NASA Human Exploration ROVER CHALLENGE

Tavares Butler
Phillip Dimacali
Jessica Meeker
Lazaro Rodriguez
Jerald Yee

Team Introductions

Tavares Butler
Project Engineer

Jessica Meeker
Mechanical Engineer

Phillip Dimacali
Design Engineer

Jerald Yee
Quality Engineer

Lazaro Rodriguez
Manufacturing Engineer

Sponsor and Advisor

Shayne McConomy, Ph.D.

Chiang Shih, Ph.D.

A statewide network of colleges and universities supporting the expansion and diversification of Florida's space industry through grants, scholarships, and fellowships to students and educators in Florida.

Objective

To produce a functional rover capable of completing challenge course obstacles and tasks while being able to traverse on various terrains and adhere to the rules set forth by the 2020 guidebook.

Project Background

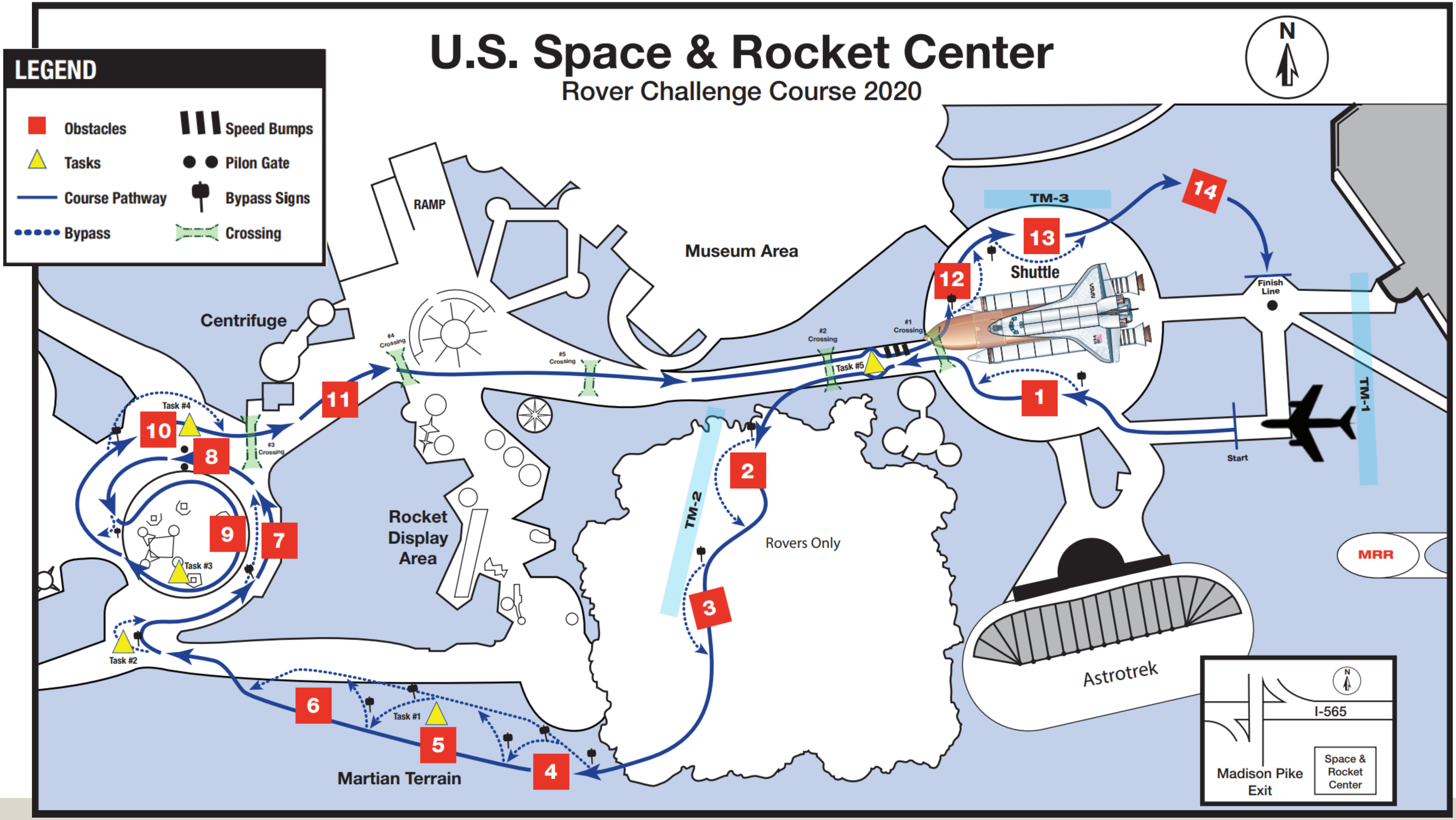
Competition Dates:

April 17-18, 2020

Location:

Huntsville, Al

- 14 Obstacles
- 5 Tasks
- 2 excursion attempts
- 8:00 minute time limit per excursion attempted
- 114 Total Points Possible


