

2018 NASA Rover Challenge

PSU Rover 1



Team Members

- Austin Throckmorton
 - Manufacturing Engineering Technology
- Taylor Handly
 - Mechanical Engineering Technology
- Bryan Wilson
 - Mechanical Engineering Technology
- Milfy Al Gaarah
 - Mechanical Engineering Technology
- Malik Alkhardawi
 - Mechanical Engineering Technology
- Mindi Jones
 - Mechanical Engineering Technology



Agenda



- Problem Definition
- Schedule
- Budget
- Design Inputs
- Design Breakdown
- Build Process
- Initial Test Results
- Pre-race Solutions
- Race Results
- Trouble Shooting
- In Retrospect
- Questions



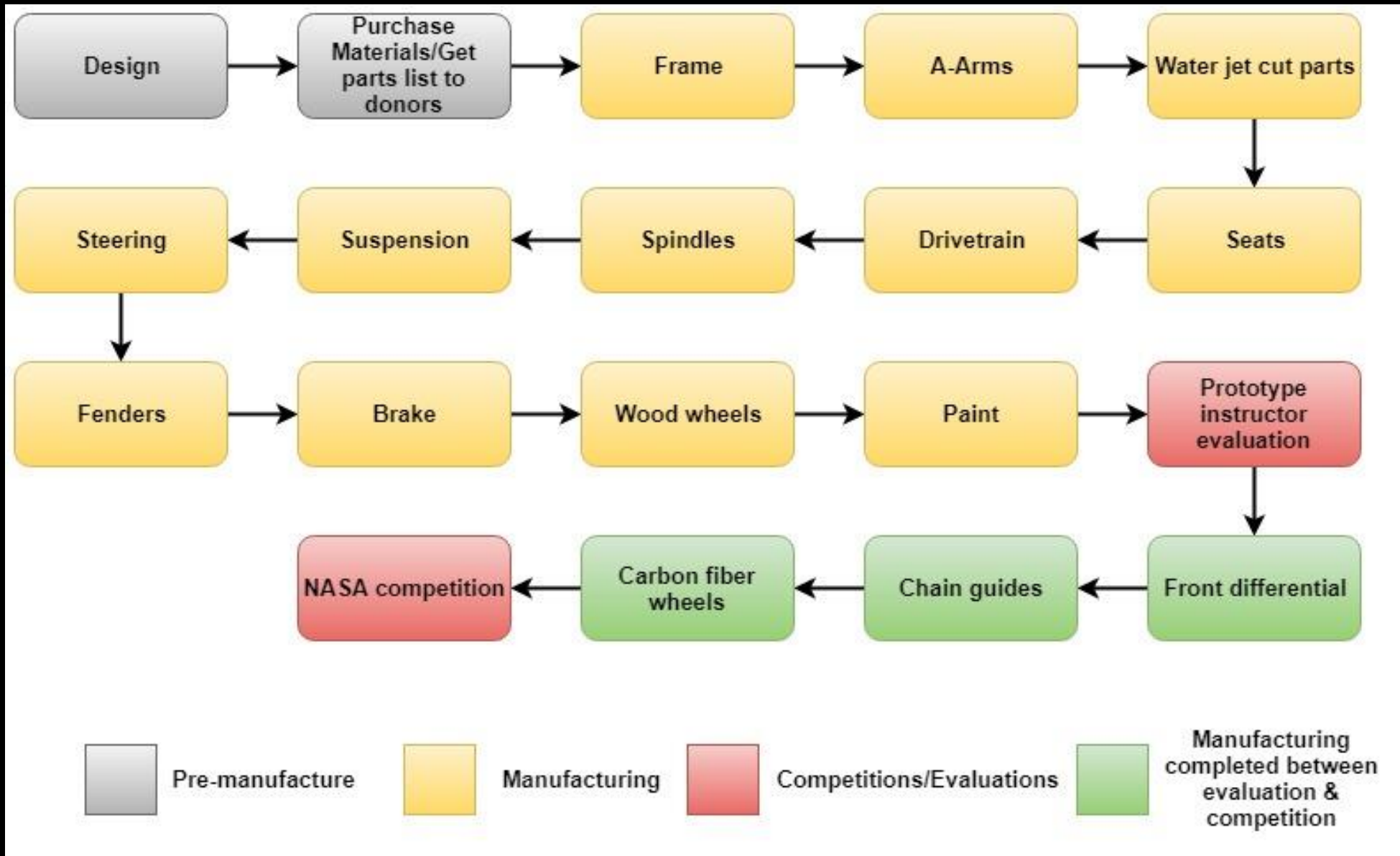
Problem Definition



- Design and build a human-powered rover for the NASA Rover Challenge
- Create and manage a mini-engineering project



Semester Flow Chart



Budget



- Money Raised: \$1643.30
- Money Spent on Materials and Parts: \$1193.79
- Money Spent on Competition: \$450.00



Customer Design Requirements



Turning Radius	15 ft.
Rider Ground Clearance	15 in.
Volume Constraint	5' x 5' x 5'
Human Powered	2 riders, 1 male, 1 female
Width Restrictions	5 ft.
Fenders	120 square inches/wheel
Seat Belts	Present
Wheel Design	No commercial parts
National/Institutional Flag	Present
Samples Container	Present



Team Design Requirements



Paint	90% of fabricated ferrous components
Weight	169 lbs
Picture taking Ability	Present w/ filter
Drive Over Cracks	5" cracks and 30° angle
Climb Inclined Hill	30° Incline up to 5'
Robust	FOS of 3 for frame and 4 for suspension
Assembly Time	Under 2 minutes





