



February 11th, 2022

Dr. Mike Hegedus
Simon Fraser University
8888 University Drive
Burnaby, British Columbia, V5A 1S6

RE: ENSC 405W/ENSC 440 Requirements Specification – Motorcycle HUD System

Dear Dr. Hegedus,

The team here at ClearNav is delighted to present the requirements specifications for our product EZhud. Our product intends to display real-time navigation and speed limit information for motorcyclists, guiding them in unknown urban environments. By using a heads up display (HUD), our solution allows riders to view wayfinding information whilst keeping their eyes towards the road – improving their situational awareness.

The document below will inform key stakeholders of the various requirements of our device, specifically throughout the proof-of-concept, engineering prototype and final product stages of development. Sections of the document will also provide specific requirements for the software, hardware and electrical systems.

EZhud will consist of a lightweight attachment to a modern full face helmet. After the initial setup, users will be able to program routes via their smartphone, and use the HUD device for navigation from point A to point B. The device will also include a front-facing camera which will allow the microprocessor to extract speed limit data from the image feed.

Our team consists of a diverse set of engineers from the computer, electronic and biomedical concentrations. Our members include Taimoor Ahmed, Muhammad Ahmed Athar, Namsakhi Kumar, Spencer Lall, William Huong and William Xue. Our multifaceted skill sets will allow us to engineer reliable systems and deliver clear documentation.

The team here at ClearNav would like to thank you for taking the time to read our requirements specification document. If there are any questions or concerns, please do not hesitate to contact me at zjxue@sfu.ca.

Sincerely,

William Xue
Chief Executive Officer
ClearNav



Requirements Specification

EZhud

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Abstract

EZHud is a Heads-up display module compatible with any full face motorcycle helmet. Our aim is to design a product that makes the rider's journey safer by offering a more secure alternative compared to the phone mounted on the handlebars. EZHud is integrated to your motorcycle helmet to guide you with step by step navigation and inform you about the speed limit.

This document specifies the functional and non-functional requirements that must be met by our product. We start the discussion with the background and scope of our project, identify the needs to be met within our target market and how the vision of ClearNav's product will solve these needs. From here onwards we will discuss the various requirements of the product at various stages of development, starting with general system requirements and then working our way down through the major subsystems.

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Glossary

Acronym	Definition
GPIO	GPIO (General Purpose Input Output) pins enable the microcontroller to communicate with different components
Highway Speeds	Highway speeds in British Columbia – ranging from 80 km/h to 120 km/h [1]
HUD	Heads-up Display
LCD	Liquid crystal display
LCOS	Liquid crystal on silicon
MCU	Microcontroller unit
OLED	Organic light emitting diode
Rider	Motorcycle Rider in British Columbia

1 Introduction

1.1 Background

Motorcycles lack the convenience of easily visible navigation and speed information that most car drivers are very much used to. Firstly, unlike driving a modern car, motorcycles do not provide a built-in turn-by-turn navigation system presented on a large display in the center of the dashboard. Secondly, glancing down at the speedometer on a motorcycle is much more dangerous than in a car and a lack of attention to the driving task is a common factor for motorcycle accidents [2]. Lastly, many drivers are often unaware of the speed limit on the current road, and this is especially true in motorcycles with no display for speed limit information.

ClearNav believes that EZhud is the most convenient and intuitive solution that mitigates all these problems. EZhud is a smart heads-up display that any user can attach to their existing helmet. After programming the route via the smartphone mobile app, the user is immediately provided with turn-by-turn navigation, current speed, and speed limit within your peripheral vision. Especially useful for riders who rely on navigation guidance or riders who simply want to see more information in their peripheral vision. Users with EZhud can keep their eyes on the road while still being guided by technology that we're all used to in cars.

1.2 Scope

The following requirements specification outlines the functional and non-functional requirements that must be met by the EZhud system as a whole. Requirements for each component of the system will be specified and categorized into three product phases (Proof Of Concept, Engineering Prototype, and Final Product).

1.3 Intended Audience

This document serves as EZhud's functional requirements guide for the Company 11 team, its potential clients and partners, Dr. Mike Hegedus, Dr. Andrew Rawicz, and ENSC 405W / 440 teaching assistants. Any future design revisions or modifications will draw from the requirements detailed in this document.

