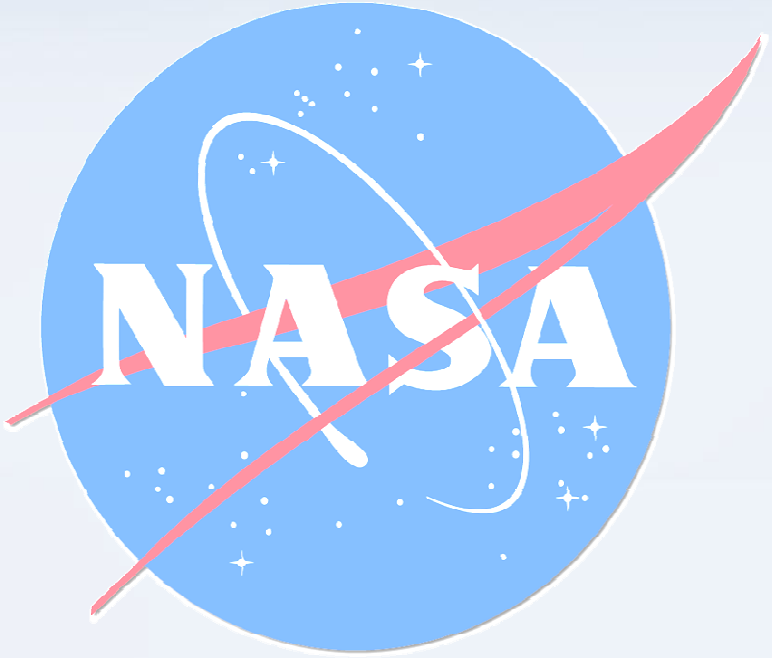
MECH 4240 - Concept Review



Corp_2 – Lunar Excavator

Anna Holland
Kyle Otte
Alex Hollis
Cody Salmon
Han Cho

Outline

- Mission Objective
- Gantt Chart
- Final Design
- Subsystem Work to Date
  - Analysis & Testing
  - Details of Subsystem
- Prototype
- Cost Analysis
- Mass Breakdown
- Fall Work Breakdown

Mission Objective

Create an autonomous excavator that weighs less than 80 kg, can collect and deposit at least 300 kg of lunar regolith within the 15 minute time limit, and that will win the 2012 Lunabotics Mining Competition. The overall size cannot exceed 0.75 m width x 1.5 m length x 2 m height at the start of the competition. However, the length and width constraints may be exceeded once the competition starts.

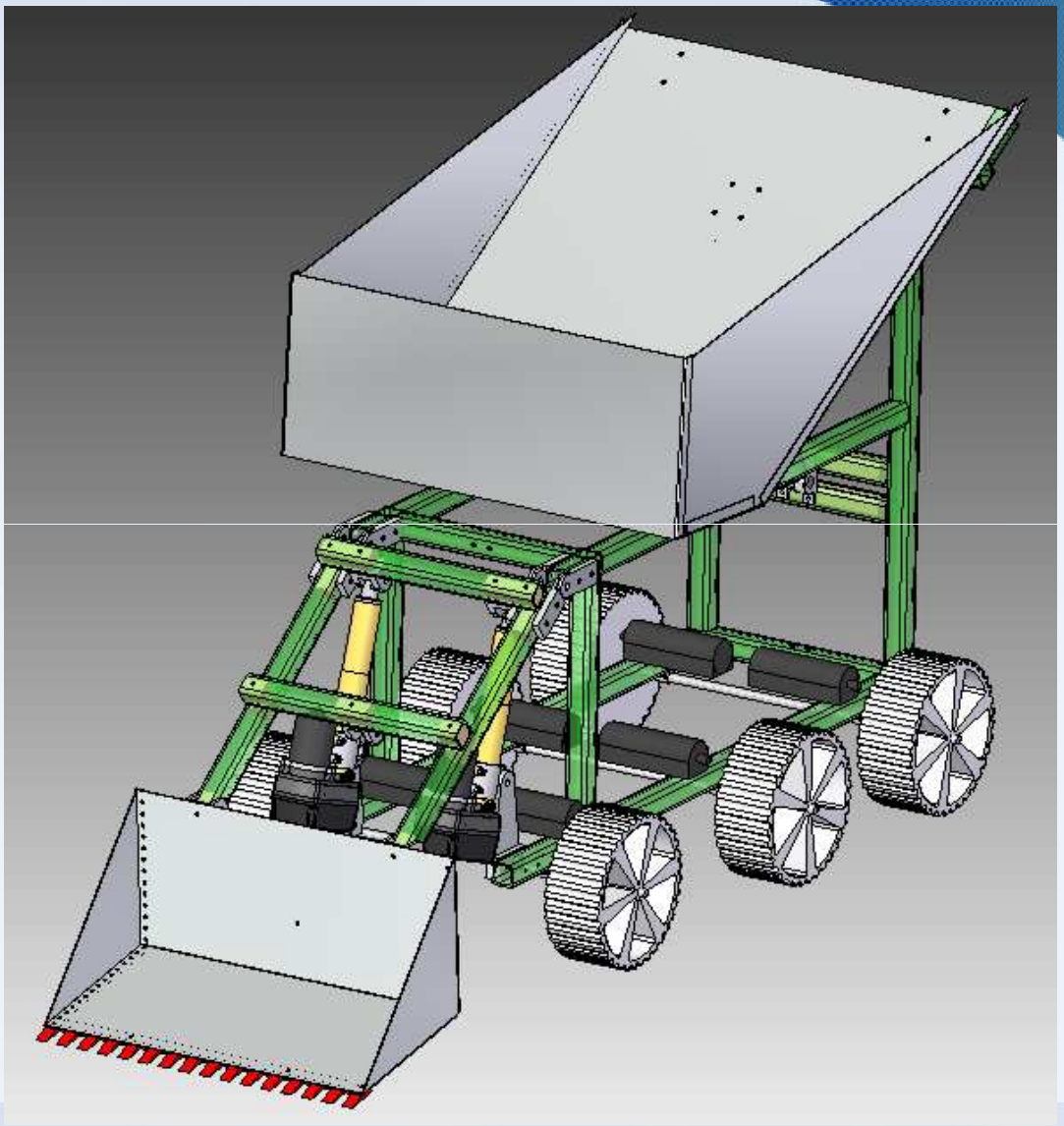
Gantt Chart

Milestone		Schedule by Week									
Associated Major Task		5/30 - 6/5	6/6 - 6/10	6/11 - 6/17	6/18 - 6/24	6/25 - 7/1	7/2 - 7/8	7/9 - 7/15	7/16 - 7/22	7/23 - 7/29	7/30 - 8/5
Total Days Since Received Project	29										
Project Groups Assigned											
Concept Generation / Research											
Assemble Old Excavator											
Learn to Operate Excavator											
Test / Run old Excavator											
Final Concept Chosen											
Concept Analysis											
Report/Powerpoint											
Midterm Presentation and Delivery											
Testing											
Dimensioned CAD Drawings											
Scaled Down Prototype											
Final Report/Powerpoint											
Final Presentation and Delivery											
Journal											
Gantt Chart											

