FSGC NASA Human Powered Vehicle

Team 509:

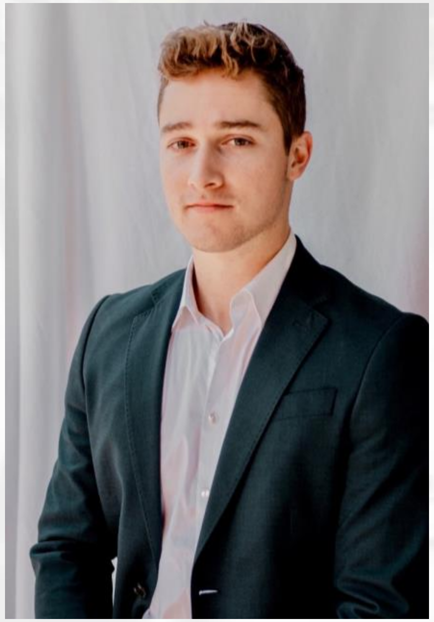
Ryan Floyd, Nicolas Picard,

Ninett Sanchez, Andrew Schlar

Presenters: Nicolas Picard, Ryan Floyd

Nicolas Picard

NASA Human Powered Vehicle Team 509



Ryan Floyd
Project and Materials Engineer

Nicolas Picard
Design Engineer

Ninett Sanchez
Design Engineer

Andrew Schlar
Team Leader,
Design Engineer, and
Point of Contact

Nicolas Picard

Sponsor and Advisor

Florida Space Grant Consortium

Dr. Shayne McConomy

Special thanks to Dr. Shayne McConomy for advising and mentoring the team

Nicolas Picard

Objective

The objective is to design and manufacture a human powered vehicle to traverse exoplanetary terrain in a NASA hosted competition.

Ryan Floyd

Project Background

- Apollo 14 lunar mission complications
- Annual NASA Human Exploration Rover Challenge Competition
- Artemis Moon Program
  - Lunar Mission 2024
  - Sustained Settlement 2028

Apollo 14 Flight Crew [1]

Ryan Floyd

Competition

Competition Date(s):

- April 15th - 17th, 2021

Location:

- Huntsville, Alabama
- Virtual hosting decision on February 4th, 2021

Course Details:

- 14 obstacles simulate lunar terrain
- 5 optional tasks, similar to astronaut missions
- 8-minute time limit represents theoretical oxygen supply

Student competitors completing competition challenge [2]

Ryan Floyd

Project Requirements

Dimensions

- Collapse to fit within 125 cubic feet
- 12-inch ground clearance
- 30° approach, departure, and breakover angles
- Overall width ≤ 5 feet

Input/Output

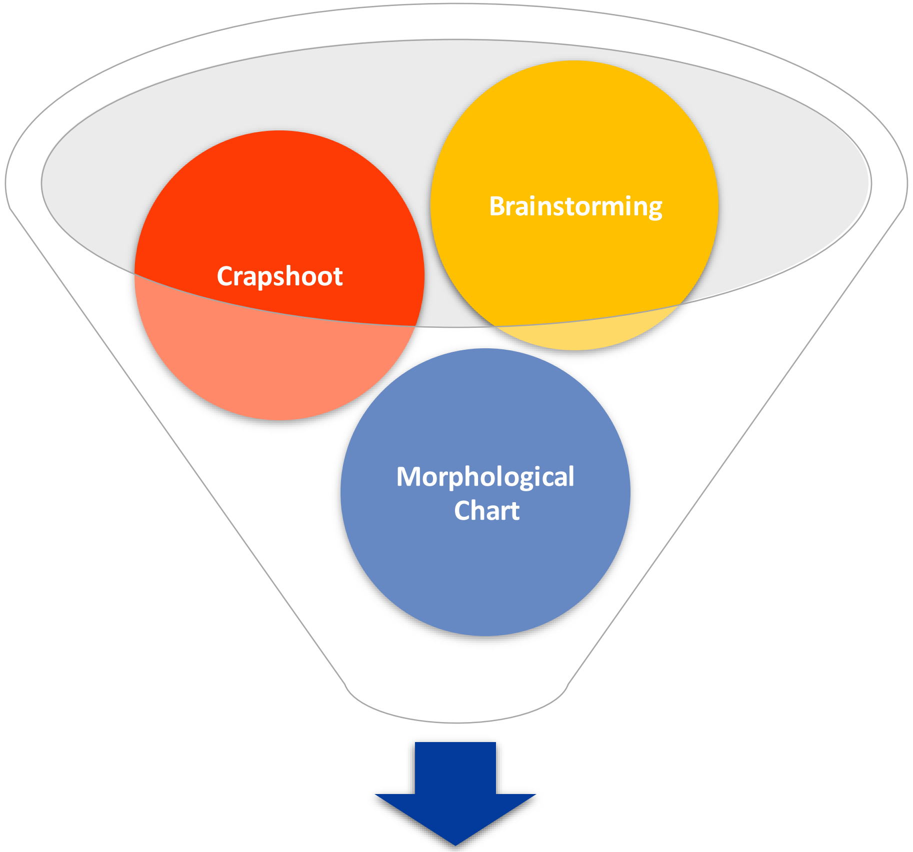
- Proportional Steering
- Maximum turning angle of 20°
- Turning radius ≤ 15 feet
- Pinion sizes: 16, 20 teeth
- Cassette, drive gear sizes: 32, 45 teeth

Safety

- Riders secured to vehicle
- Stopping distance ≤ 8 feet (from 10 mph)

