Hardware Review 1

21-Spr-GA

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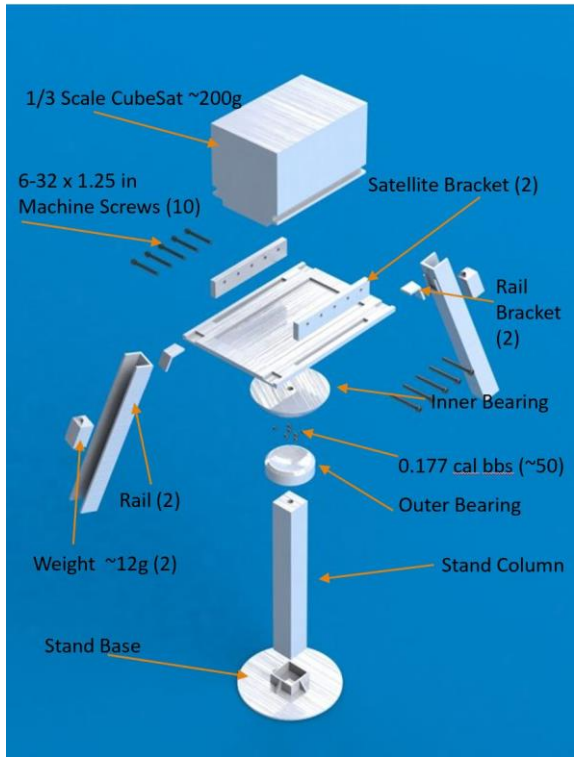


Figure 1: 1/3 Scale Model

Figure 2: X and Z Proof of Concept

Previous Iterations

Video of 1/3 scale model
https://www.youtube.com/watch?v=GiU3P0_KwF4 [1:25]

- The 1/3 scale model was unfortunately damaged in transit during a move but worked significantly better than originally expected. It has been repaired but the efficacy may have suffered.
- The x and z proof of concept was used to test the effectiveness of using the satellite itself as the weight in those directions and give us a general set of tolerances to expect for the threaded rod setup.

Purpose of this Iteration

- The purpose of this iteration is to try to solve as many of the mechanical problems of the design as possible so that electrical and software development can become the primary focus.
  - It is our hope that we can complete most of our testing on this system and get reasonable results as well as make improvements for the final mechanical design that will be completed later in the semester.

Current Progress

- Last semester
  - Designed overall mechanical assembly
  - Prototyped 2 sub-assemblies
- Currently
  - Submitted all stock orders for machining
  - Ordered electronics for motor control
  - Researching simulation techniques

Replica Satellite – 3D printed

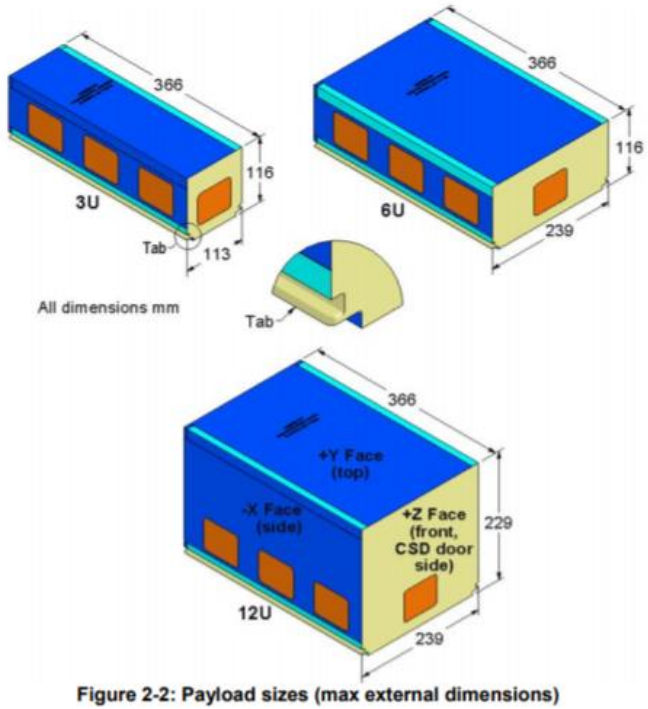


Figure 3: Sizes of Satellites [1]

- As our design should be able to test the 3U, 6U and 12U versions of the satellite, and the size of all of these would be far too large to be 3D printed as a single part, the overall size of the 12U has been broken down into 8 parts that can interface to assemble any iteration of the satellite with locations for weights to be places in order to imitate the approximate weight and center of mass of the actual satellites.
  - This is currently being 3d printed but each part takes roughly 500g of filament and over 28 hours to print so this is a slow process that has also required us to order additional filament.

Satellite Brackets - Machining

- Modular
  - Minimum and Maximum Dimensions
  - 3U 6U and 12U
- Manufacturing
  - Manufactured from aluminum in NAU machine shop
  - Potentially save money by using spare stock pieces

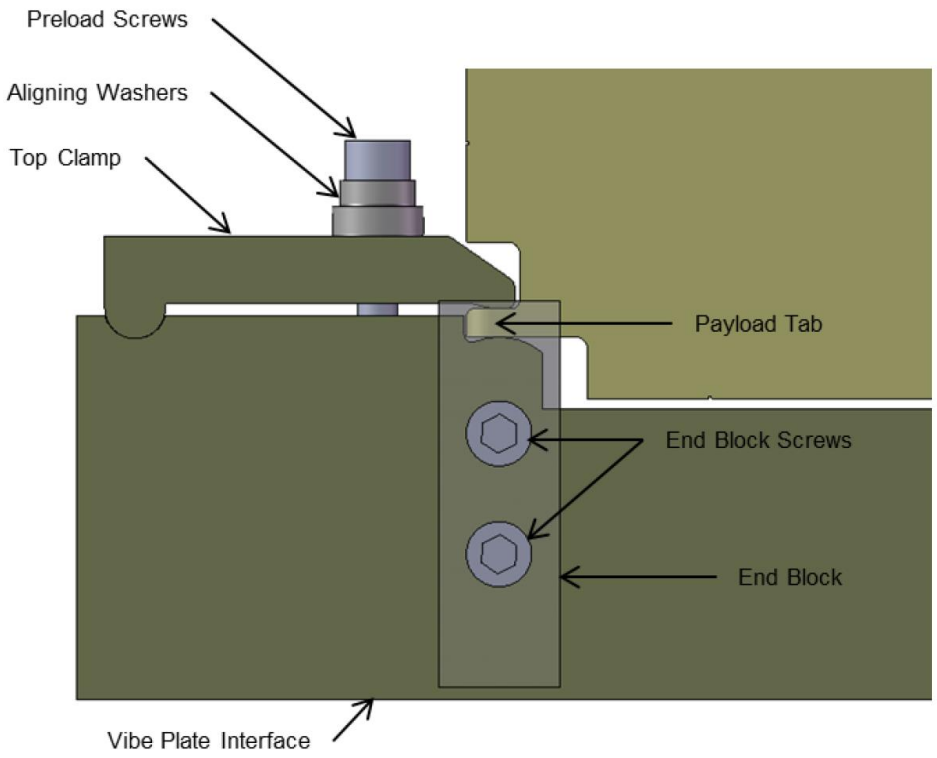


Figure 4: Mounting Bracket

Satellite Plate - Machining

- Modular
  - 3U 6U and 12U
  - 2 sets of Bracket Mount holes
- Manufacturing
  - Machined at NAU Fabrication Shop ASAP.
  - Designed to fit in 12" x 18" CNC area