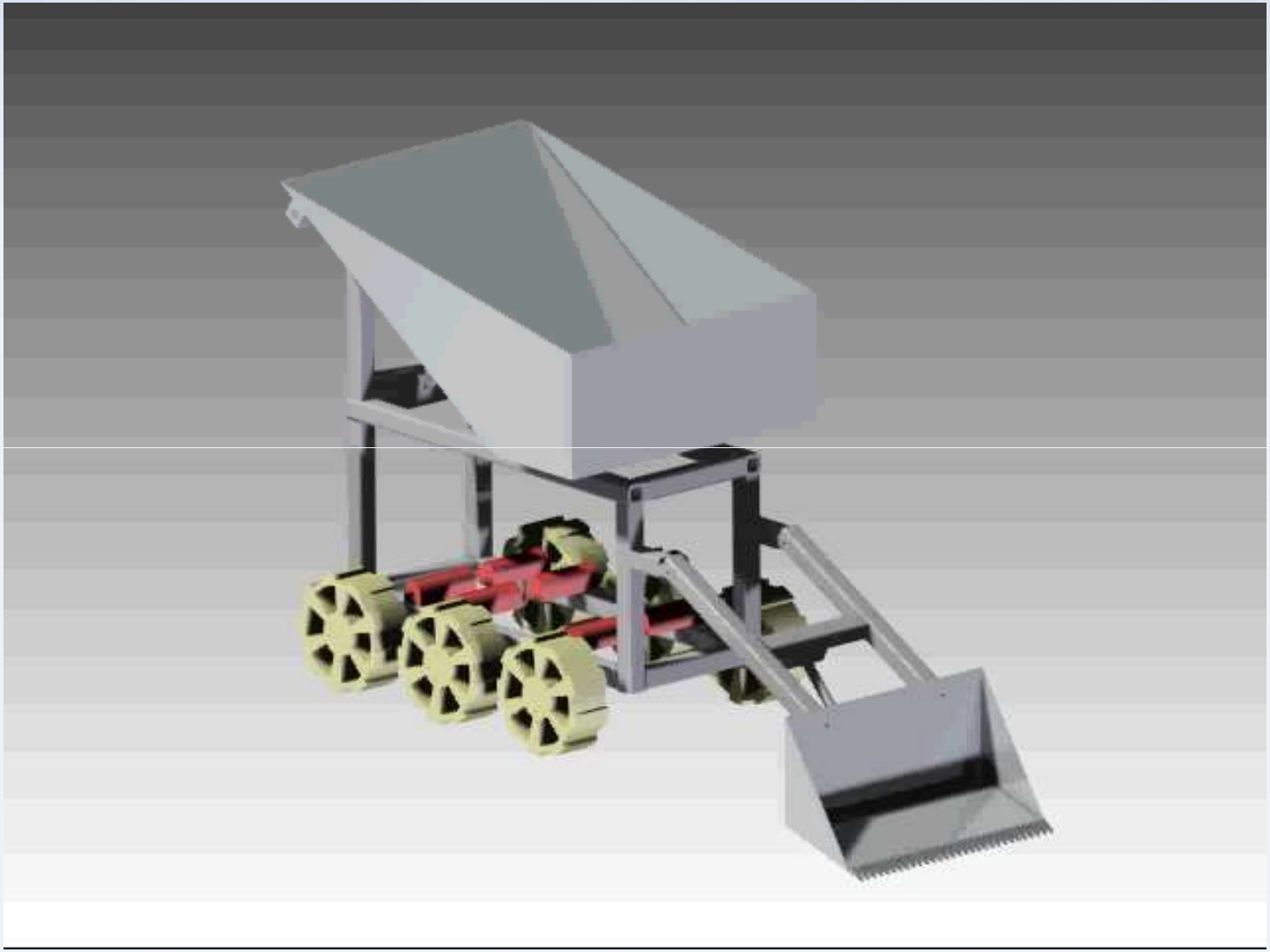
Symbol Legend	
Set Due Date	
Set/Moveable Due Date	
Department Set Date	
Finished Milestone	
Terminated Milestone	
Arrival Date	Due
Time Worked and Due Date	Due

Final Design

- 6 Wheels
- Regolith Storage Hopper
- Actuator Controlled Dump System of Entire Storage Hopper
- Single Large Bucket for Mining Regolith
- Rotational Joint on Bucket Arm
- 1 DOF Regolith Transfer

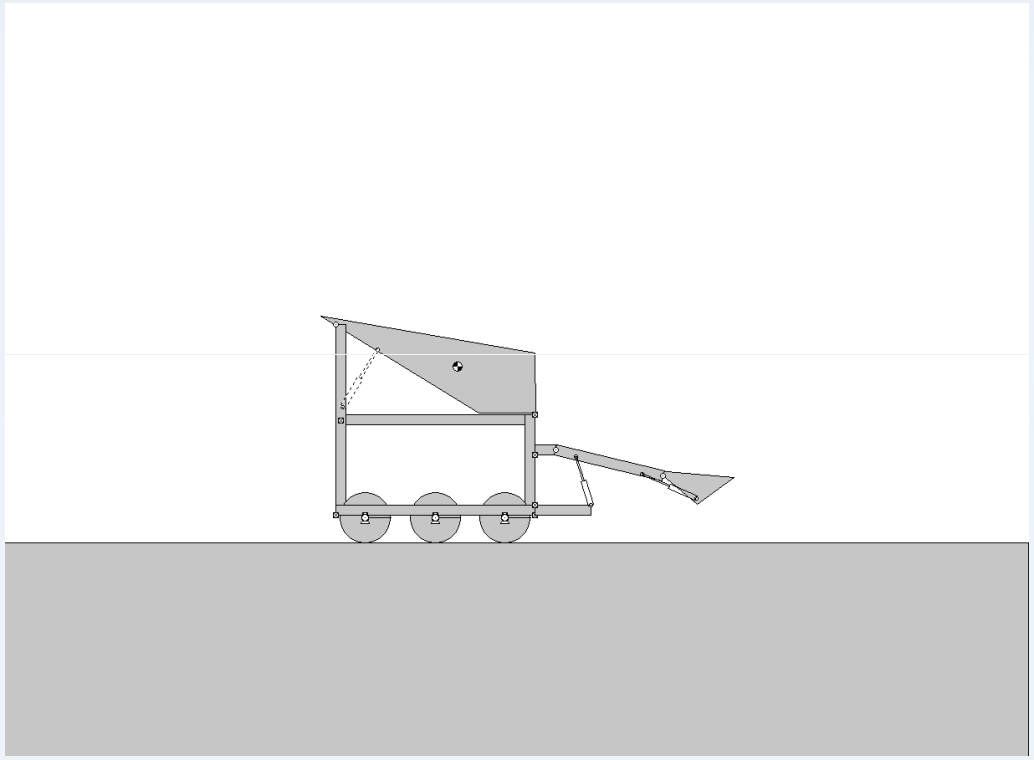


Solid Edge Simulation



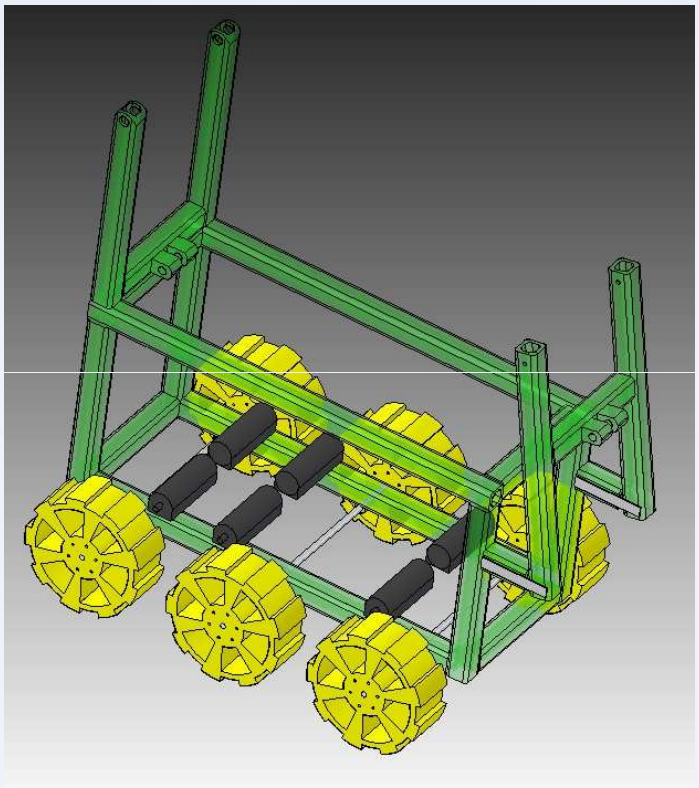
Working Model Simulation

- Actuators strong enough for max loads
- Wheels have enough torque
- Reasonable actuator lengths
- System within size limitation
- Max dump angle ~55°



Drive Subsystem

- 6 motors to control wheels
- (6) 10” x 4” Polyethylene Wheels
- Skid steer system
- Frame Material: Fiberglass Tube
- 1 m x 0.4 m x 0.5 m frame box houses motors, Netbook, & electronics



Analysis & Testing

- Required motor torque can be reached with gearing
- 6 wheels provides enough traction
- Fiberglass tubing strong enough for expected stress