Ryan Floyd

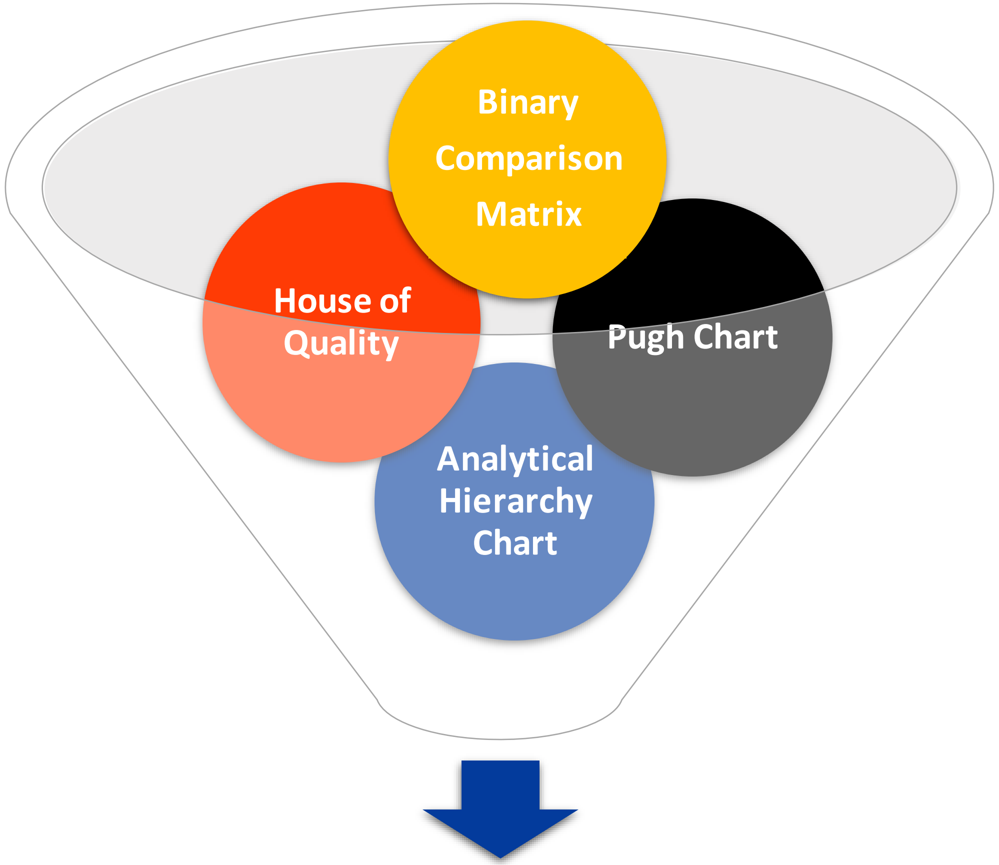
Concept Generation



Medium and High Fidelity

Nicolas Picard

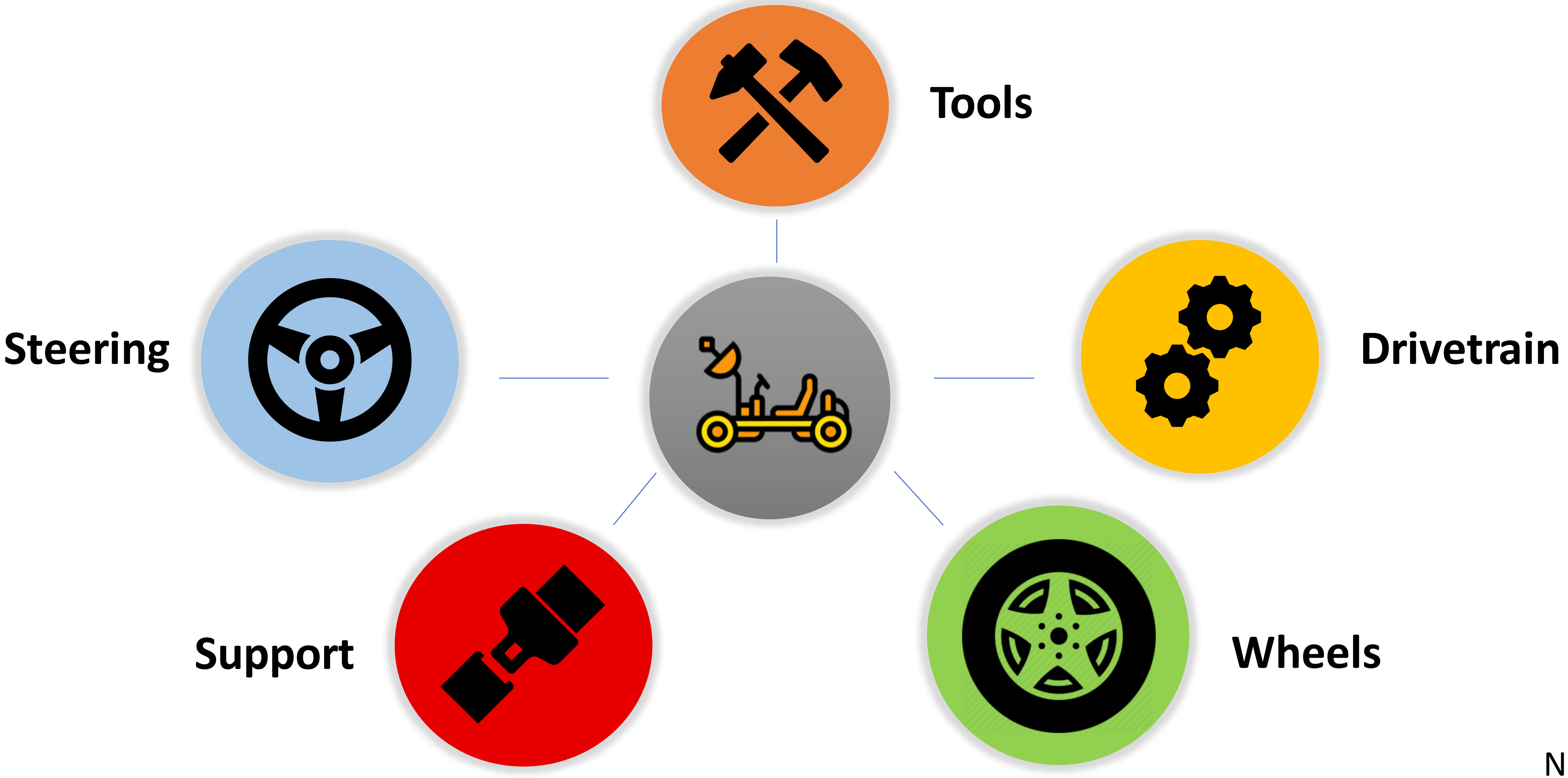
Concept Selection



Final Selection

Nicolas Picard

System Concepts

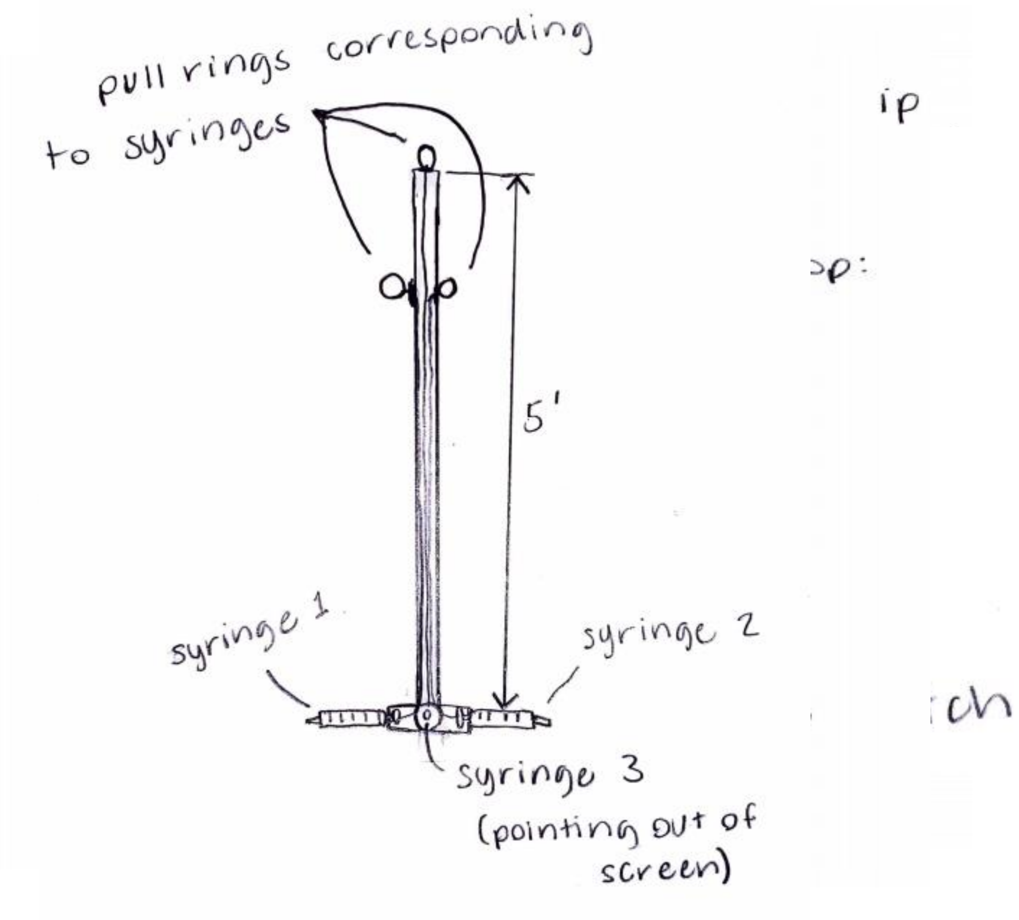


Nicolas Picard

Tools

Five Tasks

- Spectographic Analysis
- Instrument Deployment
- Core Sample Retrieval
- Solid Soil Sample Retrieval
- Liquid Sample Retrieval



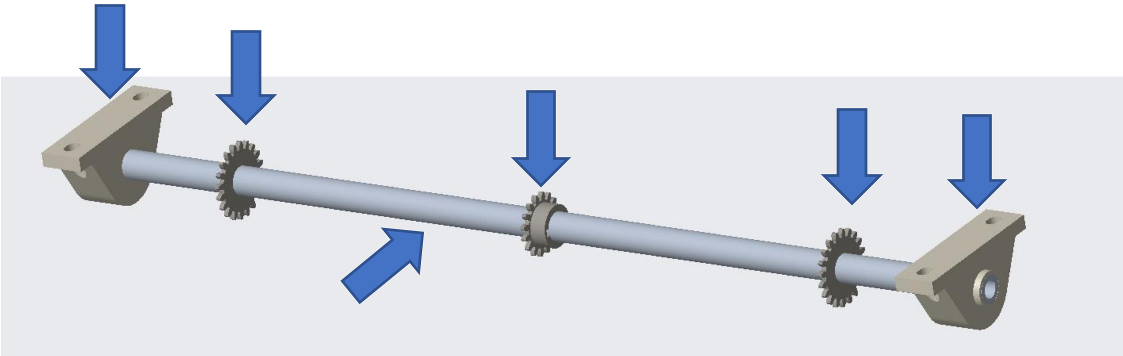
Nicolas Picard

Drivetrain

Two-Stage Chain Drive

