Travis Harrison

Connor Hoffmann

Sean McGee

Scott Mesoyedz

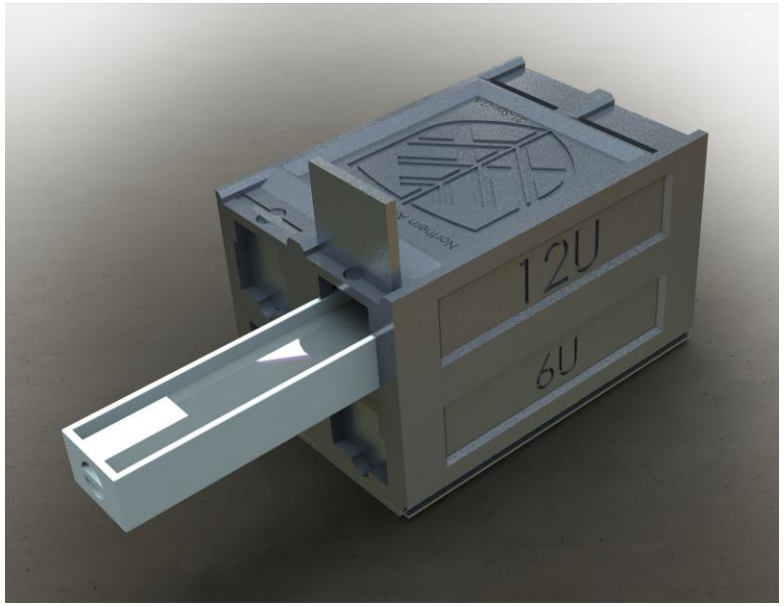
General Atomics - Midpoint Presentation

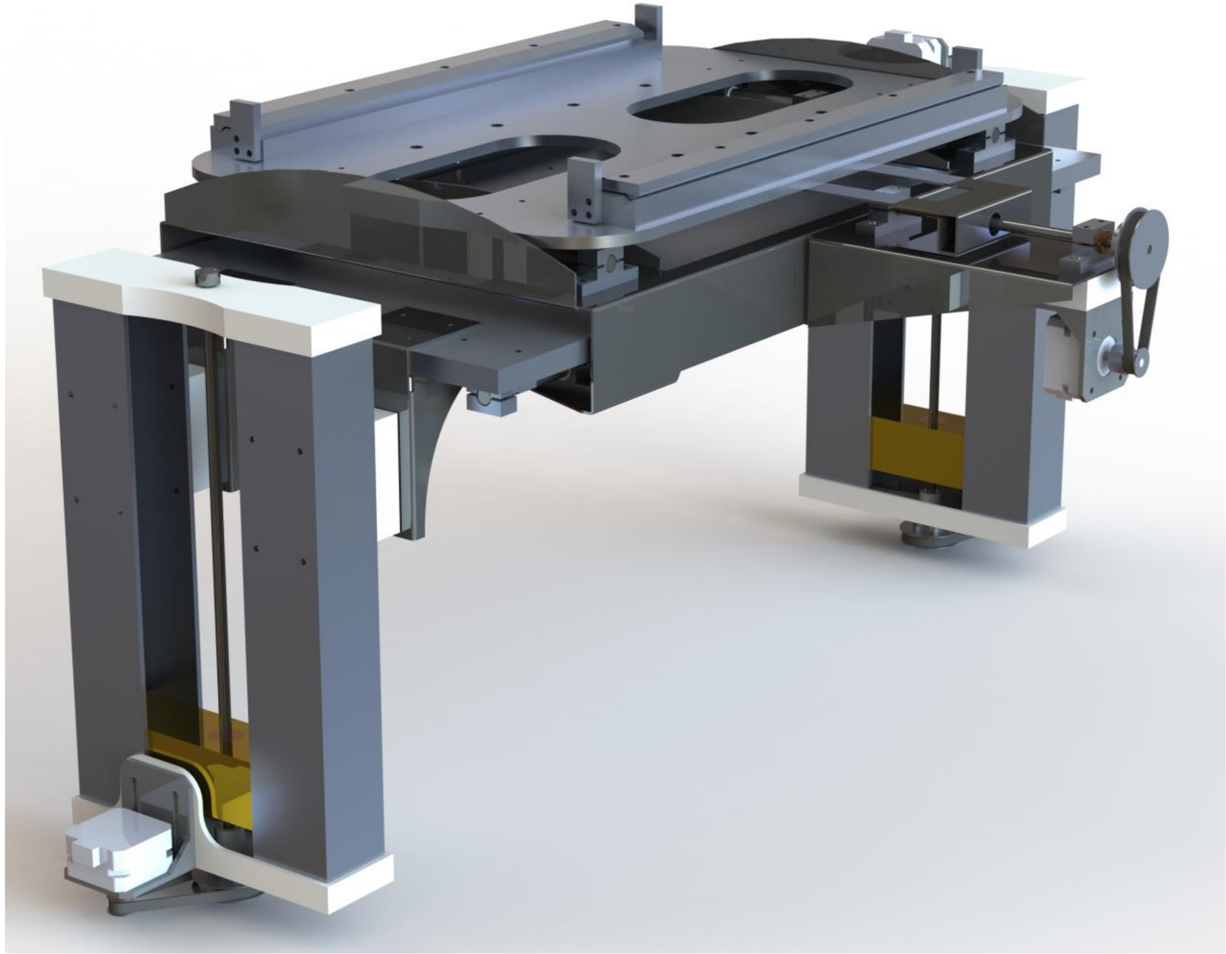
Design Description

- Design a satellite test fixture to collocate its center of mass with the center of rotation of a spherical air bearing
- Since Hardware Review 1
  - Parts acquisition
  - Manufacturing
  - Motor controls
  - Simulation
- Sponsor: General Atomics
- Client: General Atomics

Current State of Design

- Currently on the same iteration since Hardware Review 1
  - One change was made to satellite brackets
- Changes made to replica CubeSat
- Operation – No Changes
  - Use lead screws to move center of mass location



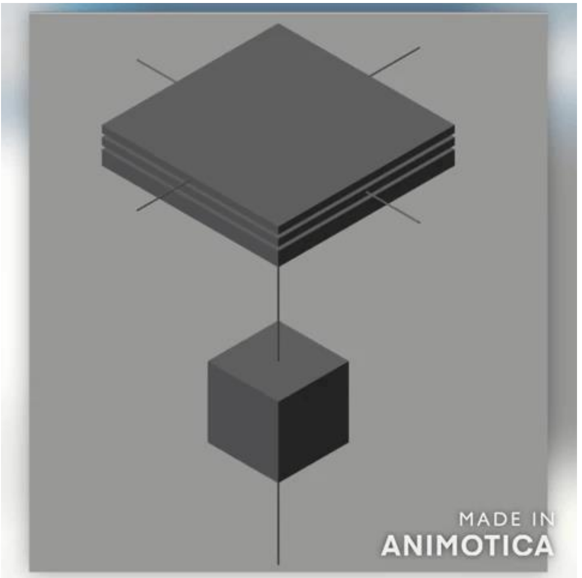


Current State of Manufacturing

- All currently manufactured parts present
- The fixture requires a method of moving in all three directions (ER #5,6)
  - The base plate has been made
  - The Z-carriage has been outsourced, to be delivered next week
  - The lead screws have been purchased and waiting for integration
  - The motors have been selected but require testing
- The system needs to be able to rotate 360 degrees and maintain 35 degrees of tilt (ER #12,13)
  - The inner bearing is recently completed
  - The angular bearing brackets that will function as the outer bearing have been milled
  - A stand needs to be made before it can be bolted down and assembled
- The bearing mount is compatible with the fixture (ER #14)
- They system is heavy (ER #8)
  - Most of the parts are made from aluminum
  - The additional weight is counterintuitive to reducing the overall weight

Current State of Controls

- Currently using open-loop control
  - Closed-loop control is being designed, but requires a completed prototype to test
- Using Simulink to create a computer model
  - Basics done, now moving towards accuracy
  - Recreating motor control and sensors within simulation
  - Goal: Have accurate and working computer model ASAP to prepare for physical model
- If we can meet the ER of accurately collocating COM with COR within simulation, then we can implement the same procedure to physical model. (ER#1-3, 6)
- Automated controls will help reduce the time required for repositioning. (ER#17, 18)



Bill of Materials

- Most important items have been purchased
- Some minor items remain such as Bolts/Hardware
- Spent: $1,988.87
- $2,000 reserved for travel
- Remaining: $4,011.13