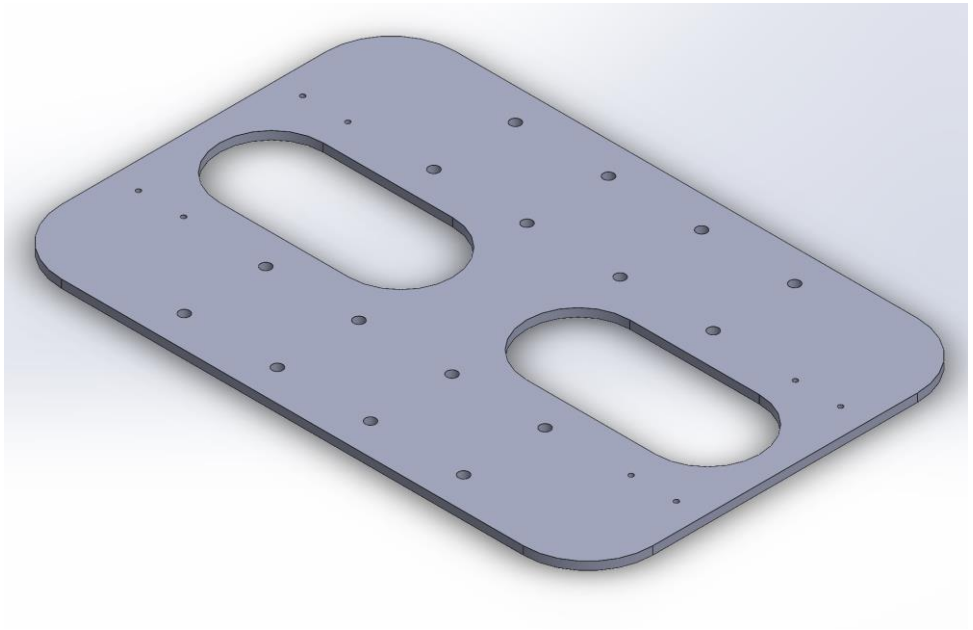


Figure 5: Satellite Mounting Plate

Base Plate - Machining

- The Aluminum plate has been ordered. When it arrives, a third party has offered to let us use their CNC mill as it is large enough to machine the entire plate.
- If that does not work, this will be done on the CNC mill at the NAU shop and will have to be indexed accurately to account for the fact that the plate is too large for the largest CNC mill available here.

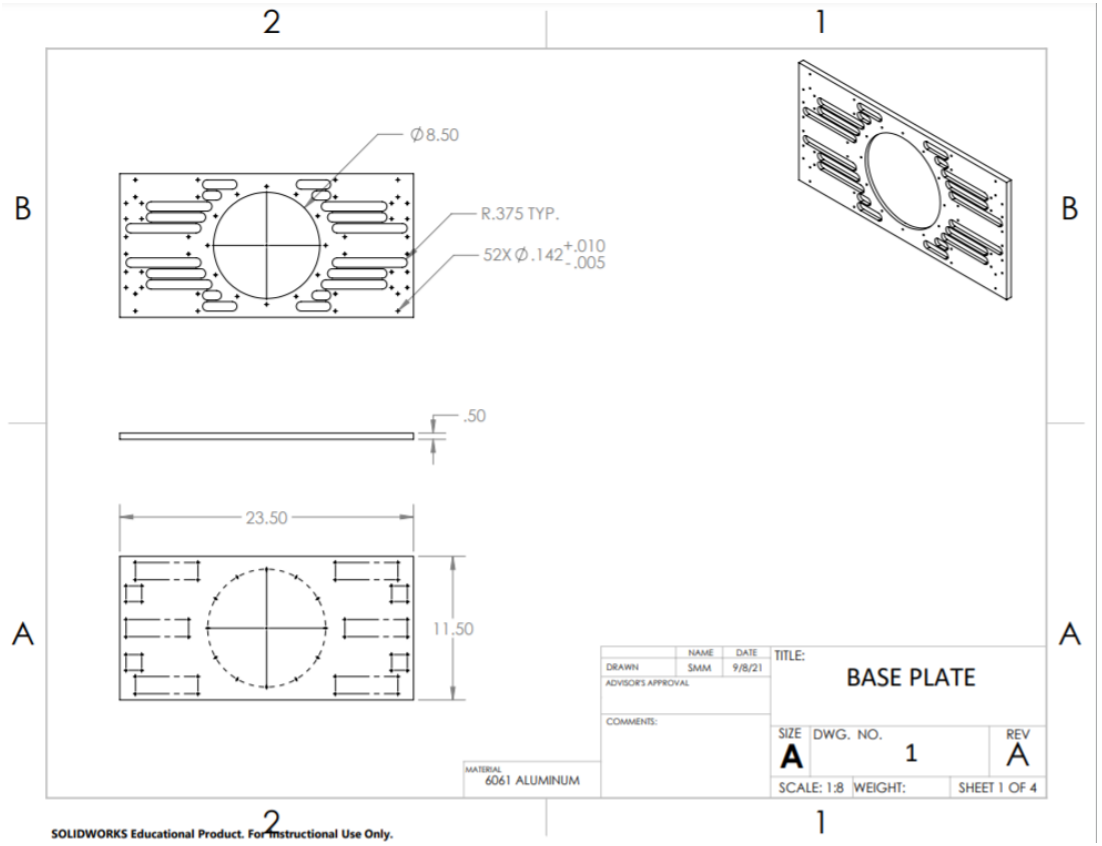


Figure 6: Base Plate Drawing

Inner Bearing - Machining

- After contacting several manufacturers in town and online, it was decided to machine this on campus at the fabrication shop to save on cost for labor. To achieve a reasonable surface finish, the part will have to be machined on a CNC mill with no greater than 0.010" stepovers so the machining process will take upwards of 6 hours if only the outside is machined precisely.
- We have been in contact with Perry Wood to bring this in and have the machining completed and this will be completed shortly after the stock is delivered.