1.4 Requirements Classification

The requirements in this document will be categorized using the following convention:

Req <Section>.<Number> - <Design Phase Acronym>

The three product design phases are as follows

Table 1.4: Product Design Phases

Acronym	Product Design Phase	Description
A	(Alpha Phase) Proof-Of-Concept	Requirements that will be presented during the ENSC 405W demo
B	(Beta Phase) Engineering Prototype	All core components of the product are integrated together and function as a single unit.
C	(Production Phase) Final Product	System meets safety and sustainability standards and fulfills all requirements specified.

2 System Overview

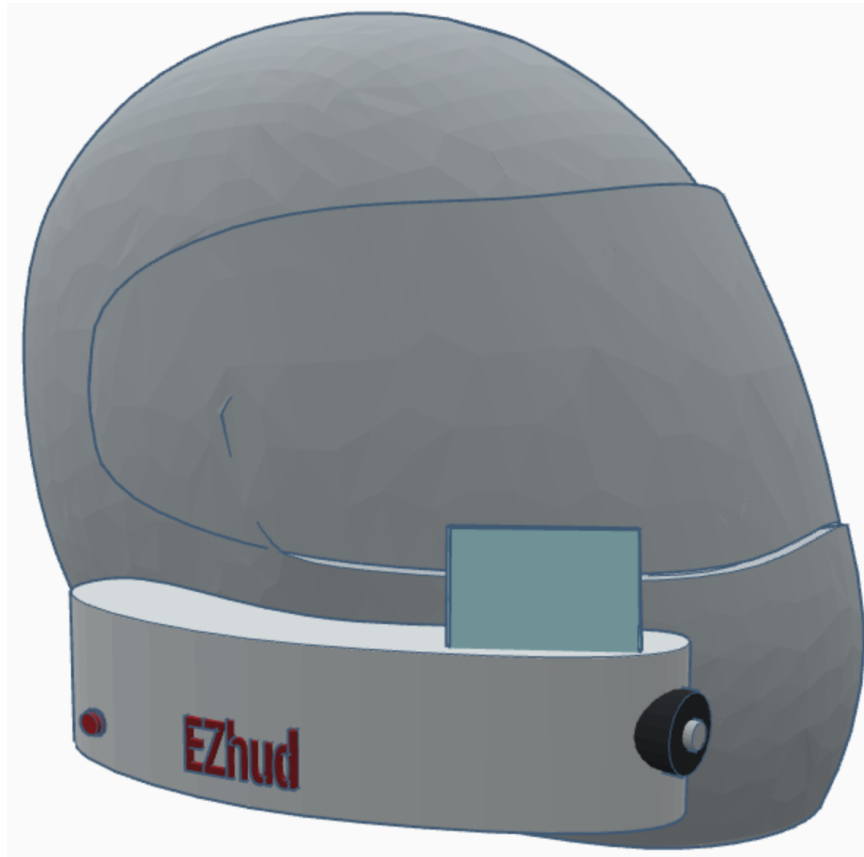


Figure 2.1: EZhud Conceptual Model On Full Face Helmet (Helmet Model From [3])

EZhud is a helmet mounted HUD composed of the following major components: the display, a microcontroller, a battery, a camera, and a smartphone app. Figure 2.1 shows an initial conceptual model of our intended design and our integrated parts. All of these components will be contained within a protective shell, save for the display, to help protect the components and keep them all in one piece. The display will be positioned to the side of the user's field of view and will be how all navigational and speed information will be provided to the user. Additionally, a camera will be mounted to the front of the device, capturing the road in front of the user. This video will be fed into the microcontroller to extract speed limits. This same microcontroller will also be responsible for controlling the display.

While some data can be inferred or generated by just the above components, we expect more complicated data such as navigation, speed, and GPS information to come from a Bluetooth connected smartphone. This smartphone will run an accompanying app, and the user will interact with this app to control EZhud. The app shall contain functionalities such as setting routes for navigation and this data will be sent to the microcontroller which will display the route on the screen. The full high level system diagram can be found in Figure 2.2 below

