ELECENG 4OI6: Engineering Design

Project Proposal

MotoVision HUD:

Advanced Helmet Display System

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Executive Summary

The safety of motorcyclists on the road is paramount especially when it comes to hazards like blind-spots. The need for real-time information without distractions is the aim of our Capstone project, MotoVision HUD which aims to enhance rider safety and situational awareness. The system will provide real-time alerts for vehicles within a 3-meter range, ensuring the rider's awareness of nearby hazards through LEDs. It will also display speed, weather, and navigation information directly through the helmet's visor, allowing for less smartphone dependence and a greater riding experience with reduced distractions. The project will leverage ultrasonic sensors and AI-powered object recognition while also offering customization features for the HUD itself along with an accompanying mobile app for real-time data monitoring and control. This innovation is aimed to build upon existing smart helmets and provide users with enhanced metrics, greater flexibility and control. With a budget of approximately $400 CAD and a six-month scheduled timeline, our team will deliver the system in three specific phases: blind spot detection, motorcycle visor HUD and full app integration as we design, prototype and implement the objectives with safety and regulatory compliance in mind.

Expression Of Need

A motorcyclist requires a smart helmet system that enhances safety by addressing the critical need for real-time detection of vehicles in blind spots, providing immediate alerts to prevent collisions. The motorcyclist also needs access to essential information such as speed, speed limit regulations, and weather updates in a hands-free manner to avoid distractions while riding. The system must seamlessly integrate these features into the helmet ensuring that the rider remains fully aware of their surroundings and reducing the risk of accidents.

Background

The following products illustrate the growing trend of incorporating HUDs and blindspot detection into motorcycle helmets, blending safety and convenience. Our project, which includes a customizable HUD and mobile app, positions itself well in this competitive landscape by offering an additional level of user customization and integration. Various stakeholders play crucial roles in this landscape.

Motorcycle riders are the primary stakeholders, as they directly benefit from enhanced safety features like blindspot detection and HUD displays, which reduce distractions. Manufacturers of helmets and smart devices are also key stakeholders, as they drive innovation and ensure these products meet safety standards. Additionally, law enforcement and road safety organizations are stakeholders interested in the adoption of technologies that improve road safety for motorcyclists. Finally, software developers and designers play a vital role in ensuring the mobile app and customization options are user-friendly, catering to rider preferences and needs.

- The iC-Rider Edition Helmets offer an integrated HUD and blindspot detection using dual ToF sensors, providing real-time obstacle alerts, crash detection, GPS, and communication, starting at $650 USD [1].
- The CrossHelmet X1 features a rearview camera and HUD for navigation and blindspot visibility, with Bluetooth connectivity for calls and music, priced at $1800 USD [2].
- The Skully Fenix AR Helmet includes a transparent HUD and rear view camera for blindspot detection, navigation, and speed monitoring, priced at $350 USD [3].

Objective

To design and prototype a smart helmet system that detects vehicles within a 3-meter range using sensors, with a response time under 200 ms. The system will trigger LED alerts within 100 ms when a hazard is detected and provide real-time speed, weather, and datetime updates on an integrated visor HUD display. Wireless communication between helmet modules will use Bluetooth with a 10-meter range and a latency of less than 50 ms,

supporting continuous operation for 8 hours. The full system will integrate with a mobile app for remote configuration and data logging, updating every 5 seconds.

Technical Modules

Blind Spot Detection

- ☐ An ultrasonic sensor based object detection system
- ☐ A RaspberryPi radio transmitter system
- ☐ An LED radio receiver notification system

Heads-Up Display (HUD)

- ☐ A visor-integrated transparent heads-up display (HUD) system
- ☐ A real-time information display software (RTD System Software)
- ☐ A wireless data communication module for HUD input

Mobile App

- ☐ A user interface (UI) design module for helmet and HUD system control
- ☐ A Bluetooth communication module for helmet-to-app connectivity
- ☐ A backend API integration module for real-time sensor data

Resources (Components, Personnel and Budget)

Personnel

- **Computer Engineers (2):** Integrate ultrasonic sensors, LEDs, and power systems in the helmet.
- **Software Engineers (2):** Program microcontroller/Raspberry Pi for sensor data processing, LED control, and HUD functionality.
- **Project Manager:** Manage progress, schedule, and budget.
- **External Consultants:**
    - **Motorcycle Safety Expert:** Advise on safety and system intrusiveness.
    - **Software/Hardware Mentors:** Guide IoT, real-time processing, and sensor integration.

