Rover 2

https://www.nasa.gov/

https://www.jpl.nasa.gov/missions/mars-science-laboratory-curiosity-rover-msl/

Team Introductions:

Ahmad Alomran
Major: **Mechanical**
Emphasis: **Design**

Ali Al Jarah
Major: **Mechanical**
Emphasis: **Design**

Logan Dillinger
Major: **Manufacturing**

Michael Deters
Major: **Mechanical**
Emphasis: **Design**

Shailyn Crisp
Major: **Mechanical**
Emphasis: **Design**

Wyatt Dodds
Major: **Mechanical**
Emphasis: **Manufacturing**

Problem Statement

"As you may know, I am a mechanical engineer."
~Bill Nye…the SCIENCE GUY

Design and Manufacture a vehicle to traverse a simulated extraterrestrial course that will compete with other students from around the world in the NASA Human Exploration Rover Challenge.

Purpose

The purpose of this event is to engage students worldwide in the next phase of space exploration.

Goal

To manufacture a rover that will complete all course obstacles and newly added tasks.

Stakeholders

- NASA
- Pittsburg State University
- Future PSU Students
- Riders

Design Requirements

Team Requirements

- Weight- 190 lbs
- Folds in two places
- 2 brakes
- 4 Wheel Independent
- 2 Min assembly time
- Storage Container

NASA Requirements

- Turning radius 15ft
- Ground clearance 15in
- Volume 5x5x5
- Dust shield -120 in^2
- Seat belts
- Design & Manufacture wheels
- Safe to drive
- Human Powered