Design Breakdown

- Frame

- Drivetrain

- Suspension

- Wheels

- Steering

- Miscellaneous

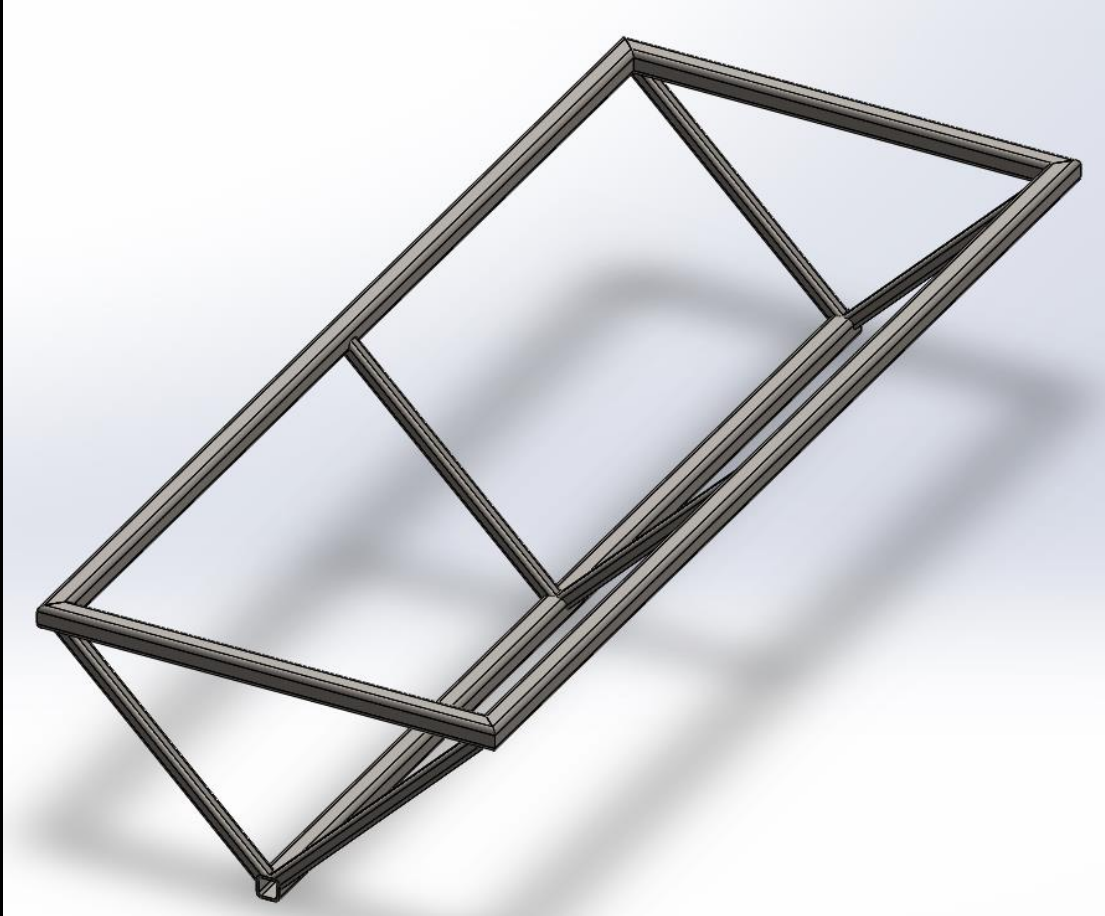




Frame



➤ Design

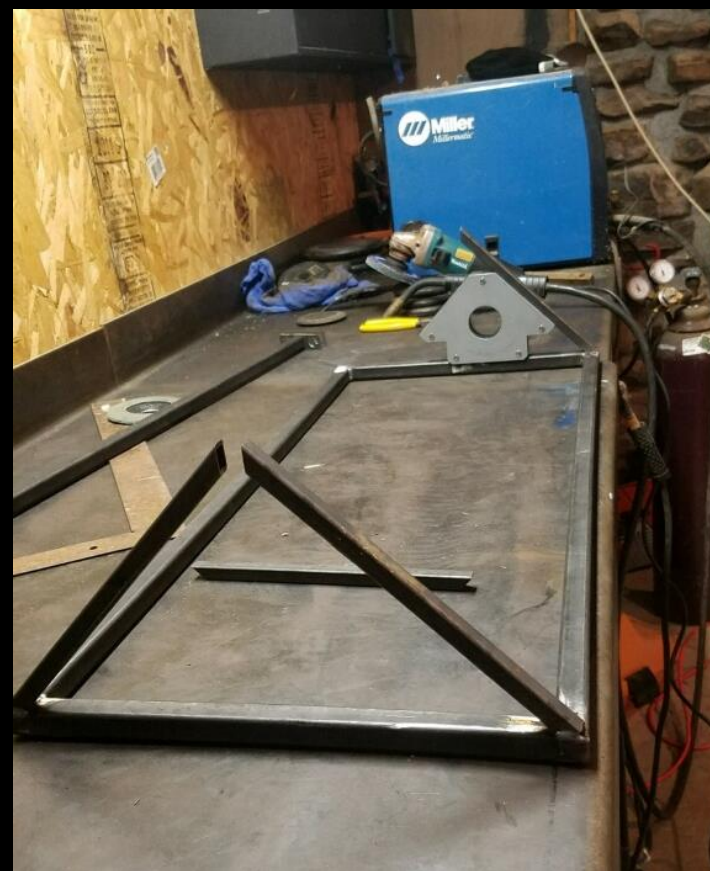


➤ As-built





Frame

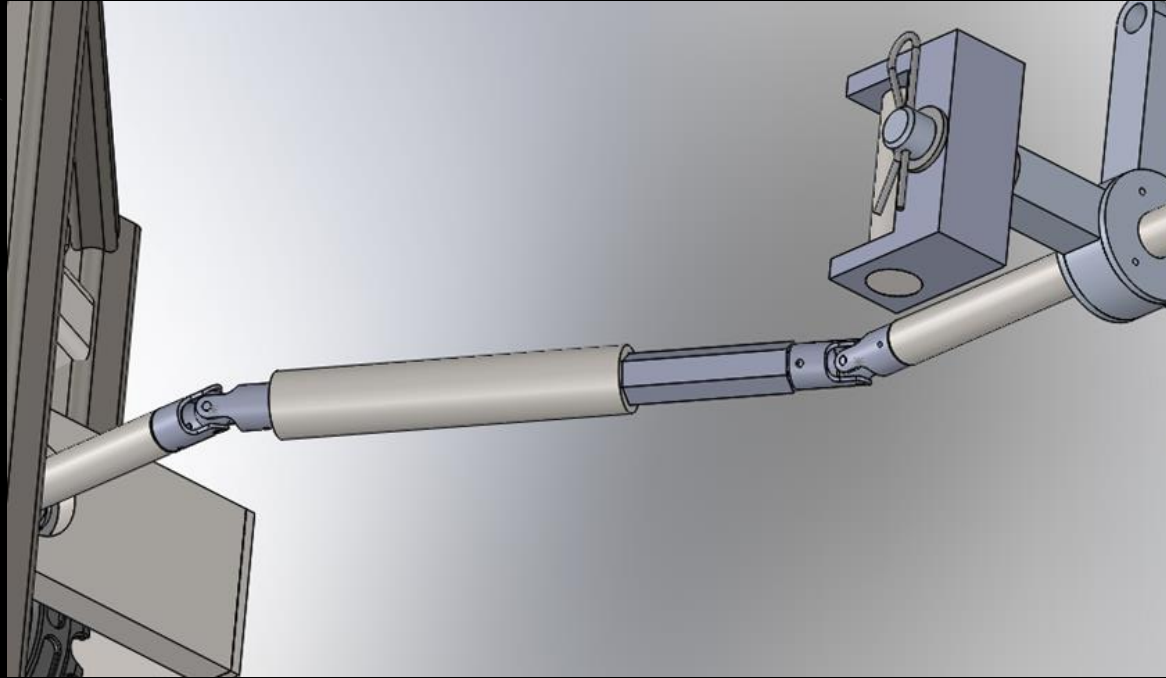




Drivetrain



➤ Design



➤ As-built





Drivetrain

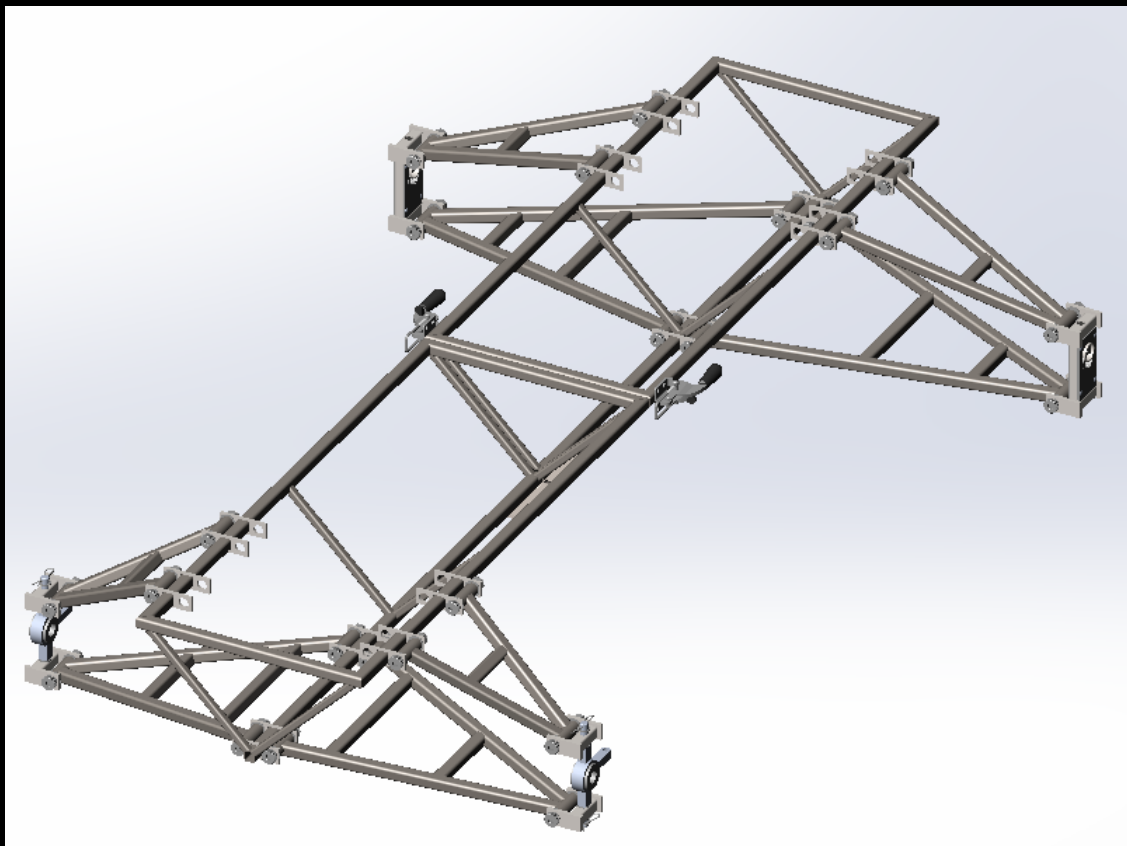
Rough mock-up





Suspension

➤ Design



➤ As-built





Suspension



A-Arm layup



Modifying suspension tabs





Waterjet

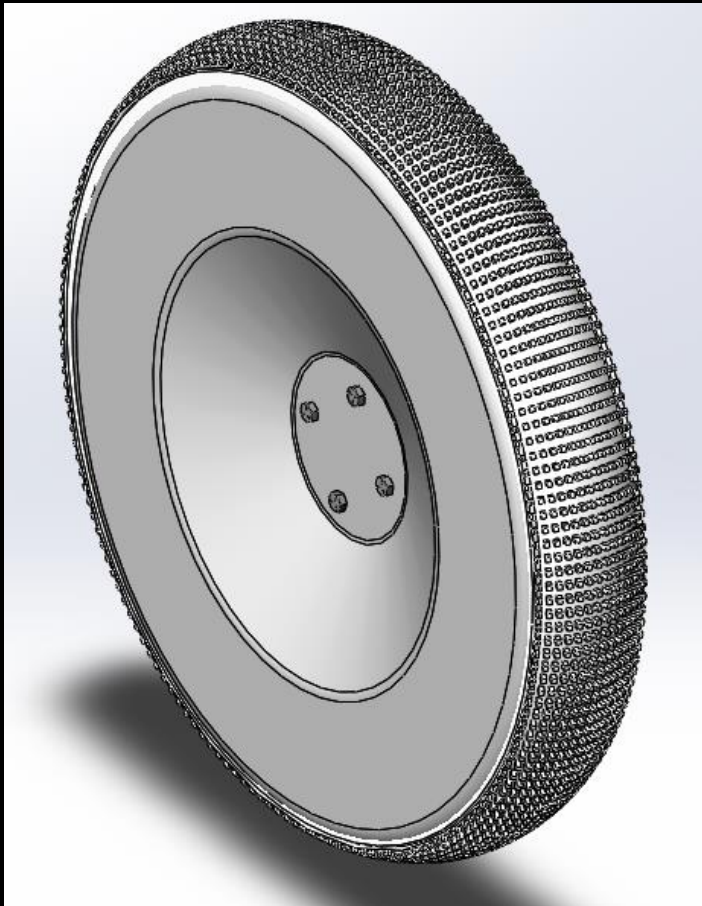
(Almost all 1/8" Plate Parts)





