STEWART PLATFORM

by

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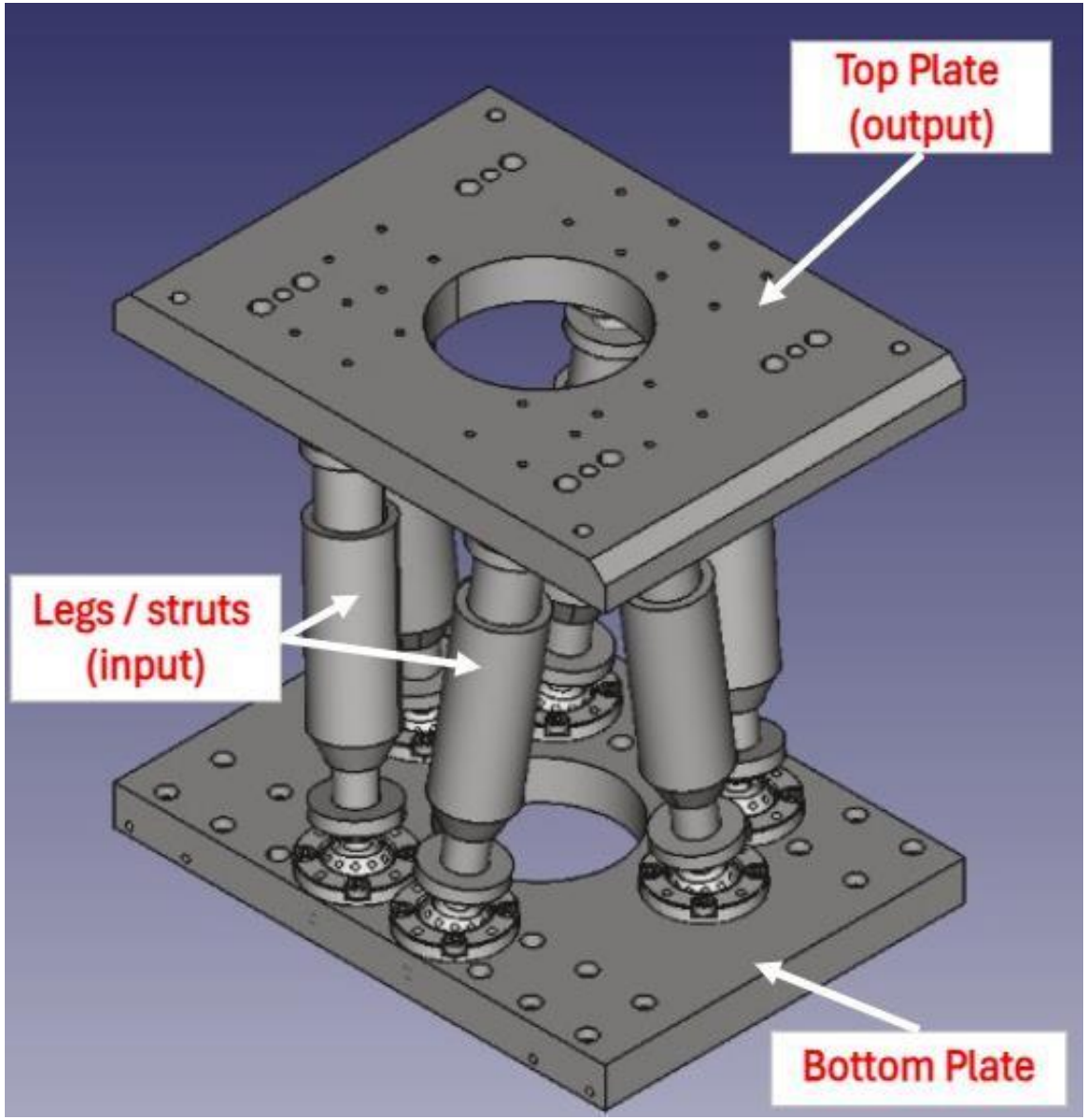
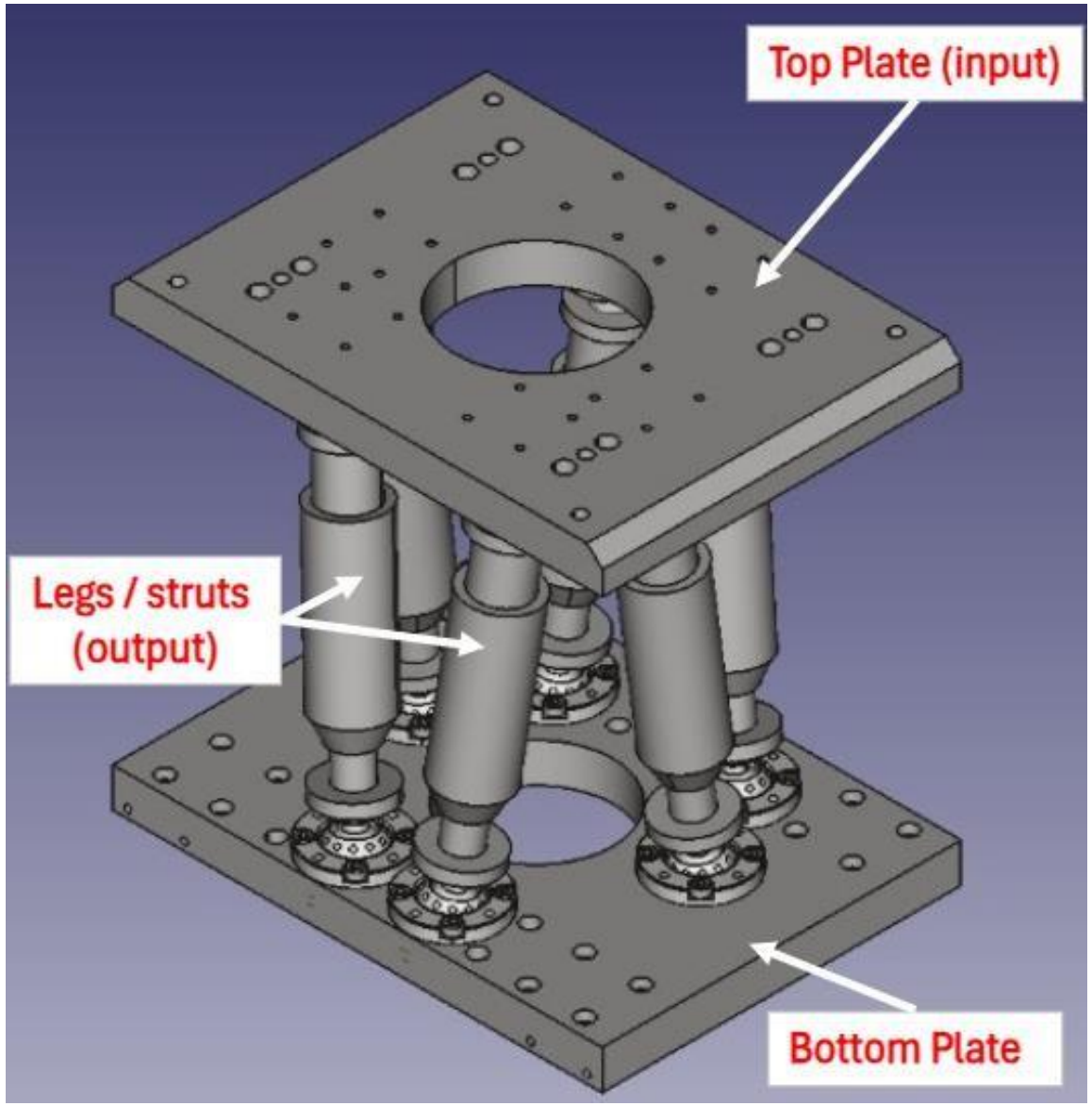
Forward Kinematics