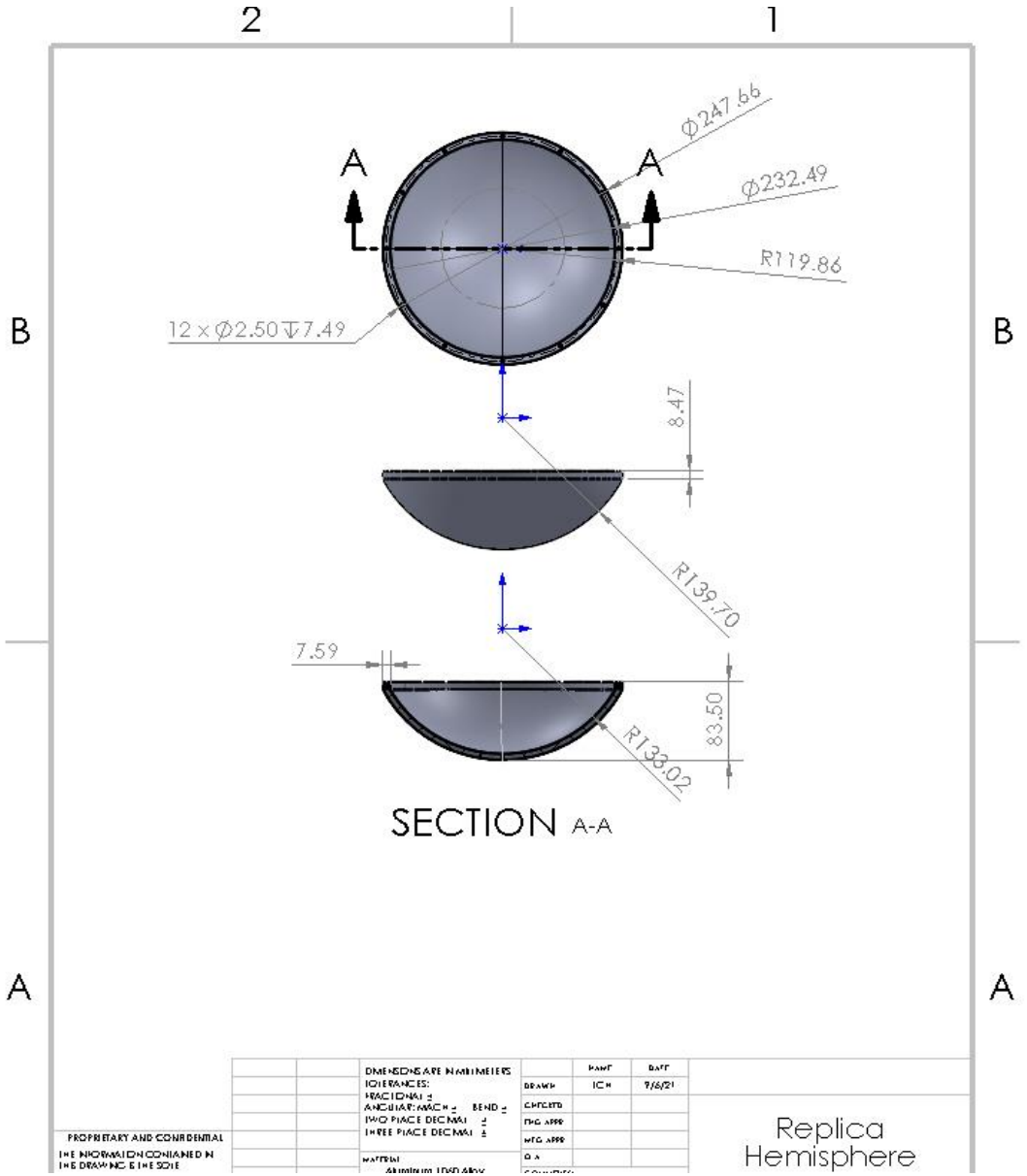


Figure 7: Inner Bearing Drawing

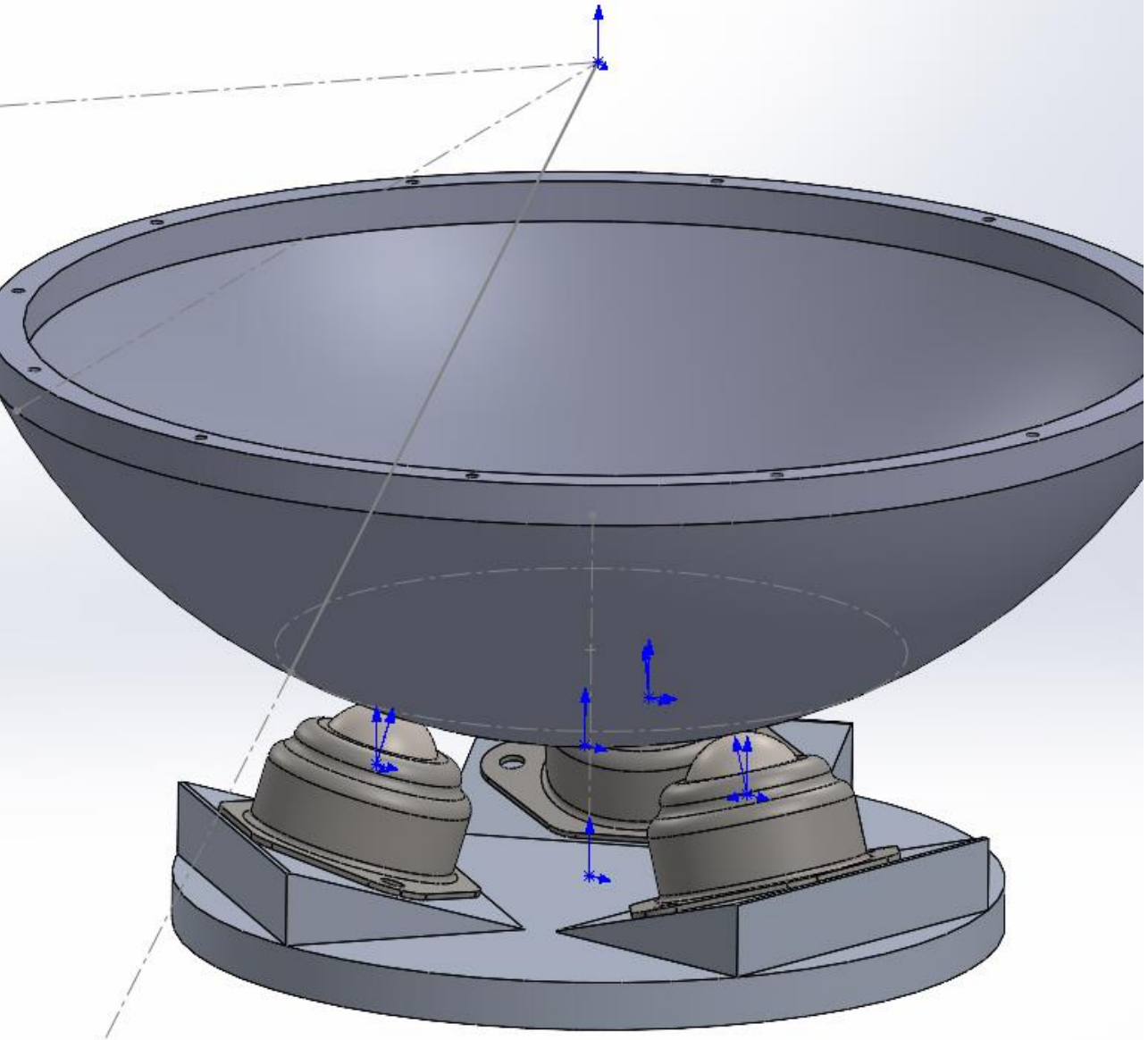


Figure 8: Full Bearing Assembly

Outer Bearing - Machining

- The outer bearing is designed to be made with excess stock that will be left over from the inner bearing and some small aluminum parts that will be welded or bolted to the plate, made from excess stock at the machine shop.
- Transfer roller bearings will be mounted to this to allow full rotation in all required directions and overcome any slight imperfections from the machining process of the inner bearing.

Stand – Purchasing

- The stand that the outer bearing would be placed on is going to be made from an old table that will have the top removed from it, and if necessary, will be machined down so that it can be bolted to the outer bearing.
- As the outer bearing size may change slightly depending on how much excess stock is left over from machining the inner bearing, this is scheduled to be purchased and assembled as soon as the bearings are completed.