Wheels

➤ Design



➤ Back-up Plan

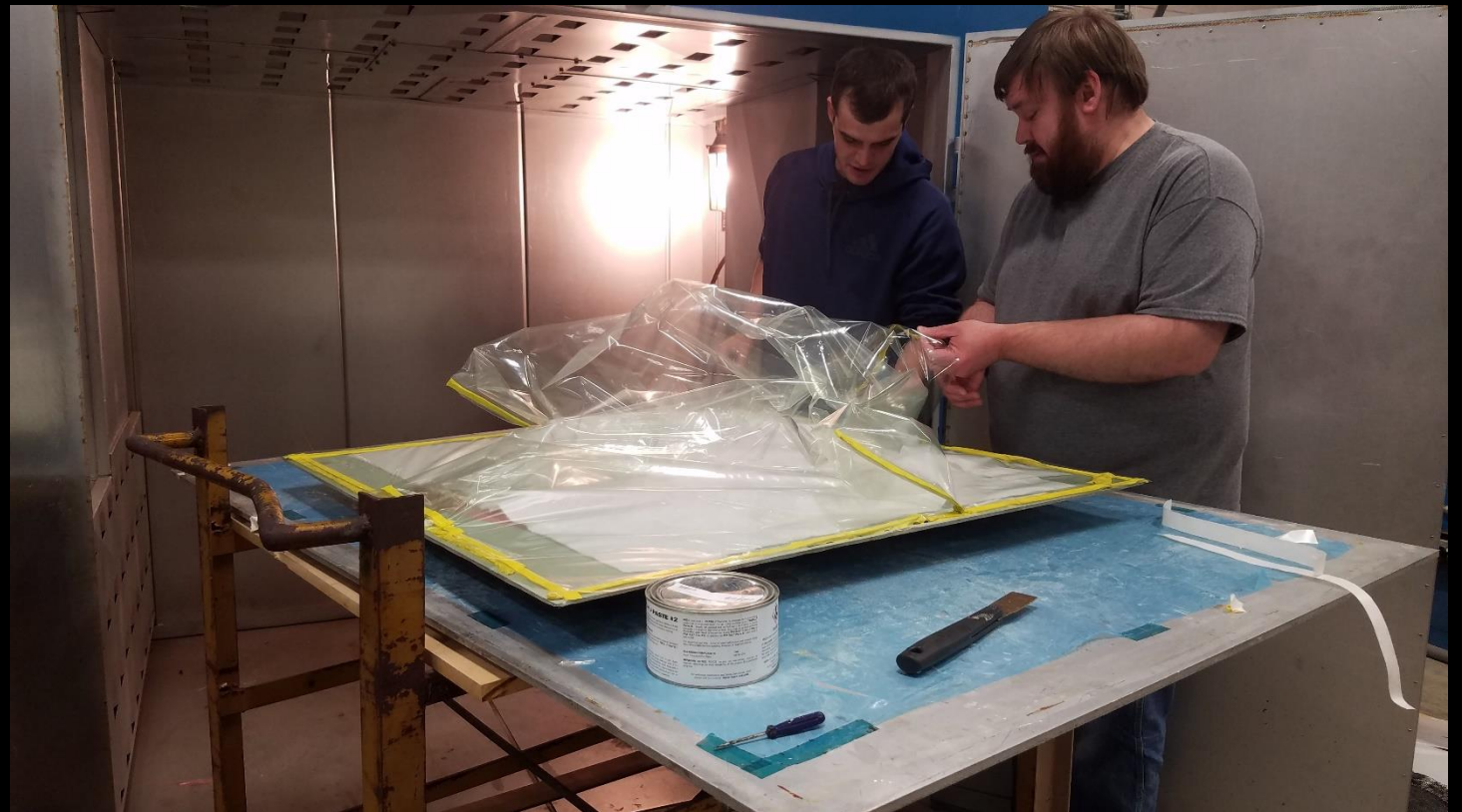


➤ As-built





Carbon Fiber





Back-up Wooden Wheels



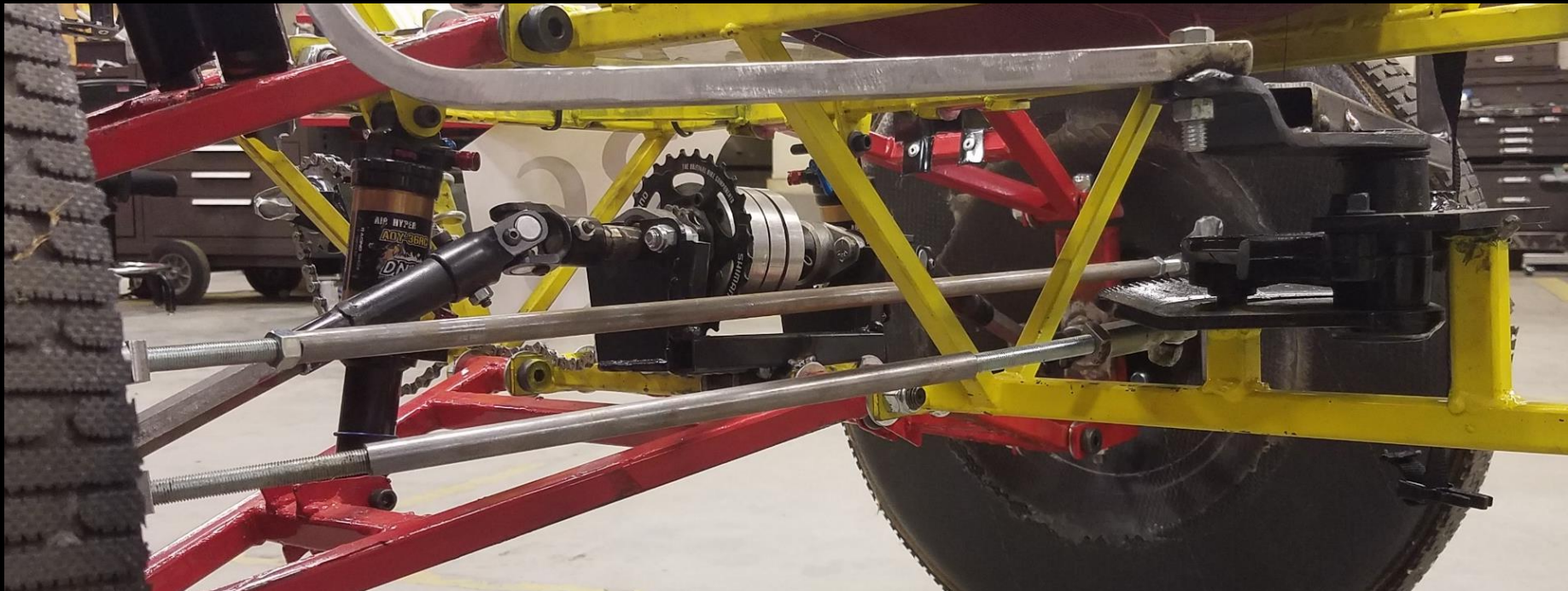


➤ Design



Steering

➤ As-built





Steering

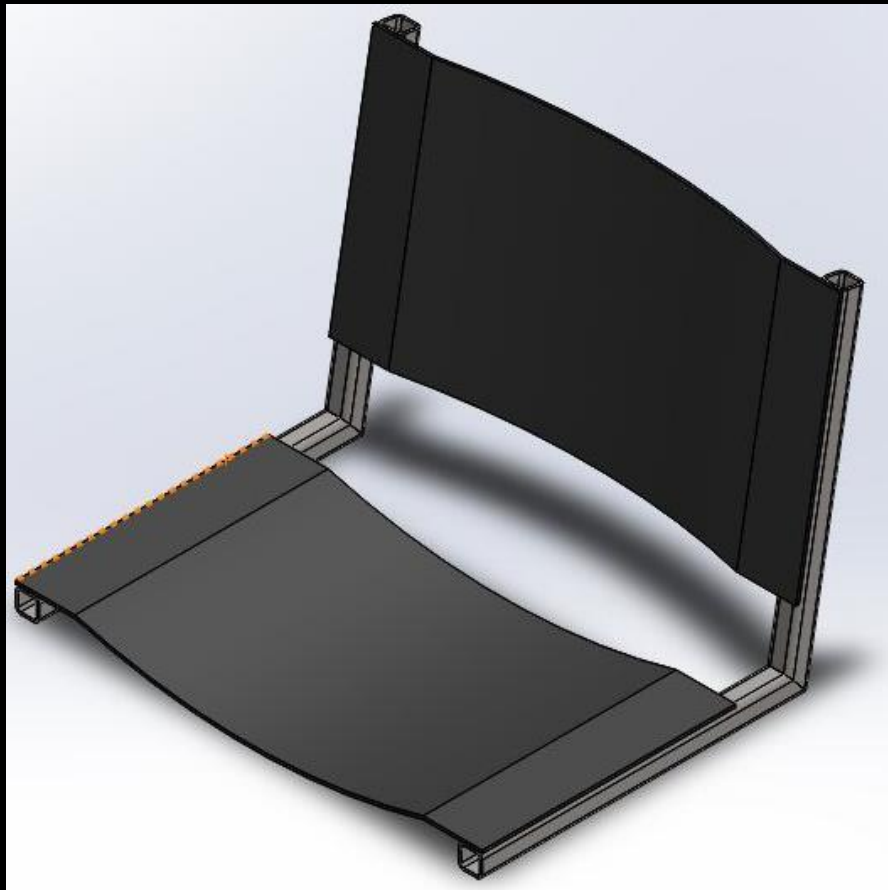




Seats



➤ Design



➤ As-built





Seats

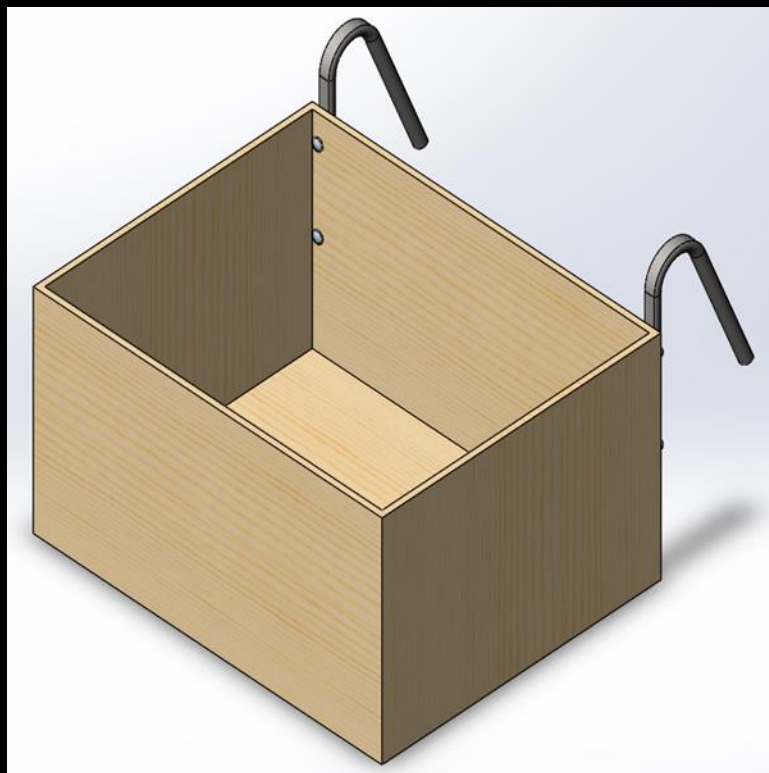




Safe Storage



➤ Design



➤ As-built

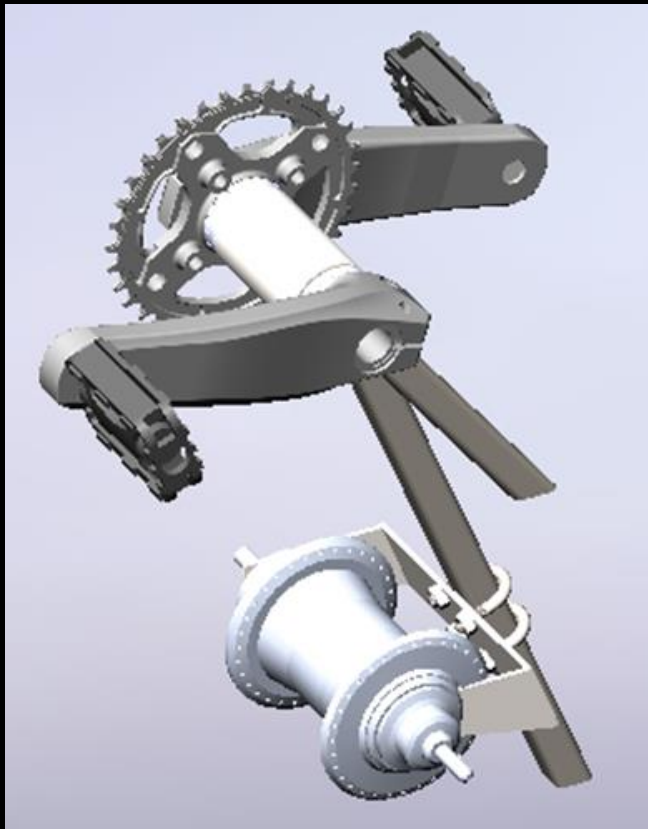




Pedal Extension Arm



➤ Design



➤ 1st Build



➤ 2nd Build

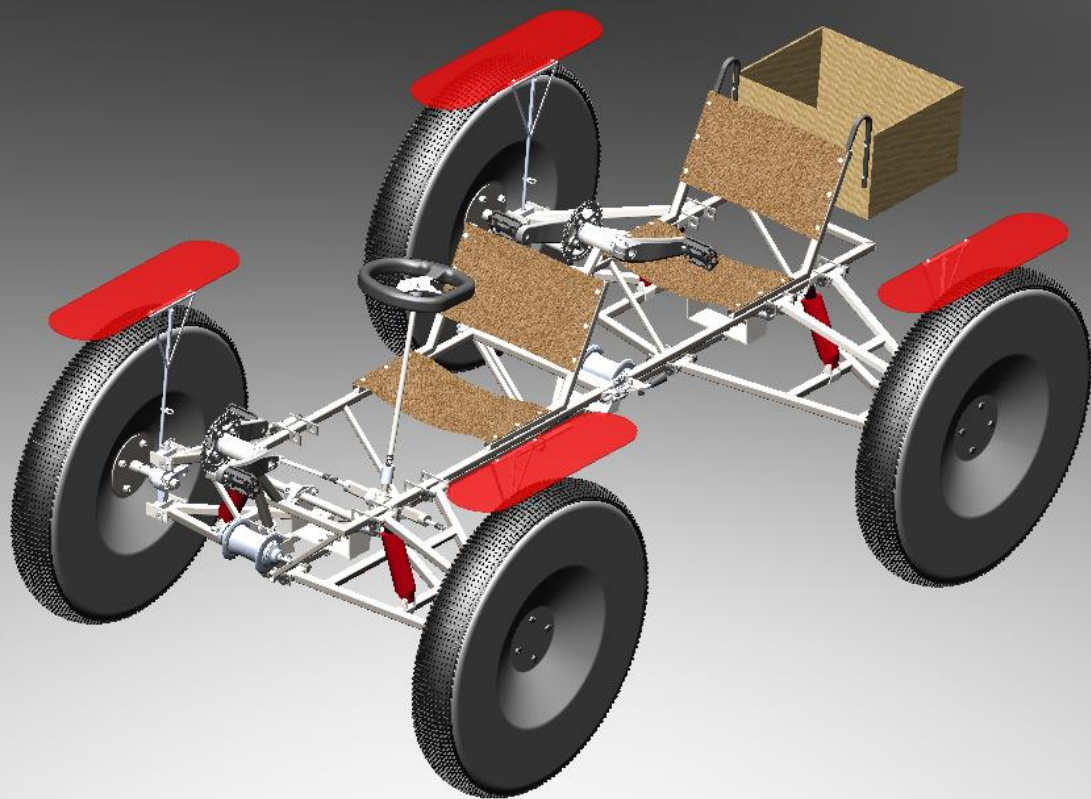




Complete Prototype



➤ Design



➤ As-built



Initial Test Results



PROS

- Sturdy
- Quick Assembly
- Size Restraints
- Gear ratio

CONS

- Turning Issues
- Overweight
- Chain slippage
- Pedal while turning



Pre-Race Solutions



- Wheels
- Steering Rods
- Bearings
- Front Spindles
- Front Differential
- 3-Wheel Drive





Bearings



➤ Original



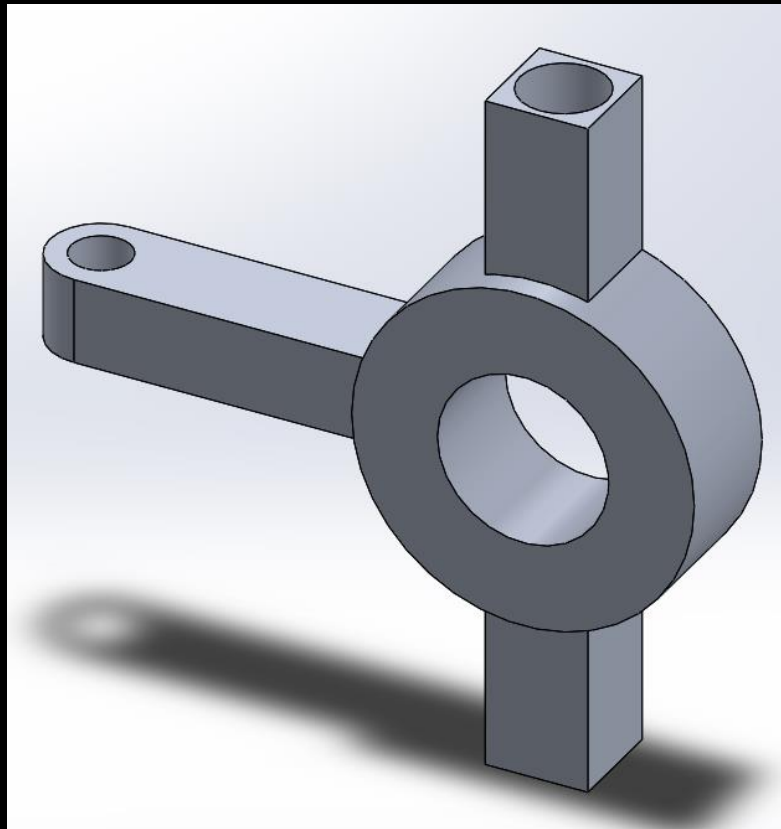
➤ Solution





Front Spindles

➤ Design



➤ As-built



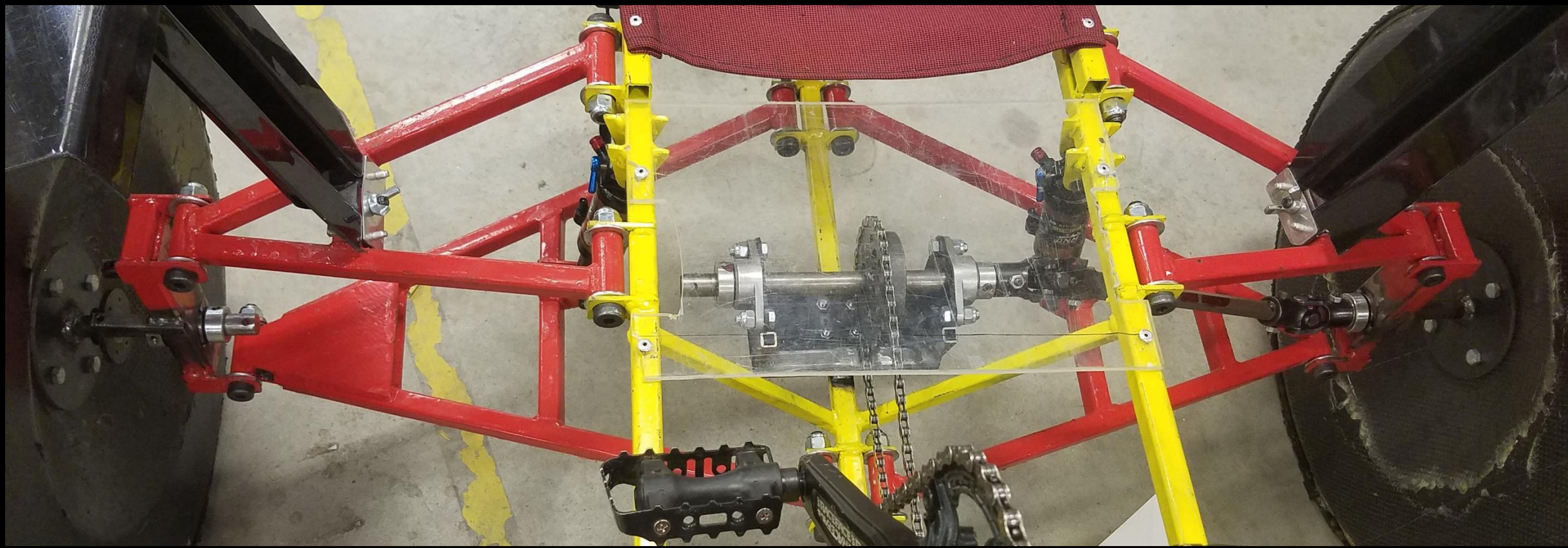


Front Differential





3-Wheel Drive





Race Results



- 66 Colleges Competed
- 1:06 Assembly Time
- Total weight: 177 lbs
- 9:15 Finish Time
- 26th Place

