FAMU/FSU College of Engineering

Department of Mechanical Engineering

Team # 22 Needs Assessment

MARSRAM

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ABSTRACT

This Needs Assessment Report details the requirements for NASA's 2017 Robotic Mining Competition (RMC). This competition entails on-site mining, a systems engineering paper, and an outreach project report. The on-site mining includes building a robot within the given size and weight limitations that will traverse simulated Martian terrain, excavate regolith and ice simulants, and return them to a collector bin. The systems engineering paper will explain in detail the methodology used during the project's inception, design, build, and testing. The outreach project report will require the team to promote STEM to the community via public outreach as well as social media.

1. Introduction

The two most important problems for this project are designing the robot to excavate both the basaltic regolith simulant (called Black Point-1/BP-1) as well as the ice simulant (gravel), and controlling the robot completely remotely with built in delay time to simulate an off-world control effort. Per the NASA Robotic Mining Competition (RMC) we are required to excavate at least 10 kg of BP-1/ice simulant and transport them to a designated collection bin.

Another problem we will encounter is navigating through the simulated Martian chaotic terrain; filled with obstacles such as rocks and craters. The mining area will consist of a layer of BP-1 on top of a layer of gravel, each approximately 30 cm in depth.

2. Project Definition

2.1 Need Statement

The purpose of this project is to design and assemble a robot for NASA's 2017 Robotic Mining competition (RMC). The robot must excavate basaltic regolith simulant (called Black Point-1/BP-1) and ice simulant (gravel) while traversing simulated Martian terrain to return the excavated mass into collector bins. Other competition requirements include a systems engineering paper as well as an outreach project report. The systems engineering paper will explain the methodology for the project. The outreach project report will require the team to promote STEM to the community via public outreach as well as social media.

2.2 Background and Literature Review

The mining of regolith and ice from Mars will ideally result in creating a sustainable human life-support system on Mars. Harnessing resources locally that can be used as materials for in-situ fabrication and repair technologies is a much more realistic imagination of a sustainable Martian colony. Additionally, excavation of martian regolith can easily provide a base chemical composition to be used to create spacecraft propellant as well as human consumables (water). This could result in longer duration stays on Mars as resupply would not be necessary. Overall, the excavation of the regolith and ice will allow for further research of the Martian soil composition to better understand how it's unique chemical composition can aid or hinder the human colonization effort.

2.3 Goal Statement and Objectives

The goal of this project is to create a robot for the 2017 NASA Robotic Mining Competition. The robot must be able to traverse a rocky terrain, mine both BP-1 and gravel, and transport them to collection bins.

The objectives to reach these goals are as follows:

- Modify previous contestants designs
- Create model
- Finalize design
- Purchase and manufacture components
- Assemble robotic prototype
- Test prototype
- Iterate and Modify Design
- Compete at the 2017 competition

2.4 Constraints

- The mining robot must be contained within 1.5 m length x 0.75 m width x 0.75 m height. The mining robot may deploy or expand beyond the 1.5 m x 0.75 m footprint after the start of each competition attempt, but may not exceed a 1.5 m height.
- The mining robot mass is limited to a maximum of 80 kg.
- Each team is allotted a maximum of 5 minutes to place the mining robot in its designated starting position within the Caterpillar Mining Arena
- The mining robot operates during the 10-minute time limit of each competition attempt.
- The minimum amount of 10 kg of BP-1 and / or icy regolith must be mined and deposited during either of two competition attempts.
- During each competition attempt, the mining robot is limited to autonomous and telerobotic operations only.
- The mining robot must provide its own onboard power.
- The mining robot must be equipped with an easily accessible red emergency stop button or "kill switch".
- The mining robot cannot employ any fundamental physical processes, gases, fluids or consumables that would not work in the Martian environment.
- Components are not required to be space qualified for Martian atmospheric, electromagnetic, and thermal environments.
- The mining robot may not use any process that causes the physical or chemical properties of the BP-1 and/or gravel to be changed or otherwise endangers the uniformity between competition attempts
- The mining robot may not penetrate the BP-1 surface with more force than the weight of the mining robot before the start of the competition attempt
- There will be three obstacles placed on top of the compressed BP-1 surface within the obstacle area before each competition attempt is made.
- Each obstacle will have a diameter of approximately 10 to 30 cm and an approximate mass of 3 to 10 kg. There will be two craters of varying depth and width, being no wider or deeper than 30 cm.
- The mining robot must operate within the Caterpillar Mining Arena[2]

3. Methodology

This section is intended to go over the broad stages we intend to move through as a team in the development of our project.

3.1 Design Stage

The design stage will focus on the appropriate systems necessary for the robot to meet the goals as set out by the competition. This includes the mining systems required to excavate and deposit the minerals, the robot moving chassis required to navigate the chaotic terrain,

The design stage will focus on researching previous contestants designs to ensure the simplest, manufacturable design will be built. A model will be built to further understand the details of the design. Based off the results of the model, the design of the project will be adjusted.