Front Axle Components

- 32-tooth chainrings, 20-tooth freewheel pinions
- ANSI size 35 steel roller chains, 16-tooth solid pinion
- 1” OD, 0.188” wall thickness steel driveshaft
- Axle mounts with embedded bearings



Front axle powertrain

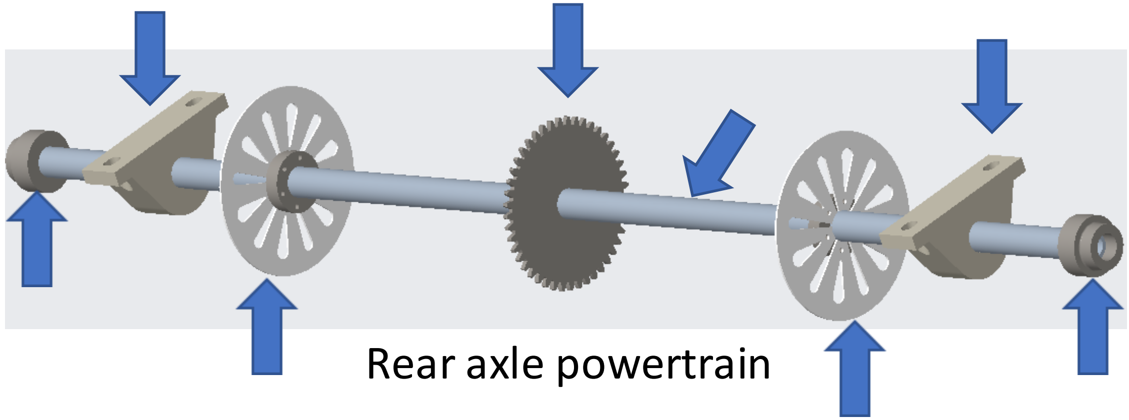
Ryan Floyd

Drivetrain

Two-Stage Chain Drive

Rear Axle Components

- ANSI size 35 steel roller chains, 45-tooth drive gear
- 1” OD, 0.188” wall thickness steel driveshaft
- Axle mounts with embedded bearings
- Disk Brake mounts and disks
- Driveshaft couplings