Trouble Shooting

(Post Race Fixes)



- Bent Axle
- Broken Brake
- Steering Control
- Fender
- Drivetrain mount



In Retrospect



- Drivetrain mounting system
- Bearing type
- Steering control
- Front and back differentials
- Rethink suspension



Questions?





References

Scheduling

ENTER START DATE:	12/1/2017			
ACTIVITY	START	END	Completed By	NOTES
Project Start	12/1/2017	5/2/2018	All	2nd Semester Breakdown
Parts Ordering	12/13/2017	12/15/2017	Mindi	McMaster, Amazon, American Floor Mats, Ebay
Waterjet Parts	12/15/2017	12/16/2017	Mindi and Austin	Suspension Brackets, Hubs, Drivetrain Brackets, Clamp Mounts, Knuckle Framing, Fender Mounts
Parts Prep 1	1/2/2018	1/9/2018	All	Prep frame parts for welding
Frame Fixtures	1/3/2018	1/5/2018	Bryan and Malik	2x4 Lumber and Plywood
Frame Welding	1/8/2018	1/15/2018	Mindi and Austin	Weld @ Gary's shop
Wheel Forming	1/16/2018	1/26/2018	Plastics	Help Plastics where needed
Parts Prep 2	1/17/2018	1/24/2018	All	Suspension, Seats, Knuckles, Drivetrain, Steering, Storage
Team Registration Deadline	1/19/2108	1/19/2108	Advisors	Advisors to complete this
Suspension/ Seat Fixture	1/22/2018	1/23/2018	Milfy and Taylor	2x4 Lumber and Plywood

Scheduling Cont'd.