- **Forward kinematics** involves determining the position and orientation of the top platform given the lengths of the six struts. This means calculating where the top platform is and how it is oriented in 3D space based on the known strut lengths.
- Steps:
  - **Input:** Known lengths of the six struts.
  - **Process:** Use geometric and trigonometric relationships to compute the position (x, y, z) and orientation (roll, pitch, yaw) of the top platform.
  - **Output:** The position and orientation of the top platform.
  - Forward kinematics for a Stewart platform is generally complex due to the non-linear relationships between the strut lengths and the platform's pose.



Inverse kinematics

- **Inverse kinematics** involves determining the required lengths of the six struts to achieve a desired position and orientation of the top platform. This means calculating how each strut should extend or retract to move the top platform to a specific pose.
- Steps:
  - **Input:** Desired position (x, y, z) and orientation (roll, pitch, yaw) of the top platform.
  - **Process:** Use the geometric and trigonometric relationships to compute the lengths of the struts.
  - **Output:** The lengths of the six struts.
  - Inverse kinematics is typically easier to solve than forward kinematics for a
  - Stewart platform because it involves direct geometric relationships.



Summary:

Forward Kinematics:

Strut lengths -> Position and Orientation of Top Plate

Inverse Kinematics:

Position and Orientation of Top Plate -> Strut lengths

Calibration using CMM*

- Fixed Platform
- Moving Platform

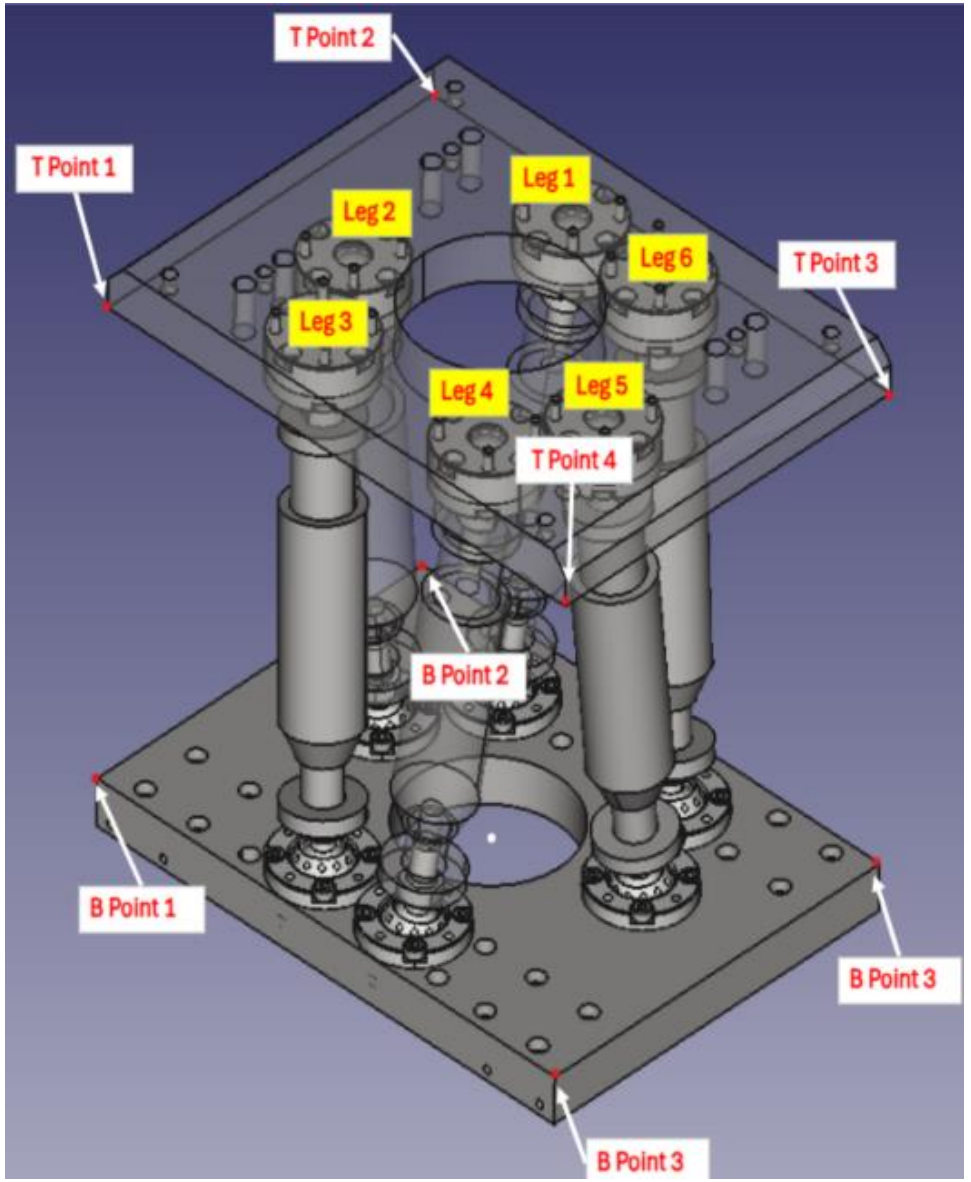
Corner points and leg center points are Recorded

Note: calibration points numbering is different from assembly points numbering

*CMM (Coordinate Measuring machine)

Calibration of Stewart Platform using CMM

- Keep all gauges at Zero position
  - Construct Top Plane of the Fixed platform
  - project bottom leg points on the Top Plane of the Fixed platform
  - Construct Bottom Plane of the Moving platform
  - project top leg points on the Bottom Plane of the Moving platform

