1. Problem Statement

1.1. Need Statement

Navigating the sandy expanse of a beach with chairs, umbrellas, coolers, and assorted gear in tow has long been a taxing endeavor for beachgoers. The task of transporting these essentials across uneven terrain not only strains the body, but it also dampens the anticipation of a relaxing day by the shore. An innovative product is needed to overcome this challenge and allow beachgoers to worry less about carrying the "necessities" by hand on a hot sunny day on the beach.

1.2. Objective Statement

The objective of this project is to design a beach cart that makes trips to the beach an easier, more relaxing experience for any beach enthusiast. This product will be motorized and equipped with an autopilot feature. The autopilot feature is designed to autonomously follow behind the user. The user also has the option to manually control the cart when needed.

1.3. Background and Related Work

The main theories required to develop The Beach Mule are autonomous tracking and object detection. These are the primary features that allow The Beach Mule to stand out. The main limit is the budget, as sensors have improved drastically over time. The electric vehicle industry is a growing industry that uses autopilot technology, like The Beach Mule.

2. DESIGN REQUIREMENT SPECIFICATIONS

2.1. Requirements

Below are the requirements that need to be fulfilled. These requirements are met to provide clarity for customers and other stakeholders while also meeting technical needs.

2.1.1. 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 seamlessly follows the user wherever they go. While also being lightweight, it offers an extraordinary level of convenience and carrying capacity. The added feature of motorized wheels further amplifies its efficiency, making it a compelling choice for the audience. What truly sets The Beach Mule apart, however, is its economic feasibility when compared to competitor's products.

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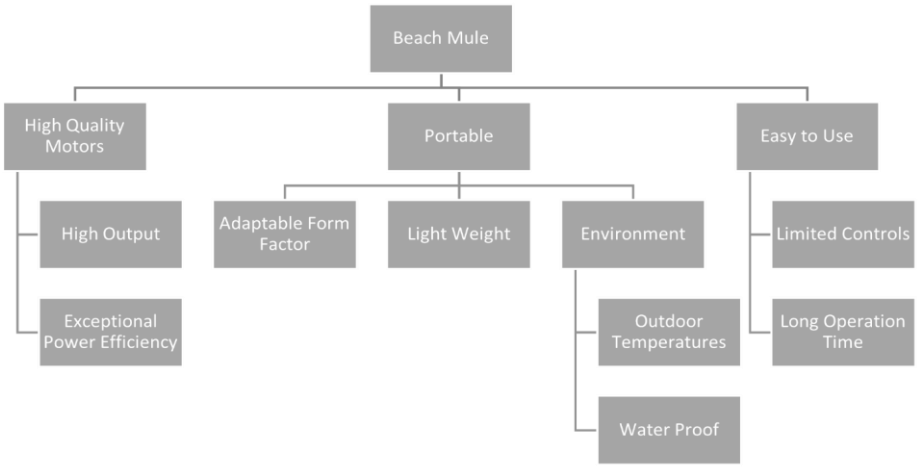

Figure2-1. Objective Tree for Beach Mule

The design requirements listed above are the basis of the engineering requirements listed below.

2.1.2. Engineering Requirements

Table 2-1: Engineering Design Requirements

Marketing Requirements	Engineering Requirements	Justification
5	1. The total weight capacity should be 130lbs	Based upon competitor's product, automated beach carts can hold this weight.
1, 2	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.
1, 2	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.
Marketing Requirements 1. The system should have motors that work efficiently. 2. The system should have high output power. 3. The system should be user-friendly. 4. The system should be low cost. 5. The system should be made from strong material.		

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

2.2. Constraints

The Along with the engineering requirements, the Beach Mule conforms to five constraints: Economic, Sustainability, Manufacturability, Health & Safety, and Environmental.

Table 2-3: Constraints

Type	Name	Description
Economic	Cost	The total budget of the project is $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. This dimension fits inside a car's trunk.
Health and Safety	Safety	The product conforms to IEC 61140 which protects the user from electrical shock.
Environmental	Heat Resistant/ Water Resistant	This product will have a battery that is water resistant and heat resistant up to 50°C (122°F)

The budget for every design group is $1000, so we cannot spend over that amount.

Every system in The Beach Mule needs to be reliable with a long lifespan. The battery needs to be the only part that requires maintenance. Performing maintenance on the motorized wheels and the autonomous tracking system makes no sense, as anyone would struggle to figure out how to fix those issues. The battery needs to be the only part that requires regular maintenance, as it is easy to replace. However, the battery life needs to be long lasting, as the battery for it is not cheap.

The dimensions of The Beach Mule need to be large enough to fit large objects, such as chairs, coolers, beach toys and more. The dimensions of 24" high, 48" wide, and 12" deep were picked because it is big enough to carry the aforementioned items, while still fitting into a vehicle.

The IEC 61140 is an International Standard that applies to the protection of persons and animals against electric shock. It is intended to give fundamental principles and requirements which are common to electrical systems.

The battery needs to be water and heat resistant, as these are two common obstacles at the beach. As tides come up and people splash water, The Beach Mule will always be at risk of getting wet. Not only does it

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risk getting wet, but the beach is typically very hot. Temperatures can be in the low hundreds for most of the day. The battery needs to be able to resist extreme heat, so that it can run efficiently without error.

2.3. Standards

The Beach Mule goes through sand, water, and rough terrains every time it is used. We have implemented 3 standards listed below.

Table 2-4: Standards

Specific Standard	Standard Document	Specification/Application
IP-67	This product meets Ingress Protection Standard 60529 set by the International Electrotechnical Commission [1]	Beach Mule is sand-tight, immersible up to 1m in water.
IEC 60086	This product meets International Electrotechnical commission 60086 [2].	Beach mule has interchangeable batteries.
IEC 60757	This product meets International Electrotechnical commission 60757 [3].	Beach mule has color coordinated wiring for power.

IP-67 was chosen because it is to make sure The Beach Mule is waterproof. As previously stated, if The Beach Mule is not waterproof, it could lead to the cart breaking or someone getting shocked. This standard was chosen for safety purposes.

It needs to be easy for batteries to be swapped. The Beach Mule's batteries will require regular maintenance every few years, so it is important that batteries are in a convenient form and fit. IEC 60086 aims for replaceable batteries to follow a standard of form and fit.

IEC 60757 requires color designation for the wires of a system. Not only will this make building The Beach Mule easier, as all the wires are color coded, but it will make maintenance easy as well.

2.4. References

[1] C. Trick, "What is an IP67 Rating?," *Trentonsystems.com*, Dec. 20, 2021. [Online] https://www.trentonsystems.com/blog/ip67-rating#:~:text=If%20a%20product%20has%20an [Accessed Sept 28, 2023]

[2] "IEC 60086-1:2021 | IEC Webstore," *webstore.iec.ch*. 2021 [Online] https://webstore.iec.ch/publication/60968 [Accessed Sept 28, 2023]

[3] "IEC 60757:2021 | IEC Webstore," *webstore.iec.ch*. 2021 [Online] https://webstore.iec.ch/publication/66266 [Accessed Sept 28, 2023].