Suspension Welding	1/24/2018	1/26/2018	Mindi and Austin	Weld @ Gary's shop
Seat/ Hub Welding	1/26/2018	1/27/2018	Mindi and Austin	Weld @ Gary's shop
Drivetrain Assembly	1/29/2018	1/31/2018	Bryan and Malik	U-Joint welds, Pedal mounts, Crankset brackets
Crowd Funding	2/1/2018	3/18/2018	-	Open for 45 days, up to the team to advertise (Riggs Chiropractic to put up sign in office)
Complete Assembly	2/13/2018	2/17/2018	All	Final parts added
Feedback/Media Release	2/16/2018	2/16/2018	Mindi	Signitures needed and returned to NASA
1st Run Testing	2/17/2108	2/18/2108	All	Trial run before PSU Competition
Adjustments	2/19/2018	2/26/2018	All	As needed
Continued Testing	2/26/2018	3/12/2018	All	Wheels, Suspension, etc.
STEM Outreach in KC	3/2/2018	3/2/2018	All	Introduce a Girl to Engineering Day in KC - reaches out to over 200 girls ages 14-18
Team Photos to NASA	3/9/2018	3/9/2018	Mindi	May need to add members from the team that isn't bringing their rover for competition
Compete for NASA (PSU course)	3/16/2018	3/16/2018	All	Top 2 teams to compete in Huntsville, AL (Team photo?)
Adjustments/Repairs/Tests	3/26/2018	4/10/2018	All	As needed
Full Rover Picture to NASA	3/30/2018	3/30/2018	Mindi	To ensure that the rover is completed before competition
NASA Competition	4/12/2018	4/15/2018	All	Day 1 = Run #1 and rover checks Day 2 = Run #2 and awards
Final Report Rough Draft	4/16/2018	4/20/2018	All	Overview of Spring Semester
Final Report	5/2/2018	5/2/2018	All	
Final Presentation	4/22/2018	4/27/2018	All	

Budget and Parts List 1

Part #	Description	Length (in or in2)	Tot. Amt. Needed	Material	Weight (lbs)	Qty Used	Price	Total Price	Supplier	Supplier part #
20-001A	3/4" Square Tubing	35.75	143	ASTM A36 Steel	2.03	4	Donation	Donation	Gary Burton	
20-001B	3/4" Square Tubing	14.75	59	ASTM A36 Steel	0.81	4	Donation	Donation	Gary Burton	
20-001C	3/4" Square Tubing	35.5	71	ASTM A36 Steel	2.06	2	Donation	Donation	Gary Burton	
20-001D	1/2" Square Tubing	9.34	74.72	ASTM A36 Steel	0.26	8	Donation	Donation	Gary Burton	
20-001E	1/2" Square Tubing	9.34	37.36	ASTM A36 Steel	0.26	4	Donation	Donation	Gary Burton	
20-002	1/8" Plate	4	8	ASTM A36 Steel	0.1	2	Donation	Donation	Gary Burton	
20-003	1/8" Plate	2	4	ASTM A36 Steel	0.01	2	Donation	Donation	Gary Burton	
20-005	Heavy Duty Hinge	-	-	Steel	1.07	1	\$ 15.20	\$ 15.20	McMaster Carr	# 3505T12
60-101	1/2" Plate	4	8	Aluminum	0.01	2	Donation	Donation	Shop floor	
60-102	1/8" Al Plate	6	12	Aluminum	0.004	2	Donation	Donation	Shop floor	
60-103	1/4" Aluminum Rod	72	72	Aluminum	0.10	19	\$ 5.99	\$ 9.59	Gary Burton	# 8974K22
60-104	1/8" Aluminum Plate	42	168	Aluminum	0.09	4	Donation	Donation	Shop floor	
60-105	Fender Cover	132	528	Plexi-glass	0.04	4	Donation	Donation	Fastenal	
60-106	10-24 x 3/8" Hex Head Screw	-	-	Zinc Alloy Steel	0.02	20	Donation	Donation	Fastenal	# 29875
60-107	10-24 Cap Locknut	-	-	Steel Nylon	0.21	25	Donation	Donation	Fastenal	# 1170957
60-001	3/4" Square Tubing	10	60	ASTM A36 Steel	1.20	6	Donation	Donation	Gary Burton	
60-002	Seat Cloth	1	4	Canvas	1.00	4	\$ 10.00	\$ 40.00	Hobby Lobby	
60-003	3/4" Square Tubing	10	20	ASTM A36 Steel	1.20	2	Donation	Donation	Gary Burton	
60-201	1/2" Steel Rod	15	30	ASTM A36 Steel	0.71	2	Donation	Donation	Shop floor	
60-202	Storage Box 8x12x15	-	-	Canvas	1.85	1	\$ 17.00	\$ 17.00	Wal-Mart	# 551914349
60-203	3/16" Washer	-	-	Low Carbon Steel	0.01	4	Donation	Donation	Fastenal	# 1133072
60-204	3/16" Rivet Mid length	-	-	5056 Al Grade 19	0.01	4	Donation	Donation	Fastenal	# 62181
60-205	3/16" Rivet Long length	-	-	5057 Al Grade 19	0.01	4	Donation	Donation	Fastenal	# 62182
60-206	3/16" Rivet Short length	-	-	5058 Al Grade 19	0.01	32	Donation	Donation	Fastenal	# 62179

Budget and Parts List 2

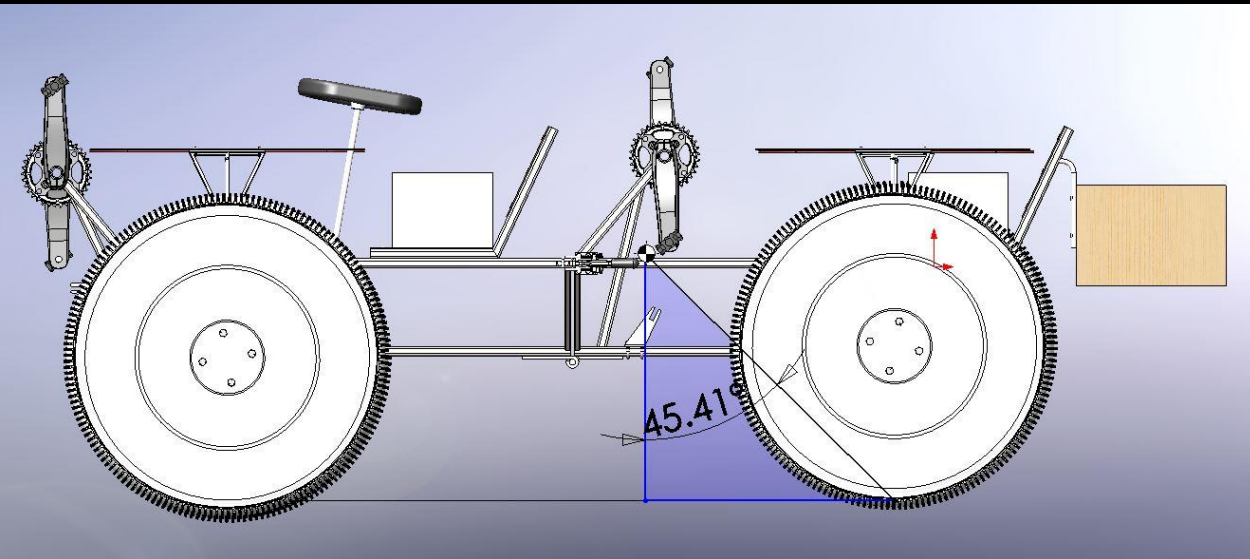
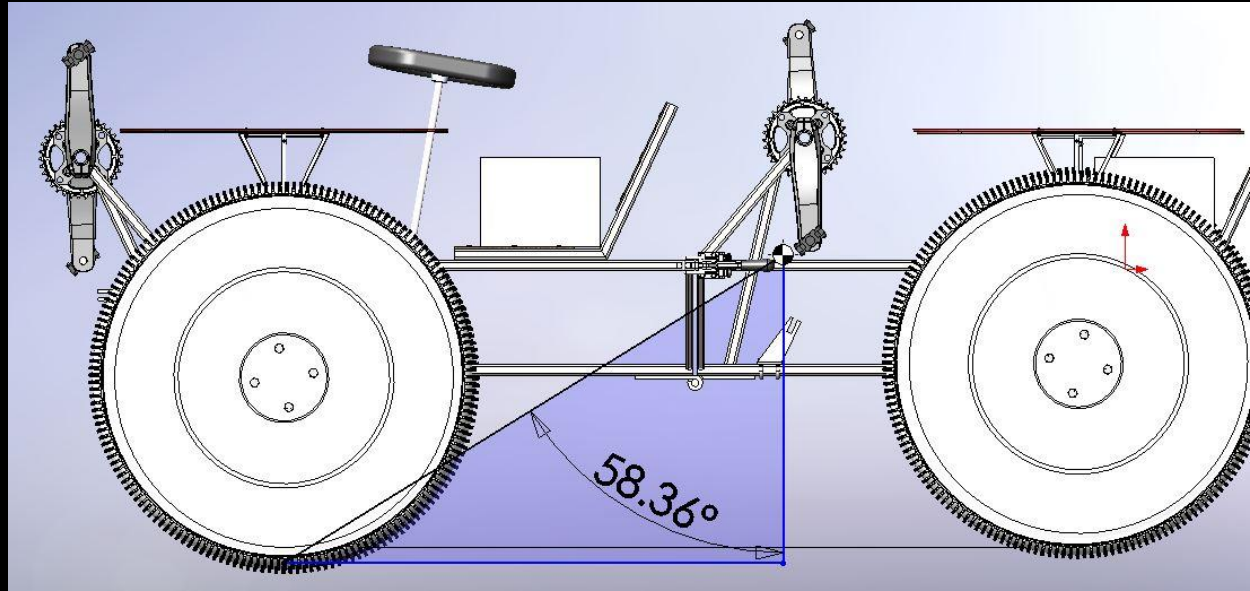
60-300	700 lb Toggle Clamp	-	-Multiple Materials	1.3	\$ 27.50	\$ 15.00	Home Depot (Online)	Model # 20307 / #207181689
60-300A	700 lb Toggle Clamp Base	-	-Multiple Materials	0.6	2 Sold with 60-300	Sold with 60-301	Sold with 60-302	
40-001	Steering Wheel	-	-Plastic	0.01	1Donation	Donation	Scraps	
40-002	1 1/2" Steel Rod	1	1ASTM A36 Steel	0.10	1Donation	Donation	Scraps	
40-003	1/2" Tube	15	15ASTM A36 Steel	0.30	1Donation	Donation	Scraps	
40-008	Lower Column Shaft	-	-Aluminum	0.08	1Donation	Donation	Shop floor	
40-009	1" Aluminum Rod	1.5	1.5Aluminum	0.09	1Donation	Donation	Gary Burton	
40-101	Steering Rack	-	-Multiple Materials	2.70	1 Donation	Donation	Scrap	
40-102	Pinion Gear and Shaft	-	-Multiple Materials	Part of 40-101	Part of 40-102	Part of 40-103	Part of 40-104	Part of 40-105
40-103	Steering Bushing	-	-Multiple Materials	Part of 40-101	Part of 40-102	Part of 40-103	Part of 40-104	Part of 40-105
40-104	Rack and Pinion Housing	-	-Multiple Materials	Part of 40-101	Part of 40-102	Part of 40-103	Part of 40-104	Part of 40-105
40-105	Steering Rack Upper Rod	-	-Aluminum	Part of 60-103 mtl.	Part of 60-103 mtl.	Part of 60-103 mtl.	Part of 60-103 mtl.	
40-201	7/8" Aluminum Plate	16	32Aluminum	0.26	2Donation	Donation	Shop floor	
40-202	1/2" Alumium Rod	2.5	10Aluminum	0.05	4Donation	Donation	Gary Burton	
40-203	3/4" Washer	-	-Zinc Alloy Steel	0.05	4Donation	Donation	Fastenal	# 11541089
40-204	1/2" Spindle Nylon Washer	-	-Zinc Alloy Steel	0.01	8Donation	Donation	Fastenal	# 11107639
40-205A	1/4" Plate	2.25	36ASTM A36 Steel	0.14	16Donation	Donation	Gary Burton	
40-205B	3/4" Square Tubing	2.25	18ASTM A36 Steel	0.13	8Donation	Donation	Gary Burton	
40-206	Spindle Cotter Pin	-	-Steel	0.02	4Donation	Donation	Fastenal	# 45286
40-301	Berg UJ3, U-Joint Ball	-	-Steel	0.03	\$ 221.00	\$ 42.00	Motion Industries	# 00506701
40-302	Berg UJ3, U-Joint Yoke	-	-Steel	0.03	\$ 221.00	\$ 42.00		
40-401	1/2" Aluminum Rod	6	-Aluminum	Part of 60-103 mtl.	Part of 60-103 mtl.	Part of 60-103 mtl.	Part of 60-103 mtl.	
40-402	1/2" Al Plate	4.5	9Aluminum	0.135	2Donation	Donation	Shop floor	
40-403	1/2" Aluminum Rod	6	-Aluminum	Part of 60-103 mtl.	Part of 60-103 mtl.	Part of 60-103 mtl.	Part of 60-103 mtl.	
40-404	Heim Joint Rod End	-	-Carbon Steel	0.03	2	\$ 5.66	\$ 11.32	McMaster Carr # 60645K441

