CANYON ONE

APE - ADS PROPOSAL

MTOC-4:
Arthur Dacunha, Scott Simmons, Aiden Causey, Jeff Demitrio, Paul Navarrette, Paul Czerniak, Drew Long, Andres Castrillon, Ashkar Victor

AGENDA

- Business Foundation
- Preliminary Design
- Final Design and Evaluation

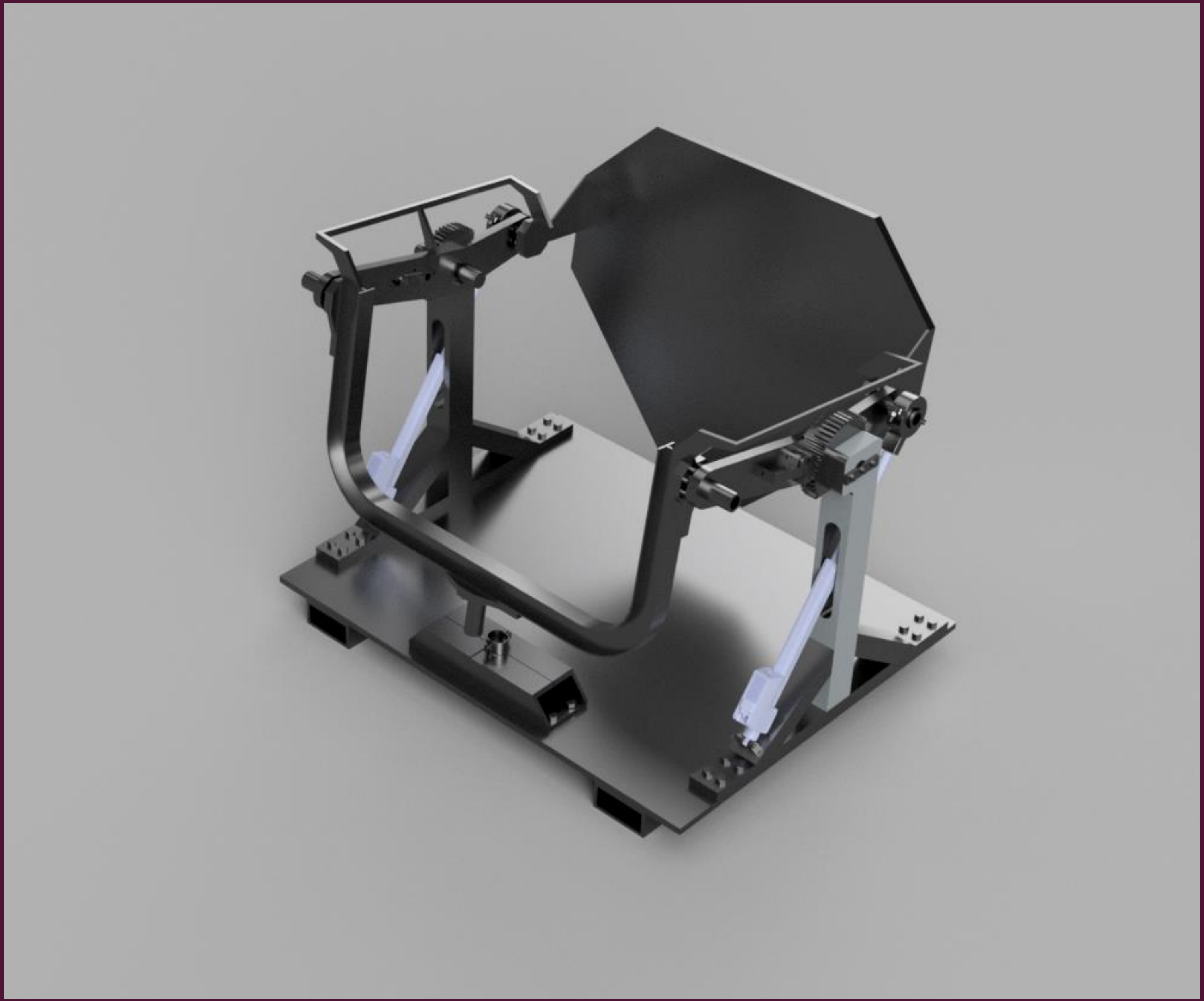
ASTRO RESTORATION PROJECT

TELESCOPES

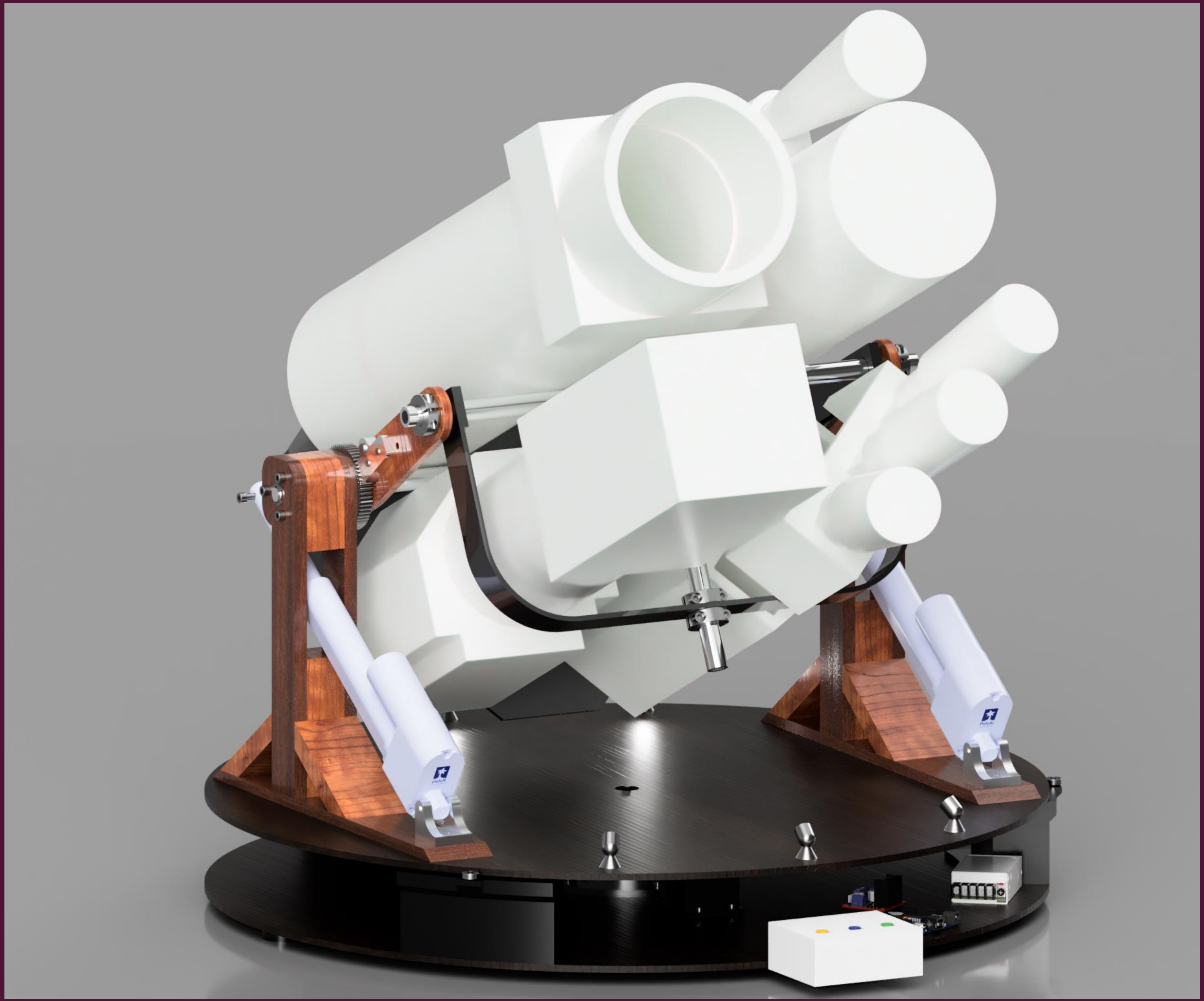
- 1 - THE HOPKINS ULTRAVIOLET TELESCOPE (HUT)
- 2 - THE WISCONSIN ULTRAVIOLET PHOTO POLARIMETER EXPERIMENT (WUPPE)
- 3 - ULTRAVIOLET IMAGING TELESCOPE (UIT)
- 4 - THE BROAD BAND X-RAY TELESCOPE