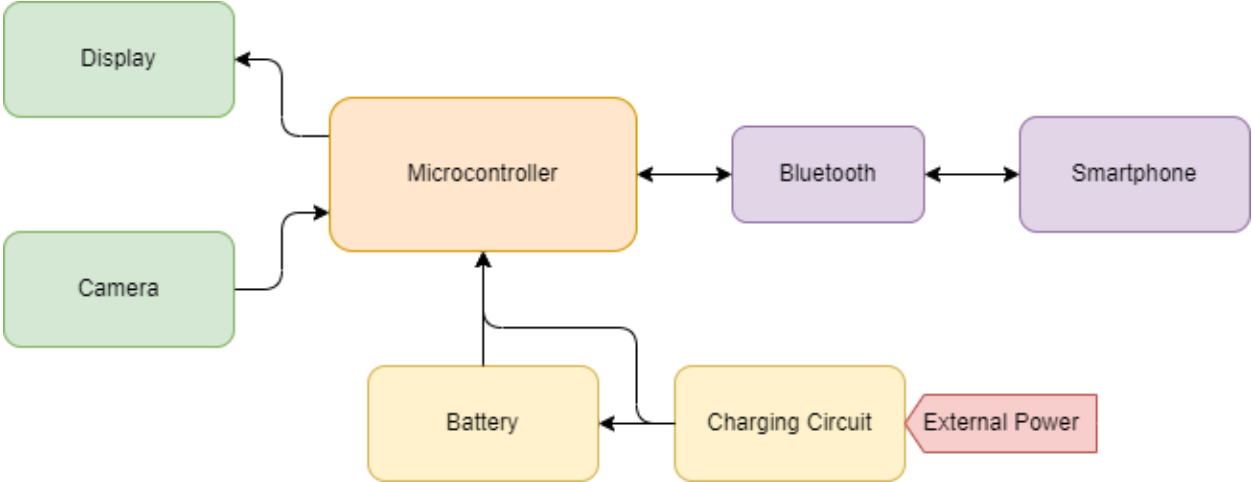


Figure 2.2: High Level System Diagram

3 General High-Level Requirements

3.1 Functional requirements

The functional requirements below shall cover the main use cases of the EZhud, especially with respect to GPS navigation and speed limit capture.

Table 3.1: Functionality Requirements

Requirement ID	Description
Req3.1.1 - A	When prompted, EZhud shall display turn-by-turn navigation instructions to the rider.
Req3.1.1a - B	The display shall not obstruct the riders view.
Req3.1.2 - B	When on, EZhud shall display the current speed and detect the speed limit.
Req3.1.2a - C	When detected, EZhud shall also display the speed limit.
Req3.1.3 - C	The device shall be lightweight and easy to attach to any full face helmet.
Req3.1.4 - B	The device shall be portable and it shall use a battery for the power source.
Req3.1.5 - C	The device shall have an option to turn off the display for riders convenience.
Req3.1.6 - B	The device shall be able to connect through Bluetooth.
Req3.1.7 - B	The device shall be android friendly.

4 System Requirements

The main enclosure of the HUD device must contain the required microcontrollers and battery pack such that the sensitive electronics are protected from wind and rain. The enclosure must also be compact and lightweight to fit properly to the surface of the helmet. Another important requirement is that the device must stay secure during normal use and operation, especially when riding at highway speeds.

Table 4.1: System Requirements

Requirement ID	Description
Req4.1 - C	
Req4.1a - B	The device shall contain a microcontroller, battery, and front-facing camera housed within an enclosure.
Req4.1b - B	The display shall be mounted external to the device such that it is visible to the rider.
Req4.1c - B	The device shall be enclosed in an outer casing that hugs the outer surface of the helmet.
Req4.2 - C	The HUD device shall remain securely fastened while in use by a motorcycle rider on British Columbia's road network.
Req4.2a - C	The device shall be rainproof.
Req4.2b - C	The device shall operate within a temperature range of -5°C to 35°C.
Req4.2c - C	The device shall remain attached to the helmet when riding at highway speeds.
Req4.4 - B	The HUD device shall maintain a battery charge of minimum 2 hours under normal operating conditions.
Req4.4a - C	The battery indicator shall notify the user when the battery level falls below 15%.
Req4.5 - A	The user shall be able to turn the device on or off.
Req4.6 - C	The enclosure shall not protrude more than 7 cm from the surface of the helmet.
Req4.7 - C	The base area of the enclosure shall be no larger than 8 cm x 14 cm.
Req4.8 - C	The device shall weigh less than 500g.
Req4.9 - C	The device should cost less than 500 dollars.

