Smarter. Greener. Together.

Seeking Smart Machine Talents

The 4th Delta Advanced Automation Contest

PROJECT PROPOSAL

TEAM Code: delta2017127 **TEAM ID: 435**

Proposal Name	**PICASO 4.0**			
Team Name	**PICASO**		**University**	Lovely Professional University, Punjab, India
Team Leader	**Name**	Mr. Arnab Kumar Das	**Department**	Bachelor of Technology Electronics and Communication
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Member Names	**Mr. Nikhil Goyal**, B.Tech Electronics and Communication Engineering, nikhilgoyal2311@gmail.com , +91 9915727112 **Mr. Veluguri Vinod,** B.Tech Mechanical Engineering, vinod.veluguri@gmail.com , +91 9872386996			

Team Building

1. **Mr. Arnab Kumar Das, Age 23**
   Bachelor of Technology Electronics and Communication Engineering, Lovely Professional University
   https://www.linkedin.com/in/arnabdasbwn/
   Specialization: Embedded System and Robotics

   ROAL: Electronics and Electrical System Design and Programming.

- **Bachelor of Technology (Honors) Electronics and Communication Engineering, 9.0 CGPA as on VII Semester (08/2013 to Present)**
- **Indian School Certificate (12th Standard), 90.0% Aggregate Result (04/2011 to 04/2013)**
- **Indian Certificate Secondary Education (10th Standard), 87.8% Aggregate Result (04/2011)**

- **Hardware:** Atmel AVR (16/32/328p), Raspberry Pi, Arduino, Microchip PIC, ARM7
- **Software Program:** AVR Atmel Studio, LabVIEW, Cadence, Eagle PCB, MATLAB, Keil MDK for ARM
- **Programming Languages:** Embedded C, Verilog, Embedded C++, Virtual Instrumentation, C, C++

- First Prize - Line Follower Robot Competition, Fluxus'16, IIT Indore, 2016
- Participated in Remote Control Ship and Aeroplane Competition, Cognizance'16, IIT Roorkee, 2016
- First Prize - Remote Control Car Race, Lovely Professional University, 2015
- Participated in E–Bike Manufacturing and Racing Challenge, Imperial Society of Innovative Engineers, 2015
- Participated in Hybrid Go-Kart Making Challenge, Imperial Society of Innovative Engineers, 2015
- Participated in World Skill India in Electronics, World Skill International Competition, 2015

2. **Nikhil Goyal, Age 21**
   Bachelor of Tech Electronics and Communication Engineering, Lovely Professional University
   https://www.linkedin.com/in/nikhil-goyal
   Specialization: Automation and PLC

   Role: PLC and HMI Programming

- **Bachelor of Technology Electronics and Communication Engineering, 9.53 CGPA as on VII Semester (08/2013 to Present)**

- **Senior Secondary School (12th Standard), 87% Aggregate marks, (June 2013)**
- **Matriculation Examination (10th Standard), 85% Aggregate Result (June 2011)**

- **Software Program:** Rockwell Automation, Factory Talk View ME, MATLAB, Proteus, Keil
- **Programming Languages**: PLC Programming, Verilog, Embedded C, C, C++, SQL, Java, Data Structure
- **Hardware:** Rockwell PLC, HMI, SCADA, Atmel AVR Microcontroller (16/32), 8051 Microcontroller

- Training on Automation, PLC, SCADA from Prudent Solutions WLL, Bahrain,2016
- Participated in Haptic Arm Robot Competition, Lovely Professional University, 2016
- Participated in IndoUs League Competition, Lovely Professional University, 2015
- Participated in Robotryst Competition, Lovely Professional University, 2015

3. **Mr. Veluguri Vinod, Age 20**
   Bachelor of Technology Mechanical Engineering, Lovely professional University
   https://grabcad.com/vinod.sunny-1
   Specialization: CAD Design and Optimization

   ROAL: Designing and Manufacturing of The PICASO 4.0

- **Bachelor of Technology Mechanical Engineering, 8.1 CPGA as on V Semester (08/2014 to Present)**
- **State Board Certificate (12th Standard), 89.7% Aggregate Result (06/2012 to 03/2014)**
- **State Board Certification of Secondary Education (10th Standard), 9.3 CGPA (03/2012)**

- **Software Program**: AutoCAD, Catia V5, SolidWorks, Ansys Workbench, Ansys APDL
- **Programming Language**: C, C++, HTML
- **Hardware**: Lath Machine, Milling, Computer Numerical Control, Shaper, 8051 Microcontroller

- Certified SOLIDWORKS Professional-Core by Dassault systems ID:C-W68QFSKGGM on 8/Jan/2016
- Training on Computational Fluid Dynamics, Technosoft Educational and Research Consultancy, Delhi, 2016
- Participated in Indo Asian Solar Challenge, Lovely Professional University
- Certified Catia, Autocad and Ansys APDL, Workbench(structural) by Canter Cadd,2016
- Certified by Trinity College of London in English, Grade -9, 2010
- Participated in Hybrid Vehicle Challenge, Lovely Professional University
- Participated in E Bike Manufacturing Competition, Lovely Professional University

Motivation and Design Concept:

Problem Insight:

If we see present painting industry, we find most of the painting are done manually using human labor. This includes house wall painting, sign board painting, advertisement painting, graffiti, line drawings etc. Manual painting is time consuming with low throughput and high cost of labor. Sometimes, it is difficult to meet the requirement of customers because of lack of painting skills. User has to be in touch with company for regular updates. Interaction with company is tedious and industry fails to fulfill customer satisfaction.

Project Idea:

Using the concept of **Industry 4.0** and **Made in China 2025** satisfying Smart Machine, Smart Robotics and Smart Manufacturing for a cost effective solution for paint industry that will increase productivity, limit human intervention, avoid physical hazard and maximize the output in limited time. We propose **PICASO 4.0** a **Delta DIA Cloud** connected **Computer Numeric Control (CNC)** machine based Multi-Axes Motion Control robot for **Automated Vertical Painting** and **Vertical Laser Engraving/Cutting** solution for **brick walls, concrete, glass, wood** etc. or any **vertical plane surface** that can accept paint or laser.

We have successfully developed a **CNC Drawing Robot** (Picture Below) based on microcontroller and stepper motor with belt driven axis and we have got drawing with precision of 0.1mm. However, the system draws/writes using pen on paper placed horizontally and has a work area of 45cmX39cm. This became the motivation for **PICASO 4.0**.

