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# DESIGN PORTFOLIO

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GOKUL MOHANDAS

MECHANICAL DESIGN ENGINEER

[gokul1401995@gmail.com](mailto:gokul1401995@gmail.com)

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## HELLO!

I believe, design is a field where one's ideas aren't inhibited, and it intrigues me to explore for more efficient and creative solutions.

- 4+ years of Design & Manufacturing expertise to create and reengineer products for better use & sustainability
- With a Master's Degree from UNC Charlotte, NC and Bachelors' from Mumbai University, INDIA
- Proficient in CAD Design, Prototyping, Analysis, Testing & Assembly
- Last name literally translates to '**Engineer**' in Persian.



Certified SOLIDWORKS Professional



Lean Six Sigma Green Belt

2020-Present

**Lead Product Design Engineer**

*Wood Designs (Monroe, NC)*

2018-2020

**Mechanical Design Engineer**

*RNS International, Inc. (Charlotte, NC)*

2015-2016

**Design Engineer**

*String Mills & Moulds (Mumbai, INDIA)*

2015-2016

**Project Trainee**

*Bhabha Atomic Research Center (Mumbai, INDIA)*

2014

**Industrial Trainee**

*Technip Engineering Works (Mumbai, INDIA)*

2013

**Industrial Trainee**

*DFPCL (Mumbai, INDIA)*

# DESIGN OF STIPPLING MACHINE

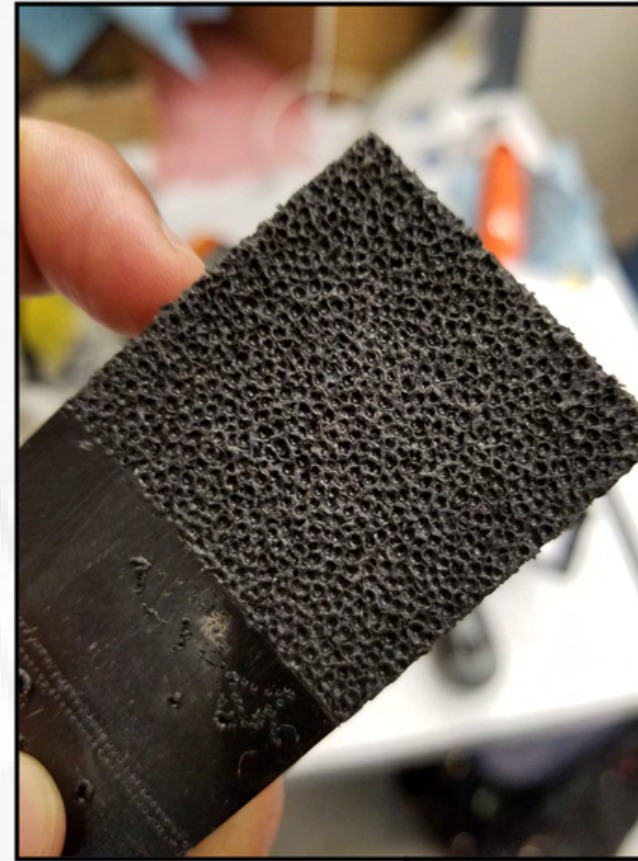
## PROBLEM:

The process of manual stippling is very time consuming and requires intensive concentration & patience, moreover the corresponding pay is really less not to mention the health risk one poses by inhaling burnt plastic fumes.

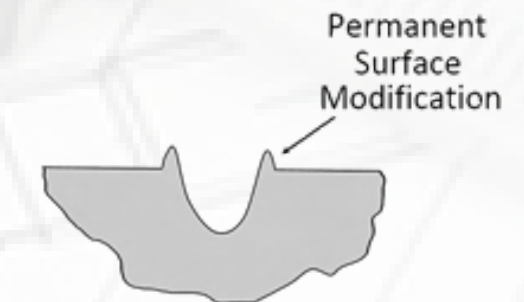
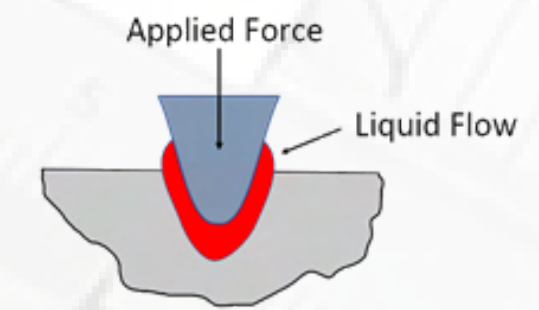
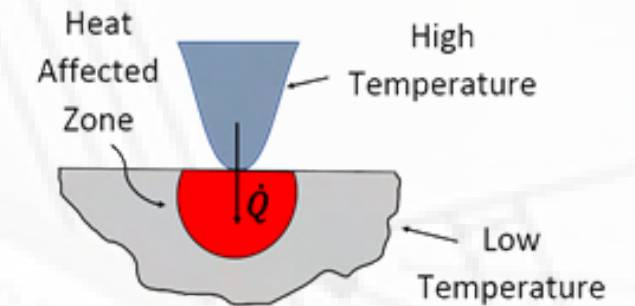
The challenge was to develop a fully functioning prototype of a multi-axis computer numerically controlled stippling machine to automate stippling process under a budget of **\$3000**

## Design Selection Matrix

|                     |              | Options              |                      |                      |
|---------------------|--------------|----------------------|----------------------|----------------------|
|                     |              | Moving Bridge Gantry | Trunnion             | Robotic Arm          |
| Criteria            | Weight (1-5) | Score/Weighted Score | Score/Weighted Score | Score/Weighted Score |
| Simplicity          | 5            | 5                    | 4                    | 3                    |
|                     |              | 25                   | 20                   | 15                   |
| Precision           | 5            | 4                    | 5                    | 3                    |
|                     |              | 20                   | 25                   | 15                   |
| Ease of Fabrication | 4            | 5                    | 3                    | 2                    |
|                     |              | 20                   | 12                   | 8                    |
| Estimated Cost      | 2            | 4                    | 1                    | 3                    |
|                     |              | 8                    | 2                    | 6                    |
| Portability         | 3            | 4                    | 2                    | 5                    |
|                     |              | 12                   | 6                    | 15                   |
| Size                | 1            | 3                    | 2                    | 5                    |
|                     |              | 3                    | 2                    | 5                    |
| Score               |              | 88                   | 67                   | 64                   |

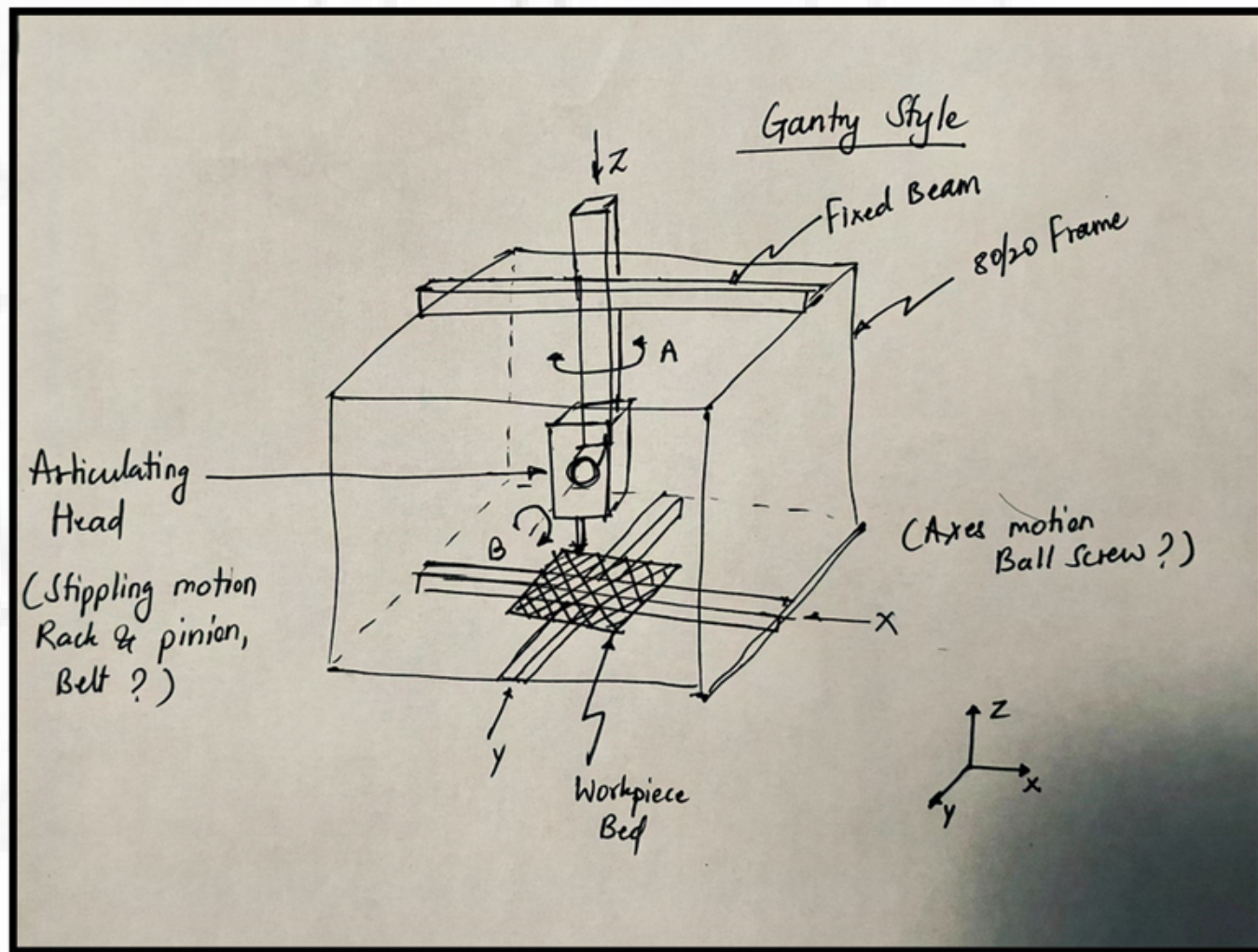


**Stippling** is the process of repeatedly indenting a surface using localized heating and load.



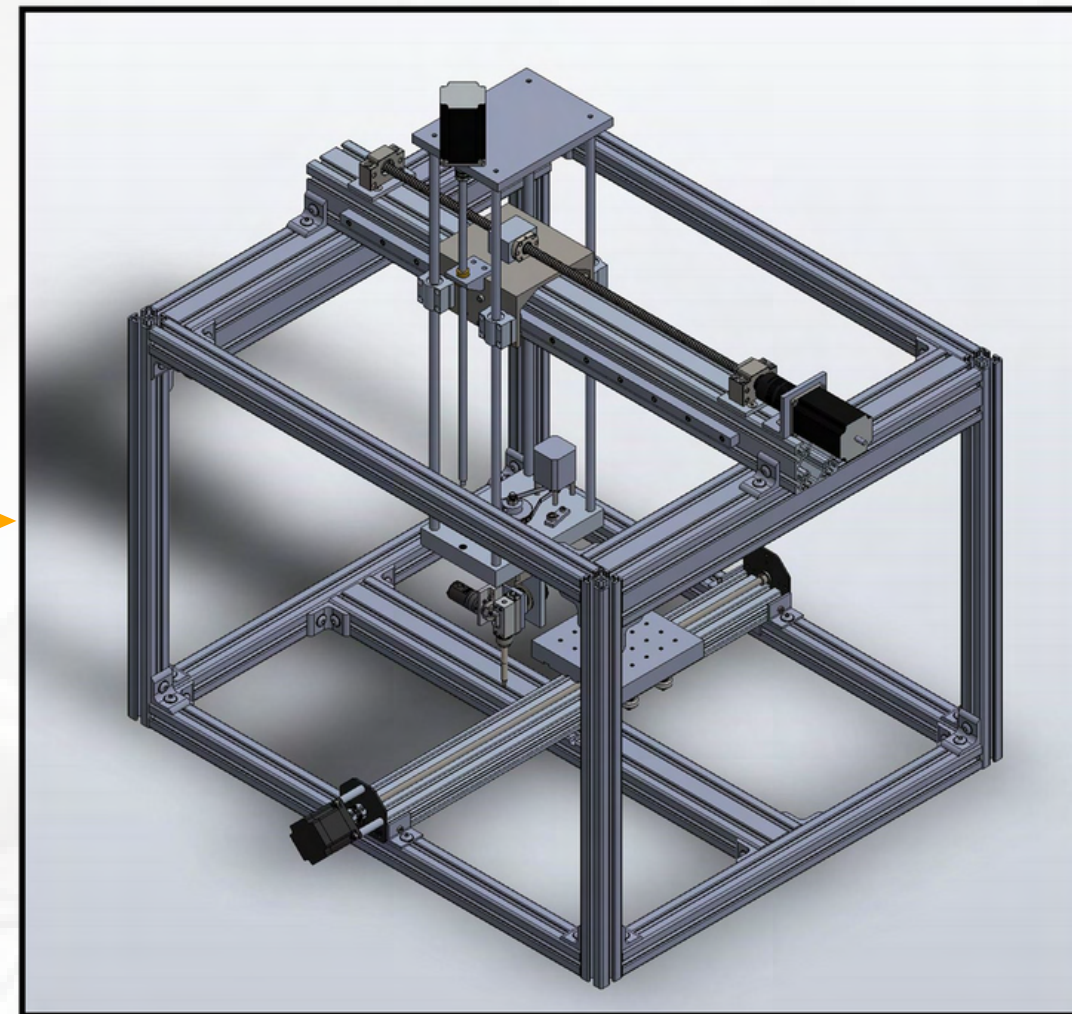
**Stippling Samples**

Based on the design matrix, "**Moving Bridge Gantry Style**" configuration was selected for the machine.



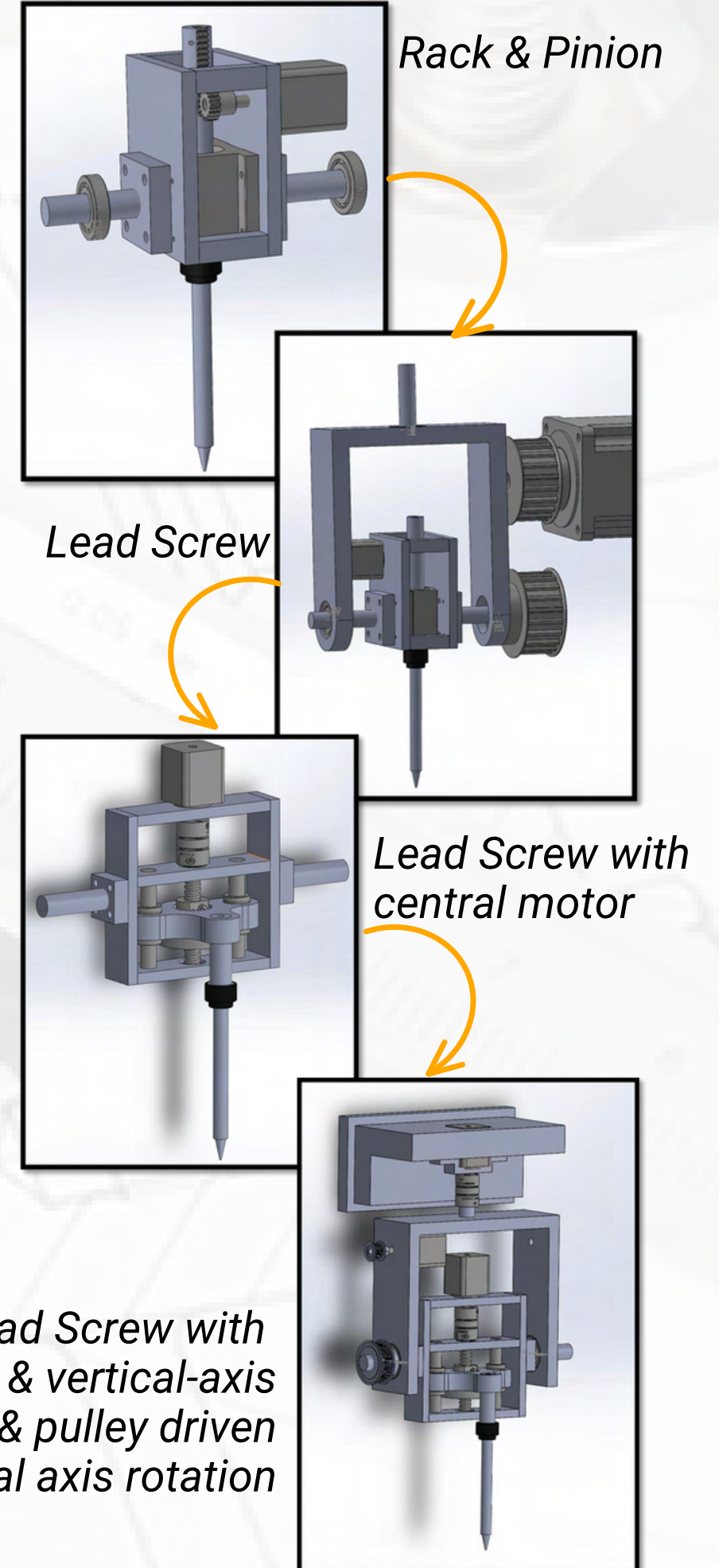
**Initial hand-drawn concept**

Consists of **3** Linear (X, Y, Z) Axes and **2** Rotary (A, B) Axes with the Stippling Head being mounted in a housing on the Z-axis