MISSIONS
Astro 1 - Space Shuttle Columbia as part of STS-35
December 2, 1990
Astro-2 Space Shuttle Endeavour as part of STS-67
March 2, 1995,

FULL-SCALE PRODUCT RENDERING



1:5-SCALE PRODUCT RENDERING



BUSINESS FOUNDATION

HEDGEHOG CONCEPT

Passion: Generating a safe and durable display that is minimalistic, not over-engineering, and places emphasis on the payload allowing the display to be non-bulky and elegant.

Expertise: Our team has knowledge and experience in mechanical design, including CAD, mechanics of materials, motor selection and programing which allows our team to work with customers to develop mechanical display stands that exceed expectations and deliver quality results.

Economic Sustainability: By minimizing costs, our team can develop display stand structures under budget while accumulating profit for company longevity as well as delivering a product that can meet or exceeds our client's expectations as well as build trust in our relationships and future projects.

"TO DESIGN SAFE, DURABLE, MINIMALIST DISPLAY STANDS, FOR IMPASSIONED MECHANICAL INNOVATION WHILE MINIMIZING EXHIBIT COST."

- CANYON ONE -

BRAND AND IP PROTECTION

- LLC Business Structure
- NDA Protection
- Register Copyrights, Trademarks, and Patents
- Administer Security Measures

CANYON ONE™

INSPIRING NARRATIVES
ENGINEERING EXPERIENCES™

KEY PRODUCT SPECIFICATIONS (FULL SCALE)

- The ADS must be black in color.
- **The ADS must allow full rotation from horizontal to vertical.**
- **The minimum factor of safety (FoS) for all components must be 3.0.**
- **Payload rotation must be able to maintain static angles of 15/30/45 degrees from horizontal. As well as maintain a vertical position (90 degrees from horizontal).**
- **All specified tilt positions must be able to be secured independent of the tilting mechanism.**
- Materials which minimally obstruct the view of the Astro payload shall be used.
- All parts of the ADS should be able to be transported using standard shop equipment (e.g. forklift).
- The full-scale width of the ADS shall not exceed 124 inches, nor shall the height exceed 225 inches.

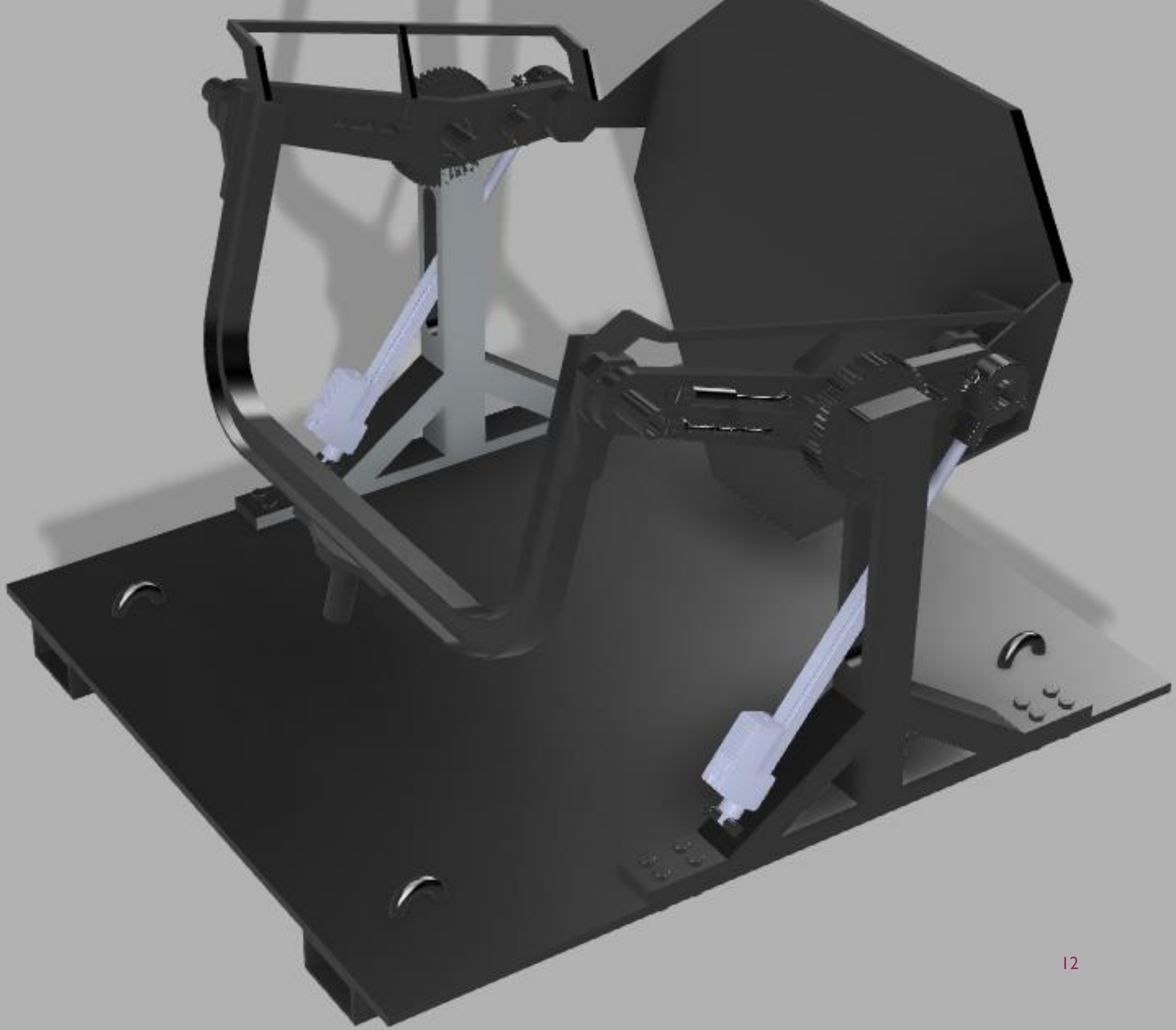
KEY PRODUCT SPECIFICATIONS (1:5 SCALE)