3.2 Prototype Stage

Following the design stage, the materials and parts will be gathered to produce the prototype. Materials determined to be costly or hard to manufacture will be replaced with similar materials for the prototypes. In the prototype stage we will build simple

3.3 Testing Stage

Through testing trials using the developed prototype design flaws will be determined and cataloged for major design modification if easily repaired. The prototype will be checked for reliability in continuous use and if weight can be reduced. Coded portions of the robot will be checked for optimal performance. The mining apparatus will be rigorously checked for apparent flaws and efficiency issues. Reliability will also be addressed at end of testing trials to determine weaknesses in the structure.

3.4 Modification Stage

The modification stage is used to analyze the data procured from the iteration stage and upgrade the robot's design. Issues discovered in the iteration stage will be address along with weaknesses in the material selections. The mining apparatus will also be determined if viable and efficient or if a new concept will need to be used.

4. Conclusion

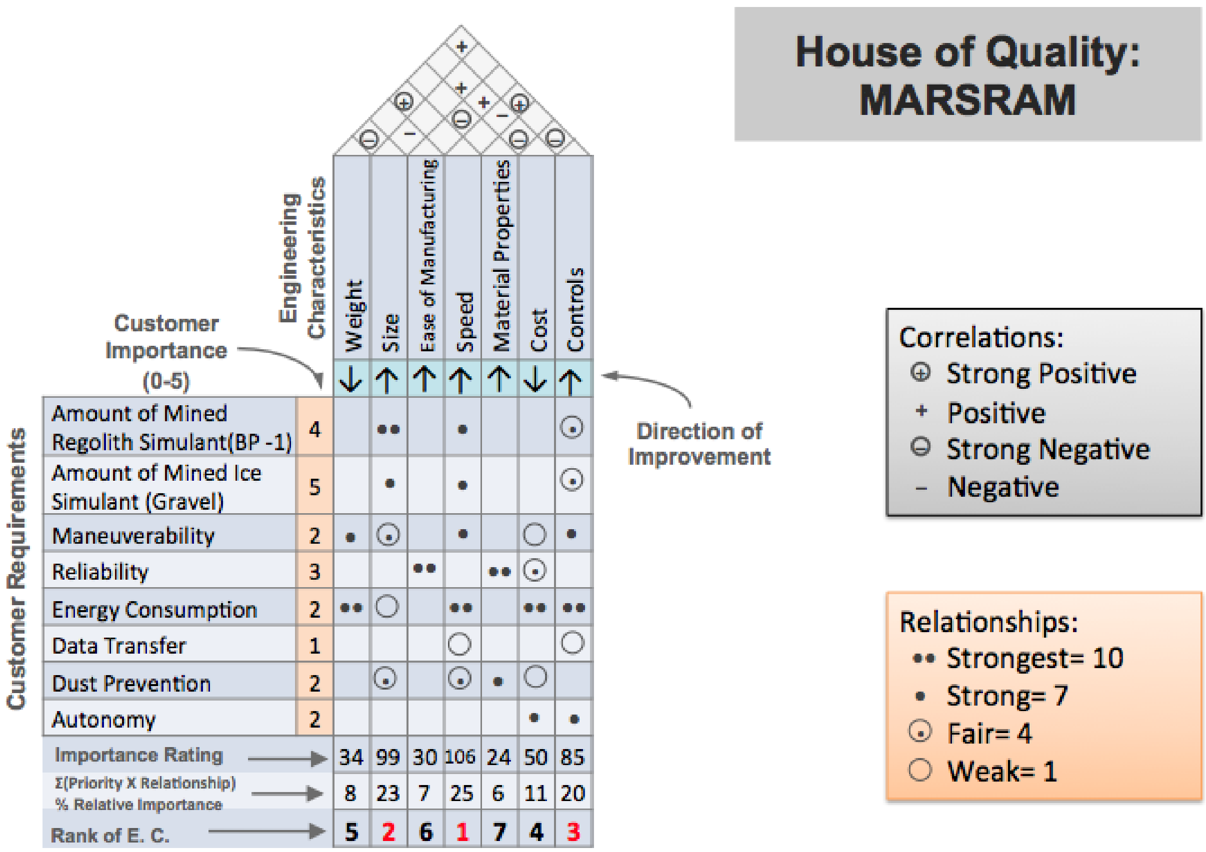
The NASA RMC requires an semi-autonomous rover that will be able to traverse terrain similar to a mars like landscape. The robot will then be able to gather regolith simulant and ice simulant and return this material to a designated location. The prototype and design of the robot will build upon results of last years competitor's designs and improved upon. The brainstorming and design of the robot will follow the guidelines provided by the engineering design methods and NASA's rules and regulations. Following these guidelines team 22's mining robot will be engineered to fill the requirements for the competition.

5. References

1. "Competition 2017 RMC." *NASA Robotic Mining Competition 2017*. NASA, n.d. Web. 29 Sept. 2016. <https://www.nasa.gov/sites/default/files/atoms/files/03competition_2017rmc.pdf>.
2. "On-Site Mining." *NASA Robotic Mining Competition 2017*. NASA, n.d. Web. 29 Sept. 2016. <https://www.nasa.gov/sites/default/files/atoms/files/rmc2017_09onsitemining_09262016.pdf>.

Appendix A

A.1) House of Quality



A.2) Gantt Chart