**CAD Model**

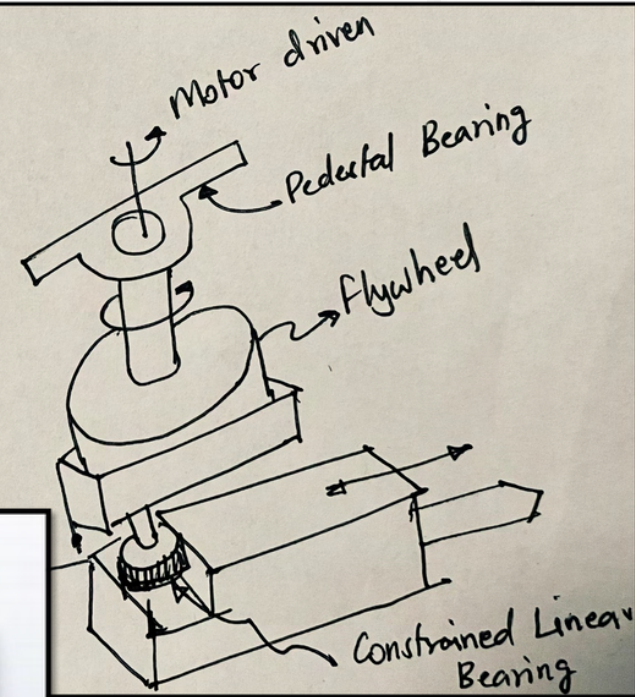
## Head Design Iterations



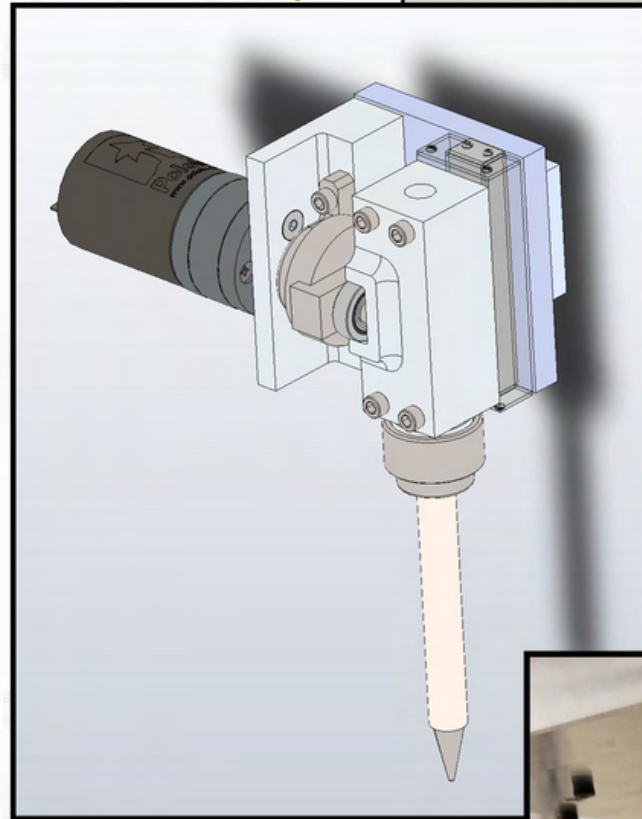
*Modified Lead Screw with central motor & vertical-axis rotation & pulley driven horizontal axis rotation*

## PROJECTS

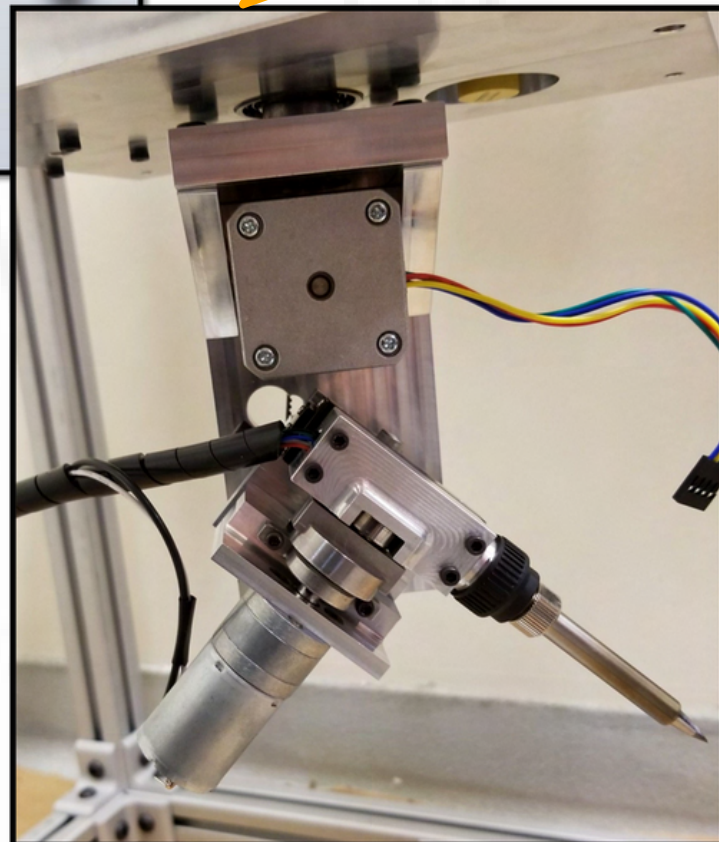
The stippling motion design implemented a modified type of the crank-slider mechanism.



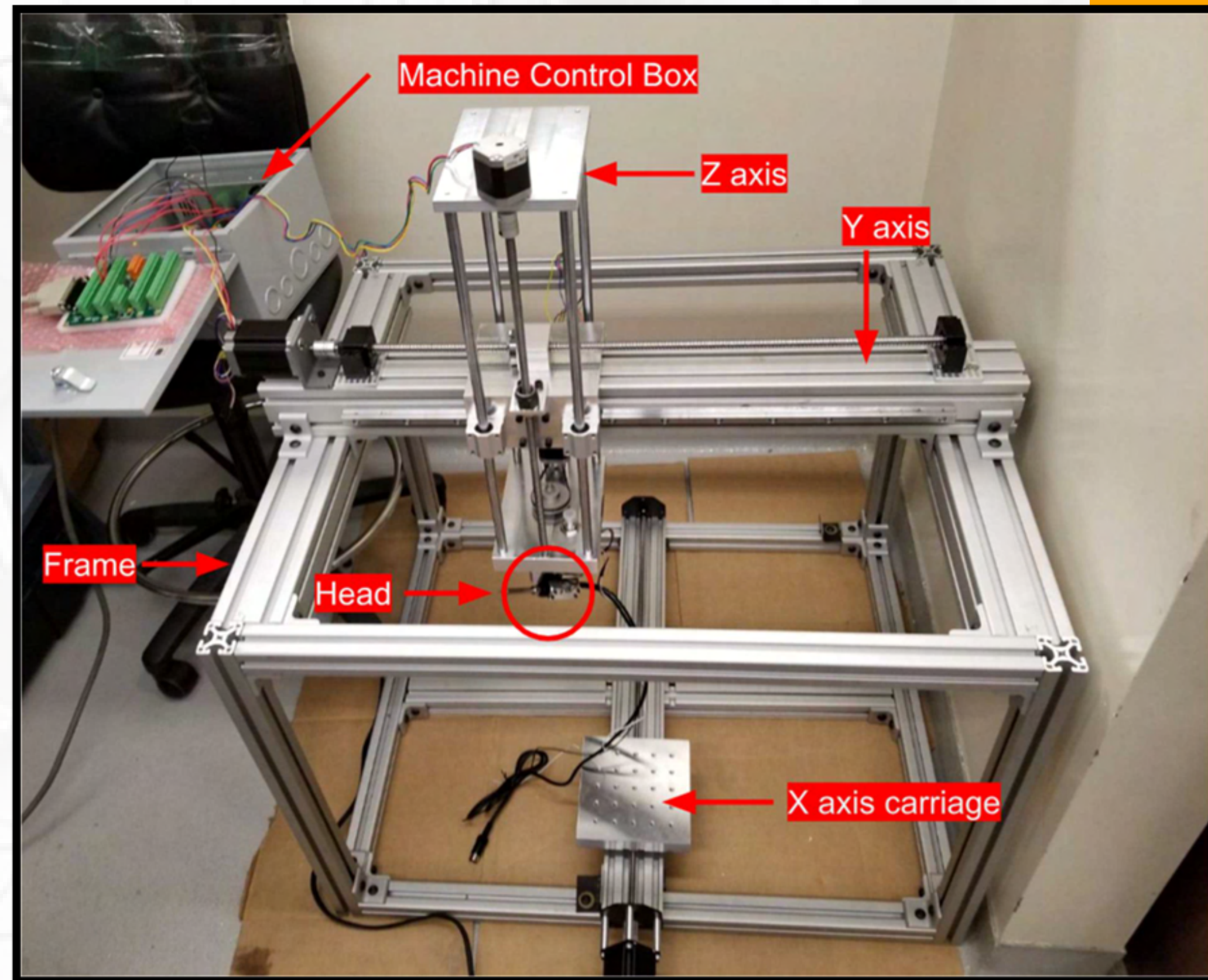
The crank arm is replaced with a circular crank & has an eccentrically inserted pin.



Attached to the pin is a bearing which rides in a slot cut inside tool tip housing. The pin is constrained in the slot by a linear bearing.



The motor shaft rotates the eccentric pin which moves in the slot, along the path of the linear bearing. Hence converting rotary motion into linear articulation.



***Stippling Machine Prototype***

**RESULTS:**

- Positional accuracy of 0.01 in
- Stippling Force of 0.42-0.5 lbs
- Working range of 150 x 150 x 150 mm on each axis
- 70% faster compared to hand stippling

**X-axis** - Lead Screw

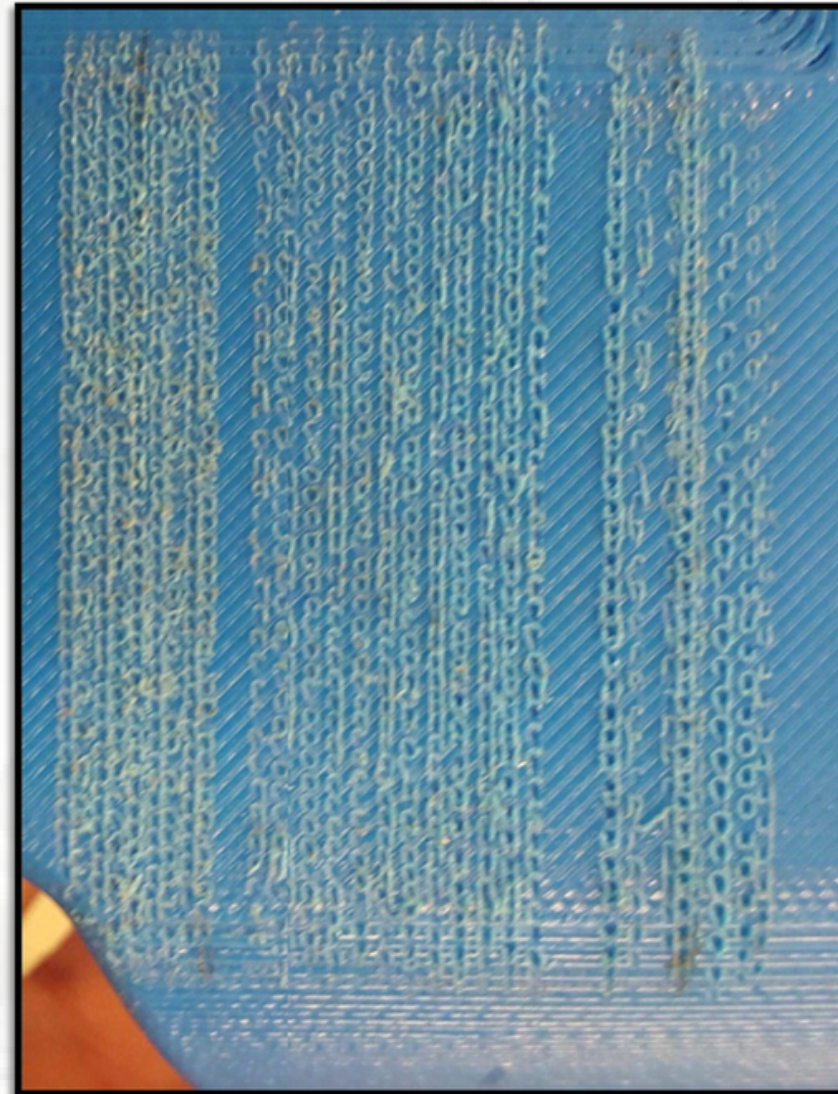
**Y-axis** - Ball screw driven by rack & pinion

**Z-axis** - Lead Screw

**A-axis** - Timing Pulley

**B-axis** - Belt and Pulley

**Stippling action** - Modified Crank Slider



***Workpiece Sample***

| Sub Assembly | Total              |
|--------------|--------------------|
| Electronics  | \$ 1,018.15        |
| Frame        | \$ 493.33          |
| Y-Axis       | \$ 340.72          |
| Head         | \$ 318.69          |
| Z-Axis       | \$ 245.21          |
| X-Axis       | \$ 209.22          |
| C-Axis       | \$ 172.74          |
| Tools/Misc   | \$ 135.24          |
| <b>Total</b> | <b>\$ 2,933.30</b> |

***Cost breakdown***

# DESIGN OF SANITATION STATION

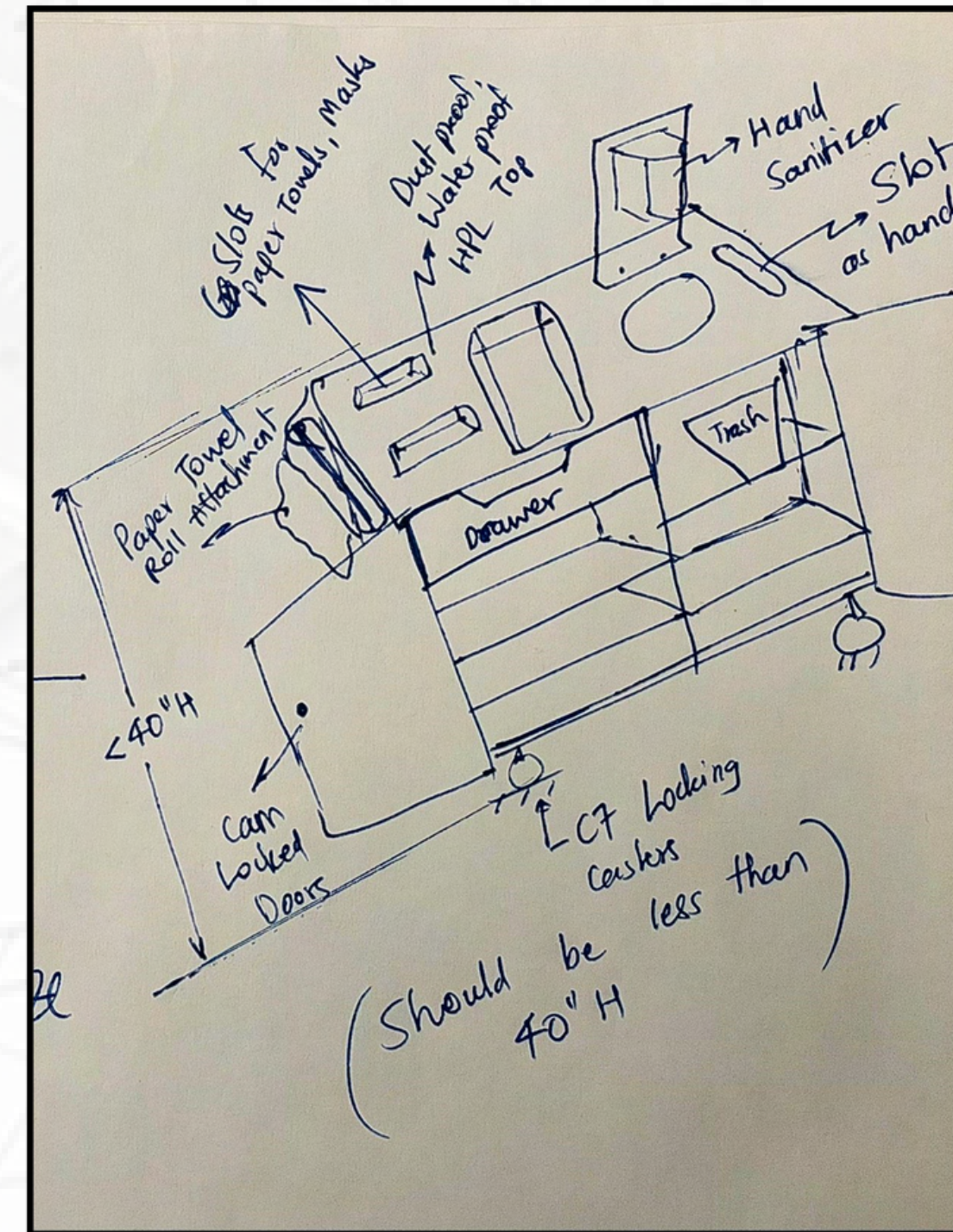
## PROBLEM:

Everyone was coping with increased sanitary requirements due to COVID pandemic. There was an immediate need to develop products that would ease the transition back to schools and offices all the while maintaining proper safety.

The challenge was to launch a product in market within 1-2 months under a reasonable cost

## Primary requirements were:

- Mobility
- Lockable
- Easy to use for all age ranges
- Paper Towels
- Masks
- Hand Sanitizer
- Supply Storage
- Waste Disposal



*Initial hand-drawn concept*



**CAD Model**

The 19"H x 8"W hand sanitizer docking station comes unattached and is easily secured with a simple (4) screw attachment and sits above the adjustable trash can compartment for easy clean up.

Keep any gloves, masks, or tissues stored in the convenient pull out drawer. Anything stored in the pull-out drawer can be easily accessed from the top cut outs while the cabinet doors are shut.

Locking doors can keep valuable supplies safe as the sanitation station is in use.

Move this heavy-duty cart comfortably with reliable locking casters and conveniently placed hand cutouts.



*The product is designed in a such a way that it flows naturally from sanitizing your hands, disposing of the paper towel and then taking a new mask*



**Final Product**

### RESULTS:

- Final Product was launched in the market in 45 days
- Its success created a whole new branch of other sanitation products like room and table dividers as well as different configurations of the sanitation station
- Proved crucial in winning a bid worth **\$300,000** for Chicago Public Schools, to remodel their elementary school classrooms with this product line

**Final product dimensions:** 42-5/8" W x 22" D x 54-1/4" H

**Weight:** 105 lbs



*Final Product*

# DESIGN OF TEST FIXTURES

## NECESSITY:

Modern electronics are an assembly of myriad of smaller sub-assemblies and electrical circuits with a variety of PCBs performing their programmed function.

It is really difficult and cumbersome to identify a faulty component or a non-working PCB after it has been deployed in the final product. Hence companies use test fixtures in QC lines for checking the operation of PCB boards or any electronic equipment before it is assembled into the final product. This significantly reduces downtime and saves time. Most of the test fixtures are designed to be operated with minimal technical knowledge and can also be easily automated.