5 Software Requirements

The software of EZhud can be broadly categorized into three components: The HUD software, the computer vision and machine learning software, and the mobile application software.

The HUD will serve as the only user interface of the product and has the purpose of displaying information quickly and safely to the user in real time.

The Computer Vision and machine learning models will be used to read the physical speed limit signs in real time using the front facing camera.

The mobile application will be used by the user to program the route onto the HUD as well as providing access to settings for user preferences on what information is shown and how.

5.1 General Software Requirements

Table 5.1: General Software Requirements

Requirement ID	Description
Req5.1.1 - A	The HUD shall support programmability with map information by the user
Req5.1.2 - C	The software shall be responsive enough to display information to the user while driving.
Req5.1.2a - B	The software shall be responsive enough on city roads.
Req5.1.2b - C	The software shall be responsive enough at highway speeds.
Req5.1.3 - B	The software shall provide a way for the user to exit navigation.
Req5.1.4 - B	The software shall automatically update navigation directions in case of missed turn or user has generally gone off route.
Req5.1.5 - C	The software shall not instruct the user to make unsafe or illegal actions.

5.2 Heads Up Display Requirements

Table 5.2: Heads Up Display Requirements

Requirement ID	Description
Req5.2.1 - A	The HUD shall correctly show map with current location
Req5.2.2 - B	The HUD shall correctly show point-to-point navigation directions after the user programs route
Req5.2.3 - B	The HUD navigation directions shall display the type of action (i.e., "left turn") and distance until action (i.e., "left turn in 100m")
Req5.2.4 - C	The HUD shall display current speed within a margin of +/- 5km/h
Req5.2.1 - C	The HUD shall update navigation, current speed, and speed limit information at a minimum of 5Hz refresh-rate.
Req5.2.5 - C	The HUD navigation notification shall appear in front of the user at a safe time and distance in advance

5.3 Computer Vision Requirements

EZhud will use computer vision and object classification techniques to read the physical speed limit signs in real time using the front facing camera. This live reading will be used in conjunction with an existing data set to provide the user with the most accurate speed limit information available. The following table lists the computer vision requirements needed to realize this feature.

Table 5.2: Computer Vision Requirements

Requirement ID	Description
Req5.3.1 - B	Computer vision system shall detect speed limit sign in front of rider
Req5.3.2 - C	Computer vision model shall correctly identify speed limit sign with 80% success rate
Req5.3.3 - C	Speed limit feature shall use an algorithm to solve conflict in the case of a conflict between ride reading and dataset
Req5.3.4 - C	The HUD shall notify the user when the current speed exceeds the speed limit.

5.4 Mobile Application Requirements

A simple mobile application is provided with EZhud to allow the user to program their route into the HUD navigation system before riding. Using this mobile application, the user will also be able to control what information (Navigation, current speed, speed limit) is displayed during the ride. The following table lists the mobile application requirements needed to fulfill this component of the system.

Table 5.2: Mobile Application Requirements

Requirement ID	Description
Req5.4.1 - B	The mobile application shall be supported on android
Req5.4.2 - B	User shall be able to program navigation route into EZhud via the mobile application over bluetooth before riding
Req5.4.3 - C	User shall be able to adjust which information (navigation, current speed, speed limit) is displayed on HUD
Req5.4.4 - C	A user experienced with smartphone operation shall be able to program their route into EZhud using the mobile application in less than 15 minutes.

6 Hardware Requirements

For EZHud to be a portable product, the hardware should be lightweight and power efficient. The following section discusses the hardware requirements for EZhud.

6.1 Microcontroller/Microcomputer Unit (MCU)

EZHud requires a microcontroller that can manage embedded functionalities of the product. MCU is the backbone of EZHud which allows the devices like camera, LCD/OLED display and GPS module to communicate with each other, and process and transfer the data for automation purposes.

Some of the popular MCUs available in the market are Arduino, MSP430, ESP32 and Raspberry Pi. Each MCU has its strong and weak points. However, the microcontroller we choose should satisfy the requirements in Table 6.1.