U.S. Space & Rocket Center
Rover Challenge Course 2020
LEGEND
Obstacles
Tasks
Course Pathway
Bypass
Speed Bumps
Pilon Gate
Bypass Signs
Crossing
N
RAMP
Museum Area
Centrifuge
Shuttle
TM-3
TM-2
TM-1
Finish Line
Start
Rocket Display Area
Rovers Only
MRR
Astrotrek
Martian Terrain
Task #1
Task #2
Task #3
Task #4
Task #5
#1 Crossing
#2 Crossing
#3 Crossing
#4 Crossing
#5 Crossing
1
2
3
4
5
6
7
8
9
10
11
12
13
14
I-565
Madison Pike Exit
Space & Rocket Center

Competition Point Breakdown

Teams Evaluated Regarding:

- Vehicle Weight
- Vehicle Volume
- Assembly Time
- Excursion Time
- Tasks and obstacles are attempted/completed
- Vehicle Performance
- Several other parameters

Obstacles

Obstacle/Task Number	Description	Bypass	Possible Points	Point Breakdown
1	Undulating Terrain	Y	2	2 points for successful completion 1 point for attempt 0 points for bypass
2	Crater with Ejecta	Y	2	2 points for successful completion 1 point for attempt 0 points for failure to attempt

Tasks

Task 3 (Obstacle 9 must be attempted to attempt Task 3.)	Core Sample Retrieval	Y	9	Core Sample Retrieval 1 point for having all tools necessary to attempt the task **(ERR)** 4 points for successful core sample extraction **(TS)** 4 points for successful return of core sample that meets designated criteria **(PER)**

Targets

Lazaro Rodriguez

Mission-Critical Targets

Target	Validation	Tools Necessary
Driver mobility limited to the extremities	Having the driving physical sit in the seat and adjust restraints accordingly	Measuring equipment and the assembled restraint system
5'0" to 6'4" Height accommodation Maximum weight capacity 400 lbs. total	Take measurements of individuals and test through 3D modeling	Measuring equipment and 3D modeling software
Pedal power Hydraulic braking Mechanical steering	Physical tests: I.e. normal brake testing (pedaling to a certain speed and breaking, then measuring the distance)	For a physical test, we need the built components of the HPV. Also, 3D modeling software to test design before the build.

Lazaro Rodriguez

Mission-Critical Targets

Torque to wheels Orientating steering system	3D modeling and physical test once the vehicle is built.	3D modeling software and physical components. Measuring equipment for torque test.
14-inch rider-related component clearance	Test through measurement and 3D modeling. We'll design to make suspension adjustable to enable additional height adjustments.	3D modeling software and measuring equipment
15 foot turning radius	Test through measurement of turning radius. Design to the specific turning radius and additional checking through 3D modeling	3D modeling software and measuring equipment

Concept Generation

Generation Methods used:

- The Morphological Chart
- Brainstorming
- Random Input technique
- Biomimicry

Lazaro Rodriguez

The Morphological Chart

Suspension	Steering	Drivetrain	Wheels
• Linkage • Coil Spring /Dampener • Leaf Springs • Independent • Rigid • Wheel Integrated	• Hydraulic • Rear • Front • Mechanical • Cable	• Chain Drive • Differential • CVT • Shaft Driven • Linkage • Gearbox • Single or Double Input • Tracks	• Integrated Spring /dampener • Pneumatic • Treaded • Foam Core

Lazaro Rodriguez

The Morphological Chart

Suspension	Steering	Drivetrain	Wheels
• Linkage • Coil Spring /Dampener • Leaf Springs • Independent • Rigid • Wheel Integrated	• Hydraulic • Rear • Front • Mechanical • Cable	• Chain Drive • Differential • CVT • Shaft Driven • Linkage • Gearbox • Single or Double Input • Tracks	• Integrated Spring /dampener • Pneumatic • Treaded • Foam Core

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Concept Selection

Tavares Butler

House of Quality

Methodology of applying relative weights to engineering characteristics based on the customer needs

		Engineering Characteristics						
Improvement direction		↑	↑	↓	↑	↑	↓	↑
Units		# of extremities	in	in*lbf	in*lbf, lbf	in	in	
Customer Requirements	Importance weight factor	Driver Mobility	Rider size accommodation	Driver Input	Rover Output	Rider position height	Turning Radius	Rover Stability
Control	7	8	4	8	8	4	8	8
Reliability	9	4	0	4	4	2	4	8
Simplicity	6	1	0	4	4	0	1	4
Impact Dampening	4	0	0	2	8	0	0	8
Assembly	6	0	1	8	4	1	2	2
Innovative	3	2	0	8	4	0	1	4
Cost effective	1	2	0	8	8	0	0	4
Safety	7	8	8	4	4	8	4	8
Machinability	2	0	2	8	4	0	0	2
Raw score (1253)		162	94	248	228	108	141	272
Relative Weight (%)		12.9	7.5	19.8	18.2	8.6	11.3	21.7
Rank Order		4	7	2	3	6	5	1