### Typical Fixture Design Flow:

Extract and identify Board Components, Dimensions and Test points from Gerber Files

Draft 2D Layout of Fixture Top Assembly

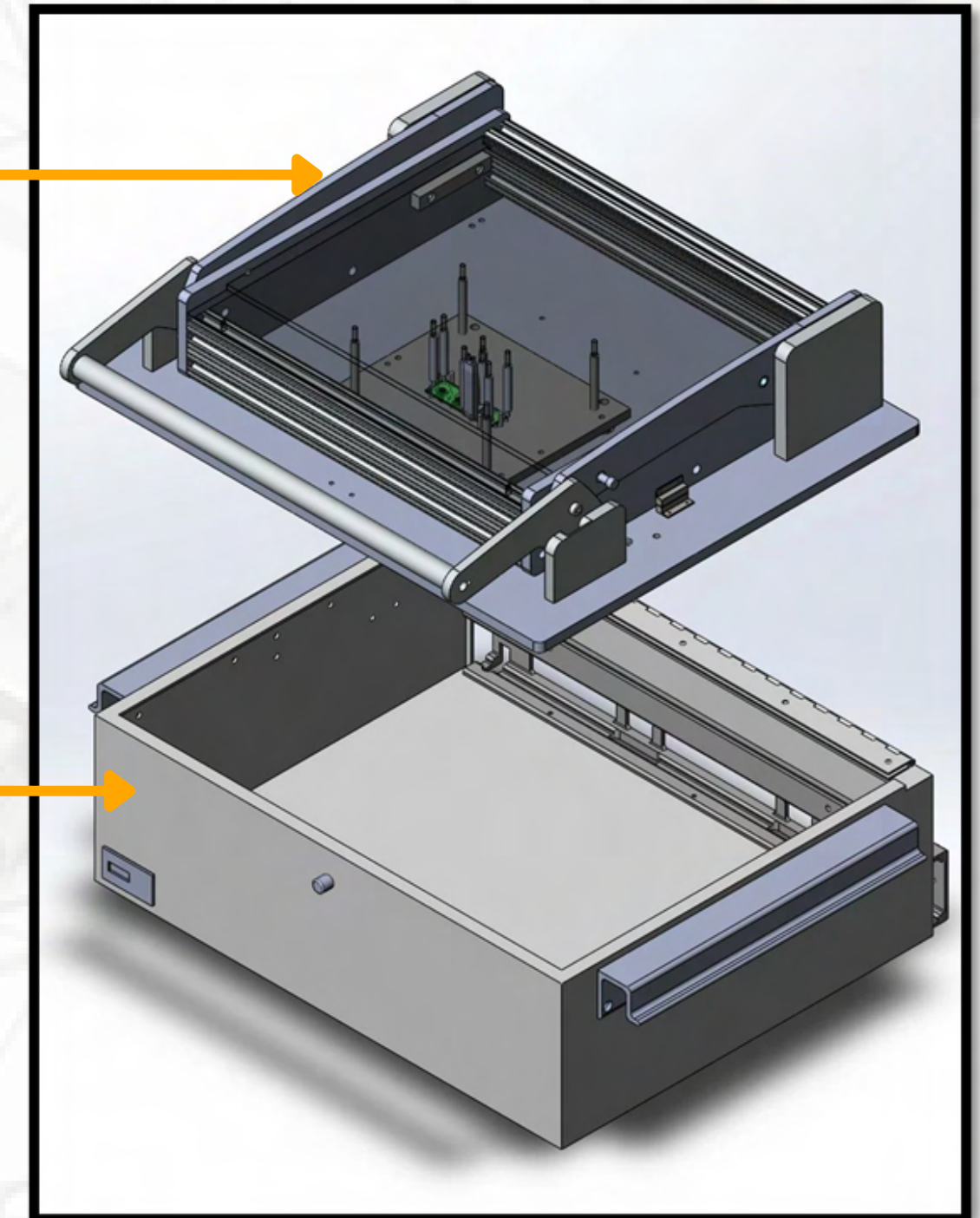
Select probes from catalog and place them in layout

Design Top Plate, Probe Plate as per probes location, size and application

Design Fixture Frame as per layout & dimensions of board, TP & PP

*Fixture Top Assembly*

*Base enclosure*



*Typical PCB Test Fixture*

## PCB Fixture Parts:

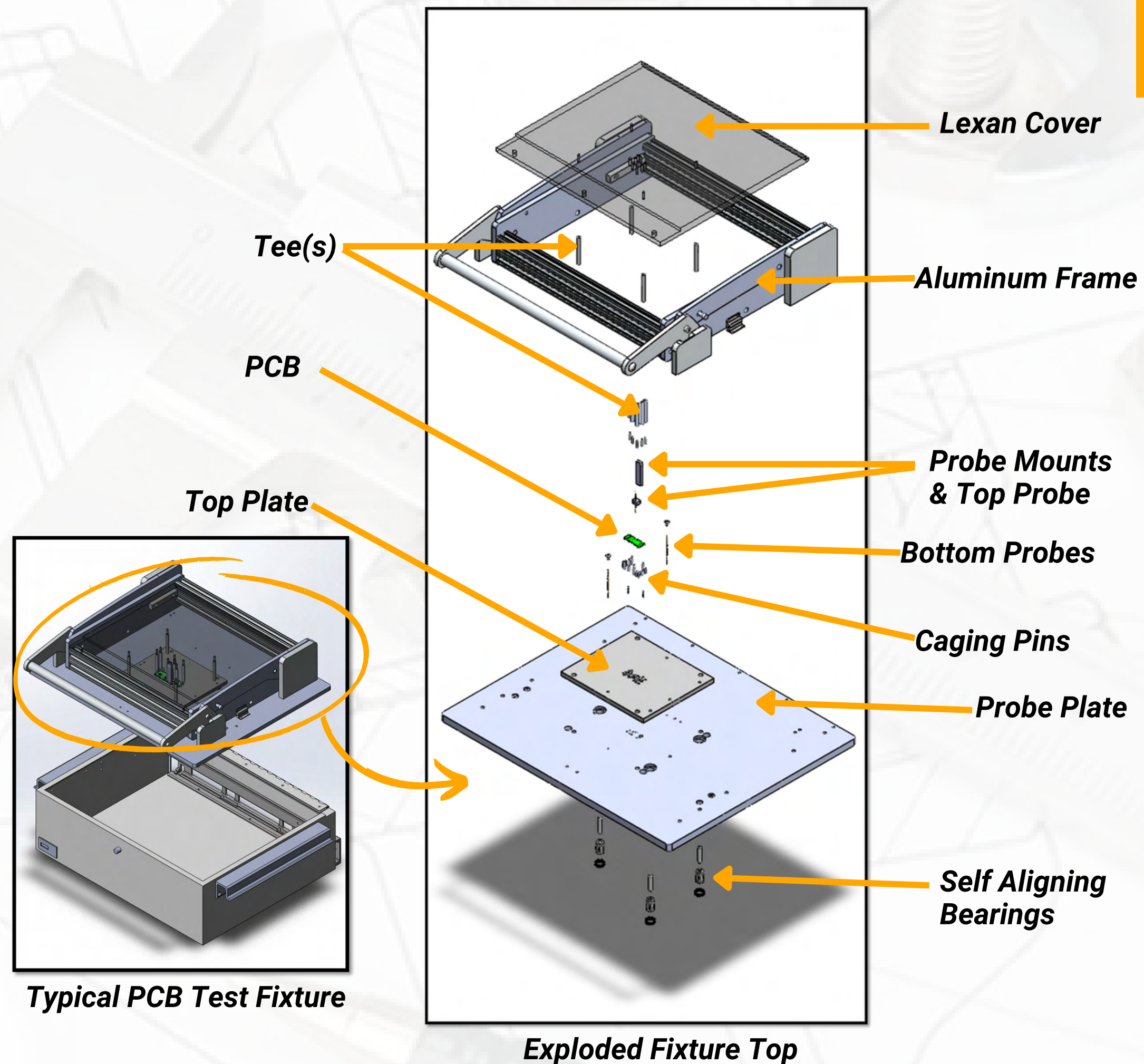
A typical PCB Fixture has a fixed **Probe Plate** on which the bottom test probes are mounted. These probes make contact with the primary test points on top of the PCB (as the board is placed upside down in the fixture for testing).

The PCB board is located on the **Top Plate** using Caging Pins. The Top Plate is spring loaded and rides on self aligning bearings on top of the Probe Plate. It has cut outs for the probe pins as well as accommodating PCB components.

An Aluminum Frame with Adjustable Arms, Fixed Arms and 80/20 Bars form the top enclosure of the fixture. It may also house the probes and mounts for testing any test points on the other side of the board.

## Operation:

The operator opens the fixture by opening the Frame and placing the PCB correctly on the Top Plate. Upon closing the Frame, the Tees press the PCB and the Top Plate against the Probe Plate on which the test probes are mounted. Thus making contact with the probes. The data from the test probes is used to verify the functionality of the board. The operator then opens the fixture and repeats the process with the next PCB.



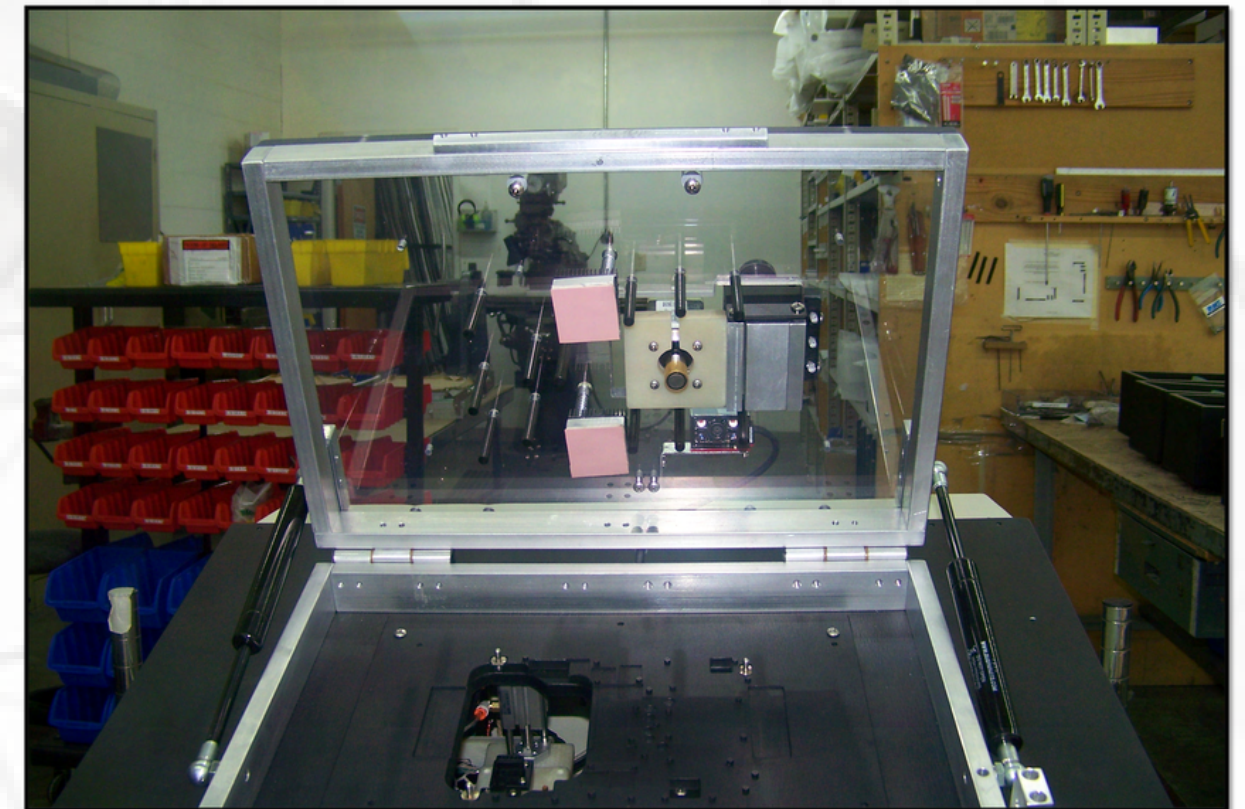
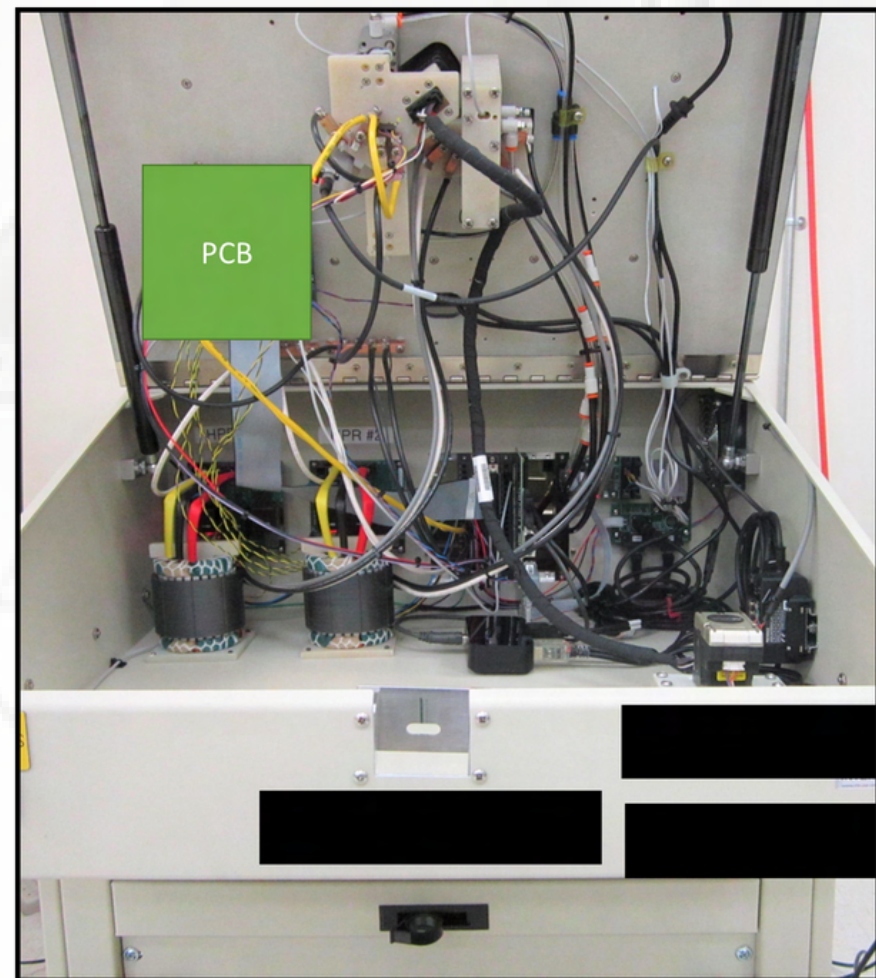
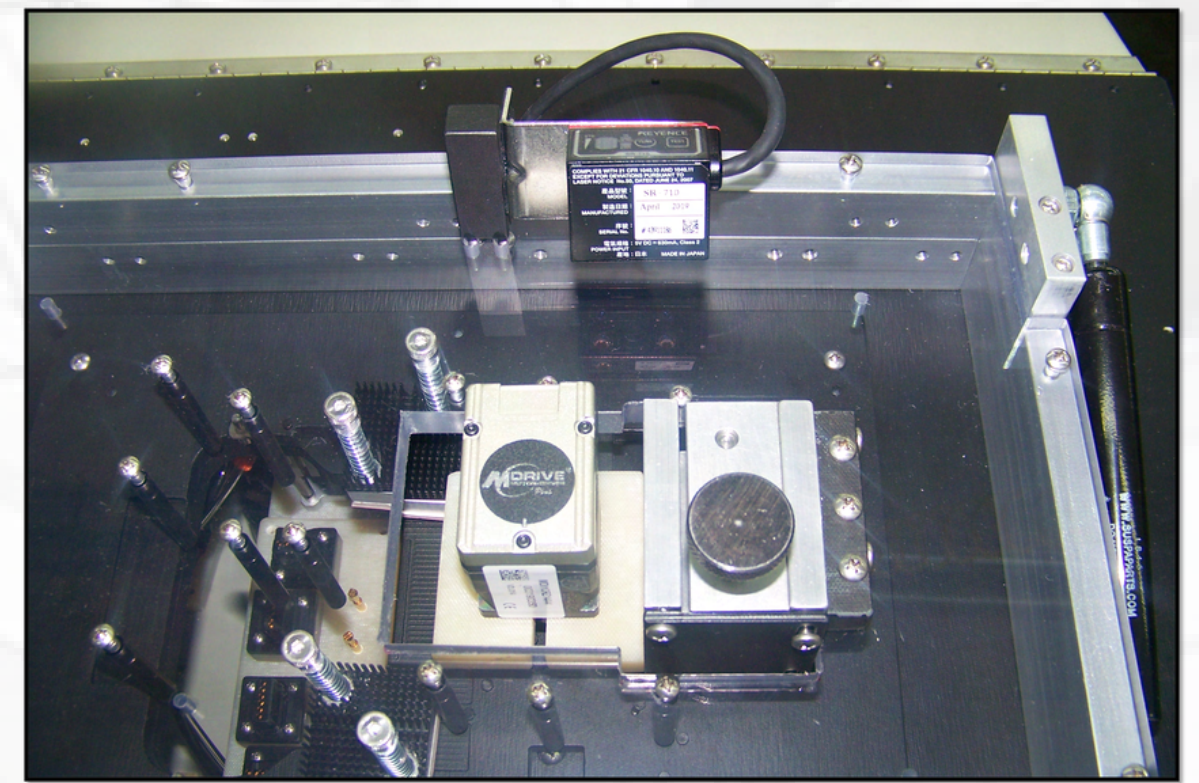
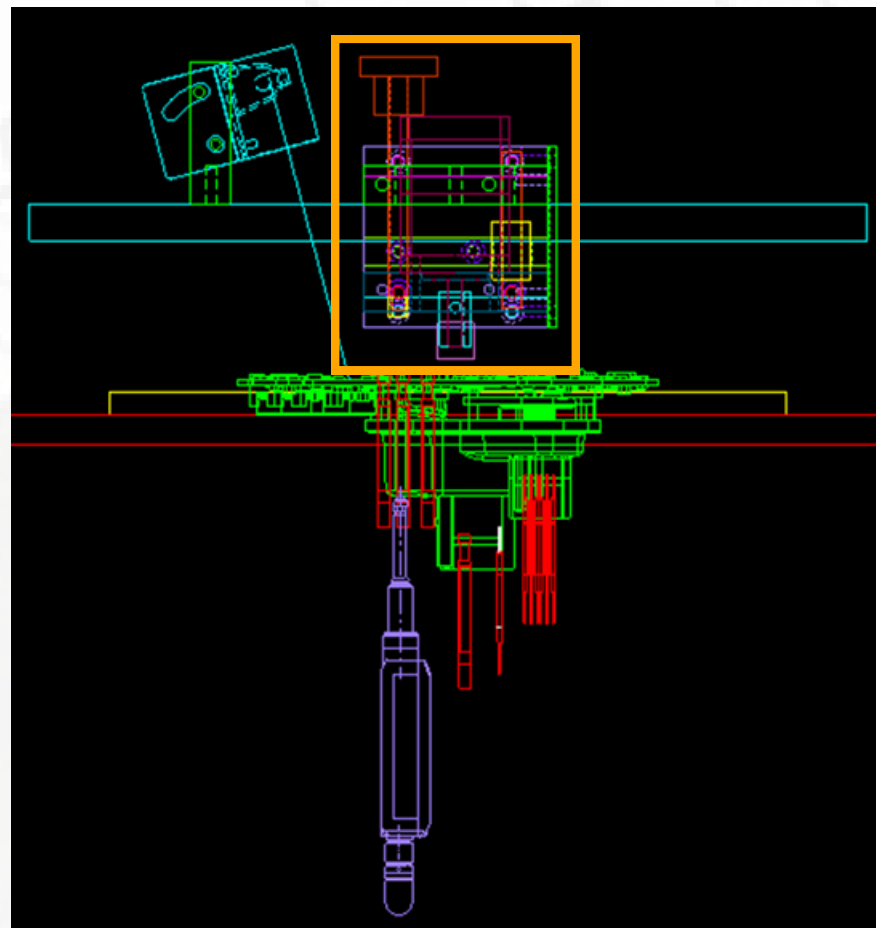
## Steering Column Sensor Testing:

One of the projects had a requirement for testing a PCB for a steering column of a car manufacturer.