Battery

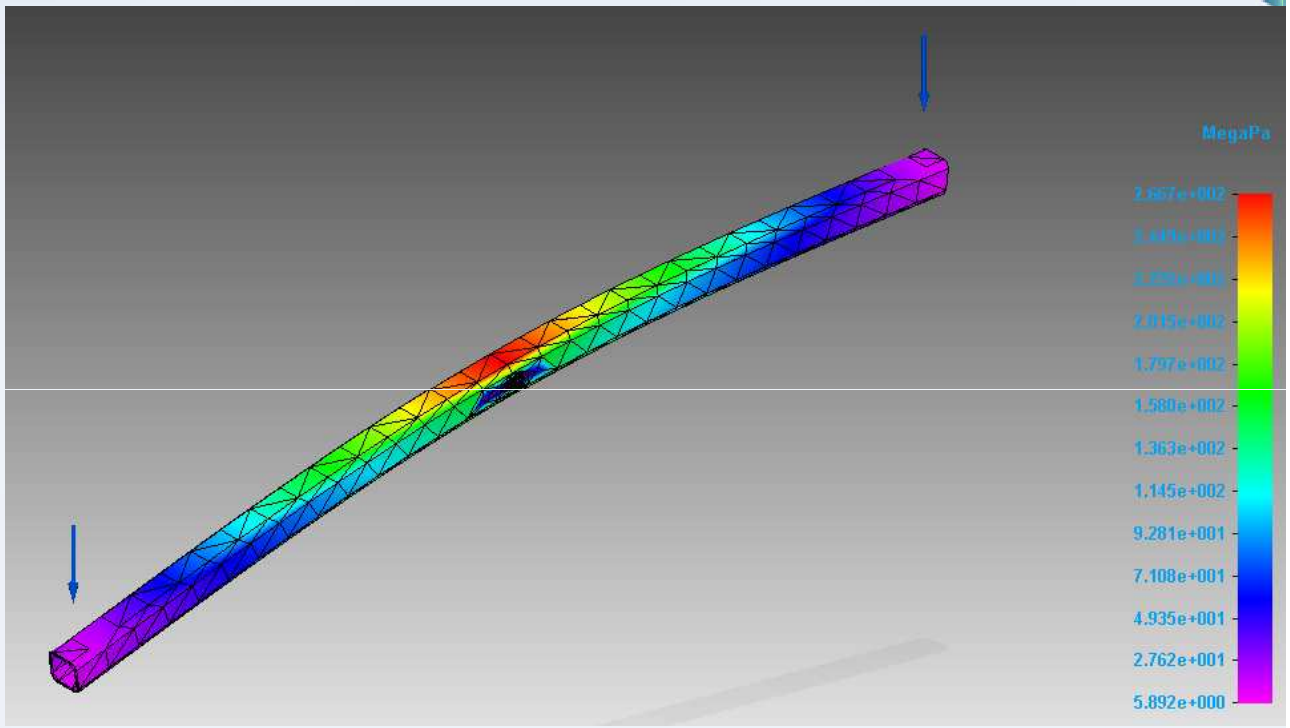
- 24 V 10 Ah NIMH battery
- Calculated the max usage of the actuators and motors in 15 min = 5.15 Ah
- 10 Ah will be sufficient for 15 min
- Free (Cost Effective)
- Light (3.08 kg)

Fiberglass Tubing

- 1.5 in. x 1.5 in.
- 1/8 in. thickness
- Ordered from McMaster-Carr
- Built in properties in Solid Edge

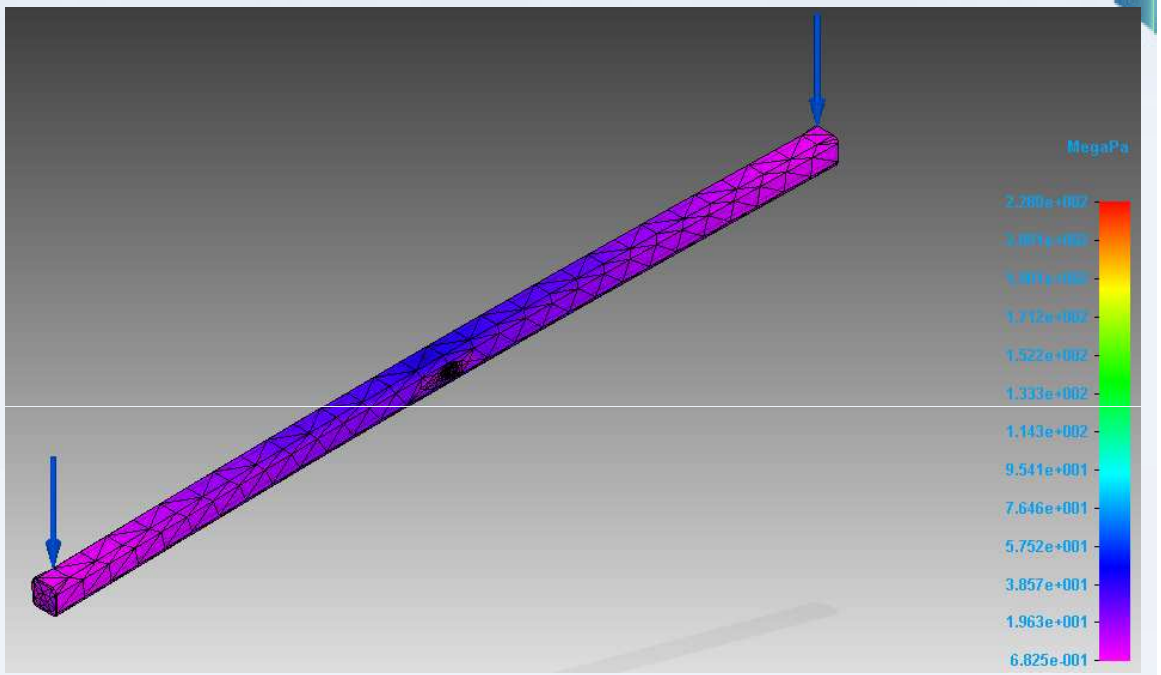
Fiberglass Stress Analysis

- 4 ft. of fiberglass tubing
- No wood insert
- 3 pt. bending test
- Fixed in middle of bar
- 250 kg. on each end
- Max. stress is 267 Mpa



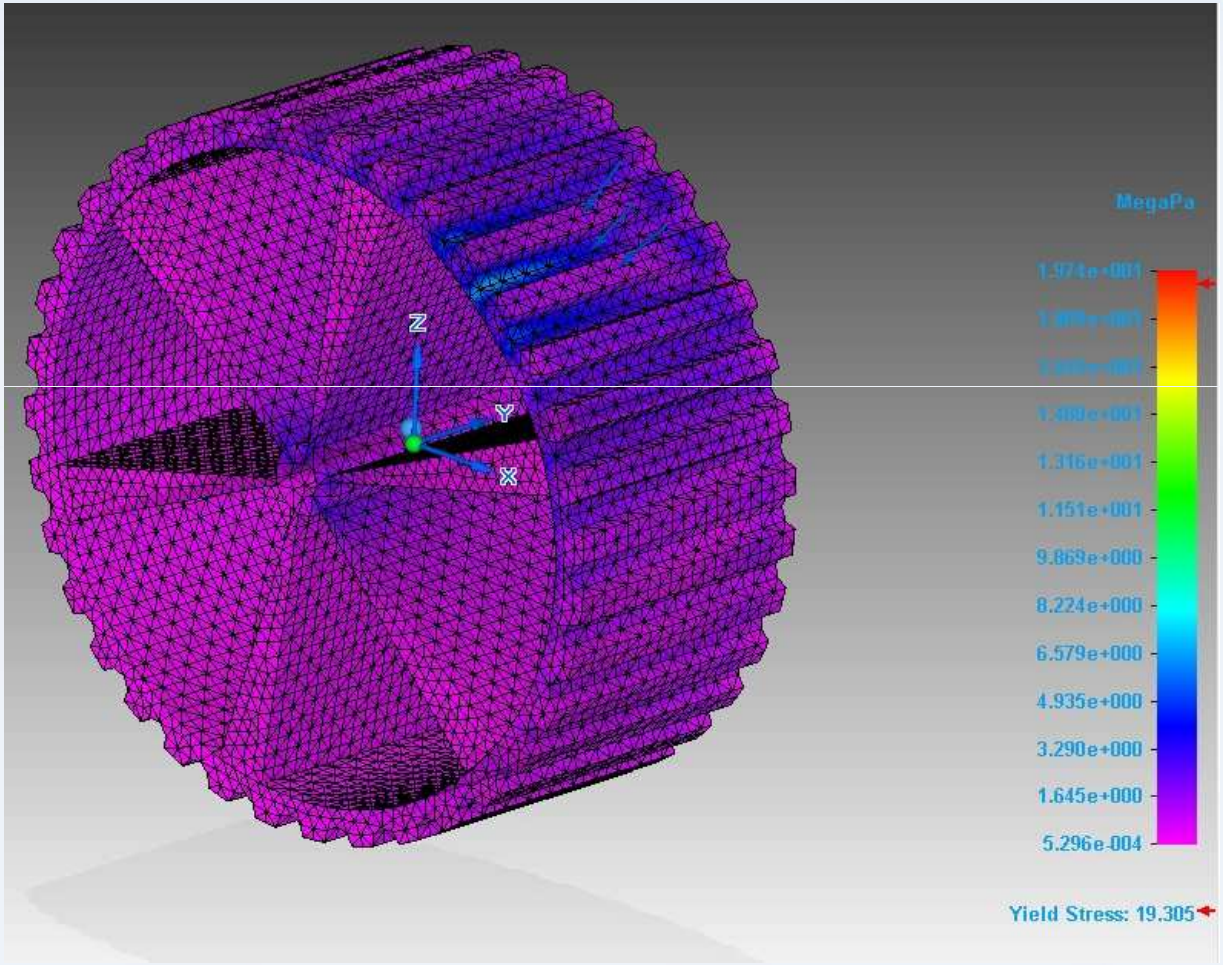
Fiberglass Stress Analysis

- 4 ft. of fiberglass tubing
- Wood insert
- 3 pt. bending test
- Fixed in middle of bar
- 250 kg. on each end
- Max. stress is 5.5 Mpa