Semester 1 Rover Design

Overall Weight

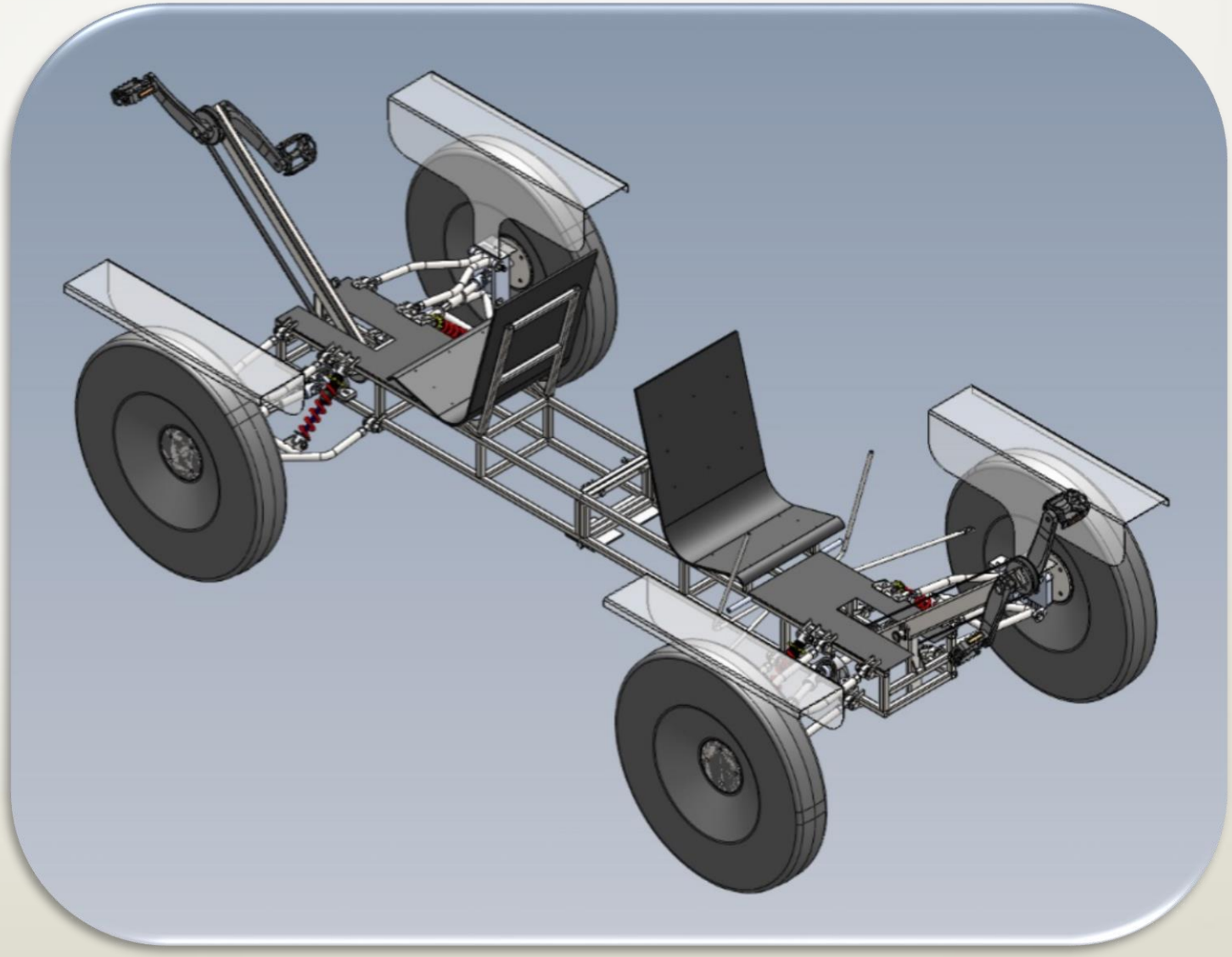
186.6lbs

Ground Clearance

18.9″

Turning Radius

11′

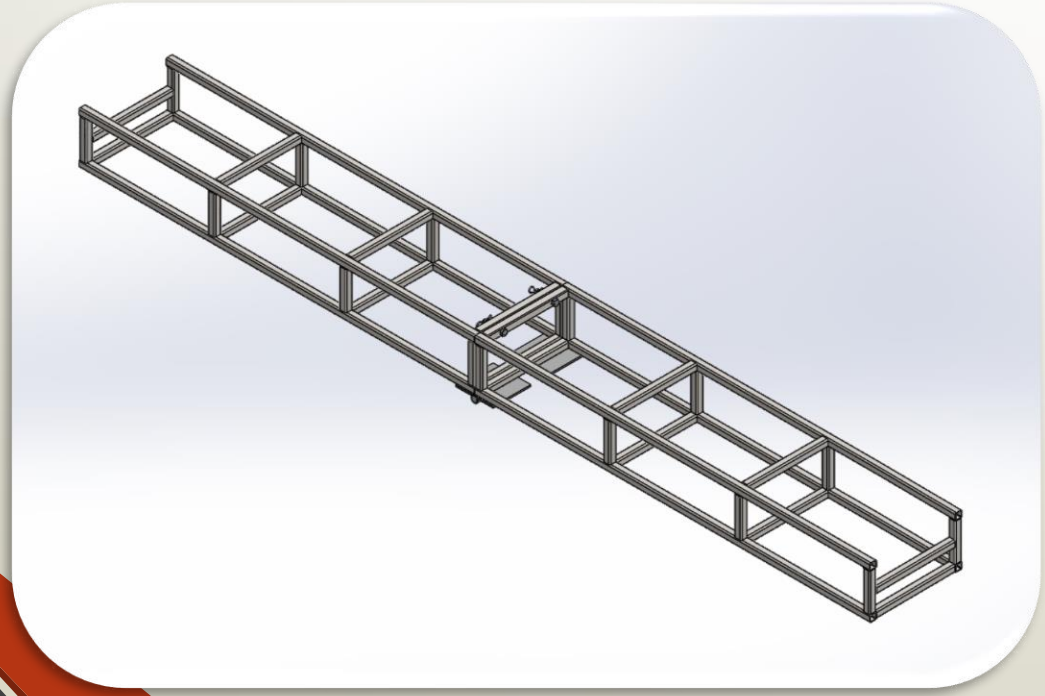


Frame

Material

Mild Carbon Steel

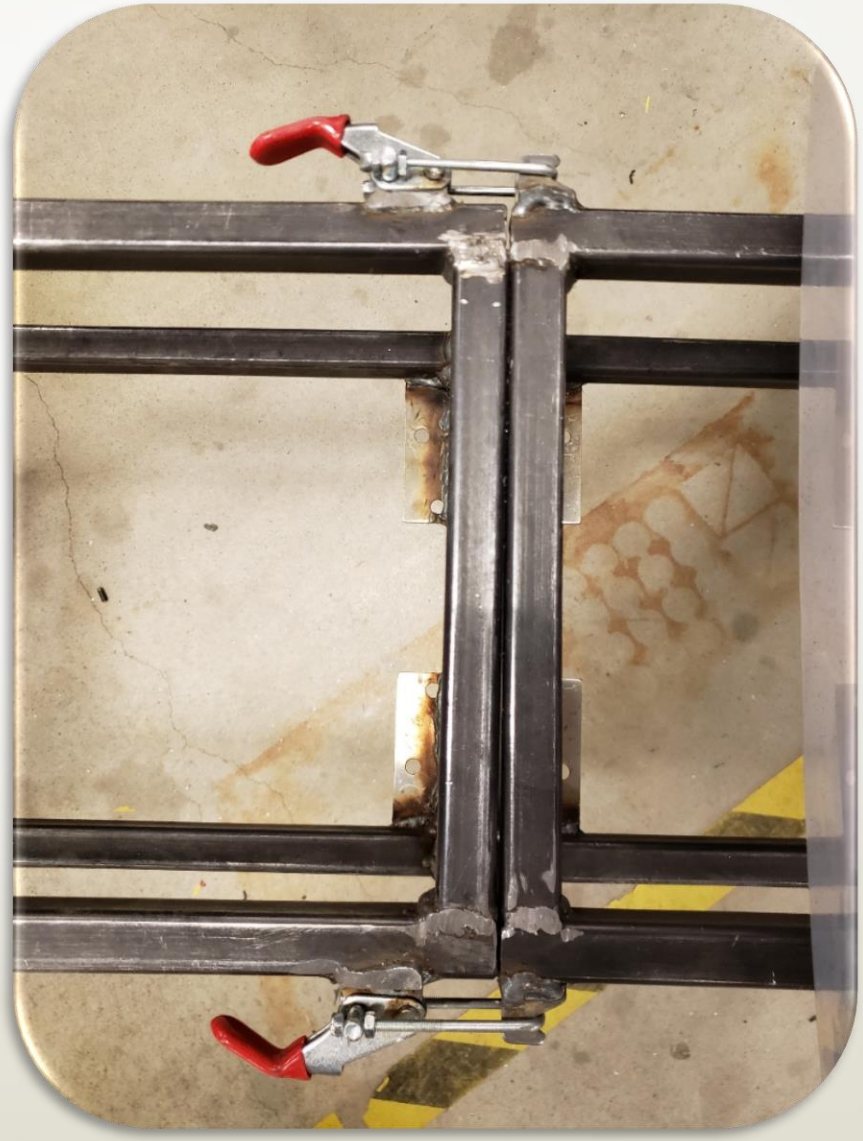
¾" X ¾" .083"- wall thickness



Frame: Modification

- how the sections locked together

- Instead of a bolt and pin, switched to two toggle clamps welded on



Frame: Modification

First set cut out on CNC Plasma Cutter

- Due to poor quality they were scrapped

These were cut on the Waterjet

Front & Back Suspension

4 Wheel Independent Suspension:

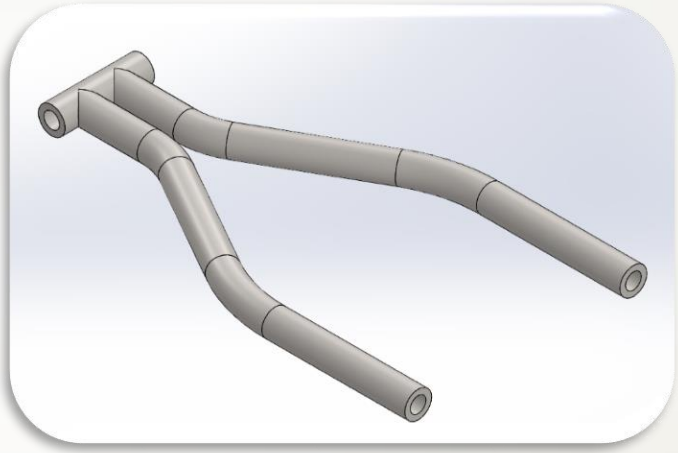
Material

1020 Steel-DOM Seamless Steel

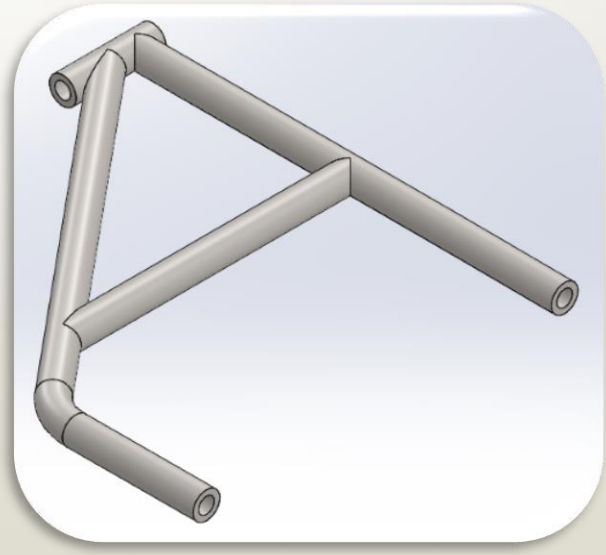
http://www.metalbythefoot.com/

⊖¾" .156"- wall thickness

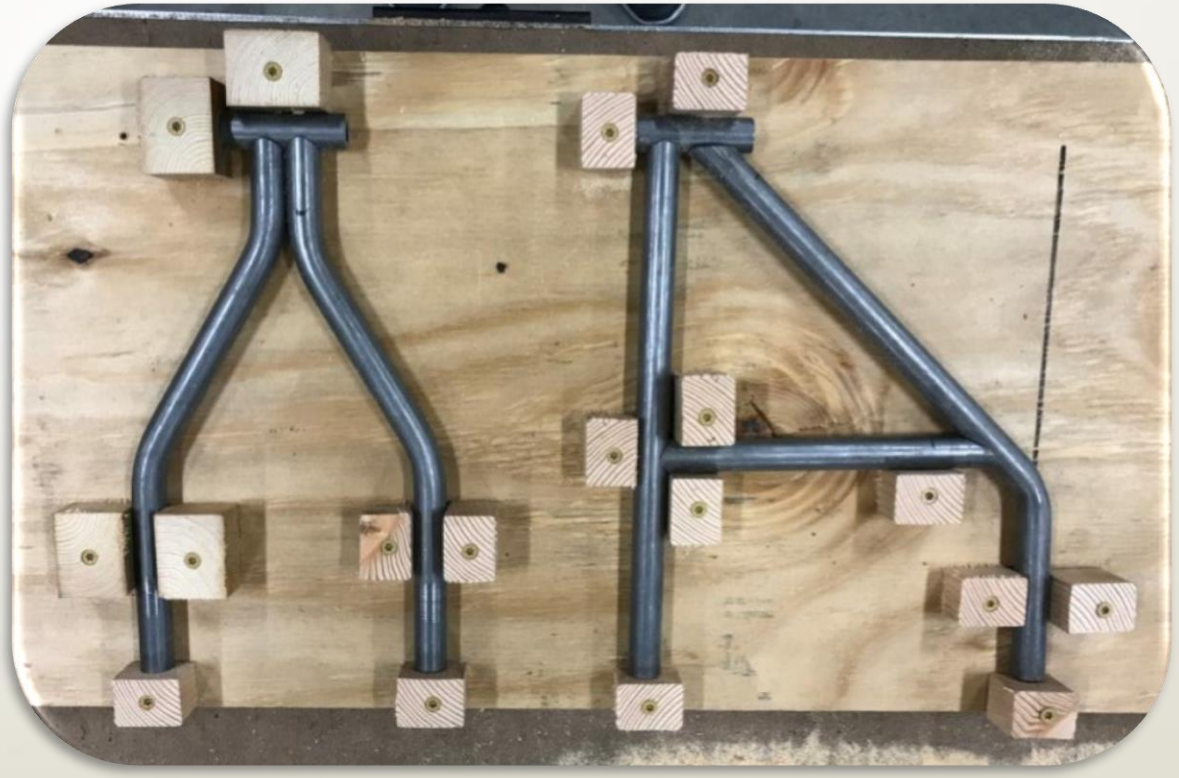
Top A-Arm



Bottom A-Arm



Front & Back Suspension



Front & Back Suspension

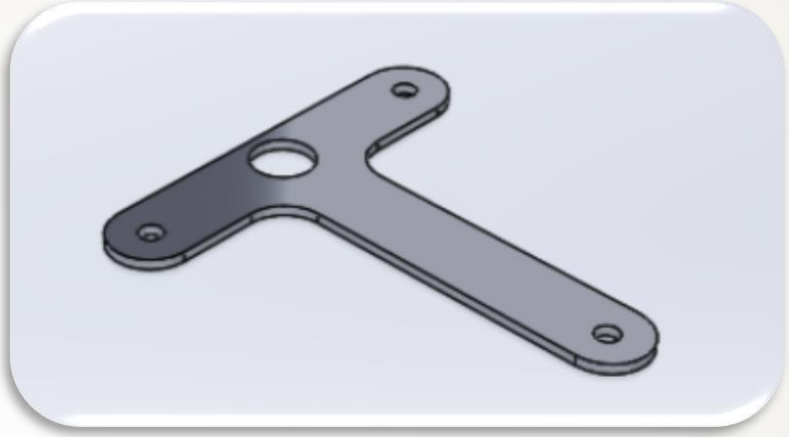
Steering

Material

1020 Steel

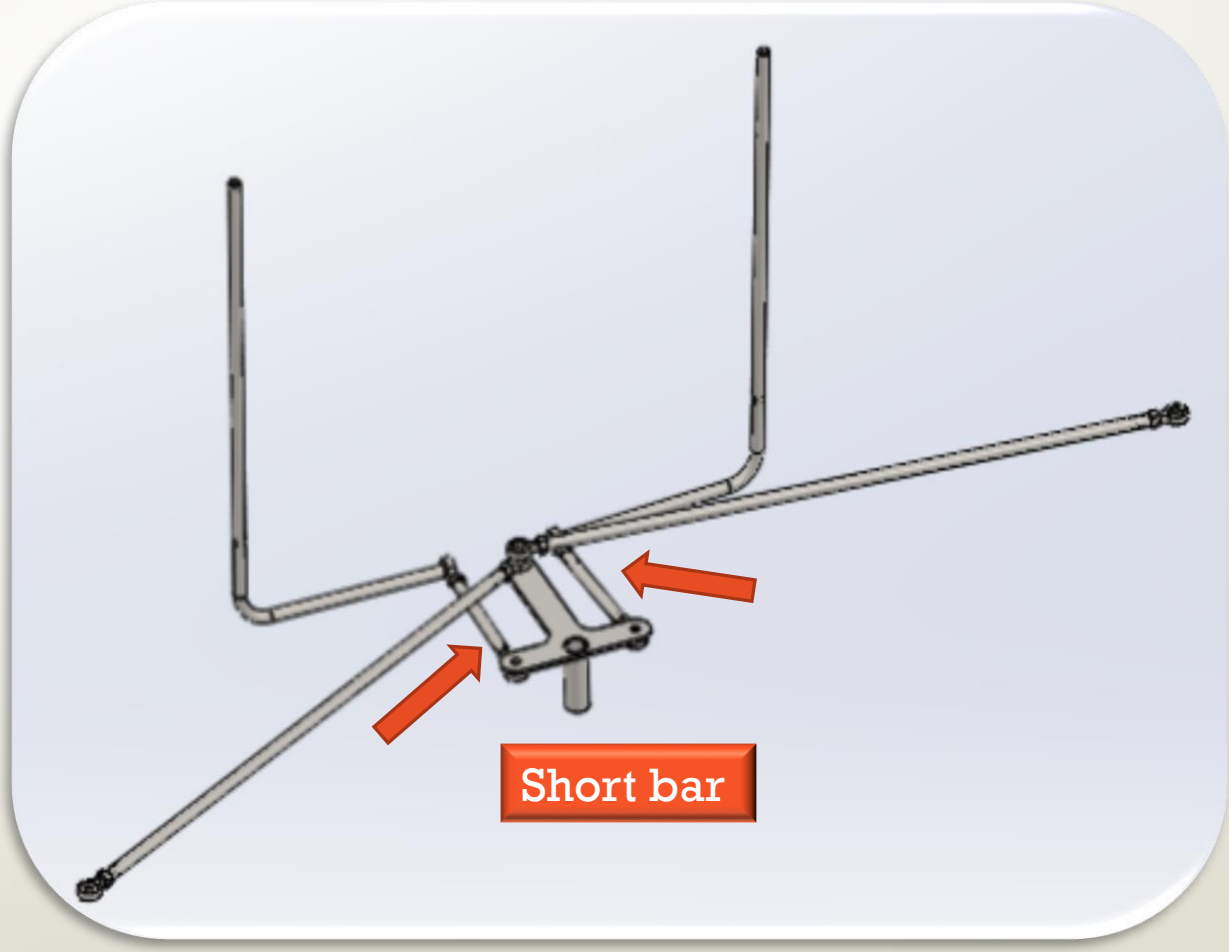
http://www.metalbythefoot.com/

¾" X ¾" .083"- wall thickness



Steering: Modification

- Short bar cut out of design
  - Handles connected straight to top of T-plate



Steering

Drivetrain

"A person who never made a mistake never tried anything new"

-Albert Einstein

Drivetrain: Modifications

- Single needle bearing damaged axle
  - Added extra needle bearing to base of pedal arm

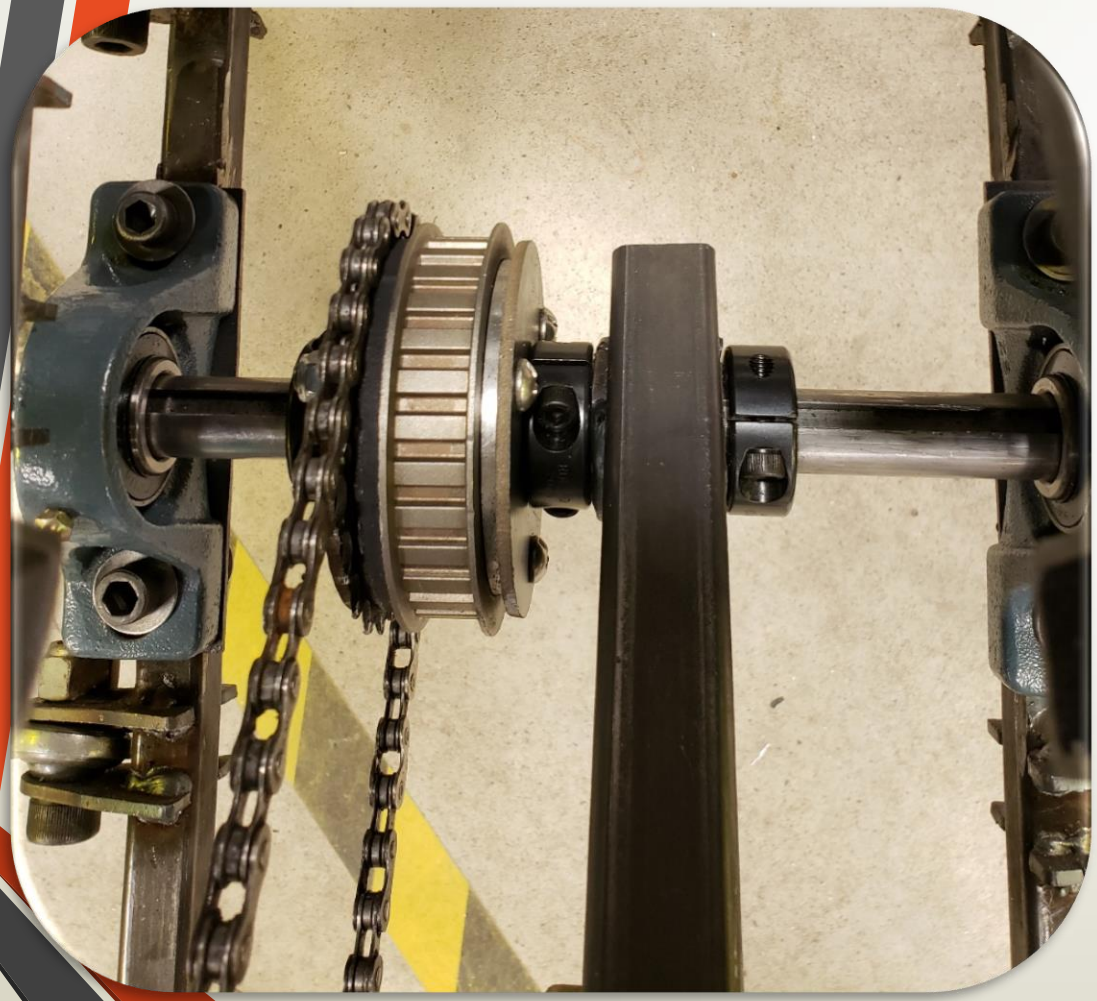
Drivetrain: Modifications

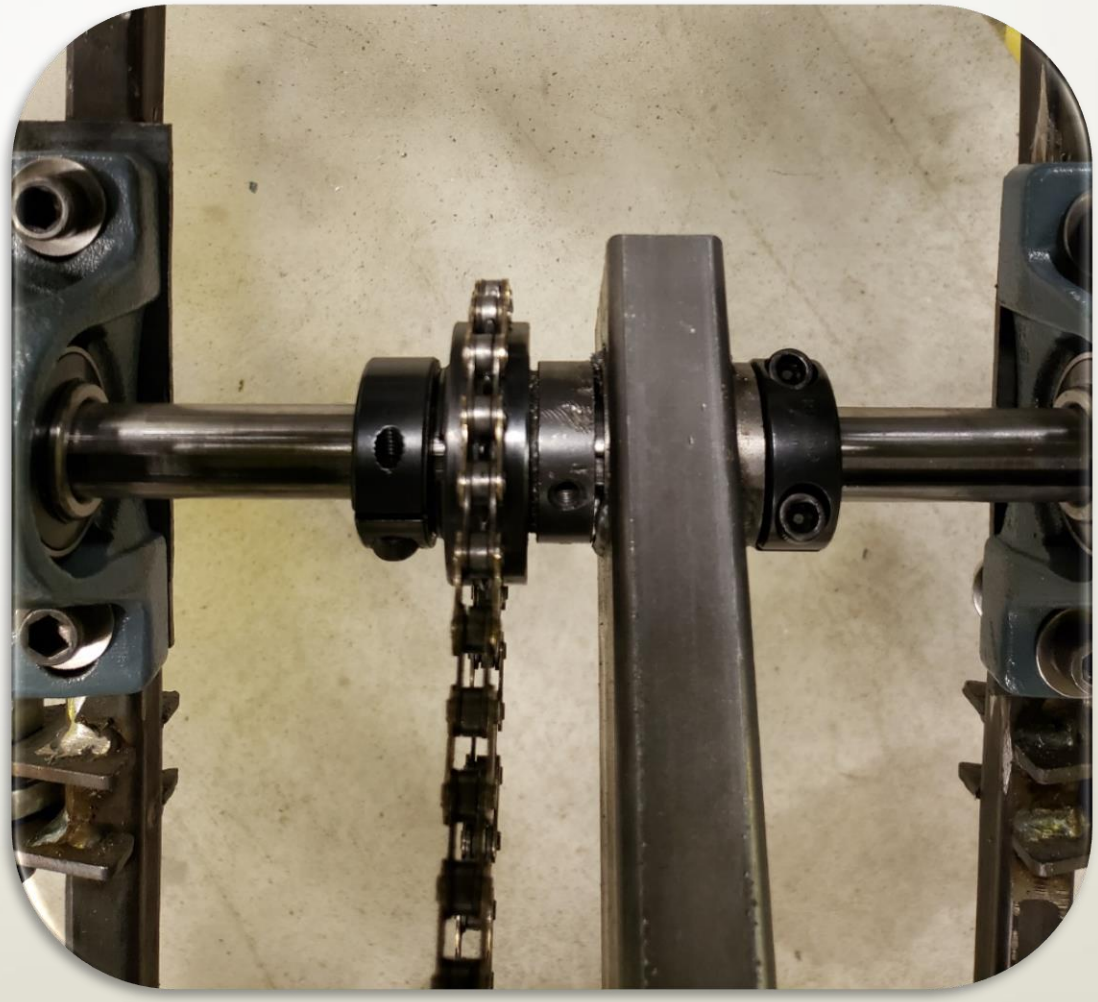
- Belts failed under required tension to carry load
  - Chain driven