Apart from making a test fixture for measuring output across test points using test probes, there was a requirement to test the non-contact hall effect rotary position sensor.

It needed a magnetic piece connected to a motor shaft to be lowered accurately into a hollow cylindrical coil.

I designed an enclosure with a lead screw on one end and support rod on the other. The enclosure can be precisely moved up and down by rotating the lead screw. Because of the support rod, the enclosure moved vertically along the lead screw instead of rotating with it. After the location is fixed, the enclosure can be locked by means of a set screw which tightens against the side of the support rod. This concept was applied after a few modifications.





*Hands-on machining, assembly and testing*

# DESIGN OF THERMALLY ACTUATED FLEXURE

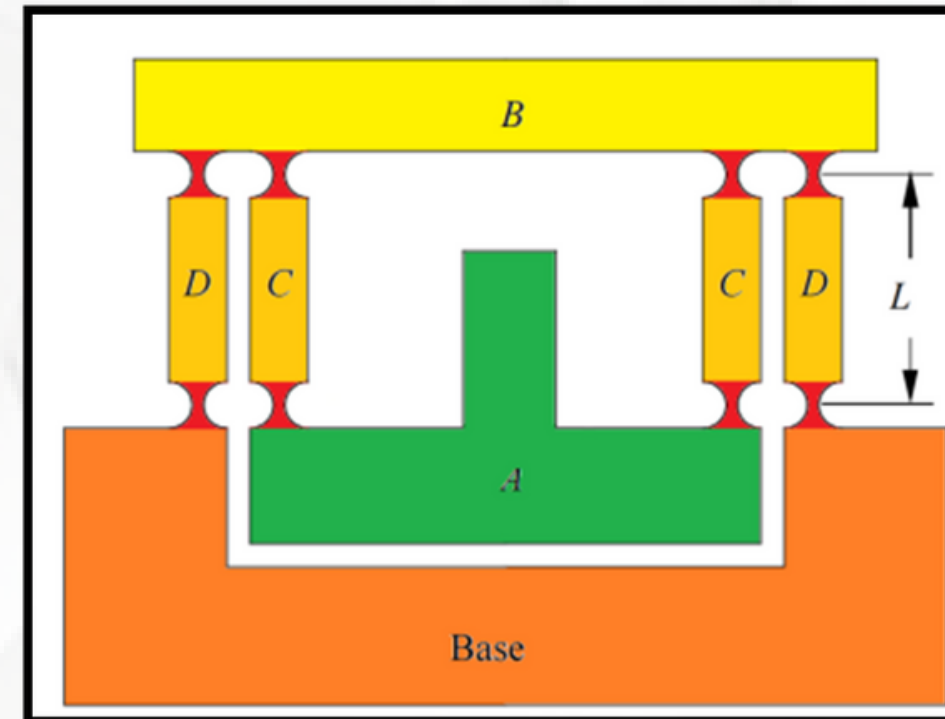
## BACKGROUND:

Flexures are structures used for micrometer scale positioning with minimal frictional losses. They are part of compliance mechanisms that achieve motion by bending.

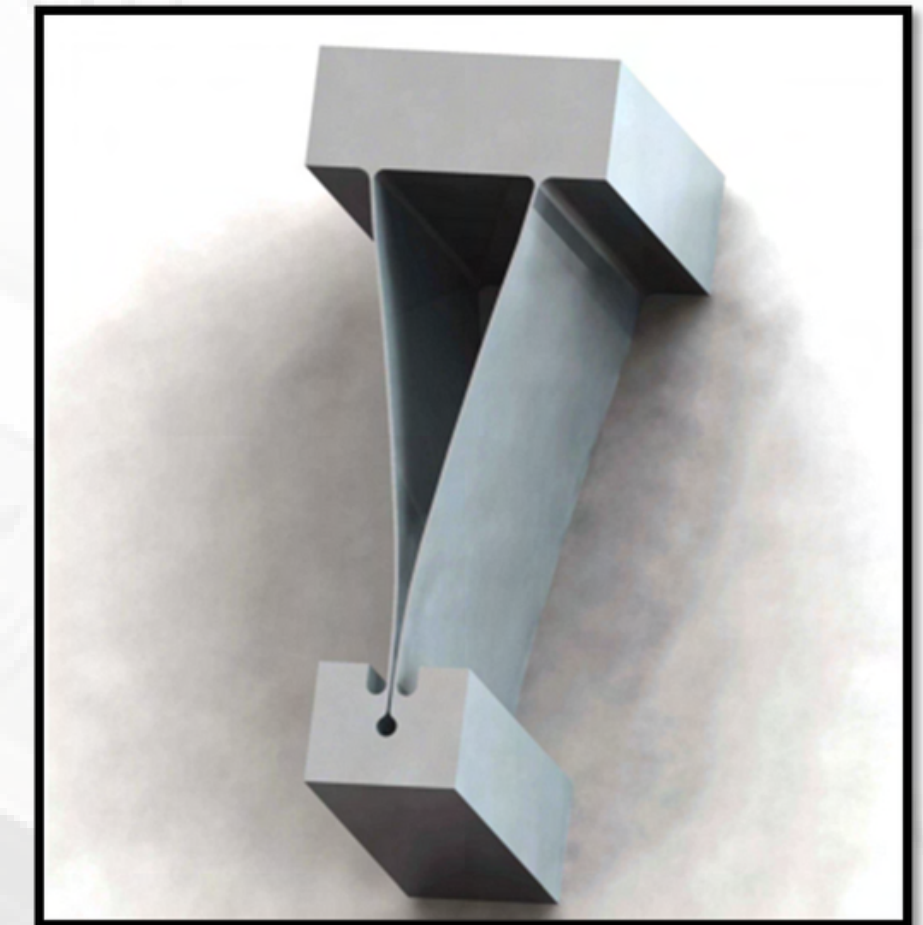
Several advantages over traditional linear movement mechanisms

- Simple Design
- Easy to manufacture
- Can be scaled down to microscopic levels
- No backlash, no lubrication and wear/tear

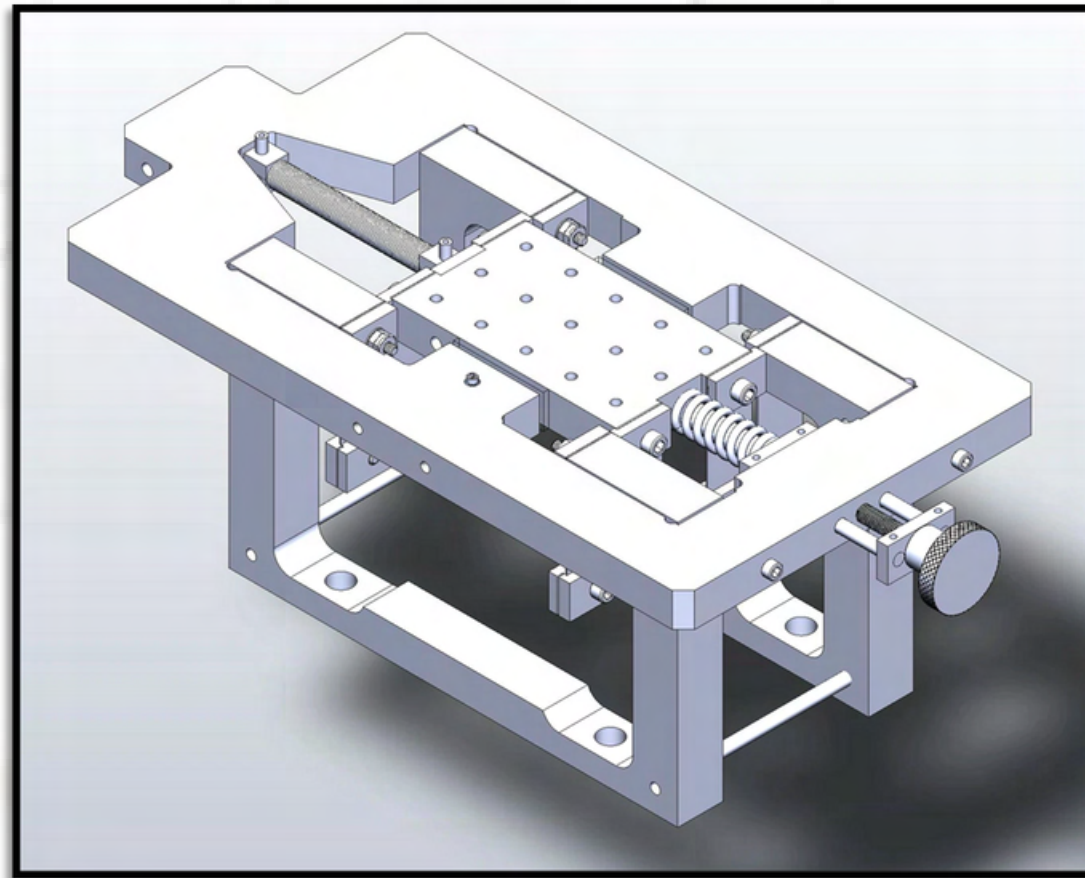
The challenge was to develop a proof of concept for getting controlled **micrometer movement** by using expansion and contraction and translate that by means of a flexure mechanism



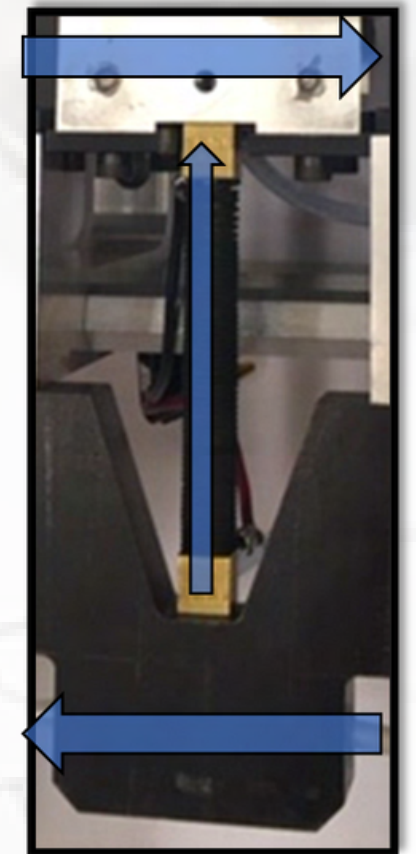
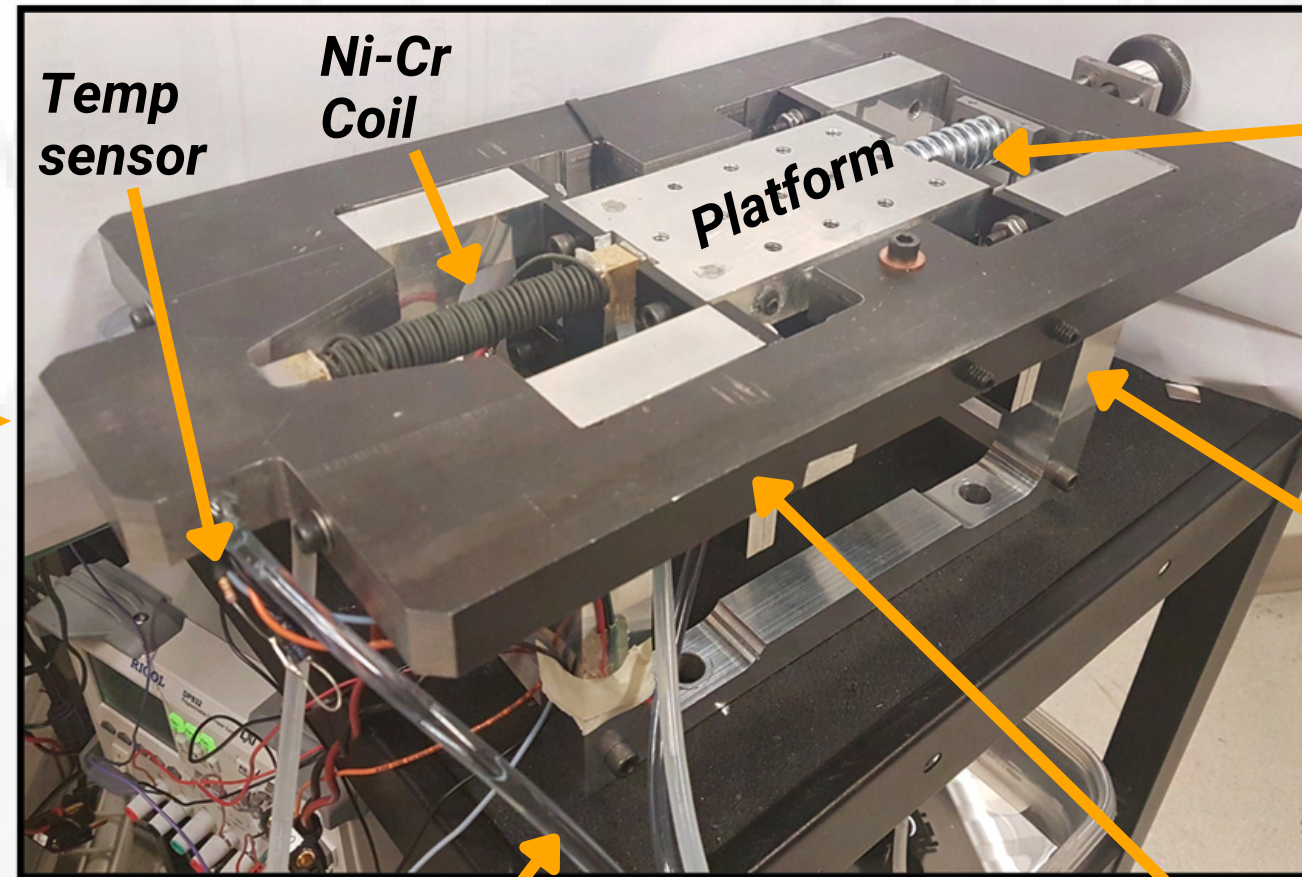
*Compound Flexure Conceptual Model*



