Submission and Poster Preparation	0%	10/5/24	12/5/24	3
GUI	0%	21/3/24	27/4/24	38

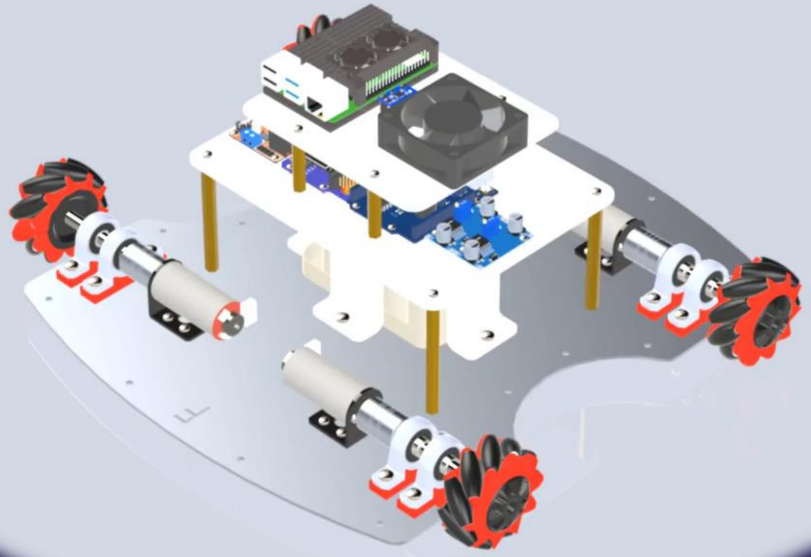
02
Design Recap

CAD
Design

02
Design
Recap

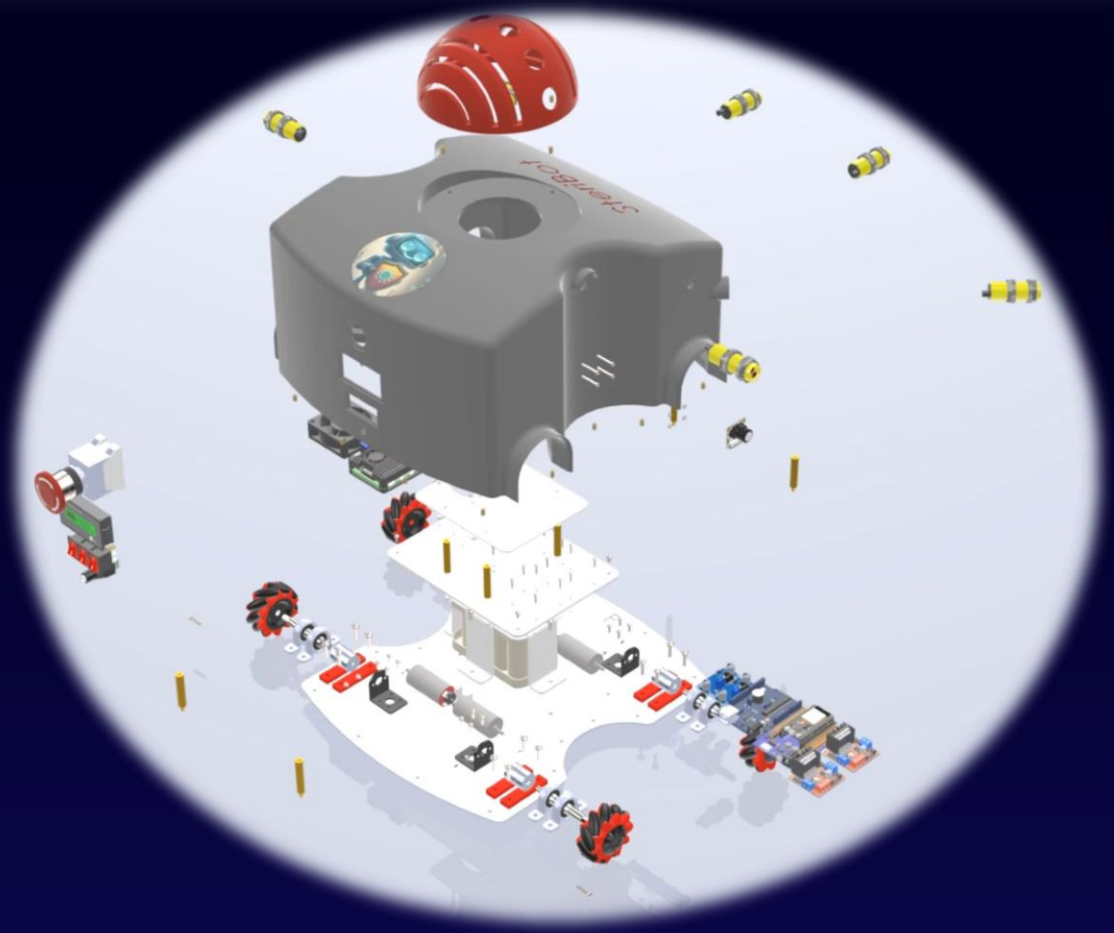
CAD
Design

02
Design
Recap



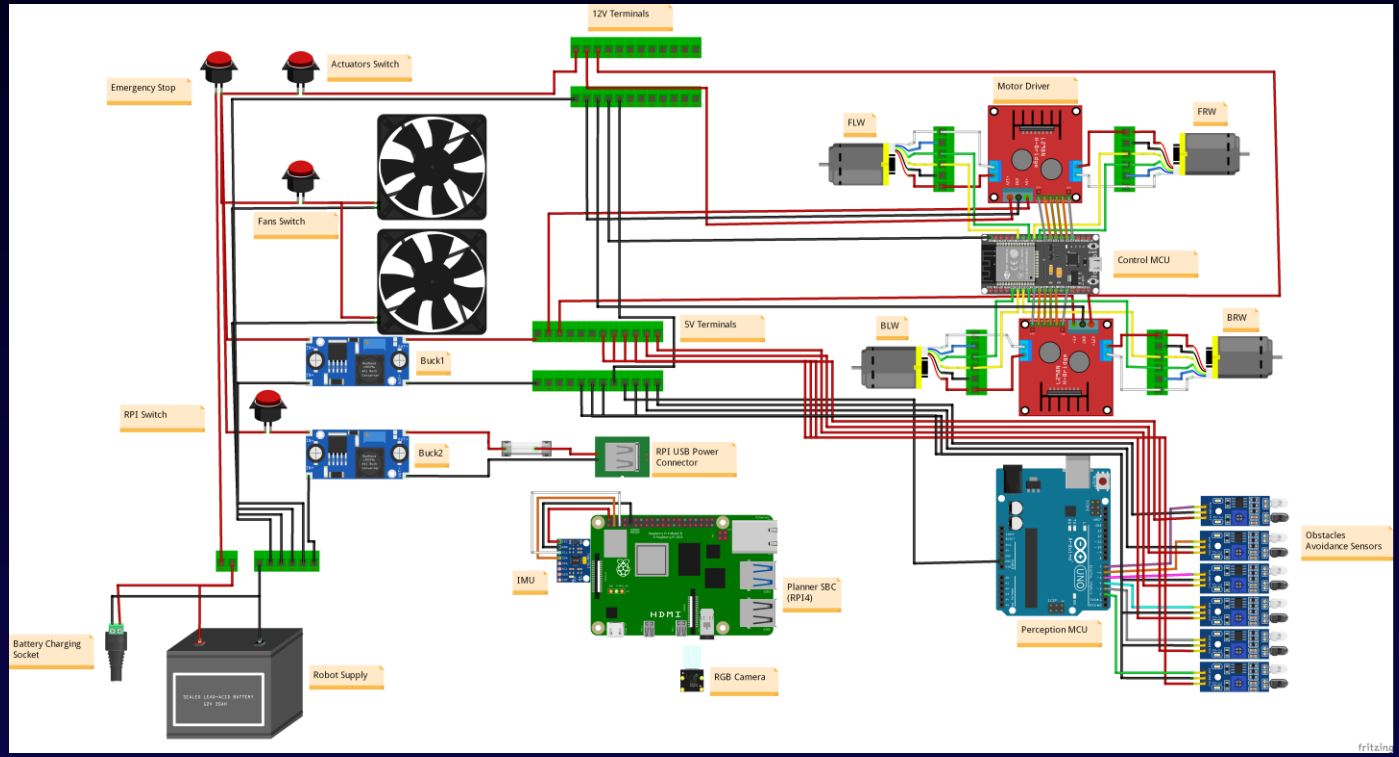
CAD
Design

02
Design
Recap



Electrical Design

02
Design Recap



03

Calculations & Analysis

Roll Calculations

```
% Roll Calculations
% Variables
Mass     = 4.13419   ;
L        = 215.02    ;    % L      ==> Wheel base
L1       = 107.35    ;    % L1     ==> Rear wheel to Cg
L2       = 107.67    ;    % L2     ==> Front wheel to Cg
g        = 9.81      ;    % g      ==> Acceleration due to gravity
hcg      = 59.78     ;    % hcg    ==> Height of Cg
W        = 350       ;    % W      ==> Wheel track
```