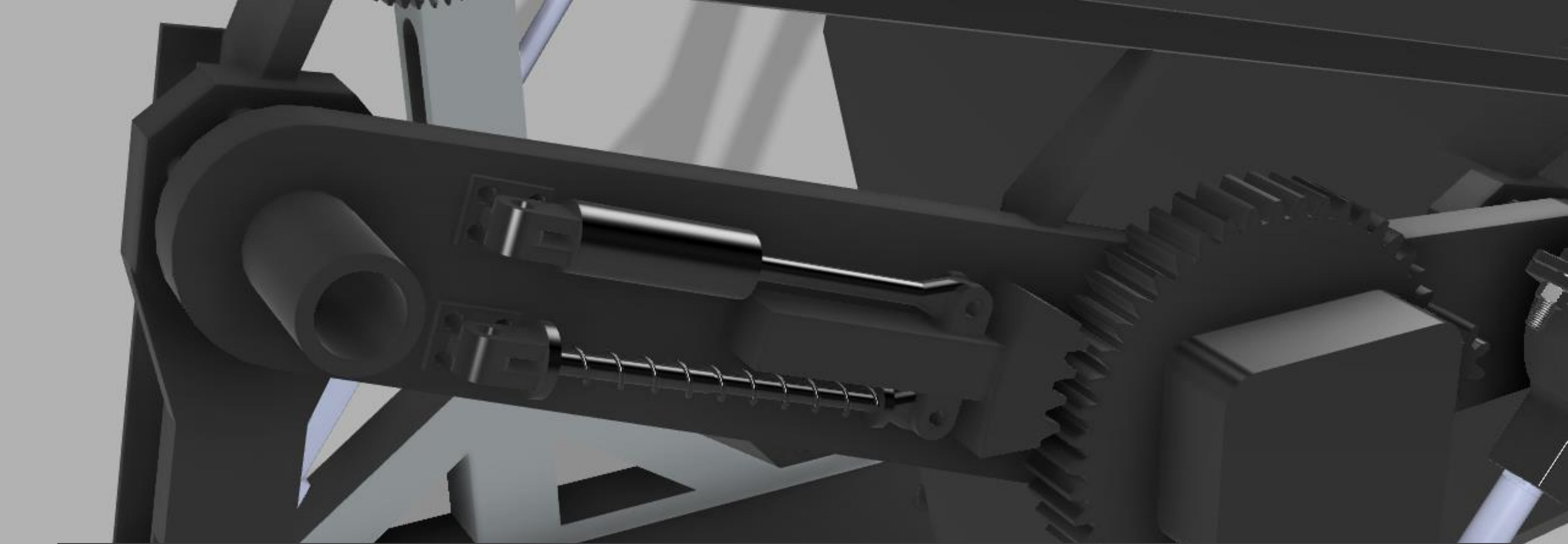
- A scaled Astro payload, ADS, and turntable shall be built at 1:5 scale.
- All interactive components must be accessible to those at and above the age of five years old.
- The scaled turntable must be able to rotate 360-degrees.
- The scaled ADS must be able to support and tilt the Astro payload independent of the turntable.
- The scaled payload must be of high fidelity to stay true to the original hardware.
- The scaled payload must be visually appealing.

INITIAL DESIGN

ADS CONCEPT

- Concept from group 7
  - Linear Actuators
  - Independent of C.G.
- Added Mechanisms
  - Automatic Locking Mechanism
  - Rotational Damper