Drivetrain: Modifications

- Included commercial bottom bracket vs in house manufactured pedal mounts
- Had to cut down pedal arms to weld on commercial parts

Drivetrain: Modifications





Wheels

Concept

Work Cohesively with all rover team designs

Material

Wheel: Carbon Fiber Layup

Manufacturing

PSU Plastics Department

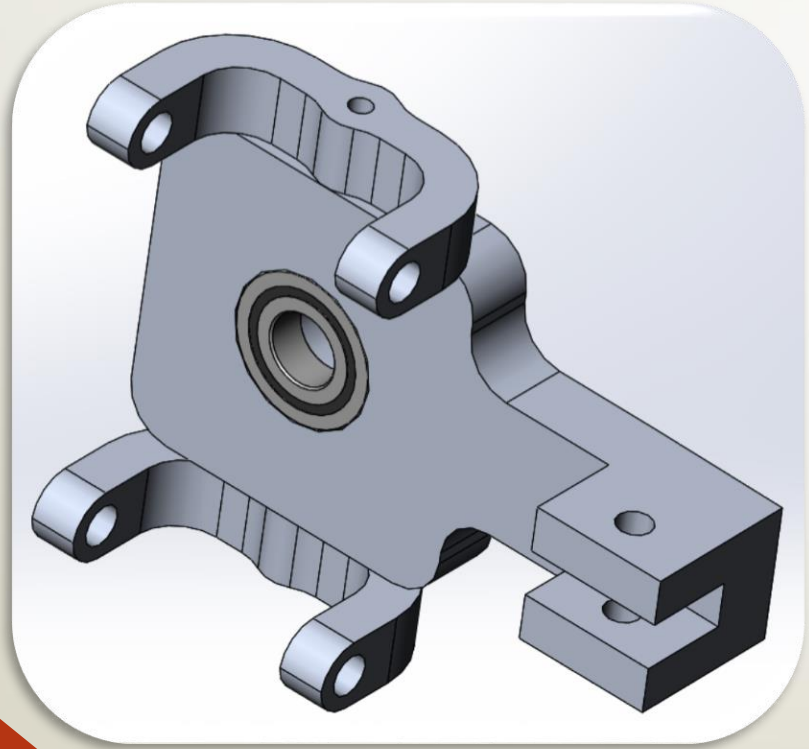
Wheels

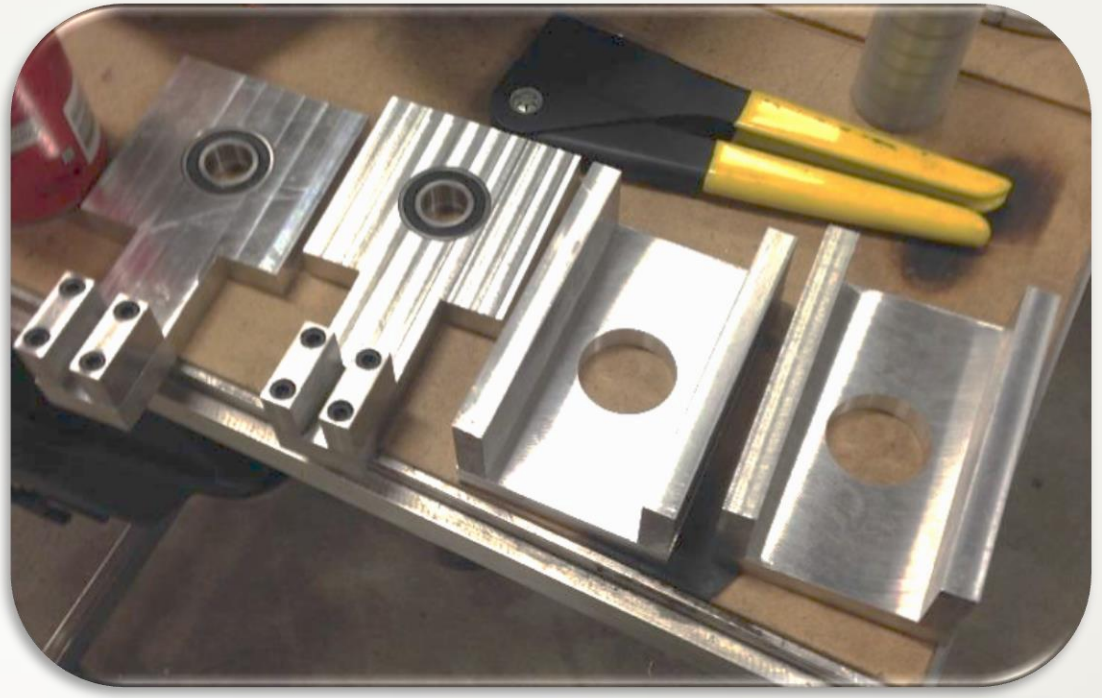
Wheels designed by students from the plastics department with the assistances of rover teams.

This allows us to meet another one of the NASA Design requirements of not having commercially available wheels.

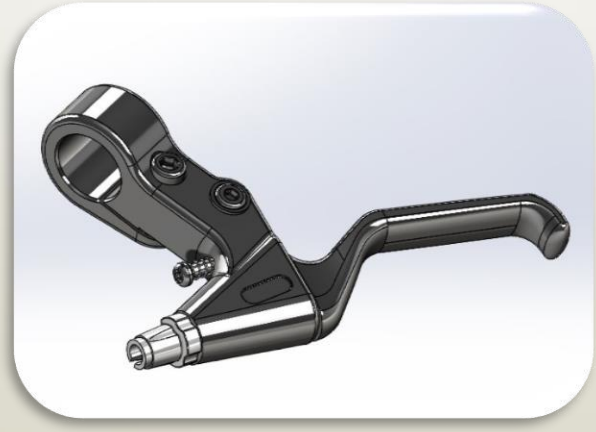
Hubs

Hub: 6061-T6 Aluminum





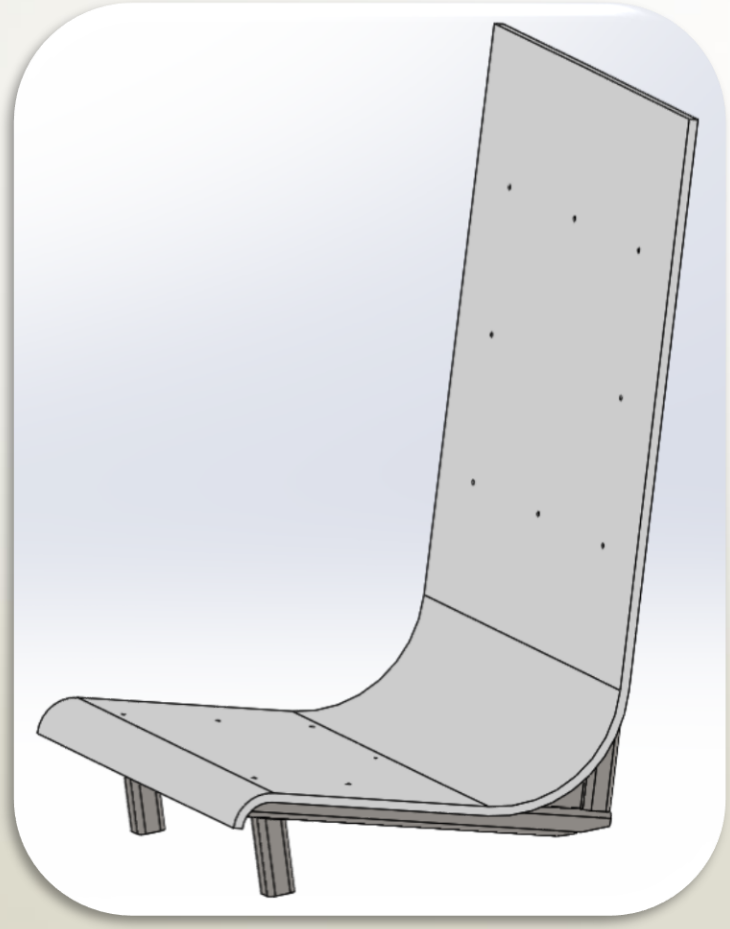
Brake System



Seats

Material

- Thermoformed ABS



Seats: Modifications

Cut outs had to be added to accommodate clearance for pedal arm fold

Budget

- Funds Raised: $1350.11
- Rover Costs: $1,245.93
- Misc Costs: $778.19
- Balance: -$674.01

