DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Design document for

Halo Helmet

Submitted to:

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1. PROBLEM STATEMENT

1.1. Need Statement

According to the National Highway Traffic Safety Administration (NHTSA), there were 5,932 motorcyclists killed in 2021, accounting for 14% of all traffic fatalities [1]. This number of traffic fatalities becomes even more concerning when one realizes that, according to J.D. Power and Associates, motorcycles account for just 3% of the registered vehicles in the country [2]. Motorcyclists are consistently at a significant risk when they are on the road. These statistics highlight why a system to increase motorcyclist visibility to other drivers as well as improving the visibility of other drivers to motorcyclists is needed.

1.2. Objective

The objective of this project is to design a device to increase the visibility of motorcyclists to other drivers and to increase the visibility of other drivers to motorcyclists using lights and blind spot monitoring. The user is alerted to oncoming traffic, and other drivers are alerted to the motorcyclist's intentions, such as turning, merging, or changing lanes.

1.3. Background and Related Work

The basic theory is that the Halo Helmet detects other motorists on the road utilizing ranging sensors to alert the motorcyclist of an approaching vehicle in their blind spot. Halo Helmet makes the rider more visible to other drivers by incorporating lighting on the helmet so motorists in higher vehicles can adequately see the lighted signals. Currently, the only other option for monitoring is expensive blind spot monitor kits. Very little is being done in terms of visibility except for traditional retroreflectors. The limitations of current designs are that blind spot monitoring offerings have low compatibility with different kinds of bikes and that retroreflectors require an oncoming light source to function. Another limitation is that current motorcycle indicators are placed relatively low, sometimes out of the line of sight of drivers in higher cars. The only similarity between Halo Helmet and other products is blind spot detection, though, as previously mentioned, Halo Helmet aims to do much more than blind spot detection. Specific technologies that are related to the design are light emitting diodes (LEDs), sensing apparatuses (ultrasonic sensors or radar), Bluetooth, universal serial bus (USB), and lithium battery technology.

2. DESIGN REQUIREMENT SPECIFICATIONS

Halo Helmet is a motorcycle helmet with advanced safety features to alert the motorcycle rider of vehicles in the rider's blind spot. Halo Helmet also increases the rider's visibility to motorists in the general vicinity. This project solves the problem of bikers not being seen on the road and the matter of bikers having to look behind them frequently, causing a safety hazard.

2.1. Requirements

Halo Helmet meets the marketing and engineering requirements set forward in this document.

2.1.1. Marketing Requirements

The Halo Helmet marketing requirements are as follows:

1. Halo Helmet is highly visible.

2. Halo Helmet is comfortable.

3. Halo Helmet is weather resistant.

4. Halo Helmet has blind spot detection.

5. Halo Helmet is portably powered.

6. Halo Helmet clearly indicates an approaching object.

Halo Helmet is highly visible to alert others on the road to the presence of the motorcycle rider. Comfort is important so the helmet can be worn with the same level of comfort as a regular motorcycle helmet. Halo Helmet is also weather resistant, so it can be worn rain or shine in an outdoor environment such as what is present on a motorcycle. Blind spot detection is also essential to alert the motorcycle rider of approaching vehicles to mitigate constant checking where the motorcyclist must take their eyes off the road. Halo Helmet is portably powered to reduce the number of wires attaching the rider to the bike, which decreases comfortability. Approaching objects are also clearly indicated to the motorcyclist to adequately warn them of their surroundings.

The team chose these goals to make Halo Helmet a safety-focused item. Congruent with the theme of safety, the highest priorities are blind spot detection, high visibility, comfort, and weather resistance. These goals are highlighted in the object tree below.