Rear axle powertrain

Ryan Floyd

Drivetrain – Future Work

Purchasing

- Driveshafts, gears, bearings and axle mounts

Fabrication Process: Welding & Machining

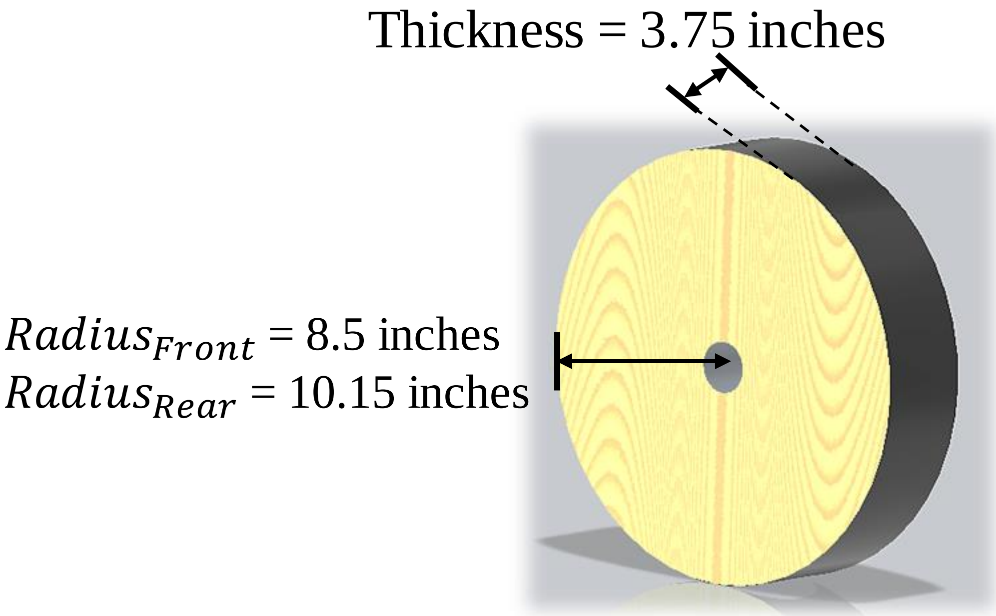
- Intermediate axle and pinions to be welded
- Rear axle and driving gear to be welded
- Machine driveshaft couplings
- Disk brake mounts to be machined and welded

Ryan Floyd

Wheels

Fabrication Process: Mold Casting

- Two female molds will be produced from plywood and veneer
- Each mold will be used to cast 2 wheels
  - 1 mold for front wheels
  - 1 mold for back wheels
- Pouring hole at the top of each mold



Ryan Floyd

Wheels Continuation

Fabrication Material: Polyurethane 2-Part Expanding Foam

- **Cheap**
  - $50 for enough material to make 12 wheels
- **Ease of shaping**
  - Starts out in liquid form, can take the shape of any mold
- **Impressive mechanical properties**
  - Compressive Strength: 580 psi
  - Tensile Strength: 450 psi
  - Shear Strength: 230 psi
  - Flexural Strength: 750 psi

Polyurethane 2-Part Expanding Foam, 2lb density[5]
*** We will be using 8lb density*

Ryan Floyd

Support

Frame

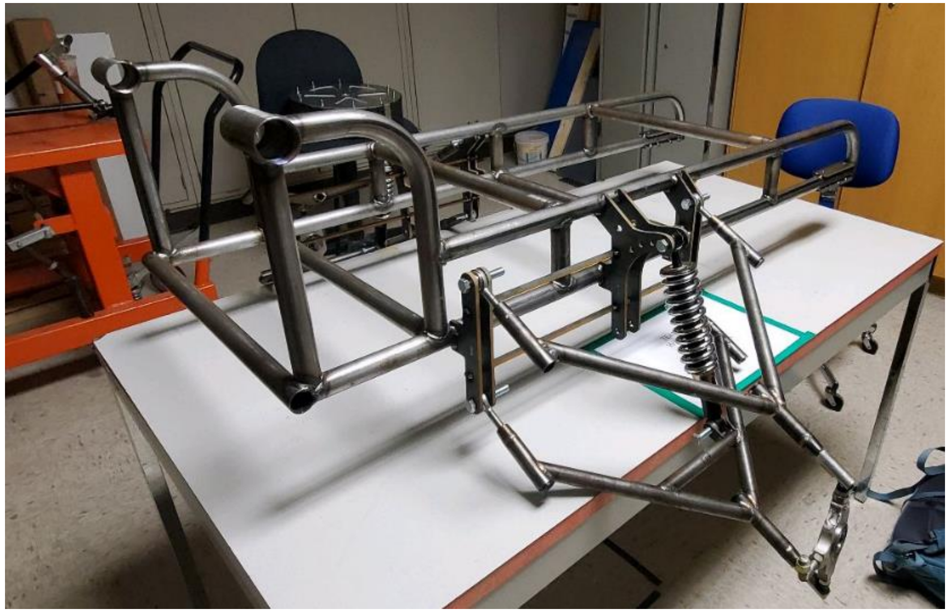
- Using frame from last year's team
- Short wheelbase

Suspension

- Double wishbone with equal length arms in front
- No rear suspension

Seating

- Side-by-side
- Recumbent style position



Nicolas Picard

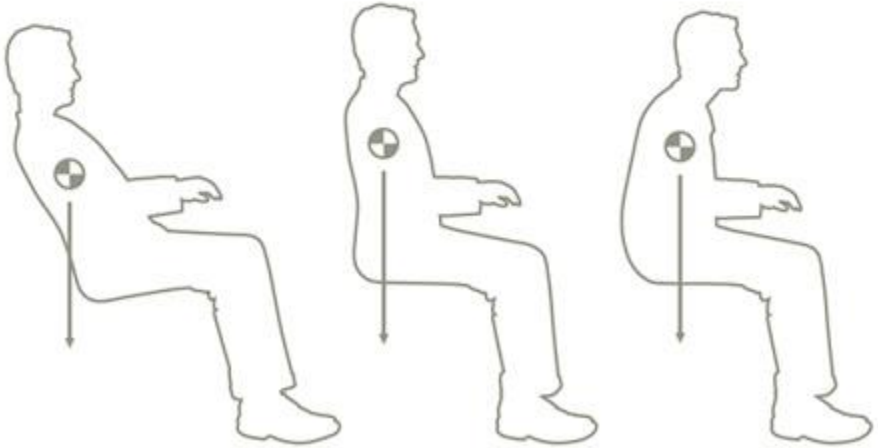
Support - Future Work

Frame

- Welds need to be checked and finished

Seating

- Angle and position
- Mounting to frame



Nicolas Picard

Steering

Dual Tiller Steering

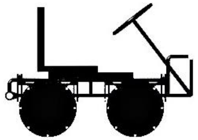
- Motion of the rover controlled by either rider
- Steering input is out of the way