*Curved hinge flexure*



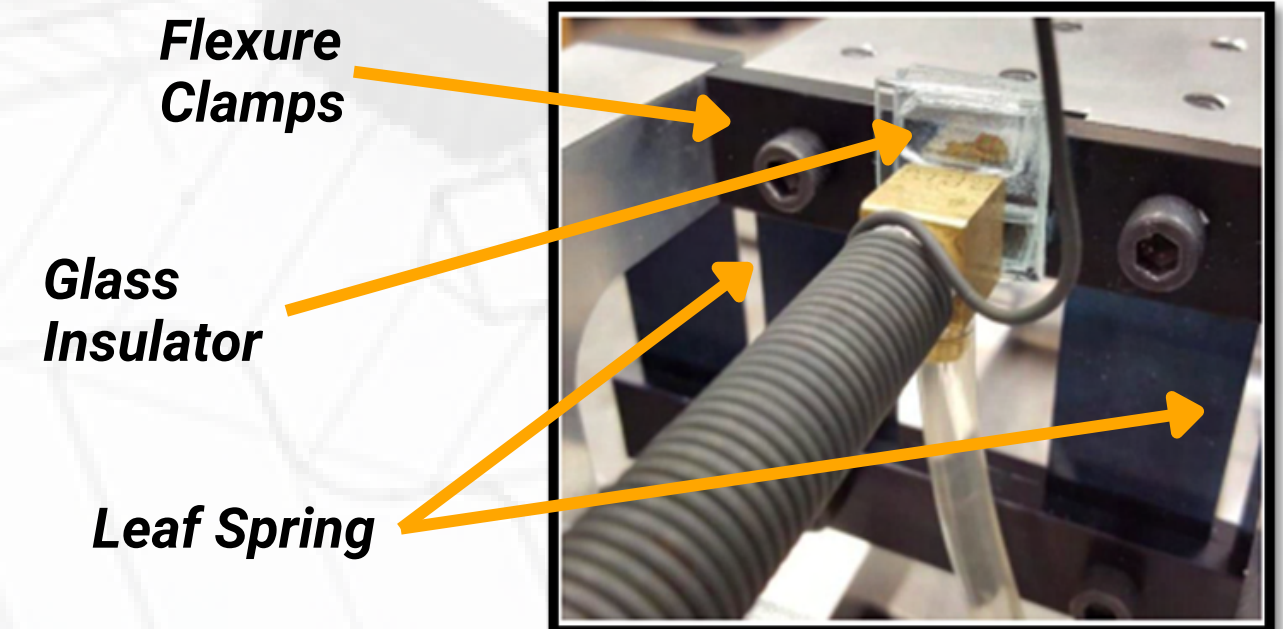
**CAD Model**



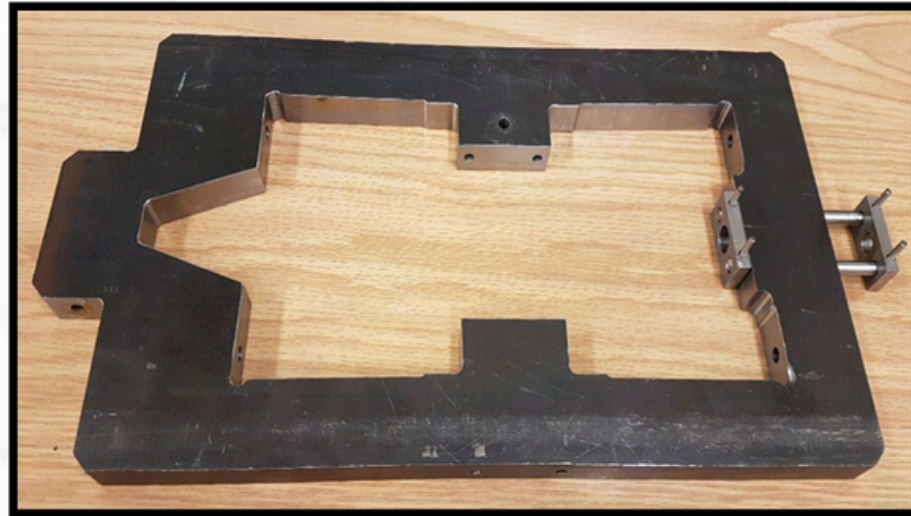
**Cooling line flow**

## Construction:

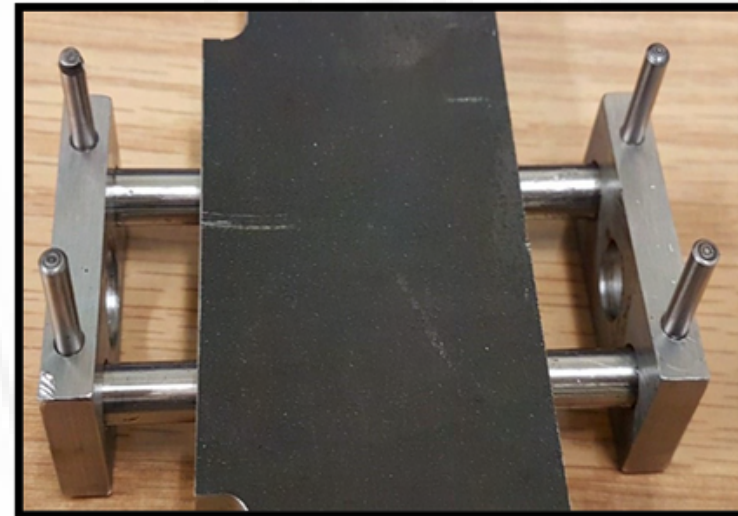
- Monolithic rigid steel frame with leaf springs as flexures
- Compression Spring loaded load application system
- Position guide pins for flexure platform
- Thermal isolation of actuator using Glass insulator
- PID heater and water pump control loop
- Cooling lines through Steel Frame



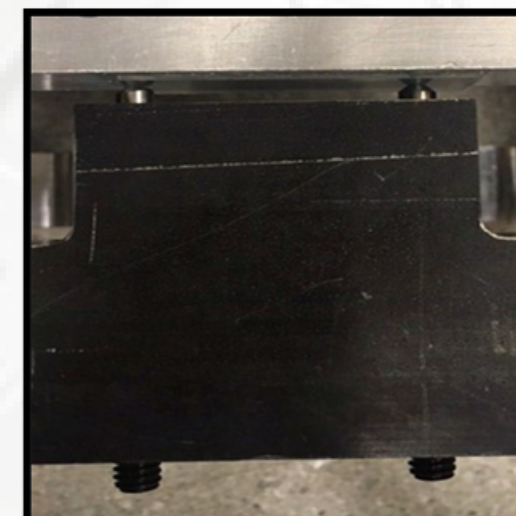
## Manufactured Pieces:



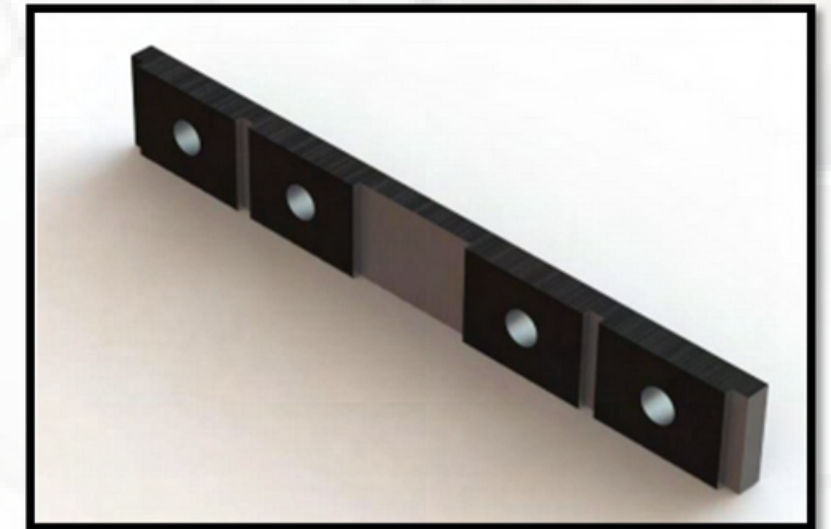
**1018 Steel Frame**



**Compression System**



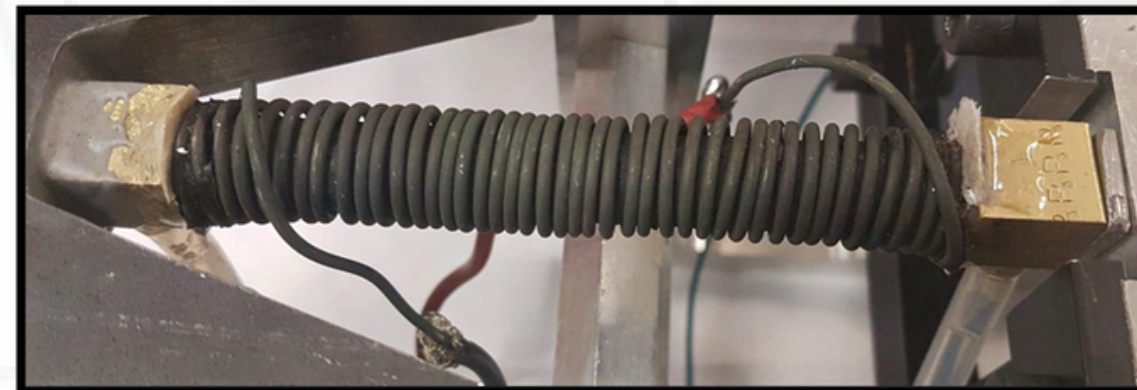
**Adjustable Guide Pins**



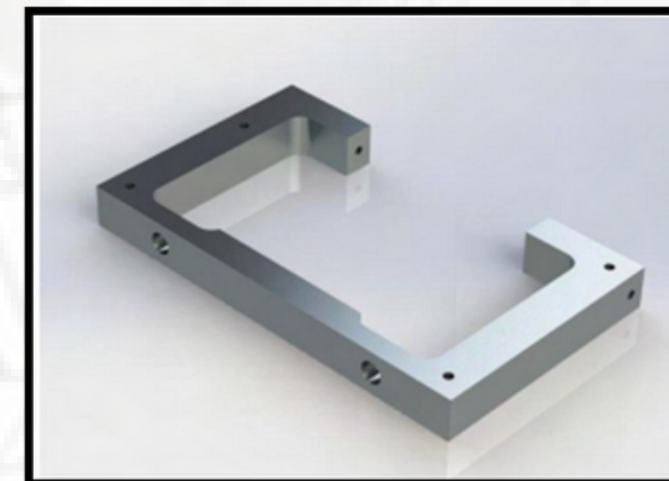
**Flexure Clamps**



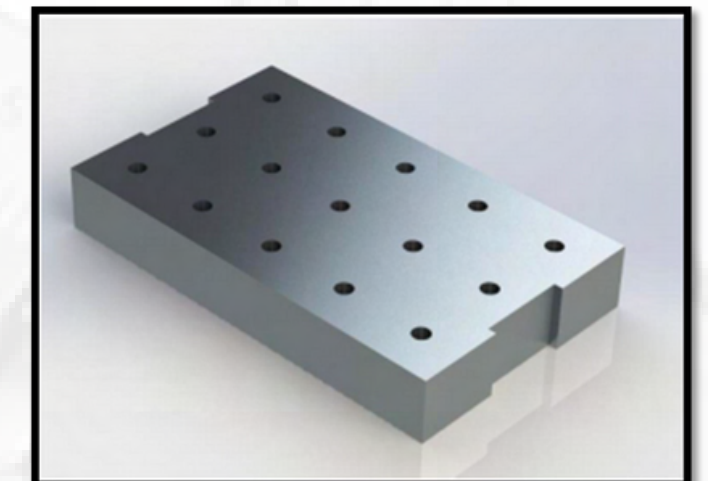
**Spring guide**



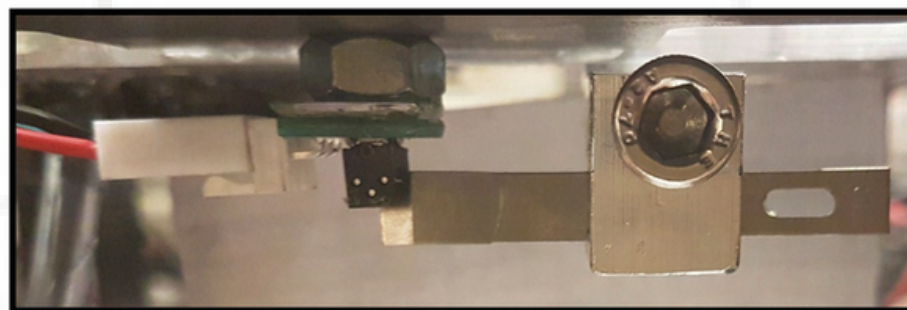
**Ni-Cr Coil**



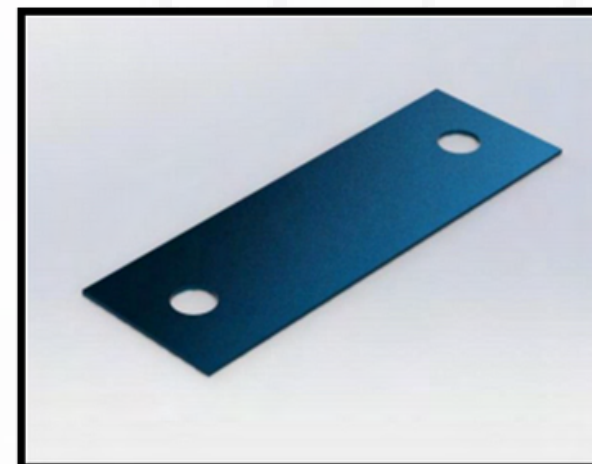
**Flexure Base Side**



**Flexure Platform**



**Knife Edge Sensor**



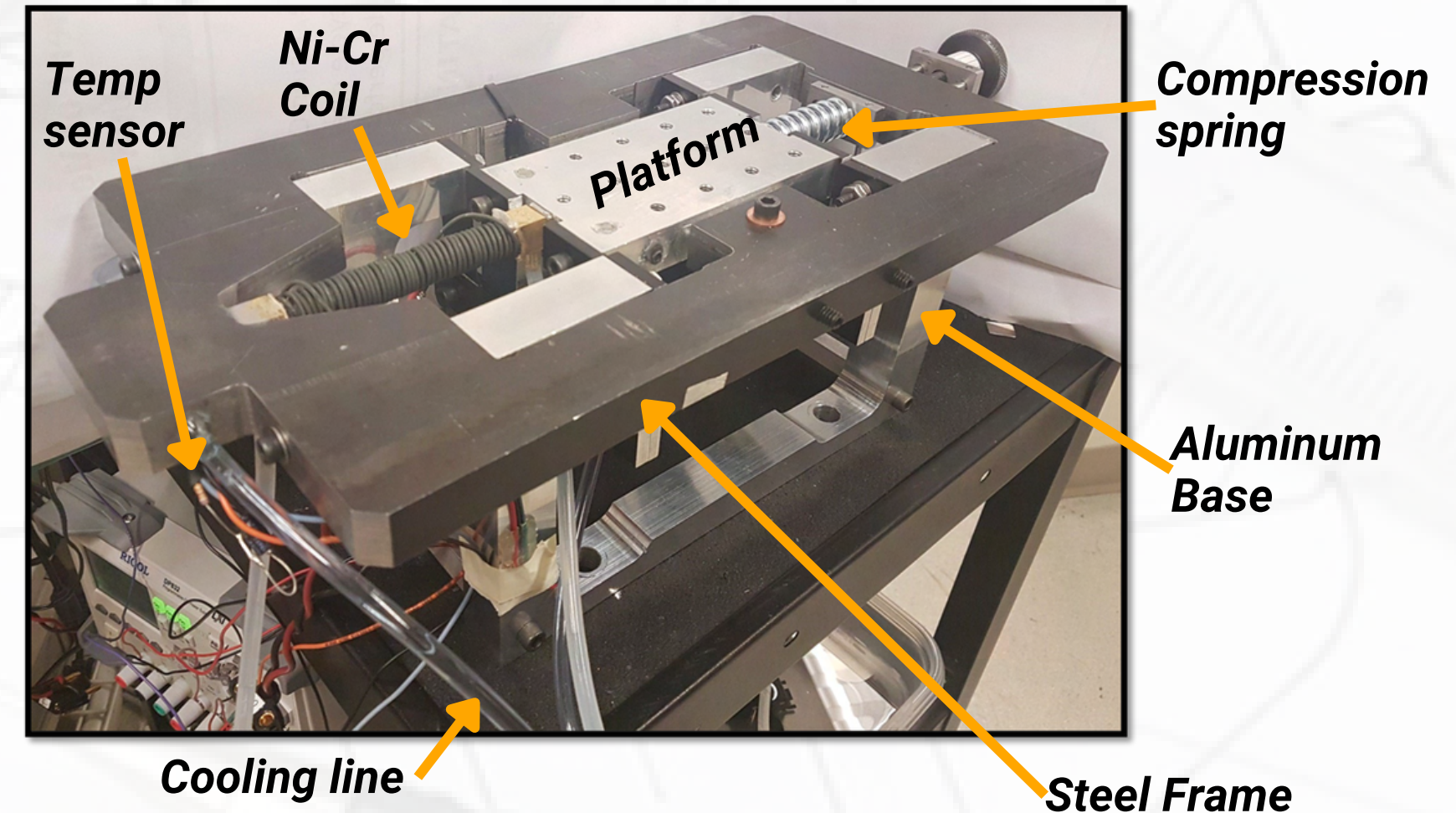
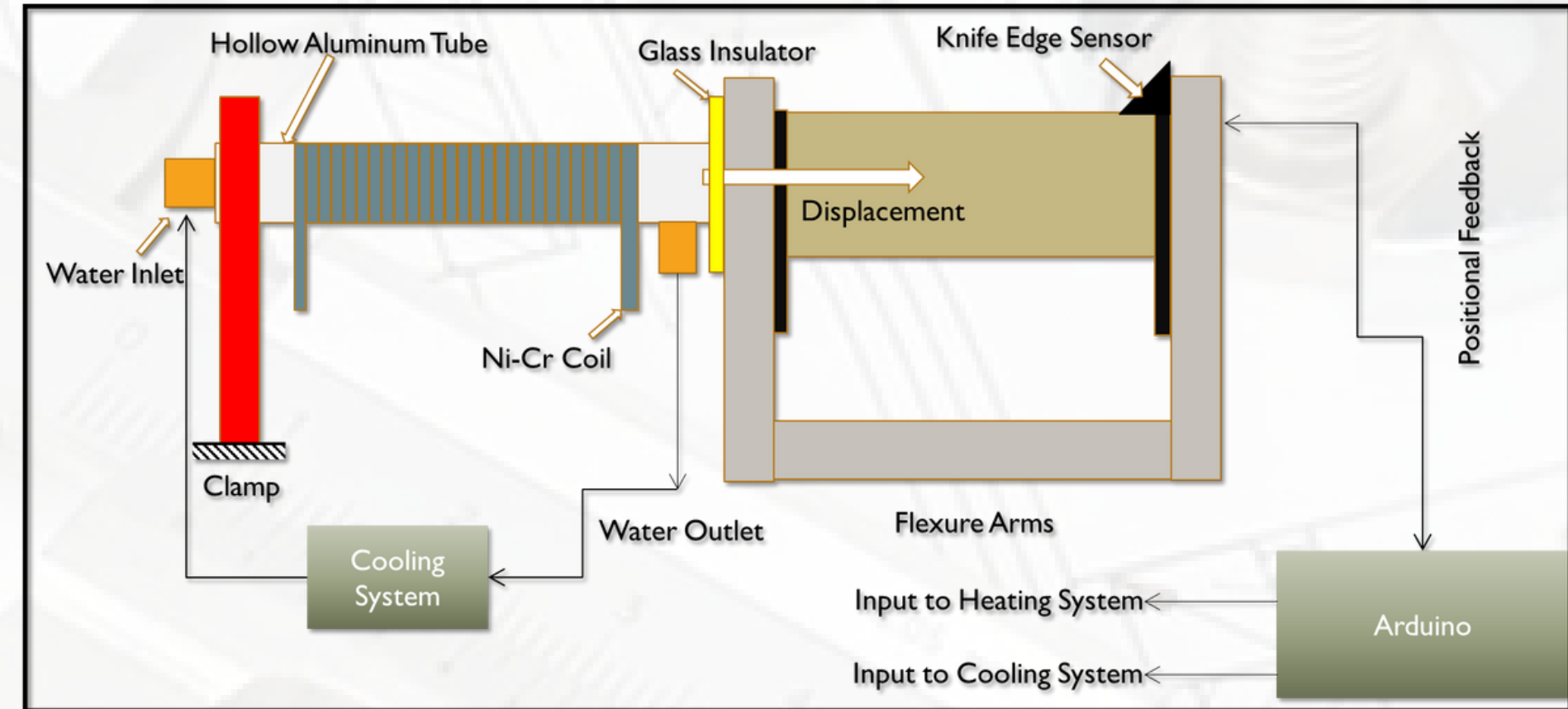
**Leaf Spring**

## Working:

The temperature and thermal expansion of the actuator is controlled using Ni-Cr wire coiled around the tube and cooling water flowing through the tube.