Roll Calculations

03
Calculations & Analysis

```
% Stability in the longitudinal direction
% Static weight
Nr = Mass * g * L2 / L; % Nr    ==> Reaction on rear wheel
Nf = Mass * g * L1 / L; % Nf    ==> Reaction on front wheel

% Weight transfer in the longitudinal direction
syms a  ;               % a     ==> Max acceleration without flipping
syms Nfd;               % Nfd   ==> Static Weight + Weight transfer
syms Nrd;               % Nrd   ==> Static Weight - Weight transfer

% Taking moment about front wheel
Nrd = Nr + Mass * a * hcg / L;

% Taking moment about front wheel
Nfd = Nf - Mass * a * hcg / L;

% Longitudinal roll over condition
a = vpasolve(Nfd == 0 , a);
```

Roll Calculations

03
Calculations & Analysis

```
% Stability in the lateral direction
% Static weight
Nout = Mass * g / 2;     % Nout  ==> Reaction on outer wheel
Nin  = Mass * g / 2;     % Nin   ==> Reaction on inner wheel

% Weight transfer in lateral direction
syms v  ;                % v     ==> Max velocity without turning over a certain ↙
corner
syms No ;                % No    ==> Static Weight + Weight transfer
syms Ni ;                % Ni    ==> Static Weight - Weight transfer
R = 0.3 ;                % R     ==> Corner radius

% Taking moment about inner wheel
No  = Nout + Mass * v^2 * hcg / W / R;

% Taking moment about front wheel
Ni  = Nin - Mass * v^2 * hcg / W / R;

% Lateral roll over condition
v = max(vpasolve(Ni == 0 , v));
```

Roll Calculations

03
Calculations & Analysis

MATLAB Variable: a Page 1
Mar 1, 2024 5:33:10 AM

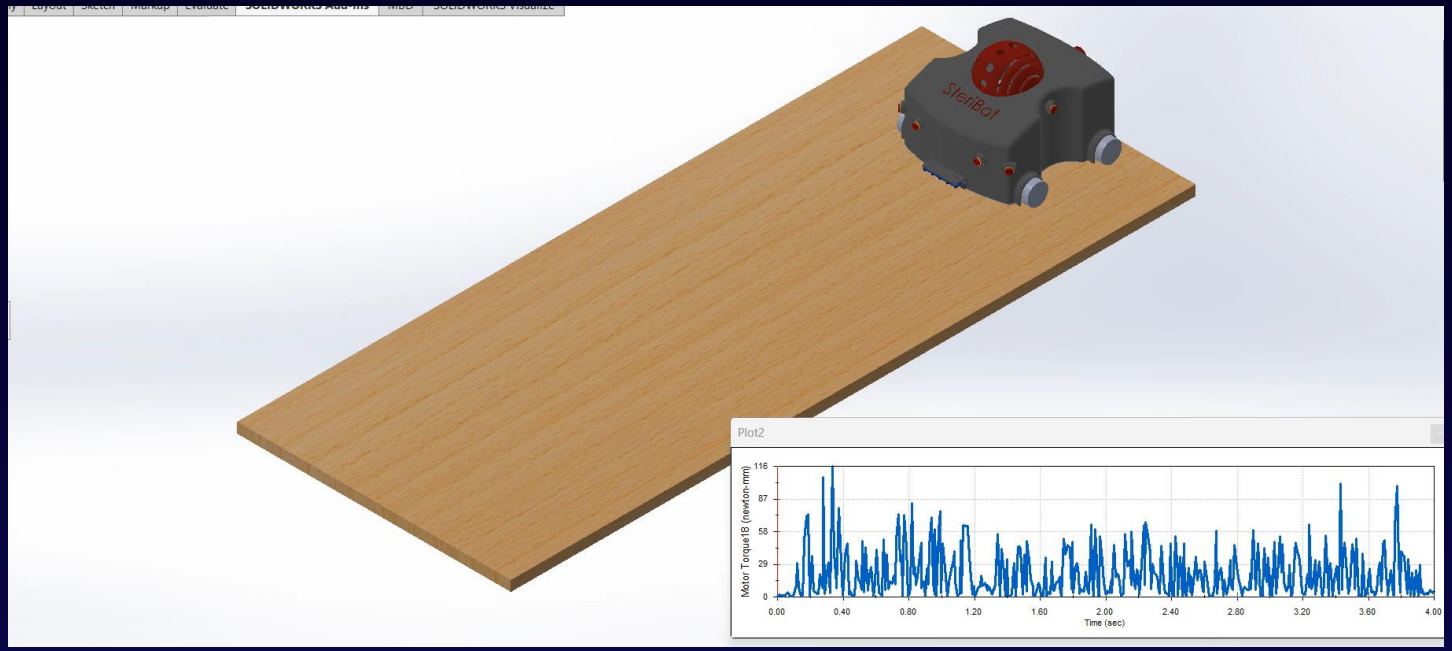
```
val =

17.616318166610905824350091179247
```

MATLAB Variable: v Page 1
Mar 1, 2024 5:33:28 AM

```
val =

2.935189870937540116378043247683 2
```

