Solar-Powered Rover

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I. Abstract

Expanding on a previous senior design project that had built a rover for educational purposes, this project intends to enhance LOUIS, the rover, by integrating solar panel(s) to the rover, creating autonomous switching between solar and battery power, and developing a cleaning system for the solar panels. With a $4,000 budget, the project will have to consider the limited leftover chassis space and the maximum additional load capacity of 36.3kg. The cleaning system will have to be gentle on the solar panels, so as not to scratch or damage it, thus maximizing the energy output. The various components should be able to withstand the different weather conditions in Louisiana, such as winds, precipitation, and heat. The system should be user-friendly, where the user can seamlessly interact with the interface with ease. The project aims to have a system that switches to battery power if the solar panels are not receiving adequate sunlight due to clouds or nighttime conditions. With regards to deliverables, the sponsor requested proof of concept. For this, the group will need to make sure to maintain the current functions, despite the additions. Additionally, if time and resources allow, the project will seek to improve the user-interface on the app and the object avoidance system.

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II. Engineering Specification

II.A. Objective Statement

The main objective of this project is enhancing the previously built rover by integrating solar power, autonomous power switching between solar and battery power, and an independent cleaning system for the solar panel. These objectives will rely on additional hardware and software added to the rover. Overall, the rover should not lose any general functionality and should perform similarly to how it does now, with these additions.

II.B. Introduction

II.B.1. Background Information

The original inspiration behind the creation of LOUIS was to expose young engineers to the development and design of rovers, as it can easily be seen that space exploration will continue to be a prominent area of work for engineers in the future. We intend to build upon that idea by incorporating solar power into the design of LOUIS. As an educational proof of concept, we will also design a power switching system to autonomously switch between battery and solar power, depending on the environment. As many NASA rovers also use solar power, this addition will push the rover one step closer to the design of rovers currently being used in space exploration missions. This will make LOUIS an increasingly relevant tool for future students who are interested in working in this field.

Picture of LOUIS:

(Meng)

II.B.2. Problem Description and Motivation for the Project

The motivation for our project is to make power improvements to a space rover engineered by a previous group of Senior Design students. We hope that our solar oriented improvements will enable enhancement opportunities for future students. Overall, our teams' motivation is to improve upon a platform that can be used as a vessel for teaching students about space rovers and solar panel systems.

II.B.3. Existing/Competing Technologies

SolarEdge Monitoring Portal: SolarEdge offers a cloud-based monitoring platform that provides real-time data on solar system performance, energy consumption, and grid interaction. The team is planning on doing something similar with a charge controller just on a smaller scale. Instead of grid integration we would be looking at solar panel voltage and current output and calculating the load needed to operate the rover.

Nanosolar Coating: This advanced nanotechnology-based coating repels water and dirt, ensuring that rainwater washes away debris without leaving residues. This is a viable way to have a passive cleaning system for solar panels. The team is currently planning on applying a similar coating to the solar panel.

Ecoppia E4: This autonomous robot uses soft brushes to clean panels without water. It can navigate arrays independently and is designed for large-scale solar farms. This robot uses a similar waterless brush system that the team is currently considering using to clean the solar panel. The main difference is that the Ecoppia runs on a motor and is designed for a solar farm.

NASA's Spirit and Opportunity Rovers: These are rovers launched by NASA in 2003. They both used solar panels to generate power. The panels collected sunlight and charged the rovers' batteries. This will be similar to what the team plans to do by adding solar panels to the existing rover. However, the team's solar panels will be able to both charge the existing battery as well as take on the electrical load of the rover.

II.B.4. Potential Customers

Primary: The LSU Electrical Engineering Department can utilize LOUIS for research, development, and educational purposes for their students.
Secondary: Future senior design students can enhance LOUIS's capabilities to learn more about the design and building process.

II.C. Functional Requirements

Table II-1: Required Functions

#	Weight	Function	Explanation
F1	0.4	Convert sunlight into an additional power source.	Utilize solar panels to absorb sunlight as an additional power source to the battery power.
F2	0.35	Autonomously switch power between power sources.	Autonomously switch between battery and solar power.
F3	0.25	Clean the solar panels.	Intermittently clean off debris from solar panel to maximize energy absorption and efficiency.