Design Requirement

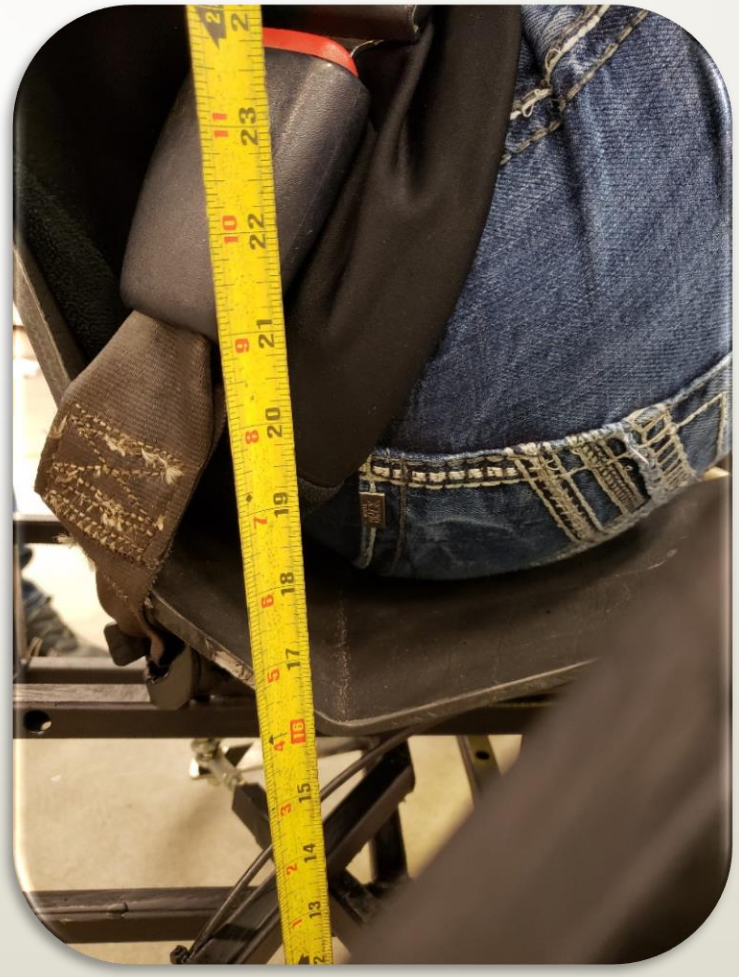
NASA

- Volume constraint:
  - 5ft X 5ft X 5ft

Design Requirement

NASA

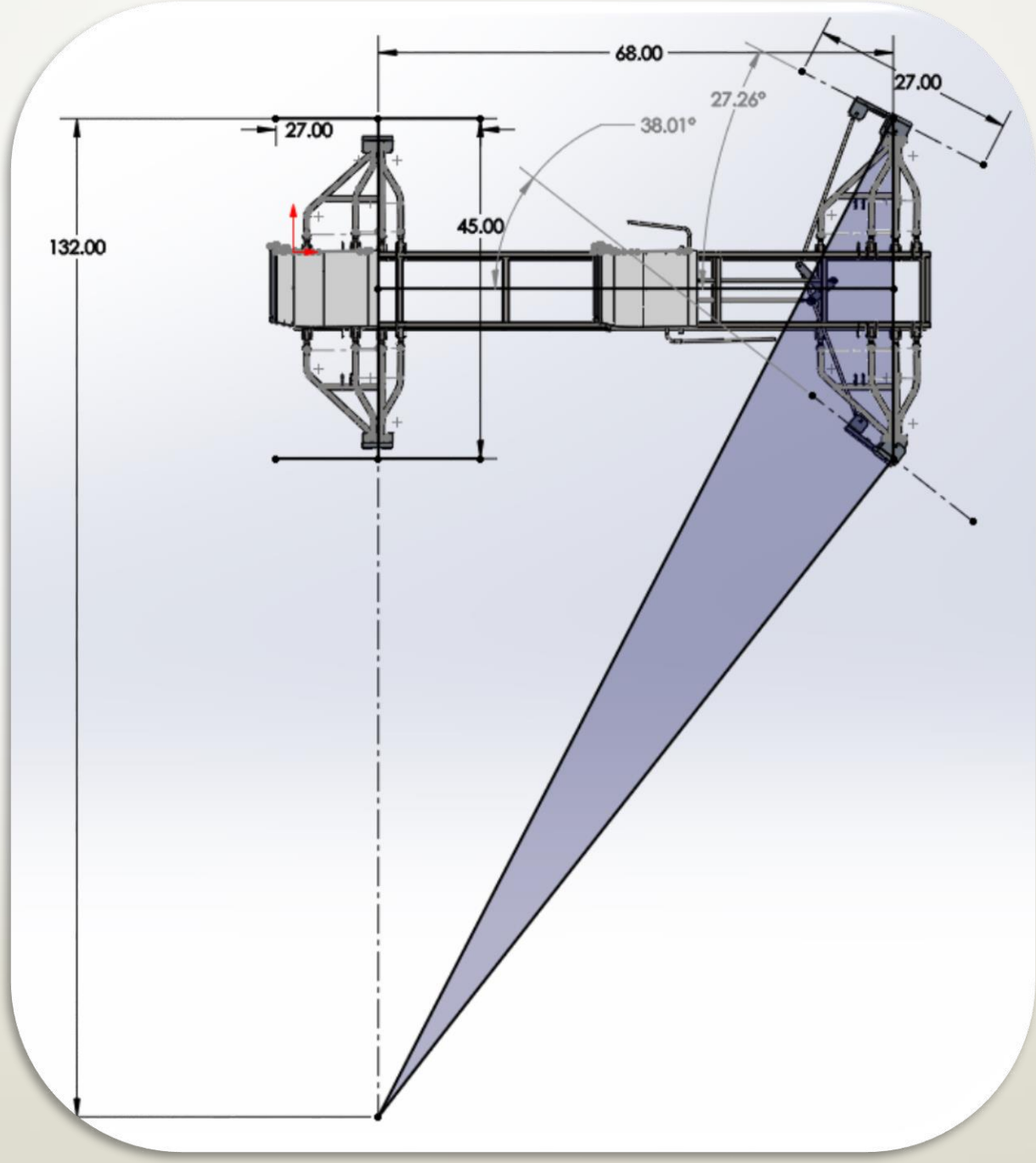
- Ground Clearance:
  - 15 in Min
    - While Loaded



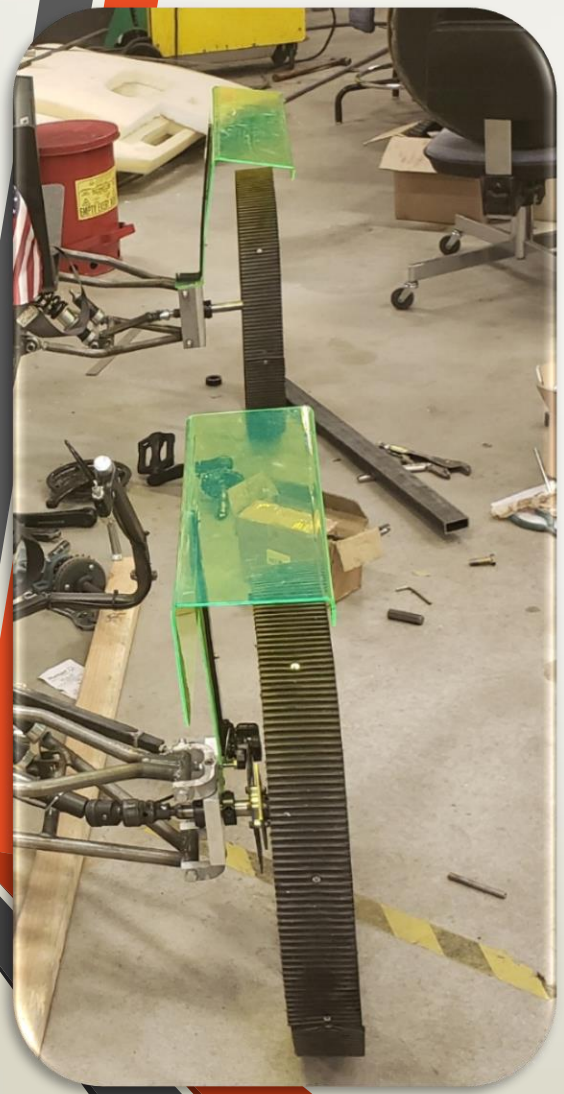
Design Requirement

NASA

Calculated value of 11 foot which fall well within the 15 foot Max NASA requirement



Design Requirement



NASA

Fender surface area: min-120in²

Ours-144in²

TEAM

Storage container for challenge equipment

Design Requirement

TEAM

- Folds: more than 2 places
  - Ours 3 folds

NASA

- Safety: Seat belts
  - present

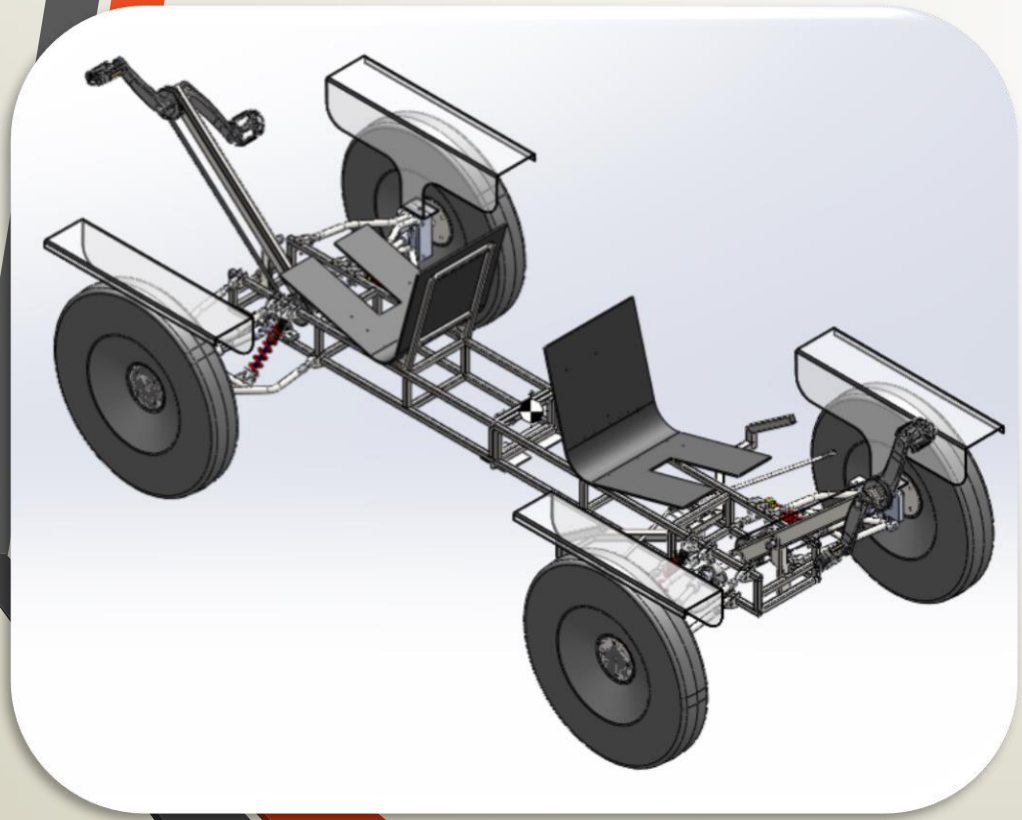
NASA

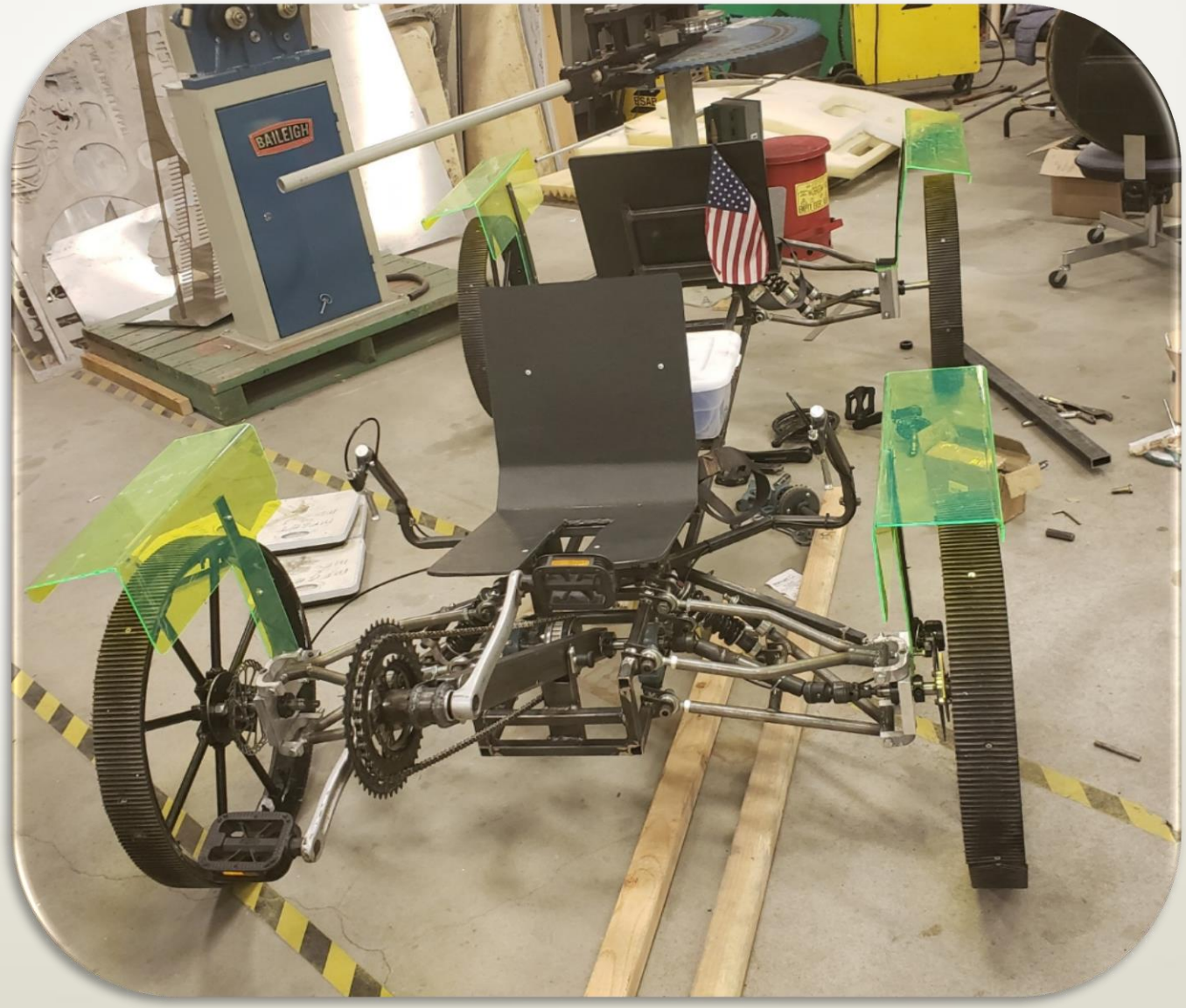
- Assembly time: under 2 min
  - Our time- under 1 min