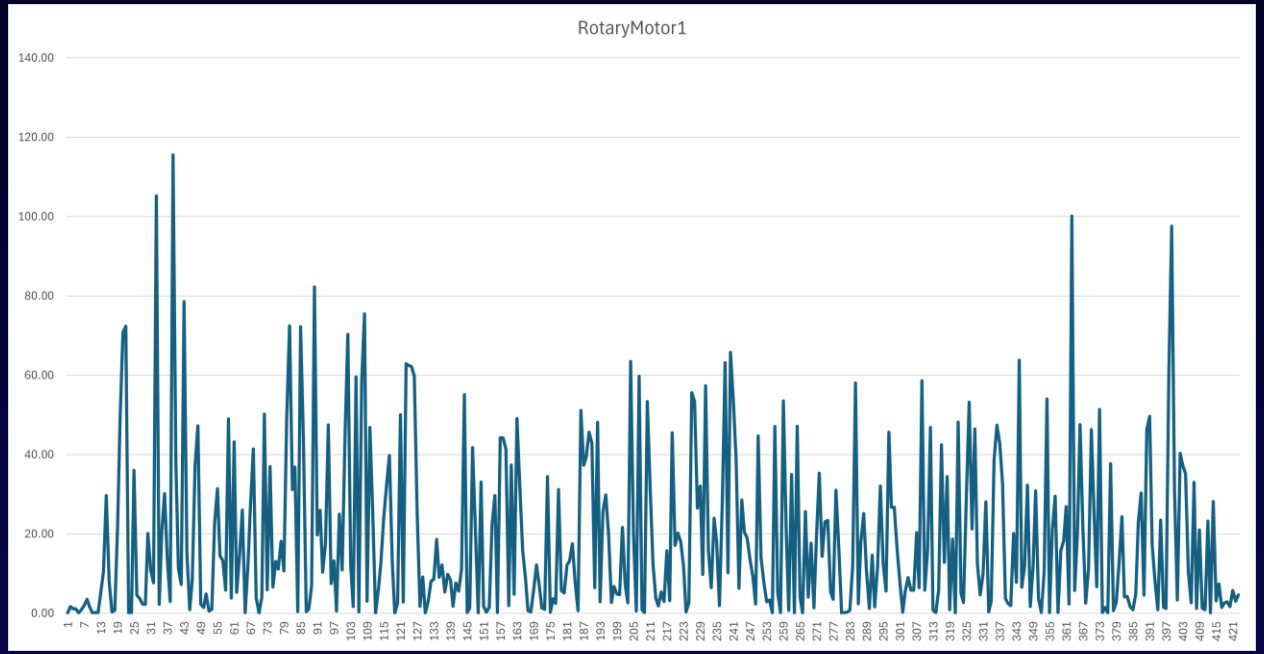
Actuator Sizing
SW

03
Calculations
& Analysis



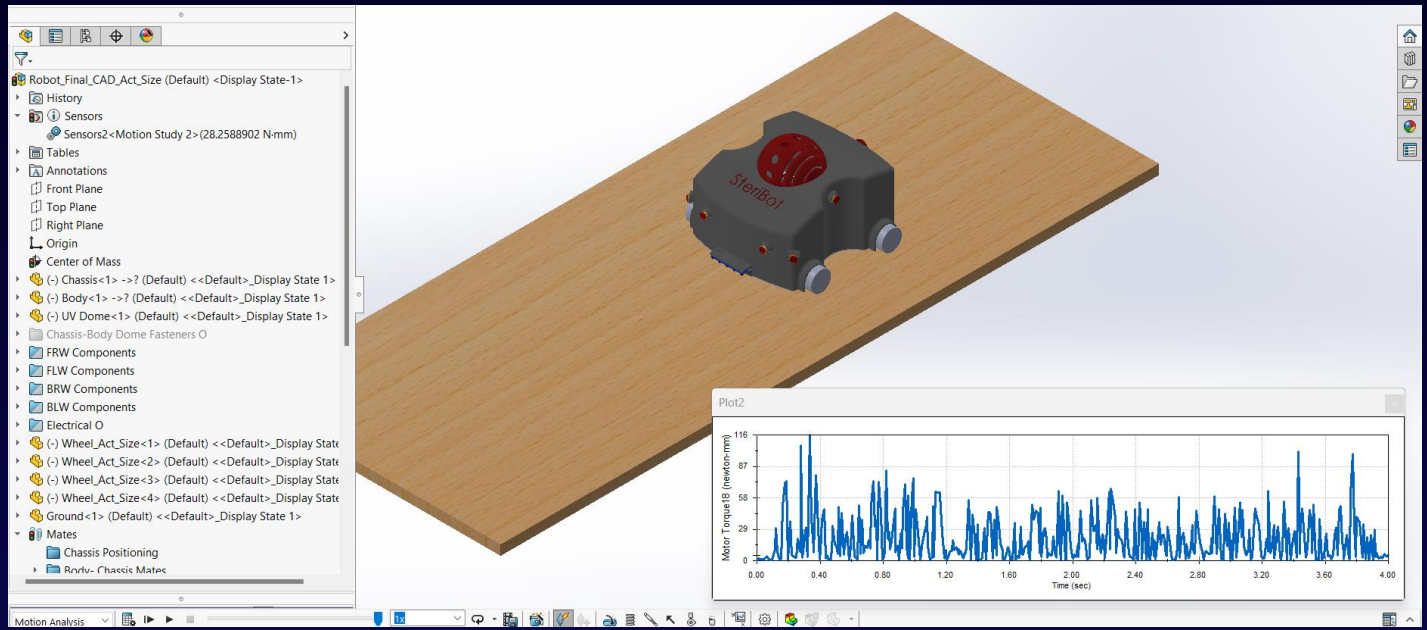
Actuator Sizing SW

03
Calculations & Analysis



Actuator Sizing SW

03
Calculations & Analysis



Actuator Sizing Hand

03
Calculations & Analysis

```
% Actuator Sizing
% Constants

Rw       =   0.0325; % Wheel Radius
Miu_r    =   0.04;   % Coefficient of rolling resistance
M        =   1.0335; % Total Mass per wheel
g        =   9.81;   % Acceleration due to gravity
Cd       =   0.27;   % Coefficient of drag (Assumed)
Ro_air   =   1.2;    % Density of air
Af       =   0.031;  % Frontal area
V        =   0.2;    % Robot Velocity
Jwheel   =   3.87e-5;% Wheel Inertia
Jshaft   =   2.59e-7;% Shaft Inertia
t        =   0.25;   % step time
eta      =   0.9;    % Efficiency
Miu_f    =   0.3;    % Coefficient of friction
```

Actuator Sizing Hand

03
Calculations & Analysis

```
% Formulas

Teffort_max =   Miu_f * M * g;
Rr          =   Miu_r * M * g;
Ra          =   (1/2) * Cd * Af * Ro_air * (V^2);
Tr          =   (Rr + Ra) * Rw;
Jload_eff   =   (Jwheel / eta) + ( Jshaft / eta);
Jlinear_eff =   M * (Rw^2);
Jmotor      =   Jload_eff;
Jtotal      =   Jmotor + Jload_eff + Jlinear_eff;
alpha_1     =   ((V/Rw) / t);
Tm          =   Tr + (Jtotal * alpha_1);
Teffort     =   Tm / Rw;

Tm_pos_acc  =   Tr + (Jtotal * alpha_1);
Tm_zero_acc =   Tr;
Tm_neg_acc  =   Tr + (Jtotal * -alpha_1);
Tm_rms      =   sqrt(((Tm_pos_acc^2)*t) + ((Tm_zero_acc^2)*2*t) + ((Tm_neg_acc^2)
*t));
```

Actuator Sizing Hand

Af	0.0310	Ra	2.0088e-04
alpha_1	24.6154	Ro_air	1.2000
Cd	0.2700	Rr	0.4055
eta	0.9000	Rw	0.0325
g	9.8100	t	0.2500
Jlinear_eff	0.0011	Teffort	1.2981
Jload_eff	4.3288e-05	Teffort_max	3.0416
Jmotor	4.3288e-05	Tm	0.0422
Jshaft	2.5900e-07	Tm_neg_acc	-0.0158
Jtotal	0.0012	Tm_pos_acc	0.0422
Jwheel	3.8700e-05	Tm_rms	0.0244
M	1.0335	Tm_zero_acc	0.0132
Miu_f	0.3000	Tr	0.0132
Miu_r	0.0400	V	0.2000

Actuator Sizing
Hand

03
Calculations
& Analysis

Tm_rms	0.0244

Bearing Selection

03

Calculations & Analysis

```
% Bearing Selection
% Variables
Mt = 0.044  ;        % Mt    ==> Wheel Mass
g  = 9.81   ;        % g     ==> Acceleration due to gravity
L1 = 22.5   ;        % L1    ==> Distance between wheel and bearing 1
L2 = 21     ;        % L2    ==> Distance between bearing 1 and bearing 2
L  = L1 + L2;        % L     ==> Distance between bearing 1 and wheel

% Measuring reaction on bearing in the vertical plane
syms Bx1;            % Bx1   ==> Reaction force on bearing 1
syms Bx2;            % Bx2   ==> Reaction force on bearing 2

% Taking moment about bearing 1
Mb1 = Mt * g * L - Bx2 * L2;
Bx2 = vpasolve(Mb1 == 0, Bx2);

% Taking moment about bearing 2
Mb2 = Mt * g * L1 - Bx1 * L2;
Bx1 = abs(vpasolve(Mb2 == 0, Bx1));

% No force in the horizontal plane
By1 = 0;             % By1   ==> Reaction force on bearing 1 in the horizontal plane
By2 = 0;             % By2   ==> Reaction force on bearing 2 in the horizontal plane
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
% So the reaction force on each bearing will be the vertical plane forces
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%
```

Bearing Selection

03
Calculations & Analysis

```
% From strandard
X  = 1;
Y  = 0;
Co = 5.2;           % Co    ==> Maximum static load the bearing can handle
V  = 1;              % V     ==> Constant depend on whether the shaft is fixed or rotating

% Calculate bearing rev per million life B
Lh = 10000;          % Lh    ==> Number of bearing working hours
N  = 100;            % N     ==> the shaft rotational speed in rpm
B = Lh * N * 60 / 10 ^ 6;

% Bearing 1 calculation
Fr1 = sqrt(Bx1^2 + By1^2);  % Radial force on bearing 1
Fa1 = 0;                    % axial force on bearing 1
Fe1 = X * V * Fr1 + Y * Fa1;
C1calc = Fe1 * (B^(1/3))    % calculate static load on bearing 1
if (C1calc < Co)
    disp('Bearing 1 Valid!')
else
    disp('Invalid Bearing 1 Selection!')
end
% C1calc < Co ==> bearing is suitable
```