WORKING VIDEO LINK OF OUR CNC DRAWING ROBOT (PLEASE WATCH)

https://www.youtube.com/watch?v=77SKv8xWuLk

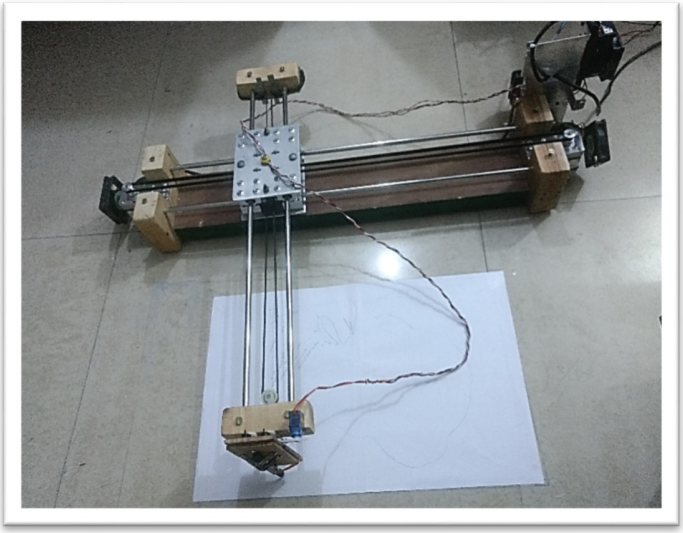


Fig 1: CNC drawing robot with paper

Fig 2: Drawing in raster printing mode

Fig 3: Raster printing output

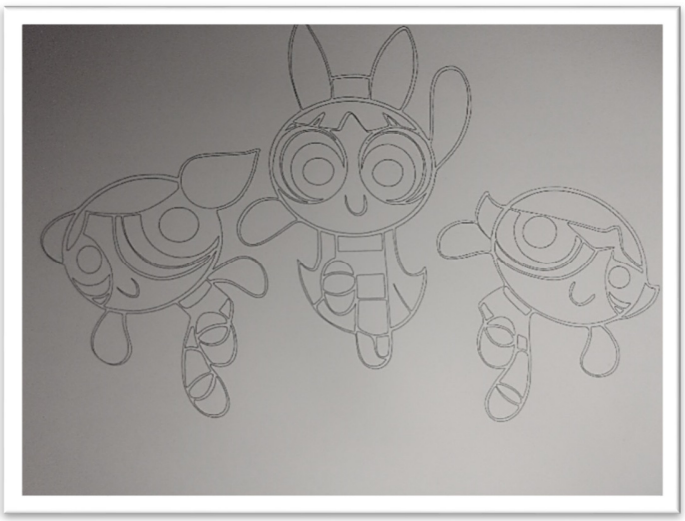


Fig 4: Vector printing output

We have improved this idea to make a CNC based vertical painting/engraving/cutting robot placed parallel to a brick wall, concrete, glass wall, wood etc. which is capable of vertical painting/laser engraving customized drawing uploaded by the user on the cloud server. The system will have two tools a painting mechanism and a laser engraving We can paint walls as well as laser engrave vertical brick walls, concrete, glass, wood etc. and an extended application will be vertical laser cutting of wood or MDF.

Objectives/Outcome:

- Automate the painting process.
- Increase precision in wall painting/engraving/cutting.
- Vertical laser engraving/cutting and vertical painting in single machine.
- Increase productivity compared to manual painting.
- Maximize profit in printing industry.
- Reduce intake of toxic fumes from paint as only robot is involved in painting.
- Can work in high rise buildings where safety is a concern.
- Remote monitoring of painting/engraving process through cloud.
- Reduce manpower and human resource.

Applications:

Case 1:

Customer Requirement:
A customer wants the wall of his house to be painted with his own customized design.

Solution:
Customer uploads the design to the cloud server, brings PICASO 4.0, aligns its painting tool towards wall, put it into painting mode, set painting area and enjoy the output.

Case 2:

Customer Requirement:
A customer has a glass door at his office entrance and he wants his company's logo to be engraved on it but he does not want to invest in a new door and also he wants to avoid disassembly and reassembly of door.

Solution:
Bring PICASO 4.0, align its laser tool towards glass door, upload company's logo to cloud server, put it into laser engraving mode, set engraving area and enjoy the output.

Case 3:

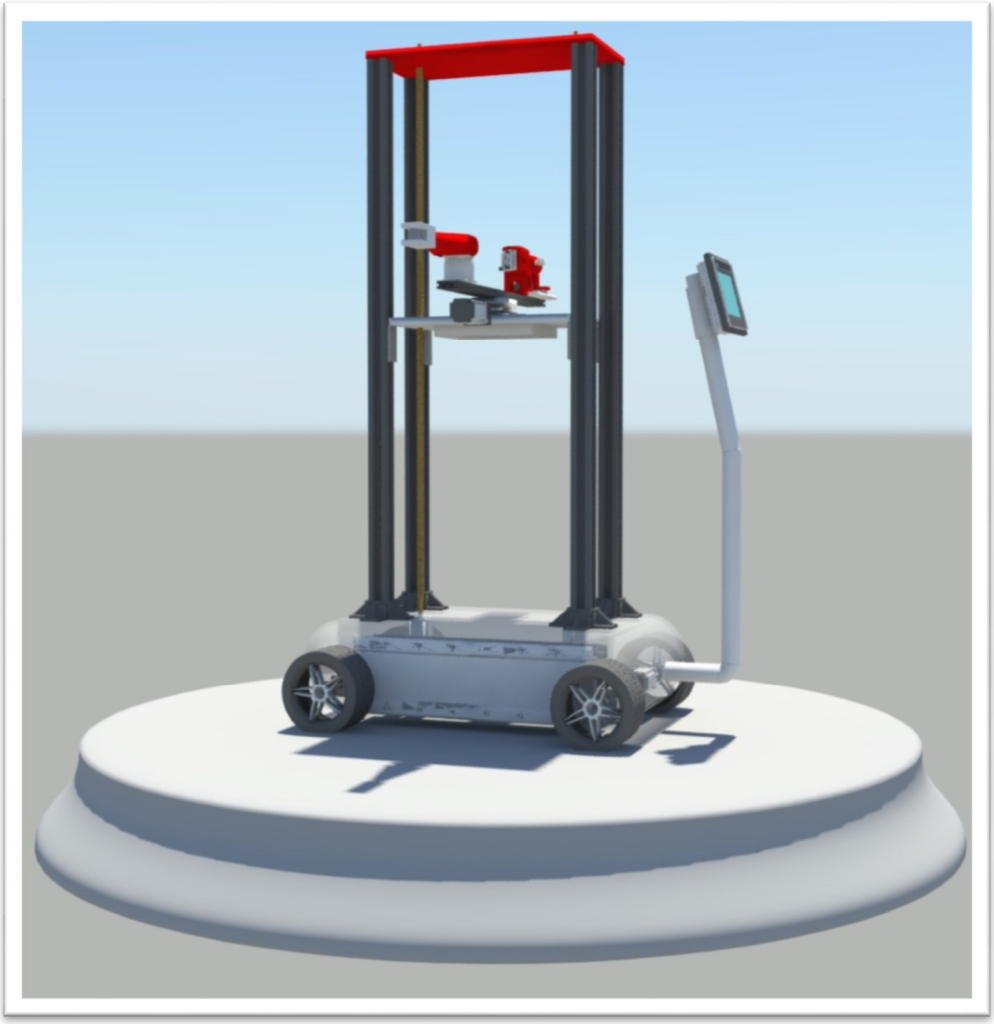
Customer Requirement
A customer has a large factory that has a concrete wall around its perimeter. Customer wants his perimeter to be painted with least labor cost and minimum time.

