NASA HERC ROVER 2022-23

Jacob Clark, Reagan Guthrie, Austin Hensley, Emma Oslakovich, Michael Simmons, Ernesto Vieyra
Design Engineering Technology
Advisor: Timothy Jenkins, Ph.D.

PROBLEM STATEMENT

The NASA Human Exploration Rover Challenge (HERC) features an engineering design challenge to engage students worldwide in the next phase of human space exploration. The HERC objective is to emphasize designing, constructing and testing technologies, and traversing in a unique environment. The designed rover must be capable of traversing over varying terrain while maintain structural integrity. With an emphasis on safety, the rover must be tested extensively, analyzing potential failure areas and ways to prevent the failure through improvements.

Figure 1: NASA HERC Exploration

CUSTOMER NEEDS

The team referenced the NASA HERC handbook for deciding the customer needs. The team determined the rover must exhibit a safe design, maintain structural integrity, be human powered by two pilots, feature a multi-functional task tool, and complete the excursion. In preparation for concept development, the team used the management of quality concept of Quality Function Deployment. In doing so, a House of Quality (HOQ) comparing the customer needs to specifications was generated. Specifications according to NASA and the team's advisor are listed in Table 1.

Table 1: Rover Requirements

Target Values	Specifications
Weight	170lbs
Collapsed Volume	5' x 5' x 5'
Unfold Time	30s
Turning Radius	10'
Ground Clearance	12"
Excursion Time	8 min
Overall Width	5'

SYSTEM-LEVEL DESIGN

System level design shows the integration between the rover subcomponents. Figure 2 details the connection of steering, drivetrain, wheels, suspension/brakes, frame, seats, task tool, and other safety components.

