Phase 1 Report: Project Proposal

Sports Vision Pro
Team #13

A Report
Presented to
The Department of Electrical & Computer Engineering
Concordia University

In Partial Fulfillment
of the Requirements
of ELEC/COEN 490

By

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ABSTRACT

As live sports evolve, hockey in particular, audiences are constantly seeking more immersive and engaging ways to experience the match. Traditional broadcasts limit viewers to predetermined camera angles and often audience members have difficulty keeping an eye on the puck and following critical moments. Despite advances in live sports coverage, there remains a gap in bringing fans closer to the authentic experience of being in the game. Current methods, such as sideline views, aerial shots, and instant replays, fall short in offering fans an intimate, first-person perspective of live sports. This limits the emotional engagement and personal involvement that audiences could have, reducing the potential excitement and connection to their favorite athletes. The hockey industry has yet to effectively capitalize on recent advances in virtual reality (VR) technology to create a product that allows users to feel like they are part of the game. Fans are left to imagine what it would be like to "glide in the skates" of their favorite hockey player. With the rapid advancement of immersive technologies, fans are increasingly demanding real-time, personalized, and interactive experiences, but the infrastructure and technology to deliver such an experience remain underdeveloped. Without such innovation, the sports viewing experience will stagnate, leaving a growing audience dissatisfied and disengaged. Additionally, player safety is a top priority. The product will provide immersive VR experiences while monitoring vital data such as heart rate and head movement, detecting risks like concussions. This data can alert medical professionals and the VR audience to potential injuries. The lightweight design (150g headband with securely attached antenna and battery) ensures it doesn't obstruct movement or vision. Temperature control keeps the device cool, and the system provides a minimum video resolution of 720p for high-quality visuals, maintaining both safety and comfort for the player.

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1 - PROJECT DEFINITION & DESCRIPTION

1.1 - Description of Product

Our team has decided to design a hockey helmet that can broadcast video of a player's point of view in real time. The helmet will have a high-quality 720p or 1080p camera, capturing the action from the player's perspective and streaming it directly to audiences via a VR platform. In addition to video streaming, the helmet will feature a built-in microphone for immersion, biometric sensors to monitor vital signs such as a pulse oximeter sensor, thermal sensor, impact sensor, inertial measurement units (IMU), and as well as an electroencephalography sensor to measure the player's speed, detect potential concussions from impact, and using an RF module or IR led and camera that will enable users to track players in real-time.

1.2 - Objectives

Problems being Addressed:

- Player safety and health monitoring (concussions)
- Real-time player performance for statistics
- Deliver an immersive experience for fans watching hockey from the player's POV

Goals:

- Obtain live video and audio streams from players on the rink
- Obtain stress/exertion/adrenaline/strain/effort levels of a player through heartbeat, blood oxygen level, and brain activity monitoring
- Obtain the position and identification of the player on the rink via infrared LED tracking
- Obtain the velocity/acceleration of a player through an accelerometer
- Create an app for VR Goggles to view the stream, with a heads-up display showing stress levels, position on the rink, velocity (and more potential features?)

Deliverables:

- Functional and interactive VR application for watching real-time streaming VR video from a hockey player’s perspective.
- Functional application for real-time vital monitoring system of player
- Functional real-time player tracking system

1.3 - Functions

Helmet Strap:

The helmet strap contains the embedded system which includes the camera and microphone for capturing what the player sees and hears, the IMU for detecting player speed and sudden collisions, the pulse oximeter and electroencephalography sensors to measure the player's stress levels, a transceiver for position triangulation, and an antenna so that all data can be transmitted to the server.

Server:

The server will accept incoming connections from the device to receive real-time data from the players, as well as other incoming connections from the VR Goggles to transmit the stream to the user.

VR Goggles:

This device will be used to view the stream of the player's point of view. This will include a heads up display with the player's position, acceleration, damage caused, stress levels using heart rate.

1.4 - Requirements

1.4.1 - Functional Requirements

- The system shall capture video and audio stream and transmit it to the server
- The system shall capture acceleration and velocity and transmit it to the server
- The system shall detect its location and transmit its position to the server
- The system shall measure the player’s heartbeat and transmit it to the server
- The server shall accept incoming connections from the device and VR Goggle
- The server shall store data transmitted from the device
- The server shall broadcast the data to the VR goggles
- The VR goggles shall show the video and audio stream from the device
- The VR goggles shall include a Heads-up display with player position, speed/acceleration, and stress indicator (heartbeat).

1.4.2 - Non-Functional Requirements

- Shockproof
- Waterproof
- Not too big/heavy
- Easy to use
- Comfortable for the player
- Button to turn device on/off
- Button to turn streaming on/off for player privacy
- Helmet should be CSA-certified

1.6 - Block Diagram Representation

This section of the report will show tentative system architectures depending on the direction we will take after prototyping. Both architectures have a microcontroller gathering input from a camera, microphone, accelerometer, and heart rate sensor, then this data is transmitted to a server that stores the data and delivers it to the VR application. The difference between both alternatives is the position detection feature, where one possibility is to use signal triangulation with a WIFI/RF transceiver, while the other uses an LED emitting infrared light that will be picked up by an IR camera and used to determine the device's position.