Wheel

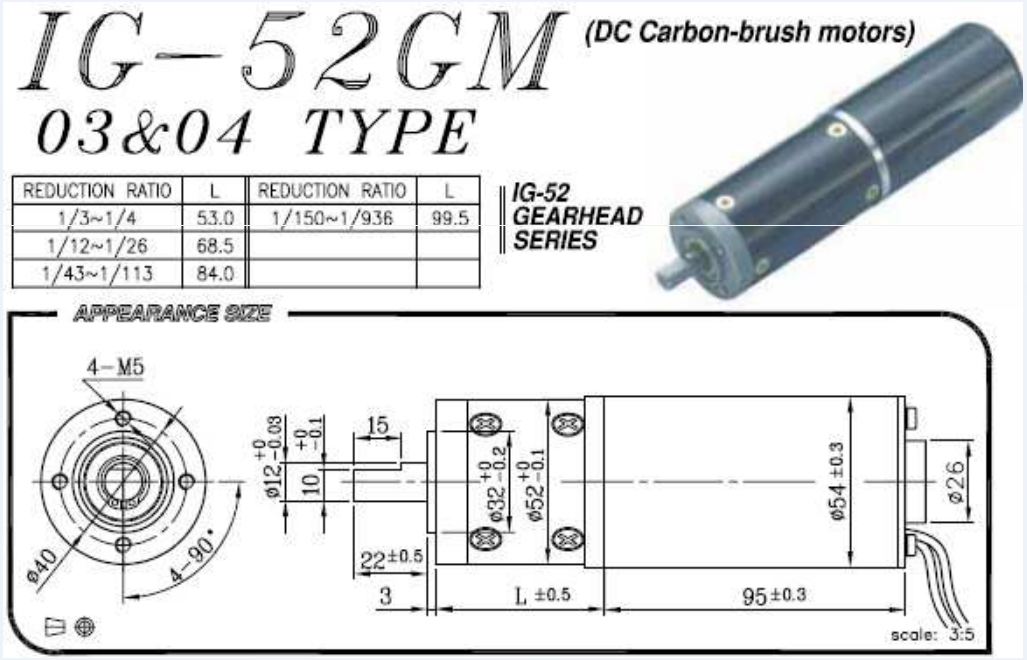
- Ultra-High Molecular Weight Polyethylene
- 10 in. diameter
- 4 in. thickness
- 250 kg. on two treads
- Max Stress 9.5 MPa
- Yield Strength 19.5 MPa



Motor

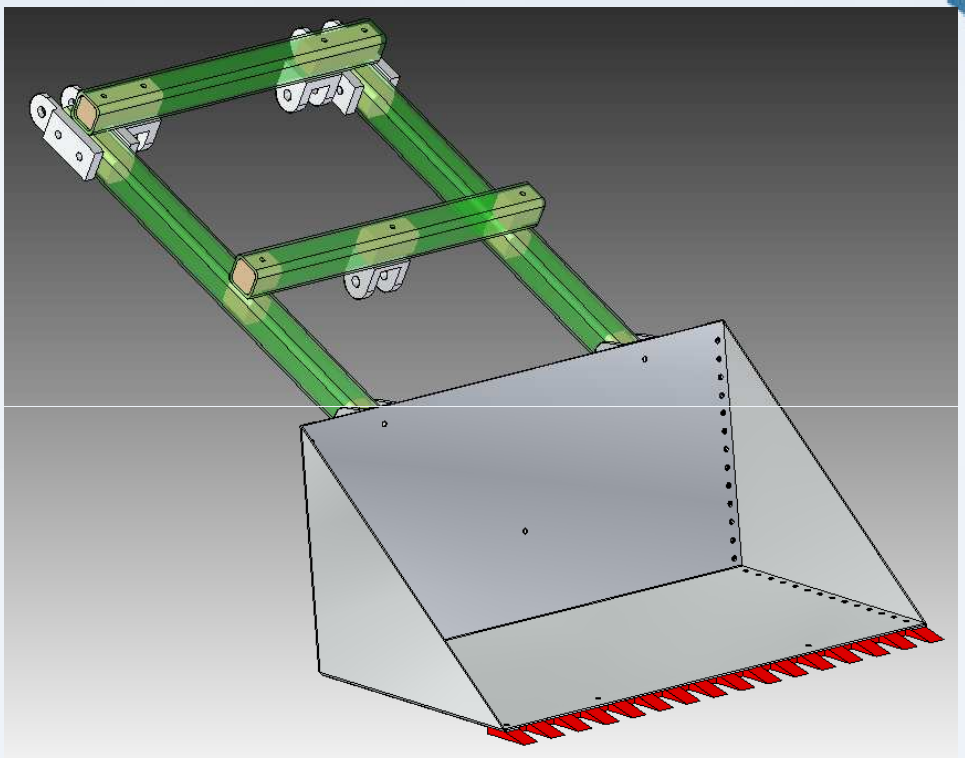
Reasons to use the same motor

- Adding two motors is cost effective
- Change the gear ratio from 3:1 to 2:1
- Improves average speed 68%
- Reliable torque (Same torque amount)



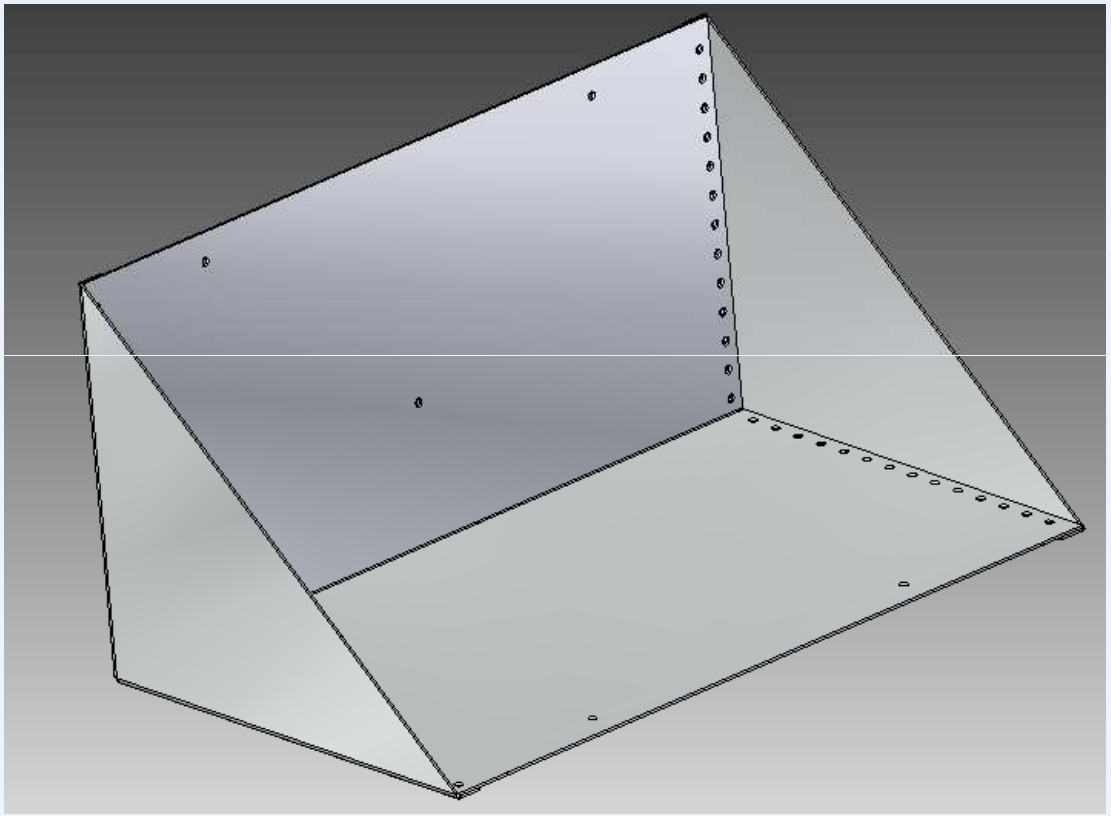
Scoop Subsystem

- Max Capacity: 23 kg
- **7** full scoops = 1 full hopper at 15 kg/scoop
- **17** small scoops = 1 full hopper at 6 kg/scoop
- Blade to cut through top layer
- Material: Aluminum 6061
- Total Weight = 19.1 kg
- Made as rigid as possible