Future Work

- Settle position of pivot joints
- Extended coupler connector to fit the frame
- Decide inner and outer tie rod locations

Nicolas Picard

Project Progress Fall 2020



Week 2
Contacted Previous Teams

Week 3
Inventoried Leftover Parts

Week 4
Research and Delegate Subsystems

Week 5
Completed Competition Registration

Week 6
Researched Previous Competitions

Week 7
Force and Strength Calculations

Week 8
CAD Prototyping

Week 9
COE Visit for Detailed Dimensioning

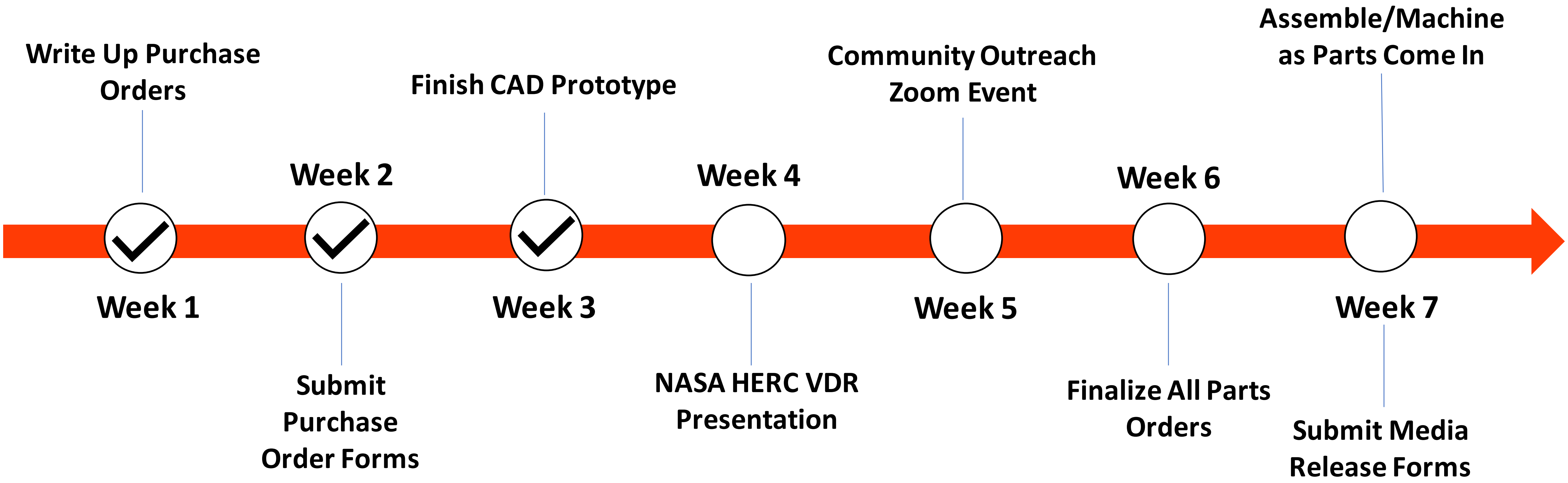
Ryan Floyd

Project Progress Fall 2020

- **Week 10** – Bike Shop Visit Q&A
- **Week 11** – CAD Design Refinement
- **Week 12** – CAD Modifications and Concept Re-selection
- **Week 13** – Bill of Materials
- **Week 14** – Update CAD Prototype
- **Week 15** – Budget and Prep Parts Order
- **Week 16** – Assemble/Machine as Parts Come In; Establish Social Media Presence

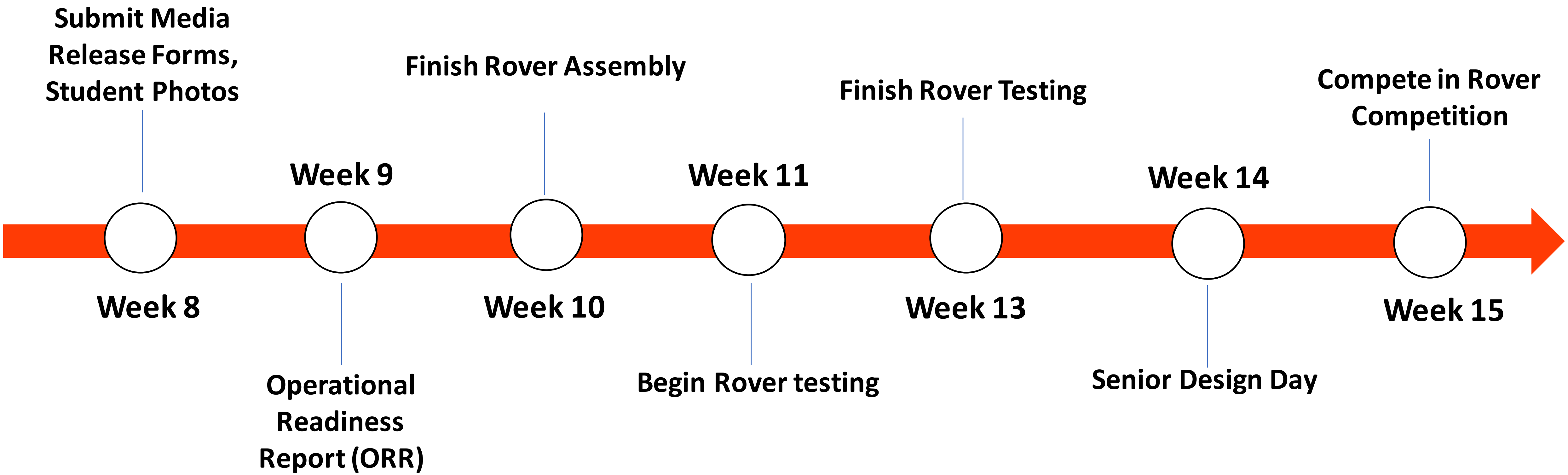
Ryan Floyd

Project Progress Spring 2021



Ryan Floyd

Project Progress Spring 2021



Ryan Floyd

Acknowledgement

- ✓ Florida Space Grant Consortium
- ✓ Special Thanks to Dr. Shayne McConomy
- ✓ Dr. Patrick Hollis
- ✓ Jessica Meeker

Ryan Floyd

Questions?