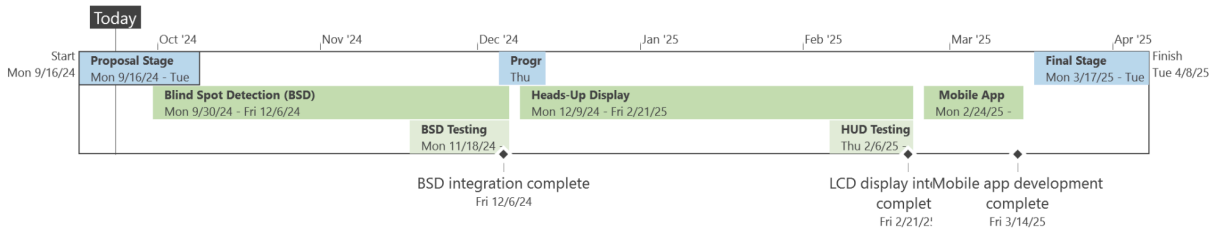
Components and Estimated Budget

Component	**Item**	**Estimated Cost**
Processing Unit	**1 x** Raspberry Pi 4 Model B ($60–$75 CAD) **2 x** ESP32 ($6–$10 CAD) (if low power & wireless communication are prioritized) **2 x** Radio Receiver and Transmitters ($10-50 CAD)	$80 - $145
Ultrasonic Sensors	**4 x** zHC-SR04 Ultrasonic Sensor ($2–$5 CAD per sensor) OR **4 x** MaxSonar Ultrasonic Sensors ($30–$50 CAD) (for longer range or better accuracy)	$20 (low-end) $64 (mid-end) $200 (high-end)
LEDs for Blindspot Indicator	**6 x** High-Visibility LEDs ($2–$5 per LED)	$12 - $30
HUD Display	**1 x** Transparent OLED or LCD Display ($50–$80 CAD) OR	$35 - $80

	1 x Adafruit PiTFT+ 3.5” Display for Raspberry Pi ($35 CAD)	
Power Source	**2 x** LiPo Battery Packs ($10–$30 CAD depending on capacity) **1 x** Battery Management System (BMS) for safe charging ($5–$15 CAD)	$25 - $75
Other Components	**1 x** Voltage Regulators and Step-down Modules ($5–$10 CAD) **1 x** PCB/Protoboard for wiring ($10 CAD) **1 x** Wires and connectors ($5 CAD) **1 x** Mounting brackets for sensors and LEDs ($10 CAD)	$30 - $35
Miscellaneous	Adhesives, plastic enclosures, small tools	$30

Total budget: $235 - $460 CAD
Total estimated cost (including owned components): $180 - $390

Schedule of Activities and Milestones



The schedule for the motorcycle HUD Capstone project is divided into three main stages:

1. **Proposal Stage (Sept 16 - Oct 8, 2024)**: Finalize objectives, technical modules, resources, and deliverables, culminating in a proposal presentation.
    a. Blind Spot Detection (BSD) development and testing (Sept 30 - Dec 6, 2024)
2. **Progress Stage (Dec 5 - Dec 13, 2024)**: Involves high-level system design, module clarification, and prototyping plans, leading to a progress report.
    a. Heads-Up Display (HUD) integration (Dec 9, 2024 - Feb 21, 2025)
3. **Final Stage (Mar 17 - Apr 8, 2025)**: Completion of the prototype, Capstone Expo, and final report.
    a. Mobile App Development (Feb 24 - Mar 14, 2025)

For the full Gantt chart, please refer to Appendix A.

Progress Monitoring and Control

Our progress monitoring system is divided into three main sections which track our task progress, our budget status and our overall schedule status. A weekly team check-in meeting will be scheduled to ensure that these systems are utilized and updated to ensure synchronization across the board.

To ensure that tasks are progressing as planned, we will implement a Task Breakdown Structure that outlines each task in detail, which includes the responsible team member, estimated completion percentage and status updates.This system will allow us to directly track the status of all individual tasks and clearly infer and update the overall schedule (Gantt Chart) to ensure compliance. This system allows us to clearly define the task,

analyze completion and status, understand the bottlenecks and finally provide a clear picture to how it will affect the overall project schedule. This will allow us to track all tasks, milestones, dependencies and the differences between planned and actual project timelines.To ensure compliance with our allotted budget range, we will regularly track our expenditures using an Excel sheet that will enable direct comparisons with our initial estimates. The budget monitoring will be done via a comparison between the planned vs actual costs which will be sourced from the receipts of all purchased items. This will enable us to highlight any deviation from the original range and define how we plan to address it.

Health & Safety

The MotoVision HUD project prioritizes user health and safety by placing an emphasis on reducing rider distractions, improving awareness of surroundings, and enhancing protection.

