1. DESIGN REQUIREMENT SPECIFICATIONS

Navigating the sandy expanse of a beach with chairs, umbrellas, coolers, and assorted gear has long been a taxing endeavor for beachgoers. The hard task of transporting these essentials across uneven terrains not only strains the body but also dampens the joyous anticipation of a relaxing day by the shore. It is this very challenge that this innovative product seeks to overcome. Introducing a cutting-edge solution, “The Beach Mule”, poised to revolutionize beach outings worldwide. “The Beach Mule”, driven by an intelligent autopilot system, navigates autonomously, avoiding obstacles along the way.

The Target audience for “The Beach Mule” is for beachgoers, families with young children, and beach cleaning organizations seeking ease and convenience in their beach experience. Families with young children, having toys and snacks when headed to the beach, find ease with the cart’s transportation capabilities. Parents can focus on keeping their children safe rather than focusing on transporting equipment on and off the beach. Overall, “The Beach Mule” is for an audience that desires an easy and hassle-free beach experience.

Powering the Beach Mule, the Beach Boys chose Sealed Lead Acid Batteries (SLA). The Beach Mule is designed to survive the high temperatures of beaches. SLA batteries can withstand up to 50°C (122°F) without significant degradation in performance. Also, SLA batteries are well protected, making it perfect for water and sand. The Beach Mule will draw approximately 24V to run. This is achieved by putting two 12V batteries in series doubling the voltage.

Hovering over sand with heavy loads requires more torque and power, so The Beach Mule utilizes a 24V 750W Brushless DC Motor to provide it with more traction and a smoother experience.

The Beach Boys chose the 12 in. balloon wheels because they are low pressure tires that glide over sand. They are not heavy, so they do not fall into holes and pits of sand.

A DC-DC converter is used because the two 12V DC batteries power the Beach Mule’s motors, while the microcontroller only requires lower voltages that range from 3.3V to 5V. The DC-DC converter ensures that the microcontroller is powered with the appropriate voltage.

For the autonomous setting, the Beach Mule uses UWB (Ultra-Wideband) sensors to detect the user of the cart. It also tracks a set distance of 4ft, matching the pace of the user. If objects were to come in between the user and the Beach Mule, ultrasonic sensors, capable of being powered and controlled via an Arduino connected to the DC-DC converter, would detect the object’s size and projected movement path. The system would then act accordingly to maintain the 4ft gap by changing course and adjusting speed.

The Beach Mule is made from high grade aluminum that can withstand heavy loads and keep the weight light. Since the aluminum is lightweight and able to withstand a heavy weight, the Beach Mule is a great product for consumers. This material allows the Beach Mule to navigate all beach terrains with ease and allows the user to focus more on enjoying their time at the beach.

1.1. Requirements

1.1.1. Marketing Requirements

The Beach Mule is an innovative and advanced beach cart that has an array of features to set it apart from competitors. Firstly, it has autopilot capabilities that will seamlessly navigate around the beach, avoiding obstacles, to wherever the user goes. While also being lightweight, it offers an extraordinary level of convenience and ease of use. The added feature of motorized wheels further amplifies its efficiency,

making it a great choice for the audience. What truly sets The Beach Mule apart, however, is the economic feasibility it has when compared to competitor products. All in all, the combination of advanced features and affordability makes The Beach Mule an ideal choice for beachgoers, families with children, and beach cleaning organizations.