Y Axis Weights - Machining

- Previous design was tall and narrow, limiting how low COM could be positioned
- Revised design uses flatter, wider geometry to lower COM position while reducing mass, cost
- Press-fit bronze lead screw nut permits inexpensive replacement after wear becomes excessive

Material	Density (g/cc)	Cost
Tungsten	19.3	$100–300/kg
Lead	11.3	$10–30/kg
Brass	8.5	$20–40/kg
Steel	7.8	$10–30/kg
Zinc	7.1	$20–40/kg
Concrete	2.5	<$1.00/kg

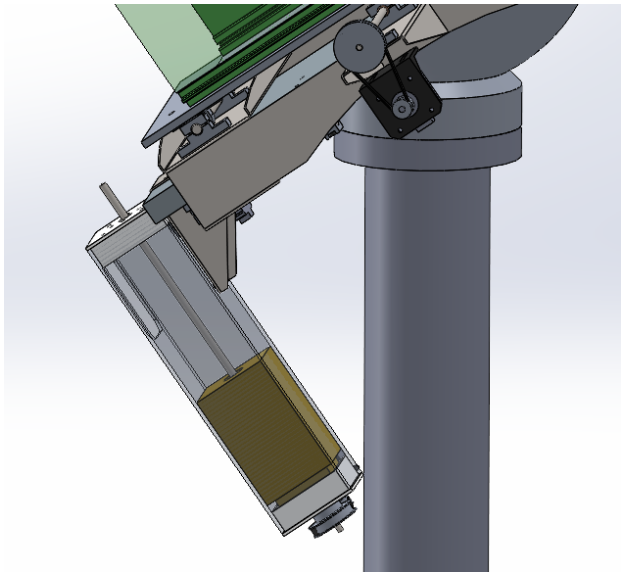


Figure 9: Previous design's lowest position, at maximum 35° tilt

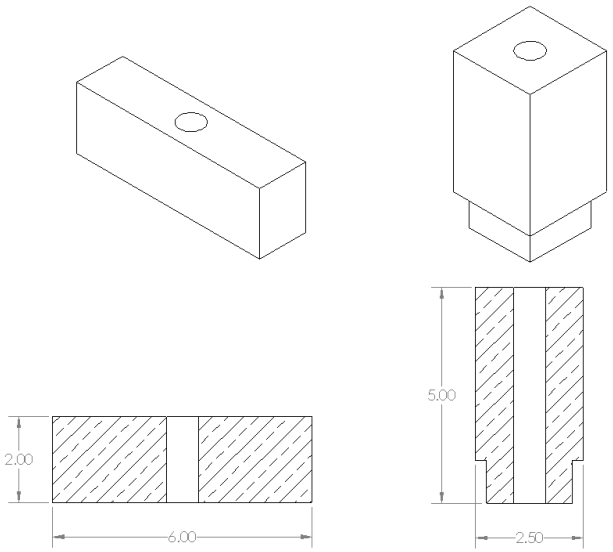


Figure 10: New design (left) compared to old design (right)

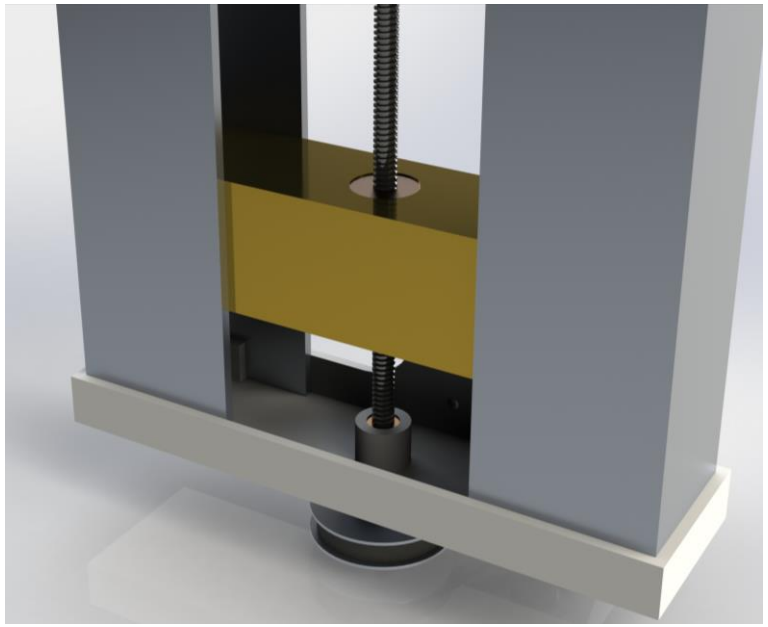


Figure 11: New design in rail subassembly

Y Axis Brackets - Purchasing

- 16-gauge CR steel sheet
- Revised design for manufacturability
  - OSH Cut [2]—extremely valuable free resource for bending!