Requirements	Weight factor	Mobility	accommodation
Control	7	8	4
Reliability	9	4	0
Simplicity	6	1	0
Impact Dampening	4	0	0
Assembly	6	0	1
Innovative	3	2	0
Cost effective	1	2	0
Safety	7	8	8
Machinability	2	0	2
Raw score (1253)		162	94

		Engineering Characteristics						
Improvement direction		↑	↑	↓	↑	↑	↓	↑
Units		# of extremities	in	in*lbf	in*lbf, lbf	in	in	
Customer Requirements	Importance weight factor	Driver Mobility	Rider size accommodation	Driver Input	Rover Output	Rider position height	Turning Radius	Rover Stability
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Assembly	6	0	1	8	4	1	2	2
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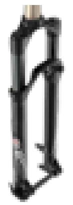
Rankings

Ranks to be used in determining following selection methods:

1. Rover Stability
2. Driver Input
3. Rover Output
4. Driver Mobility
5. Turning Radius
6. Rider Position Height
7. Rider Size Accommodation

Pugh Charts

- The ranking derived from the House of Quality are used to cross compare concepts

Front Suspension					
	Concepts				
Selection Criteria	Datum	Independent Suspension fork	Ski Fork	Rigid Bi-Wheel Fork	Independent Linkage Fork
Rover Stability	Rockshox recon suspension fork 	+	+	+	+
Driver Input		-	-	-	-
Rover Output		+	-	-	-
Driver Mobility		S	S	-	+
Turning Radius		+	S	S	-
Rider position height		S	S	S	S
Rider Size Accommodation		S	S	S	S
# pluses		3	1	1	2
# minuses		1	2	3	3

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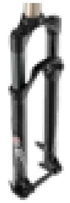
Front Suspension					
	Concepts				
Selection Criteria	Datum	Independent Suspension fork	Ski Fork	Rigid Bi-Wheel Fork	Independent Linkage Fork
Rover Stability	Rockshox recon suspension fork	+	+	+	+
Driver Input		-	-	-	-
Rover Output		+	-	-	-
Driver Mobility		S	S	-	+
Turning Radius		+	S	S	-
Rider position height		S	S	S	S
Rider Size Accommodation		S	S	S	S
# pluses		3	1	1	2
# minuses		1	2	3	3

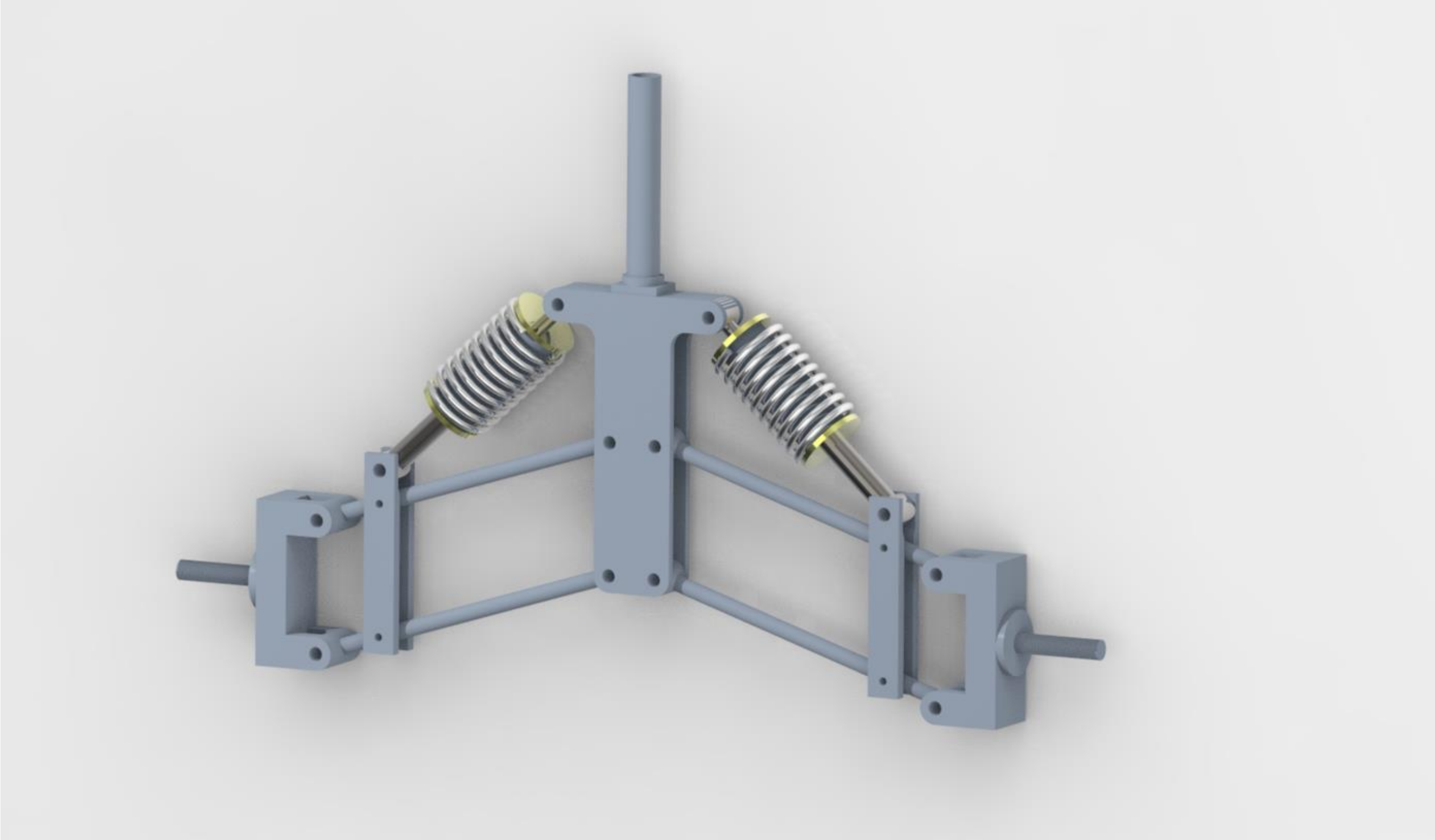
Front Suspension				
	Concepts			
Selection Criteria	Datum	Ski Fork	Rigid Bi-Wheel Fork	Independent Linkage Fork
Rover Stability	Independent Suspension fork	-	-	+
Driver Input		-	-	-
Rover Output		-	-	-
Driver Mobility		S	-	S
Turning Radius		S	S	-
Rider position height		S	S	S
Rider Size Accommodation		S	S	S
# pluses		0	0	1
# minuses		3	4	3