Final Rover

Specs

Final Weight:213 lbs





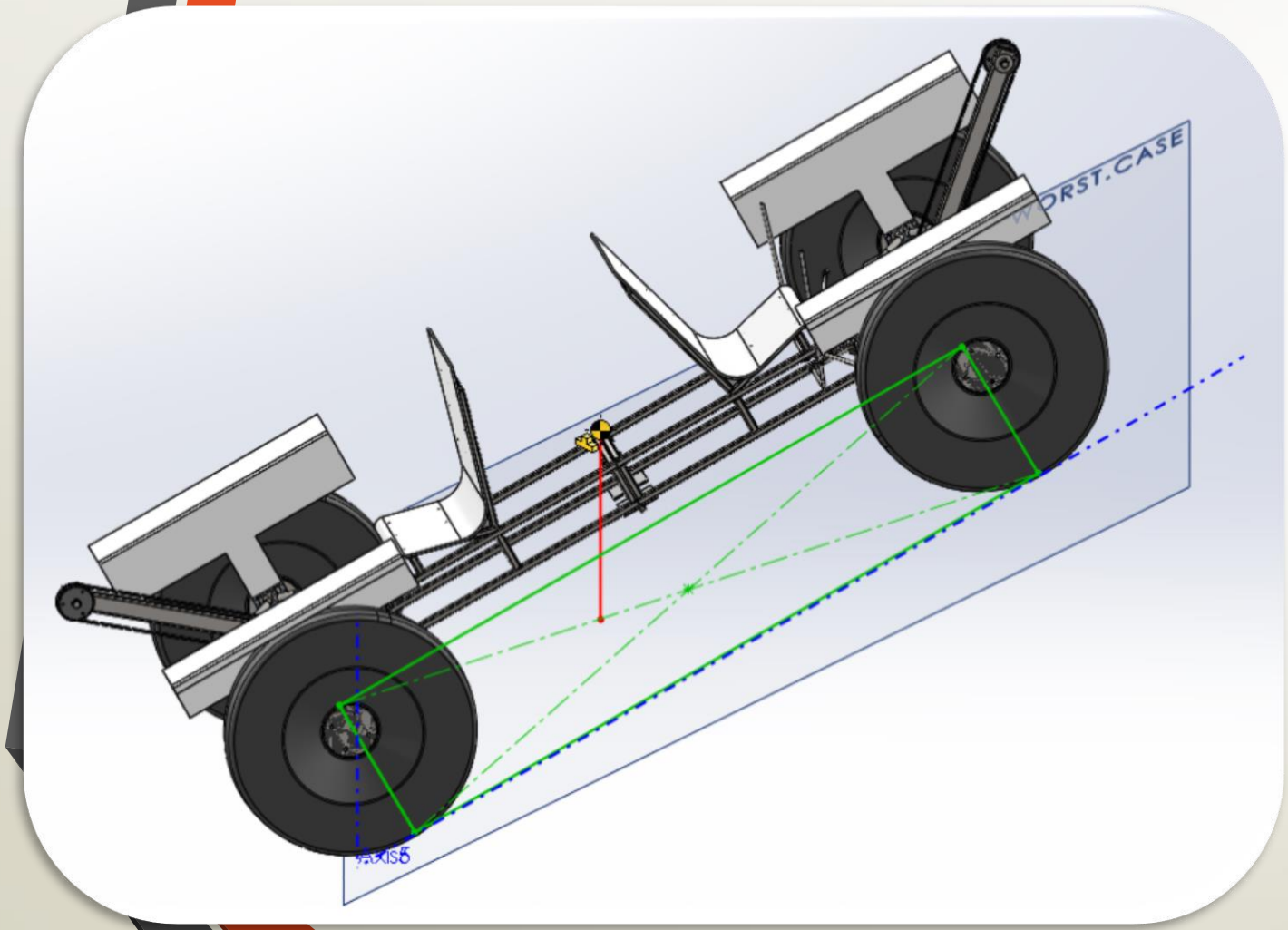
Changes We Would Make

"Engineers have more words for screwing up than the Inuit have words for snow."
— Pierce Nichols

- Chain drive
- All commercial components for drive train
- Rear Wheel Drive
- Differential - On Rear Drive
- Start Fundraising Earlier


ANY
QUESTIONS
?

Tipping Test



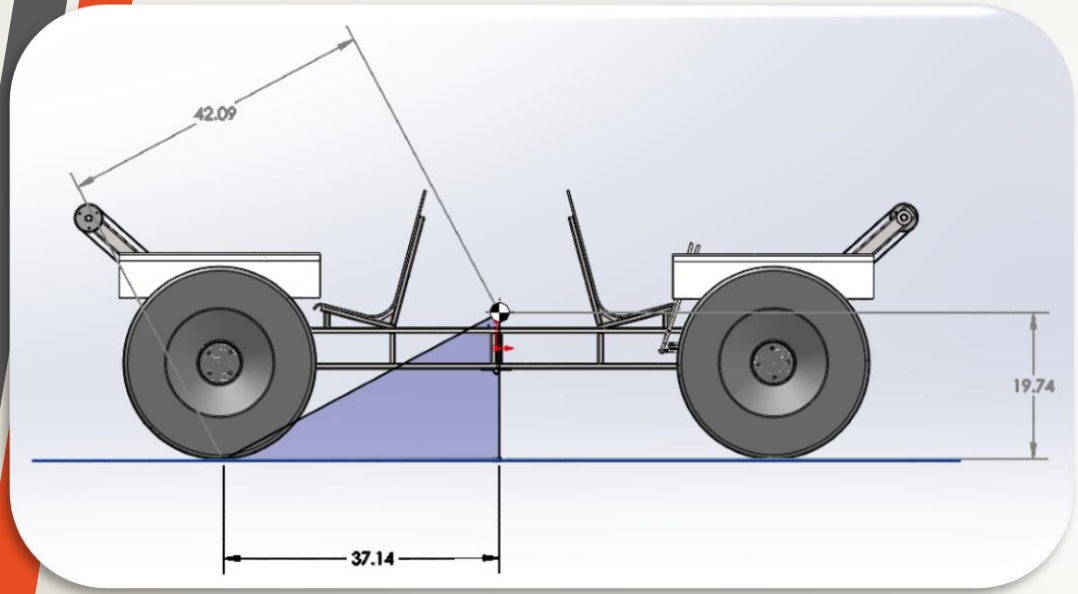
- Axis 1 created based upon 30° incline
- Axis 2 created based upon 22°roll

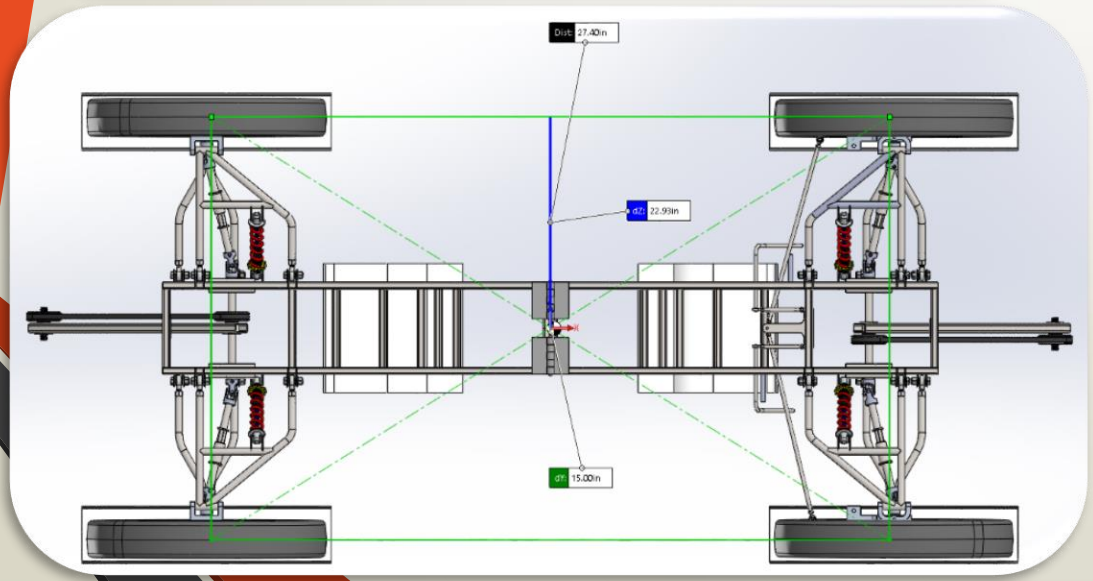
Roll Plane/ Axis Calculation:

$$\theta = \mathrm{Tan}^{-1}(d/Z_{cg}) =$$

$$\mathrm{Tan}^{-1}\left(\frac{15}{37.14}\right)_{in} = \mathbf{21.9°}$$

Tipping Test





Critical Static Pitch Angle Calculation:

$$\theta = \mathrm{Tan}^{-1}(d/Z_{cg}) =$$

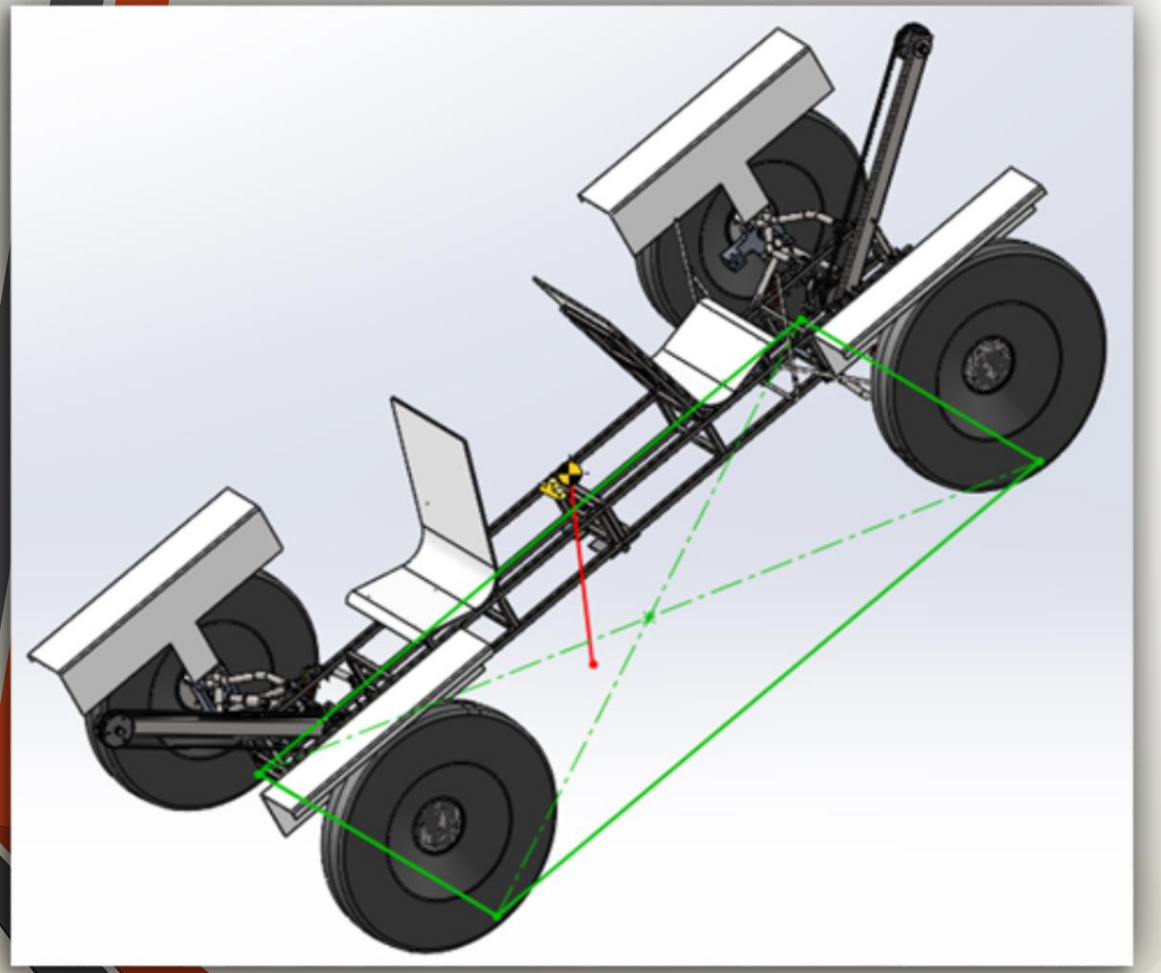
$$\mathrm{Tan}^{-1}\left(\frac{37.14}{19.47}\right)_{in} = \mathbf{62°}$$

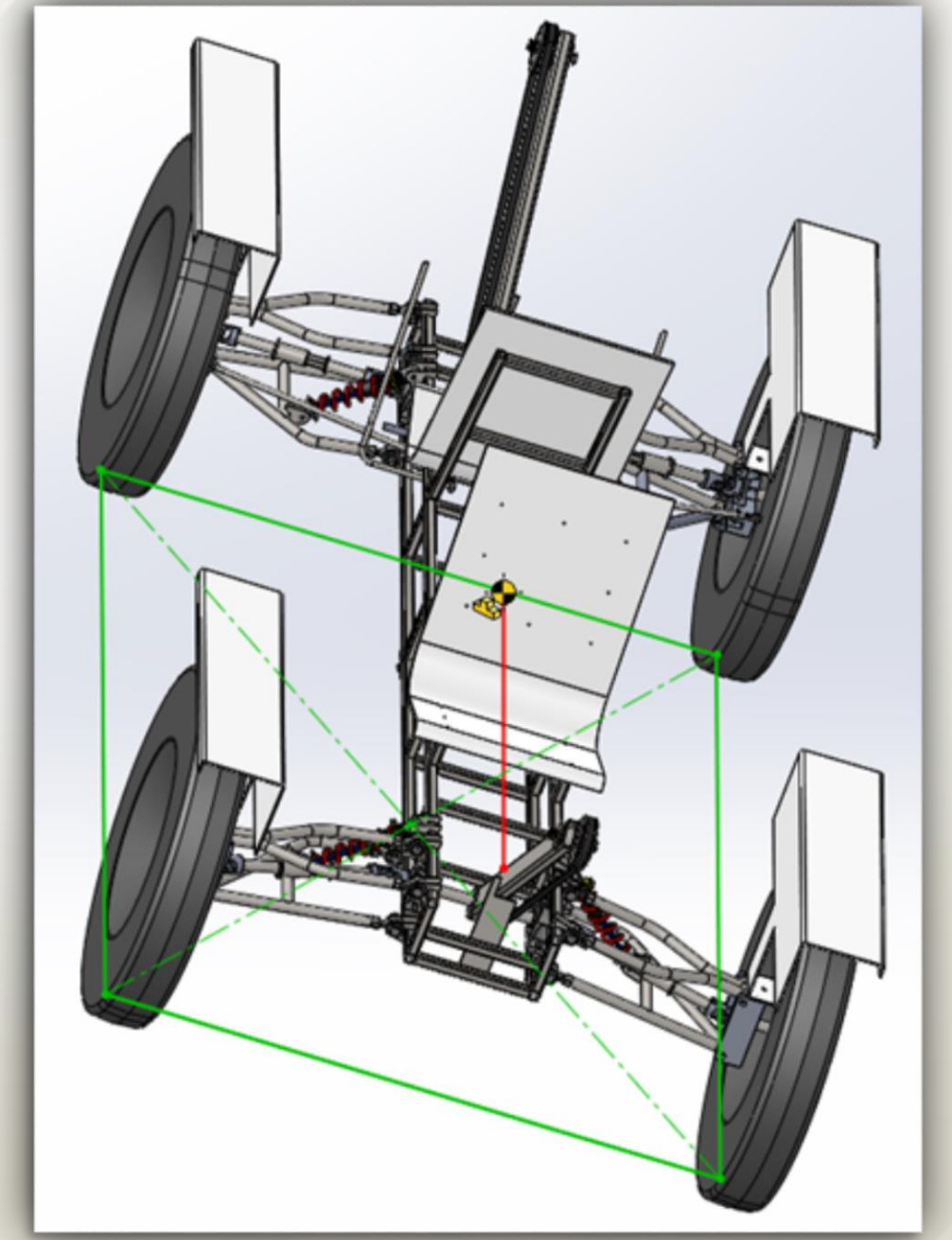
Critical Static Roll Angle Calculation:

