Needs Assessment

Team 17

NASA Human Exploration Rover Challenge

Members:

Luke Maeder – ltm12@my.fsu.edu

Jacob Van Dusen – jhv13b@my.fsu.edu

Katherine Estrella – jke13@my.fsu.edu

Quentin Hardwick – qth14@my.fsu.edu

Garrett Rady – gar11@my.fsu.edu

Faculty Advisor

Dr. Nikhil Gupta

Sponsor

Florida A&M University – Florida State University College of Engineering

Instructor

Dr. Nikhil Gupta

09/29/16

Table of Contents

Table of Figures*

ABSTRACT

The purpose of this project is to enter a vehicle into NASA's 2016 Annual Rover challenge. The challenge will focus on designing, constructing and testing technologies for mobility devices to perform in adverse environments, and it will provide valuable research that will be needed in future exploration missions. The competition will take place on a closed course in which the off road capabilities or the vehicle will be assessed.

1. Introduction

The given challenge overview best summarizes the goal and key parameters of the competition in itself.

"Rovers will be human-powered and carry two students, one female and one male, over a half-mile obstacle course of simulated extraterrestrial terrain of craters, boulders, ridges, inclines, crevasses and depressions.

Each student team of six members is responsible for building their own rover, and the two course drivers must be chosen from the team.

As a part of the challenge, and before traversing the course, unassembled rover entries must be carried by the drivers to the course starting line with the unassembled components contained in a volume of 5 feet by 5 feet by 5 feet (dimension requirements). At the starting line, the entries will be assembled, readied for racing, and evaluated for safety. Assembly occurs one time prior to the first course run."[1]

The rover challenge employs two basic concepts. Transportation of multiple humans across rocky terrain using human power only, and development of robust pressure-less wheels which give off road capabilities. The wheel design can be utilized by NASA in future endeavors both manned and unmanned. The transportation vehicle portion is speculated to be employed in NASA's mission to Mars.

2. Background and Literature Review

On November 17, 1970, the Soviet Union became the first nation ever to successfully land a remote-controlled robot on a celestial body when they landed the Lunokhod 1 on the surface of the moon. The Lunokhod 1 survived the lunar surface for 10 months and travelled further than 10 kilometers before finally calling it quits[3]. NASA landed a planetary explorer of their own the following year, although the vehicle was piloted directly by humans rather than remote control. Still, it marked the beginning of NASA's attempts to conquer alien terrain with a wheeled vehicle. It wasn't until the focus of extraplanetary exploration shifted away from the moon and towards the far more distant planet Mars that NASA became invested in remotely-controlled robotic surface exploration vehicles.

The successful landing of the NASA's Mars Pathfinder on July 4, 1997 marked the first time a remotely-controlled robotic vehicle landed on another planet. The Pathfinder only lasted about a month, but that was mostly be design. The mission was essentially a proof-of-concept, demonstrating that a robotic explorer could be landed safely and used for surface exploration for a fraction of the cost and none of potential loss of life of human exploration. The Pathfinder mission was the essentially the prototype of the modern rovers, and its success kicked off the beginning of the Mars Exploration Rover (MER) missions.

The modern rovers are part of the MER project, which formally took to the skies in the summer of 2013 with the launching of the Spirit and Opportunity rovers. Contact with Spirit was lost March 22, 2010, nearly 7 years after launch. The Opportunity rover is still going, and the success of the MER project has NASA planning similar projects for most of the other major bodies in the solar system. Part of this massive exploration project will be overcoming the difficult terrain found on desolate bodies throughout the cosmos. The NASA Human Exploration Rover Challenge was designed to encourage the development of vehicles and technologies that are up to the task of exploring such harsh environments, as well as fostering interest and creativity in young minds interested in further exploration of the universe.