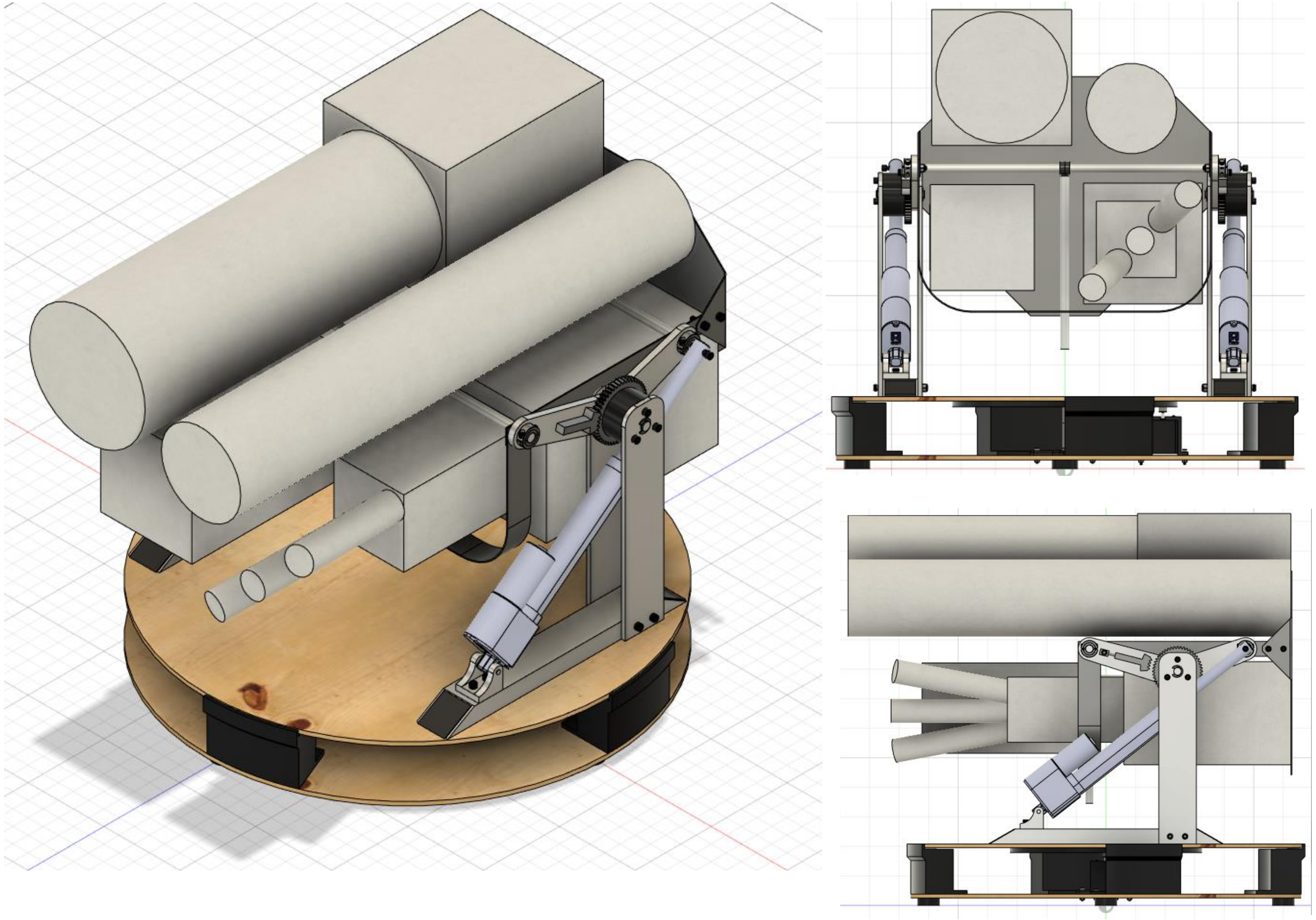


LOCKING MECHANISM FUNCTIONALITY

- “Normally Closed” position with spring system failsafe
- No direct operation required
- Unlocked by pneumatic cylinder
- Minimizes view obstruction of the Payload

PROTOTYPE MODEL

- **1:5 scale**
- Includes:
  - Payload
    - Made of foam and sheet metal.
  - ADS
    - Rotation actuated by linear actuators.
    - Automatic locking system (gear mesh).
  - Turntable



PRELIMINARY CAD

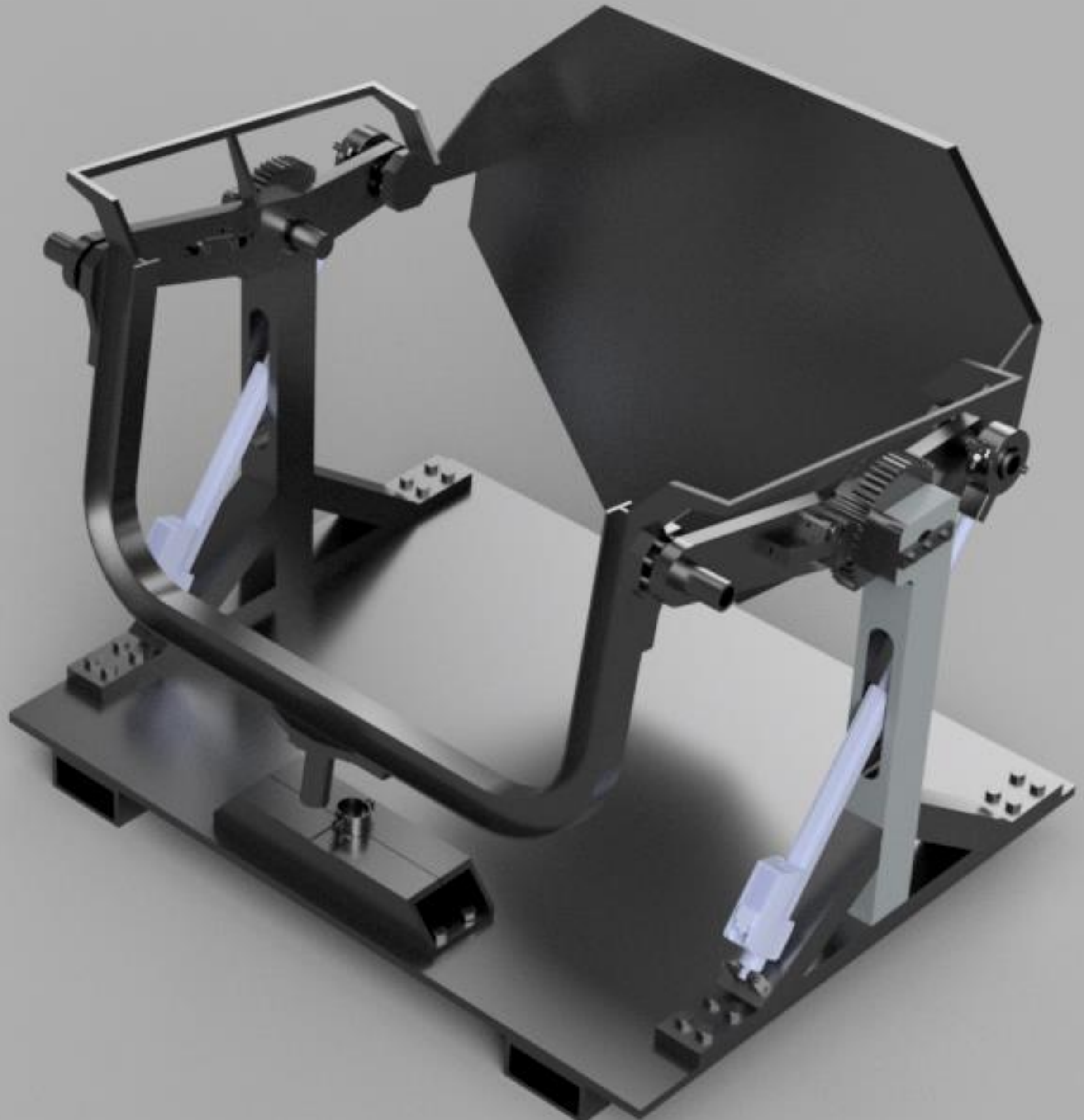
TURNTABLE

- Designed to Permit yaw motion.
- The display base is supported by four perimeter pieces.
- Lubricated steel bearing balls in each support leg.
- Center rod/shaft for middle support – connected to bearings for rotation.
- One motor driving an internal gear.