$$\theta = \mathrm{Tan}^{-1}(d/Z_{cg}) =$$

$$\mathrm{Tan}^{-1}\left(\frac{22.93}{19.74}\right)_{in} = \mathbf{49.3°}$$

Tipping Test

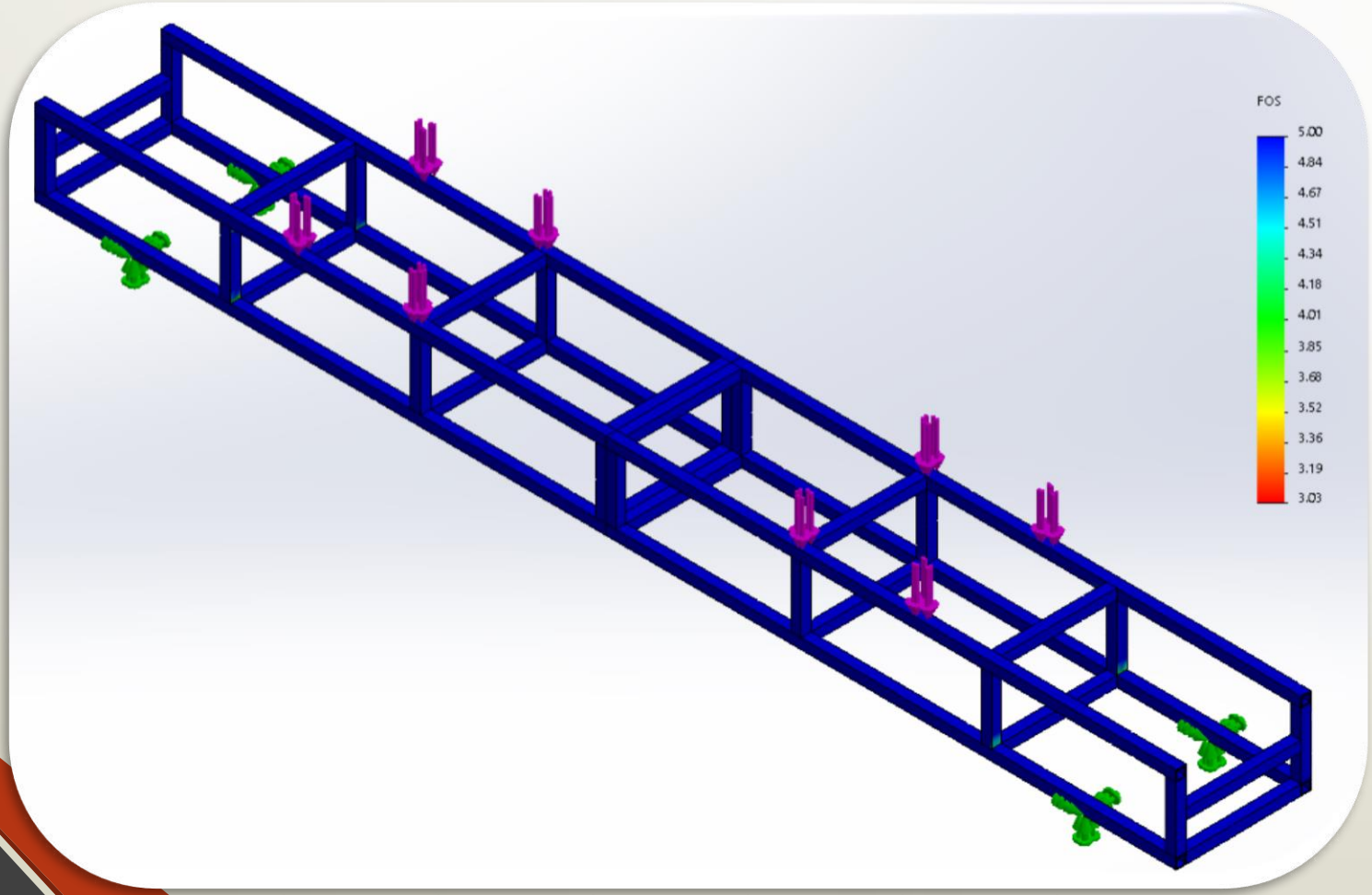


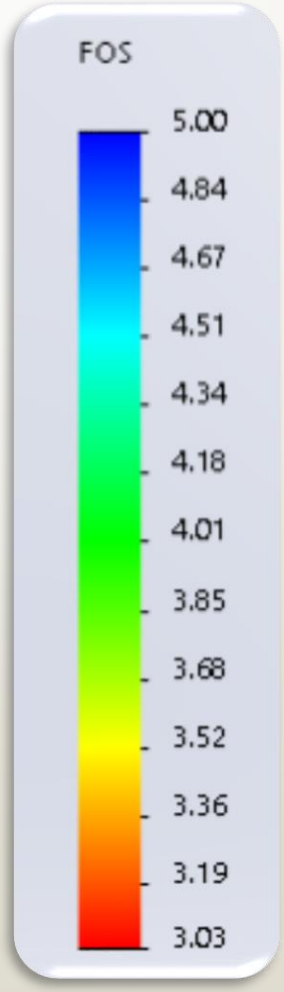


FEA: Riders Back-Back

350lbs Static Load Applied

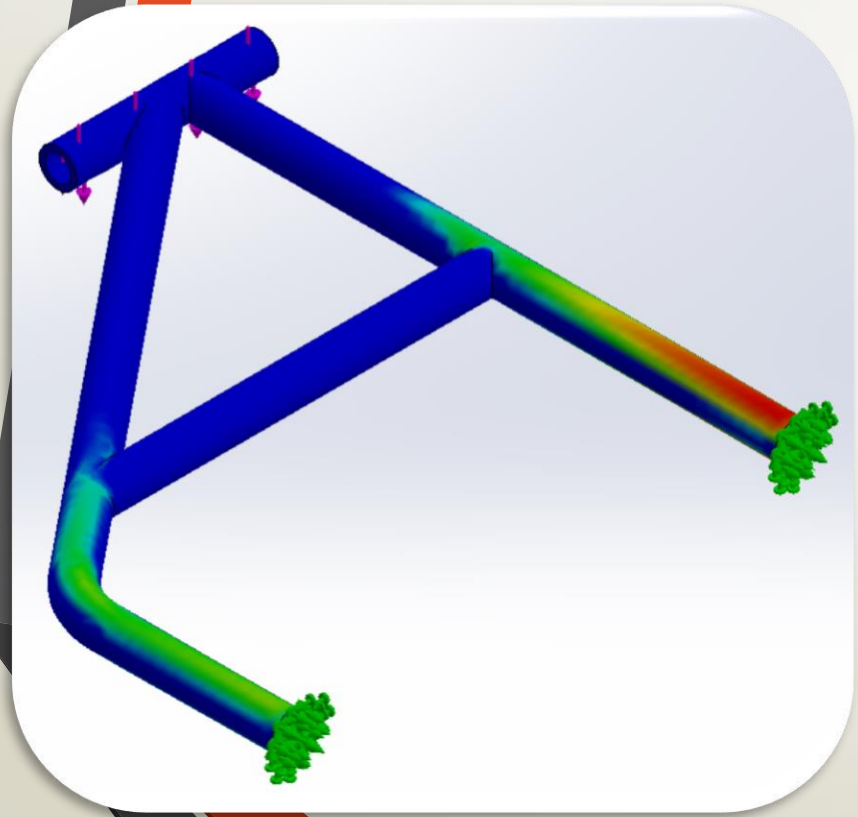
Factor of safety distribution:
Min FOS= 3

