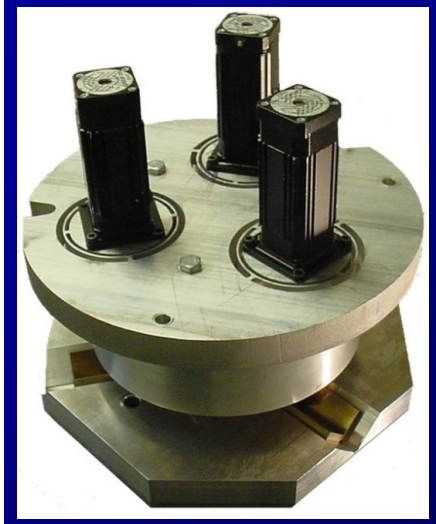
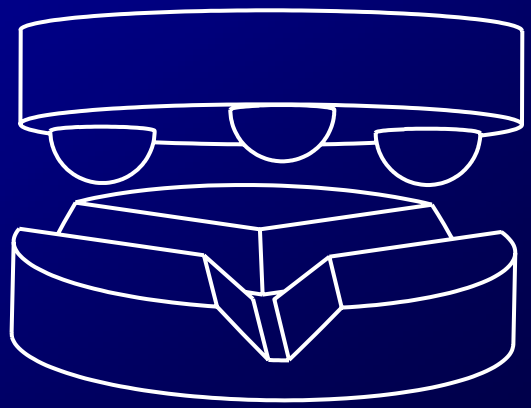
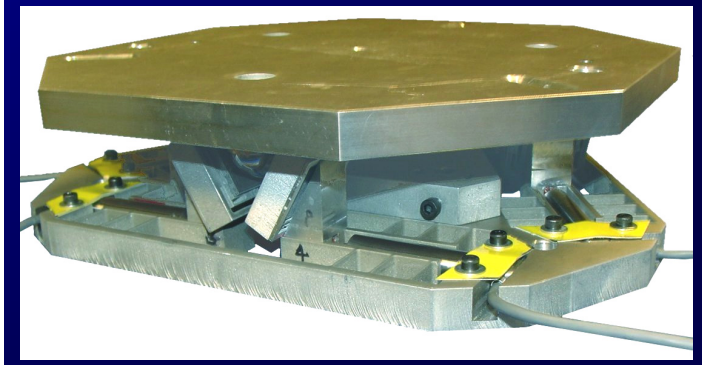
Active compliant fixtures for Nanomanufacturing







Fixtures as mechanisms

Design concepts

Modeling

Experimental results

Discussion

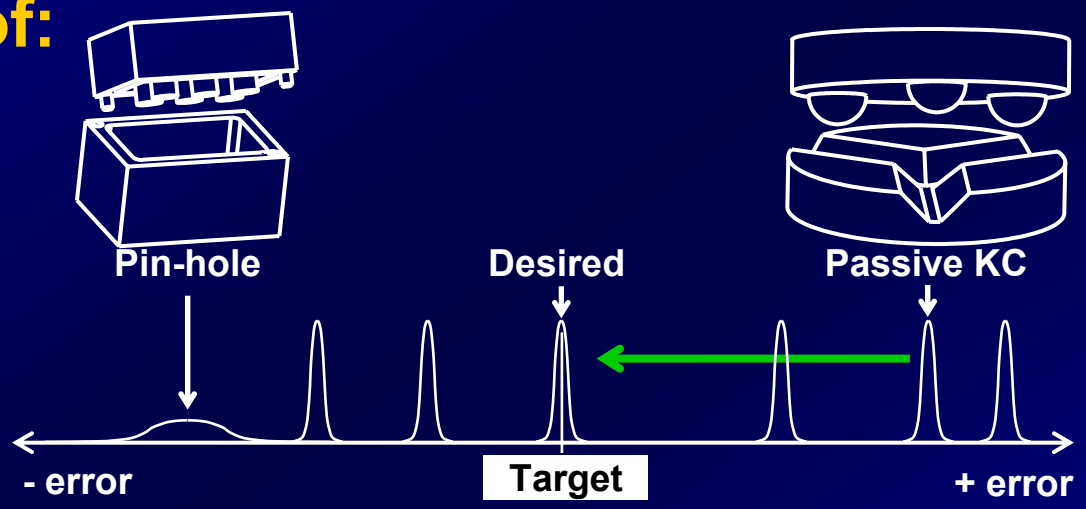
Prof. Martin L. Culpepper
Rockwell International Asst. Prof.
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MIT Mechanical Engineering
Precision Compliant Systems Lab
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Obtaining accuracy and repeatability

Accuracy is a function of:

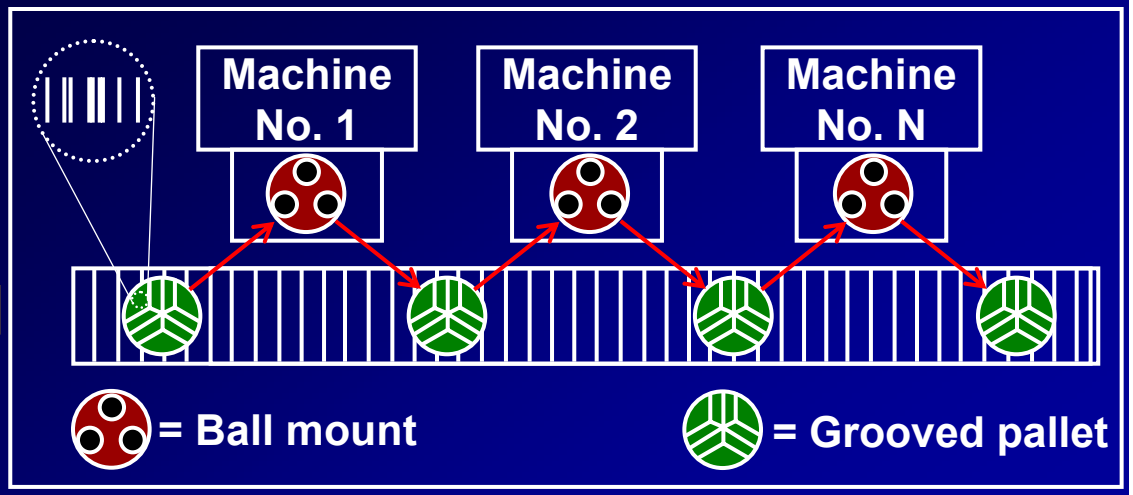
- Repeatability
- Wear
- Tolerances
- Thermal errors
- Etc…