FINAL DESIGN

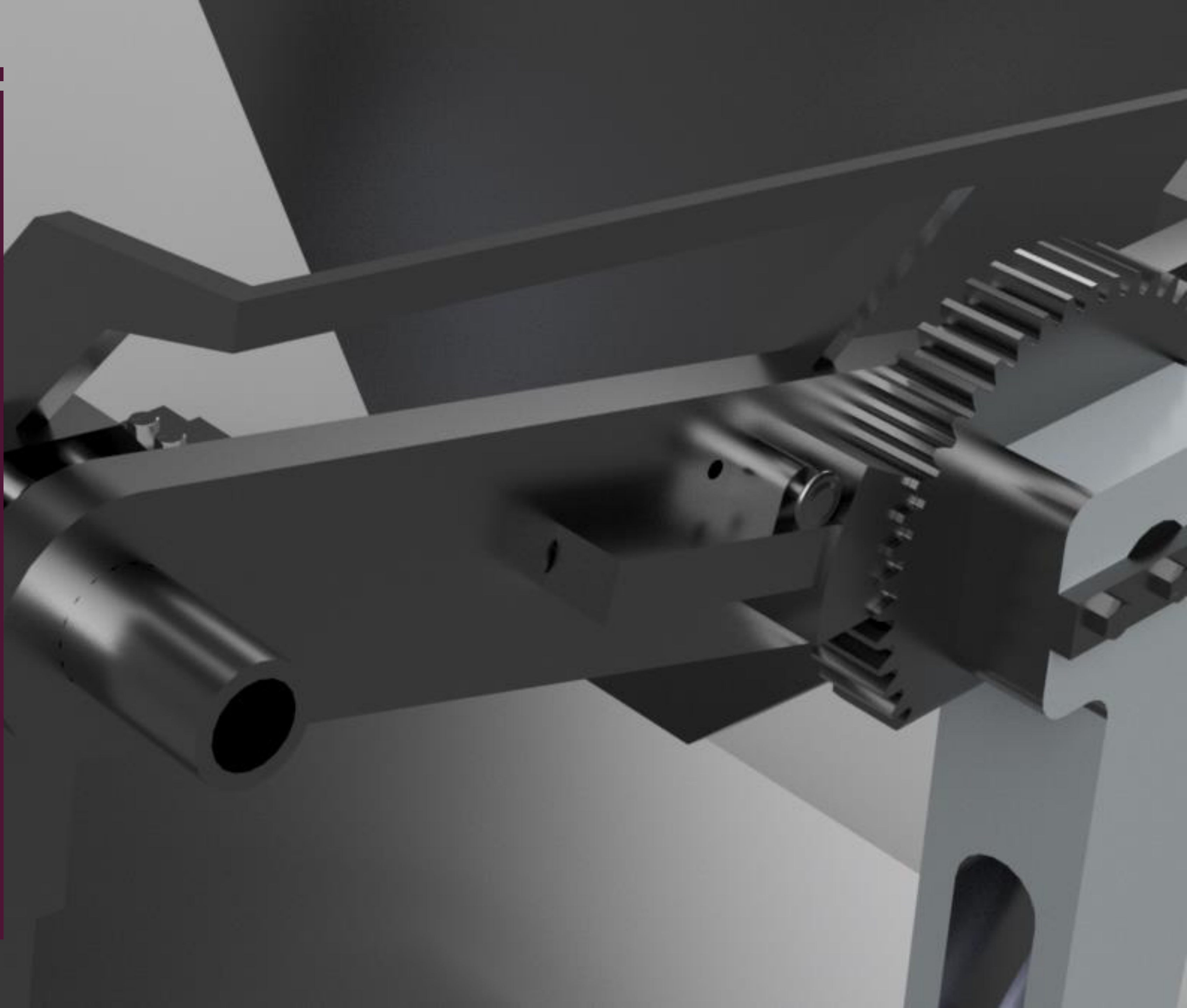
APE ONE CONCEPT

- Full-Scale Design Changes
  - Manual Locking Mechanism
  - Eliminated Rotational Damper



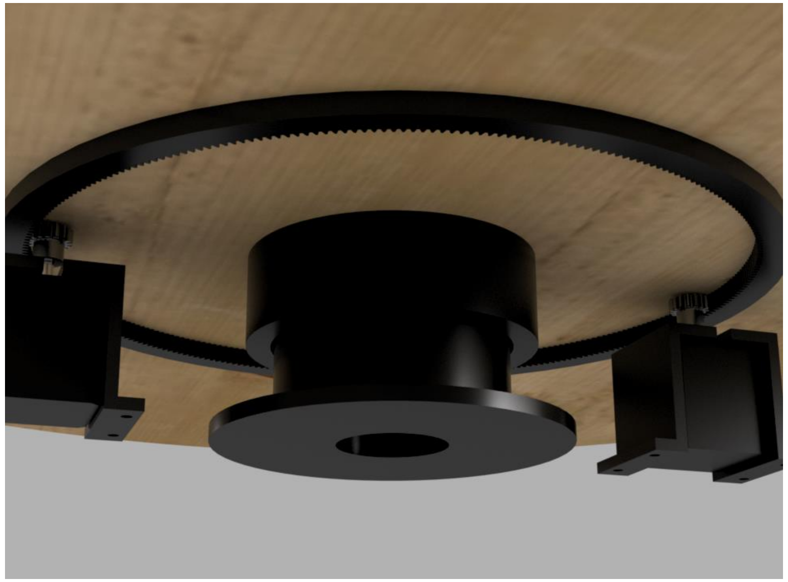
LOCKING MECHANISM (FULL-SCALE)

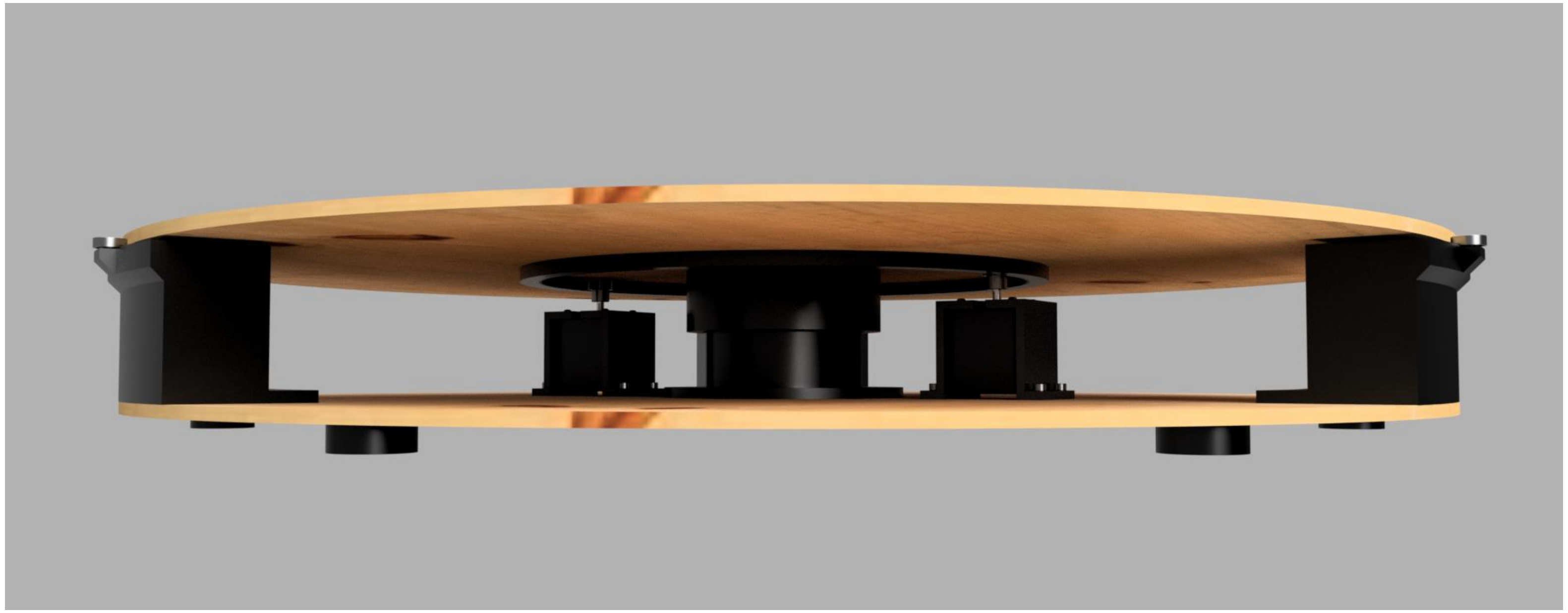
- The pneumatic actuator and the spring were removed.
- Pin held in locked position with a spring.
- Allows the locking mechanism to be manually actuated.