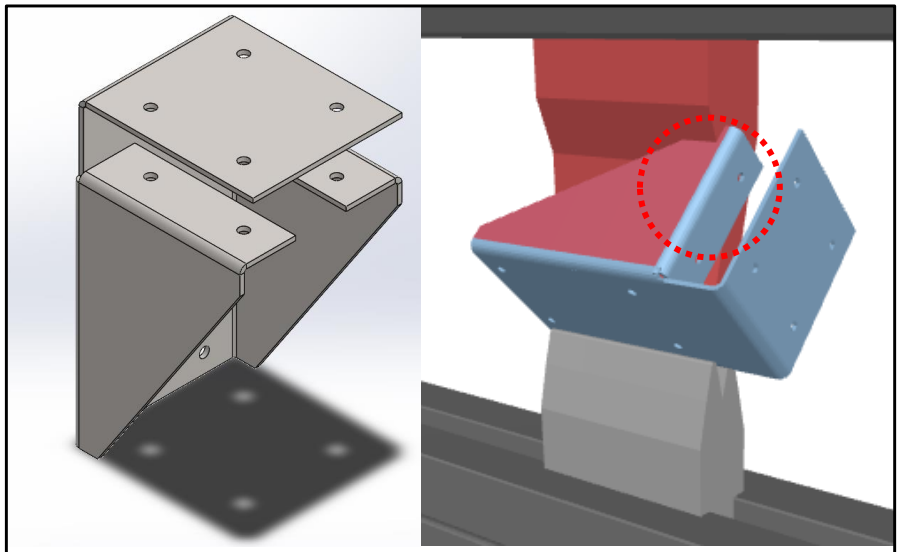


Figure 12: Original part interferes with brake

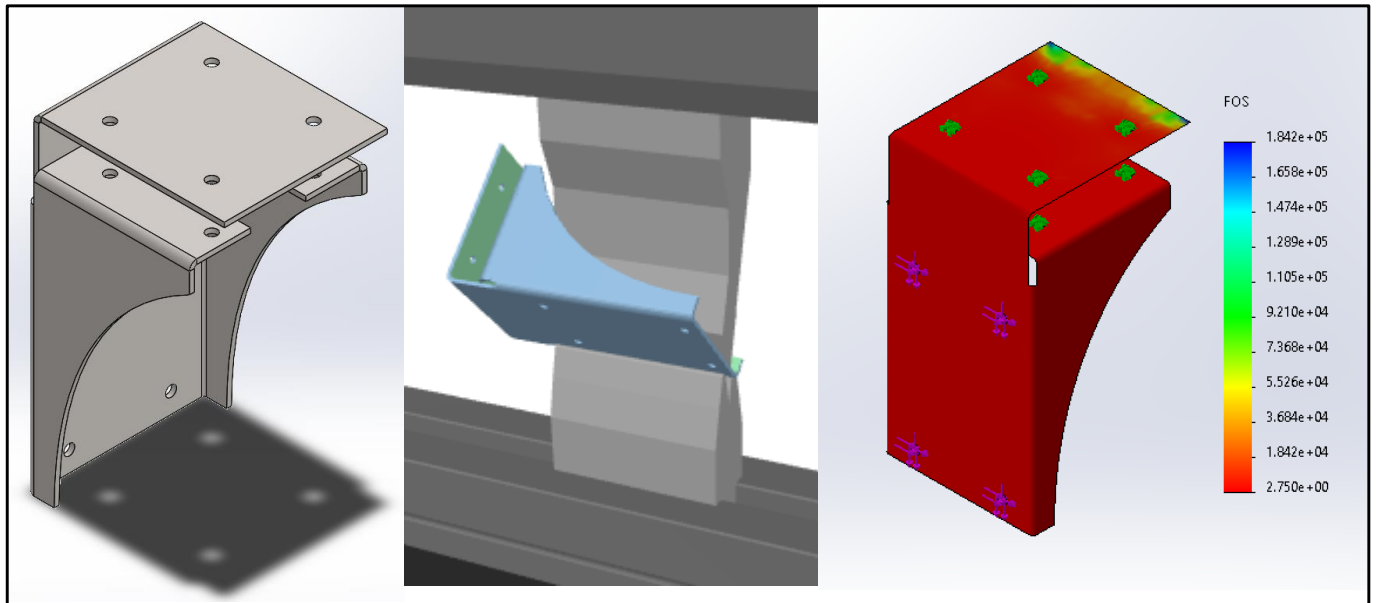


Figure 13: Redesigned part avoids brake, still provides minimum FOS of 2.75 under maximum expected 100N static load

Z Axis Carriage - Purchasing

- 16-gauge CR steel sheet
- Redesigned for manufacturability, cost
  - Still requires some manual bending