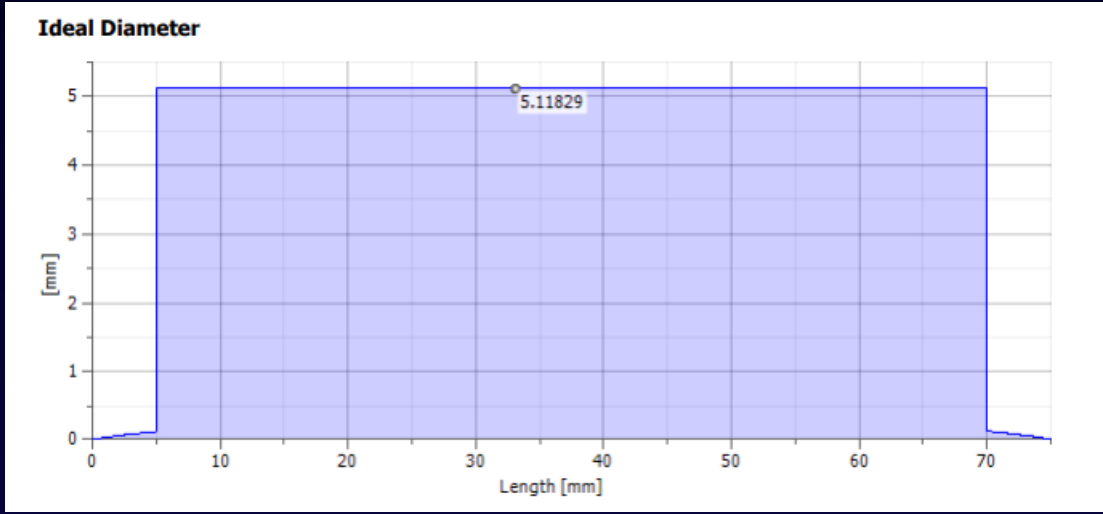
Bearing Selection


```
% Bearing 2 calculations
Fr2 = sqrt(Bx2^2 + By2^2);   % radial force on bearing 2
Fa2 = 0;                     % axial force on bearing 2
Fe2 = X * V * Fr2 + Y * Fa2;
C2calc = Fe2 * (B^(1/3))     % calculate static load on bearing 2
if (C1calc < Co)
    disp('Bearing 2 Valid!')
else
    disp('Invalid Bearing 2 Selection!')
end
% C2calc < Co ==> bearing is suitable
```

Bearing Selection

```
>> Bearing_Selection

C1calc =

1.810514430679423084269430432868 8

Bearing 1 Valid!

C2calc =

3.500327899313551508827626927279 7

Bearing 2 Valid!
>>
```