FSGC NASA Human Powered Vehicle

Our job is to design and manufacture a human powered vehicle to traverse exoplanetary terrain in a NASA hosted competition.

Feel free to ask us any questions.

Ryan Floyd

Section Links

Project Background

Competition

Project Requirements

Concept Generation

Concept Selection

Project Progress

Acknowledgements

References

Team 509

References

[1] Apollo 14 Crew Portrait. (2016, February 5). NASA. https://www.nasa.gov/image-feature/apollo-14-crew-portrait/

[2] Archive, N. (2019, May 15). NASA Celebrates 25th Anniversary Human Exploration Rover Challenge. Retrieved October 15, 2020, from https://www.flickr.com/photos/nasamarshallphotos/40890053883/in/album-72157705115914232/

[3] Dunbar, B. (n.d.). Artemis. Retrieved October 15, 2020, from https://www.nasa.gov/specials/artemis/

[4] Landau. (2019, May 31). Artemis Moon Program Advances – The Story So Far. NASA. https://www.nasa.gov/artemis-moon-program-advances

[5] Registration Open for NASA's Human Exploration Rover Challenge. (2020, October 8). NASA.Gov. https://www.nasa.gov/centers/marshall/news/releases/2020/registration-open-for-nasa-s-human-exploration-rover-challenge.html

[6] Shear, E. (2016, February 7). Apollo 14's Edgar Mitchell passes away at age 85. SpaceFlight Insider. https://www.spaceflightinsider.com/space-flight-history/apollo-14s-edgar-mitchell-passes-away-at-age-85/

[7] Late Model Restoration. (2020). 3-POINT RETRACTABLE SEAT BELT - UNIVERSAL. Late Model Restoration. Retrieved November 5, 2020, from https://lmr.com/item/LRS-B4051000/3-point-retractable-seat-belt

[8] Grainger. (2020). Trash Pickers & Grabbers. W.W. Grainger. Retrieved November 4, 2020, from https://www.grainger.com/category/cleaning-and-janitorial/waste-recycling-trash-supplies/trash-pickers-grabbers

[9] Maxpeedingrods. (n.d.). For 110cc Go Kart Steering Wheel Quad Parts W/ Steel Gear Rack Pinion. Retrieved from https://www.maxpeedingrods.com/product/fit-110cc-go-kart-steering-wheel-quad-parts-w-steel-gear-rack-pinion.html

[10] Quadratec. (2020). Seatbelt Solutions 2 Point Non-Retractable Lap Belt with Push-Button Buckle. Quadratec. Retrieved November 5, 2020, from https://www.quadratec.com/products/24247_20X_PG.htm

Team 509

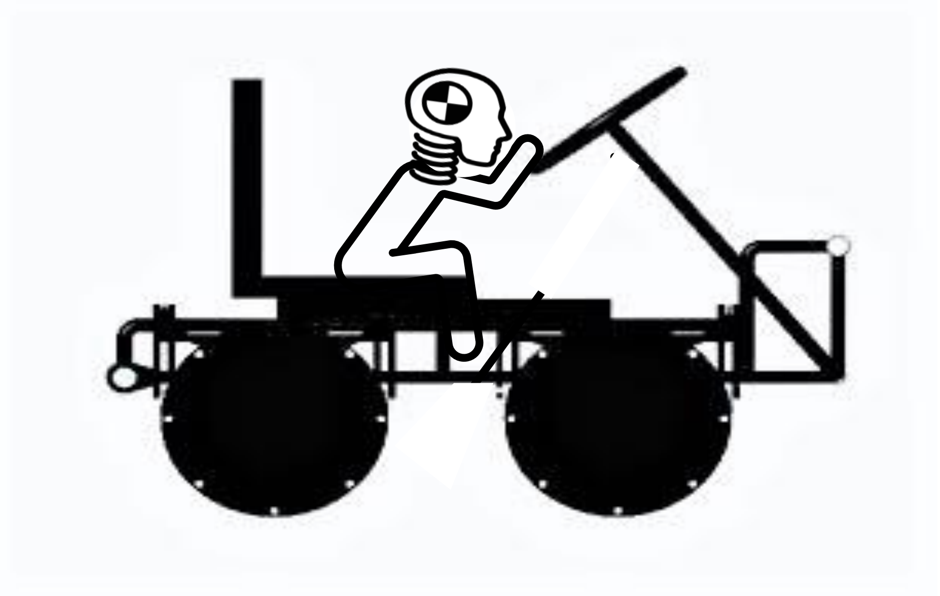
Backup Slides

Team 509

Validation

- ✓ Subsystems and components will be tested individually for their performance prior to competition

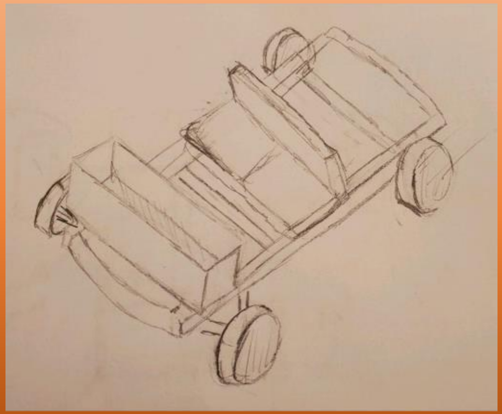
- ✓ Design will be fully validated in the field during the competition



Nicolas Picard

Medium Fidelity

Disk Brakes



Fronk Design

[7]

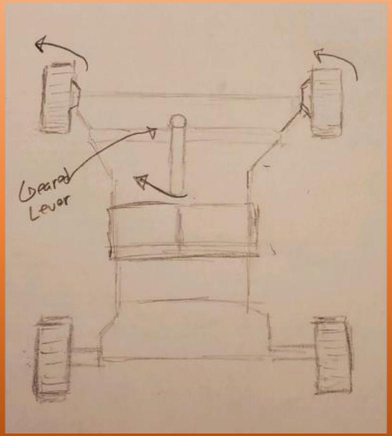
3-Point Seatbelt

Ninett Sanchez

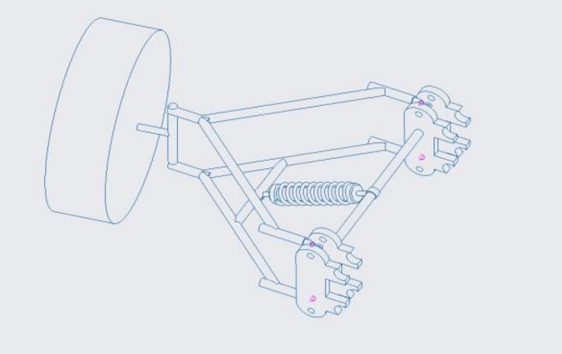
Medium Fidelity

[8]