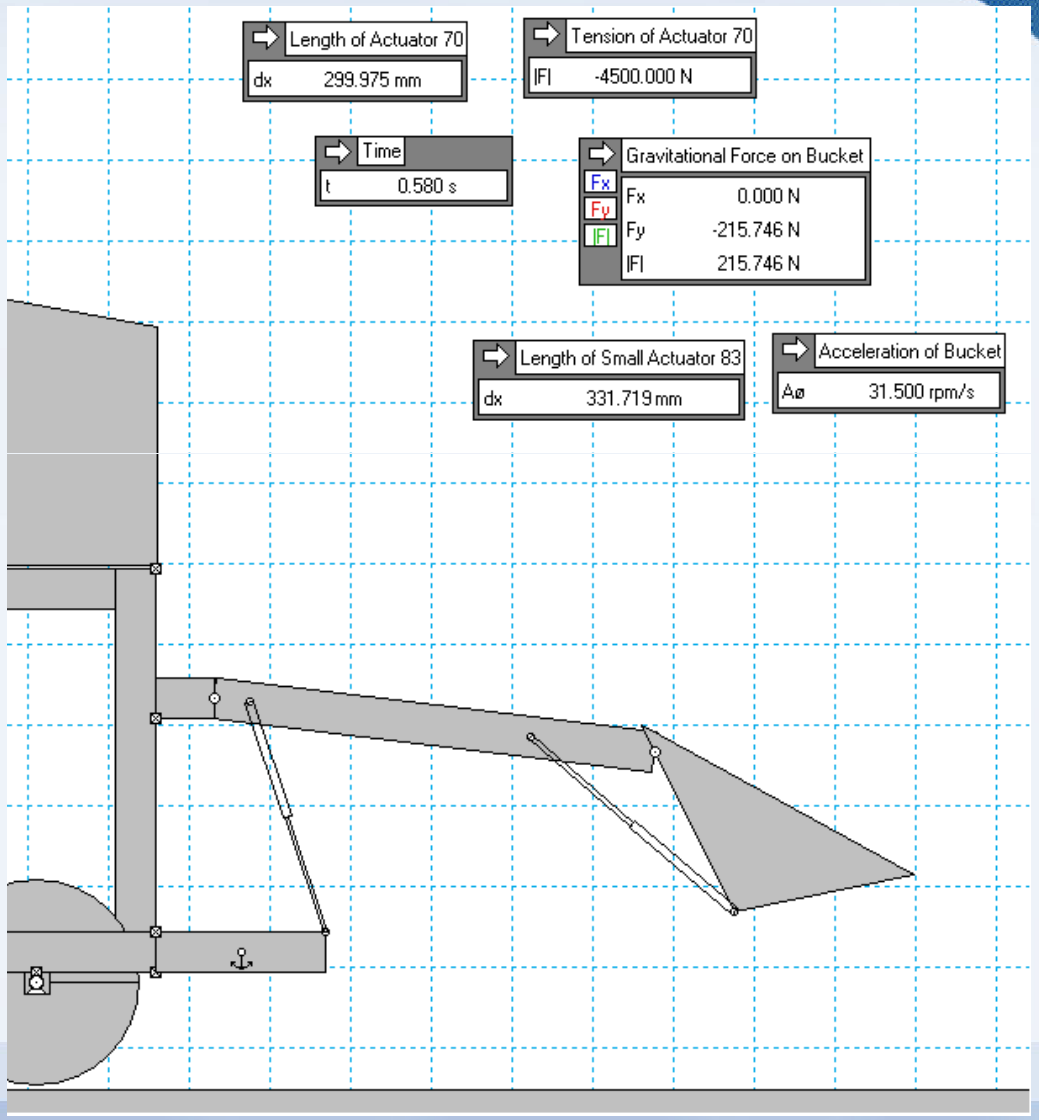
Bucket

- Made of 6061 Aluminum
- Constructed with rivets
- Weighs only 2.6 kg



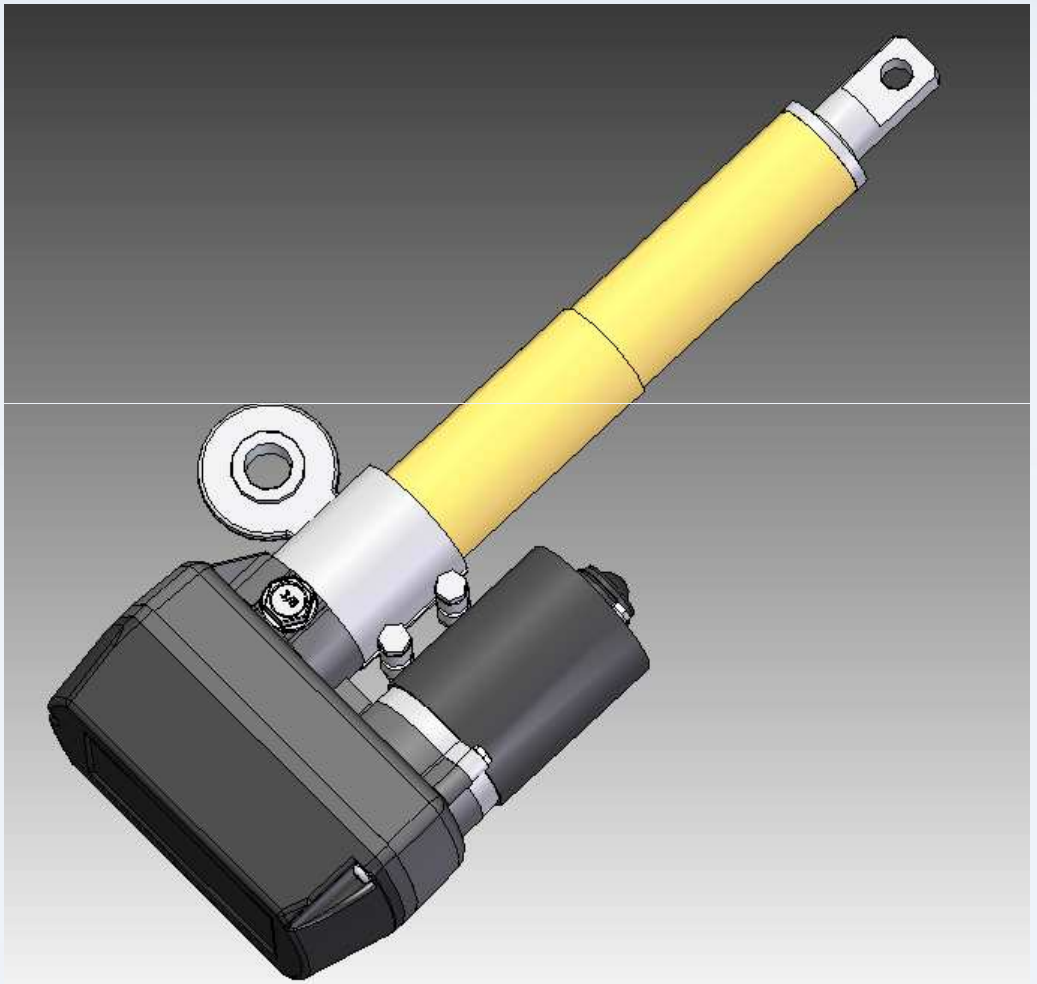
Bucket Actuator Selection

- 23 Kg in Bucket
- Varied Length of Arms and locations of mounts
- 4500 N minimum to lift bucket