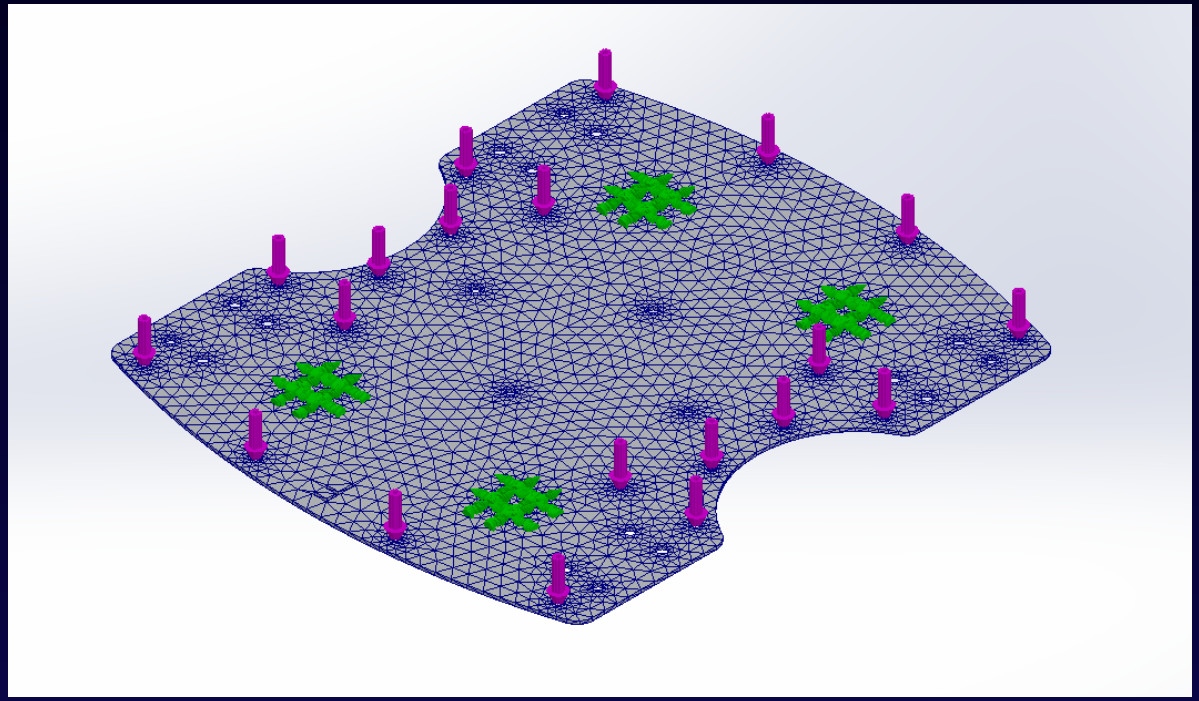
Wheel Shaft



A shaft with Φ8 is selected for the critical area

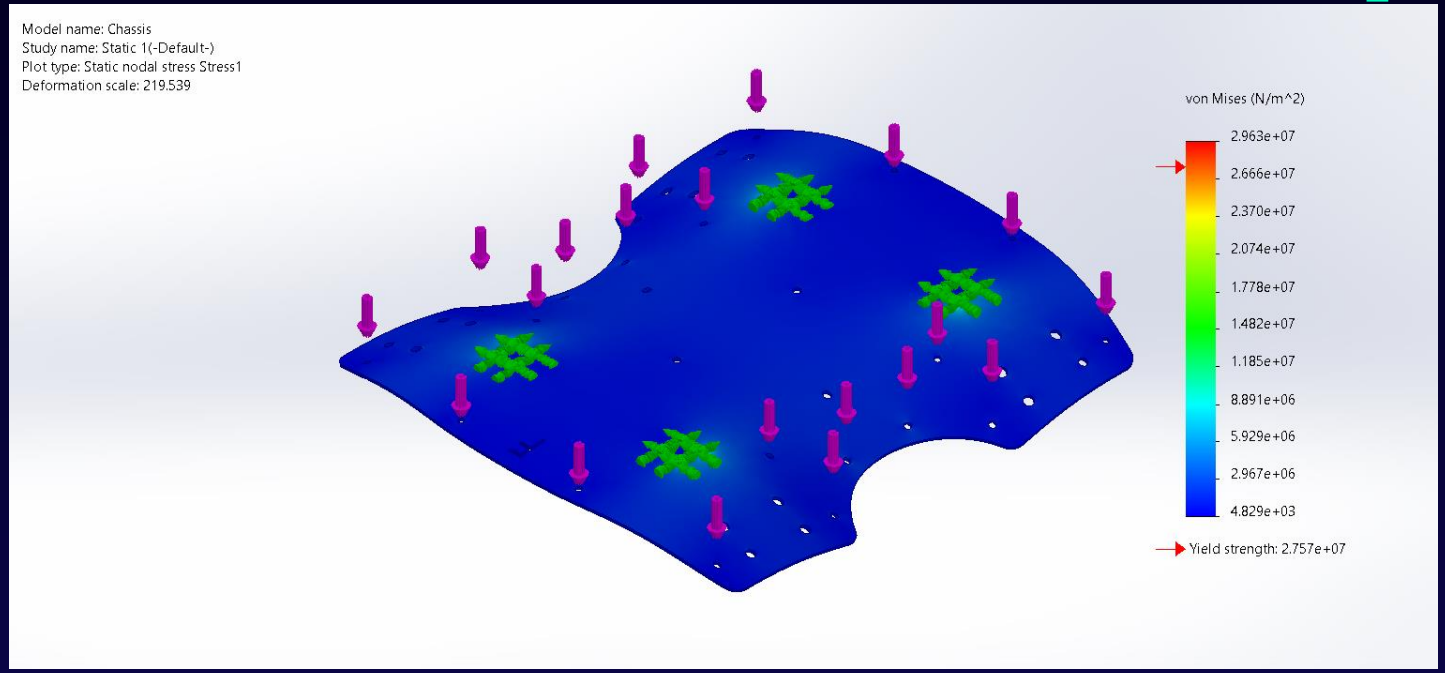
Chassis Analysis

03
Calculations & Analysis



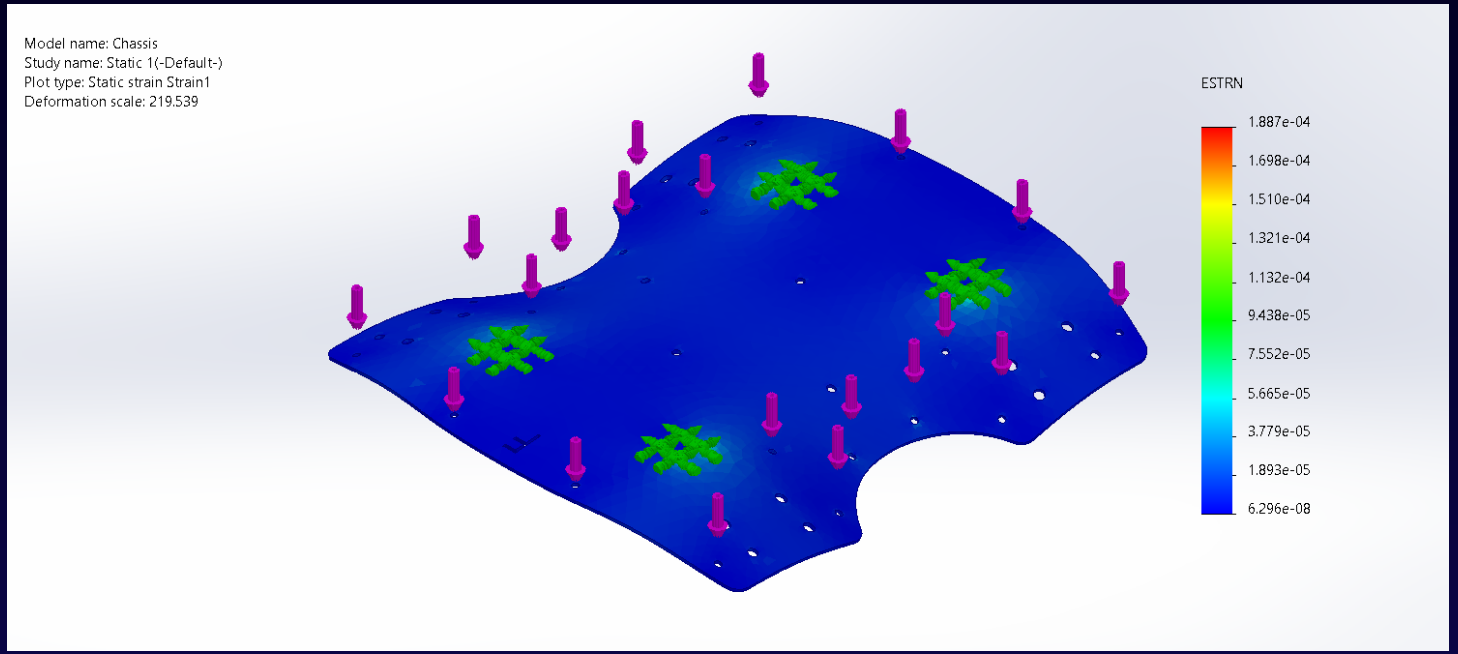
Chassis Analysis

03
Calculations & Analysis



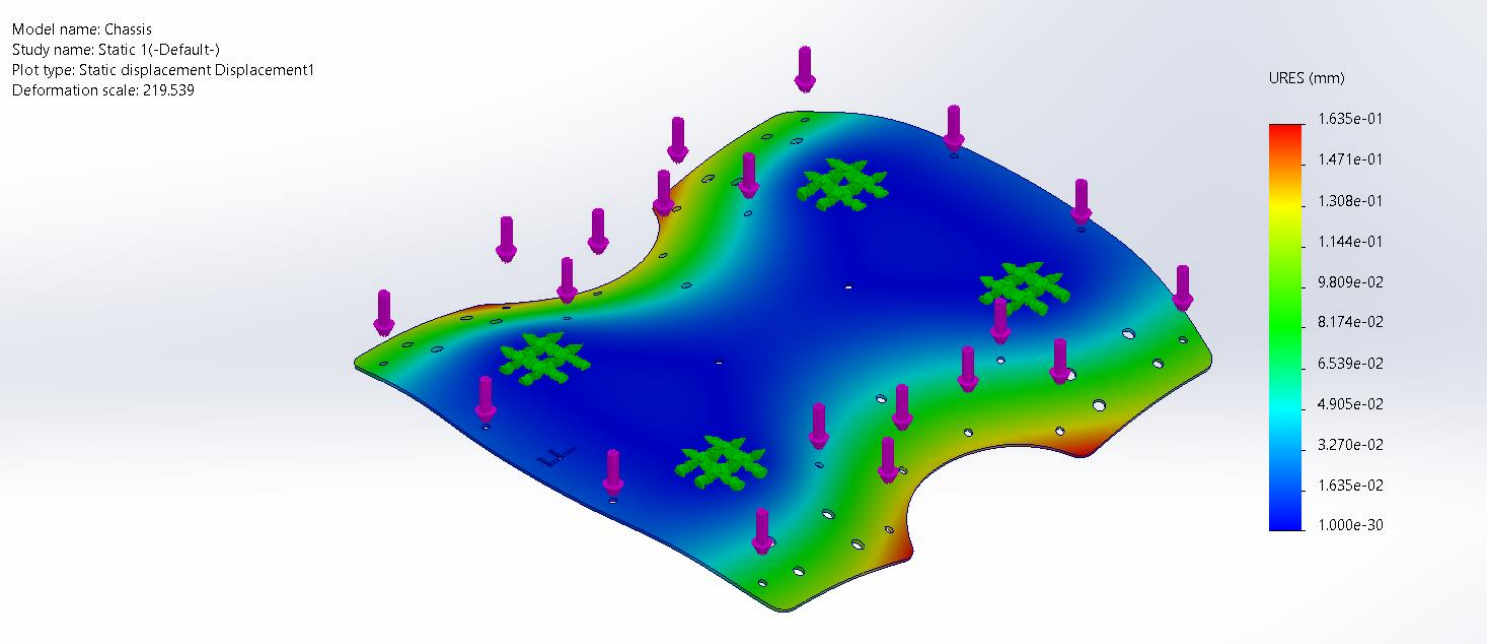