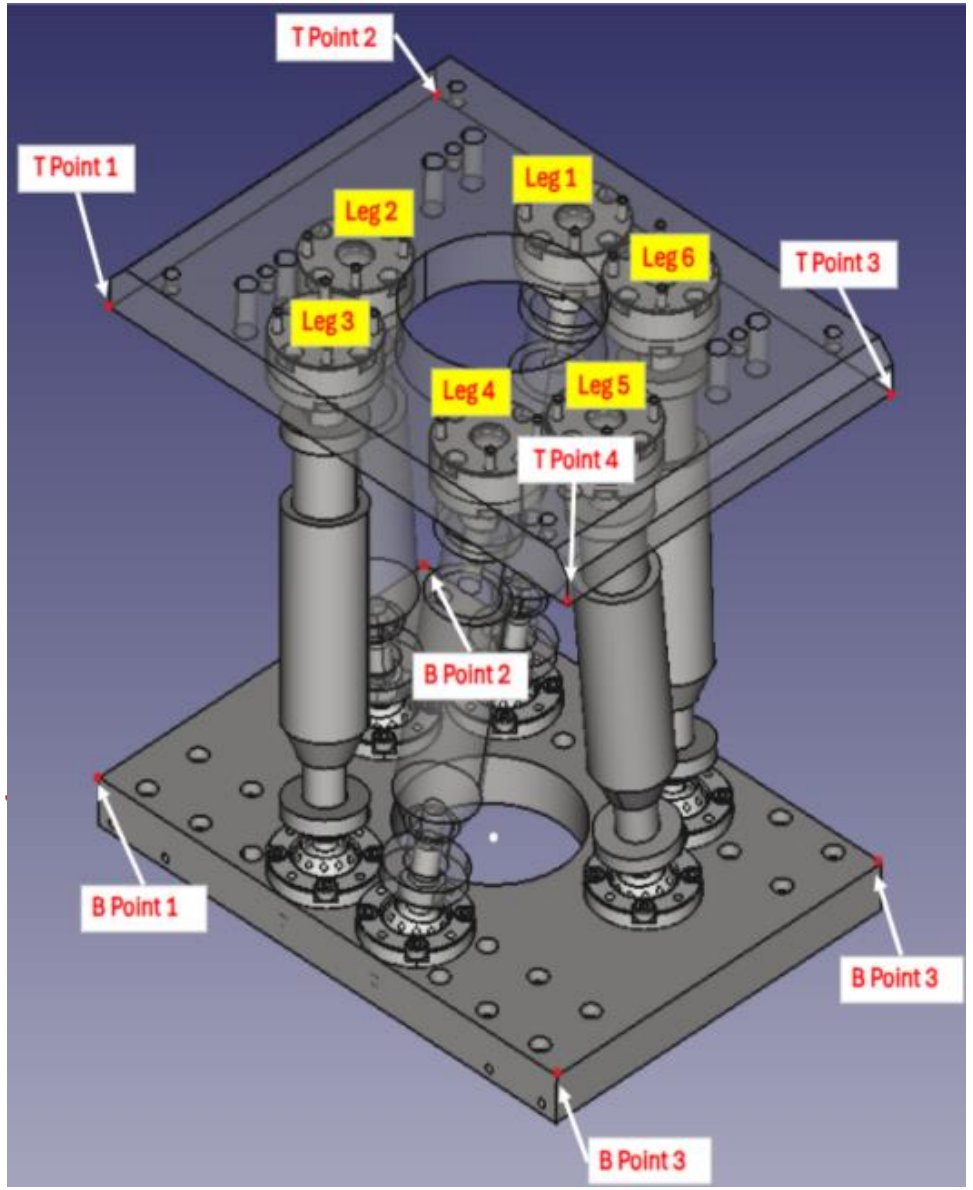


Capturing Fixed Platform corner points CMM

Take points along the four sides and Top surface of the Fixed platform using CMM.

Using the intersection of the four side planes and the top plane, locate the four corner points (B points fig) of the top plane of the bottom platform.