ADS MODEL CHANGES (1:5)

- ADS support columns and trunnion beam made entirely of wood.
- Payload model reworked to be more accurate and aesthetic.
- Spotlights added to illuminate model.
- Manual locking system (locking fork).



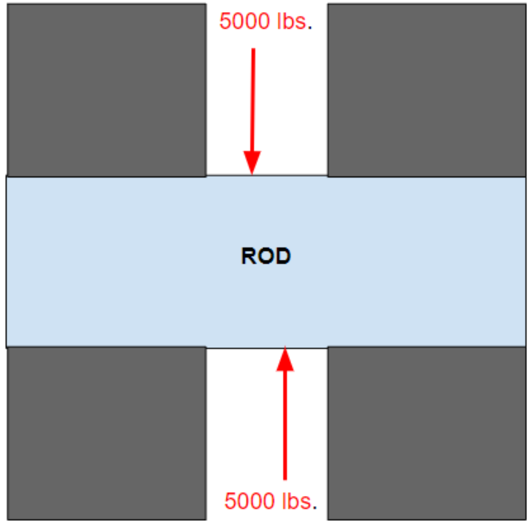


TURNTABLE (1:5)

- Designed to permit yaw motion.
- Two motors for double power output.
- Three supports on its perimeter.
- Center mount replaced center rod for slip ring (wiring).
- Bearings along wood perimeter to reduce friction.
- Center mount has a collar to minimize translation.

CENTER ROD CALCULATION

- Full-scale model calculation.
- Shear force used to calculate shear strain.
  - Worst-case scenario (half of payload weight) force was used.
- Rod in design is 3.35 in. diameter.
- Material is A36 Steel with a yield shear strength of ~125 MPa.
- F.O.S > 3

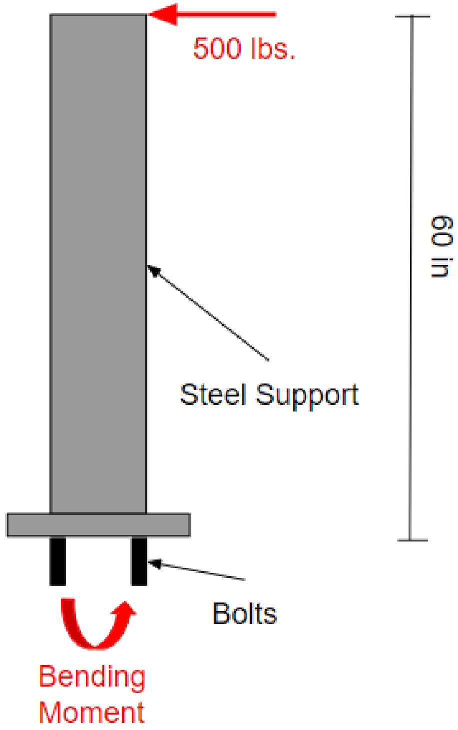


$$\sigma = \frac{F}{A}$$

$$\sigma = \frac{22241.1}{\pi \times 0.0425^2} = 3.92\ MPa$$

SIDE FORCE CALCULATION

- Full-scale model calculation.
- Side force of 500 lbs. applied to support beam.
  - Moment generated at bottom of support (along 16 bolts).
- Selected bolts are Grade 5 Steel bolts, with a flexural strength of ~724 MPa.
- Force applied to top of beam for worst-case scenario (maximum moment).
- F.O.S > 3



$$M = FL$$

$$I = \frac{1}{4}\pi r^4$$

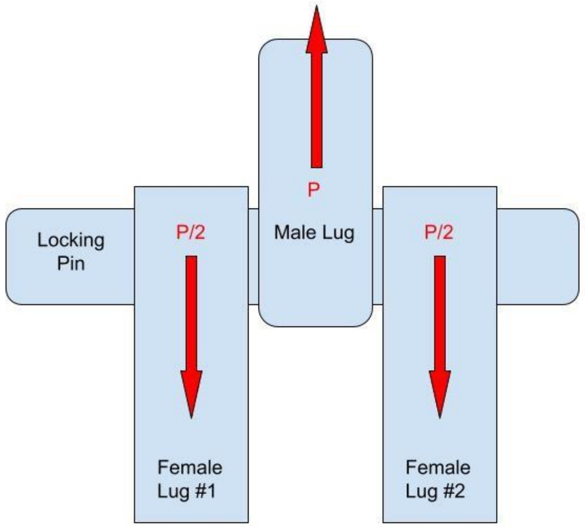
$$c = r$$

$$\sigma = \frac{Mc}{16 \times I}$$

$$\sigma = \frac{(30000)(0.6125)}{16 \times 0.1105} = 10{,}393\ psi = 71.7\ MPa$$

LINEAR ACTUATOR LOCKING PIN CALCULATION

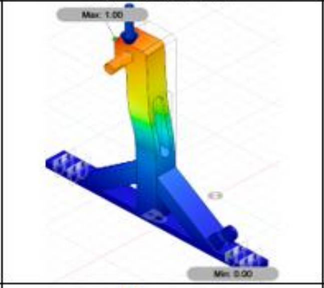
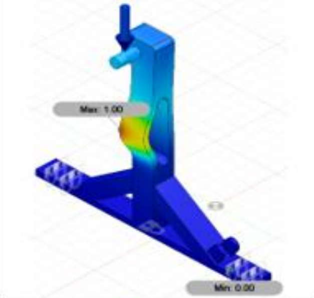
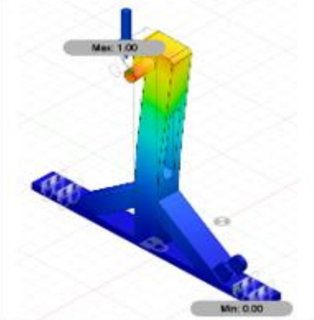
- Full-scale model calculation.
- Shear force used to calculate shear strain.
  - Load shared equally on the two female lugs
- Rod in design is 0.82 in. diameter.
- Material is A36 Steel with a yield shear strength of ~125 MPa.
- F.O.S > 3.



$$\sigma = \frac{5000/2}{\pi \times 0.82^2} = 1183.48\frac{lbs}{in^2} = 8.16\ MPa$$

STEEL SUPPORT BUCKLING FEA

- Full-scale model calculation.
- Complex geometry of support column (center slot) required use of FEA.
- Vertical force (half of payload weight) applied to beam.
- F.O.S >3 for all cases.