	Name/Description	Parts	Category	Quantity	Price
1	Male and female pin connectors	Motor Control	Motor Assembly	1	$15.16
2	Junction boxes	Motor Control	Motor Assembly	1	$8.72
3	Toggle switch	Motor Control	Motor Assembly	1	$10.91
4	Pulley assembly	Stepper motor drivetrain	Motor Assembly	4	$61.09
5	Stepper motor bracket	Stepper motor drivetrain	Motor Assembly	1	$16.36
6	12V power supply	Motor Control	Motor Assembly	1	$21.82
7	distribution board	Motor Control	Motor Assembly	2	$18.54
8	Terminal block kit	Motor Control	Motor Assembly	1	$13.53
9	Stepper motor driver	Motor Control	Motor Assembly	1	$10.14
10	Stepper motors	Stepper motor drivetrain	Motor Assembly	1	$42.56
11	Lead screws	Stepper motor drivetrain	Control Assembly	2	$26.18
12	Snap ring kit	Stepper motor drivetrain	Motor Assembly	1	$11.84
13	pulley belts	Stepper motor drivetrain	Motor Assembly	2	$24.23
14	3D print filament	Replica Satellite	Manufacturing	2	$45.98
15	Lead Screws	Stepper motor drivetrain	Control Assembly	4	$17.40
16	Linear bearing sleeve	Stepper motor drivetrain	Control Assembly	10	$9.10
17	Hex nuts	Lead screws	Control Assembly	4	$8.84
18	Linear bearing sleeve	Drive Train	Control Assembly	10	$9.60
19	linear bearing sleeve	Drive Train	Control Assembly	10	$9.40
20	Aluminum	Lead screws Mounts	Manufacturing	3	$27.36
21	Retaining rings		Control Assembly	1	$11.02
22	retaining rings	Drive Train	Control Assembly	1	$8.71
23	Linear rods	Drive Train	Control Assembly	10	$55.30
24	Lead screw clamps	Drive Train	Control Assembly	4	$29.80
25	Aluminum		Manufacturing	1	$16.00
26	Retaining rings		Control Assembly	1	$9.50
27	Set Screws		Control Assembly	1	$9.38
28	Aluminum Plate	Base Plate	Manufacturing	1	$170.48
29	Aluminum bars	Lead screws	Manufacturing	2	$127.38
30	3D Filament	Replica Sate	Manufacturing	3	$68.97
31	3D Filament	Replica Sate	Manufacturing	2	$45.98
32	Steel stock	Weights in Replica sate	Manufacturing	2	$173.76
33	JB Weld	Replica Sate	Manufacturing	3	$43.17
34	Steel Disc	Outer bearing plate	Manufacturing	1	$54.92
35	Steel Sheet	Sate plate	Manufacturing	1	$97.24
36	Steel Rod	Brackets	Manufacturing	1	$13.00
37	Brass Stock	Vertical Weights	Manufacturing	2	$151.44
38	Aluminum C channel	Vertical Weights	Manufacturing	2	$74.20
39	Brass Stock		Manufacturing	1	$26.22
40	Aluminum plate	Replica Sate	Manufacturing	2	$19.72
41	Net	Safety system	Testing	1	$23.99
42	Aluminum	Replica air bearing	Manufacturing	1	$117.69
43	Z carriage			1	$71.44
44	Vertical Brackets			5	$79.20
45	setup			1	$81.60

Implementation Plan

- All major design decisions have been finalized meaning that there will only be slight alterations based on the performance of the current iteration.
- Manufacturing is nearing completion. The final work orders are expected to be completed in the next few weeks and the remaining purchases are expected to arrive before Hardware Review 2.
- A comprehensive Bill of Materials for all required fixtures, bolts, screws, tools, etc. has been compiled and will be purchased so that the system can be assembled upon completion/arrival of the remaining parts.
- Assembly is scheduled to start around October 15th and continue through November 4th as parts are completed.
- Assuming there are no inherent mechanical problems that would require a redesign, the next step will be to start testing and implementing the coding aspect of this project.