Chassis Analysis

03
Calculations & Analysis



Chassis Analysis

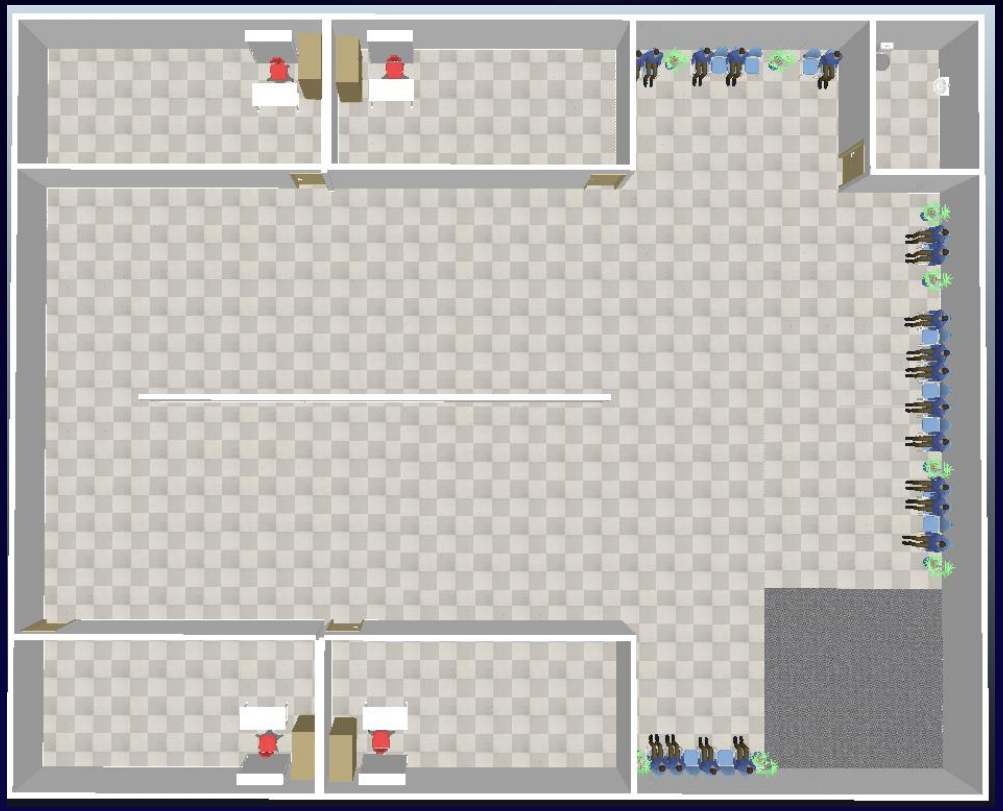
03
Calculations & Analysis



04
Simulation Progress

04
Simulation
Progress

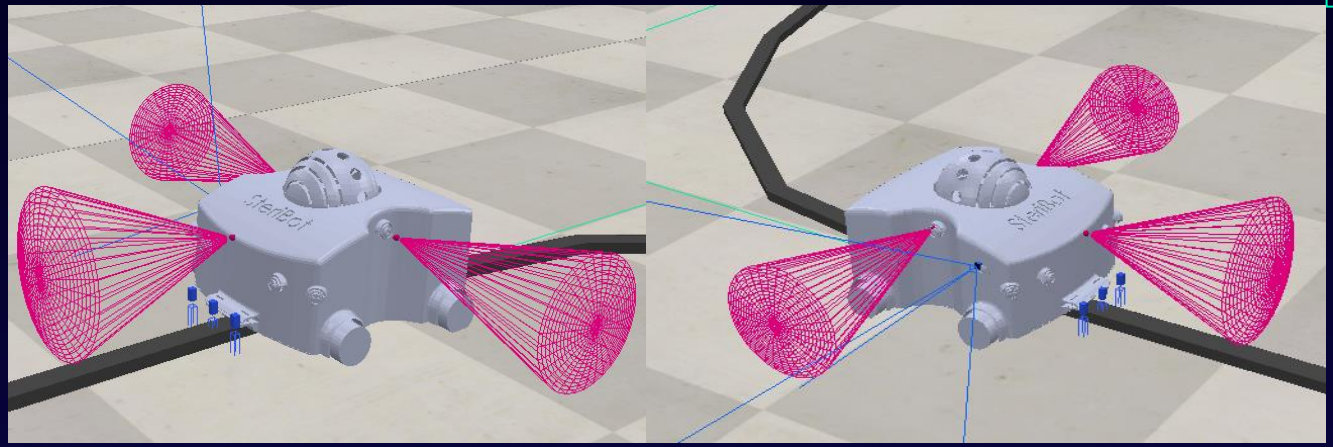
Environment



Model Importing

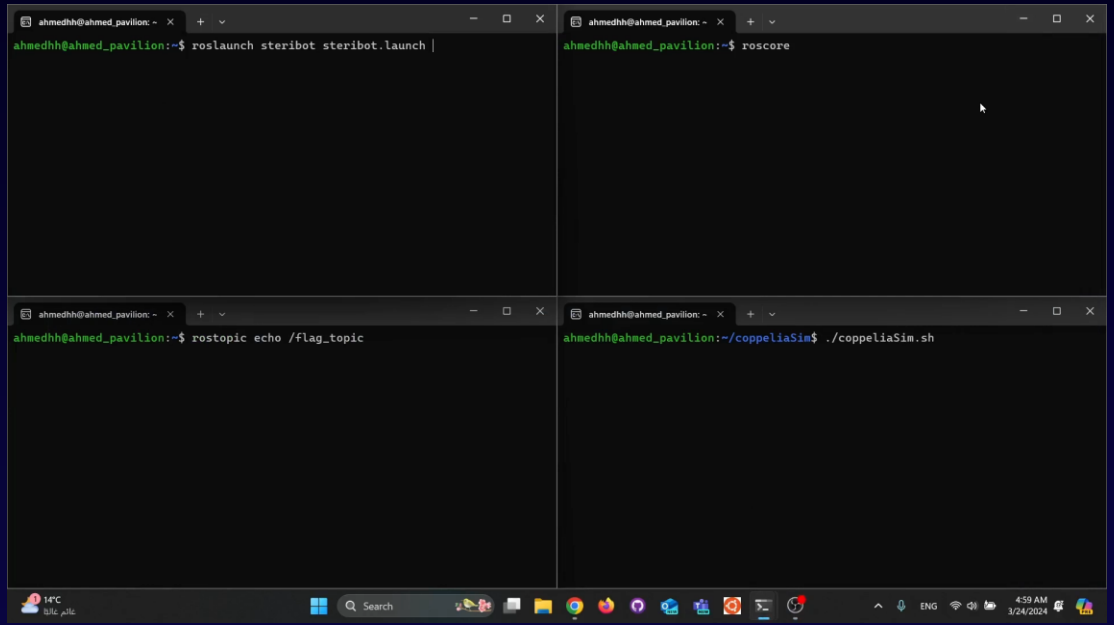
Sensors Insertion

04