Accuracy can be improved by

- Calibration via adjust
- Adding active elements

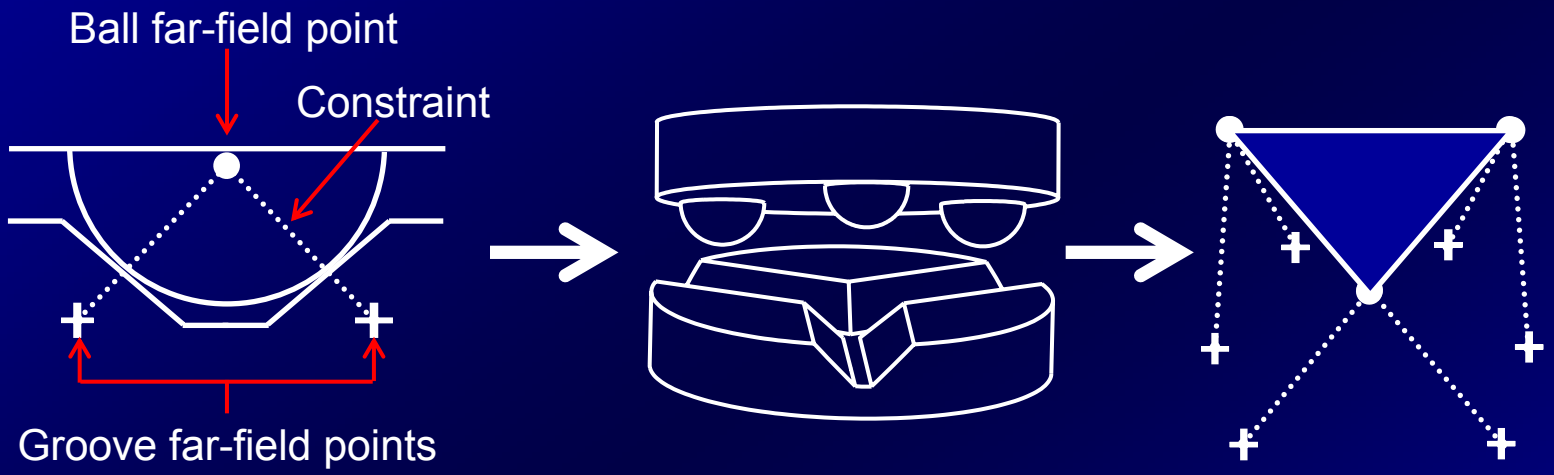
Six axis motion desired



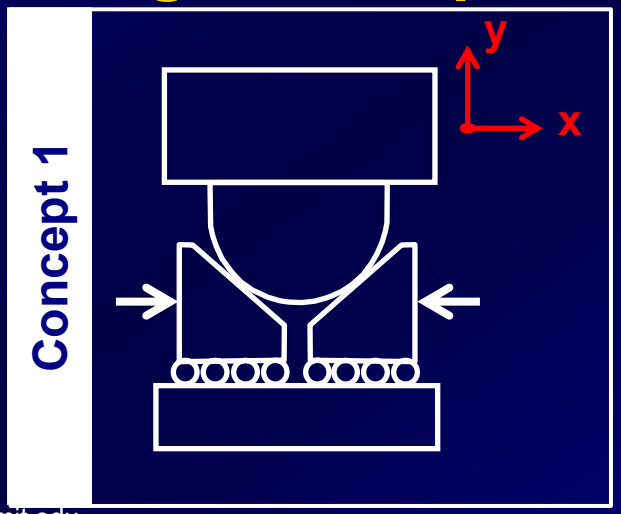
Fixtures as mechanisms

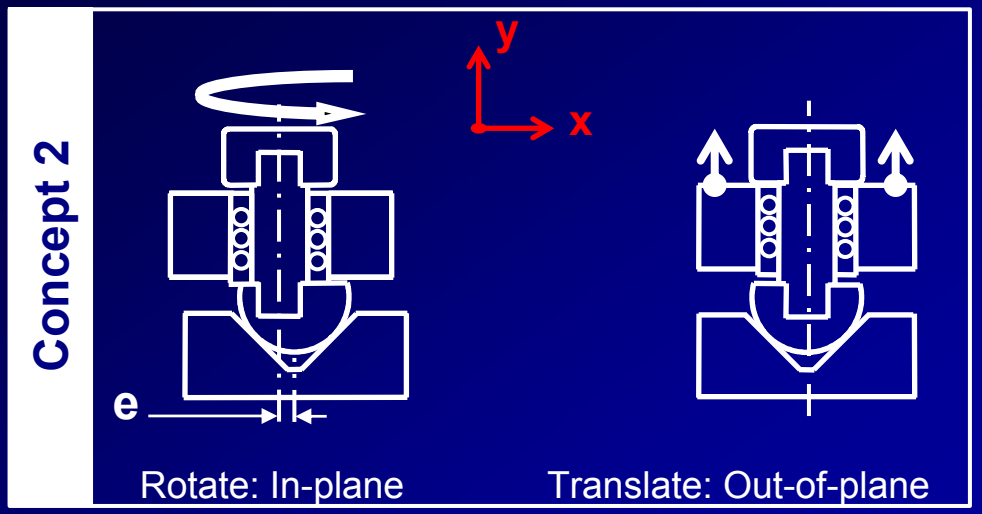
Ball-groove constraints ~ to legs of Stuart Platform