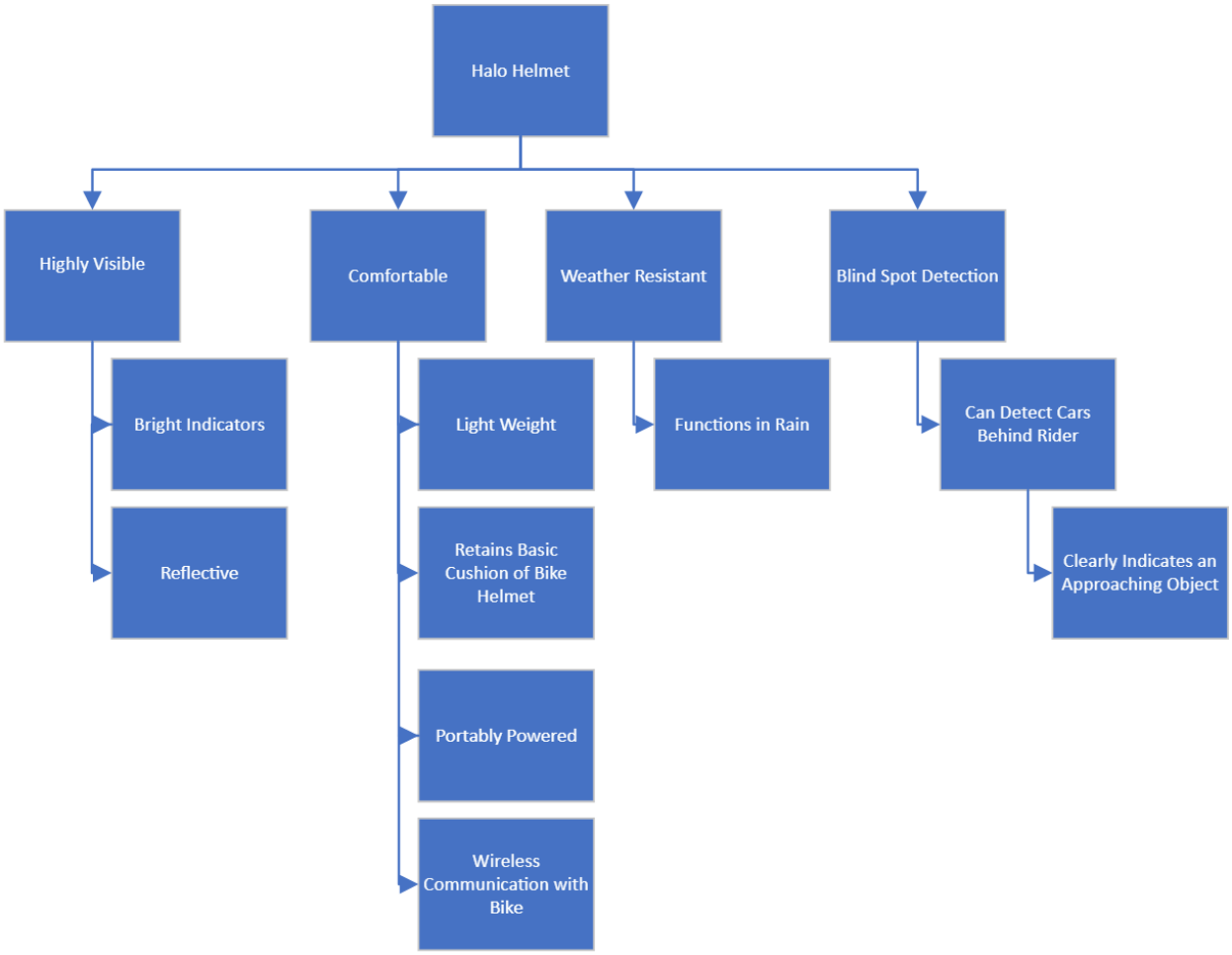

Figure 2-1. Object Tree for Halo Helmet

Figure 2-1 shows the objective tree for Halo Helmet. This objective tree is based on the marketing requirements described earlier. These marketing requirements are the foundation of the engineering requirements determined in this project.

2.1.2. Engineering Requirements

The engineering requirements for Halo Helmet are noted in the table below and explained in the paragraphs following.