Solution:
Configure PICASO 4.0 to move around the perimeter wall and paint.

Robot Design:

Our system is divided into **three axes (X, Y, Z)**. The design consists of a **base chassis** on which the whole system stands. The base chassis houses all the servo drives, power supply, PLC, wiring, servo motors, etc. The base chassis has **four servo motors** that are attached with gear box, which are further attached with wheels. The chassis along with the wheels and servo forms the X axis. The **X axis** moves horizontally parallel to wall or work surface. Above the chassis runs vertically **four aluminum extrusion** which supports the **Y axis** for the system. The Y axis moves vertically up or down using **two lead screw** with **two split nuts** attached to the base of a sliding rack. The lead screws are rotated by servo motors coupled to it and are placed inside the chassis. The **Z axis** is above the rack of Y axis and moves two tools toward or away from the wall. We can place the robot in two orientations: one with printing head towards wall for printing and other one is laser towards wall for engraving. An **HMI** is attached to the side of the robot for real time monitoring, start, stop, emergency stop, etc.

PICASO 4.0 PRODUCT DESIGN ANIMATION :: https://youtu.be/C1ulfhZpyTI



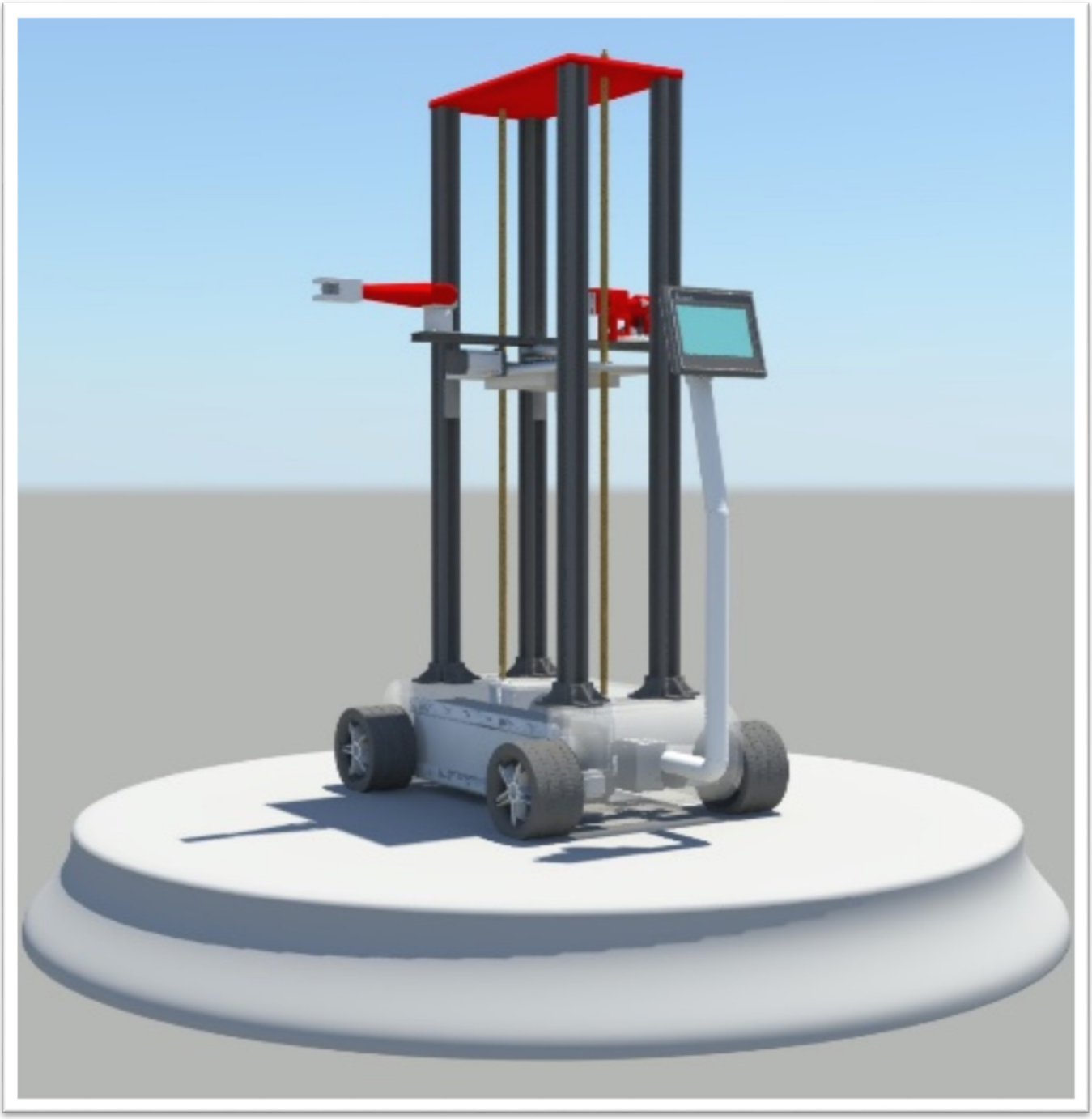
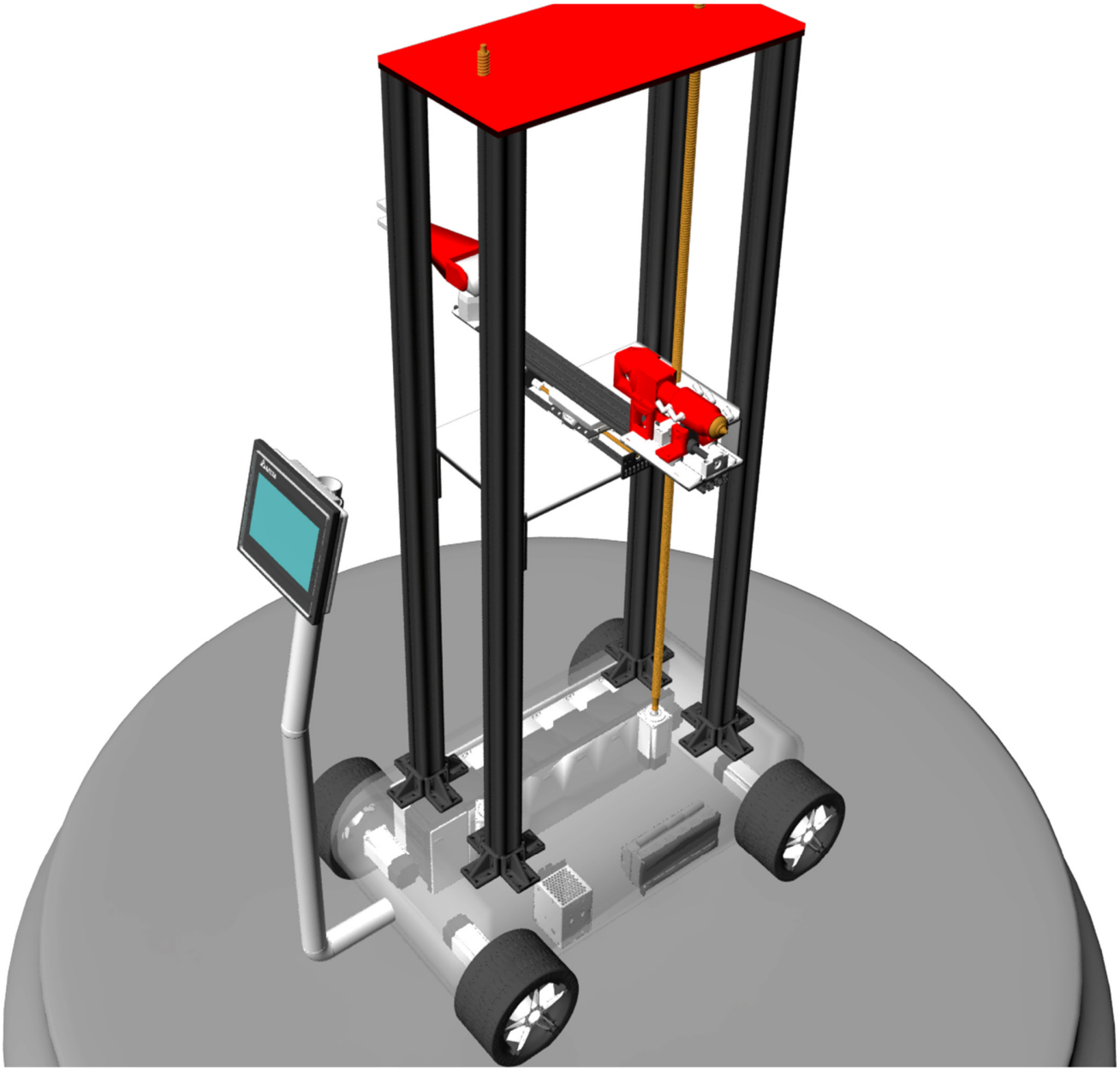
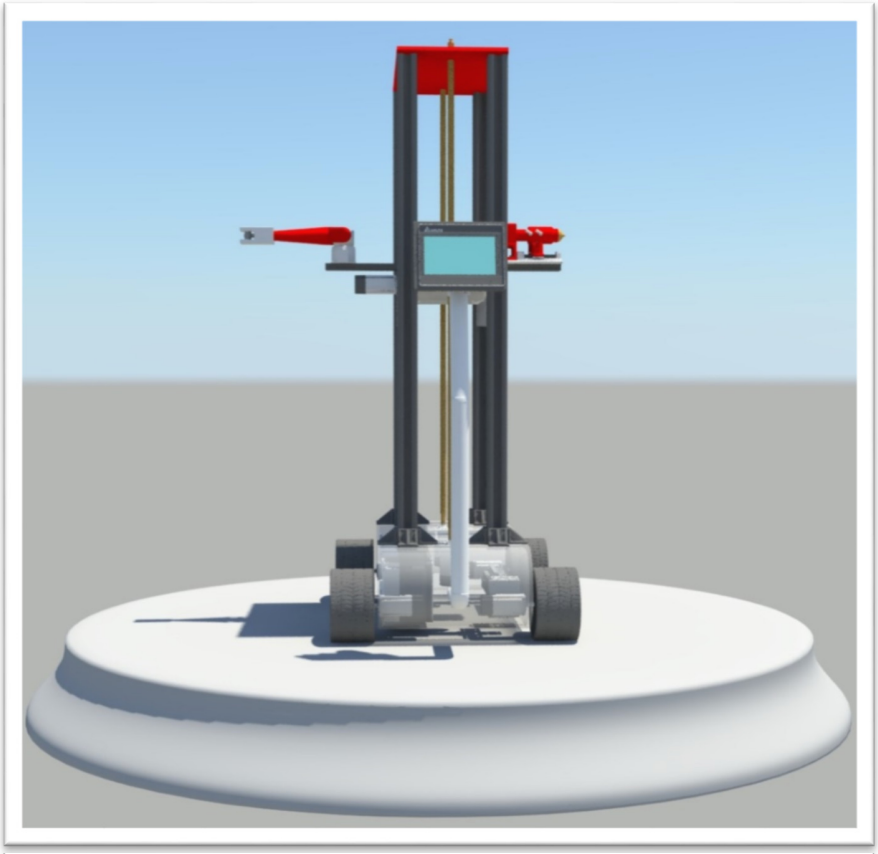
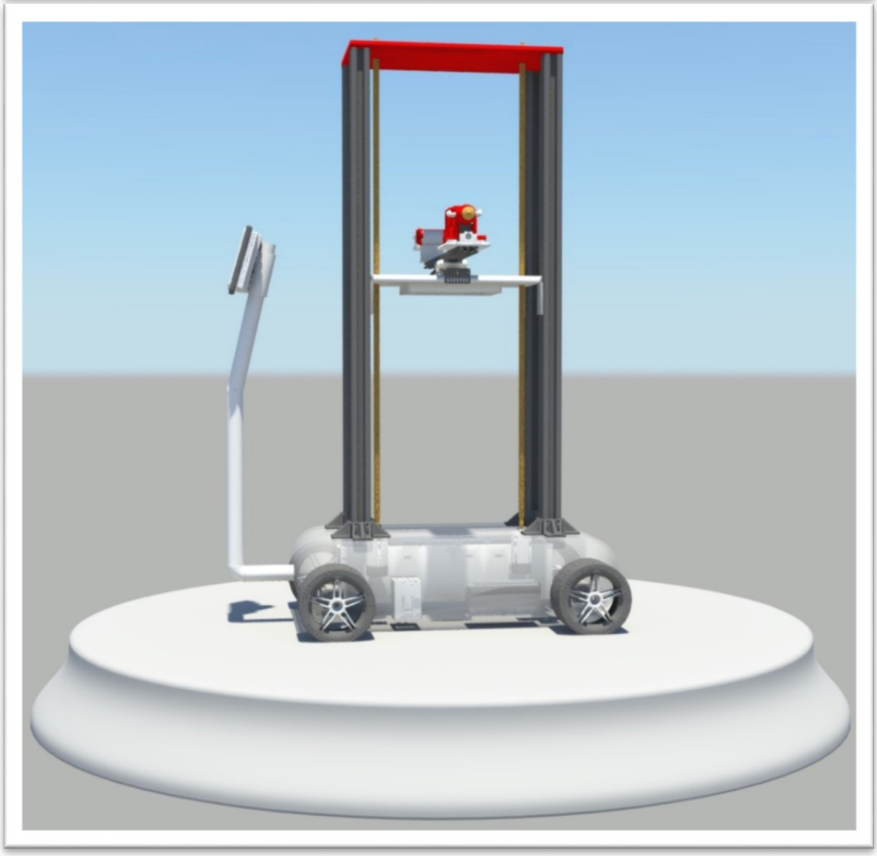