Implementation Plan Progress

Manufacturing Progress

Northern Arizona University

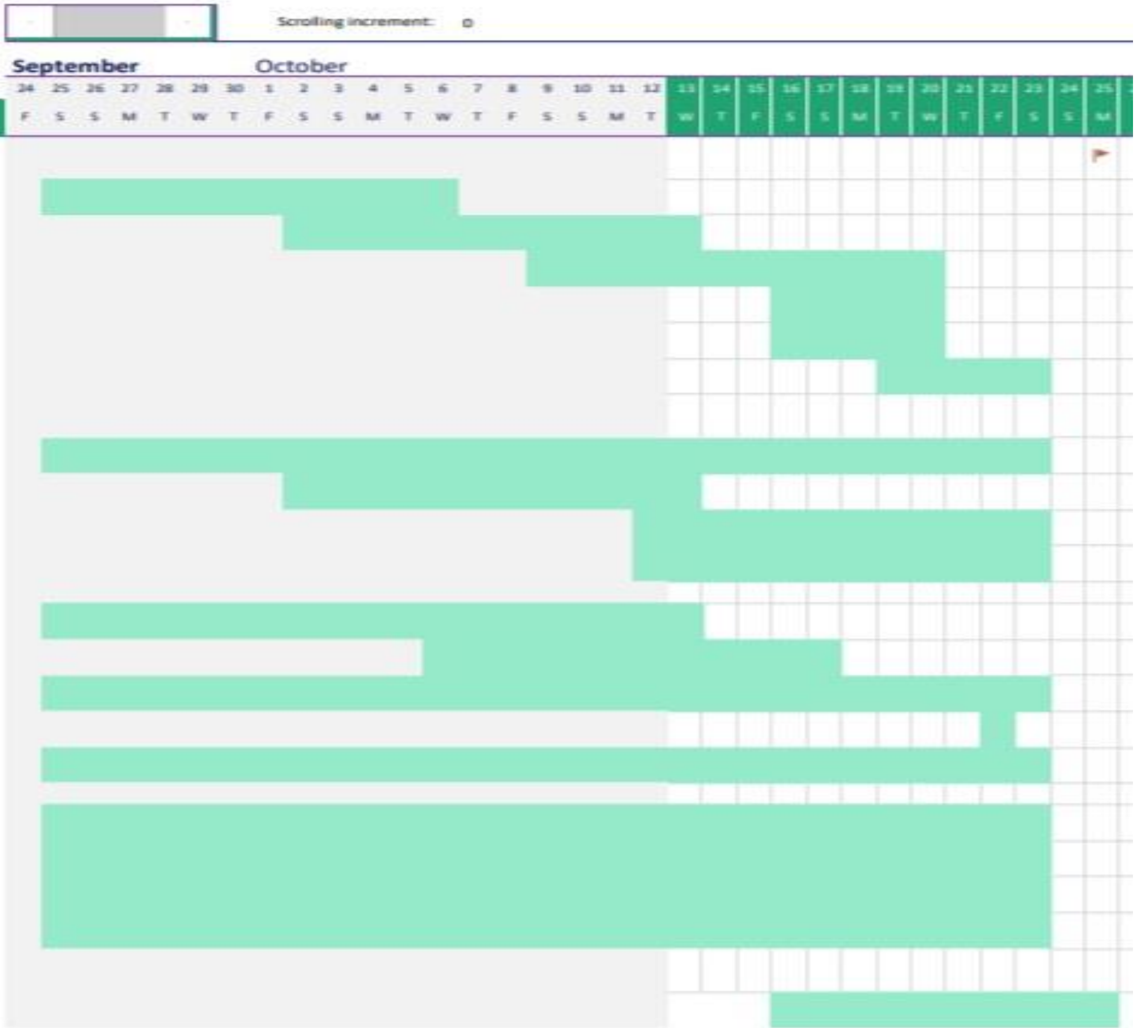
21-Spr-GA

Project start date: 9/24/2021

Milestone marker: 1

Hardware Review 2

Milestone description	Assigned to	Progress	Start	Days
Machining (smaller parts)				
Angled Plates for Outer Bearing	Travis, Scott	100%	9/24/2021	14
Satellite Brackets Lower	Travis, Scott	100%	10/1/2021	14
Satellite Brackets Upper, Side	Travis, Scott	40%	10/8/2021	14
C Channel Covers	Scott	20%	10/15/2021	7
Linear Rod Fixtures	Travis	10%	10/15/2021	7
Steel Weights	Travis	0%	10/18/2021	7
Machining (work orders)				
Inner Bearing (Hemisphere)	Machine Shop	100%	9/24/2021	31
Base Plate	Machine Shop	100%	10/1/2021	14
Satellite Plate	Machine Shop	20%	10/11/2021	14
Outer Bearing Plate	Machine Shop	20%	10/11/2021	14
3D Printing				
Replica CubeSat (12 parts)	Travis	100%	9/24/2021	21
C Channels (8 parts)	Travis	70%	10/5/2021	14
Spacers (at least 30)	Travis	40%	9/24/2021	31
Assembly	Travis	10%	10/21/2021	3
Miscellaneous	Travis	35%	9/24/2021	31
Purchasing				
Z Carraige	Connor, Sean	100%	9/24/2021	31
Y Axis Brackets	Connor, Sean	100%	9/24/2021	31
Motor Control System	Connor, Sean	100%	9/24/2021	31
Miscellaneous	Connor, Sean	90%	9/24/2021	31
Full System Integration				
Assembly	All	10%	10/15/2021	12