Buckling Mode	Model Behavior	Buckling Force > 5,000 Lbs.
1		Yes
2		Yes
3		Yes

HERTZIAN CONTACT STRESS CALCULATIONS

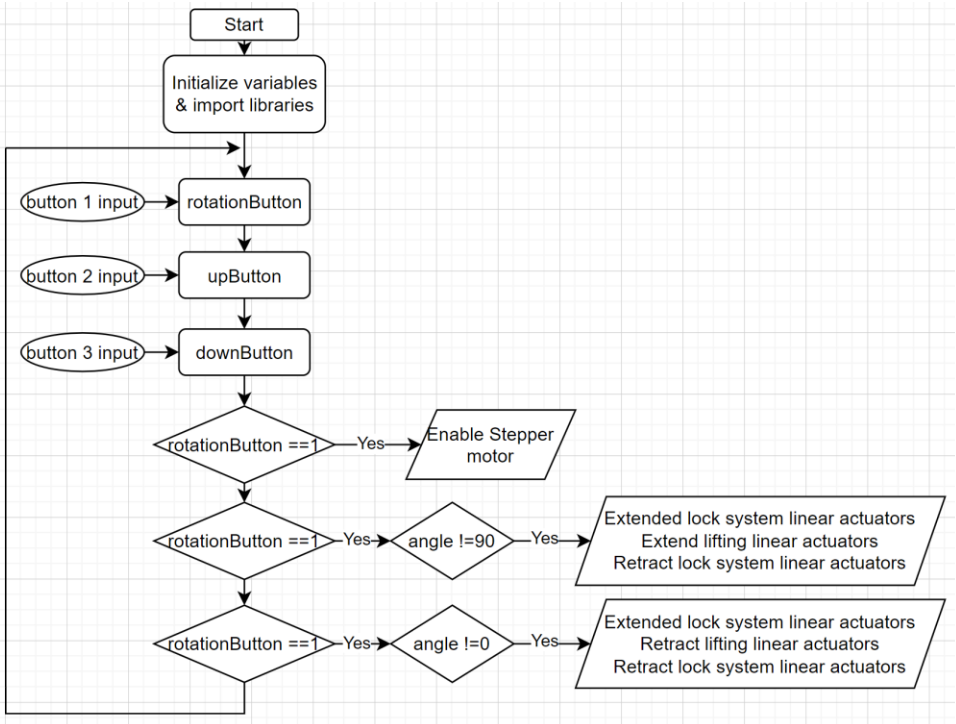
- The Hertzian contact stress was calculated to determine if the interlocking gears would withstand the force experienced by the payload to ensure a safety factor of at least 3 for the locking mechanism.

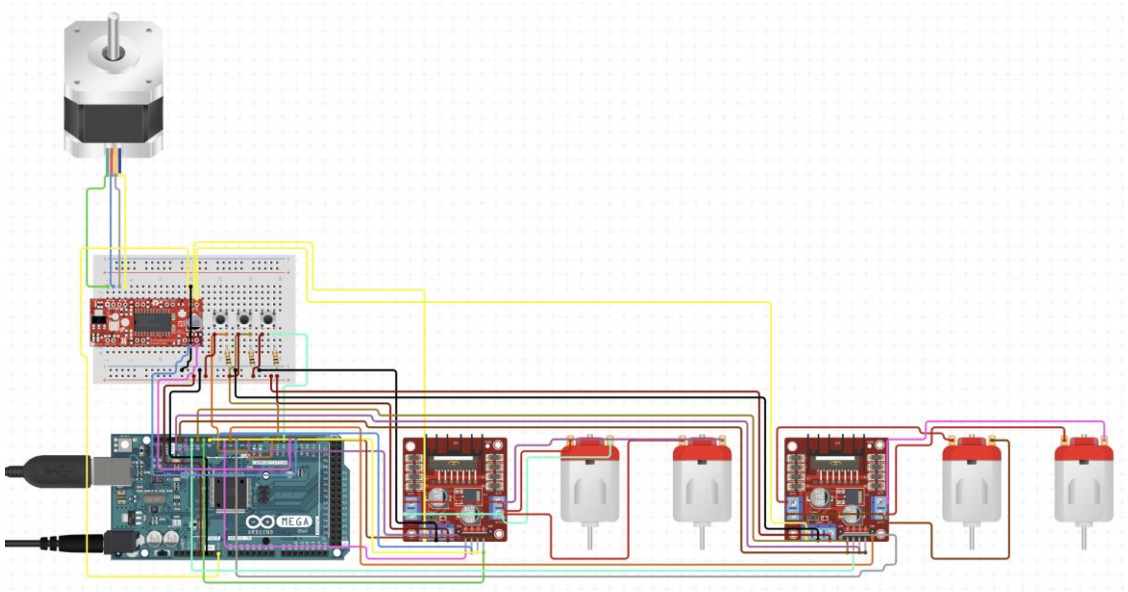
Hertzian Contact Stress	$\sigma_c = \sqrt{\frac{F(1+\frac{R_1}{R_2})}{R_1 B\pi(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2})}}$	
Contact Stress (N)	F	22241.11
Face width (mm)	B	76.2
Poisson's ratio of the one cylinder	µ1	0.3
Poisson's ratio of the second cylinder	µ2	0.3
Modulus of Elasticity of one cylinder (N/mm^2)	E1	200000
Modulus of Elasticity of secomd cylinder (N/mm^2)	E2	200000
Radius of one cylinder (mm)	R1	175.25
Radius of second cylinder (mm)	R2	78.724
Maximum value of contact stress (N/mm^2) (Mpa)	σc	613.0939
Maximum stear stress	τmax	183.9282

Torque measurements	
Radius of main gear (mm)	175.25
Force (N)	22241.11
Torque (N*mm)	3897755
Torque (N*m)	3897.755