The controlled thermal expansion of the tube generates the force that was converted into linear motion of the flexure stage. The tube actuator is thermally isolated on both ends using cooling water.

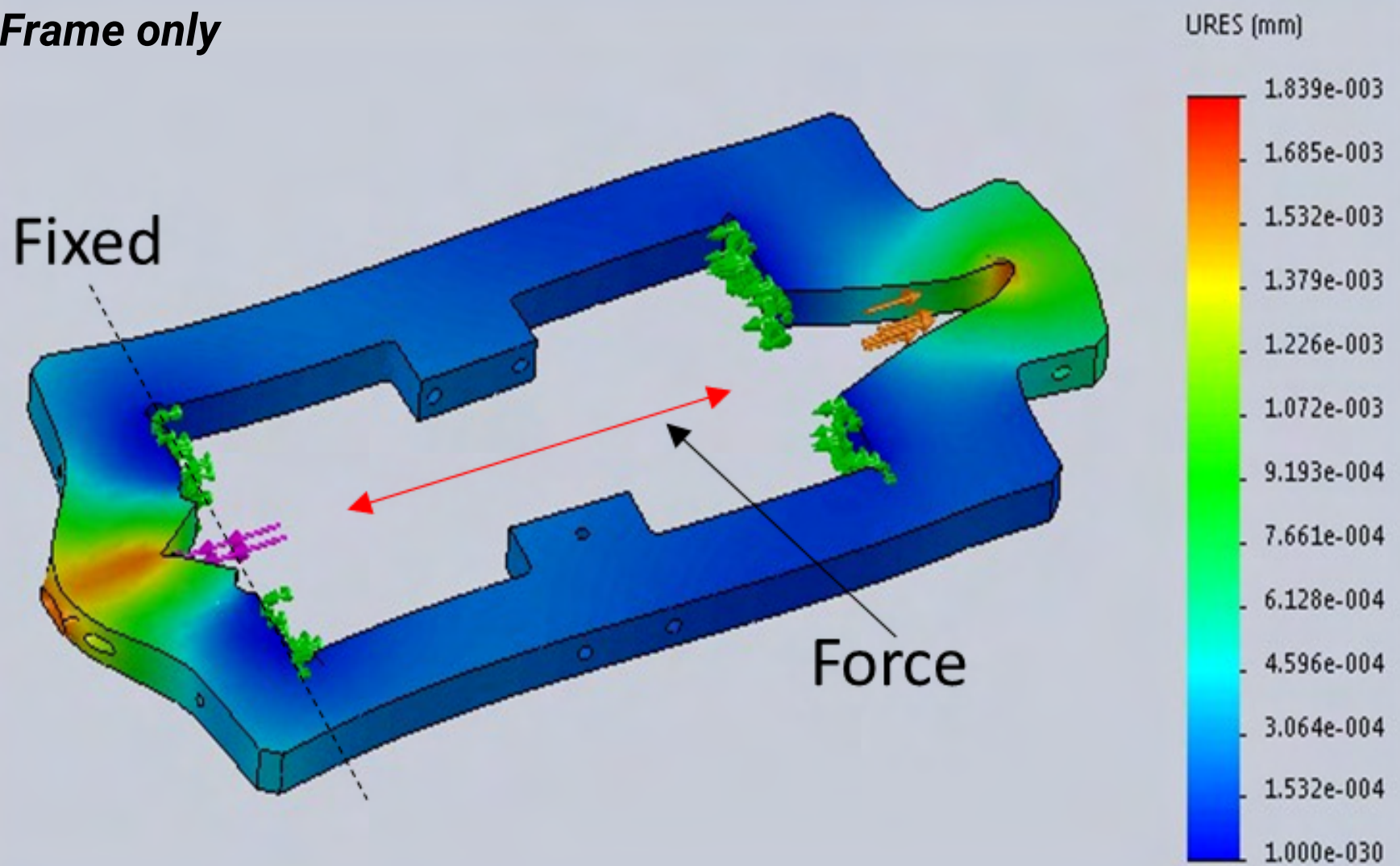
A feedback loop was implemented using an IR based optical knife-edge sensor RPI 0352E to measure the linear displacement of the flexure stage. A PID controller implemented using LabVIEW and a myRIO was used to control the power supplied to the heating coil (Ni-Cr wire) and the cooling water pumps through individual power amplifiers thereby achieving control.



## Frame Deformation:

Aluminum v/s Steel with 1000N axially along actuator

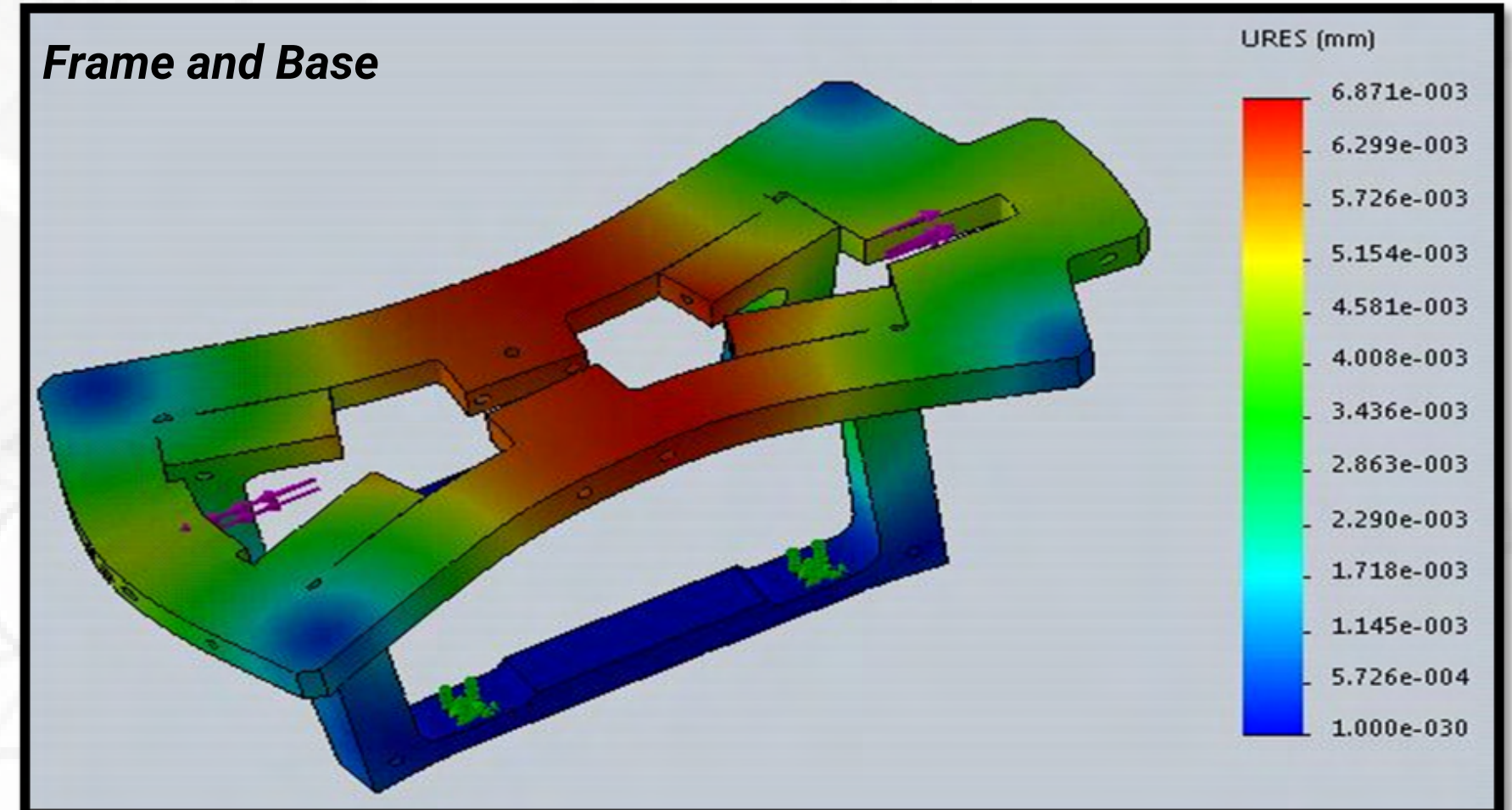
**Frame only**



### Maximum axial deflection

6061 Aluminum 1.8  $\mu\text{m}$   
1018 Steel 0.6  $\mu\text{m}$

**Frame and Base**



### Total axial deflection

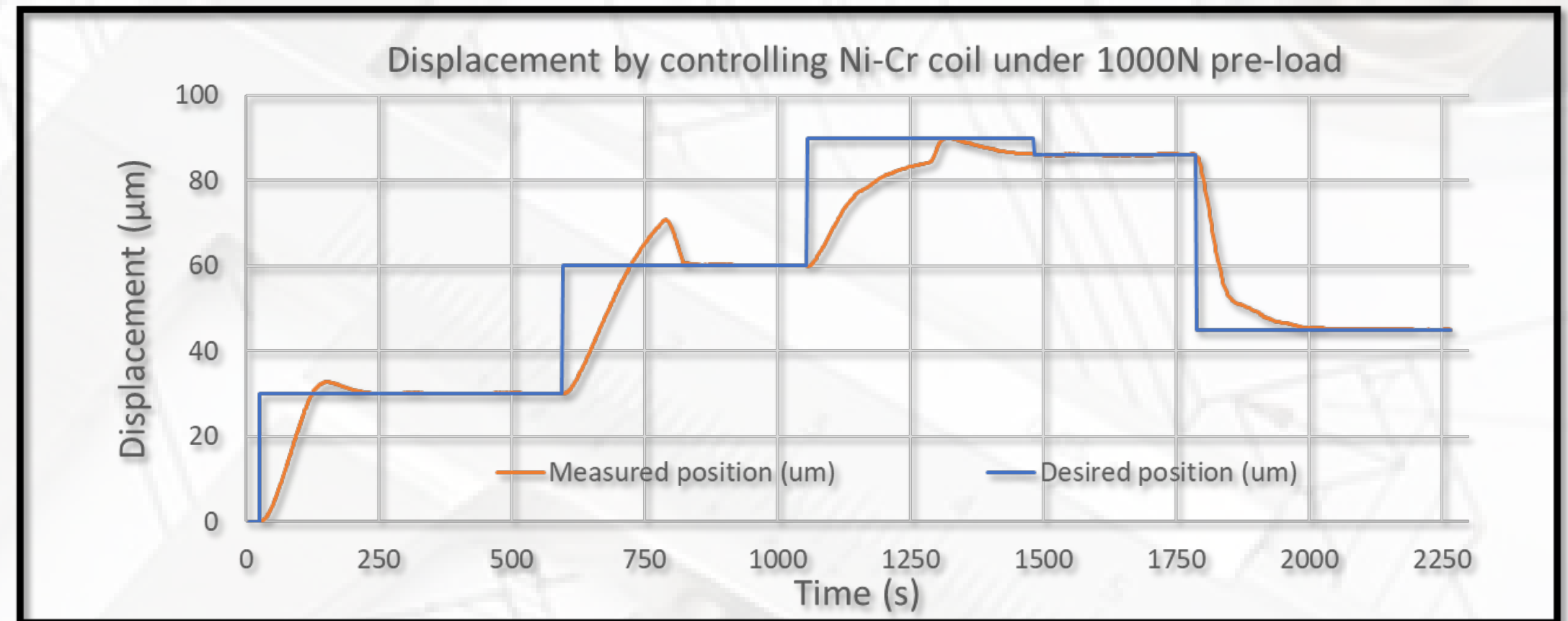
6061 Aluminum 16  $\mu\text{m}$   
1018 Steel 8  $\mu\text{m}$

**Hence 1018 steel was chosen as frame material**

**RESULTS:**

Developed flexure had load capacity of 1000N with 100 $\mu$ m full range.

Full range in 60 seconds. Which is not taking into account the 60 seconds it takes to warm up the Aluminum tube to working temperature to be in actuation measurement zone.



It was found that the flexure was successfully able to displace the projected 1000 N over a range of 100 $\mu$ m in 60 seconds. The flexure was able to retain a constant position with  $\pm 0.33\mu$ m variation. All the while, the cooling system effectively retained the frame and the flexure stage at 0.5°C above room temperature.

# MINIATURE HEXAPOD CONCEPT

## BACKGROUND:

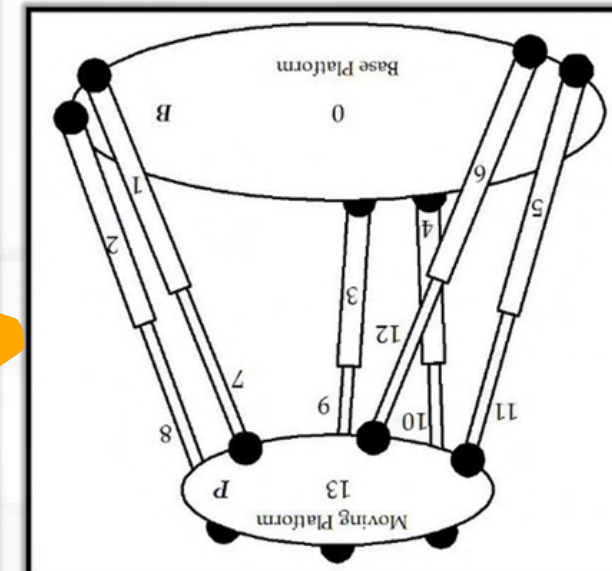
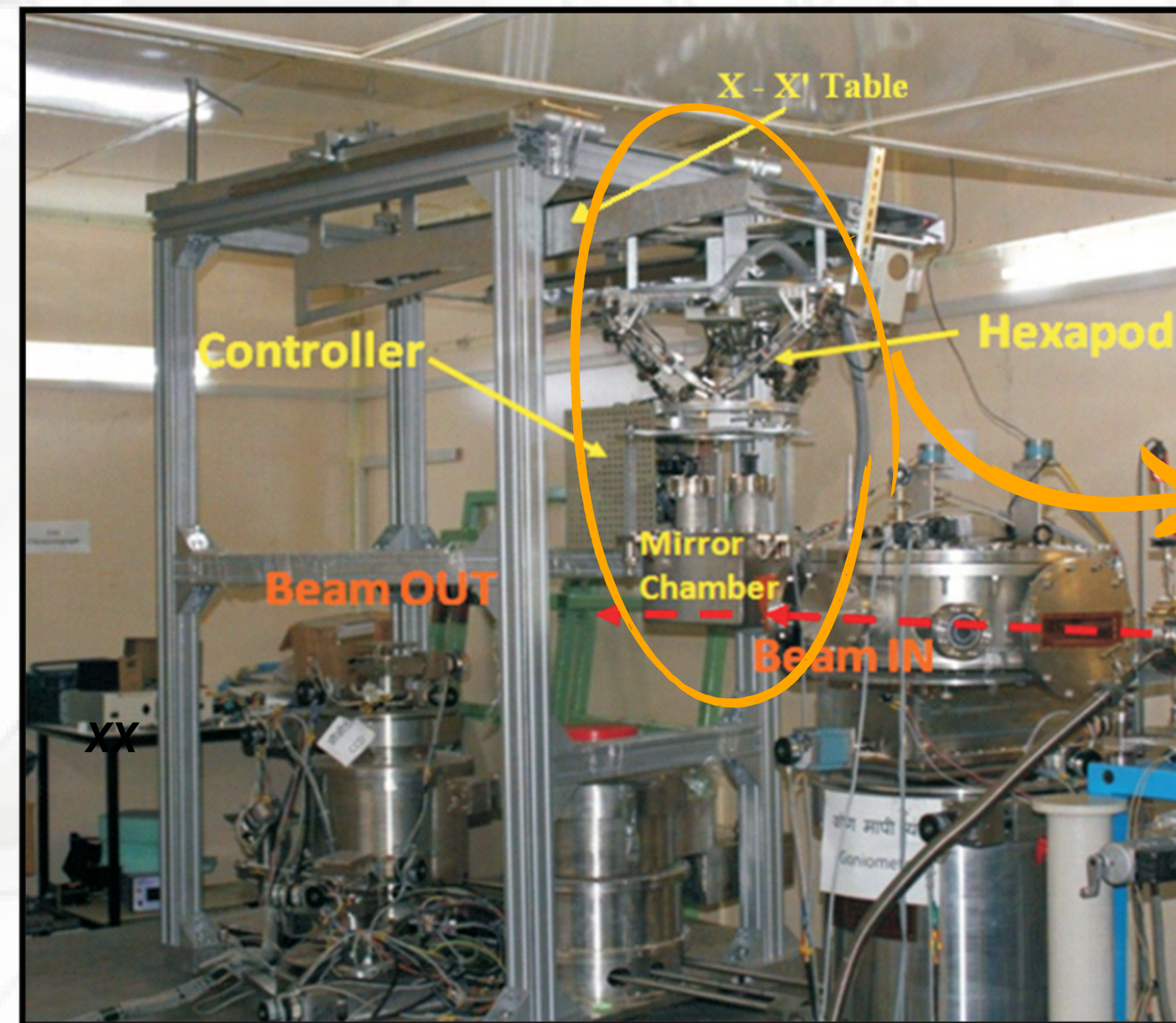
A robot manipulator is an electronically controlled mechanism, consisting of multiple segments, that performs tasks by interacting with its environment.

A manipulator is called a parallel manipulator if it is made up of closed loop kinematic chain. A hexapod is a parallel manipulator with six degrees of freedom.

A Hexapod consists of a mobile platform that is connected to a stationary base through six parallel linear independent actuators with the help of end joints.

Mobile platform is capable of moving in three linear directions and three angular directions and obtain its 6- DoF with respect to base from the combined computed movement of six independent actuators.

Thus, any pose (position and orientation) can be achieved by mobile platform in 3D space within range.



**Hexapod Concept**

**Hexapod based high precision beam alignment system deployed at BARC\***

(\*Picture courtesy of BARC -BARC Newsletter March - April 2020)

**SCOPE:**

This research was focused on the design and development of miniature 6-DOF parallel manipulator.

The selection and designing of the joints and actuators for the miniature hexapod forms the core part of design. The development was directed towards scaling down a full-scale model for lower cost and lower load capacity applications. Also, obtaining a lower stiffness to weight ratio and achieving lower friction in order to achieve high accuracy, precision and repeatability.