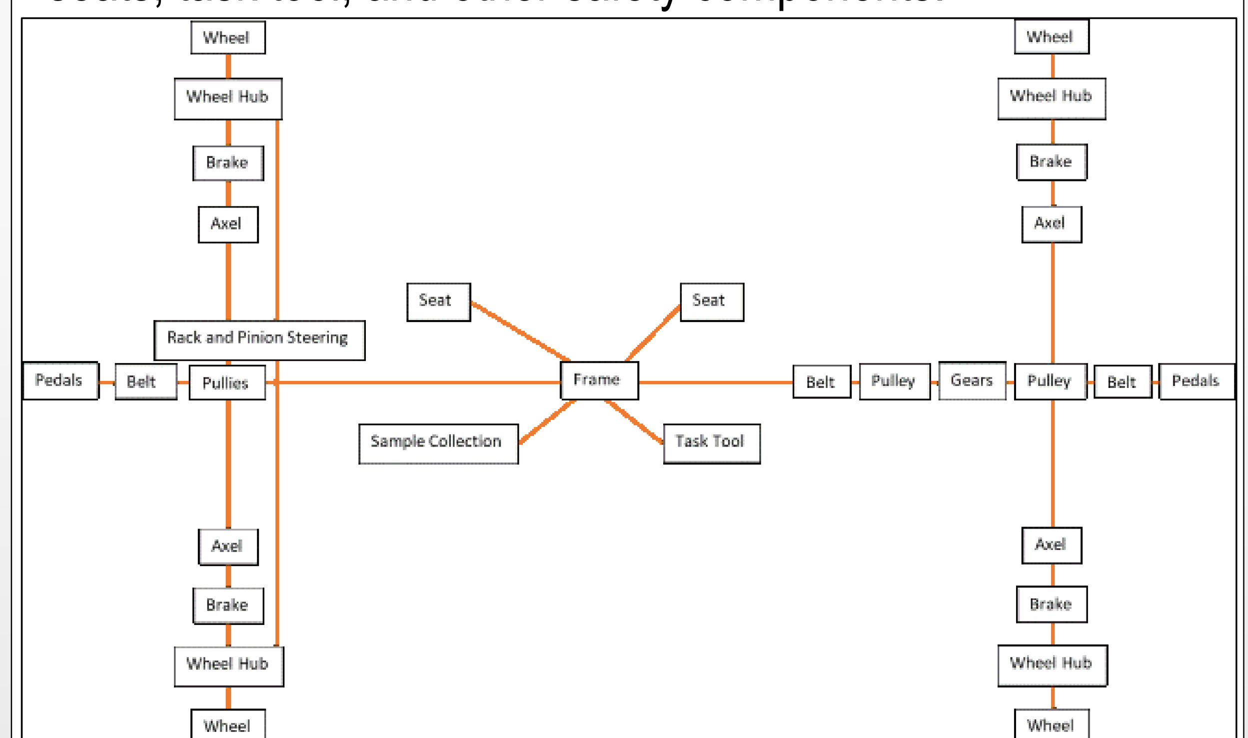


Figure 2: System-Level Design Rover

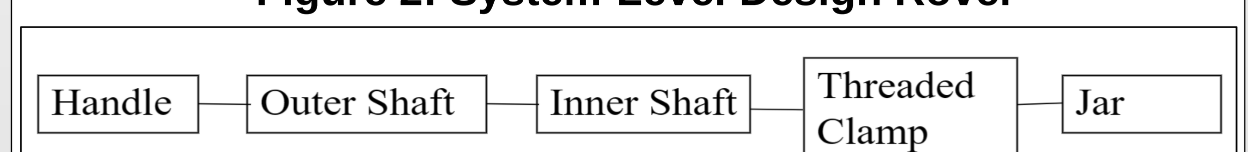
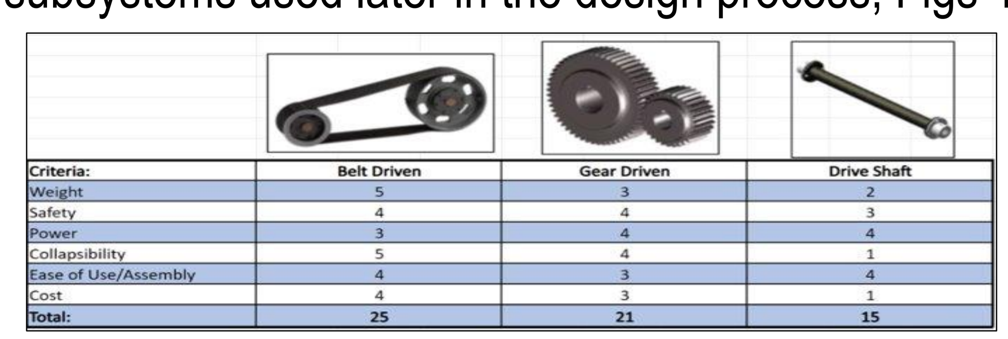


Figure 3: System-Level Design Task Tool

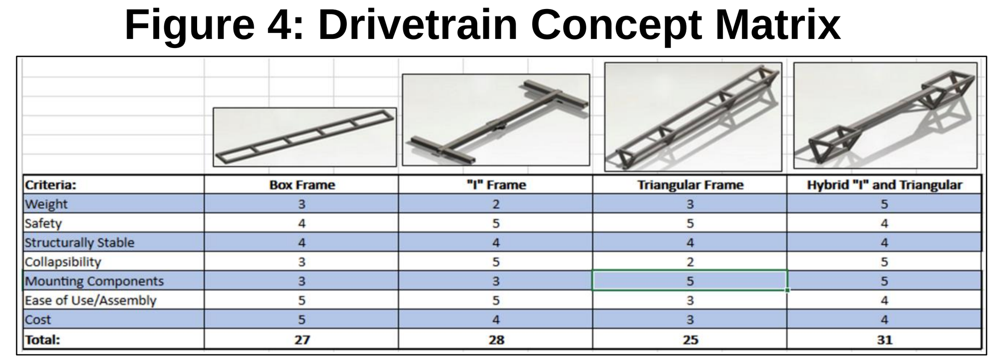
DESIGN CONCEPTS

The team was able to develop concept matrices to predict the subsystems used later in the design process, Figs 4-7.