Simulation
Progress



Simulation Video

04
Simulation
Progress

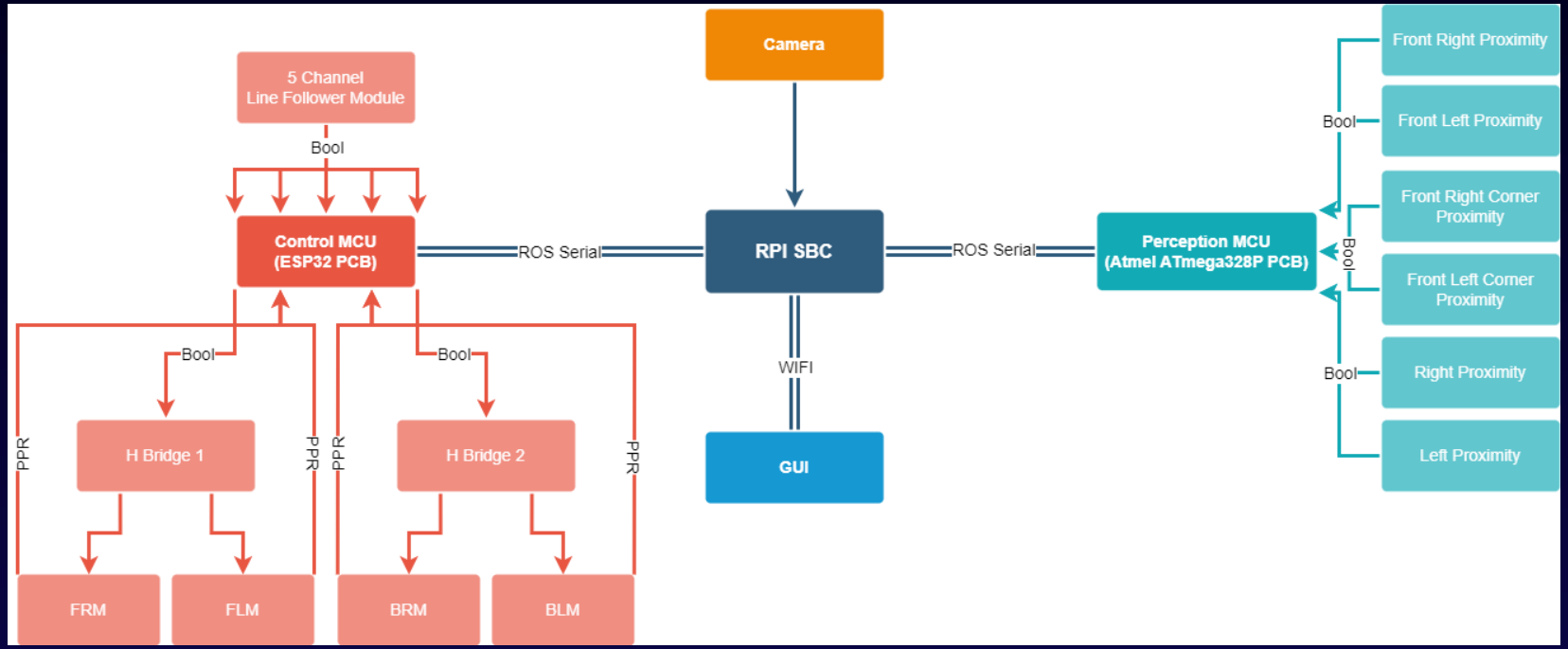


05

Process Flow

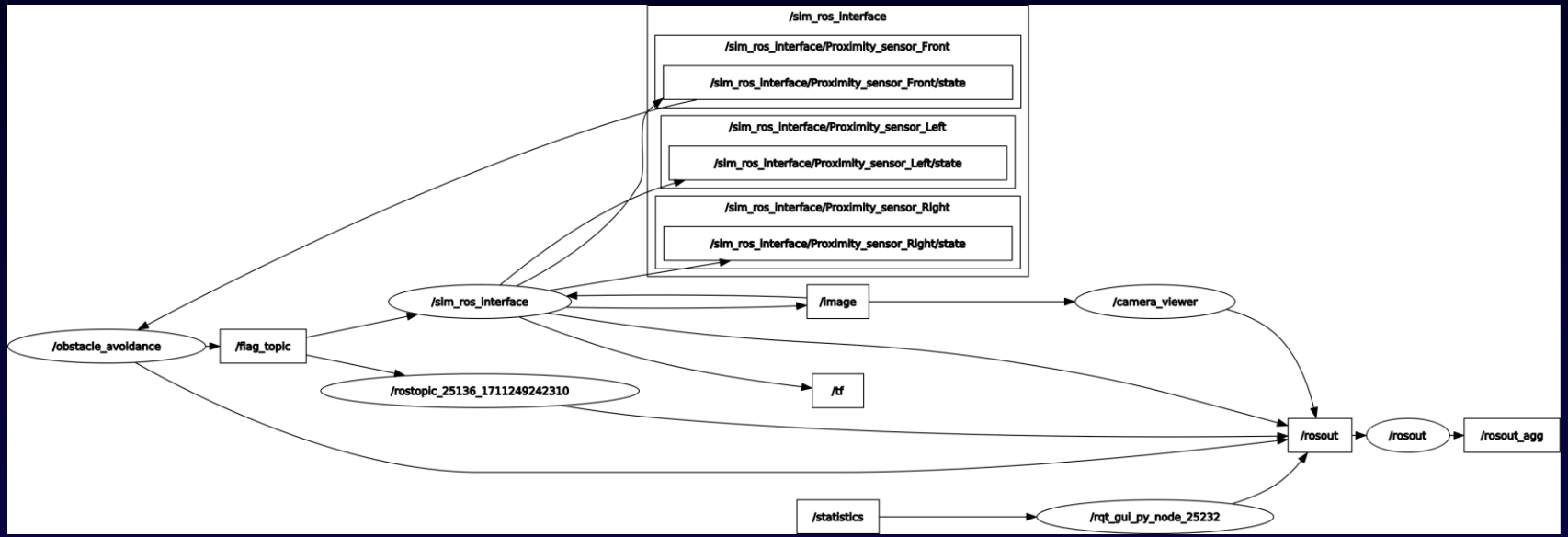
Software Architecture

05
Process Flow

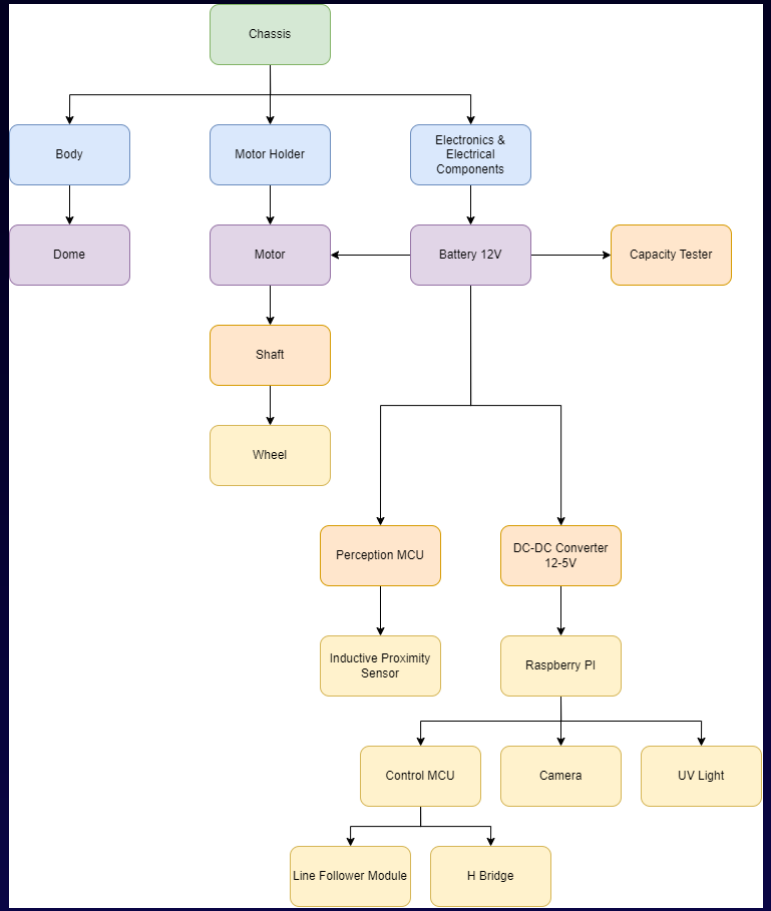


ROS Architecture

05
Process Flow

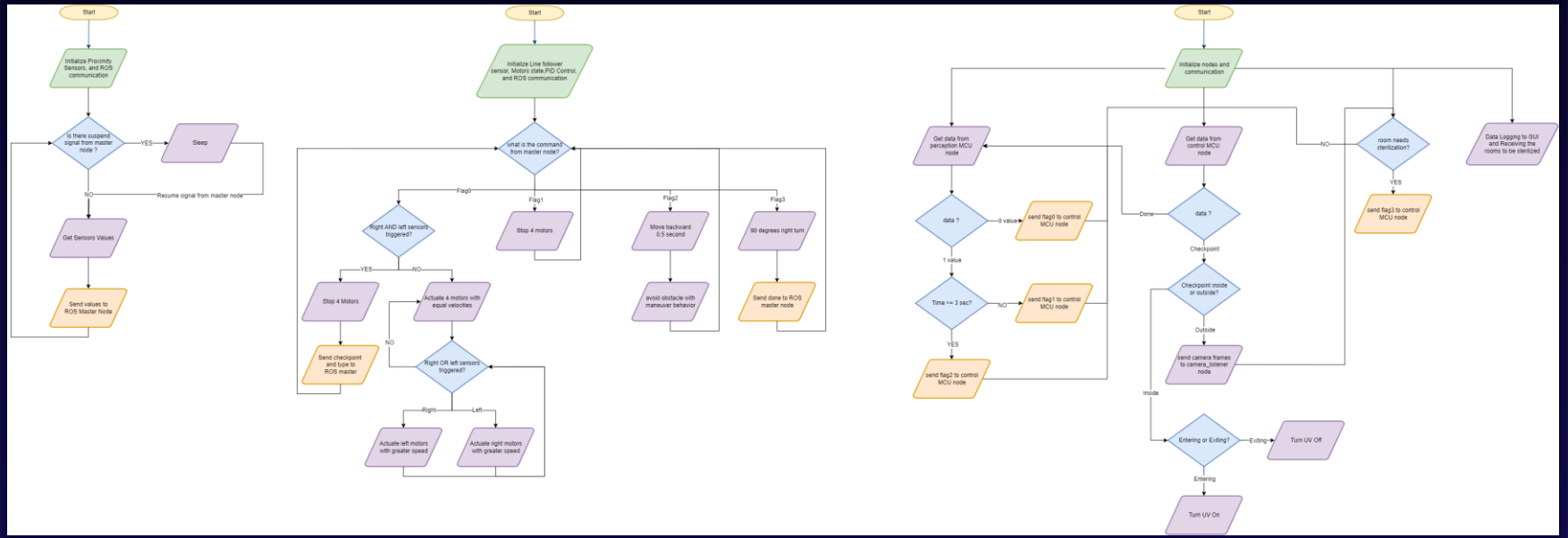