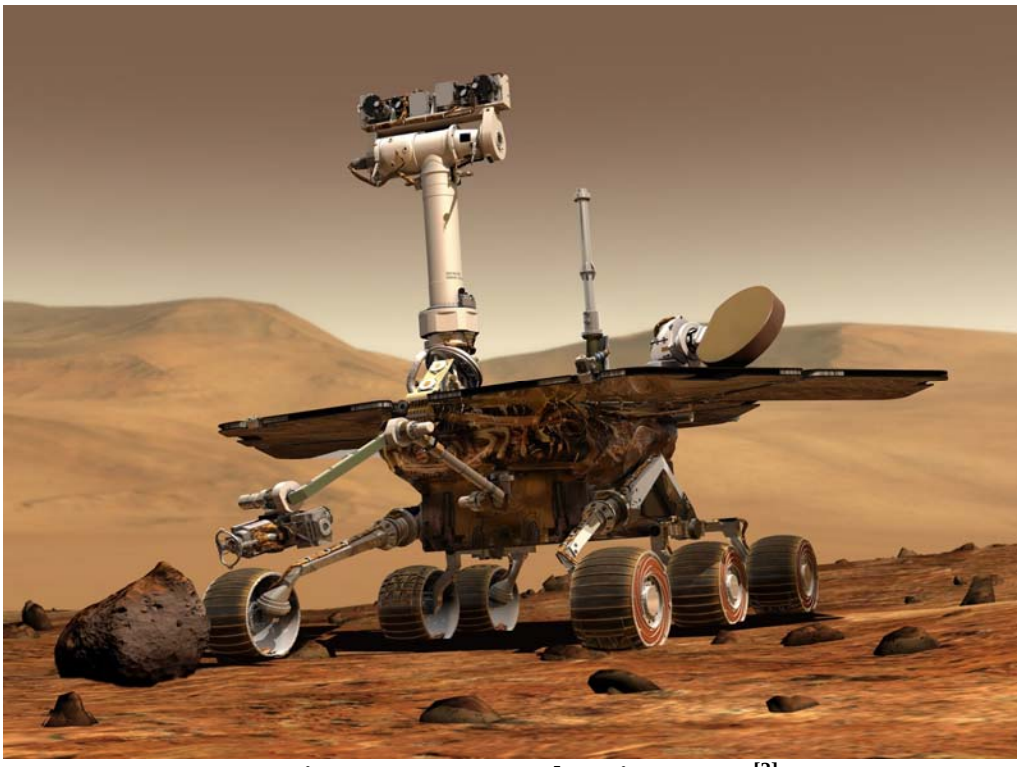


Figure 1: Mars Exploration Rover[2]

1.1 Needs Statement

The objective of this project is to design, assemble, and drive a vehicle through the 2017 NASA Rover challenge obstacle course against time. The vehicles intent is to compete against other vehicles in a time trial. Previous years vehicles will be assessed to determine their weaknesses and strengths in completing the course in order to develop a better vehicle. The main areas of focus will be: structure, weight, power delivery, wheel design, and collapsible configuration of the vehicle.

“There needs to be a ground vehicle, as well as fit male and female drivers, capable of competing in the NASA Human Exploration Rover challenge.”

1.2 Goal Statement and Objectives

The goal of this challenge is to design a human powered ground vehicle capable of placing first in time in the 2017 NASA Human Exploration Rover challenge. In order to reach this goal, we must define a few objectives, these objectives are[1]:

- Determine feasibility of previous challenge team's design vs. current concept design

- Determine wheel design based off dynamic analysis
- Finalize ground vehicle design based off structural and dynamic analysis
- Purchase, gather, or manufacture all components
- Assemble vehicle prototype and conduct time-trial testing
- Quantify vehicle performance and determine improvements
- Assure that at least three team members are physically prepared for competition
- Ensure safety at all time
- Compete at competition

1.3 Constraints

Based on the NASA Human Exploration Rover Challenge competition and rules, the manned rover is expected to navigate an off-road course (A.3) in a sufficient amount of time. The following constraints and requirements were taken from the NASA Human Exploration Rover Challenge website.

1.3.1 Team Requirements

- The rover must be the work of the university's student design team
- All of the team members must be enrolled in college/university and at least 19 years of age; the team must be able to prove their age and enrollment.
- The team must have an adult at least 21 years or older.
- The rover drivers must consist of one male and one female team member.
- Each team is required to compete for the Technology Challenge Award which will concentrate on Wheel Design and Fabrication (details of this challenge in Design Requirements)

1.3.2 Design Requirements

- The rover must be human-powered. It may not use energy storage devices, such as springs, flywheels, batteries, or others.
- Technology Challenge: Wheel Design and Fabrication:
- The wheel mounting plate, hub, rims, spokes, dish, and tire will now be referred to as wheel.
- No commercial (purchased) rims, tires, or strips of tires are allowed.
- The only commercial items that can be used in the fabrication of the rover wheels are the hubs containing bearings or bushings.
- Commercially available wheel rims and spokes may not be used.
- The collapsed dimensions must fit into a 5 x 5 x 5 feet cubical space

- The assembled rover may not be wider than 5 feet as measured from the outside wheel to the outside of the wheel on the opposite side.
- There are no height and length constraints for the assembled rover
- If the rover is deemed unsafe it may not be allowed to race the course.
- All parts of the vehicle, including the seat, steering controls and pedals, with which riders have normal contact must be designed such that their lowest surface must be at least 15 inches above the ground when the vehicle is assembled on a level surface and with riders on board.
- The vehicle should have turning radius of 15 feet or less
- The vehicle should safely handle slopes of 30 degrees' front to back and side to side
- Each rover must have seat restraints for both drivers
- All sharp edges and protrusions must be eliminated or guarded
- Dust abatement devices, fenders, must cover a minimum area of 120 square inches each and must be installed on all wheels

1.3.3 Competition Description

The competition starts off by the vehicle being lifted and carried 20 feet by the two team members, one male and one female, without any outside help. Once the vehicle is assembled, the team waits for a signal to begin navigating the course. During the race, teams may be subject to penalties that will result in additional time being added to their final time. For example, 1 minute will be added a driver has contact with the ground. Maximum allowed time to complete the course is 8 minutes, and each team will be allowed two trials. The team with the fastest course completion time wins the competition.