- Changing constraints generates motion

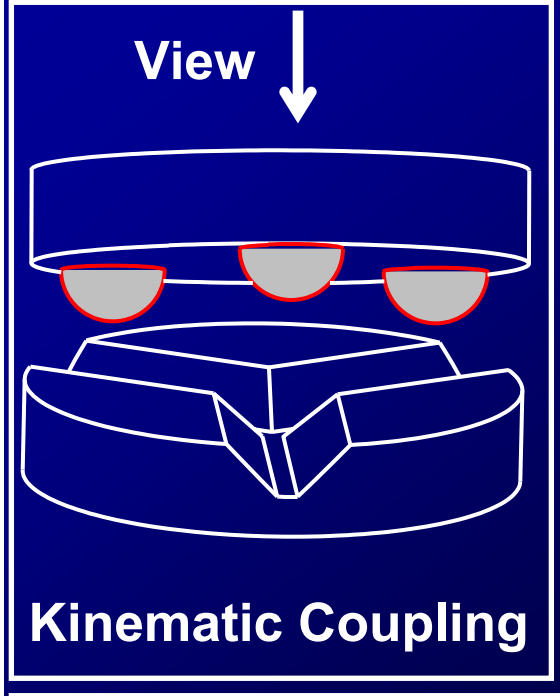


Two design concepts

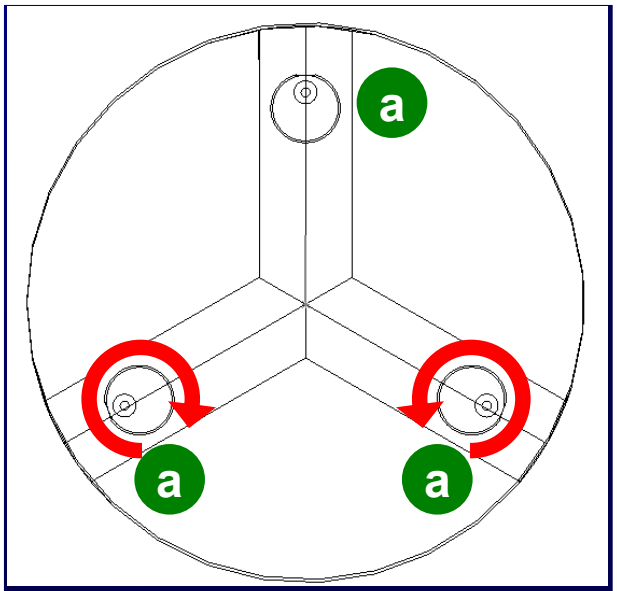




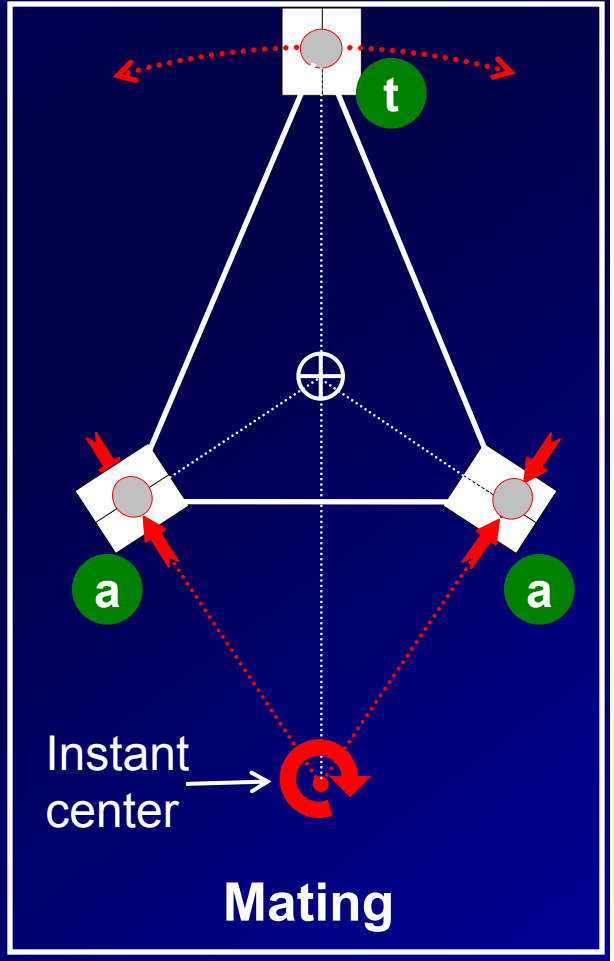
Sliding, friction and wear



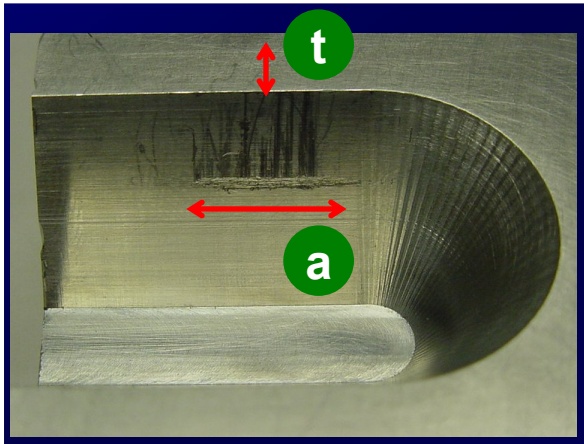
Kinematic Coupling



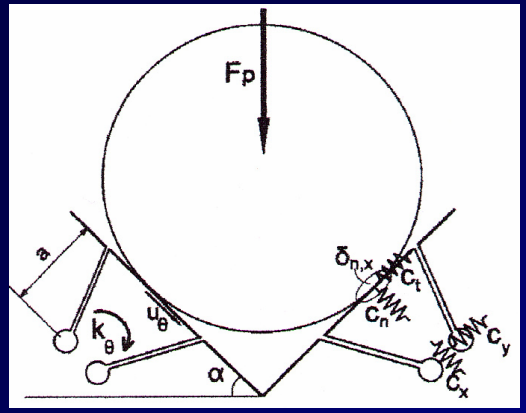
Actuation



Mating

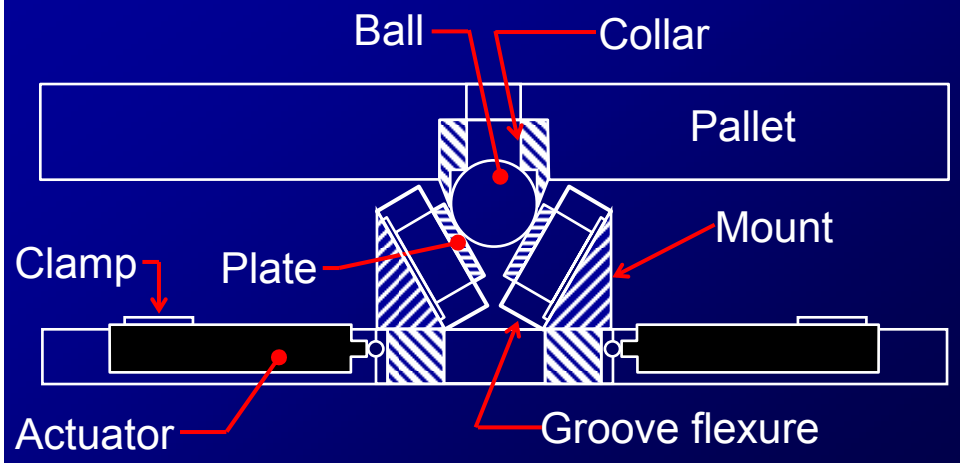


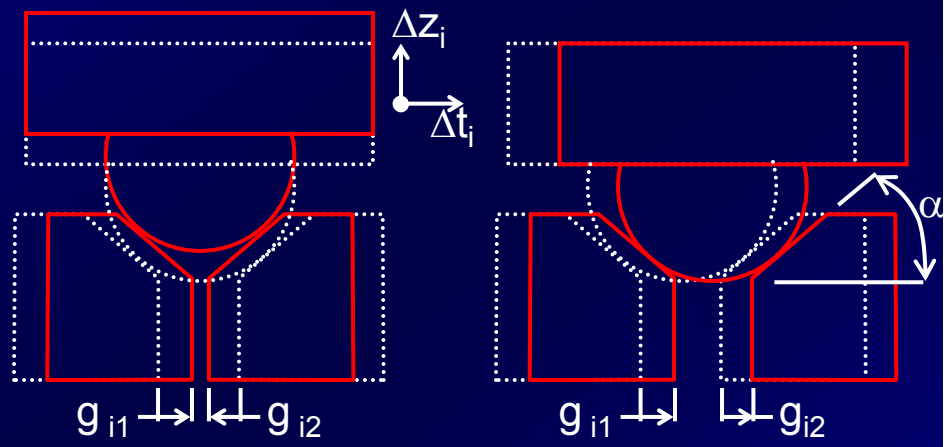
Wear indicates friction problems



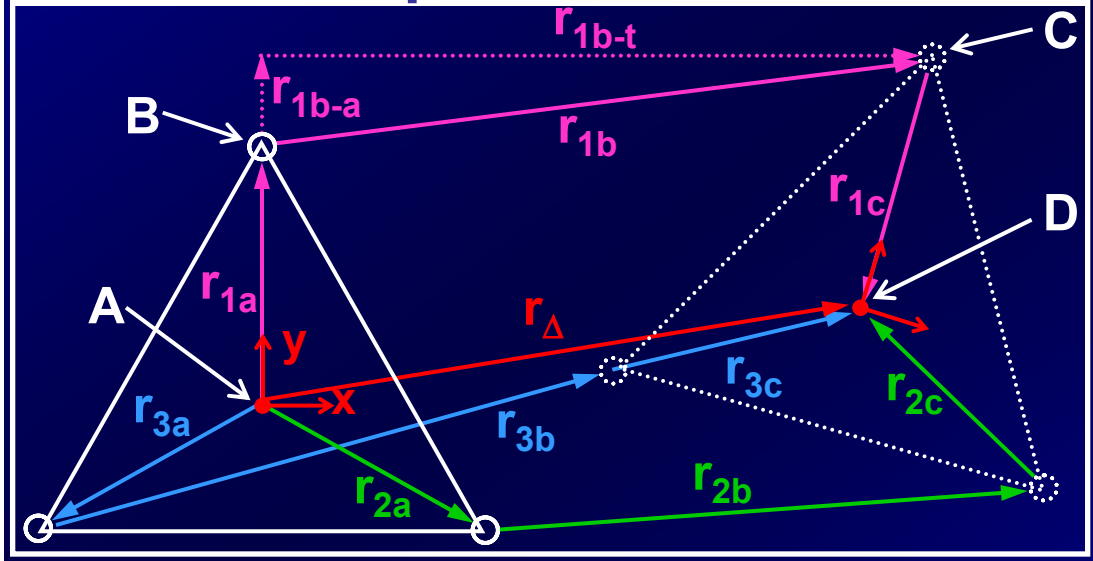
Schouten, et. al., "Design of a kinematic coupling for precision applications", Precision Engineering, vol. 20, 1997.