Implementation Plan Roles and Schedule

- Travis Harrison
  - Head of Manufacturing
  - 3D printing Specialist
  - Testing Engineer
  - CAD Engineer
- Sean McGee
  - Software Developer
  - UI Interface Developer
  - Project Manager
  - Logistics Manager
- Scott Mesoyedz
  - Manufacturing Enginee
  - Testing Engineer
  - CAD Engineer
  - Editor
- Connor Hoffman
  - Software Developer
  - Website Designer
  - Financial Manager

Remaining Deliverables

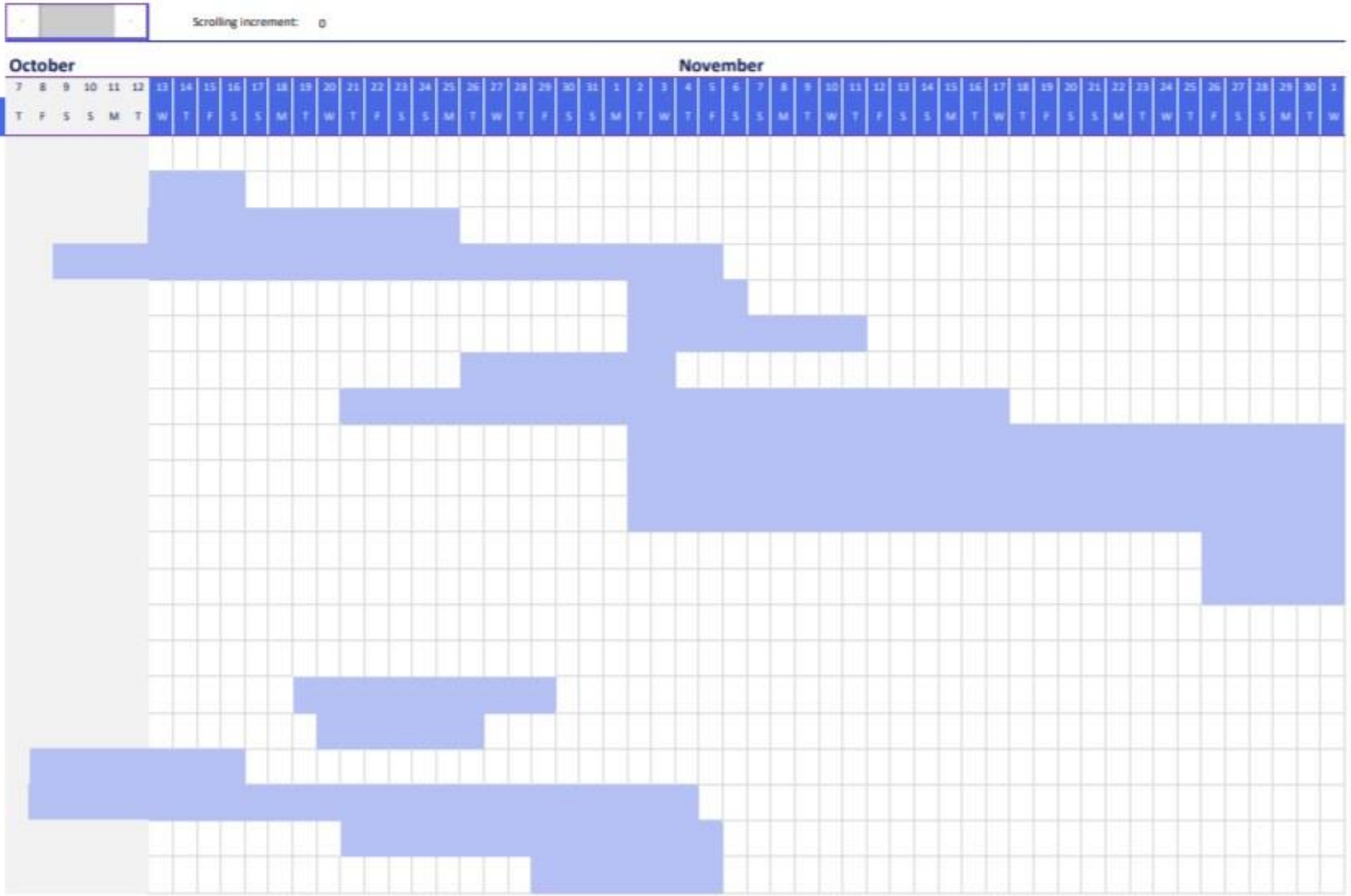
Northern Arizona University

21-Spr-GA

Project start date: 10/7/2021

Milestone marker: 1

Milestone description	Assigned to	Progress	Start	Days
Assignments				
Midpoint Presentation	All	100%	10/12/2021	6
Individual Analysis II	All	5%	10/12/2021	15
Hardware Review II*	All	50%	10/8/2021	30
UGRADS Registration	All	0%	11/1/2021	7
Draft of Poster	All	0%	11/1/2021	12
Website Check II	Connor	15%	10/25/2021	11
Final Presentation	All	15%	10/20/2021	30
Final Poster	All	0%	11/1/2021	38
Final Report	All	15%	11/1/2021	38
Final CAD, BoM	All	15%	11/1/2021	38
Operation/Assembly Manual	All	0%	11/25/2021	14
Website Check - Final	All	0%	11/25/2021	13
Client Handoff	All	0%	12/8/2021	1
Hardware Review II				
Manufacturing (Team Members)		70%	10/18/2021	13
Manufacturing (Machine Shop Staff)		80%	10/19/2021	9
3D printing		90%	10/7/2021	11
Purchasing		95%	10/7/2021	30
Assembly		10%	10/20/2021	18
Memo		5%	10/28/2021	10



Testing Plan

Three main testing procedures:

1. Functional test of fixture operation

   Equipment: Inner + outer bearing, test satellite

2. Measure fixture's mass properties

   Equipment: Inner + outer bearing, scale, IMU

3. Assess security of satellite mount

   Equipment: Force transducers, Arduino

	Engineering Requirements	Testing Procedure
1	COM location error, X (*)	1
2	COM location error, Y (*)	1
3	COM location error, Z (*)	1
4	Endures typ. wear for multiple uses (↑)	1
5	Mount fixture dims. compatible with rails (*)	1
6	CubeSat position adjustable in 3 axes (↑)	1
7	COM of assm. must be at/below bearing CR (↓)	1