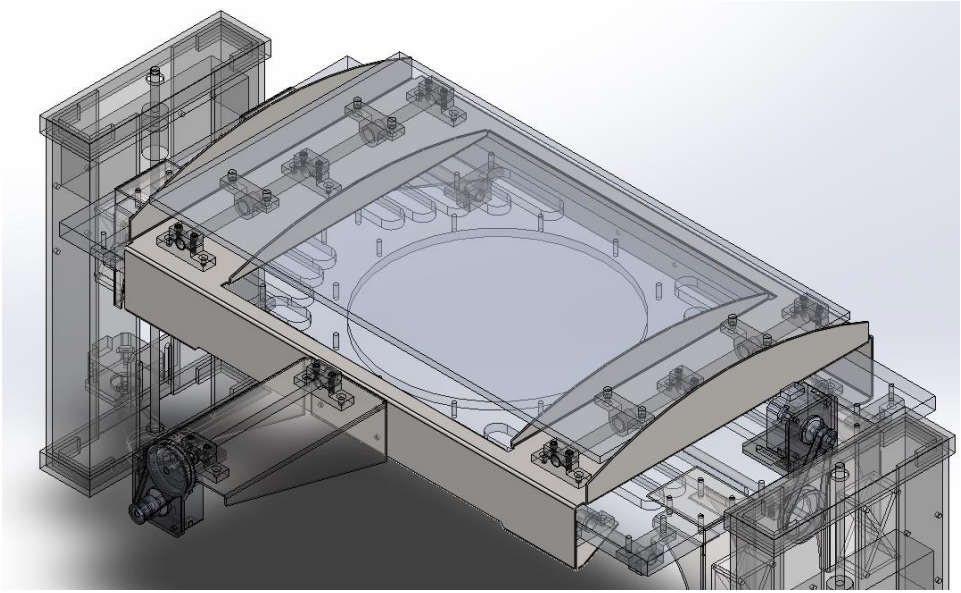


Figure 16: Part in context of assembly

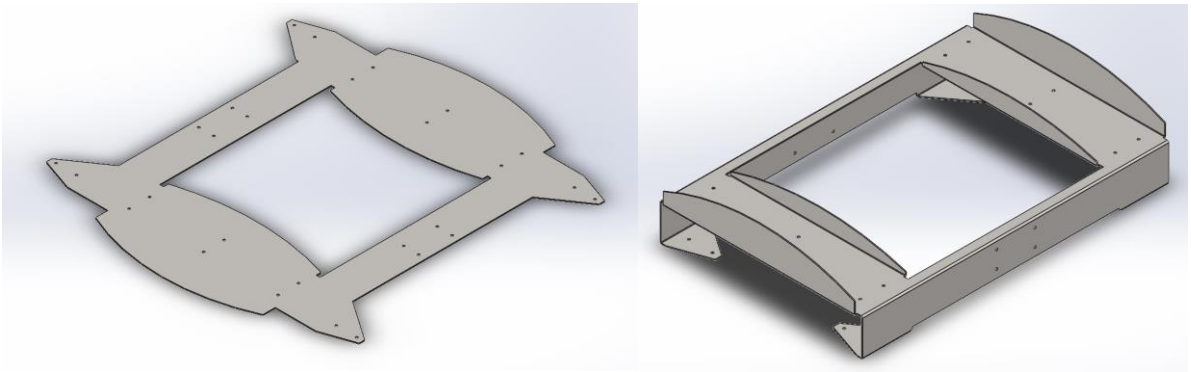


Figure 14: Before and after bending operations

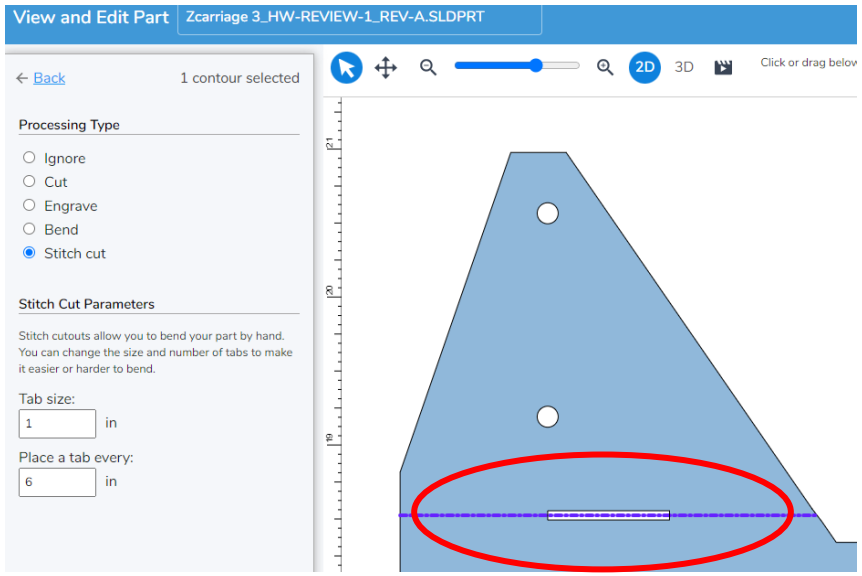


Figure 15: Replacing bends with stitch cuts where manual bending is required

Motor Control System - Purchasing

- 4x NEMA 17 bipolar stepper motors
  - Do not meet magnetic flux requirements—this will be addressed in Hardware Review #2
- 4x NEMA 17 motor brackets
- 4x A4988 stepper motor drivers
- 1x Arduino Mega
- 1x 12V power supply