Modeling

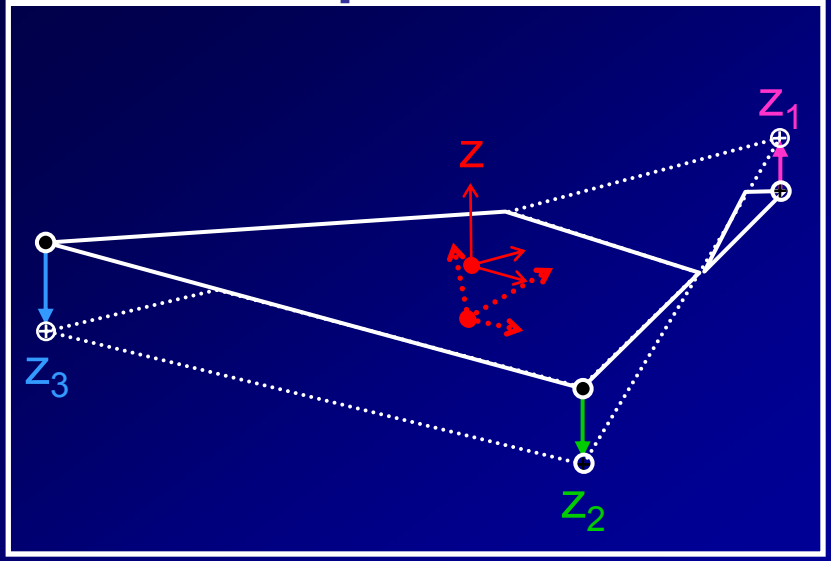




In-plane model



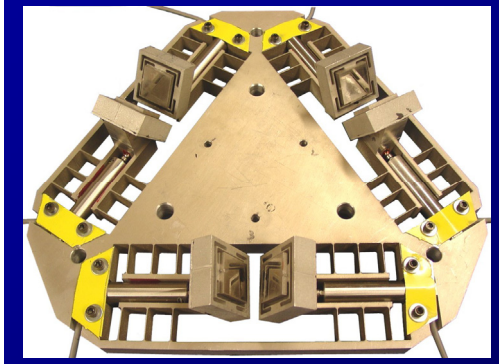
Out-of-plane model

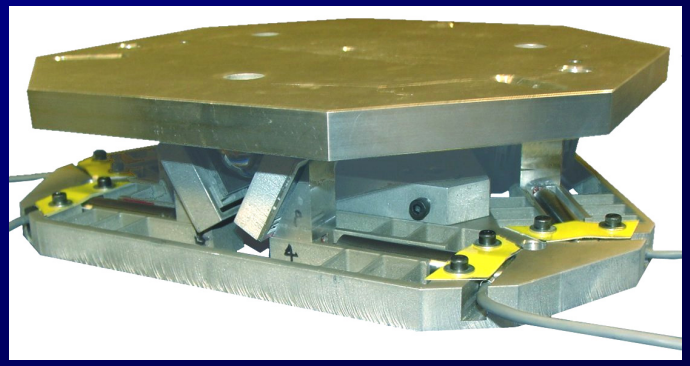


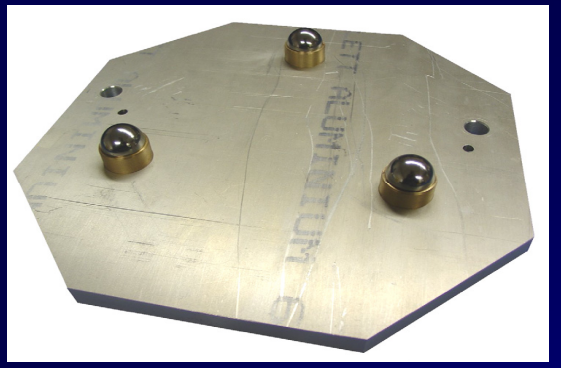
$x,\ y,\ z,\ L_{1b\text{-}a},\ L_{2b\text{-}a},\ L_{3b\text{-}a}$