Fig: Isometric View with all assembly







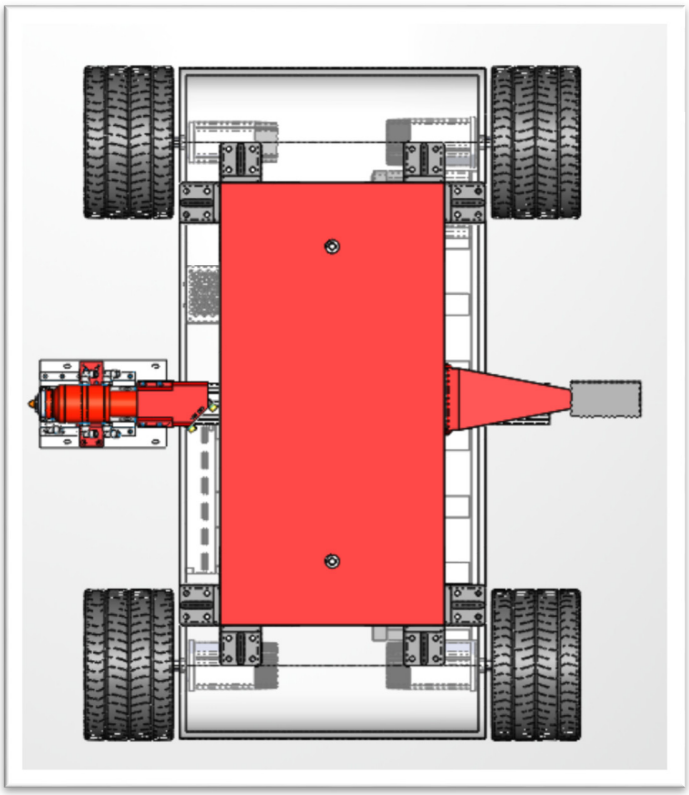


Fig: Top View

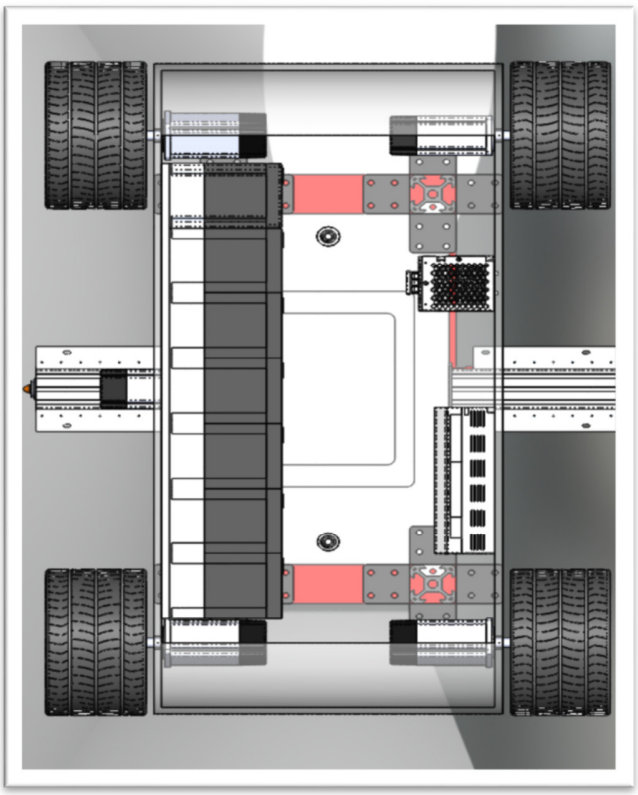
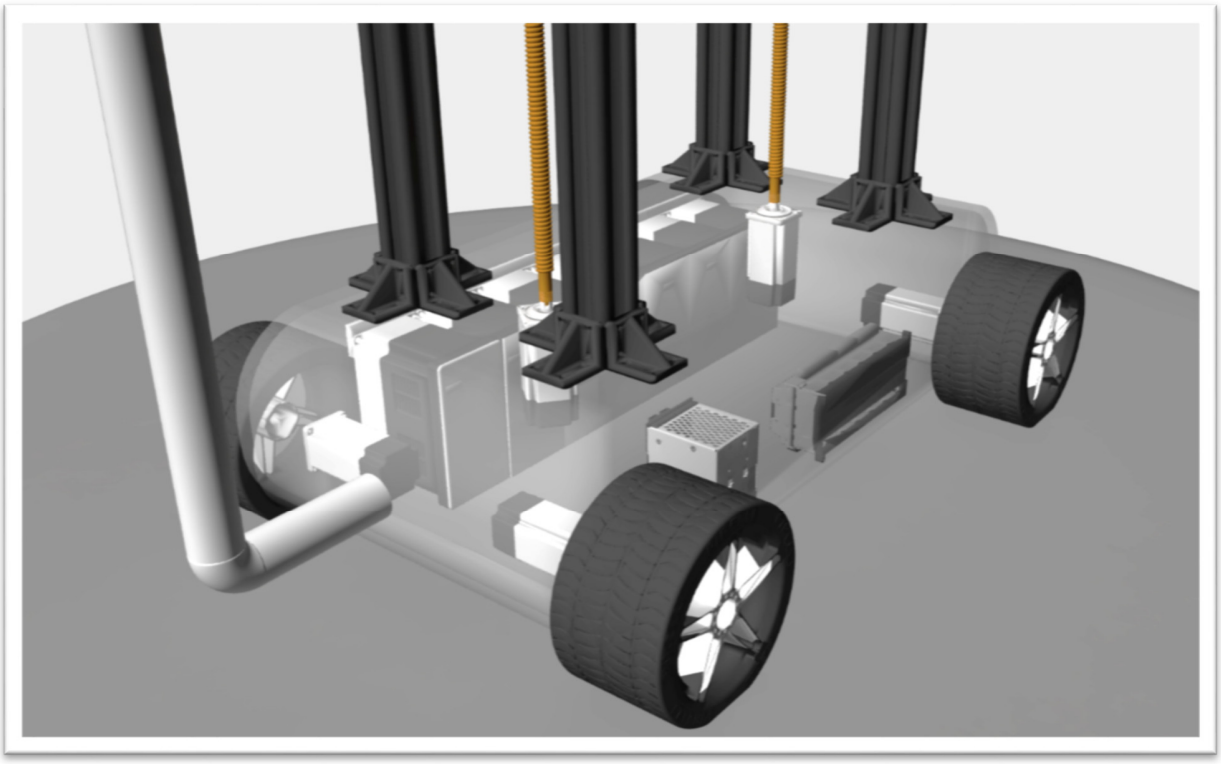


Fig: Bottom View



Mechanical Drawings:

All Measurements are in **Inch**

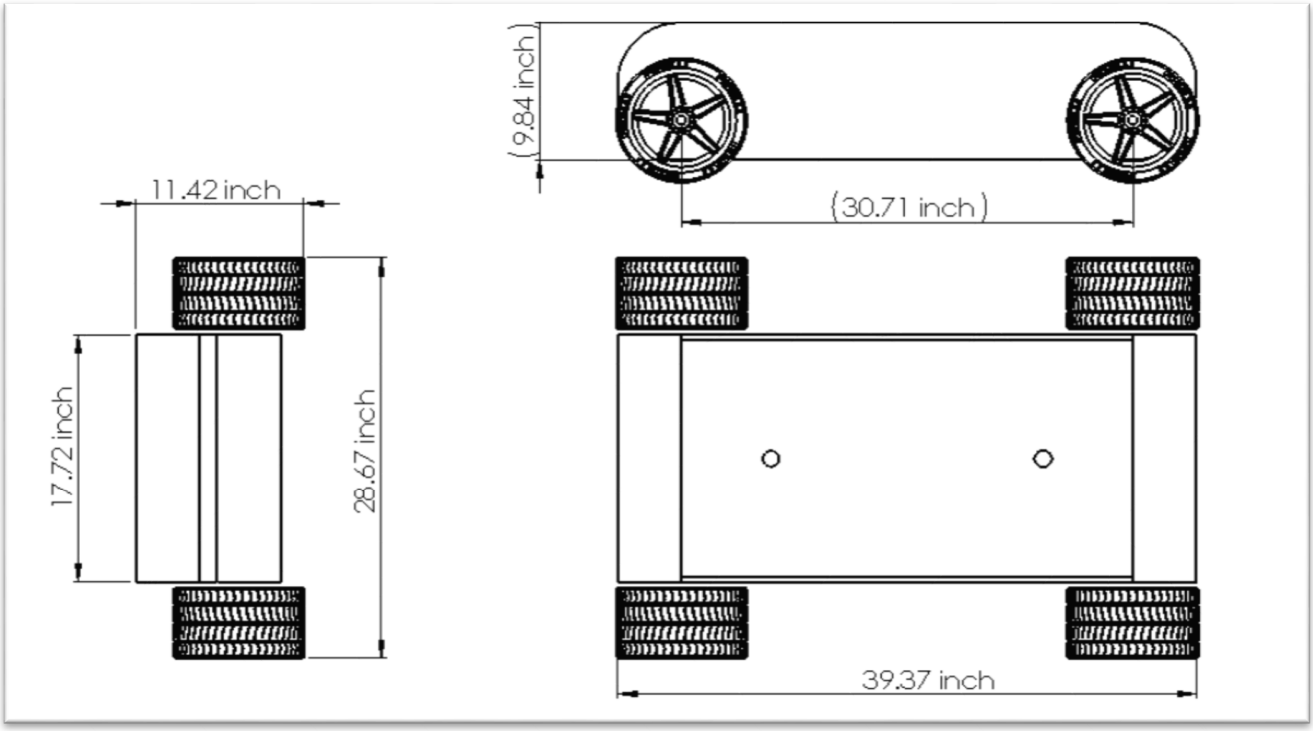
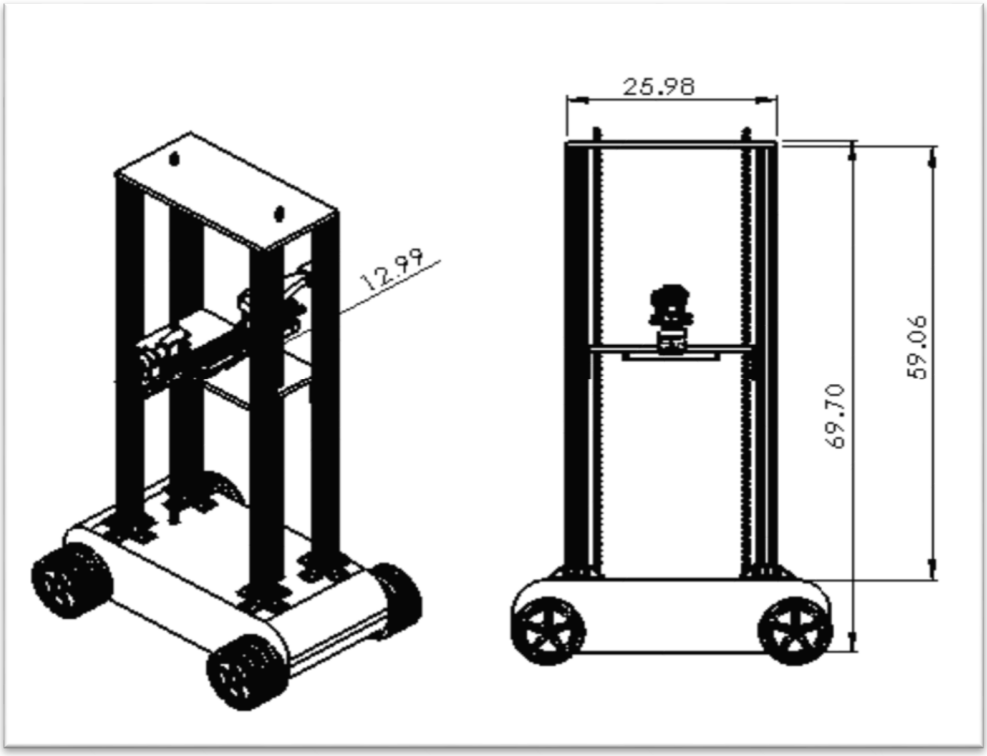


Fig: Base Cassis Measurement



Design Analysis:

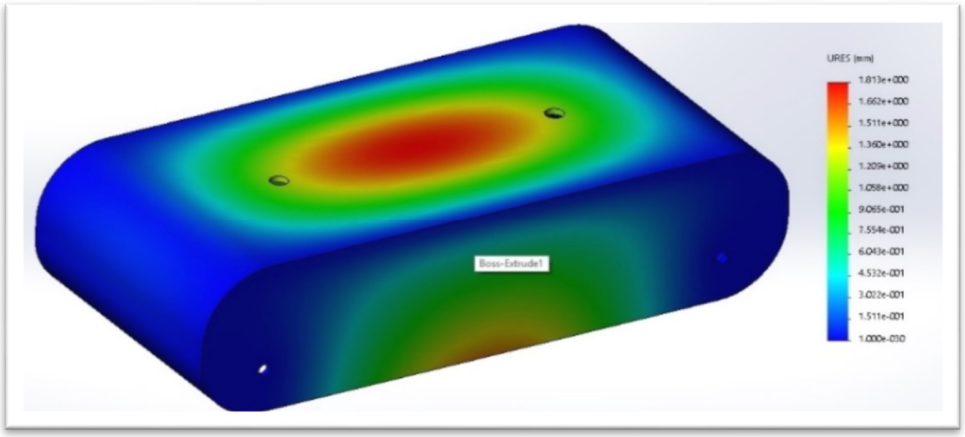


Fig: Displacement Analysis

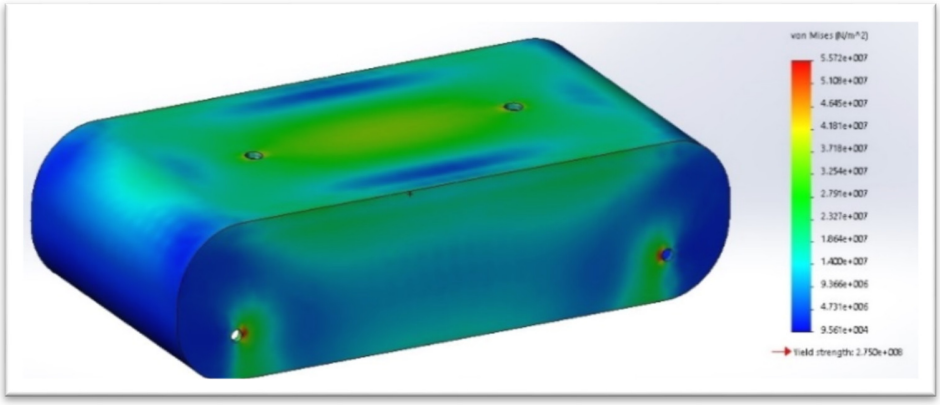


Fig: Stress Analysis

Force	2000N
Displacement	1.8mm

Motion Control:

In this project we are using multiple servo motors for controlling X, Y, Z axis motion.

1. In the **X Axis** we will use **four servo motors** that gear box coupled with **four wheels** in the base of the robot that will work in coordination to move the whole robot parallel to the wall. Feedback from **ultrasonic sensors** placed on ends of Y axis rack, facing the wall, continuously measure distance to maintain Y axis parallel to wall.
2. In the **Y Axis** we will use **two servo motors** directly coupled to **two lead screw** and will also work in lock step / synchronization.
3. In the **Z Axis** we will use **one servo motor** to move the **printing head / laser head** near and away from the wall.

   G-Codes will be used for motion control with both linear interpolation and circular interpolation.

Tool Control:

In this robot we will be controlling **two tools** that are facing opposite to each other in the design and mounted on the **Z axis**. One tool will be a p**ainting head** another will be a **laser head**. According to our need, we will place the robot in such way that the required tool will face the wall. After which the axis for that job will be assigned and the robot will move accordingly. (For the laser engraving mode the axis (-X, +X) will work vice-versa.

M-Codes will be used to control the paint head and the laser head. Only one will be activated at one time. We will be controlling the laser intensity as well as paint outflow from the Z axis.

Continuous calculation of distance between wall and the Y axis will be done using high accuracy industrial ultrasonic sensor that will give feedback for the system so that it always remains parallel to the wall. Four motors of the x axis will be differentially speed controlled to maintain equidistance between the tool and the wall or surface. Any compensation will be done using the z axis.