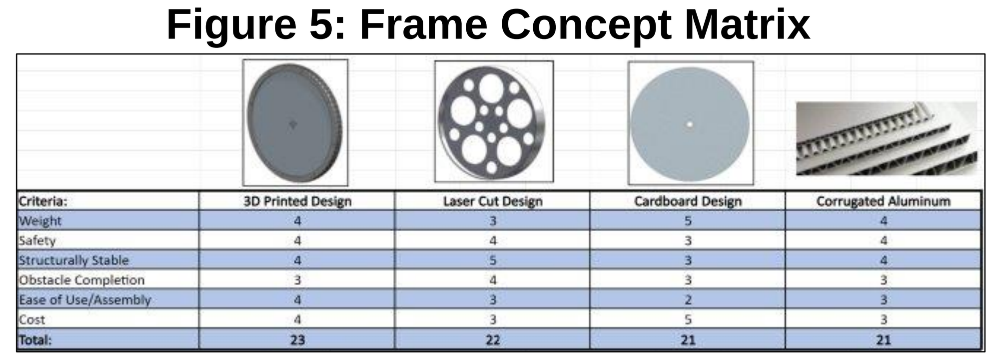
Criteria:	Belt Driven	Gear Driven	Drive Shaft
Weight	5	3	2
Safety	4	4	3
Power	3	4	4
Collapsibility	5	4	1
Ease of Use/Assembly	4	3	4
Cost	4	3	1
Total:	25	21	15

Figure 4: Drivetrain Concept Matrix



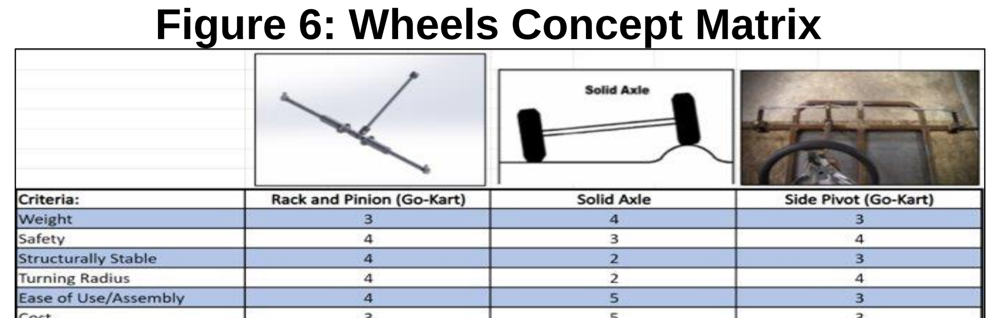
Criteria:	Box Frame	"I" Frame	Triangular Frame	Hybrid "I" and Triangular
Weight	3	2	3	5
Safety	4	5	5	4
Structurally Stable	4	4	4	4
Collapsibility	3	5	2	5
Mounting Components	3	3	5	5
Ease of Use/Assembly	5	5	3	4
Cost	5	4	3	4
Total:	27	28	25	31

Figure 5: Frame Concept Matrix



Criteria:	3D Printed Design	Laser Cut Design	Cardboard Design	Corrugated Aluminum
Weight	4	3	5	4
Safety	4	4	3	4
Structurally Stable	4	5	3	4
Obstacle Completion	3	4	3	3
Ease of Use/Assembly	4	3	2	3
Cost	4	3	5	3
Total:	23	22	21	21