Budget and Parts List 3

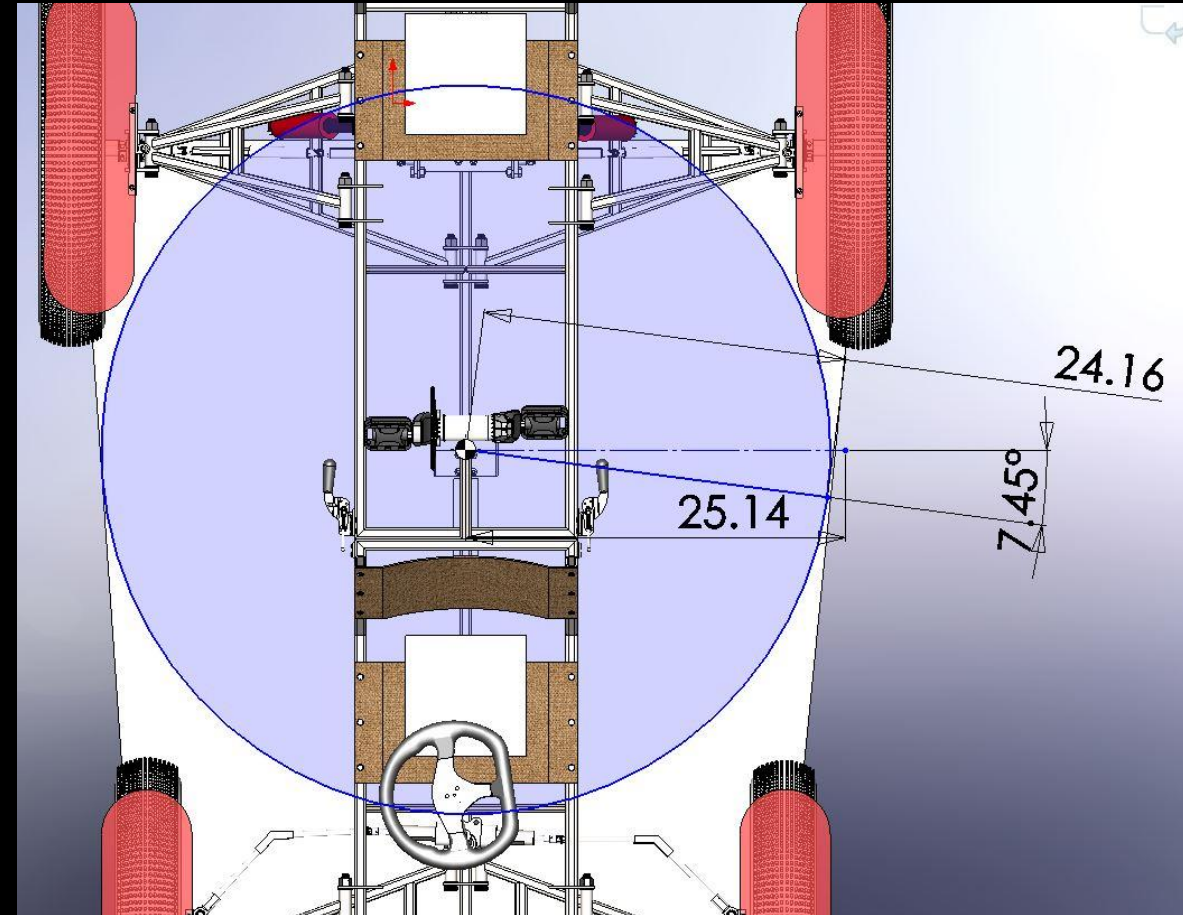
40-405	Steering Arm Nylon Washer	-	-Zinc Alloy Steel	0.001	8	Donation	Donation	Fastenal	
40-406	Steering Rod Nut	-	-Zinc Alloy Steel	0.001	2	Donation	Donation	Fastenal	
40-500AA	1/8" Plate	8	32 ASTM A36 Steel	0.27	4	Donation	Donation	Gary Burton	
40-500B	3/4" Square Tubing	4	16 ASTM A36 Steel	0.13	4	Donation	Donation	Gary Burton	
40-500C	1 1/4" Round Tubing	1	2 ASTM A36 Steel	0.06	2	Donation	Donation	Gary Burton	
30-001	1/8" Plate	3	72 ASTM A36 Steel	0.08	24	Donation	Donation	Gary Burton	
30-002A	3/4" Square Tubing	17	68 ASTM A36 Steel	3.18	4	Donation	Donation	Gary Burton	
30-002B	5/8" ID Round Tubing	2	12 ASTM A36 Steel		6	Donation	Donation	Gary Burton	
30-002C	3/4" Square Tubing	10	20 ASTM A36 Steel		2	Donation	Donation	Gary Burton	
30-002D	3/4" Square Tubing	5.75	11.5 ASTM A36 Steel		2	Donation	Donation	Gary Burton	
30-003A	3/4" Square Tubing	10.25	41 ASTM A36 Steel	1.79	4	Donation	Donation	Gary Burton	
30-003B	3/4" Square Tubing	4.25	8.5 ASTM A36 Steel		2	Donation	Donation	Gary Burton	
30-003C	5/8" ID Round Tubing	2	12 ASTM A36 Steel		6	Donation	Donation	Gary Burton	
30-011A	3/4" Square Tubing	13.75	55 ASTM A36 Steel	2.16	4	Donation	Donation	Gary Burton	
30-011B	3/4" Square Tubing	3.25	6.5 ASTM A36 Steel		2	Donation	Donation	Gary Burton	
30-011C	5/8" ID Round Tubing	2	12 ASTM A36 Steel		6	Donation	Donation	Gary Burton	
30-012A	3/4" Square Tubing	21	84 ASTM A36 Steel	3.54	4	Donation	Donation	Gary Burton	
30-012B	5/8" ID Round Tubing	2	12 ASTM A36 Steel		6	Donation	Donation	Gary Burton	
30-012C	3/4" Square Tubing	8.5	17 ASTM A36 Steel		2	Donation	Donation	Gary Burton	
30-012D	3/4" Square Tubing	4.15	8.3 ASTM A36 Steel		2	Donation	Donation	Gary Burton	
30-101	Piston Head	-	Multiple -Materials	1.00	4	Donation	Donation	Shop floor	
30-102	Piston Cylinder	-	Multiple -Materials	1.00	4	Donation	Donation	Shop floor	
30-103	1" Steel Plate	1.25	5 ASTM A36 Steel	1.00	4	Donation	Donation	Gary Burton	
30-013	1/2-13 Locknut (Gr.5)	-	-Steel Nylon	0.04	36	Donation	Donation	Fastenal	
30-014	Shoulder Bolt 5/8 x 2 3/4	-	Black Oxide Alloy -Steel	0.32	8	Donation	Donation	Fastenal	# 26376