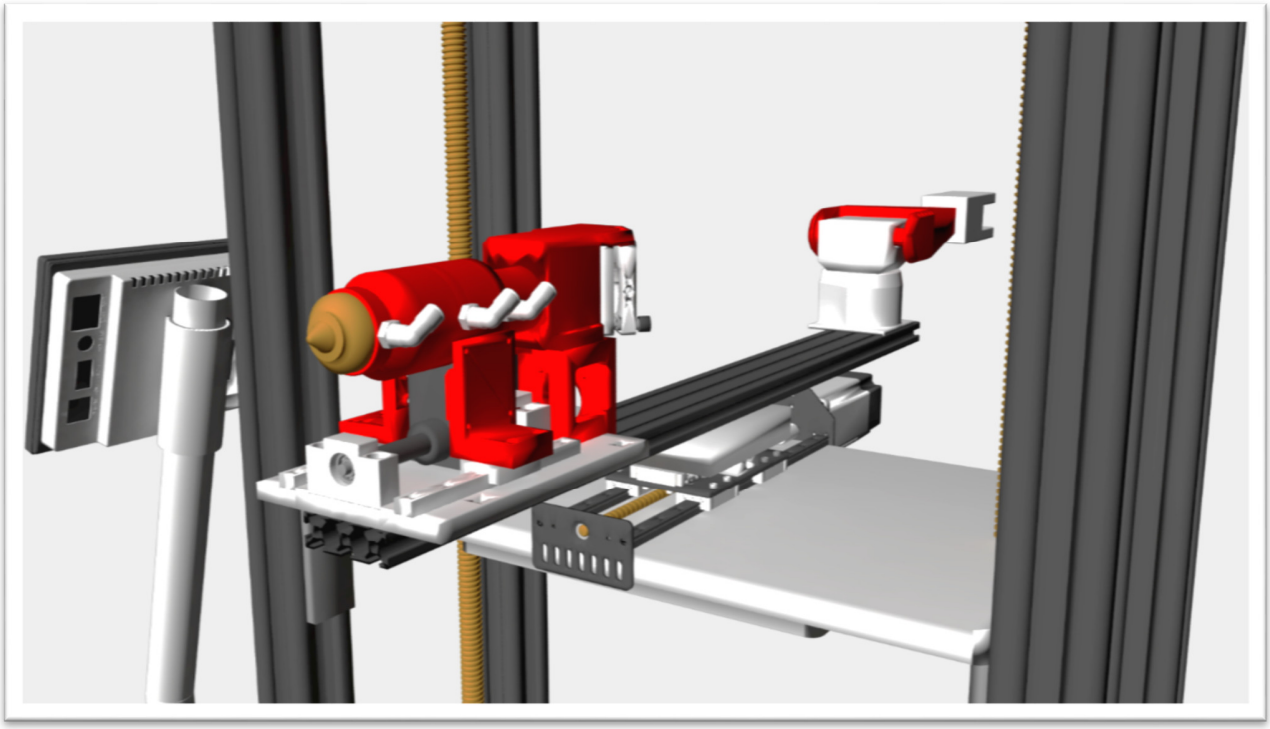


Fig: Tool Mounted on Z-axis and Facing Opposite

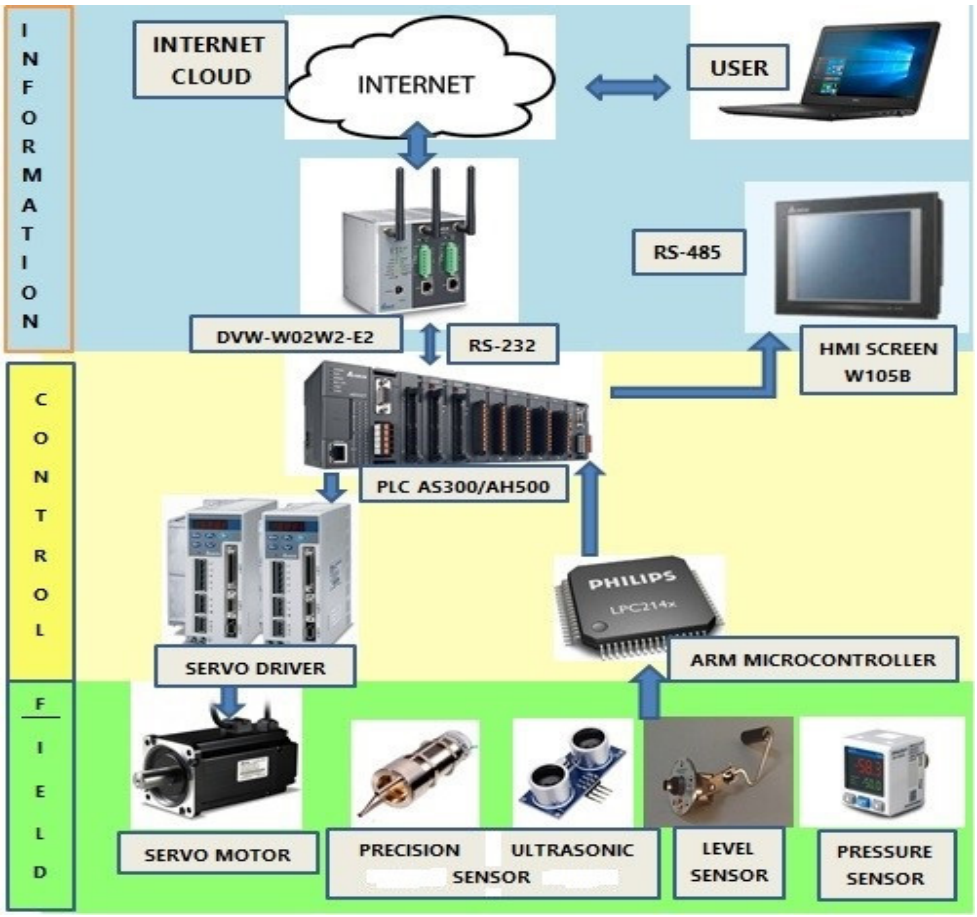
Robot's Work Space:

- Cartesian Coordinate Robot
- The robot can work only on flat-floor and flat-wall.
- Can't move on too much slanted floor (15 Degree Safe Limit)
- Cannot move pass locked door or closed door.
- Need clearance in his path for proper movement and operation.

Uncertain Error Handling:

- PICASO 4.0 will pause all its work.
- Emergency alarm will be switched on and emergency light will be displayed.
- Massage notification will be visible on HMI and will also be uploaded on cloud.
- Robot will need operator's command to resume work after solving problem.

Block Diagram



Robot Operation:

Step 1 > User will upload the image required for vertical painting or engraving with size specification to cloud server and will select the required mode i.e. painting or engraving.

Step 2 > The Image is rasterized and processed to generate G-Codes and M-Codes for the robot in the server.

Step 3 > The PLC will download the G-Code file.

Step 5 > PICASO 4.0 is placed along the wall with specific tool facing the wall.

Step 4> PICASO 4.0 will start engraving or painting according to the G-codes and M-codes.

Step 5> Live work status is uploaded to the cloud for supervisory purpose.

Innovative Planning and Value

- PICASO 4.0 can be used for both horizontal and vertical applications with slight modification in design.
- PICASO 4.0 don't have work area limitation.
- PICASO 4.0 is designed using standard industrial parts and accessories (e.g.: v-slots, lead screw, etc.).
- Easy to assemble and disassemble the PICASO 4.0
- PICASO 4.0 is connected with cloud thus accessible from anywhere.

Cost Analysis, Reasonability and Feasibility

As we are using all parts according to the industrial standards, we are have very cost effective structure. In this we need to manufacture only the base chassis in which we have to use milling and welding process. Thus Manufacturing time is low and will be done in a reasonable cost.

Components Specification & Bill Of Materials

Serial Number	Product Name	Delta Product Code	Quantity	Description
	DELTA PRODUCTS			
1	Wireless Module	DVW-W02W2-E2	1	To connect with internet
2	Power Supply (24V Output)	PMC Panel Mount Power Supply (24V Output)	1	To provide 24V to the PLC
3	PLC	AS 300 / AH 500 Series	1	Main controller which accept the input through HMI and cloud server and do control according to ladder logic.
4	HMI	W105B (10 Inches)	1	To observe the status of the robot on the field and to control it, we are using 10 inches' screen.
5	Pressure Sensor	DPA 01 M/P Series	>1	To check the pressure of the paint fluid at Inkjet Sprinkler so that spray can perform at constant pressure or flow.
6	Motor Driver	Delta Servo Drives	7-8	To drive all Axes motors
7	Servo Motor	Delta Servo Motor	7-8	To move all Axes
8	Planetary Gear Box	Delta Product	4	To attach between wheels and servo motor of X axis
9	Linear Motion Product	Delta Ball Screw Driven Delta Product (Z- AXIS)	1	For Z-Axis
	OTHER PRODUCTS			
10	Multiple High Precision Ultrasonic Sensor	Third Party	4	For calculating distance from wall
11	Limit Switch	Third Party	4	For limiting Y Axis and Z Axis motion
12	Inkjet Sprinkler	Third Party	1	For sprinkling paint on wall
13	Power Supply (5V, 5Amp)	Third Party	1	For powering microcontrollers and other peripherals
14	Microcontroller	LPC 2148 ARM TDMI (Third Party)	1	For sensor data acquisition

15	High Power Carbon Dioxide LASER	80 Watt (Third Party)	1	For engraving on wall
16	Wheels	Third Party	4	For moving the robot along X Axis
17	Flexible Motor Coupler	Third Party	2	For coupling with lead screw
18	Laser Head and Optics	Third Party	1	For focusing laser beam
19	Linear Bearing	Third Party	8	For smooth movement of Y Axis rack on aluminum extrusion
20	BLDC Blower Fan	Third Party	4	For cooling Drives
21	Fastener	Third Party	Multiple	For assembly of Robot
22	Wire	Third Party	Multiple	Wiring
23	Aluminum 6063 T6 Extrusion 6 Feet	Third Party	4	For construction of Y axis
24	Wire Connector	Third Party	Multiple	Wiring
25	Aluminum L Joints	Third Party	24	For construction of Y axis
26	Lead Screw 16mm Diameter 4mm Pitch	Third Party	2	For Y axis
27	Bearings	Third Party	Multiple	For putting with rotary parts

Future Scope:

1. We can modify the system to perform a complete wall painting process including buffing, cleaning, moisture sensing, painting, drying, and final image processing based monitoring.
2. Addition of gyroscope and accelerometer data fusion algorithm with PID can be used to painting on uneven surface. The robot will automatically compensate the slating of surface.
3. We can do large scale 3D printing by attaching specific tool.
4. Horizontal printing on roads, floors, any horizontal surface (e.g. Zebra Crossing Printing).
5. Connected machines (IOT) that will do multiple section of a wall at same time, working hand in hand to complete a task in much less time.