Selected Concepts

Phillip Dimacali

Front Independent Suspension Fork

- Suspended, Symmetrical 4-bar double-rocker
- 4-bar double rocker for steering input mechanism



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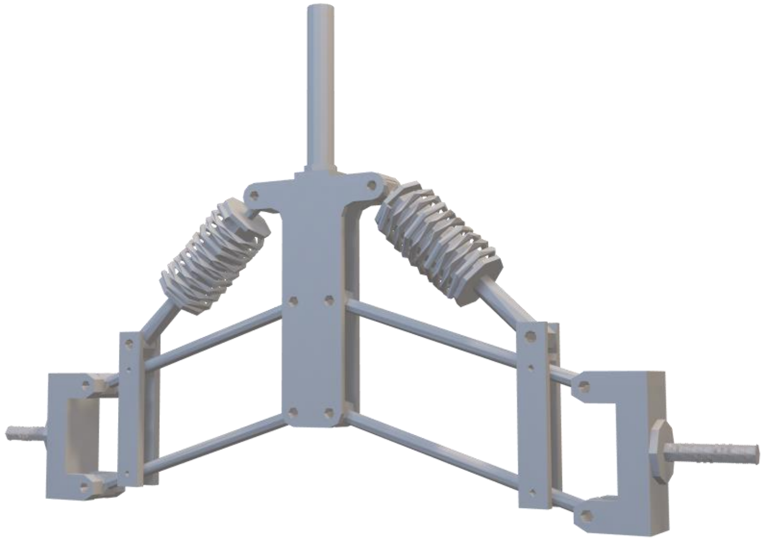
Suspension Fork Refinement



Structural Analysis:

- Loading Characteristics on Joints and Linkages
- Rider height considering spring displacement

Machine Design:

- Integrating fork with steering system
- Specifying components (bearings, coil spring, etc.)