Table 2-1: Engineering Design Requirements

Marketing Requirements	Engineering Requirements	Justification
1	Indicators have effective projected luminous lens area of 3 ½ inches.	This is the visibility suggestion based on the NHTSA. [3]
4	Helmet detects objects behind the helmet on either side up to a distance of 10 feet.	This is based on the typical range of ultrasonic sensors [4].
5	Battery lasts for six hours of continuous use and is rechargeable.	This number was generated based on how often a motorcyclist should stop riding and rest [5].
6, 4	Flashing LEDs of 2.2 millicandela (mcd) internally in the driver's periphery indicate on which side a motor vehicle is relative to the driver.	The rating of 2.2 mcd was derived from the brightness of typical offerings as well as the thought that the driver should not be too distracted by the light [6].
2	Helmet weight does not exceed five pounds.	This is a weight only slightly above the weight of a typical full faced helmet [7].
3	Helmet electronics function with spraying water at any angle up to 60 degrees from the vertical congruent with a rating of IP-X3 [8].	The helmet would work best by not failing in the rain.

Marketing Requirements
1. Halo Helmet is highly visible.
2. Halo Helmet is comfortable.
3. Halo Helmet is weather resistant.
4. Halo Helmet has blind spot detection.
5. Halo Helmet is portably powered.
6. Halo Helmet clearly indicates an approaching object.

The marketing requirement numbers in Table 2-1 concern the marking requirements in the numbered list above. The engineering requirements pair with each marking requirement, along with a justification of why these requirements are valid.

The Halo Helmet indicator lights have an effective projected luminous lens area of at least three and a half inches [3]. This brightness makes any motorcyclist visible, assuming typical weather and no fog. Using the suggestion based on NHTSA guidelines, no motorcyclist should have any problems being seen by other drivers.

Since Halo Helmet functions in inclement weather, the electronics can withstand being sprayed with water from an angle of 60 degrees, which is compliant with IP-X3 guidelines and is typical of an extreme rainstorm incident [8]. Halo Helmet can also withstand small amounts of water at less predictable angles.

Halo Helmet detects vehicles or other motorcycles behind and at either side of the motorcyclist. The helmet detects if a vehicle is too close, within approximately 10 feet of the motorcyclist. Car blind spot sensors detect if another vehicle gets within 10 feet of the bumper [4]. Since motorcycles are much smaller, the sensor achieves similar effectiveness given its location. These distances ensure the helmet can see the vehicle coming and alert the user before a problem occurs.

Halo Helmet is at most five pounds to stay near the recommended helmet weight of between three and four pounds [7]. The system incorporated into Halo Helmet will keep the weight light enough for the driver to stay comfortable on long-distance drives.

Halo Helmet has a battery pack that powers the system for six continuous hours. The rider can enjoy long-distance travel without going unseen by others due to a dead battery. Motorcyclists are encouraged to stop and rest every two to three hours or every 150 miles [5]. With Halo Helmet's incorporated battery pack, motorcycle riders can make more than this three-hour drive without worrying about the battery dying. The rechargeable battery pack charges via Universal Serial Bus (USB) to ensure an easy and quick charge to keep the motorcyclist on the road.

Flashing LEDs of 2.2 mcd indicate on which side a motor vehicle is, relative to the motorcycle driver. The LEDs are placed inside the helmet and are present in the motorcyclist's peripheral vision. The rider can see the blind spot indicator lights flashing inside the helmet without losing focus on the road and what is ahead. The blind spot indicator LEDs are not bright enough to distract the driver but are bright enough to indicate which side the detected object is approaching. LED intensity is measured in candela, in which one candela is approximately the brightness of a candle; this is about 450 times brighter than the LED indicators inside of Halo Helmet [6]. This intensity ensures the motorcycle driver is not blinded or distracted by the interior lights.

2.2. Constraints

Halo Helmet is subject to multiple constraints listed in the table below. These constraints are described in more detail in the paragraphs following the table. Many constraints exist when creating a product, primarily focusing on safety, especially in a regulated environment like public roadways.

Table 2-2: Constraints

Type	Name	Description
Social	DOT Regulations	Conforms to DOT light color regulations and helmet regulations.
Economic	Cost	The cost does not exceed $1000 to create.
Environmental	Reusability	This device is interchangeable with multiple different helmets. If the user decides to get a new helmet; the unit will not have to be thrown out.
Welfare	Human Welfare	This unit mitigates electrical shock to the user to not be harmful. The device will be properly insulated.
Safety	Helmet	The helmet continues to function as a properly rated helmet; the structural integrity of the helmet remains intact.
Health	Neck Strain	Helmet weight does not exceed five pounds.