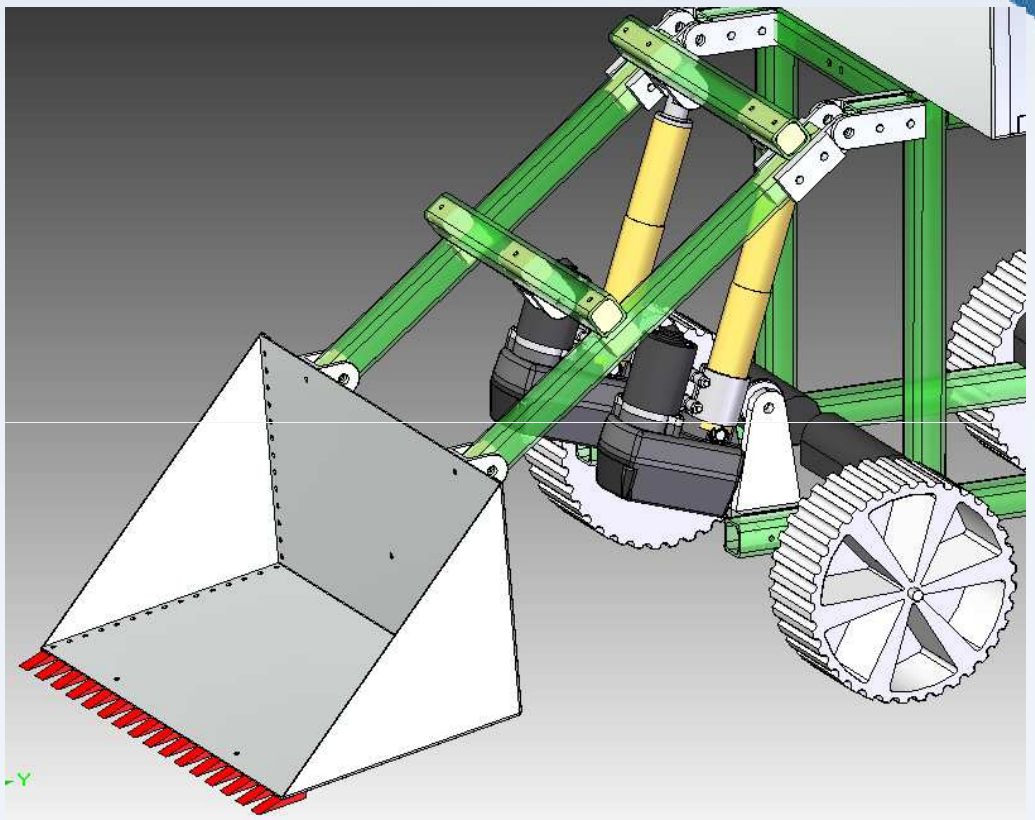
Large Bucket Actuator

- 24 Volt
- 102 mm stroke
- 28 mm/s speed
- 11 amp draw
- 3330 N capacity
- Adjustable mount
- 4 seconds to lift bucket from digging position to dumping position



Large Actuator Location

- 2 units mounted In parallel
- Combined 6660 N lifting force
- 4 seconds from digging to dumping

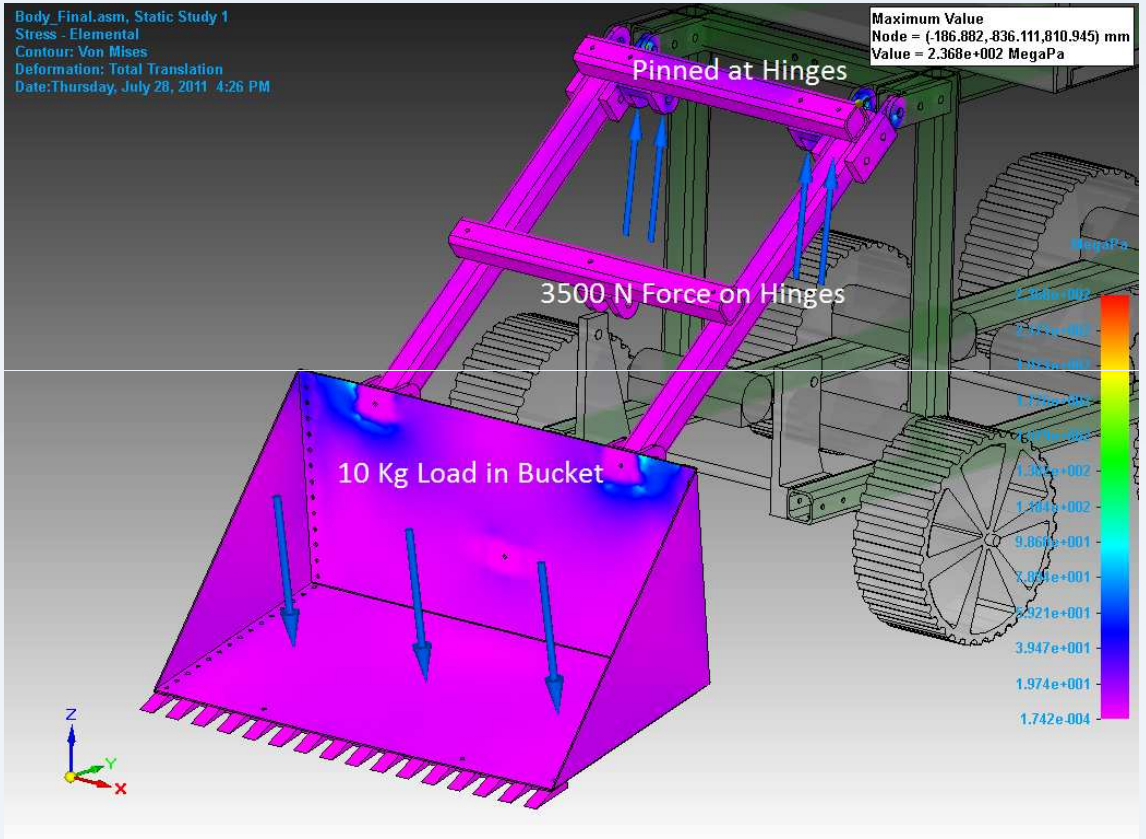


Small Bucket Actuator

- Used to tilt bucket for optimal digging
- 2 seconds to tilt bucket from digging position to dumping position
- Mounted directly behind bucket

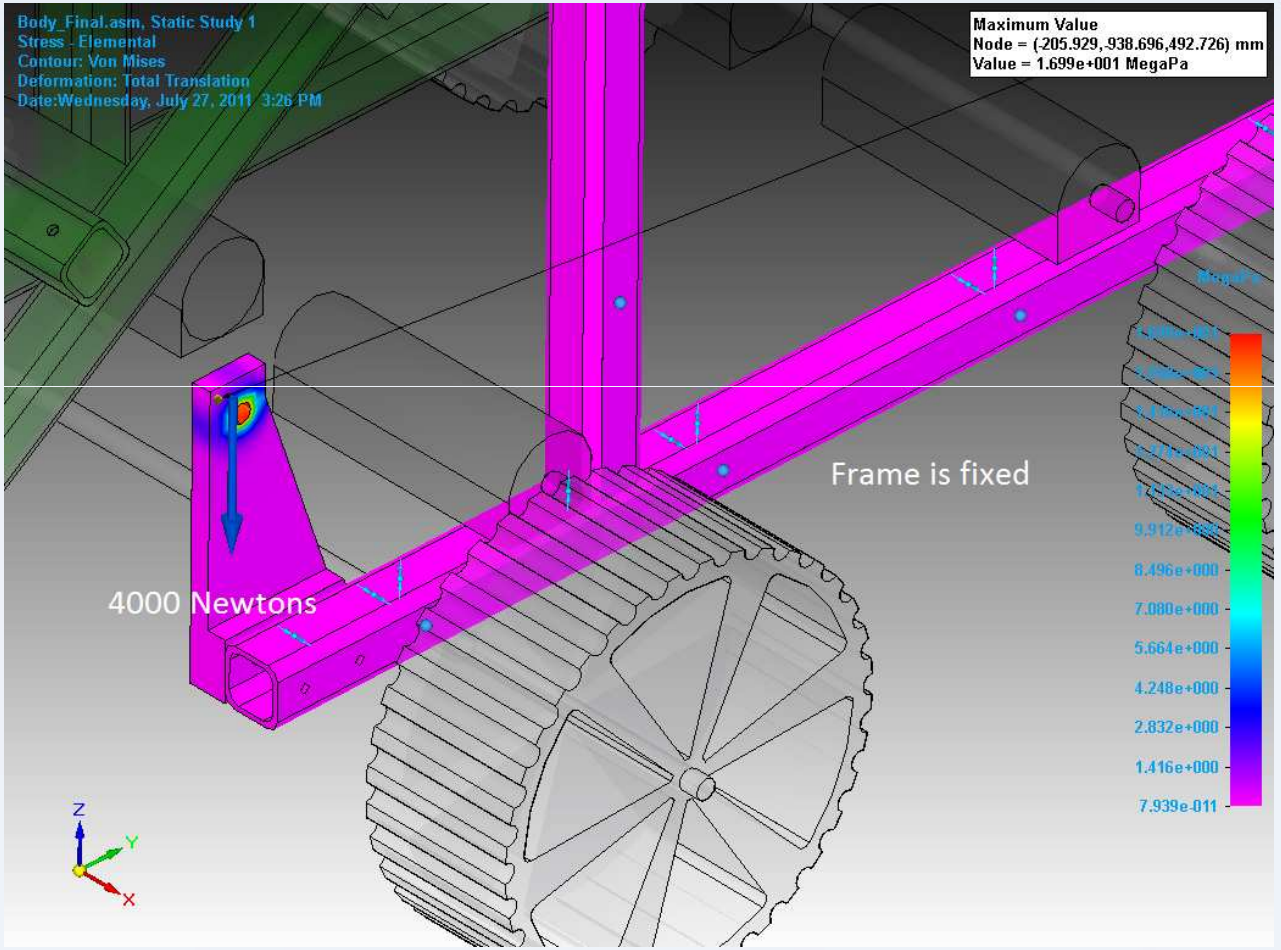
Bucket Testing

- 10 Kg load in bucket
- 3500 N on actuator brackets
- Pinned at 4 hinges
- Max Von Mises Stress at hinges was 237 Mpa
- No yielding