- Visual Safety and Display Clarity:
    - The information shown on the helmet's integrated HUD (Heads-Up Display) needs to be clear and unobtrusive. Depending on the lighting circumstances (day and night), the display brightness should automatically adapt to maintain visibility without glaring or blocking the rider's perspective. [4]
    - The display must be positioned so that it gives the rider the information they need without taking their eyes off the road.
- Operational Safety and Human Factors:
    - The MotoVision HUD has to be simple to use and intuitively designed so that the rider isn't distracted. For example, non-intrusive visual or audio signals that don't overwhelm the rider with information or add to their cognitive burden must be used to convey system alarms. [4]
    - The system has to be calibrated to reduce false positives and needless notifications as excessive alarms might cause riders to become stressed or distracted.
- Regulatory Compliance:
    - The finished integrated helmet and all of its parts must abide by all relevant safety laws, including those pertaining to electronic devices (like FCC requirements for wireless devices) and helmets (like DOT, ECE, or Snell ratings). [5]
    - Any changes made to the helmet must guarantee that it continues to comply with local traffic safety regulations governing rider visibility, sound, and the use of electronic devices while riding.

Deliverables

Tier	**Deliverable**	**Expected Completion Date**
Bronze	Blind Spot Detection System - Detect vehicles within a 3-meter range using sensors, with a response time under 200 ms and trigger LED alerts within 100 ms when a hazard is detected.	Dec 2024
Silver	Heads-Up Display (HUD) System - Provide real-time speed, weather, and datetime updates on an integrated visor HUD display.	Feb 2025
Gold	Integrated Mobile App - Integrate system with a mobile app for remote configuration and data logging, updating every 5 seconds.	Mar 2025

References

[1] iC-Rider Edition Helmets, Intelligent Cranium Helmets, [Online]. Available: https://intelligentcraniumhelmets.com/. [Accessed: 25-Sep-2024].

[2] CrossHelmet X1, CrossHelmet, [Online]. Available: https://www.crosshelmet.com/. [Accessed: 25-Sep-2024].

[3] Skully Fenix AR Helmet, Wearable Tech, [Online]. Available: https://wearabletech.io/skully-fenix-ar-helmet/. [Accessed: 25-Sep-2024].

[4] R. Häuslschmid, B. Fritzsche, and A. Butz, "Can a Helmet-mounted Display Make Motorcycling Safer?," *Proceedings of the 23rd International Conference on Intelligent User Interfaces (IUI '18)*, Tokyo, Japan, Mar. 2018, pp. 409–413, doi: 10.1145/3172944.3172963.

[5] Government of Ontario, "Regulatory Registry: Amendments to Safety Helmets Regulation under the Highway Traffic Act," *Ontario Regulatory Registry*, 2012. [Online]. Available: https://www.ontariocanada.com/registry/view.do?postingId=8502&language=en.

[6] Shahram Shirani, "Engineering Design Process Proposal 24" ELECENG 4OI6, McMaster University, September 2024. [Online]. Available: https://avenue.cllmcmaster.ca/d2l/le/content/627715/viewContent/4750659/View

Appendix A: Gantt Chart

GANTT CHART

	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**General**	**146 days?**	**Mon 9/16/24**	**Tue 4/8/25**	
2		**Proposal Stage**	**17 days?**	**Mon 9/16/24**	**Tue 10/8/24**	
3		Finalize project objective and technical modules	3 days	Thu 9/19/24	Mon 9/23/24	
4		Create list of resources	1 day	Mon 9/23/24	Mon 9/23/24	
5		Finalize deliverable list (bronze, silver and gold)	1 day	Mon 9/23/24	Mon 9/23/24	
6		Complete schedule of activities and milestones	3 days	Mon 9/23/24	Wed 9/25/24	
7		Complete individual written parts	3 days	Wed 9/25/24	Fri 9/27/24	
8		Proposal report complete	0 days	Fri 9/27/24	Fri 9/27/24	3,4,6,5,7
9		Proposal presentation complete	0 days	Tue 10/8/24	Tue 10/8/24	8
10		**Progress Stage**	**7 days**	**Thu 12/5/24**	**Fri 12/13/24**	
11		Finalize high level system design	2 days	Thu 12/5/24	Fri 12/6/24	
12		Clarify description of design modules	2 days	Thu 12/5/24	Fri 12/6/24	
13		Prototyping and testing plan	3 days	Mon 12/9/24	Wed 12/11/24	
14		Finalize plan for completion	2 days	Thu 12/12/24	Fri 12/13/24	
15		Progress report complete	0 days	Fri 12/13/24	Fri 12/13/24	11,12,13,14
16		**Final Stage**	**16 days**	**Mon 3/17/25**	**Tue 4/8/25**	
17		Prototype ready for demo	0 days	Mon 3/17/25	Mon 3/17/25	21,33,44
18		Capstone Expo	0 days	Tue 4/1/25	Tue 4/1/25	
19		Final report complete	0 days	Tue 4/8/25	Tue 4/8/25	
20		**Tasks**	**120 days**	**Mon 9/30/24**	**Fri 3/14/25**	
21		**Blind Spot Detection (BSD)**	**50 days**	**Mon 9/30/24**	**Fri 12/6/24**	
22		Sensor research and selection	5 days	Mon 9/30/24	Fri 10/4/24	
23		LED component research	5 days	Mon 9/30/24	Fri 10/4/24	
24		Hardware integration for blind spot detection (BSD)	21 days	Mon 10/7/24	Mon 11/4/24	22,23
25		Algorithm development for BSD	30 days	Mon 10/7/24	Fri 11/15/24	
26		LED alert trigger logic	14 days	Mon 10/28/24	Thu 11/14/24	
27		Helmet visor integration	10 days	Tue 11/5/24	Mon 11/18/24	24