- Simulation results support design goals

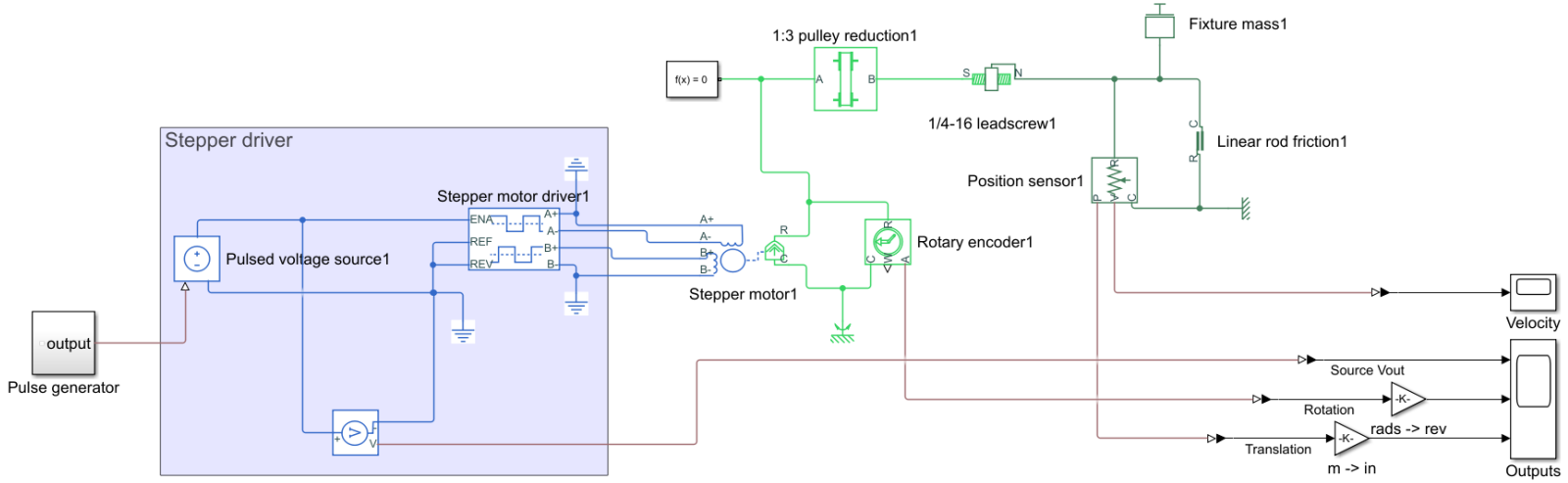


Figure 17: Simulink model of motor control system

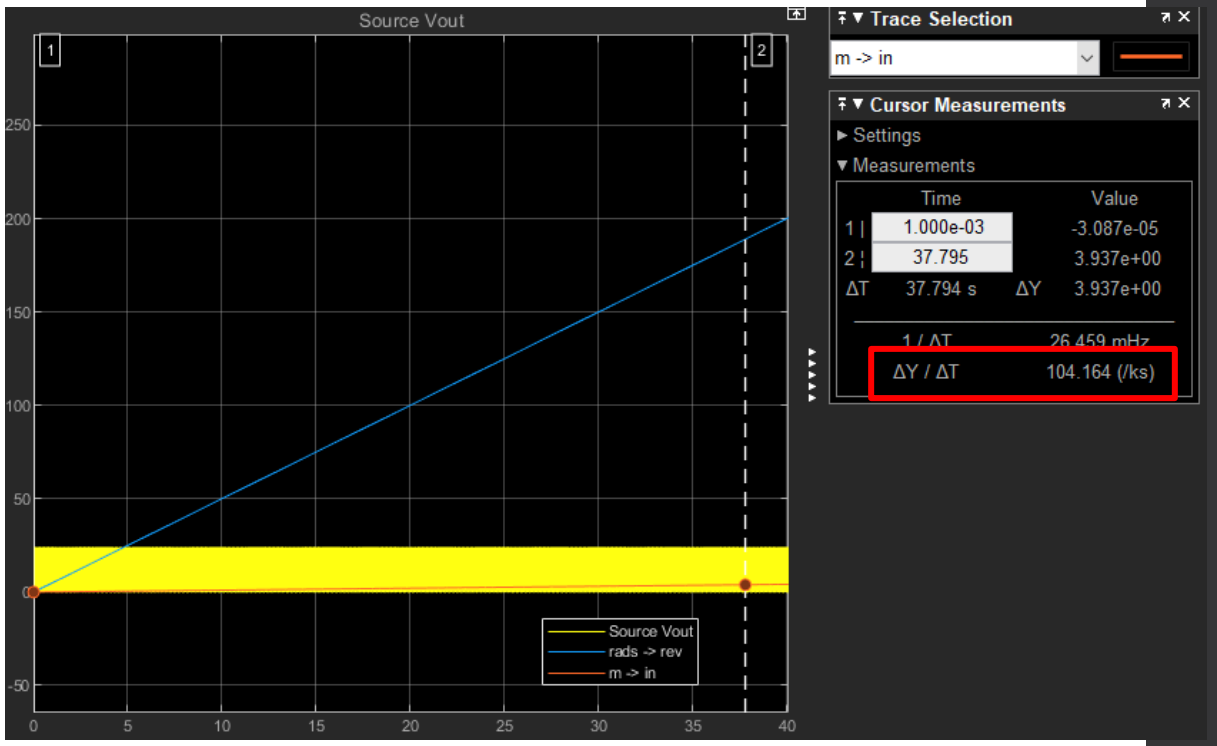


Figure 18: Simulation results, achieving maximum required 10cm displacement in about 40 sec.