3. Methodology

1.1 Design Stage

The objective of the design stage is to use engineering principles to develop appropriate wheels and frame of the vehicle. Research will be conducted on previous successful designs to initiate a proof of concept for the design in question. The design approach taken will be a modular in order to ease internal constraints on wheel design, which must be done separate from the rest of the vehicle. The design stage will end with the completion of design drawings.

1.2 Prototype Stage

The prototype stage will begin with gathering of materials and constructing the vehicle. Prototyping will be done with two of the best suited team members according to weight and strength in order to produce the best time in a trial. A crude testing course will be erected to attempt to replicate the course parameters described above, and develop a baseline time-trial score for the vehicle.

1.3 Verification Stage

The verification stage is used to ensure basic necessary functions are possible. Once the prototype accomplishes the basic tasks of navigating the course regardless of time-trial score without damage to the vehicle or injury to the operators.

1.4 Modification Stage

If any of the crucial functions do not behave as intended or if the vehicle becomes damaged in testing phase, the modification stage will be used to correct them. If modifications to fulfil basic requirements are not needed will be reserved to optimize the design. These optimizations can place emphasis on completing the competitions' secondary objectives/ improving time-trial scores.

4. Expected Results

Due to the long nature of this project, the expected results have been broken up into three sections to ensure that all tasks efficiently contribute to the overall process throughout the year. Each task is well explored in more detail through a Gantt Chart located in Appendix A. Following this chart will ensure that the vehicle is competition ready before the deadline.

The rover should be capable of traversing hills up to 5 feet high and pathways inclined up to 30 degrees' transverse to their direction of travel. Wheels and drivetrains should be designed to satisfy both speed and the ability to perform across the terrain. Findings, discussion of results OR project. It is best to also reiterate information in your literature review to help substantiate the findings of your research/project.

1.1 Before Competition

- All necessary documentation will be reviewed by team and submitted prior to competition deadline
- Proper organization of documentation, reports, presentations, designs, and testing results will be kept, in order to provide a well versed technical journal
- The team will maintain a high level of safety when working with vehicle
- All necessary measures will be taken to ensure vehicle is safe to operate
- Constant communication will be kept with Advisors and stakeholders through process

1.2 Vehicle

- The vehicle will meet all constraints set forth by the competition and by the design team
- Vehicle will be capable of course worthy operation by March 2017
- Vehicle will be completely designed and partially assembled by end of year 2016

1.3 During Competition

- Team will ensure proper transportation of vehicle
- Team will represent FSU & FAMU in a respectful and professional manner
- Team will ensure of vehicles readiness and compliance
- The team members in operation of vehicle will not engage in risky maneuvers
- The vehicle shall be able to traverse the obstacles on the course without variance in intended vehicle function
- In the event of a mechanical failure, the vehicle will be dragged to completion of course

5. Conclusion

The NASA Human Exploration Rover competition requires two drivers to navigate a human-powered ground vehicle over various obstacles and terrain. Team 17 has researched and evaluated the competition to garner the best idea for a vehicle to succeed in the task. Using the underlying guidelines and official rules to the competition as a guideline to design along with the use of the engineering design process, Team 17 will be able to engineer a vehicle design that will dominate the competition.

References

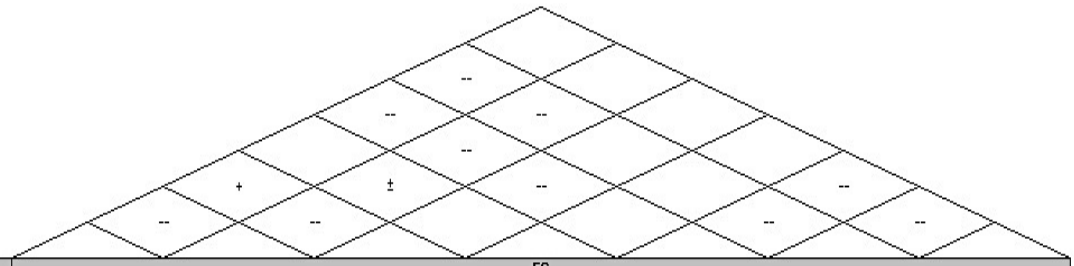
[1] May, Sandra. "Human Exploration Rover Challenge: About the Challenge." *NASA*. NASA, 28 Sept. 2016. Web. 30 Sept. 2016.

[2] Viotti, Michelle. "Mars Exploration Rovers." *NASA*. NASA, n.d. Web. 30 Sept. 2016.

Appendix A

A.1 Gantt Chart

A.2 HOQ



Customer Requirements	CI	EC						
		Frame Strength	Vehicle Weight	Number of Wheels	Wheel Design	Frame Length	Frame Width	Frame Height
Lightweight	6	7	10	7	7	5	5	5
Strong	7	10	7		7	7	5	3
Stable	10			8			7	8
Fast	5		7	7	7		5	
Safe	10	7		5				6
Can traverse obstacles	7	5		7	9	5		
Seats Two Adults	10	7				8	8	
Fits in a 5x5x5 ft box	10					10	10	10
Less than 15 ft Turning Radius	10			5		7	7	
		287	144	256	189	364	410	291

A.3 Course Map