Sample Gathering Tool



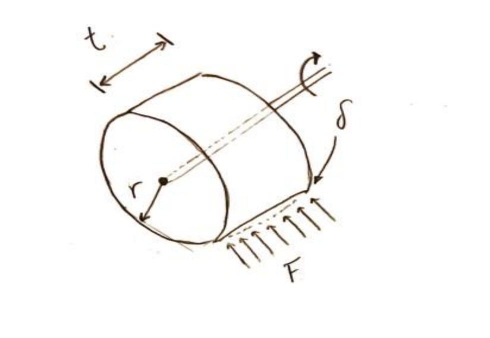
Tiller Steering Mechanism



Double Wishbone Suspension (Front and Rear)

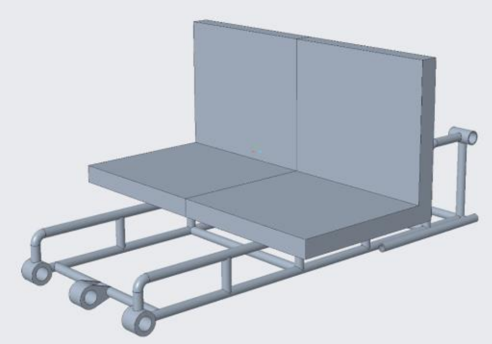
Ninett Sanchez

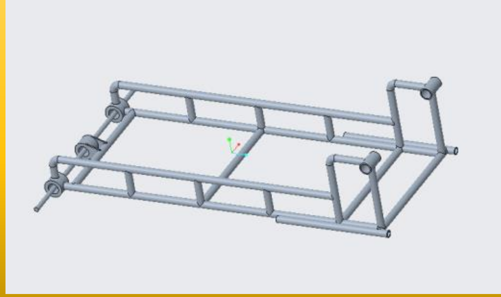
High Fidelity



High Density Rigid Polymer Foam Wheels

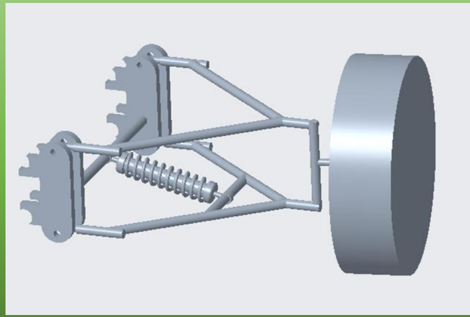
Side-by-Side Seating





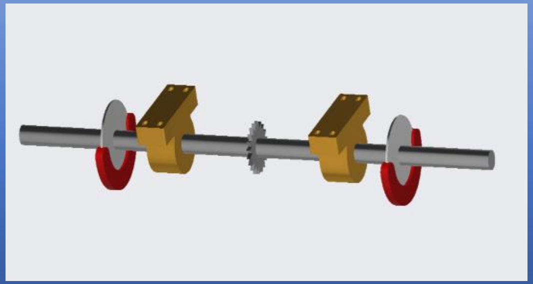
Frame from Previous Year's Team 514

Double Wishbone Suspension (Front only)

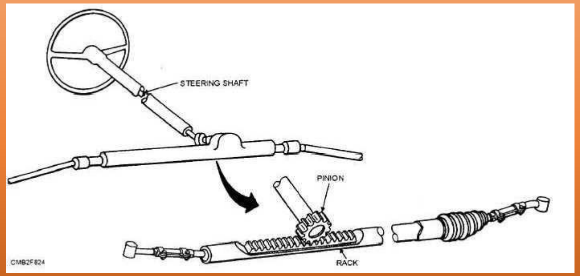


Ninett Sanchez

High Fidelity



Rear Axle Powertrain and Disk Brakes



[9]

Rack and Pinion Steering

[10]

2-Point Seatbelt

Ninett Sanchez

Binary Comparison

Binary Comparison Matrix

House of Quality

Pugh Chart

Analytical Hierarchy Chart

Customer Requirements	Importance Weight Factor
Maintain Functionality	7
Cost Effective	6
Maintain Operator Safety	5
Ease of Production	4
Handle Rough Terrain	2
Rider Size Accommodation	2
Ease of Assembly	2

Nicolas Picard

House of Quality

Binary Comparison Matrix

House of Quality

Pugh Chart

Analytical Hierarchy Chart

		Engineering Characteristics						
Improvement Direction	↑	↑	↓	↑	↑	↑	↑	↑
Units		N/A	inches	Number of seats	inches	inches*lbf	in	in^3 N/A
Customer Requirements	Importance Weight Factor	Stability	Turning Radius	Seating Accommodation	Ground Clearance	Rover Torque	Stopping Distance	Storage
Handle rough terrain	2	8	4	0	8	4	2	0
Maintain operator safety	5	4	2	8	2	0	2	0
Maintain functionality	7	2	2	0	2	8	8	4
Ease of production	4	0	0	4	4	4	2	2
Rider size accommodation	2	4	0	8	2	2	2	4
Cost effective	6	4	2	2	2	4	0	2
Ease of assembly	2	2	2	4	2	2	0	0
Raw Score (552)		86	48	92	76	112	82	56
Relative Weight (%)		15.58	8.70	16.67	13.76	20.29	14.86	10.14
Rank Order		3	7	2	6	1	4	5