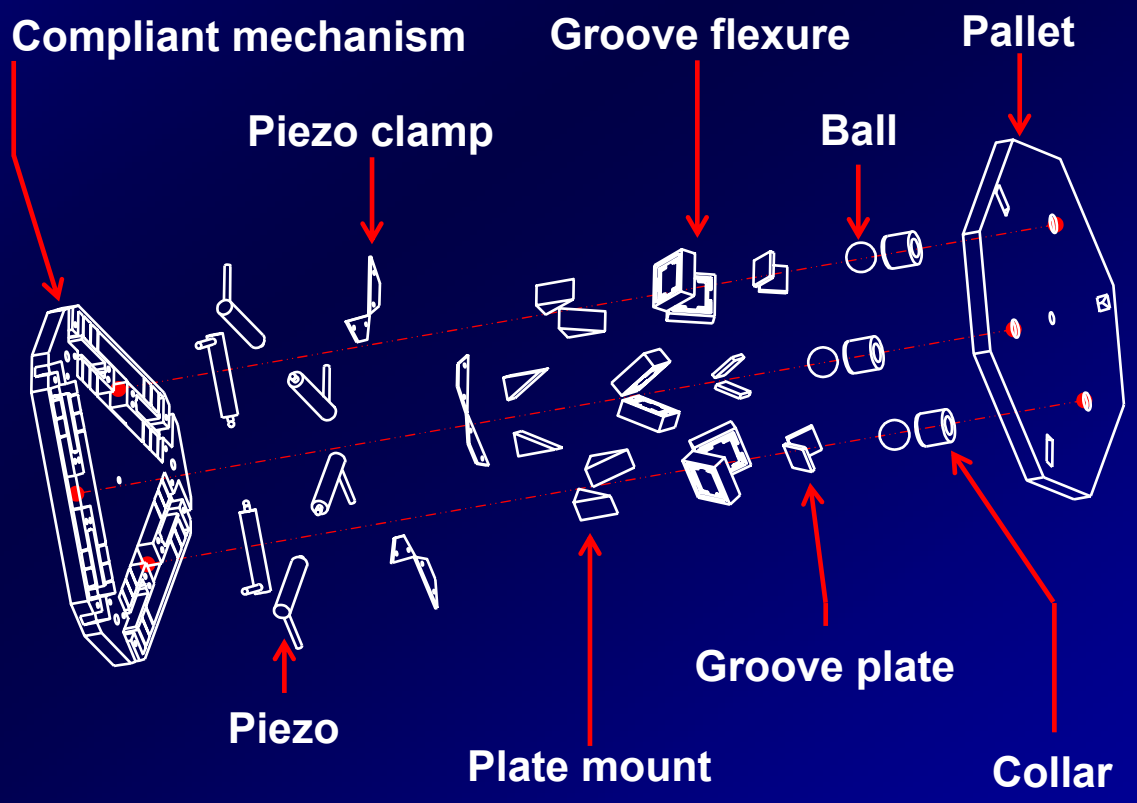
$\theta_x,\ \theta_y,\ z$

Translating groove prototype

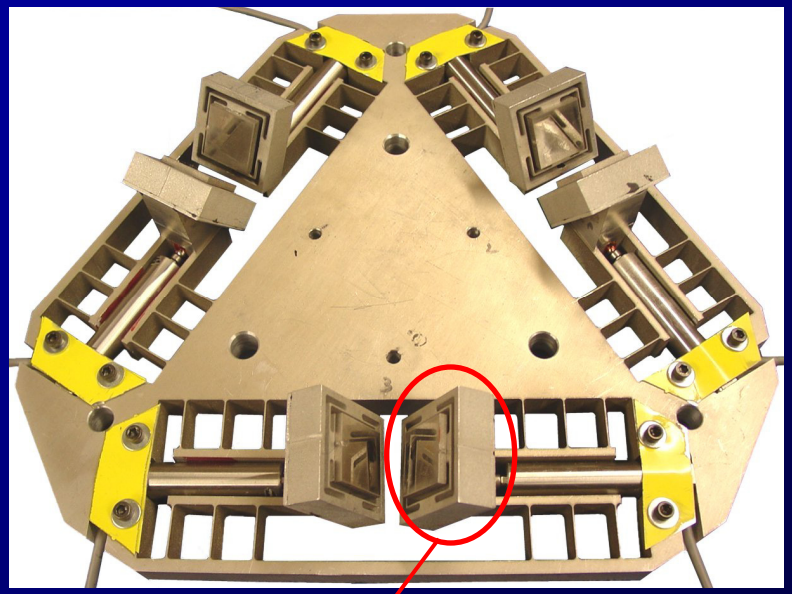


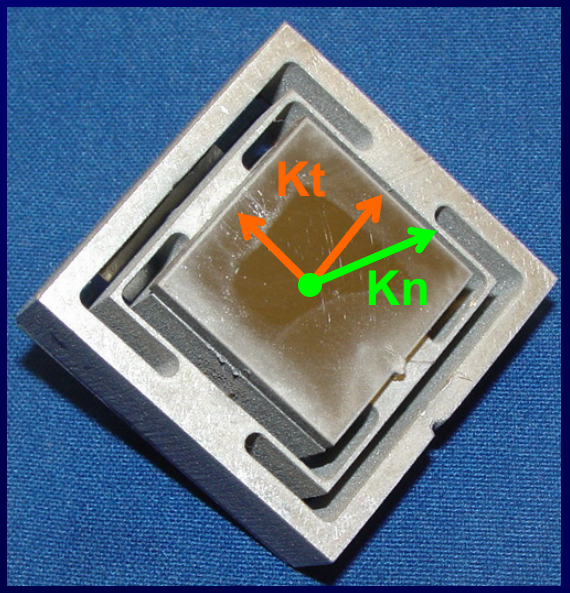






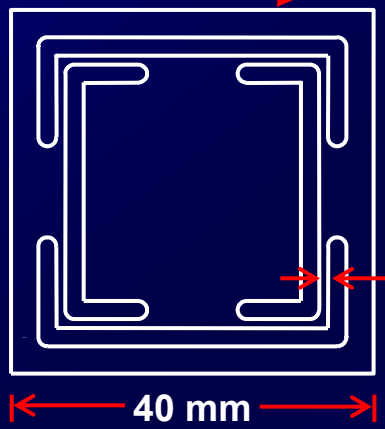
Translating groove prototype



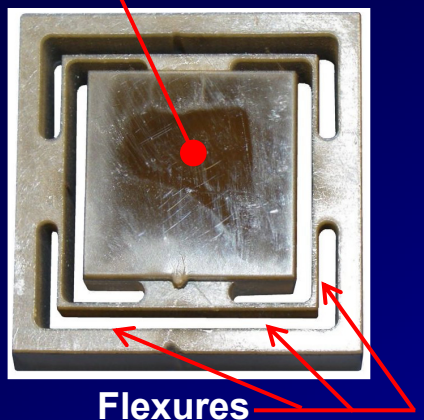


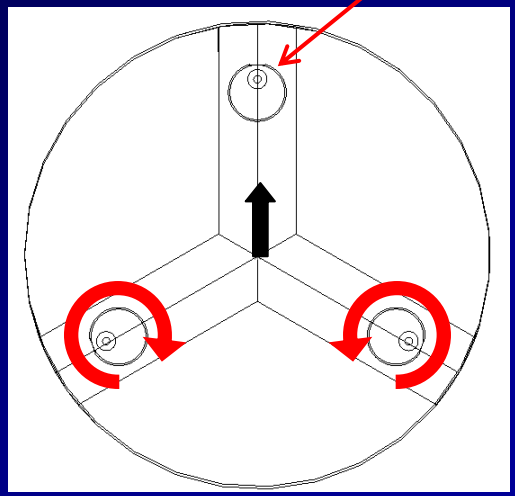
Design goals:

- Kt < 0.1 Kn
- Kt = 2.1 N/μm
- Kn = 34 N/μm

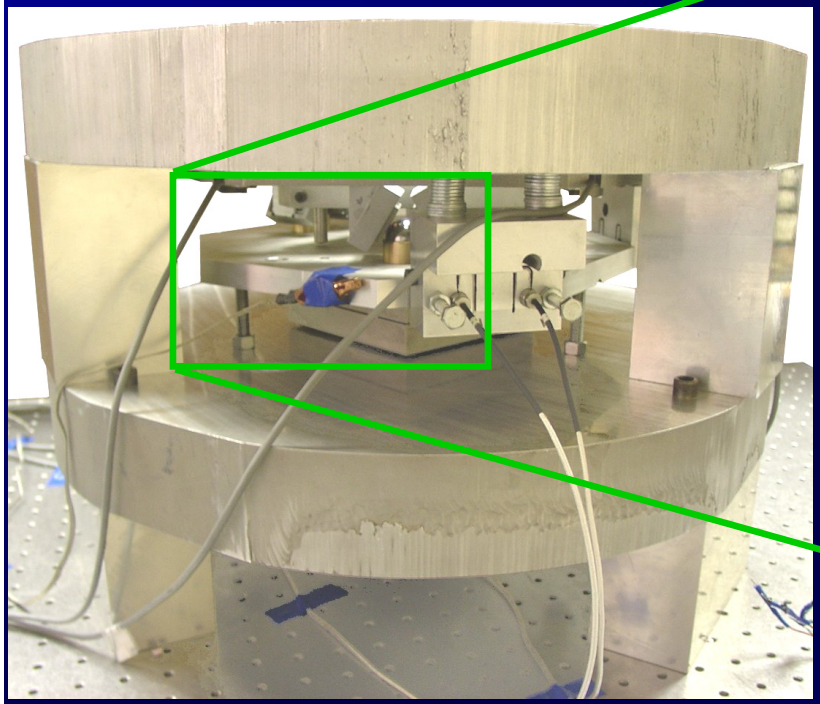


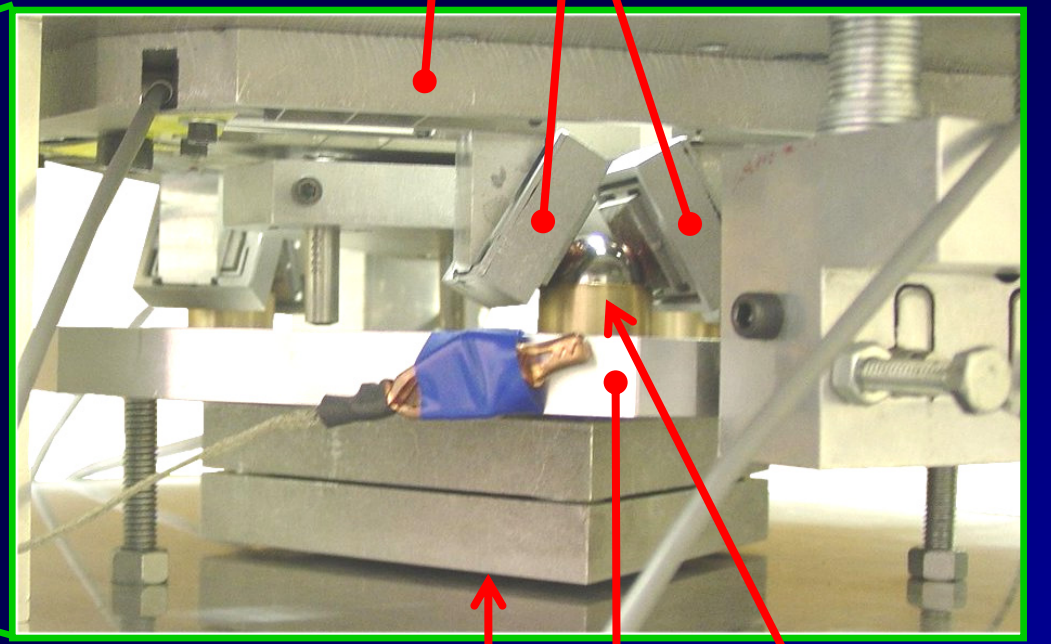






Experiment





Compliant mechanism

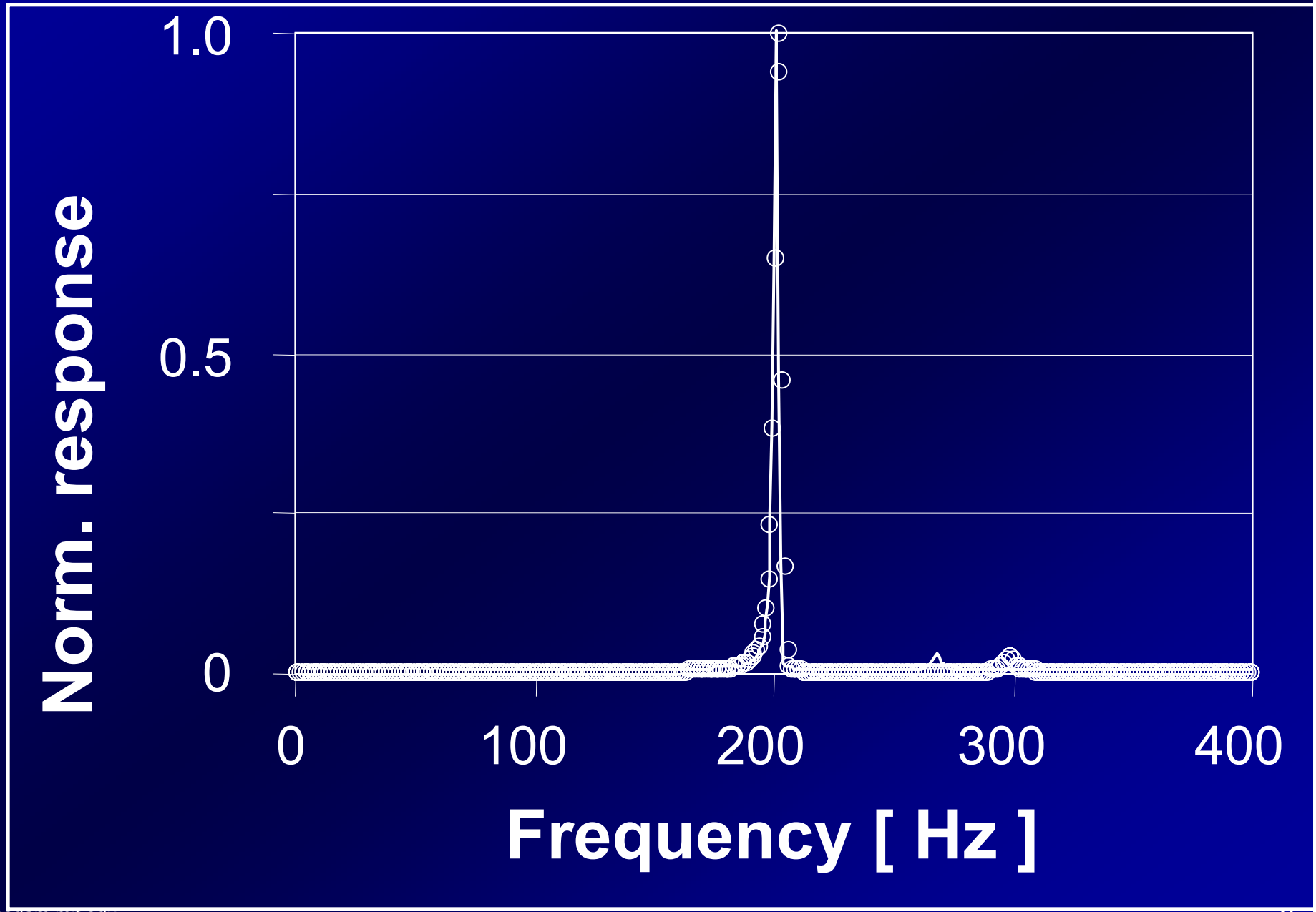
Groove flexures

Decoupling flexure

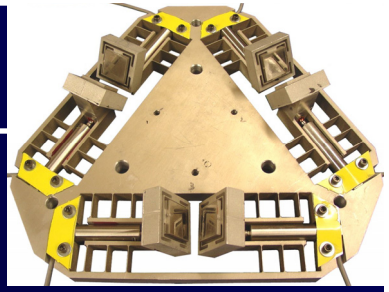
Pallet

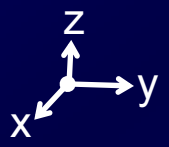
Ball

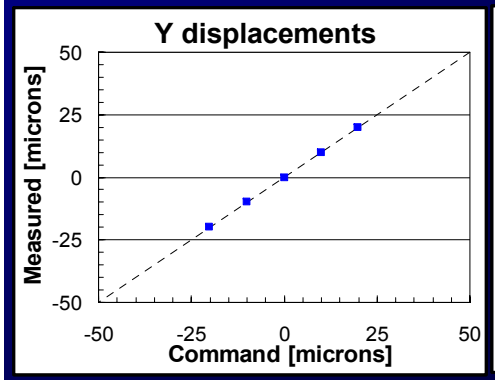
Dynamics

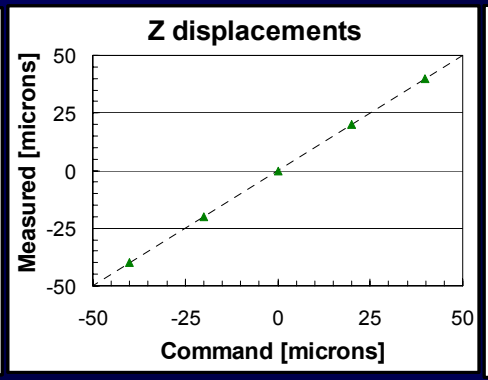


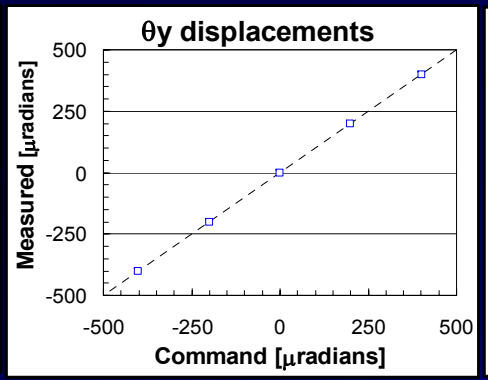
Open loop adjustment

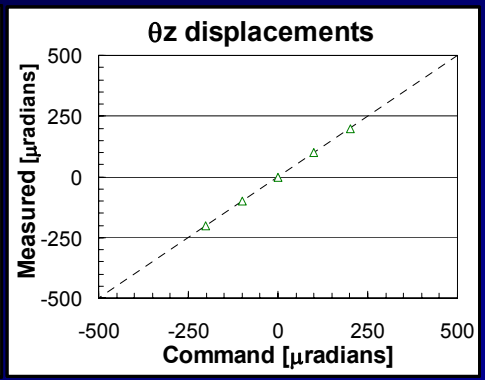


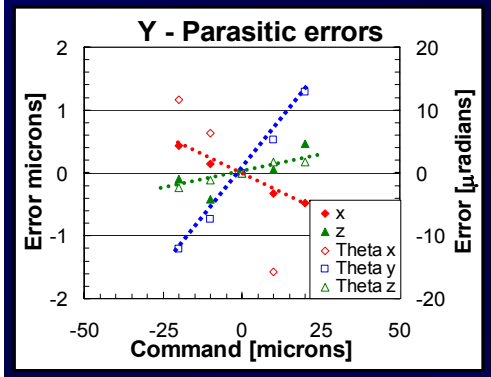