Figure 6: Wheels Concept Matrix

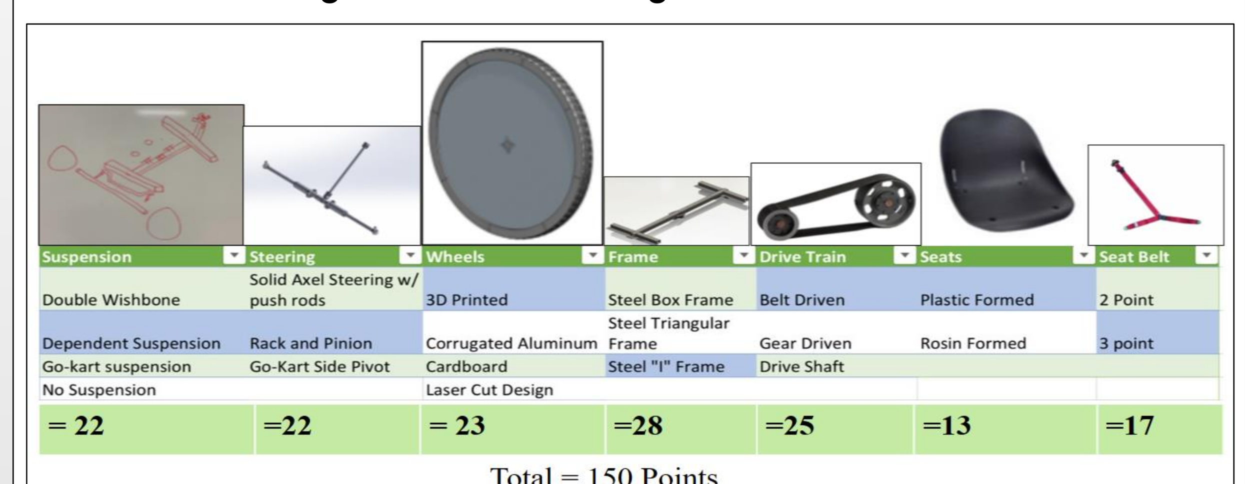


Criteria:	Rack and Pinion (Go-Kart)	Solid Axle	Side Pivot (Go-Kart)
Weight	3	4	3
Safety	4	3	4
Structurally Stable	4	2	3
Turning Radius	4	2	4
Ease of Use/Assembly	4	5	3
Cost	3	5	3
Total:	22	21	20

Figure 7: Steering Concept Matrix

INITIAL DESIGN

After systematically selecting subcomponents, an initial design was finalized. This included an "I" frame, using belts for the drive train, hybrid 3D printed wheels, rack and pinion steering, dependent suspension, adjustable seats (plastic formed), three-point seat belts, and a 3D printed task tool. The outcome was a design that all team members agreed upon. This was the initial design presented to NASA for the Operational Readiness Review report and presentation and shown in Figures 8 and 9. The task took design is shown in Figure 10.



Suspension	Steering	Wheels	Frame	Drive Train	Seats	Seat Belt
Double Wishbone	Solid Axel Steering w/ push rods	3D Printed	Steel Box Frame	Belt Driven	Plastic Formed	2 Point
Dependent Suspension	Rack and Pinion	Corrugated Aluminum	Steel Triangular Frame	Gear Driven	Rosin Formed	3 point
Go-kart suspension	Go-Kart Side Pivot	Cardboard	Steel "I" Frame	Drive Shaft		
No Suspension		Laser Cut Design				
= 22	=22	= 23	=28	=25	=13	=17

Total = 150 Points

Figure 8: Initial Design Matrix

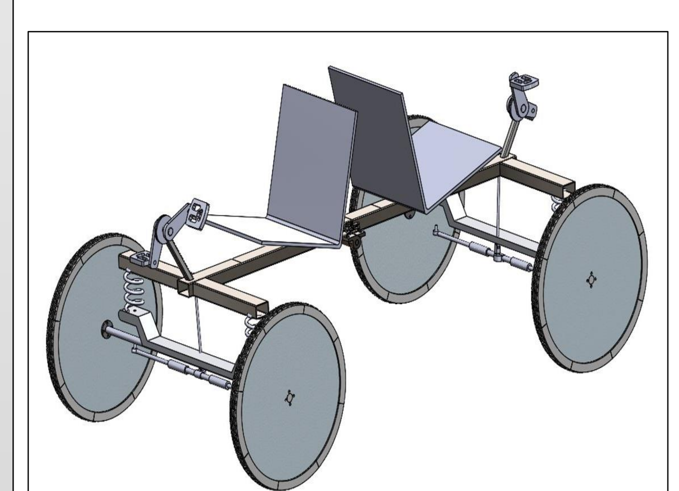


Figure 9: Initial SolidWorks Model of the Rover

Figure 10: Initial Model of the Task Tool

TEST RESULTS

For testing, the team used FEA and physical testing, Figures 11 and 12. During testing, some adjustments needed to be made as components did not meet the FOS in FEA and during physical testing some components broke. Therefore, a redesigned of the frame, the steering assembly, and task tool occurred.