8	Minimize weight of mount assembly (↓)	2
9	Reduce time needed for CubeSat install (↓)	1
10	Reduce number of tools needed for CubeSat install (↓)	1
11	Force needed to dislodge CubeSat (↑)	3
12	Range of motion of mount, rotation (↑)	1
13	Range of motion of mount, tilt (↑)	1
14	Bearing mount dims. compatible with bearing dims. (*)	1
15	Minimize mount's moment of inertia (↓)	2
16	CubeSat mount fixtures compatible w/ 3U,6U dims. (*)	1
17	Minimize time required to reposition COM (↓)	1
18	Reduce number of steps requiring operator input (↓)	1

Test #1: Functional Test

- Mount test satellite with known COM location
  - Is mounting hardware compatible? (ER#5,16)
  - Is mounting hardware easy to use? (ER#9,10)
  - Is fixture stable atop outer bearing? (ER#7)
- Perform translations needed form COM/COR colocation
  - Are translations within tolerance? (ER#1,2,3)
  - Is colocation process user-friendly? (ER#6,17,18)
- Simulate typical operation
  - Do all components operate as expected? (ER#12,13,14)
  - Do any components experience excessive wear? (ER#4)

Test #2: Mass Properties

- Identify fixture mass (ER#8)
  - Use scale to measure mass of fixture without satellite, inner bearing
- Identify principle moments of inertia (ER#15)
  - Mount inner bearing to fixture, place onto outer bearing
  - Allow fixture to come to rest
  - Invoke some known translation input
  - Measure resulting angular velocity, acceleration
  - Calculate moments of inertia, uncertainty

Test #3: Satellite Mount Security

- Determine holding force of satellite mounting hardware (ER #11)
  - Keep fixture stationary (e.g., bolted to surface)
  - Mount test satellite to fixture
  - Apply increasing force in X and Z directions, using force transducers to measure
  - Cease applying force once:
    - Satellite shifts position within mounting hardware
    - Mounting hardware fails
    - Other fixture components deform excessively or show signs of impending failure
    - Applied force exceeds required 750 N

Questions?