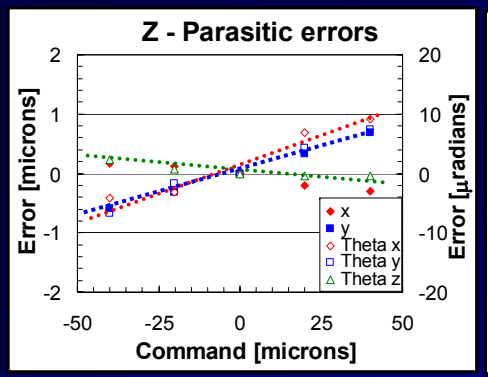


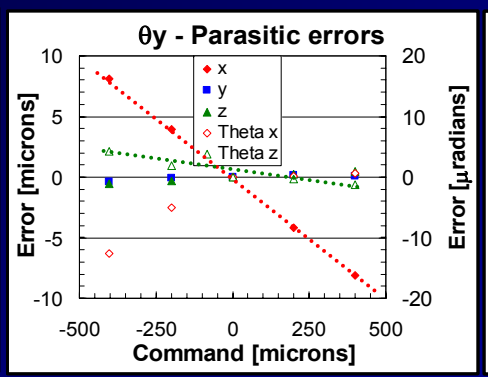


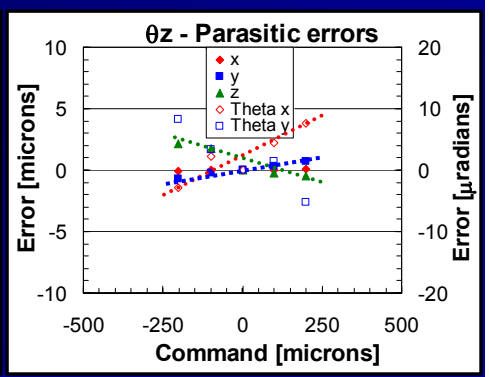




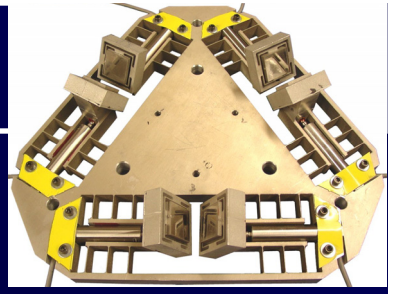


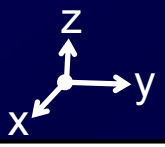


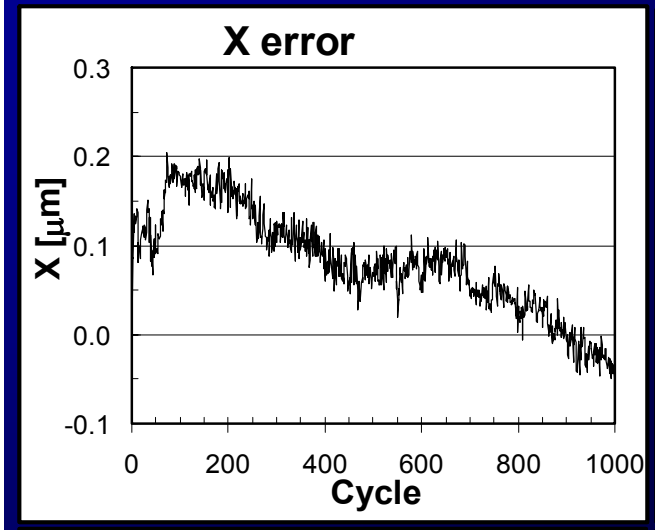


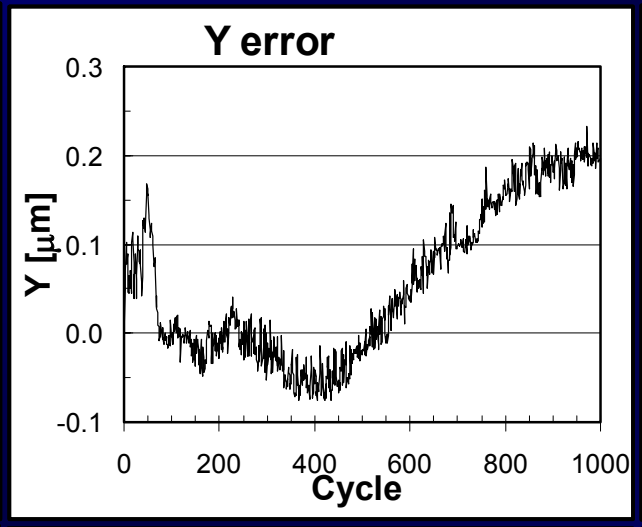


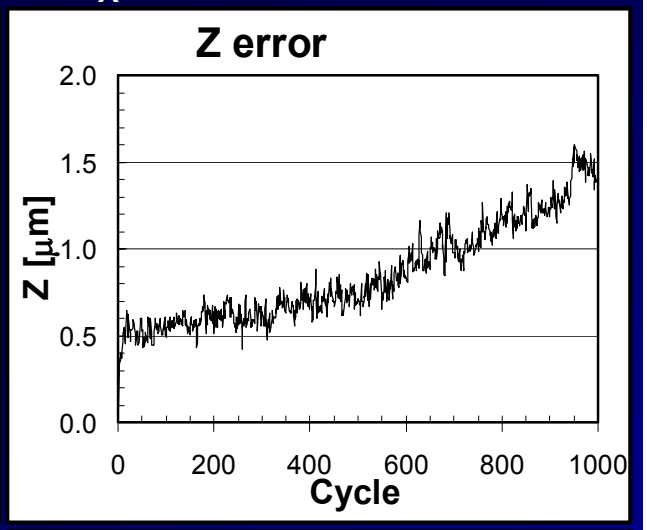
Repeatability

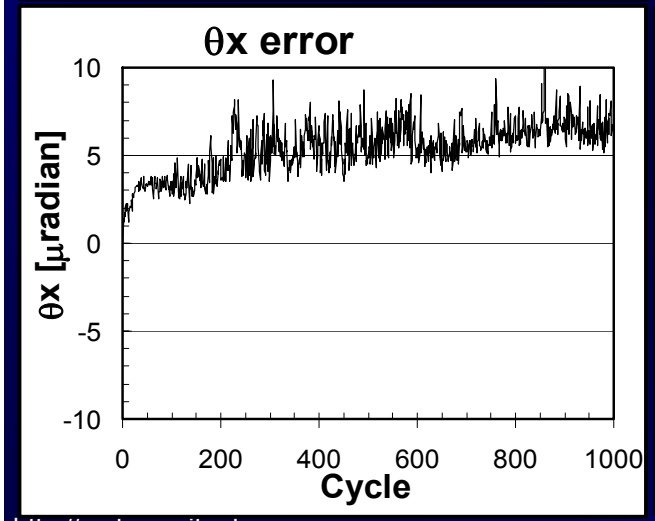


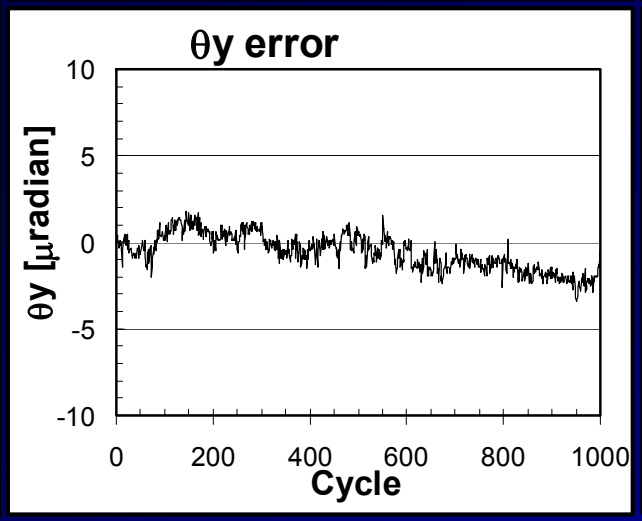


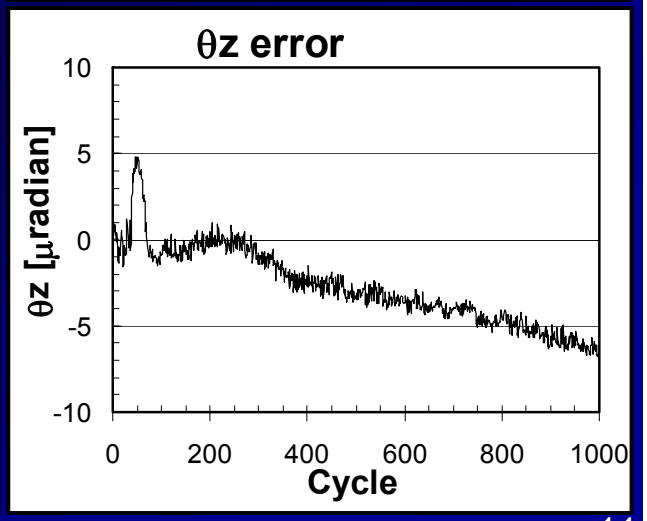




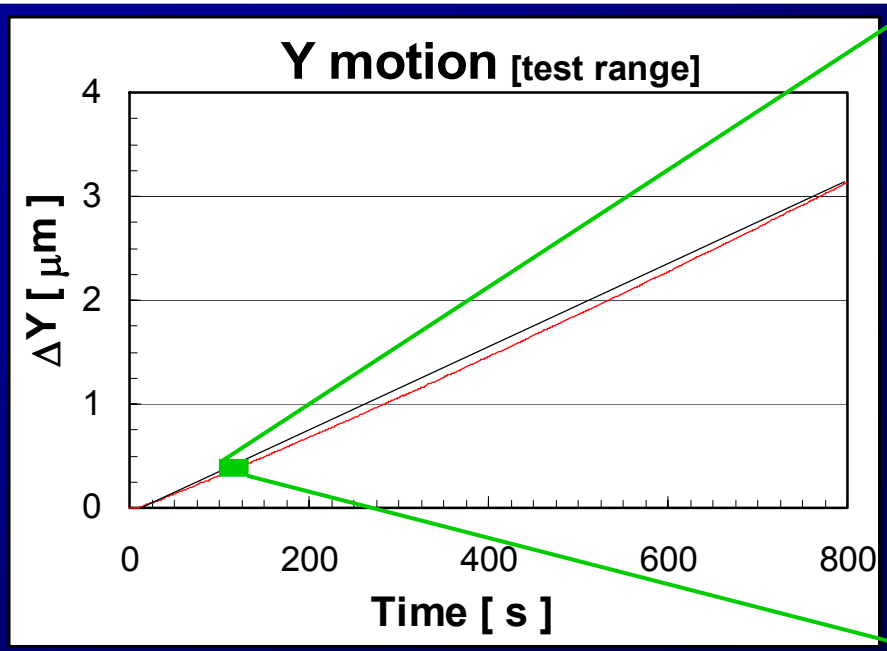