II.D. Qualitative Constraints

Table II-2: Required Qualitative Constraints

#	Weight	Qualitative Constraint	Explanation
Q1	0.40	Compatibility With Existing Design	Make sure that the new implementations to the previous rover are compliant with each other. The additions should merge with the existing design seamlessly.
Q2	0.35	Weatherproof Design	The solar panel system should be built to withstand the elements of Louisiana such as wind, precipitation, and heat.
Q3	0.25	Portability	Make sure that the system doesn't hinder the transportation of the rover. Should be convenient to maneuver without disassembly.

II.E. Measurable Engineering Specifications

Table II-3: Required Measurable Engineering Specifications

#	Weight	Name	Symbol	Units	Value(s)	Explanation
M1	0.5	Budget	B	$	4000	A budget of $4000 was decided upon by the sponsor.
M2	0.4	Interior Space	S	M^3	0.977	This is the amount of available space inside the rover's chassis to install new electronic components.
M3	0.1	Weight limit	W	Kg	<36.3	The max additional weight load was measured at 36.3kg. The team would like to stay under this variable.

II.F. Deliverables

This project will add renewable solar power to a preexisting rover that was designed last year. The project will work to have solar power be the main source of power, with a battery back-up also kept charged by the solar power. The rover should be able to freely switch between solar and battery power depending on how much power is being generated. For example, if it is cloudy or dark the rover would switch to battery power. The rover will also have a cleaning system to ensure that the solar panel can maximize its efficiency. Like the power switching, the cleaning system will be programmed to operate on its own and conduct a cleaning sequence when necessary. It is crucial to mention that with these additions the overall general functionality of the rover remains unchanged, and that these additions work to improve the rover.

III. Project Management

III.A. Schedule and Milestones

We are currently still in concept generation and the selection phase of our project. However, by early October we should have completed concept generation and selections. In early October, our group should have also made the proper selections for our rover solar panel system like selections of our solar panel type, solar panel mounts, and charge controller. The cleaning system is still an ambiguity as we are still finalizing a decision on a method to execute this function. By the end of September, we should have a concept generation for the cleaning system, and a selection of the cleaning system components by the first week of October. For the cleaning system, we are still deciding between three concepts which involve a system with a compressed air blowing system to clear the surface of the solar panels, a brush system that would wipe the surface of the solar panels clean, or an electrostatic film/coating system that is designed to use voltage wired to the film/coating to repel dust and debris from the surface of the solar panels. For these three systems we would need to make selections for a drive for the system (air compressor, motor, or voltage source), a frame (system structure), and the cleaning device (non-scratching brush, high-pressure air fixtures, or an electrostatic film/coating). We hope to use the remainder of the Fall Semester to run the appropriate analyses to ensure that our designs are thorough and functional. In the next semester of Senior Design, we hope to do the appropriate ordering, manufacturing, and testing for our rover Louis.

IV. Appendix

IV.A. Quality Function Deployment (QFD) - HoQ

The House of Quality pictured in Figure IV-1 demonstrates the relationships between the functions of the project and constraints that must be met to accomplish these functions. Weights were assigned in ranking of importance from the perspective of the sponsor's desired results. Values of 1, 3, or 9 were assigned to the relationships between functions and constraints to show these relationships as weak, moderate, or strong.

Quantitative constraints are those that can be assigned specific values for physical limitations on the project. As this project is desired by the sponsor to be more of a proof of concept, we have very few quantitative constraints, giving us great flexibility in our design. The only sponsor-assigned quantitative constraint is that the project should remain within a budget of $4,000. Upon visual inspection and measurements of the rover, it was determined that we must fit any additional electronics or components within a $0.977m^3$ space to ensure that the electronics are contained within the chassis of the rover. The tested additional load of the rover was 36.3kg, so we cannot exceed this weight when adding the solar power and power switching systems.

The more components that are required to accomplish our goals with this project, the higher our costs and the more weight capacity and space will be taken up. This results in positive correlations between cost and available space/weight. There is a strong positive correlation between space being used and added weight to the rover, as taking up more of the available space in the chassis with electronic components will increase the weight of the rover as well.