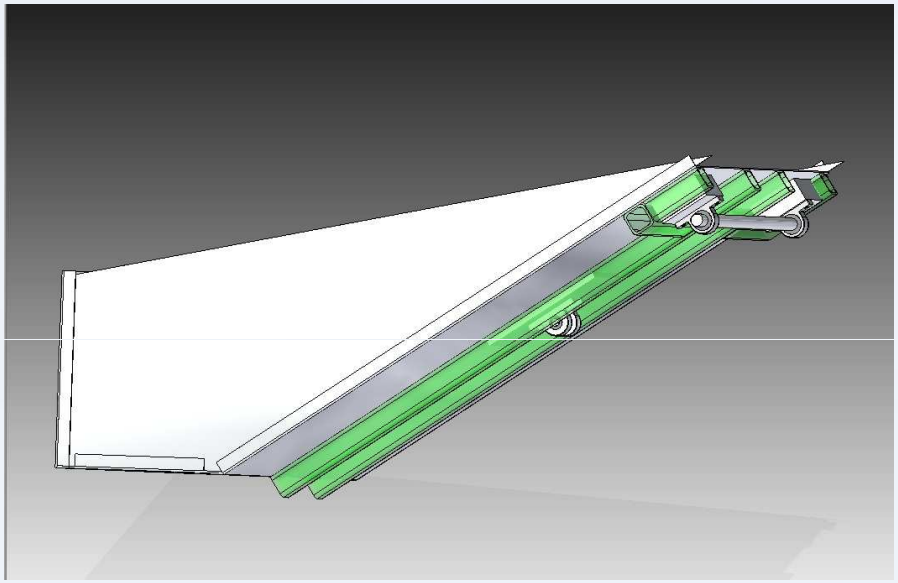
Bucket Bracket Testing

- Bracket for bottom of large actuator
- Frame was fixed in all DOF
- 4000 N Down
- Max Von Mises stress 170 Mpa
- Yield Strength 276 Mpa



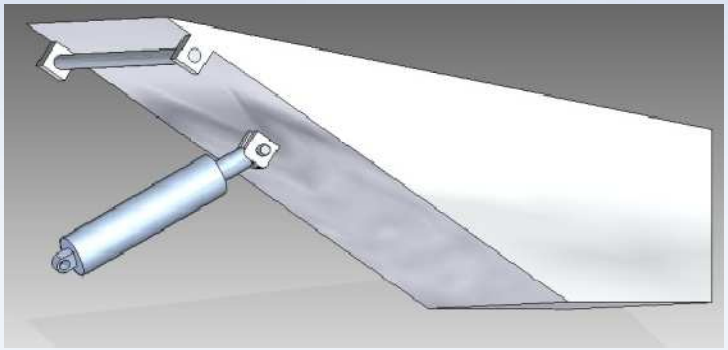
Hopper Subsystem

- Main Body 2 mm thick 6061 Al plates
- Upper Al shaft for connection to frame
- Lower Steel shaft for connection to actuator
- Rigid Fiberglass Support bars
- 0.375” Al actuator support plate to dissipate force
- Yield Strength of 6061 Al ~276 MPa
- Yield Strength of Fiberglass ~162 MPa



Dump Subsystem

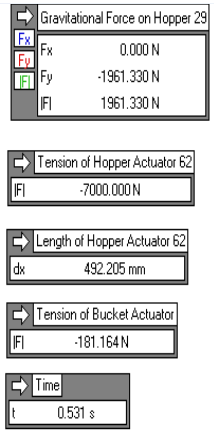
- Max Capacity: 150 kg
- Material: Aluminum 6061

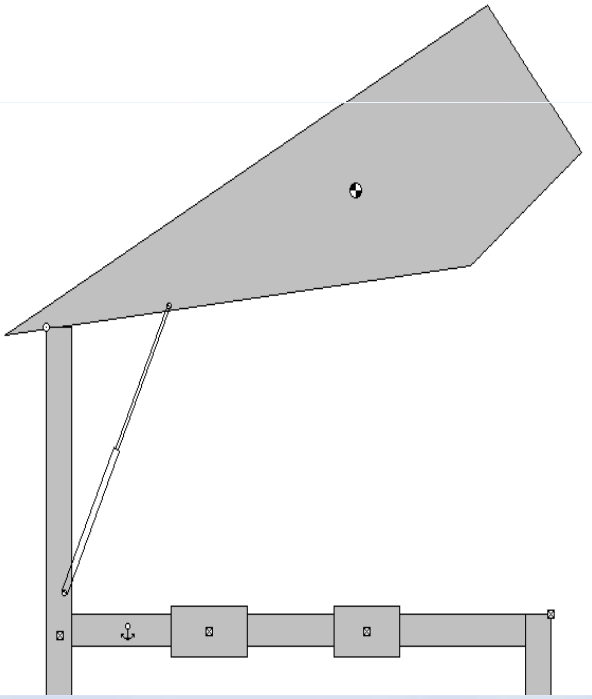


Analysis & Testing

- 7000 N actuator strong enough to lift full load

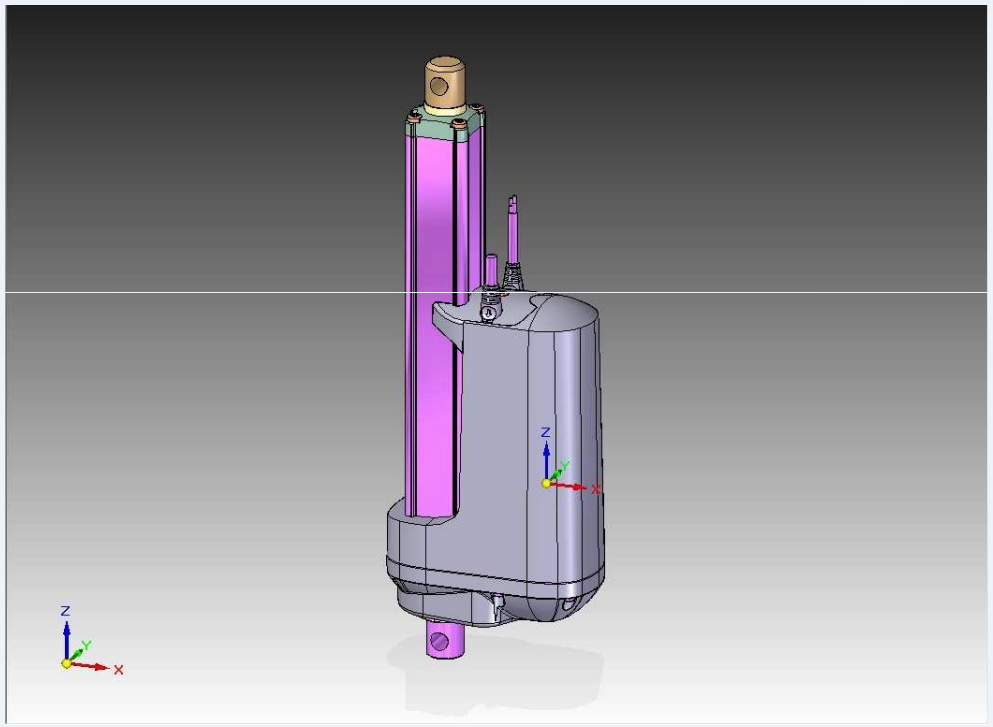
- Length of Actuator is reasonable (12 in)