Phillip Dimacali

Linkage Drivetrain

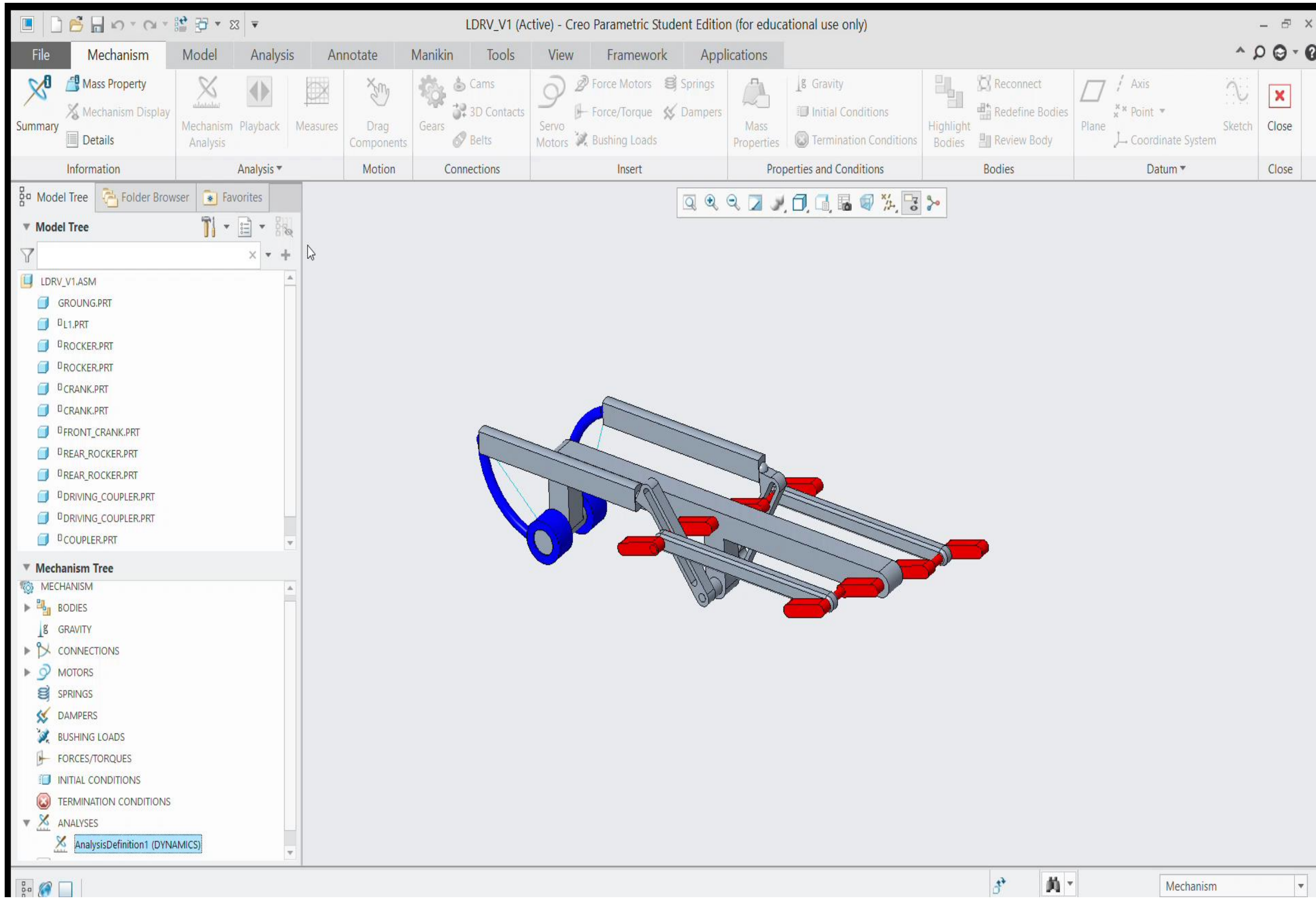
Blue component: Ratcheting (or one-way) mechanism

- Transmits torque to axle shaft only propelling vehicle forward

Red component: Crank for driver pedal input

Refinement:

- Determine ratcheting or one-way mechanism (considering one-way bearings)
- Design slot for constant angular velocity during power stroke given constant input
- Integrate system into chassis