GANTT CHART

	Task Mode	Task Name	Duration	Start	Finish	Predecessors
28		**BSD Testing**	**15 days**	**Mon 11/18/24**	**Fri 12/6/24**	**22,23,24,25,26,27**
29		Detection accuracy	5 days	Mon 11/18/24	Fri 11/22/24	
30		Sensor response time	5 days	Mon 11/18/24	Fri 11/22/24	
31		Sensor calibration for various environmental conditions	10 days	Mon 11/25/24	Fri 12/6/24	
32		BSD integration complete	0 days	Fri 12/6/24	Fri 12/6/24	
33		**Heads-Up Display**	**55 days**	**Mon 12/9/24**	**Fri 2/21/25**	**21**
34		LCD research and selection	3 days	Mon 12/9/24	Wed 12/11/24	
35		Real-time display software for speed and navigation	30 days	Thu 12/12/24	Wed 1/22/25	34
36		Communication module selection and implementation	25 days	Mon 12/16/24	Fri 1/17/25	
37		Battery and power management system design	10 days	Thu 1/23/25	Wed 2/5/25	35
38		Helmet visor integration	10 days	Thu 1/23/25	Wed 2/5/25	36,35
39		**HUD Testing**	**12 days**	**Thu 2/6/25**	**Fri 2/21/25**	**34,36,35,37,38**
40		Detection accuracy	5 days	Thu 2/6/25	Wed 2/12/25	
41		Sensor response time	5 days	Thu 2/6/25	Wed 2/12/25	
42		Sensor calibration for various environmental conditions	10 days	Mon 2/10/25	Fri 2/21/25	
43		LCD display integration complete	0 days	Fri 2/21/25	Fri 2/21/25	
44		**Mobile App**	**15 days**	**Mon 2/24/25**	**Fri 3/14/25**	**33**
45		Bluetooth connection setup	7 days	Mon 2/24/25	Tue 3/4/25	
46		User interface design	3 days	Mon 2/24/25	Wed 2/26/25	
47		HUD display settings	10 days	Mon 3/3/25	Fri 3/14/25	
48		Data logging implementation	7 days	Wed 3/5/25	Thu 3/13/25	45
49		Helmet status monitoring	3 days	Wed 3/12/25	Fri 3/14/25	
50		Power management software	2 days	Thu 3/13/25	Fri 3/14/25	
51		Mobile app development complete	0 days	Fri 3/14/25	Fri 3/14/25	

Proposal Report Rubric

	1	2	3	4
Summary is well written				
Expression of need and background provides context, stakeholders, similar products				
Objectives are clearly defined and quantifiable				
Technical modules (at least one module for each group member) that can be completed in parallel				
Format, length is correct				
Method of progress monitoring and control well defined				
Deliverables are in-line with project objectives and modules and are well identified				
Health, sustainability, environmental, ethical, security, economic, aesthetics and human factors, and compliance with regulatory aspects (if applicable)				
Resources (components, people and budget) are clearly defined				
Milestones well defined and achievable				

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Criteria	Level 4 2 points	Level 3 1.5 points	Level 2 1 point	Level 1 0.5 points	Criterion Score
Summary is well written					/ 2
Background provides context, stakeholders, similar products					/ 2
Objectives are clearly defined					/ 2
Technical approach is well defined and logical					/ 2
Deliverables are in-line with project objectives and are well identified					/ 2
Format, length is correct					/ 2
Proposal is technically sound					/ 2

Total	/ 14