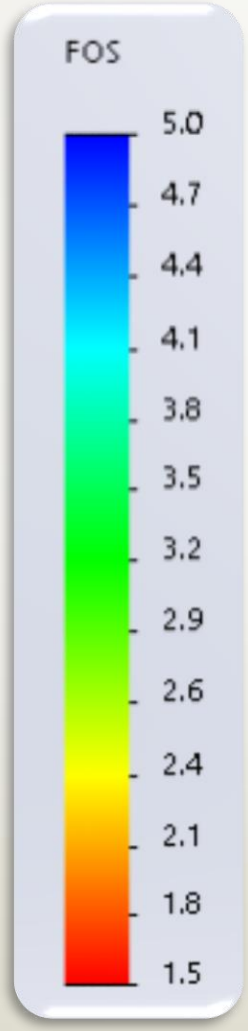




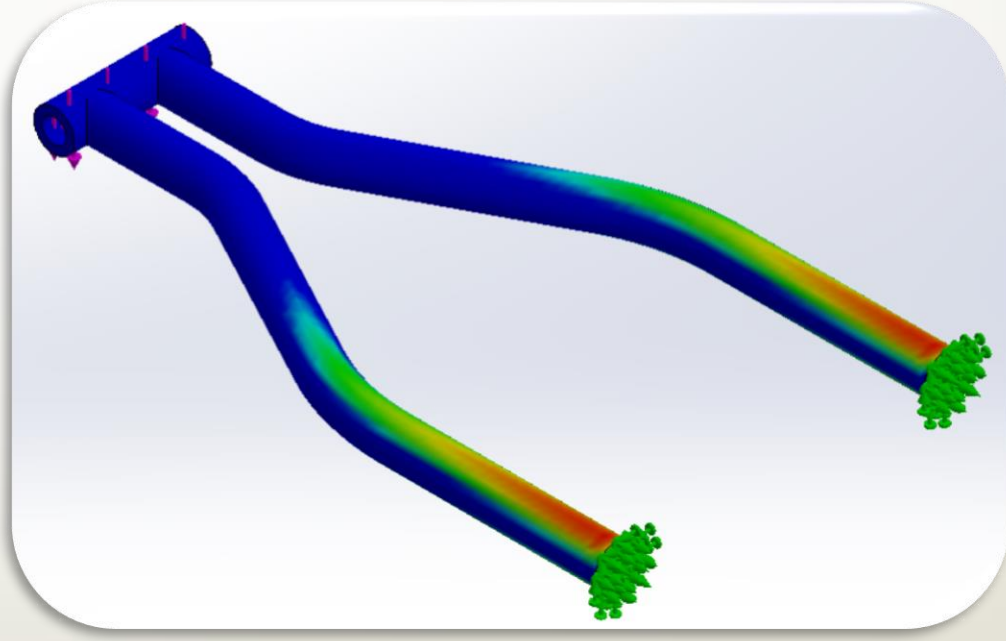
Front & Back Suspension: FEA

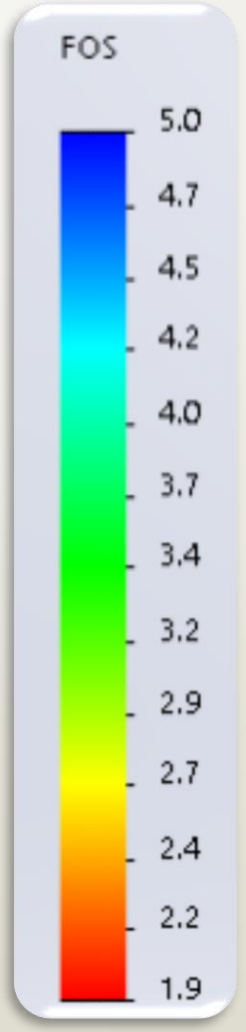
Bottom A-Arm: 100lbs





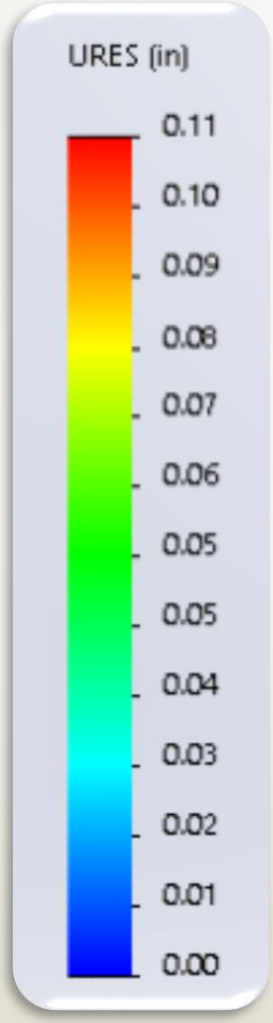
Top A-Arm: 100lbs

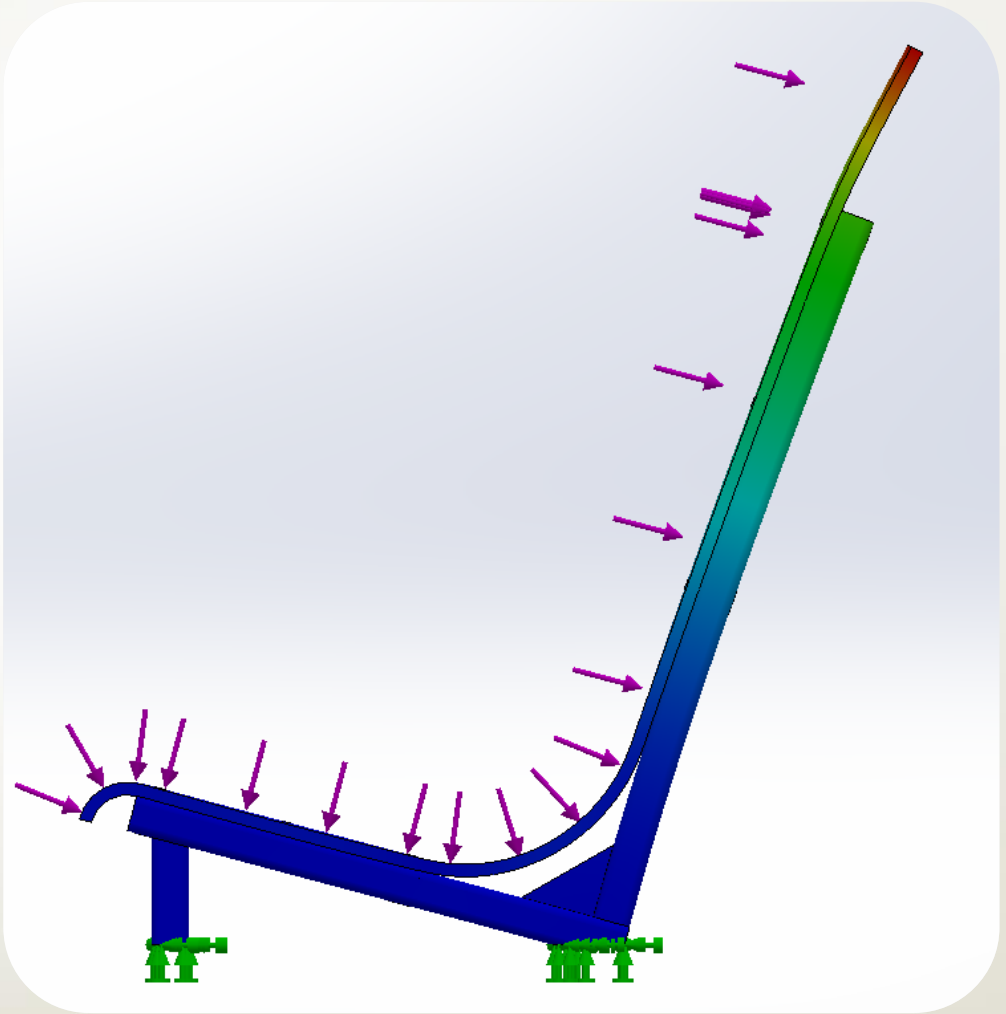




Seats: FEA Displacement

Heaviest rider weight applied 160 lbs





Manufacturing Schedule

ACTIVITY	START	END
Project Start	1/16/2018	
Cut Frame Parts	1/19/2018	1/19/2018
Weld Frame	1/20/2018	1/22/2018
Cut and Weld Suspension tags	1/22/2018	1/27/2018
Cut A-arm material to length	1/22/2018	1/27/2018
Bend, ream and cope A-arms	1/29/2018	2/4/2018
Weld A-arms onto frame	2/2/2018	2/4/2018
Cut and Weld seat frame	2/5/2018	2/12/2018
Thermofold Seats	2/12/2018	2/18/2018
Drivetrain	2/19/2018	3/11/2018
Steering	2/26/2018	3/4/2018
Hubs	2/12/2018	2/18/2018
Fenders	2/12/2018	2/16/2018
Install breaks, shocks and all other hardware	2/24/2018	3/2/2018
Testing	3/16/2018	3/25/2018
Rover Due	3/25/2018	3/25/2018
Design Re-Work	3/26/2018	4/2/2018
CNC brackets	4/5/2018	4/7/2018
Mount bicycle bearings	4/5/2018	4/7/2018
Donations Follow up	4/9/2018	4/13/2018
Re-assemble front and rear drivetrain	4/9/2018	4/12/2018
Rover Competition	4/13/2018	4/15/2018
Update Drawings	4/16/2018	4/27/2018
Final Presentation	4/30/2018	4/30/2018
Work on Report	4/16/2018	5/6/2018
Report Due	5/7/2018	5/7/2018

Budget

Project Budget: Rover 2

BUDGET
$ 1,778.15

	MATERIALS		SHIPPING	Tax	BUDGET
TASK	UNITS	$/UNIT			
FRAME					
Square Steel Tubing (1020 Steel)	60	$ 1.00	$ -		$ 60.00
Pedal Arms					
Toggle Clamp	1	$ 9.99			$ 9.99
Hinge	1	$ 10.03			$ 10.03
					$ 80.02
SUSPENSION					
3/4" Diameter (1020 Steel)	40	$ 3.86			$ 154.40
3/8" Deep Socket	4	$ 8.00	$ -		$ 32.00
1/2" Rod Ends	4	$ 28.95	$ -		$ 115.80
					$ 302.20
BRAKES					
Brake Kit	1	$ 24.99			$ 24.99
					$ -
					$ 24.99
STEERING					
3/4" Diameter (1020 Steel)	8	$ 3.27			$ 26.49
1/4" Rod Ends	1	$ 24.95			$ 24.95
1/8" Plate Steel		$ -			$ -
					$ 51.44

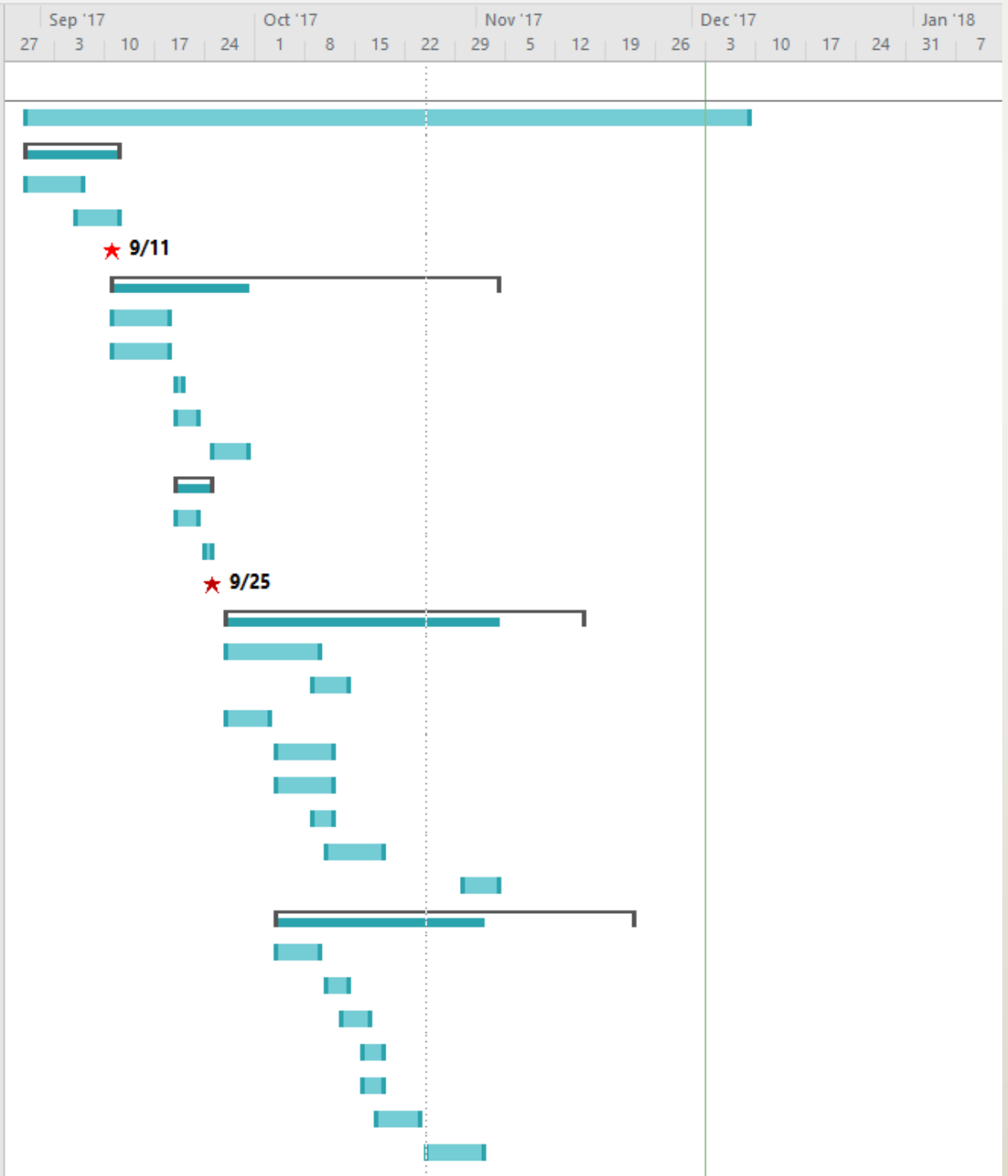
Budget

DRIVETRAIN					
Belts	2	$ 22.15			$ 44.30
Pulleys	4	$ 41.64			$ 166.56
20 mm Sprag Clutch	3	$ 17.99			$ 53.97
Dbl Side Sealed Ball Bearing	5	$ 5.97			$ 29.85
Mounted Bearing	4	$ 20.25		$ 7.51	$ 88.51
Socket for Slip Joints	4	$ 8.00			$ 32.00
Needle Bearing	4	$ 21.98			$ 87.92
Rotary Shaft	1	$ 26.77			$ 26.77
Spring Locks	2	$ 13.21			$ 26.42
1/2" Universal Joints(O'Reilly)	2	$ 8.99		$ 1.62	$ 19.60
1/2" Universal Joints(Tractor Supply)	2	$ 6.99		$ 1.32	$ 15.30
Keyways	1	$ 6.99		$ 0.66	$ 7.65
Slip Joint	2	$ 7.99			$ 15.98
Axle (Low Carbon Steel Rod)	3	$ 30.94			$ 92.82
					$ 496.79
HARDWARE					
3/8" Washers	1	$ 7.79			$ 7.79
1/2" Washers	1	$ 13.49			$ 13.49
1/2" Lock Nut	1	$ 12.82			$ 12.82
3/8" Lock Nut	1	$ 12.82			$ 12.82
					$ 46.92
CHALLENGE EQUIPMENT					
Sample Rod	1	$ -			$ -
Sample Cups	3	$ -			$ -
Storage Container	1	$ 2.98			$ 2.98
Task					$ -
					$ 2.98

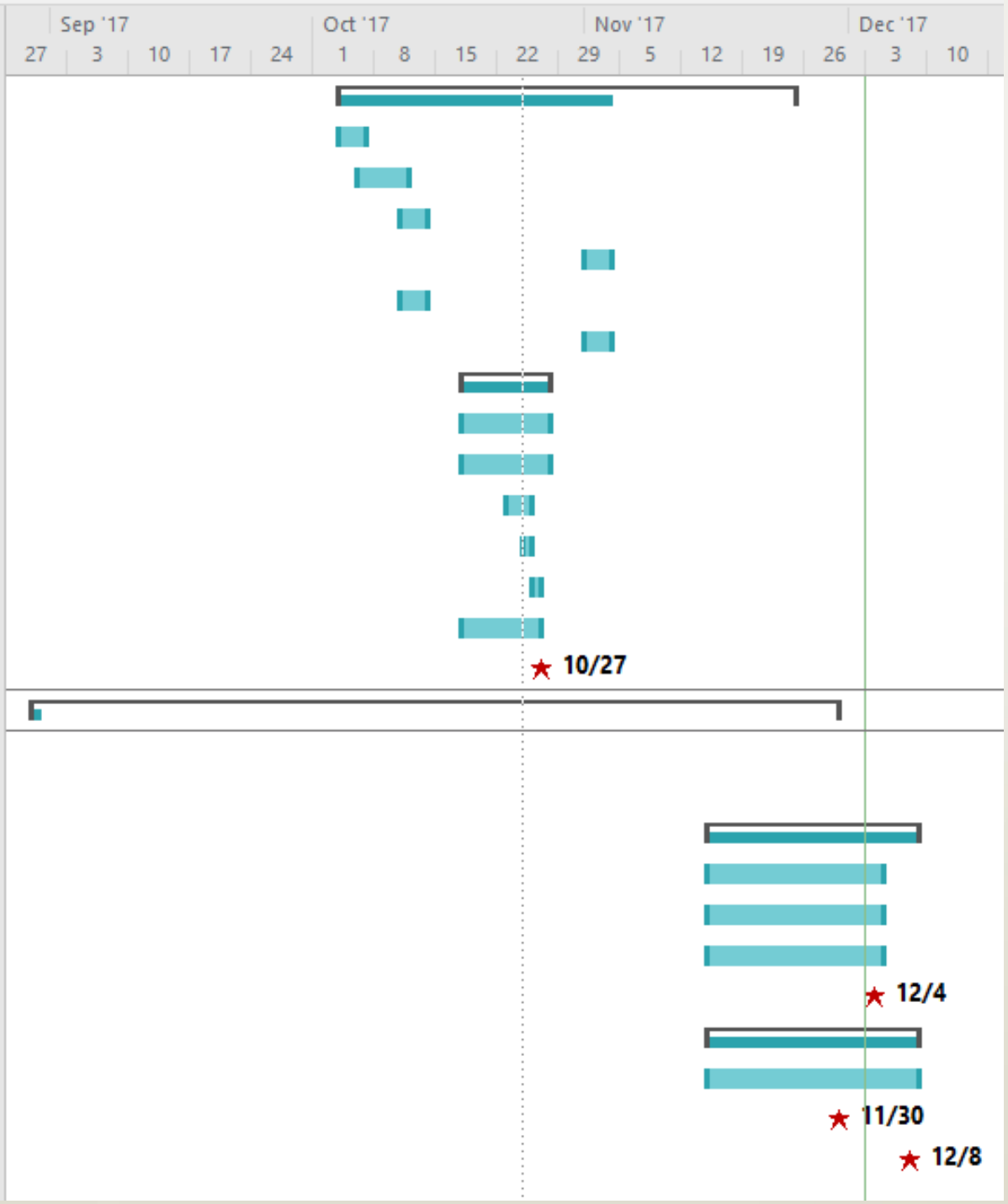
Budget

Pedal Arms					
20mm Shaft Bearing 47mm Od	2	$ 6.87			$ 13.74
20mm Bearing	4	$ 15.47			$ 61.88
Axel		$ -			$ -
Pedals	2	$ -			$ -
Rectangular Tubing 1020 Steel	20	$ 2.95			$ 59.00
					$ 134.62
MISC					
Polos	6	$ 32.69			$ 196.14
Hotel	7	$ 63.15			$ 442.05
					$ 638.19