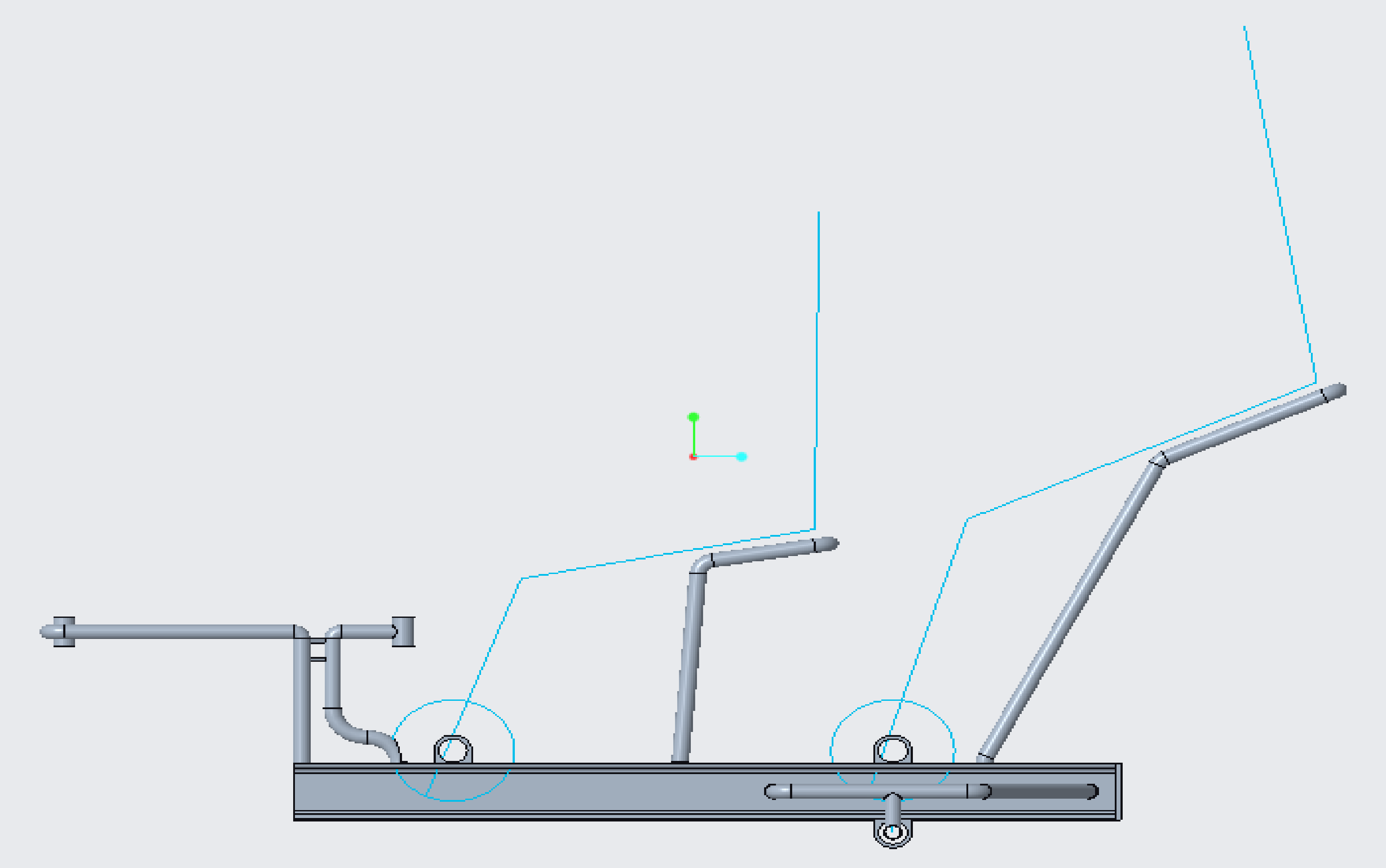
Variable Height Driver Layout

Considerations:

- Rider Dimensions
- Component integration
- Size Restrictions
- Design for Manufacturing and Assembly

Refinement:

- Structural analysis
- FEA considering varying loads
- Determination of fixtures (weld, through bolt, etc.)
- Make rover modular