Budget and Parts List 4

30-015	Shoulder Bolt 5/8 x 2 1/2	-	- Black Oxide Alloy Steel	0.32	24	Donation	Donation	Fastenal	# 26376	
30-016	5/8" Washer	-	- Zinc Alloy Steel	0.04	60	Donation	Donation	Fastenal		
							\$			
30-017	3/4" ID Needle-Roller Bearing	-	- Steel	0.05	8		11.62	92.96	McMaster Carr	# 5905K136
						\$				
N/A	Sample Containers by JUVITUS	-	- PET Plastic	-	1	10.00		10.00	Wal-Mart	
70-001	1/8" Plate	36	144 ASTM A36 Steel	0.83	4	Donation	Donation	Gary Burton		
						\$				
70-002	Wheel tread	82	328 Nitrile Rubber	6.5	4	29.16		116.64	Americanfloormats.com	ERSSSP or ERS
70-003	1" Steel Bar	1	4 ASTM A36 Steel	0.13	4	Donation	Donation	Gary Burton		
70-004	Wheel	-	- E-Glass	11.00	4	Donation	Donation	Plastics		
70-005	3/8-16 x 1" Bolt (Gr.5)	-	- Zinc Alloy Steel	0.01	16	Donation	Donation	Fastenal		
70-006	3/8-16 Locknut (Gr.5)	-	- Zinc Alloy Steel	0.003	16	Donation	Donation	Fastenal		
50-003A	3/4" Square Tubing	14	14 ASTM A36 Steel	0.50	1	Donation	Donation	Gary Burton		
50-003B	3/4" Square Tubing	8.5	8.5 ASTM A36 Steel	0.68	1	Donation	Donation	Gary Burton		
50-004A	3/4" Square Tubing	10.25	10.25 ASTM A36 Steel	0.50	1	Donation	Donation	Gary Burton		
50-004B	3/4" Square Tubing	13.5	13.5 ASTM A36 Steel	0.78	1	Donation	Donation	Gary Burton		
						\$				
50-002 and 50-022	3/4" Steel Rod	36	36 ASTM A108	3.45	1	15.50		15.50	Gary Burton	# 8920K195
						\$				
50-011	3/4" Steel Rod	36	36 ASTM A109	3.45	1	15.50		15.50	Gary Burton	
50-012	3/4" Shaft Clamping Collar	-	- ASTM A108	0.17	8	Donation	Donation	Fastenal	# 0403733	0.24 Online Price
							\$			
50-005	1 3/4" Hollow Tube	3	6 Steel	0.28	2		6.00	12.00	Nova Cycle Supply	Sku202405
50-007 and 50-008	104mm BCD Crankset	-	- Steel	2.00	1	Donation	Donation	Shop floor		
							\$			
50-007 and 50-008	104mm BCD Crankset	-	- Steel	2.00	1		50.00	50.00	Amazon	CYSky
50-010	Pedal	-	- Plastic	0.50	4	Donation	Donation	Shop floor		
							\$			
50-009	32 Tooth Chain Ring	-	- Aluminum	0.25	1		20.00	20.00	Amazon	
							\$			
	3/4" x 3/4" Dia U-joint	-	- Forged Steel	0.06	8		19.00	152.00	Amazon	Tomsclassic - 34r34rsb
							\$			
50-016	Mounted Sleeve Bearing	-	- Bronze Aluminum	0.16	4		15.51	62.04	McMaster Carr	# 5912K18
							\$			
Multiple Parts	5/8" Hex Stock	36	36 ASTM A108	3.45	1		13.69	13.69	Gary Burton	# 6512K221
							\$			
	1/2 x 5/8 Deep drive socket	-	- Steel	0.25	4		7.83	31.32	Amazon	Tekton
							\$			
N/A	KMC X9 93 9 Speed Chain	-	- Steel	1.00	4		18.00	72.00	ChainReactionCycles.com	sku432971
50-018 and 50-017	1/8" Plate	28.5	57 ASTM A36 Steel	1.25	2	Donation	Donation	Gary Burton		
50-013 and 50-014	1/8" Plate	18	36 ASTM A36 Steel	1.25	2	Donation	Donation	Gary Burton		
						\$				
50-024	5/8" Hex Stock	6	4 Low Carbon Steel		1	13.69		13.69	McMaster Carr	6512K221 3ft length
						\$				
50-025	5/8" Deep drive socket	-	- Chrome plated steel		4	11.19		44.76	McMaster Carr	5545A283
						\$				
50-026	25 tooth ANSI 40 sprocket	-	- Steel	2.46	2	40.50		81.00	McMaster Carr	6236K322
50-015	U-Bolt 3/4" x 1 1/8"	-	- Black Oxide Alloy Steel	0.06	8	Donation	Donation	Fastenal		
						Grand Total	\$	995.21		

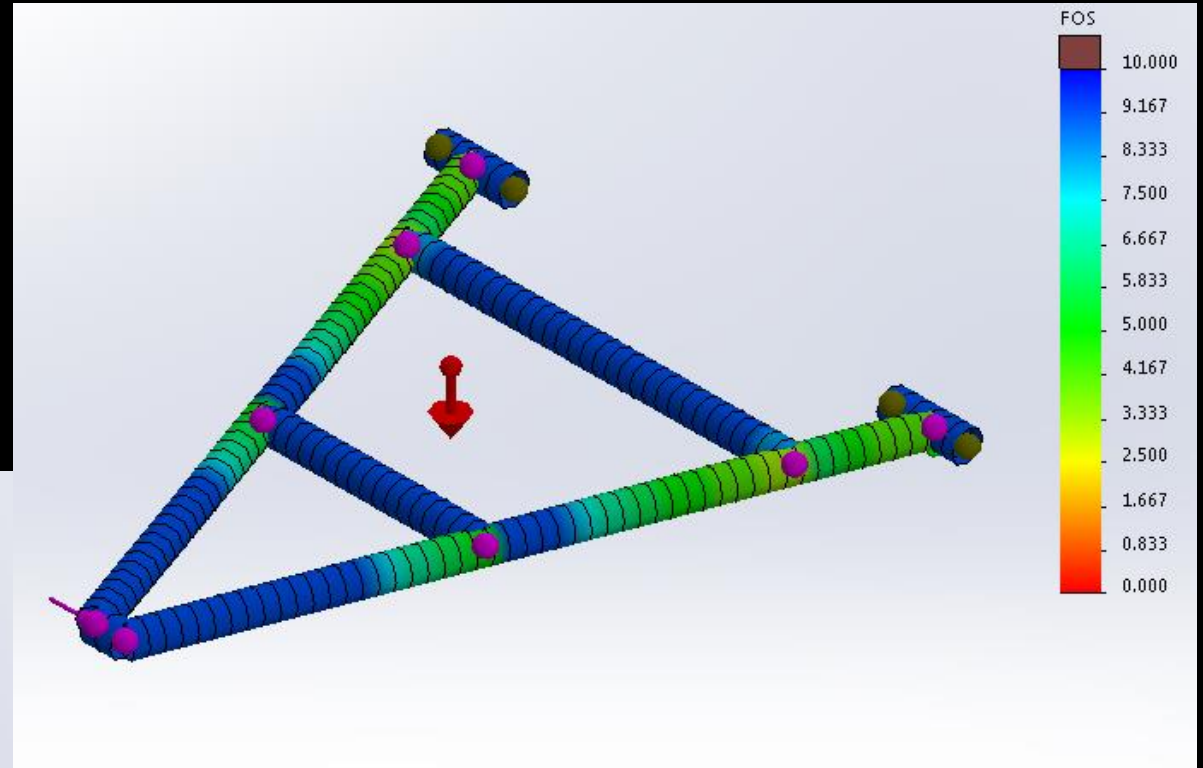
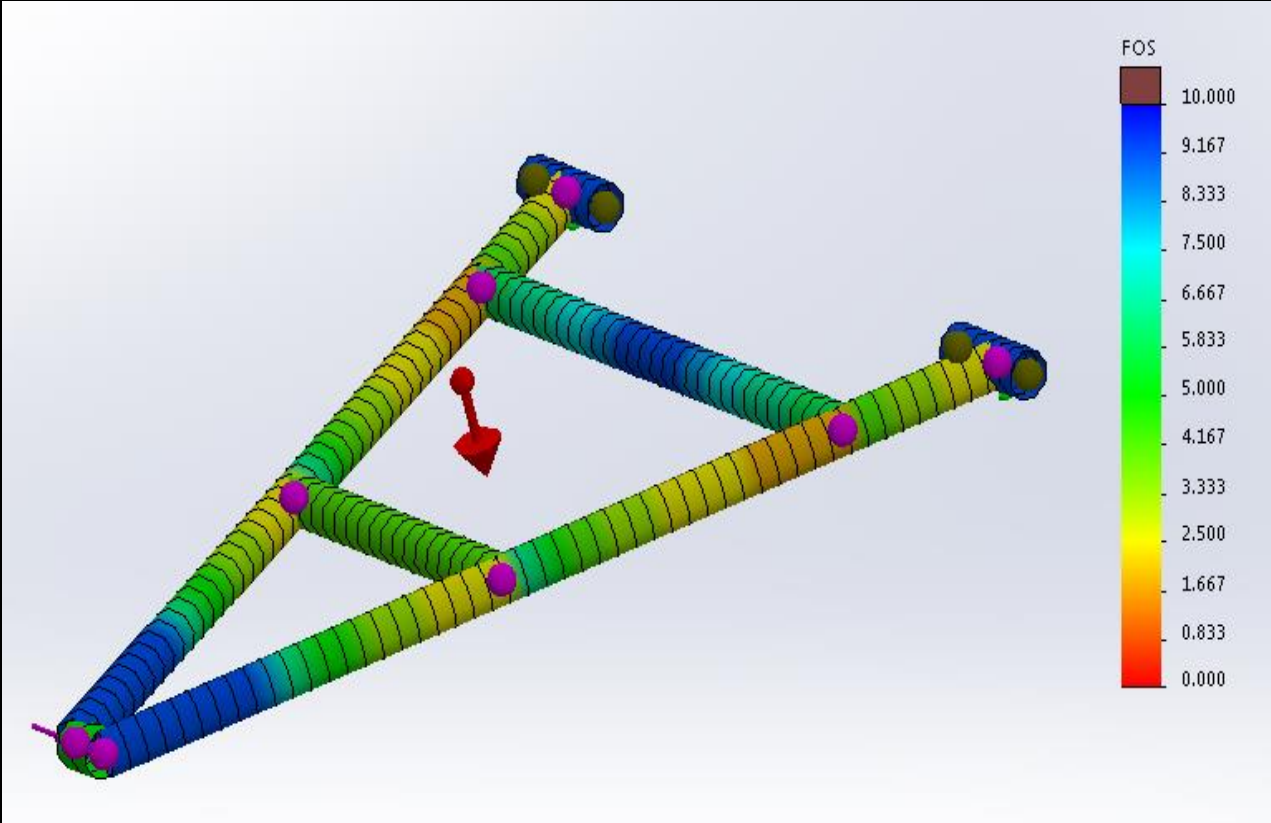