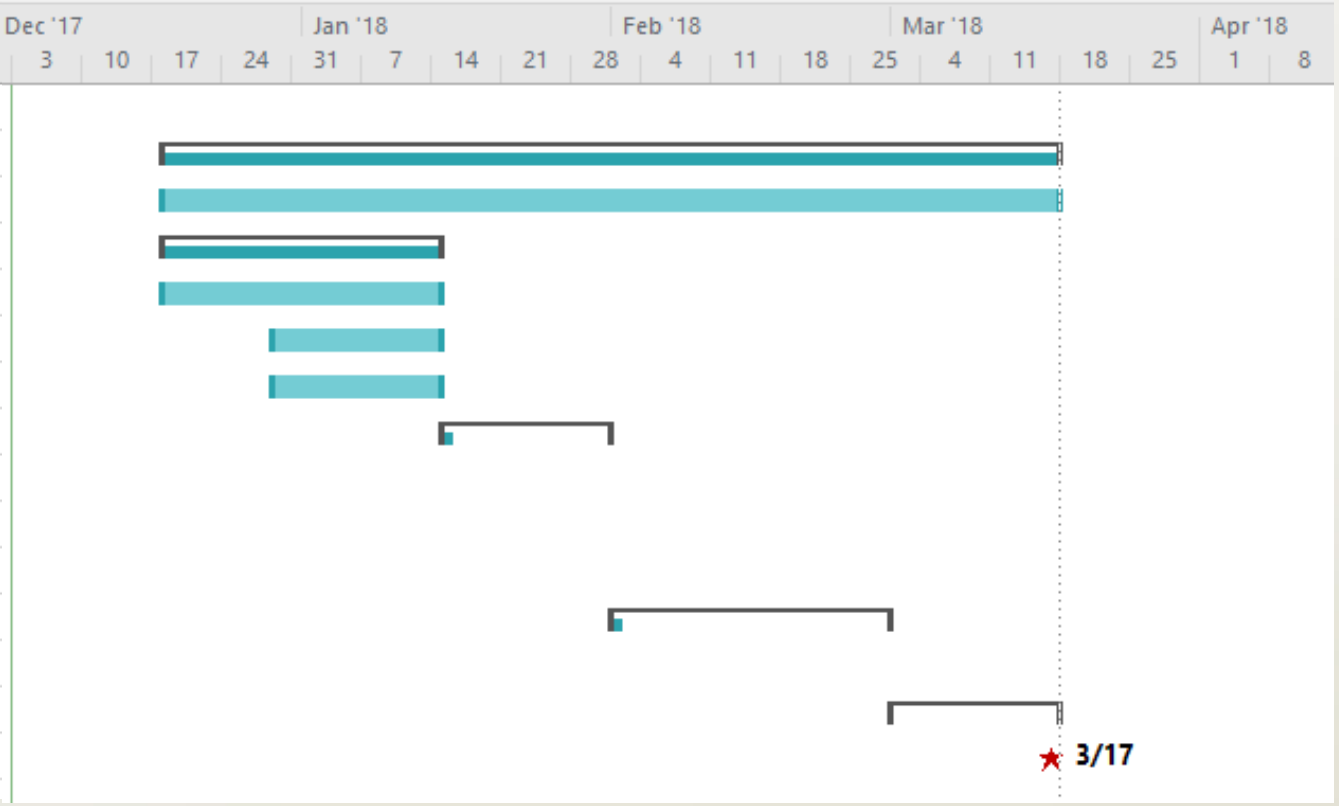
Task Mode	Task Name	Duration	Start	Finish
	ROVER 2 2017-2018 FULL SCHEDULE			
	Design Schedule Semester 1	**73 days**	**Wed 8/30/17**	**Fri 12/8/17**
	Rover Idea Research	**9 days**	**Wed 8/30/17**	**Mon 9/11/17**
	Brainstorm Research	6 days	Wed 8/30/17	Wed 9/6/17
	Concept Generation	4 days	Wed 9/6/17	Mon 9/11/17
	Begin Design for Frame	**0 days**	**Mon 9/11/17**	**Mon 9/11/17**
	Frame	**40 days**	**Mon 9/11/17**	**Fri 11/3/17**
	Work on Individual Frame Designs	6 days	Mon 9/11/17	Mon 9/18/17
	Research Materials for Frame	6 days	Mon 9/11/17	Mon 9/18/17
	Team Meeting to Discuss Frame	1 day	Wed 9/20/17	Wed 9/20/17
	Frame Assembly	3 days	Wed 9/20/17	Fri 9/22/17
	Frame FEA	5 days	Mon 9/25/17	Fri 9/29/17
	Presentation 1 Prep.	**4 days**	**Wed 9/20/17**	**Sun 9/24/17**
	Start Powerpoint	3 days	Wed 9/20/17	Fri 9/22/17
	Practice Presentation	1 day	Sun 9/24/17	Sun 9/24/17
	Presentation 1	**0 days**	**Mon 9/25/17**	**Mon 9/25/17**
	A-Arm	**36 days**	**Wed 9/27/17**	**Wed 11/15/17**
	Begin Design for A-Arms	9 days	Wed 9/27/17	Mon 10/9/17
	Research Shocks	5 days	Mon 10/9/17	Fri 10/13/17
	Research Material for A-Arms	4 days	Wed 9/27/17	Mon 10/2/17
	Begin Design Hub	6 days	Wed 10/4/17	Wed 10/11/17
	Reseach Materical for Hub	6 days	Wed 10/4/17	Wed 10/11/17
	Research Hardware	3 days	Mon 10/9/17	Wed 10/11/17
	Assembly of A-Arm	6 days	Wed 10/11/17	Wed 10/18/17
	FEA A-Arm	5 days	Mon 10/30/17	Fri 11/3/17
	Drive Train	**36 days**	**Wed 10/4/17**	**Wed 11/22/17**
	Brainstorm Ideas	4 days	Wed 10/4/17	Mon 10/9/17
	Research Chain VS Belt	3 days	Wed 10/11/17	Fri 10/13/17
	Research Belt Types	2 days	Fri 10/13/17	Mon 10/16/17
	Research Materials for Axle	3 days	Mon 10/16/17	Wed 10/18/17
	Bearing Research	3 days	Mon 10/16/17	Wed 10/18/17
	Design Axle	4 days	Wed 10/18/17	Mon 10/23/17
	FEA Axle	6 days	Wed 10/25/17	Wed 11/1/17



Task Mode	Task Name	Duration	Start	Finish
	Seat/Misc	**38 days**	**Wed 10/4/17**	**Fri 11/24/17**
	Material Research	3 days	Wed 10/4/17	Fri 10/6/17
	Concept Design Research	4 days	Fri 10/6/17	Wed 10/11/17
	Seat Design	3 days	Wed 10/11/17	Fri 10/13/17
	Seat FEA	3 days	Wed 11/1/17	Fri 11/3/17
	Grabber Arm Design	3 days	Wed 10/11/17	Fri 10/13/17
	Storage Container Design	3 days	Wed 11/1/17	Fri 11/3/17
	Presentation 2 Prep.	**8 days**	**Wed 10/18/17**	**Fri 10/27/17**
	Start Powerpoint	8 days	Wed 10/18/17	Fri 10/27/17
	Upload Screenshots	8 days	Wed 10/18/17	Fri 10/27/17
	Upload Current FEA	3 days	Mon 10/23/17	Wed 10/25/17
	Find and Buy Matching Shirts	1 day	Wed 10/25/17	Wed 10/25/17
	Group Headshots	1 day	Thu 10/26/17	Thu 10/26/17
	Handout	7 days	Wed 10/18/17	Thu 10/26/17
	Presentation 2	**0 days**	**Fri 10/27/17**	**Fri 10/27/17**
	Wheel	**66 days**	**Wed 8/30/17**	**Wed 11/29/17**
	Wheel Updates			
	Work with Plastics Dept. When Requested			
	Presentation 3 and Final Paper	**18 days**	**Wed 11/15/17**	**Fri 12/8/17**
	Start Powerpoint	14 days	Wed 11/15/17	Mon 12/4/17
	Upload Images to Powerpoint	14 days	Wed 11/15/17	Mon 12/4/17
	Upload all Final FEA	14 days	Wed 11/15/17	Mon 12/4/17
	Presentaion 3 Submission	**0 days**	**Mon 12/4/17**	**Mon 12/4/17**
	Final Paper	**18 days**	**Wed 11/15/17**	**Fri 12/8/17**
	Work on Paper	18 days	Wed 11/15/17	Fri 12/8/17
	Writing Center App.	**0 days**	**Thu 11/30/17**	**Thu 11/30/17**
	Final Paper Submission	**0 days**	**Fri 12/8/17**	**Fri 12/8/17**



Task Name	Duration	Start	Finish
Manufacturing Schedule Semester 2	**66 days**	**Mon 12/18/17**	**Sat 3/17/18**
Order Spare/Extra Parts	66 days	Mon 12/18/17	Sat 3/17/18
Christmas Break	**21 days**	**Mon 12/18/17**	**Sun 1/14/18**
Cut/Bend/Cope Tubing	21 days	Mon 12/18/17	Sun 1/14/18
Cut Brackets	12 days	Fri 12/29/17	Sun 1/14/18
Weld Frame/Brackets/A-Arms	12 days	Fri 12/29/17	Sun 1/14/18
January	**13 days**	**Mon 1/15/18**	**Wed 1/31/18**
Sort Hardware			
Cut and Bend Plastic Seat Covers			
Machine Parts			
February	**20 days**	**Thu 2/1/18**	**Wed 2/28/18**
Testing			
March	**13 days**	**Thu 3/1/18**	**Sat 3/17/18**
Complete Rover	**0 days**	**Sat 3/17/18**	**Sat 3/17/18**



Design Requirement	Nominal	Tolerance	Rationale	Importance
Turning radius	15'	max	NASA requirement	10
Ground clearance	15"	min	NASA requirement	10
Width, Length, and Height of folded rover	5' Square	max	NASA requirement	10
Overall weight of rover (no riders onboard)	190 lbs.	max	Team Requirement	10
Dust shield surface area	120 in^2 each	min	NASA requirement	10
Seat belts	Present (Quantity 2)	N/A	NASA requirement	10
National or institution flag	Present, removable for deployment	N/A	NASA requirement	10
Center of gravity	Must handle 30 degree incline and not tip over	min	Safety	10
Design wheels	Compatible with Plastics Engineering Design Wheels	N/A	NASA requirement	10
Strength of rover (max payload capacity)	400 lbs.	min	Must be able to support riders	10
Must climb 30 degree incline hill	Climbs up to 5'	min	NASA requirement	10
1 male 1 female rider	Present	N/A	NASA requirement	10
Human powered	Present	N/A	NASA requirement	10
Go over cracks	Wheel must handle 5" wide crack up to 30 degrees included angle	N/A	Course challenge	5
Rider Safety	Cover for pinch points sharp edges etc.	N/A	Safety	10
Racing Attire	Helment, Gloves, Long Sleeve, safety glasses, long pants	N/A	NASA requirement	10
Suspension	4 wheel Independent	N/A	Team Requirement	10
Assembly Time	2 min	max	Team Requirement (based off NASA Scoring System)	10
Brakes	2 Brakes	Min	Team Requirement	10
Compactibility	Folds in 2 places	Min	Team Requirement	10
Able to take Pictures	Filtered and Unfiltered	N/A	NASA Scoring Point system	10
Storage Container	6-50 mil samples, antenna assembly, solar panel, camera, color filter	N/A	NASA Scoring Point system	10
FOS	1.5	min	able to finish course	10
Pedal input force	Withstand 200 lbs. / rider	min	Team research	8