Phillip Dimacali

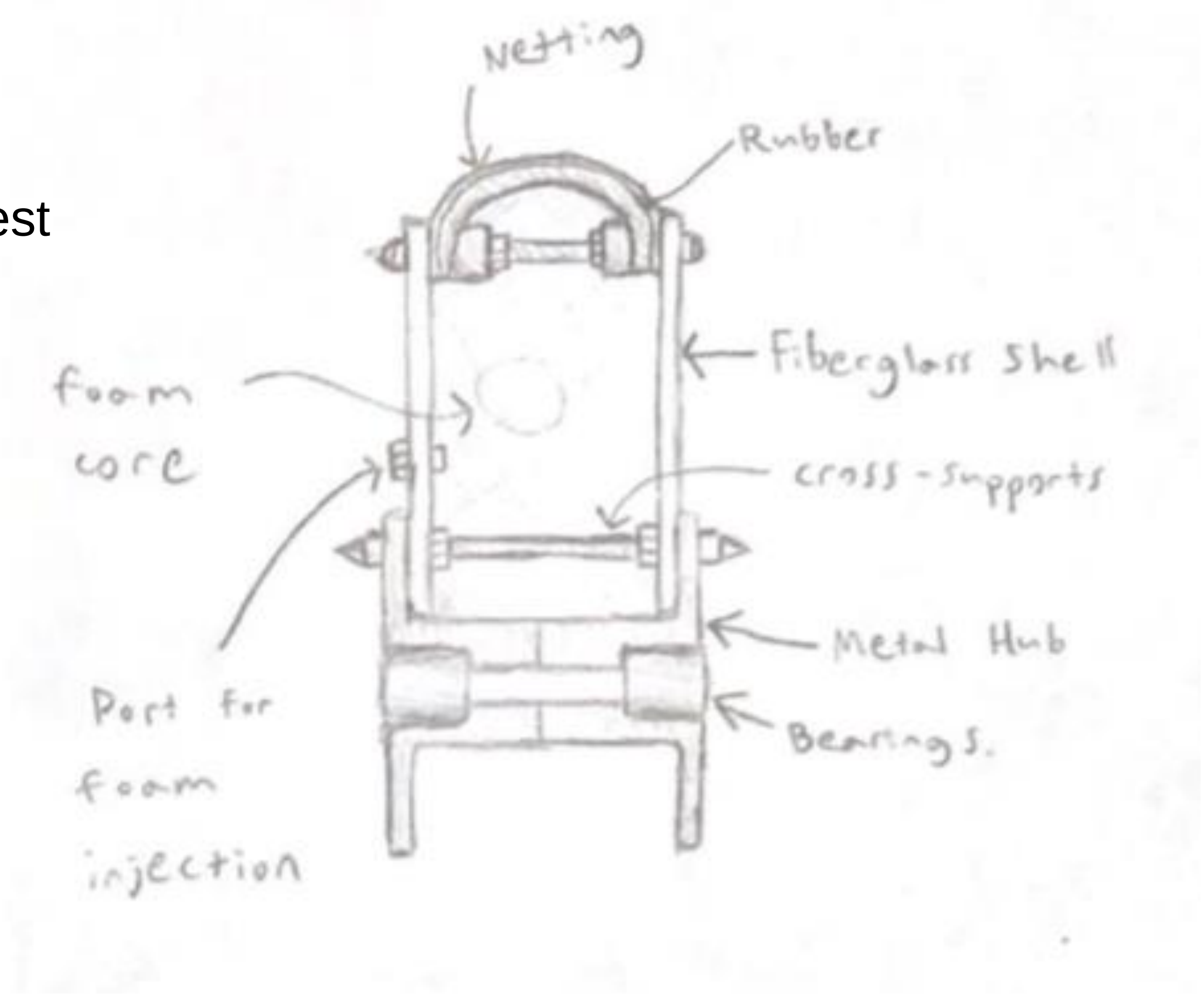
Phillip Dimacali

Foam Core Wheels

Refinement:

- Foam Core testing
  - Foam core dog bone compression test
- Structural analysis
- Design for manufacturing and assembly
- Material and component selection

Wheel Cross-section



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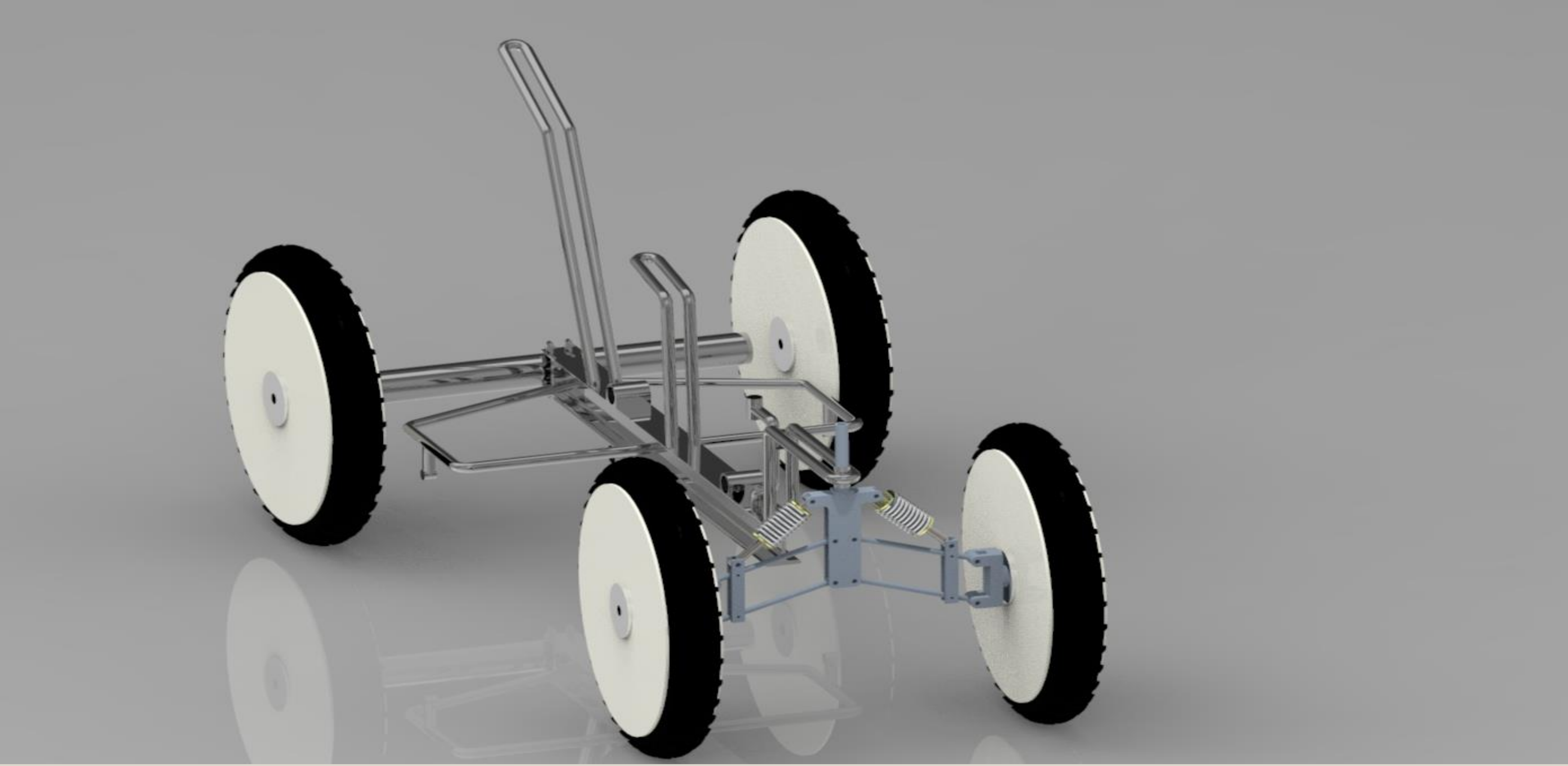