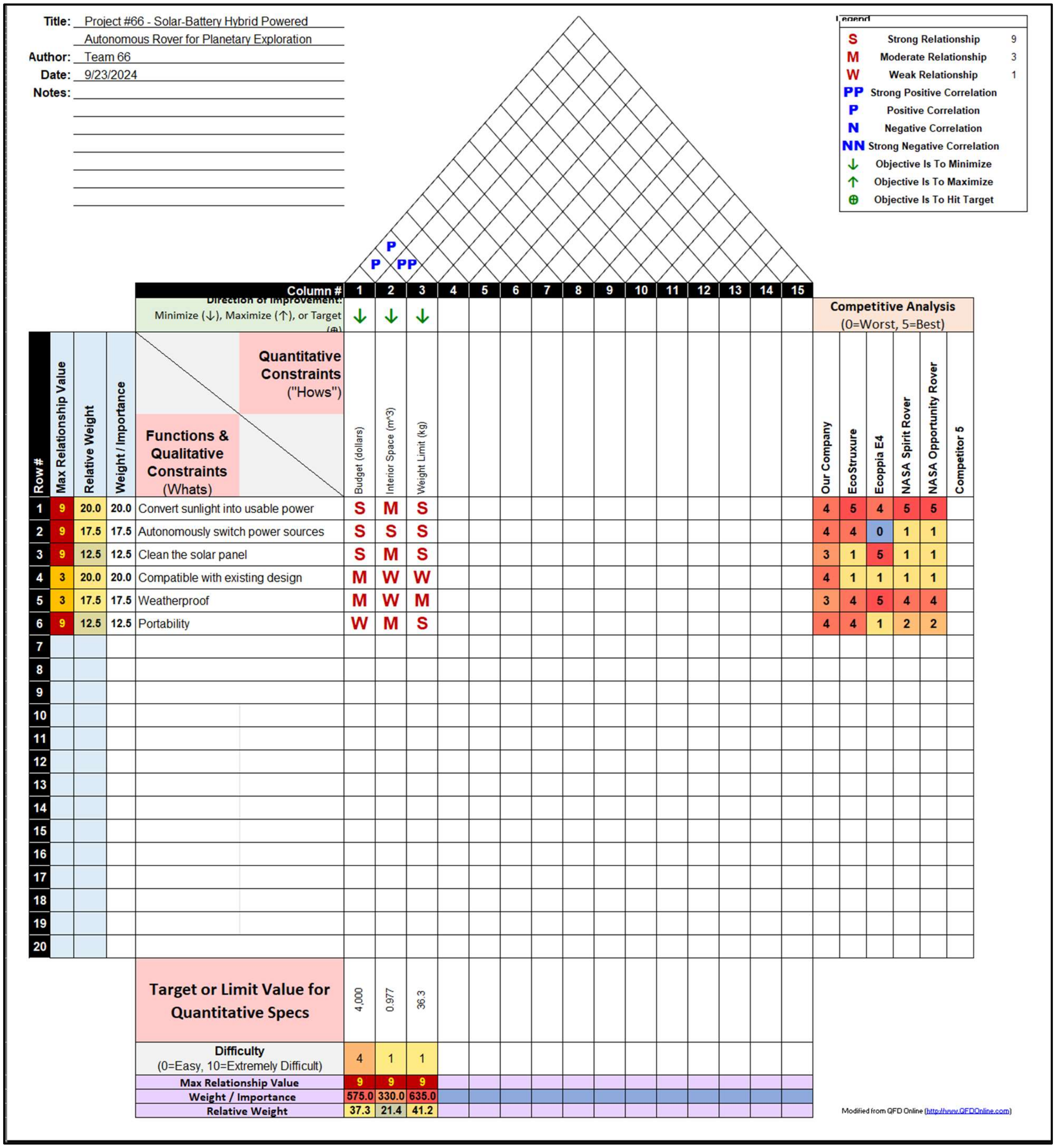

Figure IV--1: The House of Quality for the project.

IV.B. Reference Materials

IV.B.1. References and Bibliography

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