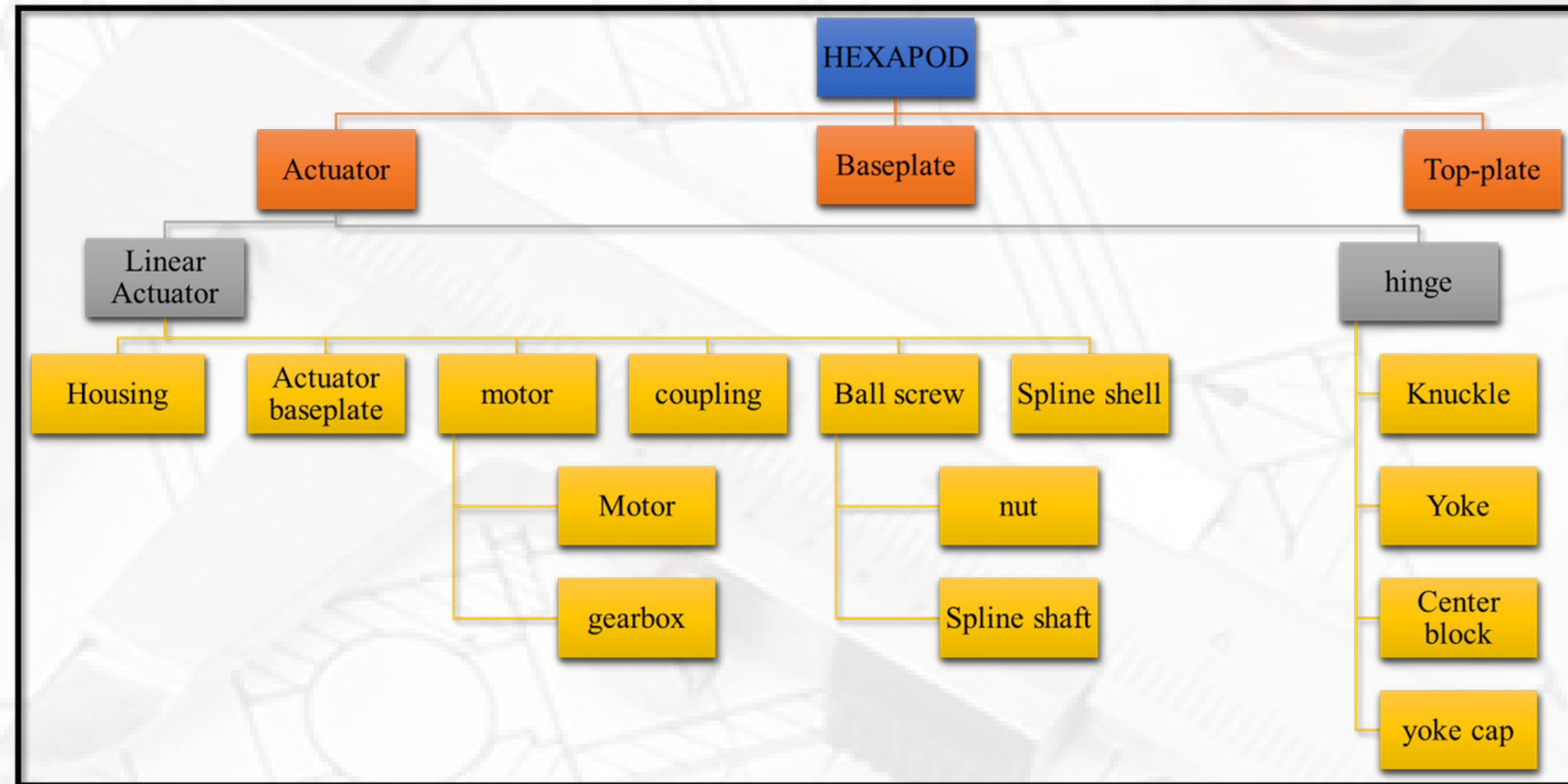
**OBJECTIVES:**

Design of various components of Miniature Hexapod for the given load and generating a CAD model.

Testing these components for various modes of failure. Performing static and dynamic analysis using software.

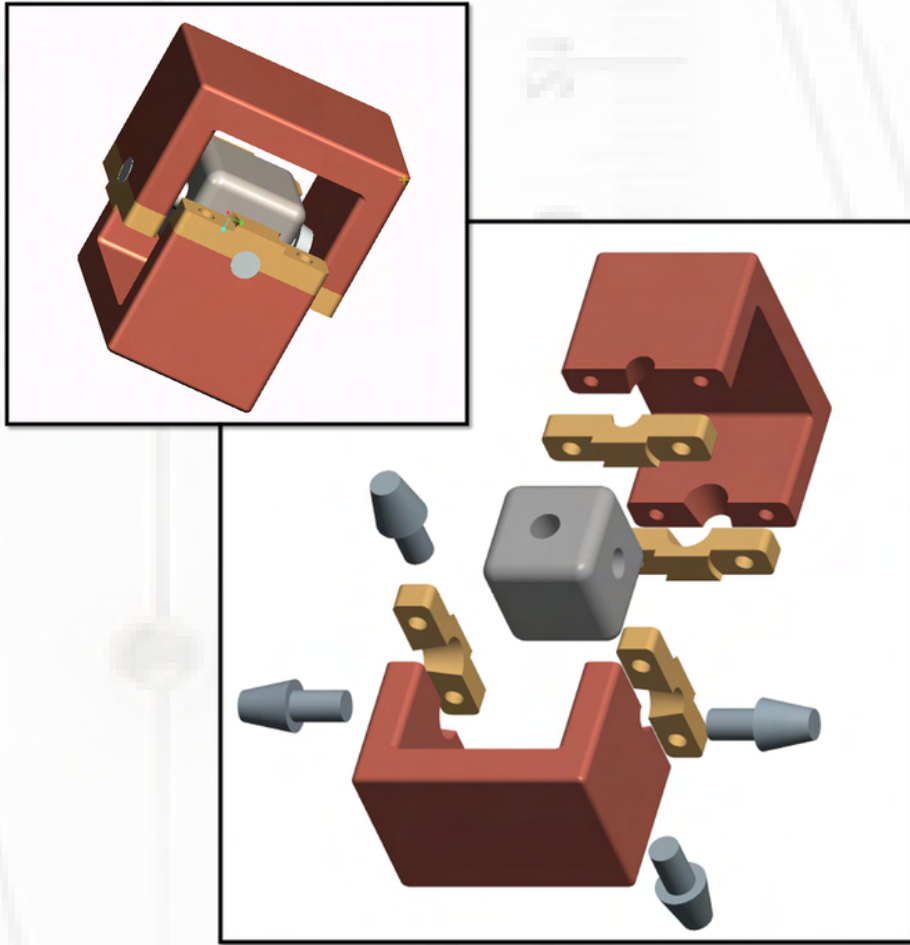
Evaluating results based on calculations & comparing calculated results with output obtained through simulation.

Simulate the motion and working of the miniature hexapod using MATLAB



**Modeling Tree**

## HINGE JOINT:



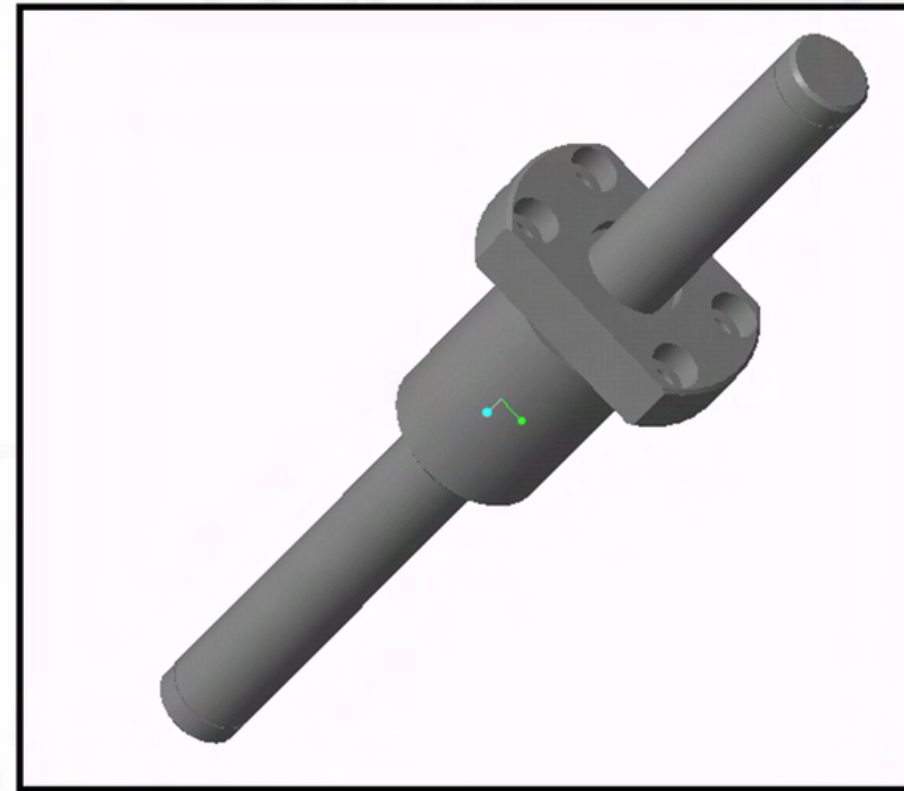
### Failure Criteria:

- Yoke – Crushing & Shear
- Clamp – Shear
- Hinge Body – Shear

### Material Selection:

Corrosion resistant alloy steel and Nickel based coating

## BALL SCREW SELECTION:



### Based the permissible axial load:

- Calculation of maximum axial load ( $F_{max}$ )
- Buckling load of screw shaft ( $F_1$ )
- Permissible compressive and tensile load of screw shaft ( $F_2$ )

### Selection:

DIK 1404 Ball screw and nut from THK Catalogue

## ACTUATOR SELECTION:

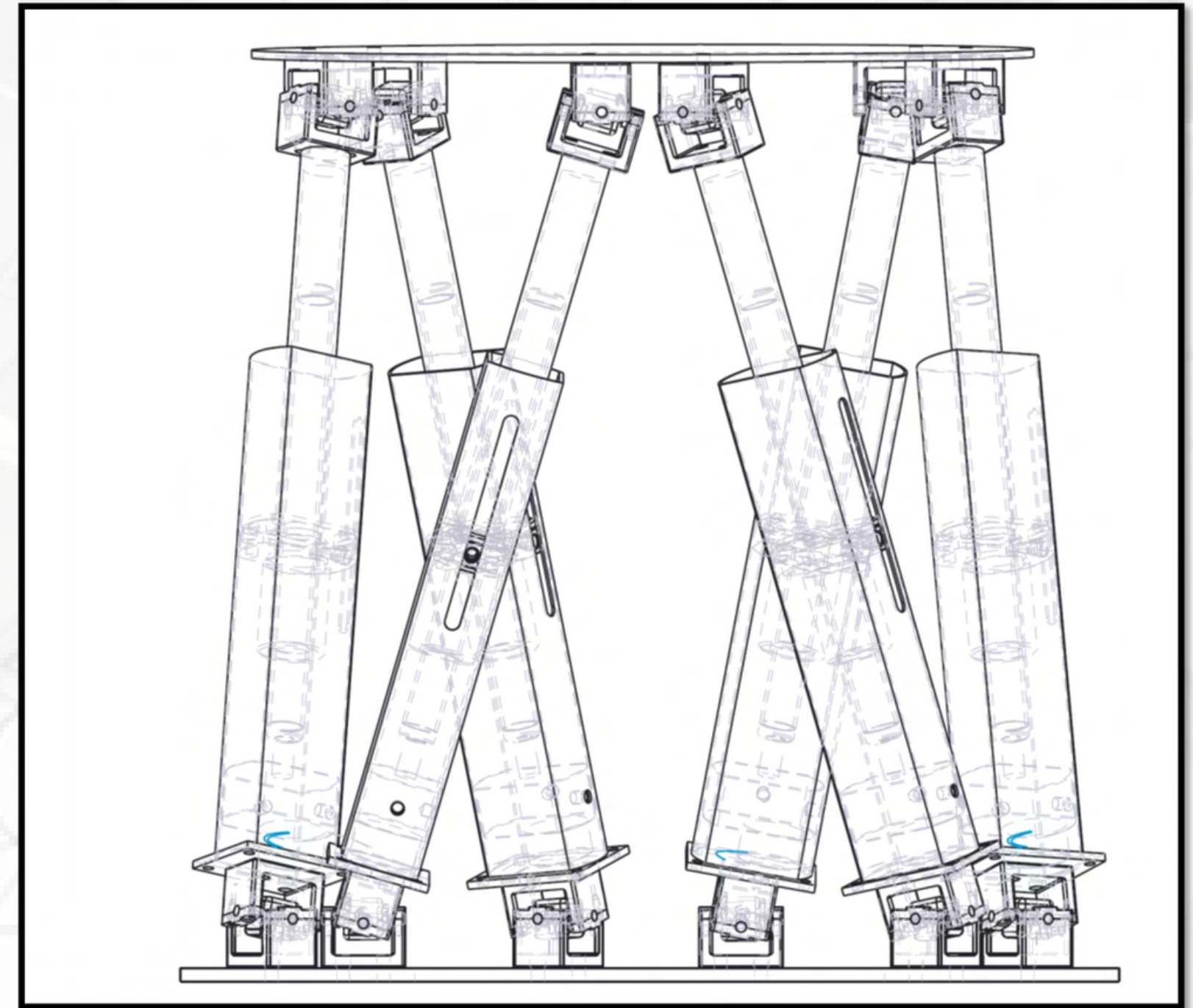


### Component Selection:

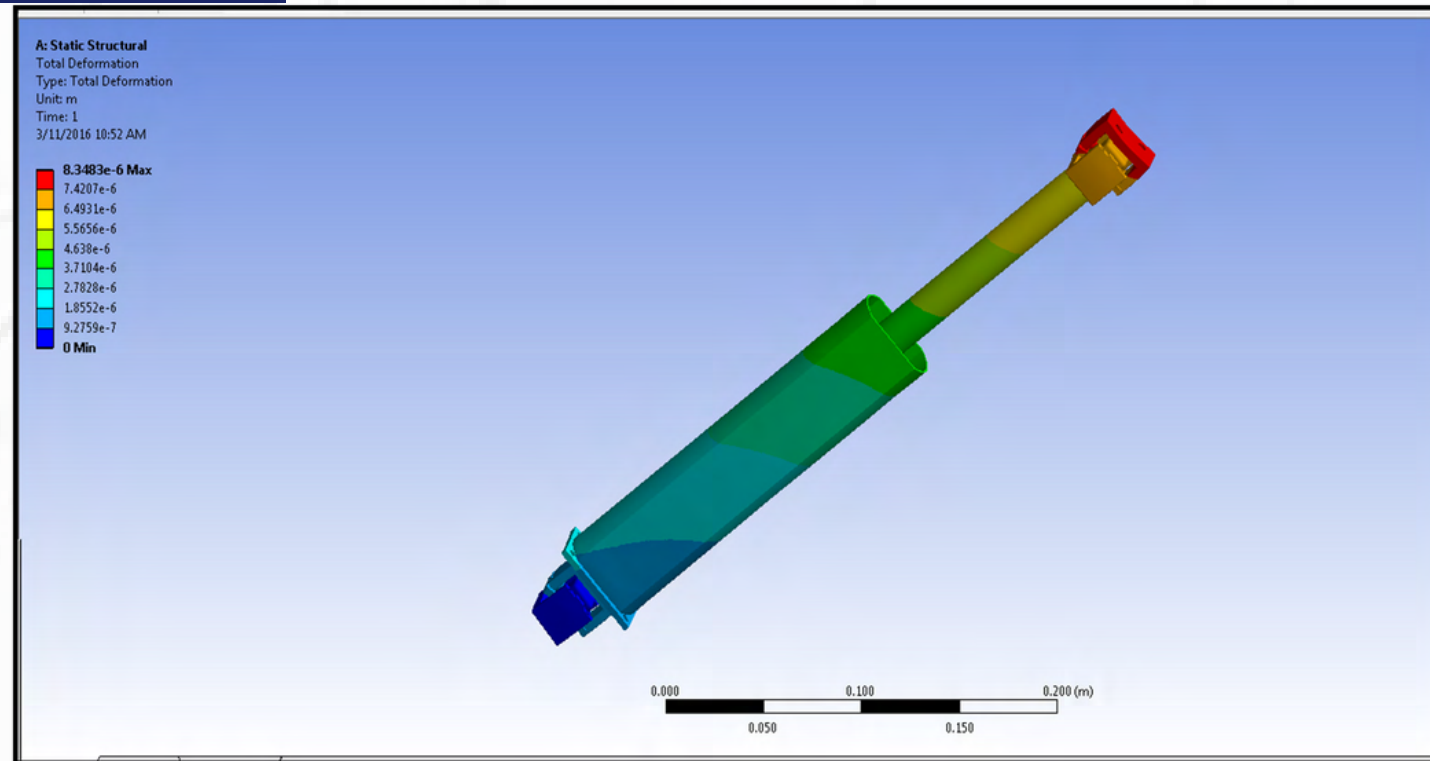
- Ball screw and nut - Size & Load
- Motor selection - Velocity & Torque
- Housing – Aluminium (2 mm thickness)
- Coupling – Muff Coupling
- Screw shaft casing - Aluminium

### BASE & TOP PLATE SELECTION:

Gauge 6 Sheet Metal based on deformation under max load.