2.2.1. Social Constraints

Halo Helmet must comply with 2020 Mississippi Code under the following Motor Vehicle Regulations:

§ 63-7-23 Color of lighting devices states that the only color to be used on the rear of a vehicle is a light of red color and that a red light is only allowed on the rear of the vehicle and is to be mounted at no other place than rear facing as to avoid a forward-facing red light. Any warning lights on the rear of any motor vehicle may be red or amber [9].

§ 63-7-27 Performance and visibility of stop lights: incorporation with tail lamps: States that all stop lights must be triggered when the brake is applied and when lighted must be visible at a distance of 100 feet away under normal daylight conditions [9].

Halo Helmet is also Compliant with SAE (Society of Automotive Engineers) and DOT Regulations.

2.2.2. Economic

Halo Helmet is limited to $1000 for total development. This budget is a constraint given by the nature of the class. However, the funding could increase if Halo Helmet undergoes further development beyond the scope of Senior Design.

2.2.3. Environmental

Halo Helmet's systems must easily and safely attach and detach, so if the rider decides to purchase a new helmet, Halo Helmet can accommodate. This modularity means the helmet will have area constraints. Many helmets are full-face helmets with a full-face shield. However, some riders prefer an open-face or even a half-shell helmet. These styles are DOT-approved and acceptable for road use, necessitating Halo Helmet's ability to mount to each helmet design.

2.2.4. Welfare

To ensure human welfare, the electronics in Halo Helmet are well insulated and cannot short out, be affected by weather, or dangerously contact the rider.

2.2.5. Safety

Due to safety concerns and the inability to manufacture a broad range of helmet styles, Halo Helmet is an attachment to an already existing DOT-approved motorcycle helmet.

2.2.6. Health

Weight is a factor when designing a piece of head equipment. The weight of a motorcycle helmet is around three pounds, and the design of the Halo Helmet needs to keep that as close to the original three pounds as possible. The Current goal is at most two pounds of added weight to make the entire helmet five pounds or less. Another factor is weight distribution. The Product should be symmetrical so that one side of the helmet doesn’t weigh significantly more than the other side.

2.3. Standards

Halo Helmet abides by the standards listed in Table 2-3. These standards ensure the customer's safety and the Halo Helmet's reliability. Team 2-Stroke conducts tests based on the requirements provided in the documentation for each standard.

Table 2-3: Engineering Standards

Specific Standard	Standard document	Specification / application
IP-X3	Halo Helmet meets Ingress Protection (IP) Standard 60529 set by the International Electrotechnical Commission [8].	Halo Helmet withstands heavy rain while traveling at highway speeds.
USB	Halo Helmet follows Universal Serial Bus Specification [10].	Halo Helmet utilizes USB interface for rechargeable batteries.
Modular Transmitters	Halo Helmet abides by Code of Federal Regulations (CFR) 47C 15.212 for wireless communications [11].	Halo Helmet utilizes Bluetooth for wireless internal communication.

2.3.1. Ingress Protection Standard

Ingress Protection Rating IP-X3 states that components are resistant to water spraying onto the device. Halo Helmet adheres to this standard by having encased lights, microcontrollers, and sensors.

2.3.2. Testing Standards

Halo Helmet resists heavy rainfall during routine operation. Team 2-Stroke evaluates this by following the testing procedures listed in IEC 60529. A spray nozzle emits water onto the Halo Helmet from various angles. To adequately cover the surface area of the Halo Helmet, it undergoes this test for approximately 5 minutes [12].

2.3.3. Universal Serial Bus Standard

Halo Helmet uses the Universal Serial Bus standard for battery charging. Team 2-Stroke adheres to official USB standards by implementing certified USB devices into the Halo Helmet's design.

2.3.4. Bluetooth Standard

The communication system utilized within Halo Helmet is considered a split modular transmitter by the CFR 47C 15.212 Standard. This standard outlines the requirements for wireless transmit and receive devices within a product [11]. Team 2-Stroke abides by this standard by implementing approved Bluetooth devices into the Halo Helmet's design.

2.3.5. Documentation Standards

Team 2-Stroke follows IEEE standards for documentation and source citation.

3. REFERENCES

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