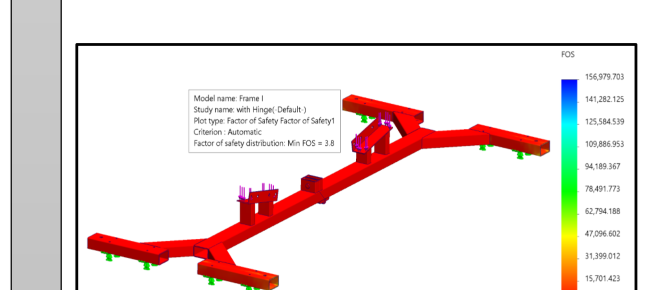


Figure 11: Frame FEA Showing FOS of 2.1

Figure 12: Physical Frame Testing

FINAL DESIGN

The final rover design allowed the team to fully meet the requirements from NASA and team specifications. The final rover consisted of a belt drivetrain, a steering assembly, steel wheels, a steel frame, no suspension, seats, a two-point seat belt, a task tool, and sample storage.

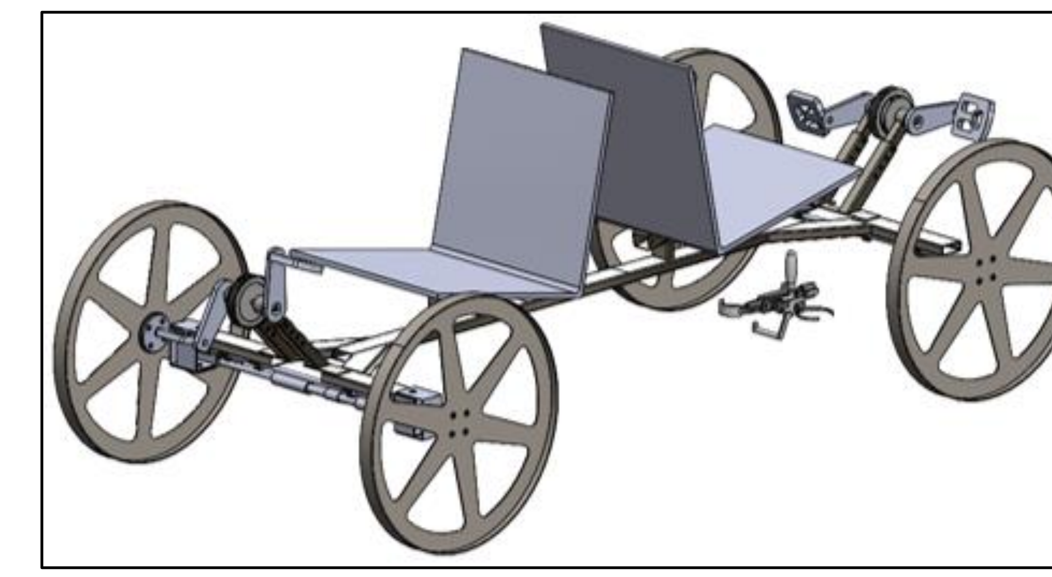


Figure 13: Final SolidWorks Model of the Rover

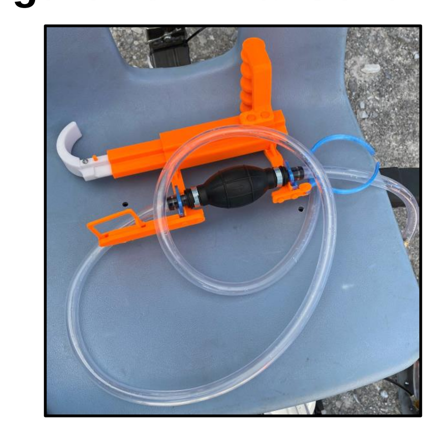


Figure 14: Final Model of the Task Tool

COMPETITION RESULTS

The team traveled to Huntsville, Alabama to compete against 37 other college teams. The team placed 10th overall.

Figures 15-16: Final Rover at NASA Competition

LESSONS LEARNED

- Time-management
- Communication
- Professionalism
- Patience
- Problem Solving
- Team Collaboration
- Machining Skills
- Mechanism Development

ACKNOWLEDGEMENTS

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