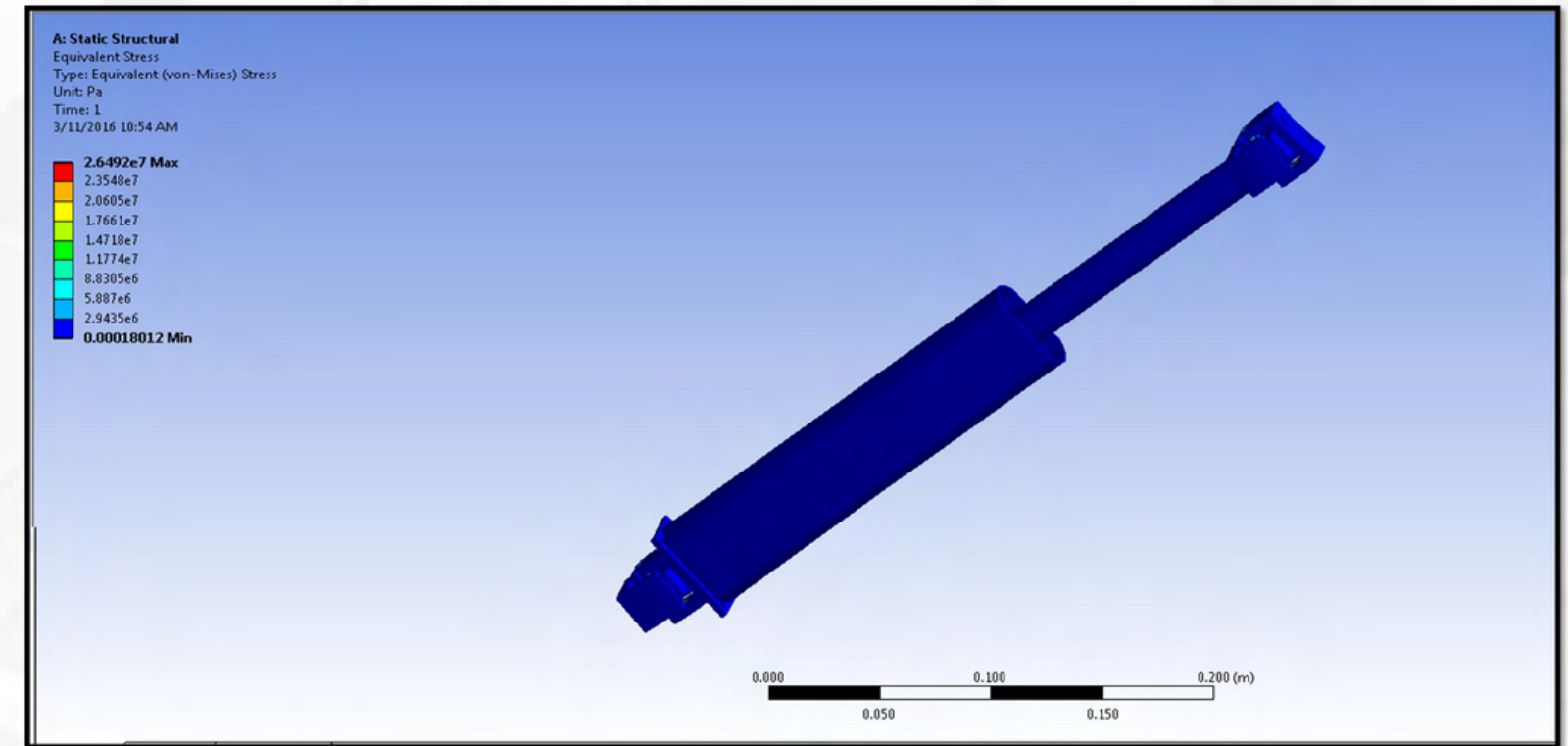


***Miniature Hexapod CAD Model  
(360mm Base x 400mm Height)***



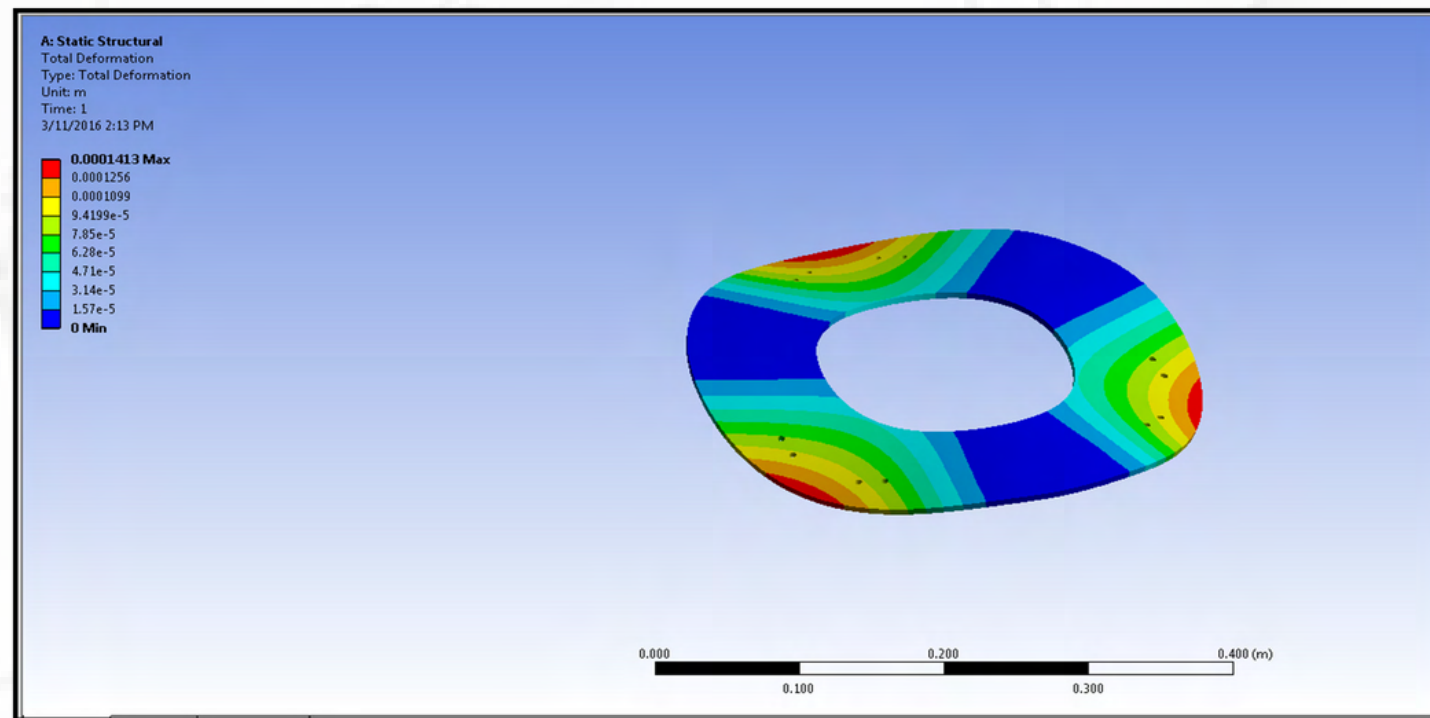
**Actuator Deformation at 100N**

Total Deformation = 8.348  $\mu\text{m}$



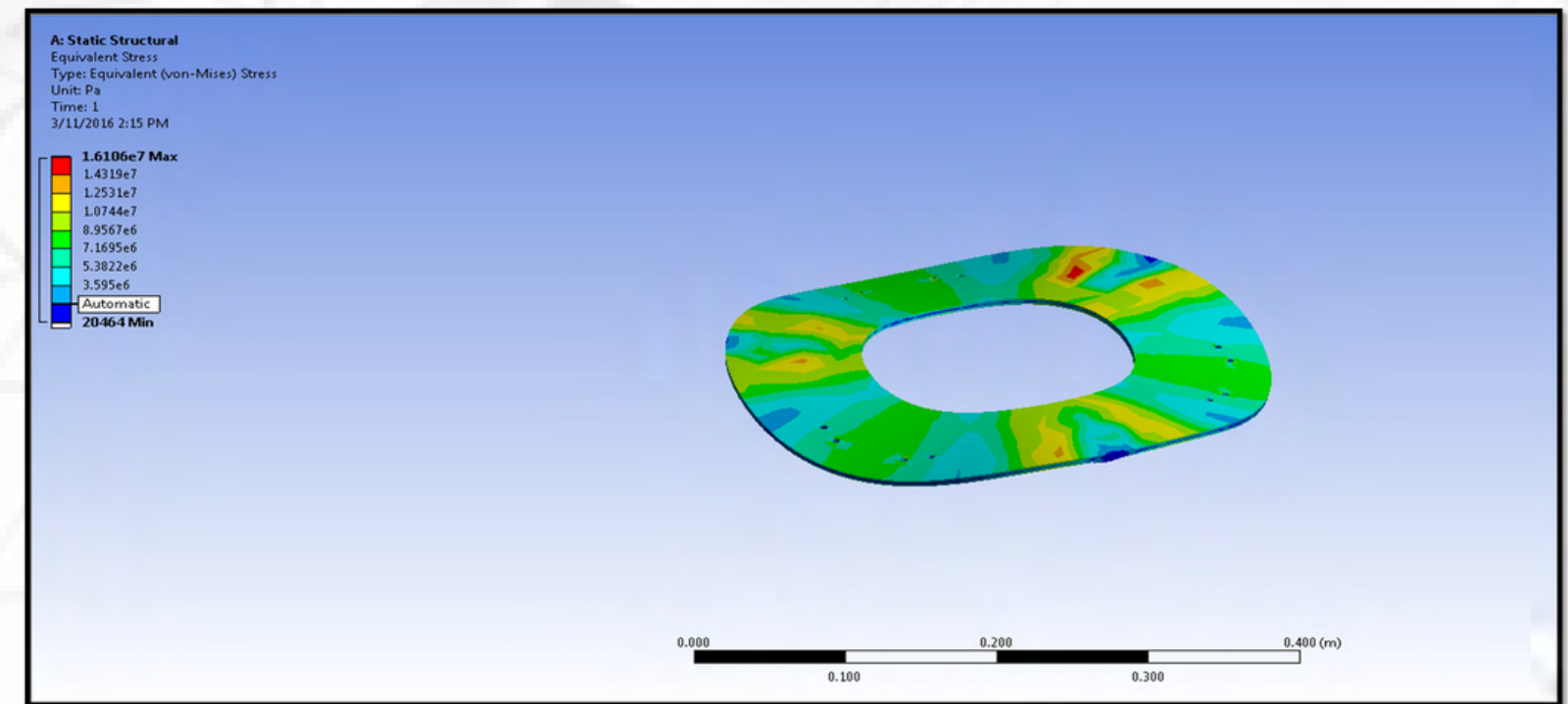
**Actuator Stress at 100N**

Max Equivalent Stress=26.49 MPa



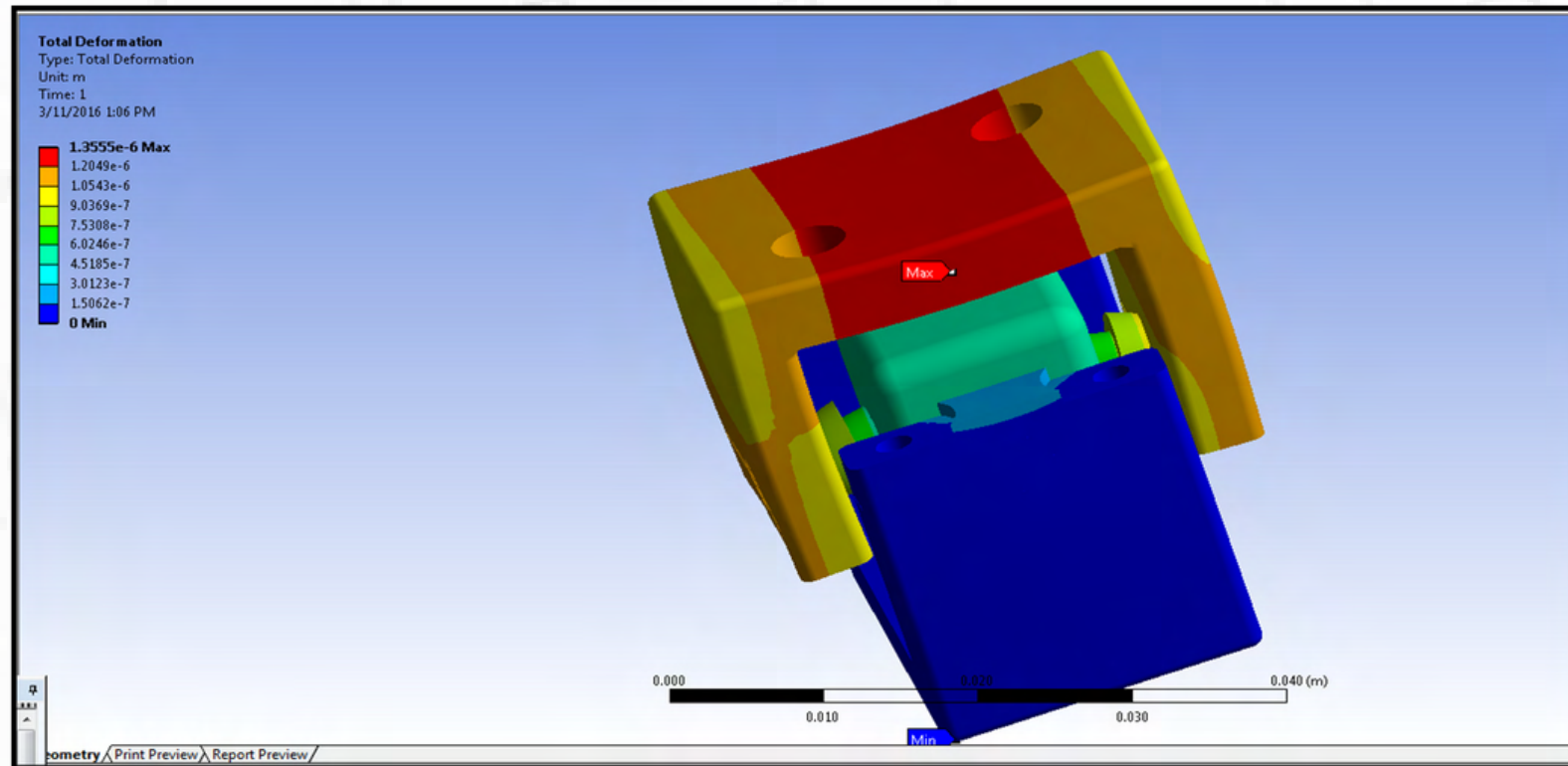
**Base Plate Deformation at 100N**

Total Deformation = 141.3  $\mu\text{m}$



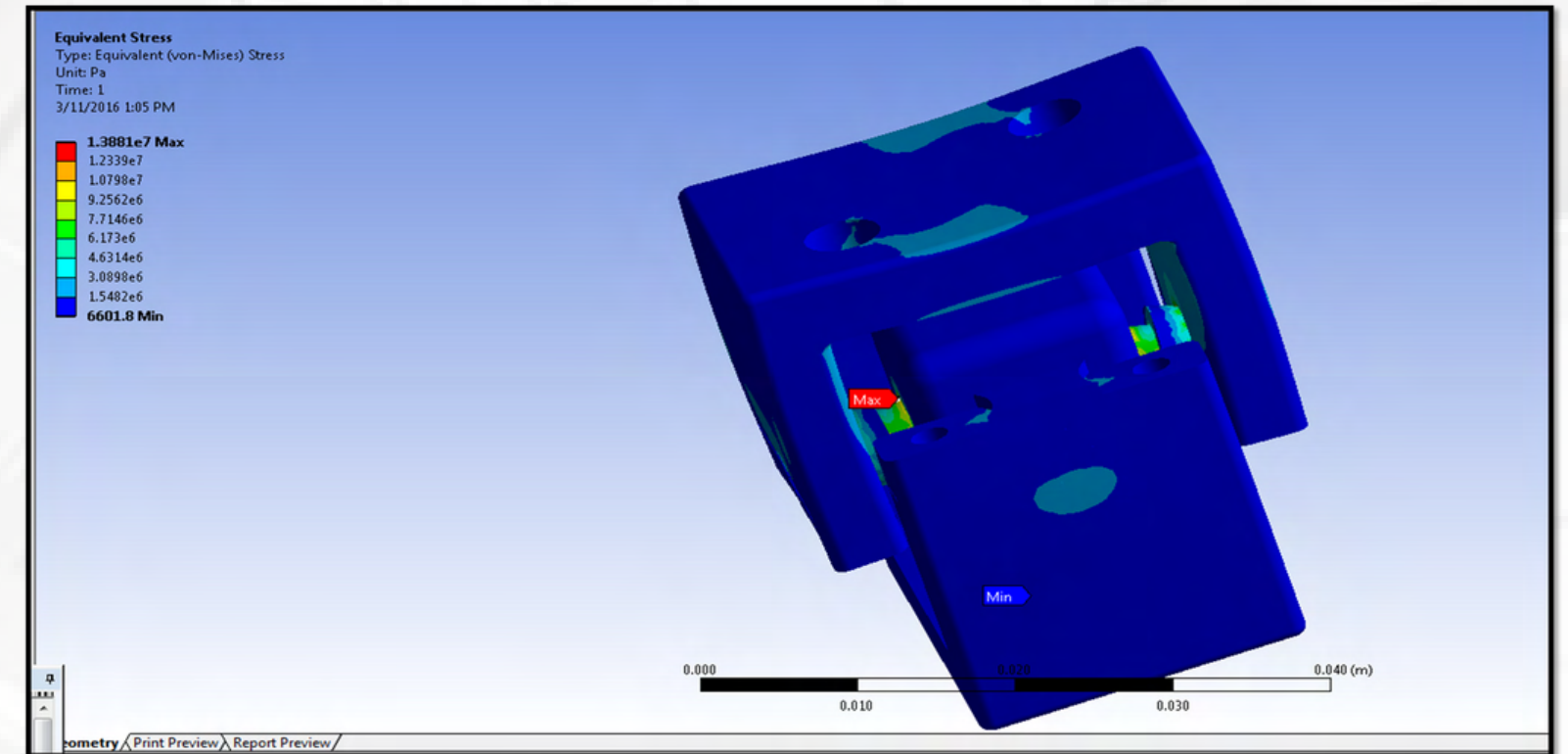
**Base Plate Stress at 100N**

Max Equivalent Stress=16.10 MPa



## Hinge Joint Deformation at 100N

Total Deformation = 1.33  $\mu\text{m}$



## Hinge Joint Stress at 100N

Max Equivalent Stress=13.88 MPa

## RESULTS:

- The maximum deflection of the whole assembly was well under 1 mm limit.
- The maximum load capacity for 1mm deflection was found out to be 300 N.

A Miniature Hexapod can be developed for low load applications desiring high level positioning accuracy & balancing.

Miniature Hexapod can be modified to do long distance remote precision surgery.

It can also be modified to accurate positioning of heavy artillery in military applications.

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# THANK YOU!

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GOKUL MOHANDAS

[GOKULMOHANDAS.COM](https://GOKULMOHANDAS.COM)

[gokul1401995@gmail.com](mailto:gokul1401995@gmail.com)

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