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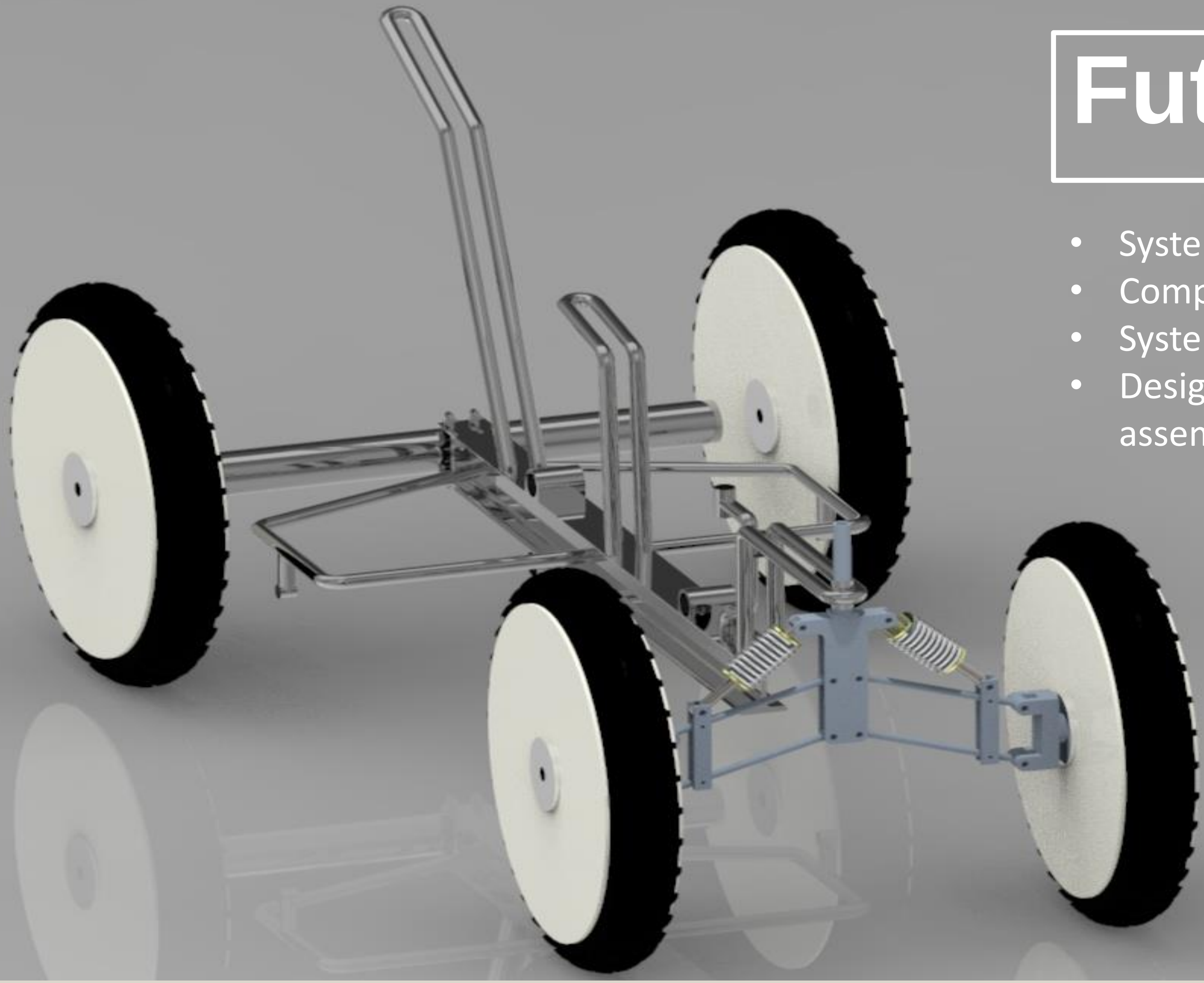

Future Work

- System Refinement
- Competition Strategy Optimization
- System Integration
- Design for manufacturing and assembly

Phillip Dimacali

References

National Aeronautics and Space Administration. (2020). Human Exploration Rover Challenge: 2020 Guidebook. *NASA Human Exploration Rover Challenge: 2020 Guidebook*. Alabama , United States of America.

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If I have seen further than others, it is by standing upon the shoulders of giants. ~ Sir Isaac Newton