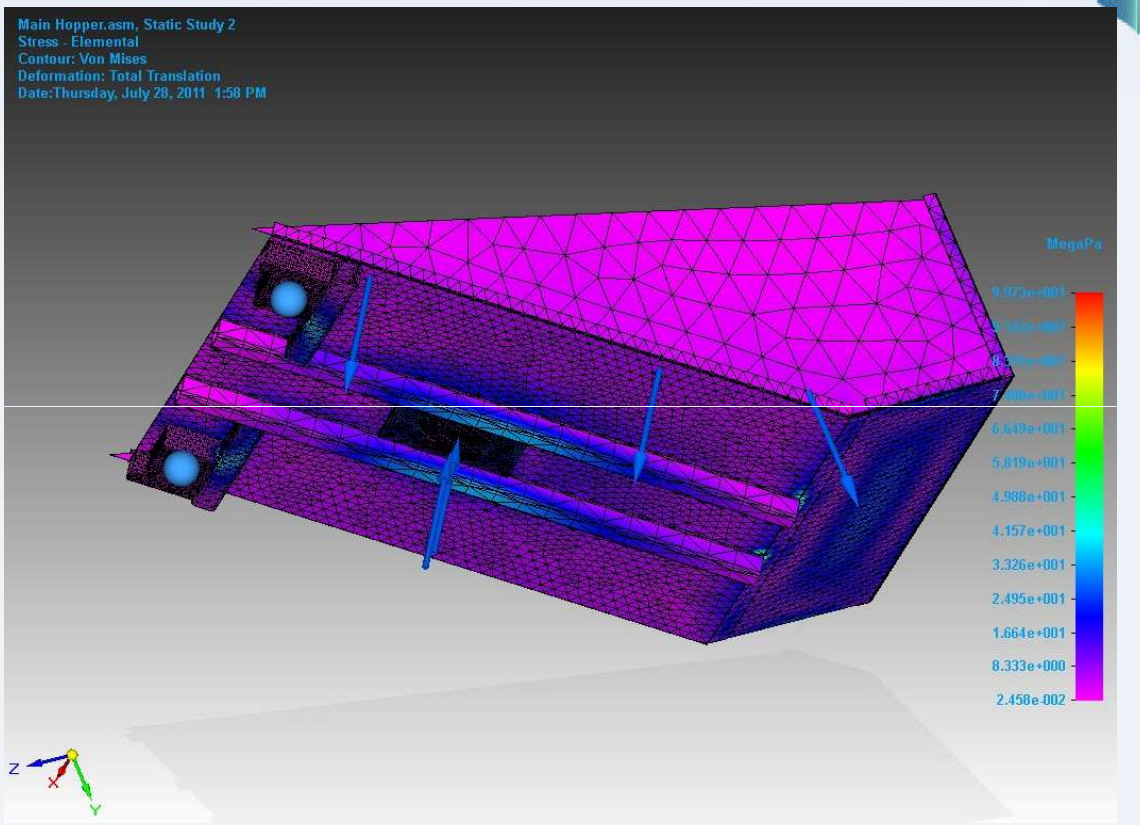
Hopper Actuator

- LINAK LA36
- 6800 N Max Force
- No Load Speed
  ~ 15.7 mm/s
- Full Load Speed
  ~12.7 mm/s
- Compressed length
  ~500 mm
- Stroke ~300 mm
- ~22 seconds to dump



Finite Element Analysis

- 110 kg on Bottom Plate distributed evenly
- 40 kg on Main Plate distributed evenly
- 4000 N applied to Hopper Actuator plate
- Bearing Extenders pinned to allow rotational motion only
- Max Von Mises stress of 99.7 MPa
- Yield Strength of 6061 Aluminum ~276 MPa
- Yield Strength of Fiberglass ~162 MPa
- Maximum Displacement ~2.7 mm



Aluminum Angle Test

- Sheet Aluminum
- Concrete Mix
- Lowest Angle 31°
- Highest Angle 36°
- Verification 45° Dumping Angle is Sufficient

Electrical System

Issues from testing

- Battery and Netbook housing
- Loss of battery connection

Re-Design

- Incorporate specific housing to prevent battery from disconnecting
- Protect/cushion the Netbook from vibration damage
- EE Senior Design Group assigned to project in fall

Prototype

- Actual Size Prototype
- Bucket, Hopper, & Wheels – Plywood
- Frame Material – Fiberglass Tubing
- Final Fiberglass Frame 80% Complete
- Verification of Solid Edge and Design
- Verification of Wheel Clearance

CDR Economic Analysis

Item	Description	Supplier	Supplier Part #	Lead Time	Original Unit Cost	Qty	Total Estimated Cost
1	6061 Aluminum 36"x48" sheet, 0.08" thick	Metals by the Inch		2-3 days	$79.17	4	$316.68
2	2x6x8' Untreated Pine Wood	Home Depot		1 day	$2.40	1	$2.40
3	Bucket Tilt Actuator	Moteck	ID10-12-20-A-100	2 weeks	$108.00	1	$108.00
4	Bucket Lift Actuator	Nook Ind.	CC-18	3-4 weeks	$600.00	2	$1,200.00
	Hopper Actuator (reuse)			-		1	$0.00
5	Fiberglass Tubing 1-1/2" x 1-1/2" 10' Section	McMaster-Carr	8548K32	1 day	$63.41	3	$190.23
6	UHMW Polyethylene 10" Diameter 4" Cut to Length	Eplastics		3-5 days	$167.46	6	$1,004.76
7	Motor	?			?	6	$0.00
8	Electrical Circuit System (reuse)	Sparkfun Electronics		-	$70.00	1	$0.00
9	Batteries (reuse)	10 Ah, 24V		-	$130.00	2	$0.00
10	Netbook (reuse)	Netbook Samsung NF310-A01		-	$400.00	1	$0.00
11	Cameras (reuse)	Newegg.com/		-	$40.00	3	$0.00
12	Fasteners	McMaster-Carr	1558A21	1 day	$100.00	1	$100.00
13	Router (reuse)	Newegg.com/ ASUS Router		-	$65.00	1	$0.00
14	Axle	McMaster-Carr	8974K113	1 day	$12.82	3	$38.46
15	Sabertooth Motor Controllers	Trossen Robotics	126233		$125.00	2	$250.00
16	Extra Electrical Components	Sparkfun Electronics			$50.00	1	$50.00
17	94 lb Portland Concrete Mix	Home Depot		1 day	$9.85	20	$197.00
18	Report Copies for all 4 Presentations	Copy Cat		-	$100.00	1	$100.00
19	Plywood for Mock up	Home Depot		1 day	$11.00	1	$11.00
20	Tools for DML	Sparkfun Electronics		1 day	$100.00	1	$100.00

TOTAL ESTIMATED COST	**$3,668.53**

Design Mass Breakdown

Mass Budget Tracking				
Subsystem	**Component**	**Mass (kg)**	**Qty**	**Mass Total (kg)**
Scoop System	Bucket	4.608	1	4.608
	Lifting Actuator	4.000	2	8.000
	Tilting Actuator	3.636	1	3.636
	Mechanical Arms	2.862	1	2.862
Drive System	Wheel	2.180	6	13.080
	Motor	0.920	6	5.520
	Axles	0.771	3	2.313
Dump System	Bucket	12.225	1	12.225
	Actuator	5.400	1	5.400
Frame	Body (tubing, panels, etc)	6.479	1	6.479
	Plastic Sheeting	0.420	1	0.420
	Electrical Circuit System	0.500	1	0.500
	Batteries	2.700	2	5.400
	Netbook	1.500	1	1.500
Miscellaneous	Cameras	0.097	3	0.291
	Fasteners	2.500	1	2.500
Total Weight (kg)				**74.7348**

Fall Work Breakdown

Week	Dates	Tasks
1	8/17-8/19	Orders all Materials/Parts - Finish Building Frame
2	8/22-8/26	Build Hopper and Bucket
3	8/29-9/2	Machine Wheels
4	9/6-9/9	Machine Wheels
5	9/12-9/16	Mount Drive System/Test Drive System
6	9/19-9/23	Assemble Actuators/Test Scoop & Dump Systems
7	9/26-9/30	Complete Assembly of Excavator Work on Report/Presentation
8	10/3-10/7	**MIDTERM PRESENTATION**
9	10/10-10/14	Testing
10	10/17-10/21	Testing
11	10/24-10/28	Testing
12	10/31-11/4	Testing
13	11/7-11/11	Testing
14	11/14-11/18	Testing - Work on Report/Presentation
15	11/21-11/25	THANKSGIVING BREAK
16	11/28-12/2	**FINAL PRESENTATION**

Any Questions?