Stability



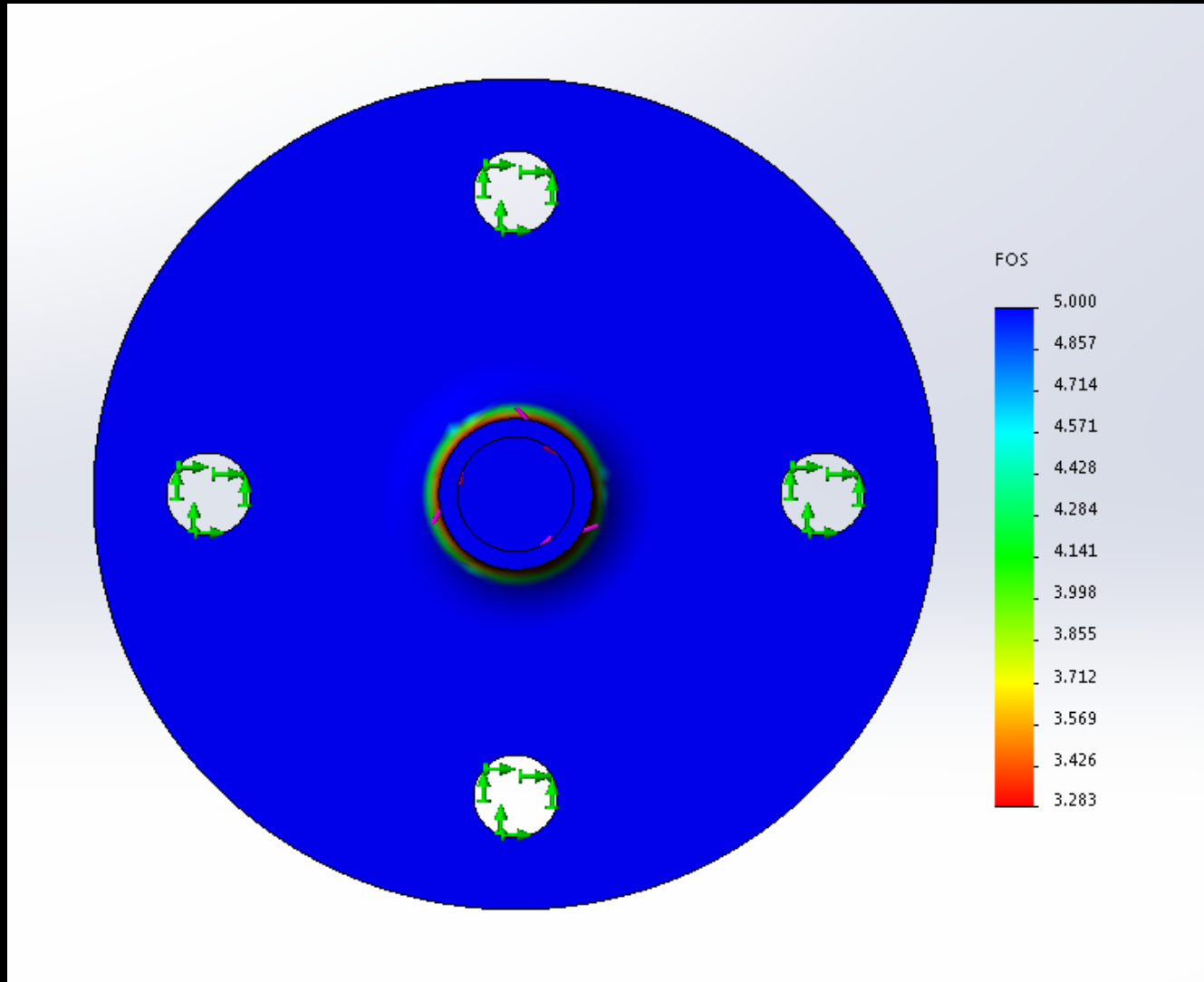
Suspension FEA

Front

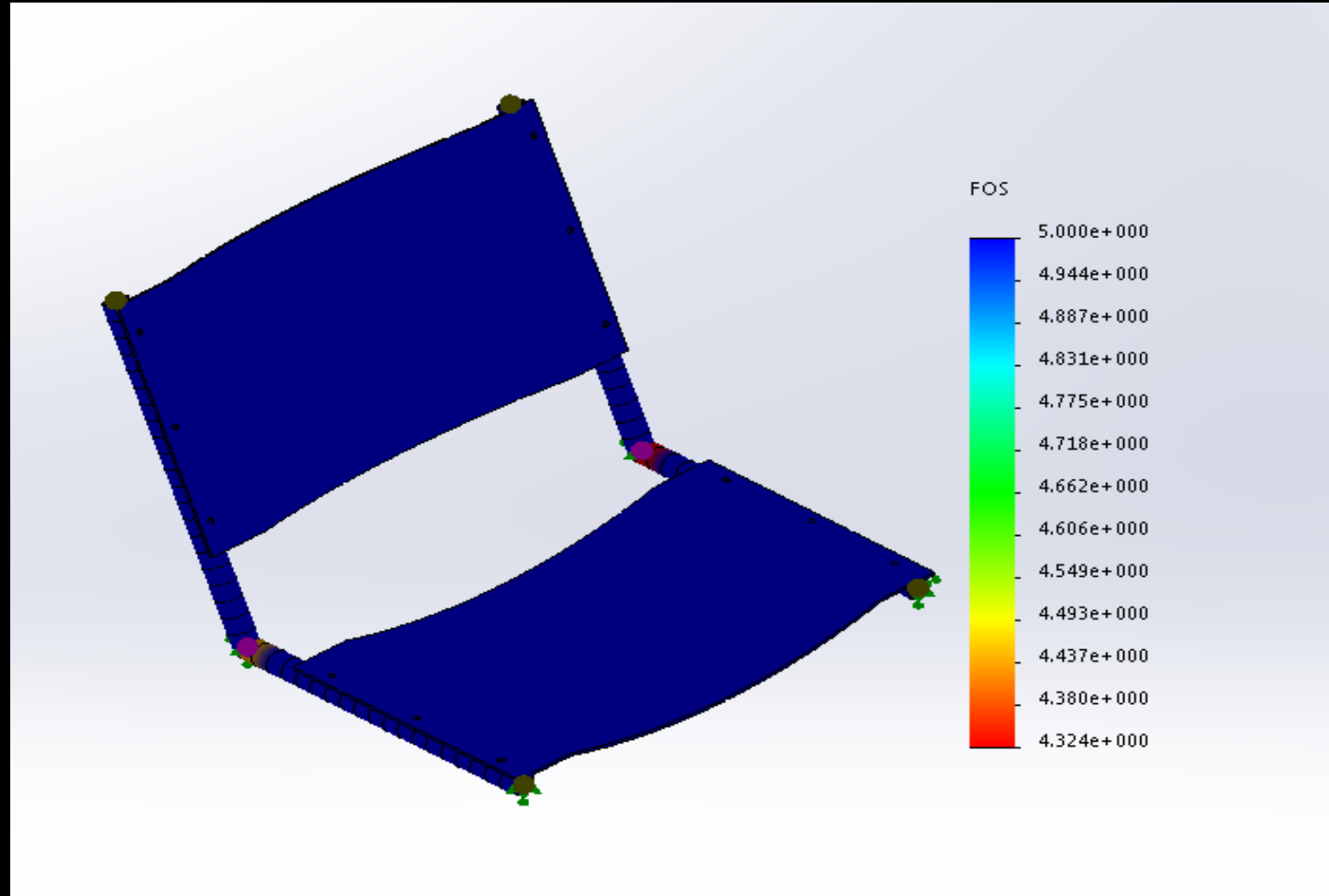


Rear

Hub FEA



Seat FEA





2018 Rover Challenge College Results

April 13, 2018

Ranking	TeamID	SchoolName	Division	Total Points	Excursion Time	No Official Points Awarded	Rover Weight
1	59	University of Alabama in Huntsville - Team 1	College	61	4:51		213
2	13	University of Colorado Denver	College	49	5:01		158
3	92	East Carolina University*	College	48	5:24		262
4	38	Auburn University	College	43	5:47		159
5	23	Tennessee Tech University - Team 1	College	38	6:03		250
6	98	University of Georgia College of Engineering*	College	35	4:31		240
7	99	University of the District of Columbia*	College	30	6:29		195
8	33	Southwestern Oklahoma State University	College	30	6:34		182
9	46	Owensboro Community and Technical College	College	27	6:43		231
10	17	Southern Illinois University - Team 1	College	24	4:50		161
	2	University of PR at Humaco - Team 2	College	57	13:58	NOPA	117
	6	University of PR Mayaguez	College	55	7:50	NOPA	169
	4	Rhode Island School of Design	College	54	13:00	NOPA	100
	1	University of PR at Humaco - Team 1	College	48	14:51	NOPA	119
	22	Middle Tennessee State University - Team 2	College	43	8:11	NOPA	280
	34	Louisiana State University	College	36	9:17	NOPA	200
	9	University of Central Missouri Team 1	College	34	8:17	NOPA	182
	24	Tennessee Tech University - Team 2	College	28	7:14	NOPA	215
	39	Tecnológico de Monterrey	College	24	10:14	NOPA	152
	25	Ohio State University	College	23	7:26	NOPA	188
	18	Southern Illinois University - Team 2	College	22	7:29	NOPA	170
	50	University of Houston - Team 1	College	20	8:40	NOPA	203
	10	University of Central Missouri Team 2	College	20	11:31	NOPA	184
	69	Bol futuro SRL*	College	20	12:06	NOPA	232
	79	Indo Swiss Training Centre - Team 1*	College	19	7:23	NOPA	203
	26	Pittsburg State University Team 1	College	19	9:15	NOPA	177
	60	University of Alabama in Huntsville - Team 2	College	18	7:22	NOPA	131

* Denotes Rookie Teams

NOPA Designates Teams That Did Not Complete The Course In Under 7 Minutes

Almost met goal weight



Volume Restraints Met