Remember origin at center of rectangle

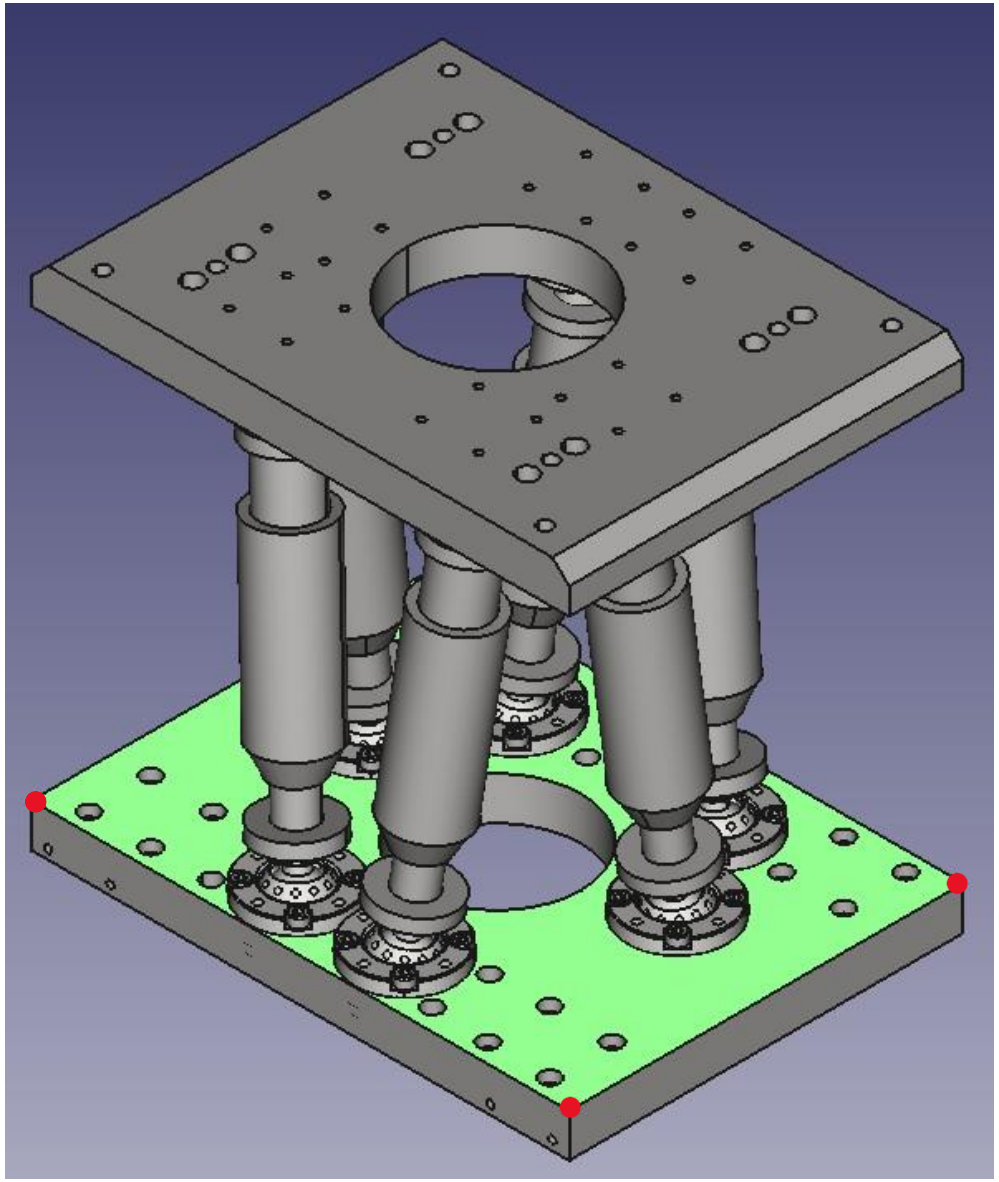


Steps to Determine the Bottom Platform Top Plane and Leg Points

How to construct Top Plane of Fixed platform

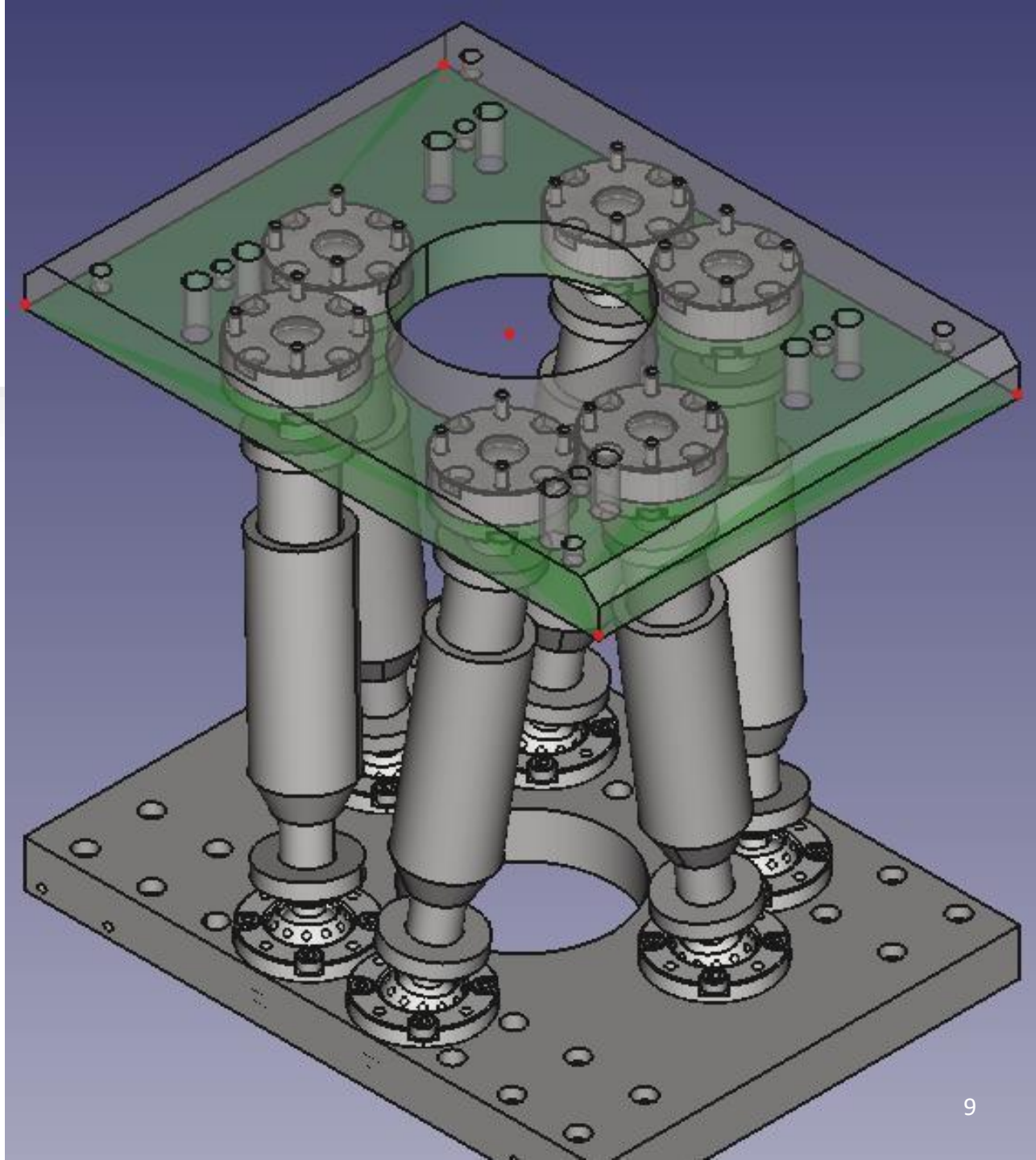
- Take points along the top edges of the bottom platform.
- Construct the top plane using these points to accurately represent the top surface of the bottom platform.
- Calculated the Rotational matrix at the center and projected the calibrated leg points on the plane

CMM code is written



Steps to Determine the Top Platform Top Plane and Leg Points

- Repeat the same steps outlined for Bottom Platform.
- Take readings on bottom surface of top plane.
- Remember origin at center of bottom rectangle



Checking

Case 1: After completing the previous steps:

Calculate leg lengths using inverse kinematics (MATLAB) and store it as leg1

Case 2: Adjust leg lengths manually as needed and note down increments / decrements in length:

Leg 5 and 6 increased by 4mm

Repeat all steps of case 1 and Calculate leg lengths using inverse kinematics (MATLAB) and store it as leg2

Verify change:

Case 1 Lenths + increments / decrements = Case 2 Lenth

Conclusion

- Model predicts the change in leg lengths perfectly

- Model verified

```
MATLAB Command Window

>> load('Calibration_results.mat')
>> legs1

legs1 =

  180.7243  180.5463  181.5145  180.8529  181.0489  180.4685

>> legs2

legs2 =

  180.7056  180.5515  181.5194  180.8481  185.0625  184.4675

>> legs2-legs1

ans =

   -0.0186    0.0052    0.0049   -0.0048    4.0136    3.9990
```

THANK YOU
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