Updated CAD Model

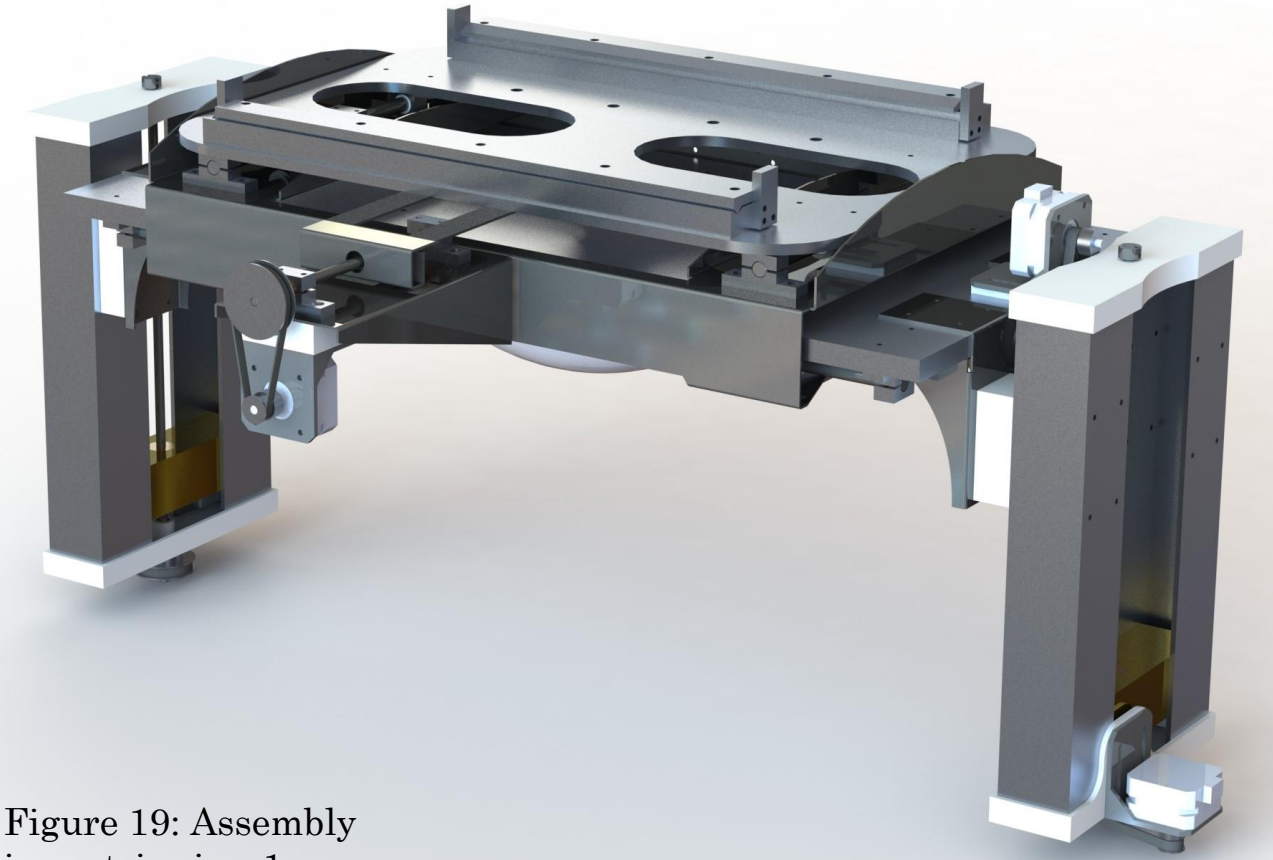


Figure 19: Assembly isometric view 1

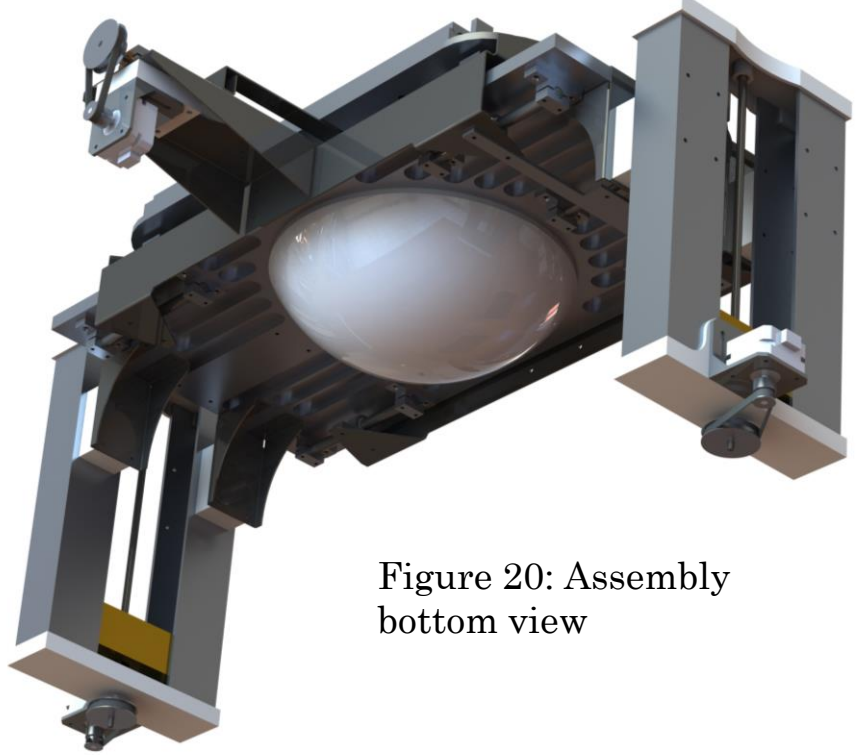


Figure 20: Assembly bottom view

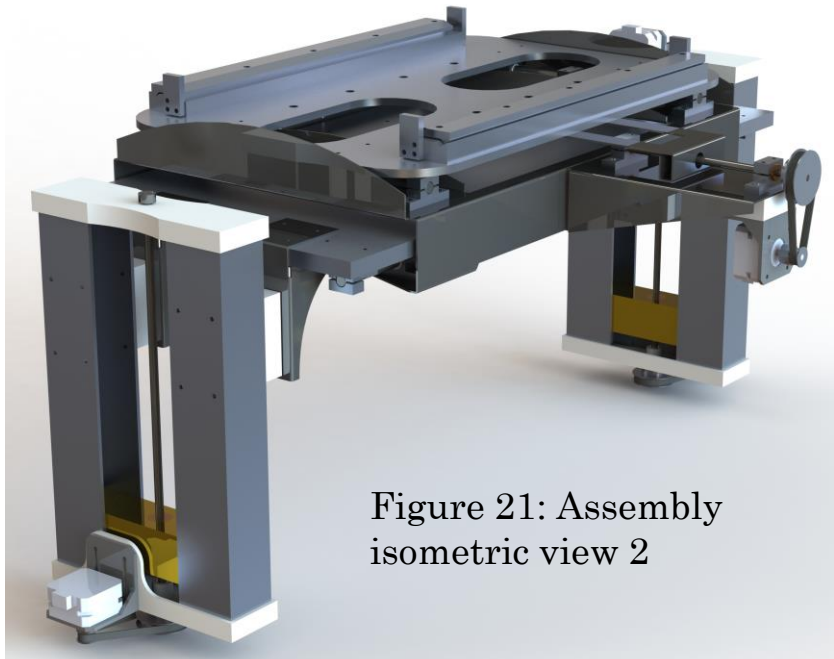


Figure 21: Assembly isometric view 2

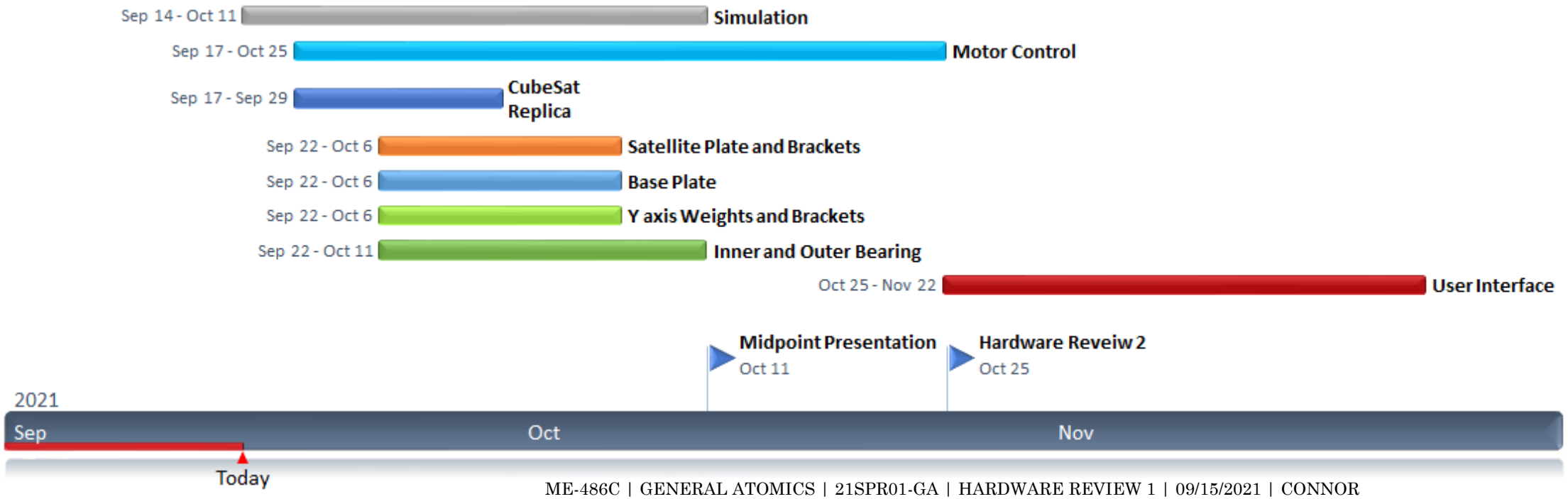
Current Status of All Parts, Purchases

Part	Qty	Vendor	Status	ETA
Satellite	1	N/A	Currently mfg.	9/29
Satellite Brackets	4	McMaster-Carr	Ordered	10/6
Satellite Plate	1	McMaster-Carr	Ordered	10/6
Base Plate	1	McMaster-Carr	Ordered	10/6
Inner Bearing	1	USA Metal Online	Ordered	10/11
Outer Bearing	1	USA Metal Online	Ordered	10/11
Stand	1	N/A	Currently mfg.	9/29
Y Weights	2	McMaster-Carr	Ordered	10/6
Y Brackets	4	OSH Cut	Ordering	10/6
Z Carriage	1	OSH Cut	Ordering	9/24
Motor Control System	-	Amazon	Ordered	9/19

Conclusion, Future Progress

- With functional mechanical design, work may begin on:
  - Magnetic field elimination/mitigation
  - Motor Control/COM measurement system
  - UI for ease of device usage

- About $7,000 of $8,000 budget remaining



References

- [1] Planetary Systems Corporations, "PAYLOAD SPECIFICATION FOR 3U, 6U AND 12U," 2018.
- [2] OSH Cut, “On Demand Metal Fabrication | OSH Cut,” 2021. https://oshcut.com/ (accessed Sep. 06, 2021).