Nicolas Picard

House of Quality

Binary Comparison Matrix

House of Quality

Pugh Chart

Analytical Hierarchy Chart

		Engineering Characteristics						
Improvement Direction	↑	↑	↓	↑	↑	↑	↑	↑
Units		N/A	inches	Number of seats	inches	inches*lbf	in	in^3 N/A
Customer Requirements	Importance Weight Factor	Stability	Turning Radius	Seating Accommodation	Ground Clearance	Rover Torque	Stopping Distance	Storage
Handle rough terrain	2	8	4	0	8	4	2	0
Maintain operator safety	5	4	2	8	2	0	2	0
Maintain functionality	7	2	2	0	2	8	8	4
Ease of production	4	0	0	4	4	4	2	2
Rider size accommodation	2	4	0	8	2	2	2	4
Cost effective	6	4	2	2	2	4	0	2
Ease of assembly	2	2	2	4	2	2	0	0
Raw Score (552)		86	48	92	76	112	82	56
Relative Weight (%)		15.58	8.70	16.67	13.76	20.29	14.86	10.14
Rank Order		3	7	2	6	1	4	5

Nicolas Picard

House of Quality

Binary Comparison Matrix

House of Quality

Pugh Chart

Analytical Hierarchy Chart

		Engineering Characteristics						
Improvement Direction	↑	↑	↓	↑	↑	↑	↑	↑
Units		N/A	inches	Number of seats	inches	inches*lbf	in	in^3 N/A
Customer Requirements	Importance Weight Factor	Stability	Turning Radius	Seating Accommodation	Ground Clearance	Rover Torque	Stopping Distance	Storage
Handle rough terrain	2	8	4	0	8	4	2	0
Maintain operator safety	5	4	2	8	2	0	2	0
Maintain functionality	7	2	2	0	2	8	8	4
Ease of production	4	0	0	4	4	4	2	2
Rider size accommodation	2	4	0	8	2	2	2	4
Cost effective	6	4	2	2	2	4	0	2
Ease of assembly	2	2	2	4	2	2	0	0
Raw Score (552)		86	48	92	76	112	82	56
Relative Weight (%)		15.58	8.70	16.67	13.76	20.29	14.86	10.14
Rank Order		3	7	2	6	1	4	5

Nicolas Picard

Steering Pugh Chart

Binary Comparison Matrix

House of Quality

Pugh Chart

Analytical Hierarchy Chart

Steering				
	Concepts			
Engineering Characteristics	Rack and pinion Steering from previous year	Tiller Steering Mechanism	Double Wheel Steering	Rear Wheel Steering
Stability	Datum	S	-	-
Turning Radius		-	-	-
Seating Accommodation		S	S	S
Ground Clearance		+	S	S
Drivetrain Torque		S	S	S
Stopping Distance		S	S	S
Storage		S	S	S
# pluses		1	0	0
# minuses		1	2	2

Ninett Sanchez

Suspension Pugh Chart

Binary Comparison Matrix

House of Quality

Pugh Chart

Analytical Hierarchy Chart

Suspension				
	Concepts			
Engineering Characteristics	Double wishbone suspension (front)	No suspension	Double wishbone suspension (front and rear)	MacPherson Strut (front)
Stability	Datum	-	+	-
Turning Radius		S	S	S
Seating Accommodation		S	S	S
Ground Clearance		+	-	S
Rover Torque		-	+	S
Stopping Distance		-	-	S
Storage		S	S	S
# pluses		1	2	0
# minuses		3	2	1

Ninett Sanchez

Frame Pugh Chart

Binary Comparison Matrix

House of Quality

Pugh Chart

Analytical Hierarchy Chart

Frame				
	Concepts			
Engineering Characteristics	Frame from previous year	Elongated and segmented frame from previous year	Single beam, segmented frame	Wooden frame with center fold joint
Stability	Datum	-	-	-
Turning Radius		-	-	-
Seating Accommodation		S	S	S
Ground Clearance		S	S	S
Rover Torque		S	S	S
Stopping Distance		S	S	S
Storage		+	+	-
# pluses		1	1	0
# minuses		2	2	3

Ninett Sanchez

Wheels Pugh Chart

Binary Comparison Matrix

House of Quality

Pugh Chart

Analytical Hierarchy Chart

Wheels				
	Concepts			
Engineering Characteristics	Cork wheels, solid throughout	High density rigid polymer foam wheels	Wooden wheels	Patterned aluminum wheels
Stability	Datum	+	-	-
Turning Radius		S	S	S
Seating Accommodation		S	S	S
Ground Clearance		+	+	+
Rover Torque		S	-	-
Stopping Distance		S	S	S
Storage		S	S	S
# pluses		2	1	1
# minuses		0	1	2

Ninett Sanchez

Analytical Hierarchy Process

Binary Comparison Matrix

House of Quality

Pugh Chart

Analytical Hierarchy Chart

Evaluation Criteria

Final Concepts

Evaluated Comparison

Ninett Sanchez

Final Selection

- Double wishbone front suspension
- Side-by-side forward facing seating
- Rack and pinion steering
- Rear-axle drive train
- Rear-axle disk brakes

Nicolas Picard

Binary Comparison

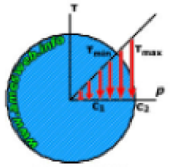
- **Binary Comparison Matrix**
- House of Quality
- Pugh Chart
- Analytical Hierarchy Chart

	1	2	3	4	5	6	7	8	Total
1. Handle rough terrain	-	0	0	0	0	0	1	1	2
2. Maintain operator safety	1	-	0	1	1	0	1	1	5
3. Maintain functionality	1	1	-	1	1	1	1	1	7
4. Ease of production	1	0	0	-	1	0	1	1	4
5. Rider size accommodation	1	0	0	0	-	0	0	1	2
6. Cost effective	1	1	0	1	1	-	1	1	6
7. Ease of assembly	0	0	0	0	1	0	-	1	2
Total	5	2	0	3	5	1	5	7	-

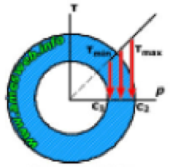
Team 509

Driveshaft Calculations

Torsion of Shaft Calculator:



SOLID SHAFT



HOLLOW SHAFT

Shaft style	○Solid Shaft ◉Hollow Shaft	
INPUT PARAMETERS		
Parameter	**Value**	
Torque [T]	166	lbf*ft
Rotation speed [w]	82	rpm
Shaft outer radius [c_2]	1	inch
Shaft inner radius [c_1]	0.188	
Shaft length [L]	48	
Modulus of rigidity [G]	11.12	psi*10^6
Calculate		

RESULTS		
Parameter	**Value**	
Maximum shear stress [τ_{max}]	1269.733	psi
Angle of twist [θ]	0.005	Radian
Power requirement [P]	2.592	hp
Polar moment of inertia [J]	0	ft^4

Source: https://amesweb.info/Torsion/torsion-of-shaft-calculator.aspx

Team 509