Components Architecture



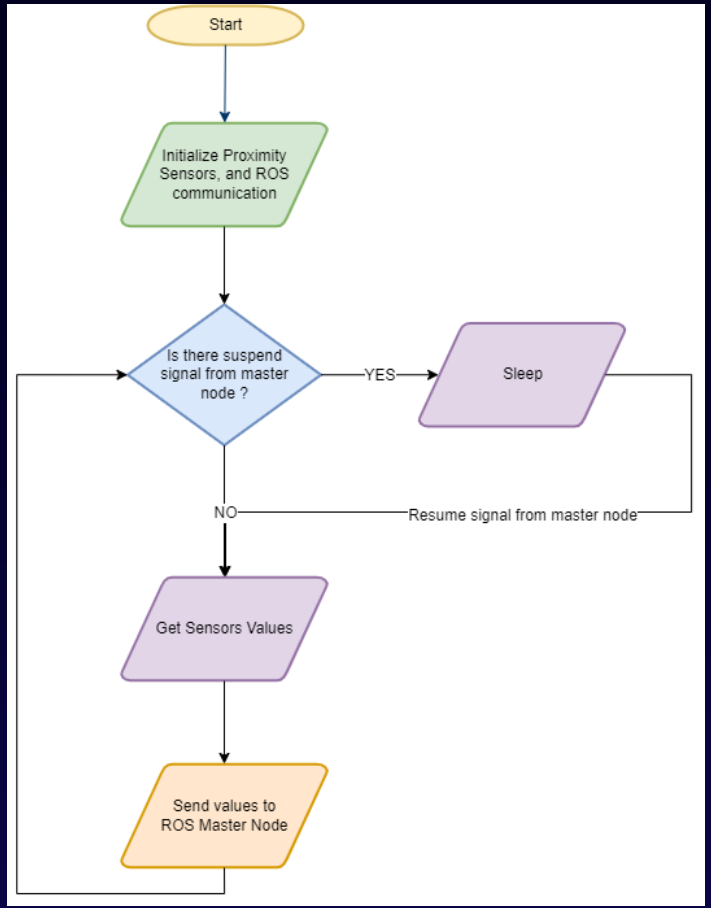
Logic Flow

05
Process Flow

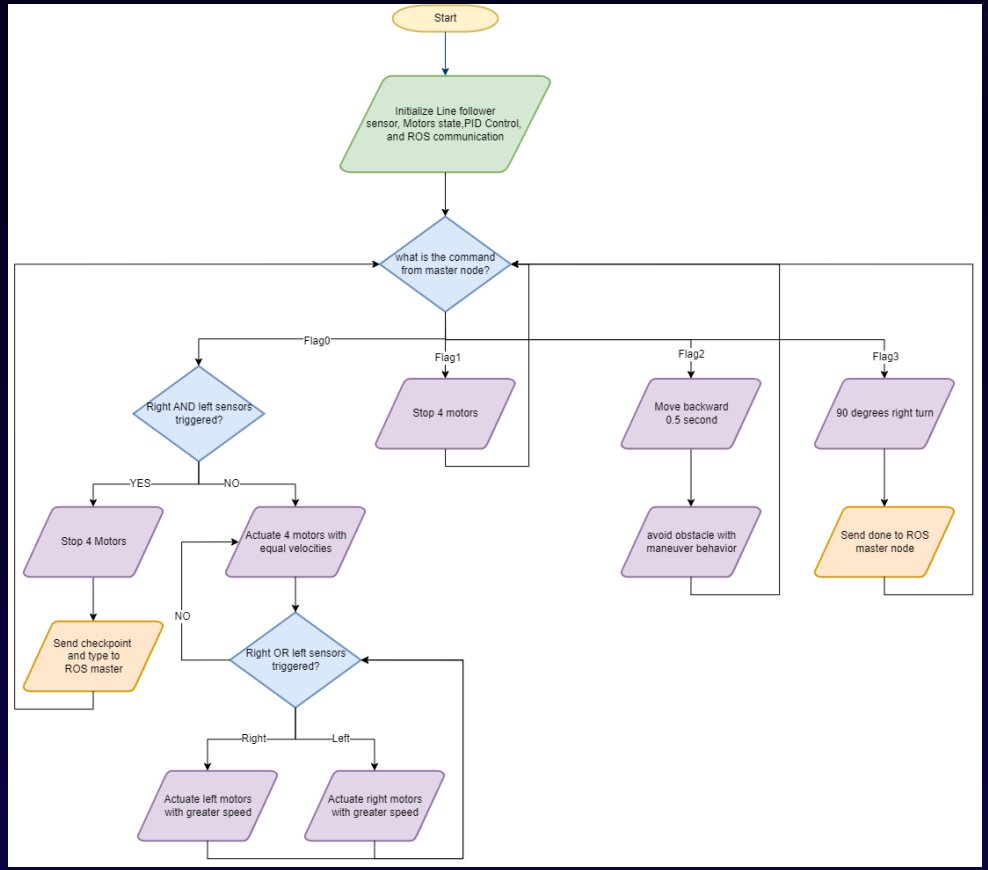


Perception MCU Flow

05
Process Flow



Control MCU Flow

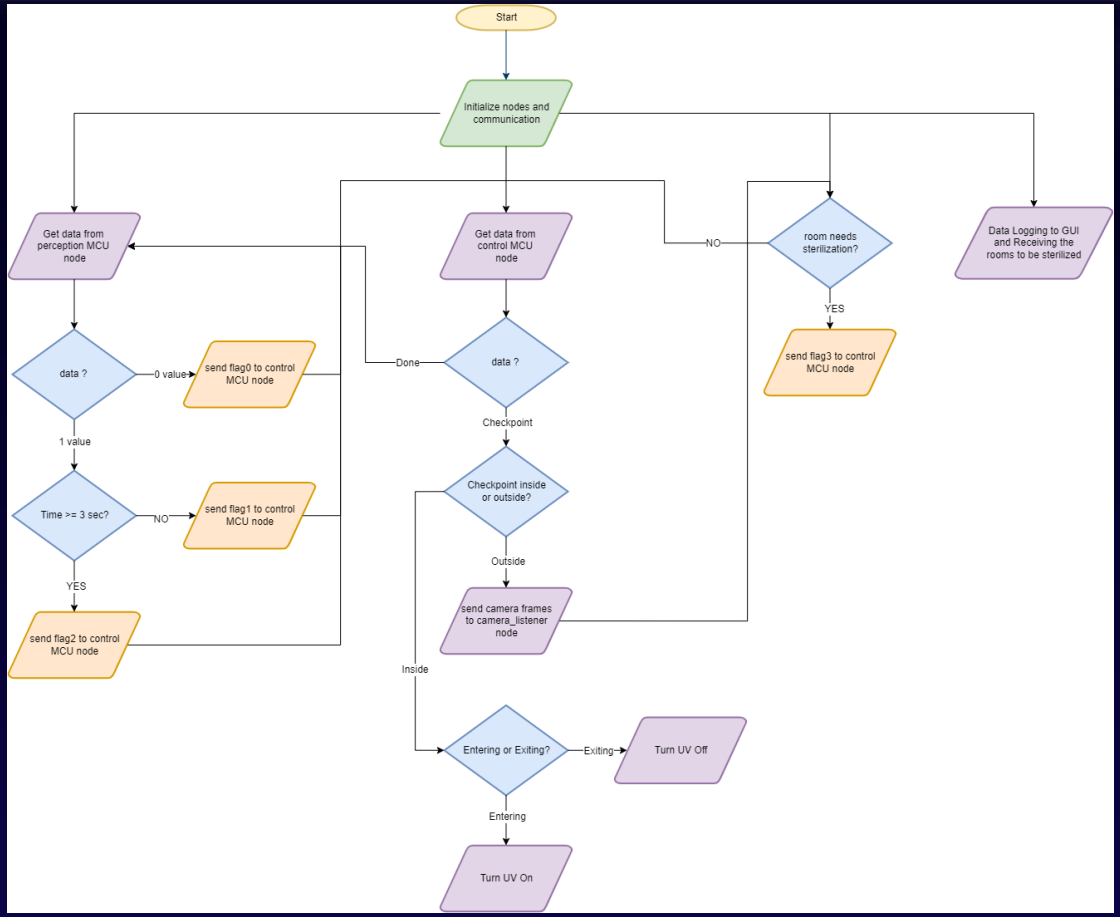


05

Process Flow

Master Flow

05
Process Flow



Extra Details ??

That's It For Today