Table 6.1: Microcontroller Requirements

Requirement ID	Description
Req6.1.1 - A	MCU shall support Bluetooth connectivity
Req6.1.2 - A	MCU shall support Wi-Fi connectivity
Req6.1.3 - A	MCU shall work with a 5V/2.5A DC power supply [4]
Req6.1.4 - B	The processor of the MCU shall be powerful enough to run image processing and navigation at the same time
Req6.1.5 - A	MCU shall support power input and data transfer over USB
Req6.1.6 - B	MCU shall be able to easily connect with a LCD/OLED display
Req6.1.7 - B	MCU shall be able to communicate with the camera

6.2 Electrical and Power Supply Requirements

For EZHud to be operational and portable we would need a battery to power the microcontroller and other components. The electrical and power supply requirements are listed in Table 6.2.

Table 6.2: Electrical and Power Supply Requirements

Requirement ID	Description
Req 6.2.1 - A	Need to supply between 3.3V to 5V for the microcontroller to operate [4]
Req 6.2.2 - B	Power supply/battery shall be able to provide a minimum of 2.5A and not more than 3A [4]
Req 6.2.3 - B	Battery shall provide sufficient power to run the camera and support maximum GPIO current draw on the microcontroller
Req 6.2.4 - B	Supply circuit needs to have circuit protection for microcontroller and other devices

6.3 Display Requirements

For EZHud, one main hardware requirement is to have a display for the user to see the navigation, current speed and the speed limit. Some display options suitable for our project are Vufine LCOS display, LCD and OLED display. Table 6.3 below lists the display requirements.

Table 6.3: Display Requirements

Requirement ID	Description
Req 6.3.1 - B	Resolution shall be sharp enough to read the map and speed limit
Req 6.3.2 - B	Size of the display shall be small enough to not obstruct the riders view
Req 6.3.3 - C	Display shall have an option to adjust the brightness

7 Conclusion

EZhud is a portable and lightweight HUD unit targeted for motorcycle riders that provides navigational and speed information in the riders' peripheral vision. Our portable and lightweight solution allows riders to keep their vision towards the road whilst viewing critical wayfinding information. Our system also displays the current speed and the detected speed limit to allow riders to properly maintain a safe speed. The team here at ClearNav hopes to engineer a reliable and practical system that can provide riders with a safe and convenient experience.

In this document, many requirements specifications were listed for the different components of the system. The requirements that we cover include the functional, system, software and hardware components. The hardware section lists specifications for the microcontroller, display and power systems whereas the software section talks about the display contents, mobile application and computer vision requirements. The functional requirements go through the target functionalities of the device and the system requirements cover the integration aspects of the final product. By adhering to the specifications listed in this document, the ClearNav team hopes to bring an elegant and reliable solution to the exciting world of motorcycle riding.

8 Appendix A – Proof of Concept Functionalities

For our proof-of-concept poster presentation at the end of 405W, the following requirements will need to be satisfied.

- Map displaying on a display screen that will show navigation details
- Microcontroller operated through a laptop
- Simple demonstration of speed limit sign detection on laptop

Requirement ID	Description/Test
Req3.1.1 - A	When prompted, EZhud shall display turn-by-turn navigation instructions to the rider
Req4.5 - A	The user shall be able to turn the device on or off
Req5.1.1 - A	The HUD shall support programmability with map information by the user
Req5.3.1 - B	Simple demonstration of speed limit sign detection on laptop
Req6.1.5 - A	MCU shall support power input and data transfer over USB
Req 6.2.1 - A	Need to supply between 3.3V to 5V for the microcontroller to operate [4]

9 References

[1]"Road and Driving Information | Transportation | Travel Resources", *Travel British Columbia*, 2022. [Online]. Available: <https://www.travel-british-columbia.com/travel-resources/transportation/road-driving-info/>. [Accessed: 14-Feb- 2022]

[2]*Hg.org*, 2022. [Online]. Available: <https://www.hg.org/legal-articles/little-known-facts-about-motorcycle-accidents-31124>. [Accessed: 14-Feb- 2022]

[3]"Motorcycle Helmet v2 Free 3D Model - .obj .stl - Free3D", *Free3d.com*, 2022. [Online]. Available: <https://free3d.com/3d-model/motorcycle-helmet-v2--886241.html>. [Accessed: 14- Feb- 2022]

[4]*Datasheets.raspberrypi.com*, 2022. [Online]. Available: <https://datasheets.raspberrypi.com/rpi4/raspberry-pi-4-datasheet.pdf>. [Accessed: 14- Feb- 2022]