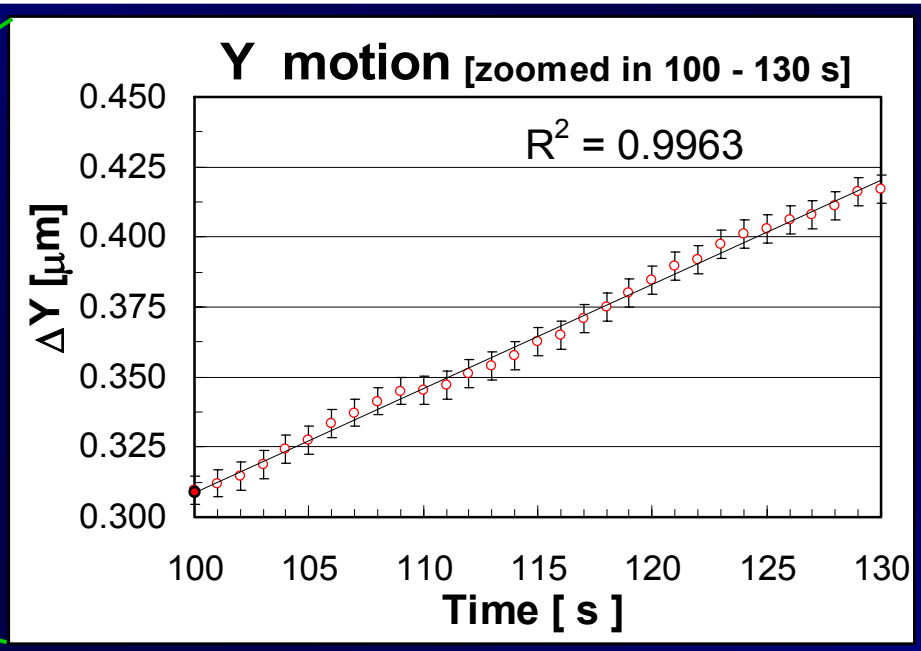


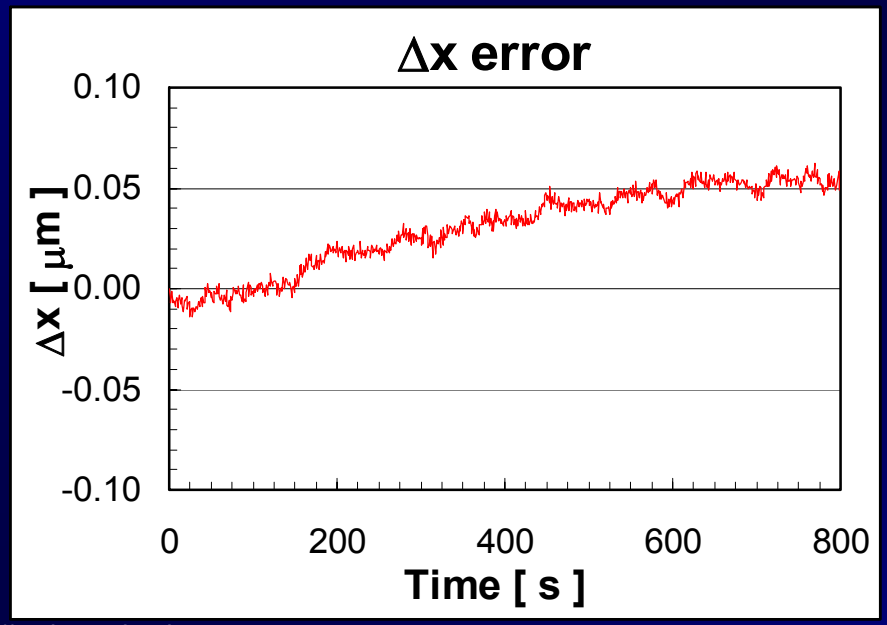


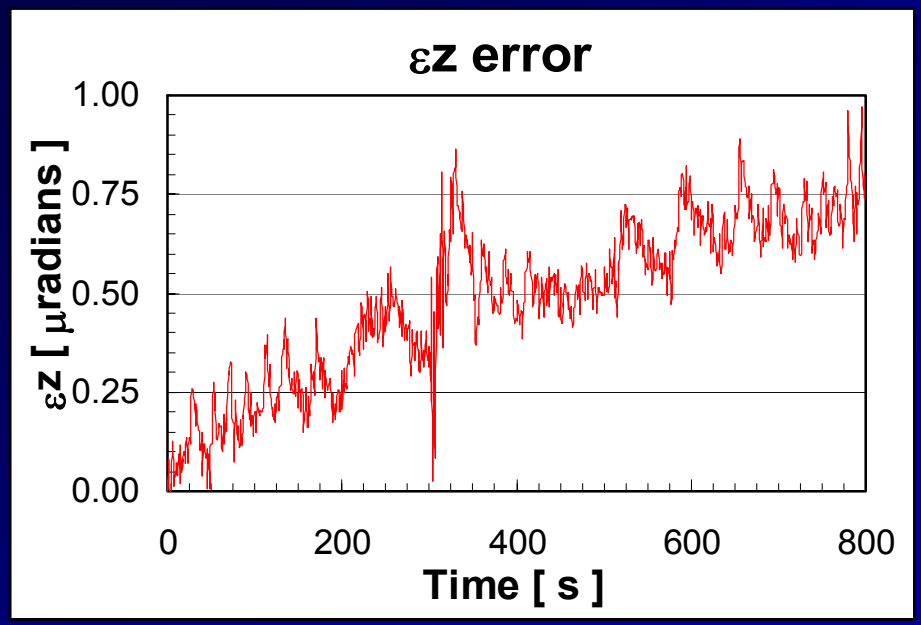


Movement while engaged





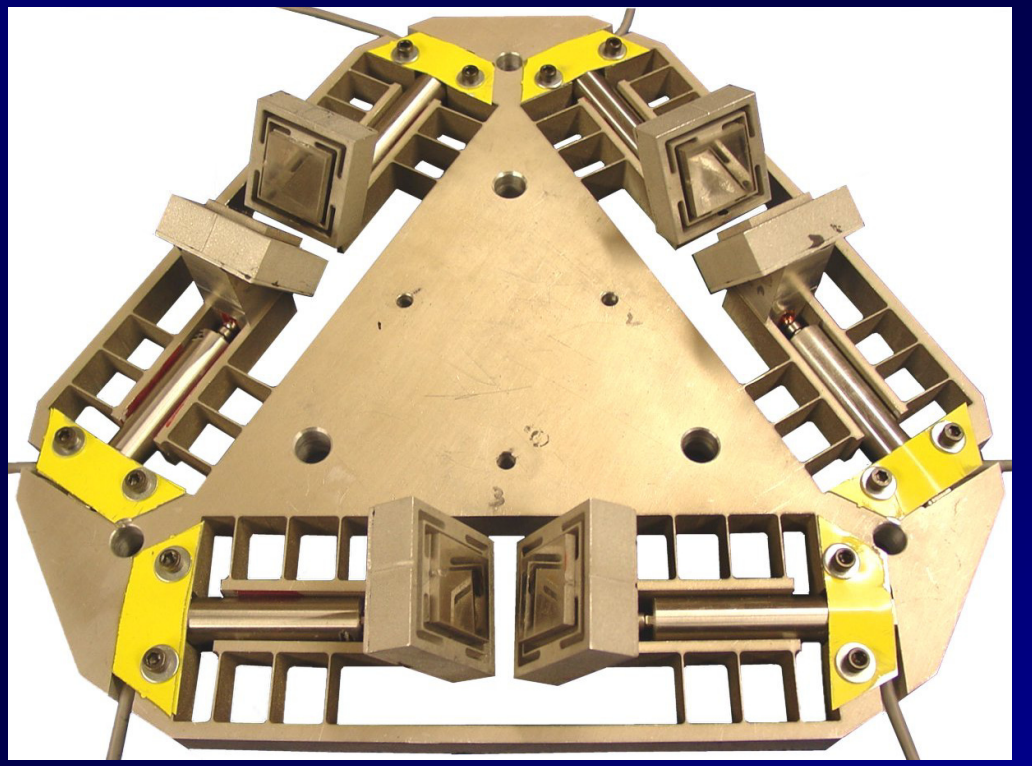




Finish

Where we are now

- Kinematics
- Error correction
- Friction
- Model



What is next

- Dynamics
- Cost appropriate
- Stiffness
- E_{mfg} / E_{act}

Ford Motor Company / Ford-MIT alliance
Ford / MIT Alliance

NSF Nanomanufacturing Program [Grant No.: 0348242]
CAREER: Research and Education Plans for Modeling and Design of Fixtures and Six-Axis Manipulators for Nanomanufacturing