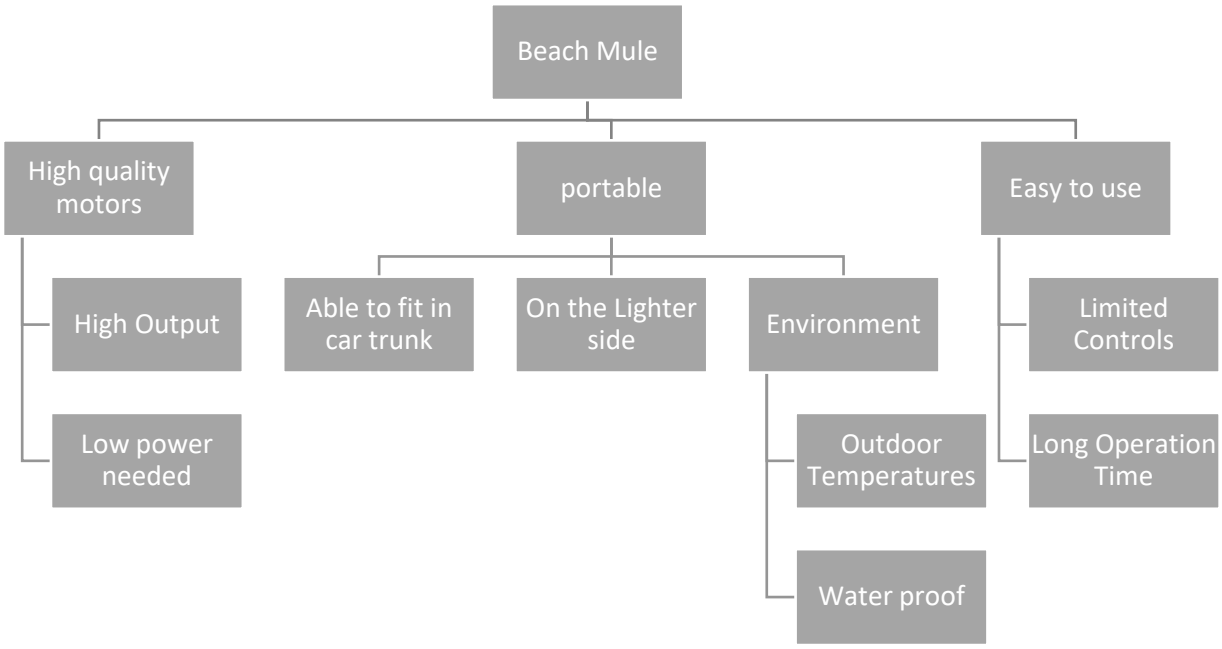

Figure 1-1. Object Tree for Beach Mule

Table 1-1: Engineering Design Requirements

1-4	5. The dimensions should not exceed	Fits in a typical car trunk. Competitors models do not fit a typical car trunk
1-4	6. Production cost should not exceed $1000	This is based upon competitive market analysis and previous system designs.
Marketing Requirements 1. The system should have motors that work efficiently. 2. The system should have high output power. 3. The system should be easy to work. 4. The system should be low cost.		
Marketing Requirements	**Engineering Requirements**	**Justification**
1, 2, 4	1. The total harmonic distortion is less than 5%	Based upon competitor's product, automated beach carts can obtain this level of THD
1-4	2. Should be able to sustain an output power that averages 24V.	The power range provides more than adequate power throughout the cart. It is a sustainable output power for projected motor complexity.
2, 4	3. Should have an efficiency of 60%	Achievable with several different classes of motors
3	4. Average installation time for the power connection should not exceed 30 minutes with charge.	Past trials using standard charge demonstrate that this is a reasonable installation time.

The Beach Mule has motors that work efficiently to effortlessly move on beach terrain. Its high output power delivers exceptional performance. Simplicity reigns supreme, with a user-friendly interface that makes the cart operation easy, ensuring a joyous experience at the beach. Lastly, affordability is a main concern without compromising quality. The Beach Mule embodies advanced features for a fraction of the price compared to competitors.

1.2. Constraints

The Beach Mule is designed for beachgoers, families with children, and beach cleaning organizations. It has advanced features such as autopilot to make the users life easy. It has a 24V battery that powers the motorized wheels, autopilot, and controls. This system boasts the utmost efficiency due to its 750-watt motors. The Beach Mule fulfills 5 constraints: Economic, Sustainability, Manufacturability, Health & Safety, and Environmental.

Table 1-2: Constraints

Type	Name	Description
Economic	Cost	The expected retail for this price is $1500 based on a parts cost of $1000.
Sustainability	Reliability	This system is designed to operate over a three-year period without failure. The expected battery life is three years, and the battery is the only part requiring regular maintenance.
Manufacturability	Size	The physical dimensions are 24" high, 48" wide, and 12" deep.
Health and Safety	Safety	The product conforms to UL Specification 631, which requires that this unit not deliver an electrical shock to the user.
Environmental	Weather	This product will have a battery that is waterproof and heat resistant up to 50°C (122°F)