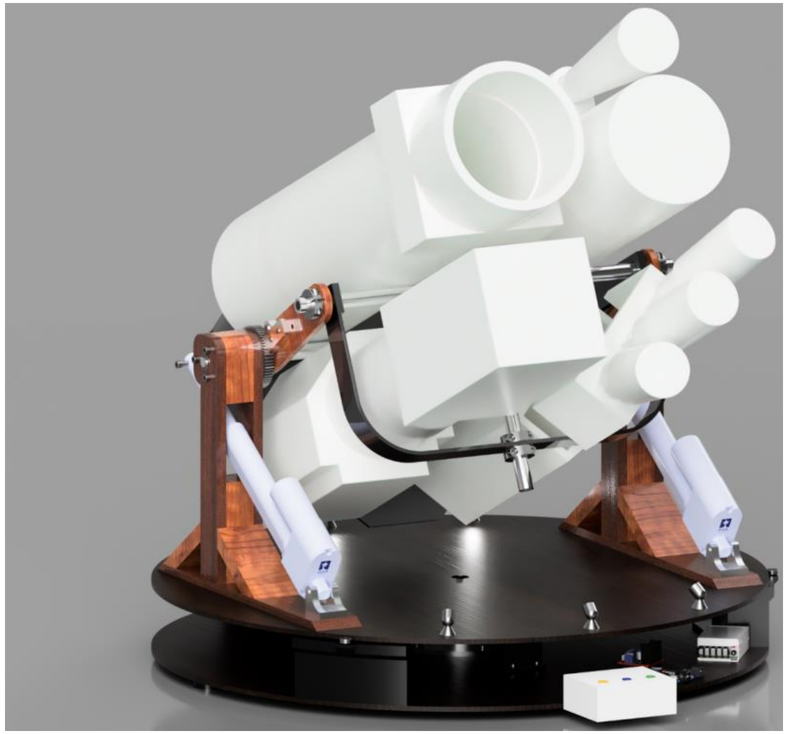
$$\sigma_{max} < \frac{\sigma_y}{0.6}$$

True for high cabon steel at a yield strength of 159 Mpa





SOFTWARE AND ELECTRICAL SYSTEMS



MANUFACTURED 1:5 SCALE PRODUCT

MANUFACTURED 1:5 PRODUCT VIDEO

FINAL DESIGN EVALUATION

TESTING PROTOCOL I

- Testing the payload's ability to be transported long term by transporting the model across three, 25-mile trips
- The payload and fasteners were then analyzed for any damage or loose fasteners
- The results of our testing protocol showed that only one fastener came loose after all three rounds of testing

TESTING PROTOCOL II

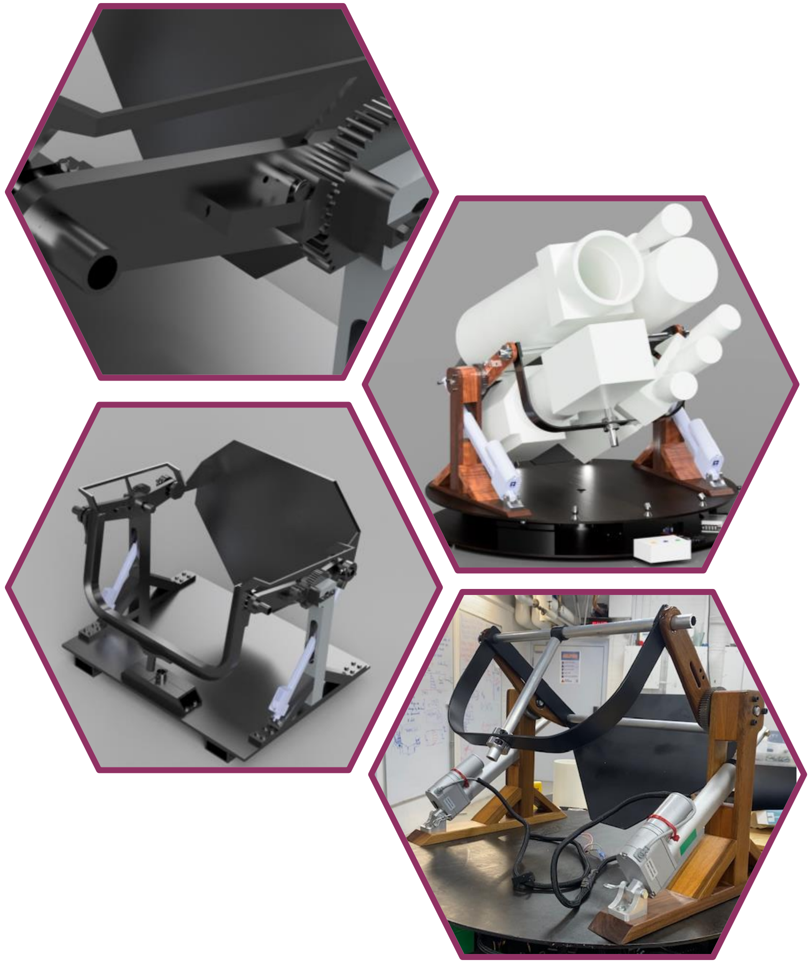
- Testing the ability of the angle locking mechanism to hold the payload at the five specified angles
- The mechanism was tested using an iPhone gyroscope that tested if each angle was locked within a tolerance of 3 degrees
- The results of testing the five angles across three iterations found that the angle locking mechanism could lock at all degrees within the tolerance

BOM

Part Name	Part Quantity	Total Cost	Manufacturing Time (hrs)
Linear Actuator	2	$ 6,000	N/A
Support Columns	2	$ 7,446	N/A
Locking Forks	2	$327.32	2.5
Locking Fork Pins	2	$ 40	1
Trunnion Plate	2	$2,548.35	3
Trunnion Rest	1	$ 550	2
Trunnion Rest Collars	2	$ 301	3
Bolt	52	~$ 100	N/A
Nuts	40	~$ 20	N/A
Spotlights	6	$ 81	N/A
Base Plate	1	$11,293.64	8.2
Turn Table	1	N/A	N/A

VALUE PROPOSITION

- Simple design; few moving parts
- Safe operation of locking mechanism
- Easy to assembly
- Minimizes obstruction of payload
- Structure visually complements payload
- Independent of center of mass location



QUESTIONS?

FULL BOM

Item No.	Part Number	Material (Individual Custom & Modified OTS Parts)	Qty.
1	Base	A36 STEEL	1
2	Support beam left2	A36 STEEL	1
3	Support beam right	A36 STEEL	1
4	Main gear (Angle lock system)	AISI 409 CARBON STEEL	2
5	Cruciform-grp8	A36 STEEL	1
6	Trunnion 1	A36 STEEL	2
7	No. 6217 bearing	NOT MODIFIED	4
8	Gear stopper	NOT MODIFIED	2
9	Trunnion Cylinder Connector	A36 STEEL	4
10	Cylinder Housing	NOT MODIFIED	2
11	Cylinder Rod	NOT MODIFIED	2
12	Spring Column Housing	NOT MODIFIED	2
13	Spring Column Rod	NOT MODIFIED	2
14	Spring	NOT MODIFIED	2
15	Linear Actuator with clamp	NOT MODIFIED	2
16	Rotary Damper Gear	NOT MODIFIED	2
17	Rotary Damper Body	NOT MODIFIED	2
18	98306A513_1004-1045 Carbon Steel Clevis Pin	NOT MODIFIED	2
19	Wire retainer for clevis pin	NOT MODIFIED	2
20	Grade 5 Steel Bolt 1.25 inch 7 tpi	NOT MODIFIED	16
21	Grade 5 Steel Nut 1.25 inch 7 tpi	NOT MODIFIED	16
22	Grade 5 steel bolt for clamp 0.75 md and 10 tpi	NOT MODIFIED	4
23	Grade 5 Steel nut for clamp 0.75 and 10 tpi	NOT MODIFIED	4
24	91310A848_M16_60mm_High-Strength Class 10.9 Steel Hex Head Screw	NOT MODIFIED	4
25	90447A109_M16_85mm_High-Strength Class 10.9 Steel Hex Head Screw	NOT MODIFIED	20
26	91310A873_M20_45mm_High-Strength Class 10.9 Steel Hex Head Screw	NOT MODIFIED	4
27	90685A120_M16_High-Strength Steel Hex Nut	NOT MODIFIED	24