Position Triangulation using RF or WIFI:

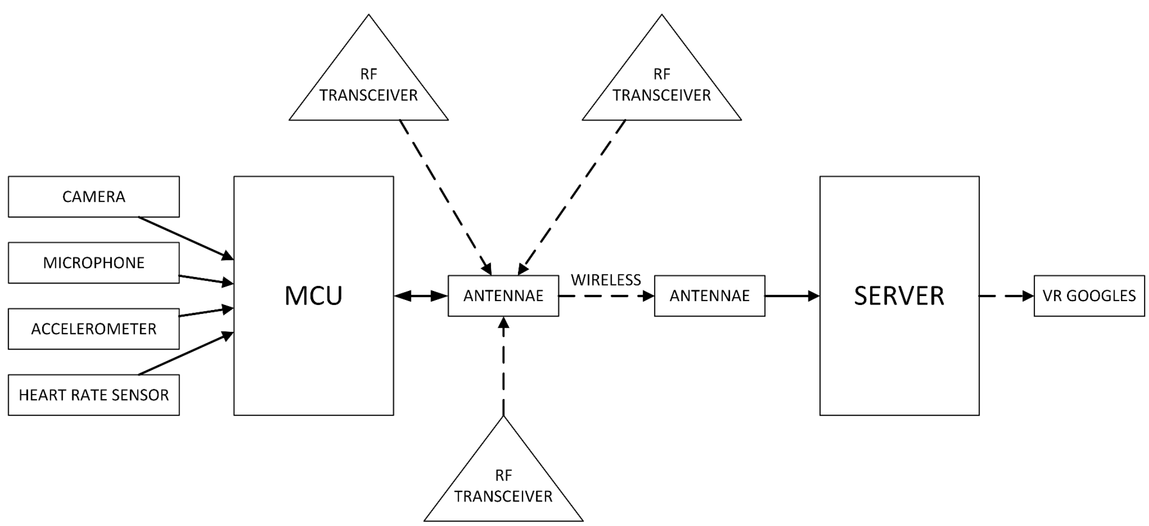

Figure 1: Potential system architecture using position triangulation.

Position Tracking using IR Light Detection:

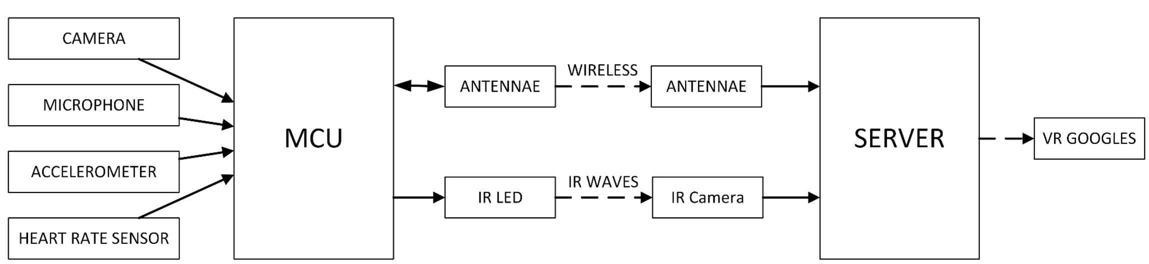

Figure 2: Potential system architecture using position tracking with IR LED.

2 - DESIGN SPECIFICATION

2.1 - Customer's Specifications

Table 1: Customer Specifications

#	Description/ Parameter	Test Conditions	Value			Unit
			Min	Typical	Max	
1	Temperature (Ambient)	Normal[1]	12	-	20	Celcius (°C)
2	Relative Humidity	Non-condensing	30	-	70	Percent (%)
3	Frequency Range (802.11n)	Normal[1]	-	2.4	-	Gigahertz (GHz)
4	Frequency Range (802.11ac)	Normal[1]	-	5	-	Gigahertz (GHz)
5	Data Rate	-	-	-	20	Megabits per second (Mbps)
6	Framerate	-	15	30	60	Frames per second (fps)
7	Latency	-	-	50	100	milliseconds (ms)
8	Shock	-	-	-	30	Acceleration (G)
9	Continuous Operating Time	-	60	-	90	Minutes (min)
10	Weight	-	-	-	650	Grams (g)
11	Field of View	-	-	120	-	degrees
12	Infrared LED Intensity	Normal[1]	-	-	25	mW/sr
13	Infrared LED Pulse	Normal[1]	10	-	100	Hz

[1] Normal test conditions mean that the test is conducted at ambient temperature +20°C, 65% RH, no direct sunlight. No wind. No precipitation. The device is powered by a lithium ion battery. A distance of 3 to 6 meters from the 100º FOV infrared camera.

2.2 - Final Design Specifications

Table 2: Final Design Specifications

#	Description/ Parameter	Test Conditions	Value			Unit
			Min	Typical	Max	
1	Temperature (Ambient)	Normal[2]	12	20	30	Celcius (°C)
2	Relative Humidity	Non-condensing	30	60	70	Percent (%)
3	Frequency Range (802.11n)	Normal[1]	2.4	-	2.5	Gigahertz (GHz)
4	Frequency Range (802.11ac)	Normal[1]	5	-	5.8	Gigahertz (GHz)
5	Data Rate	-		10	20	Megabits per second (Mbps)
6	Framerate	-	15	30	60	Frames per second (fps)
7	Latency	-	-	2	5	Seconds (s)
8	Shock	-	-	-	25	Acceleration (G)
9	Continuous Operating Time	-	60	-	100	Minutes (min)
10	Weight	-	-	-	720	Grams (g)
11	Field of View	-	-	120	-	degrees
12	Infrared LED Intensity	Normal[1]	-	-	50	mW/sr
13	Infrared LED Pulse	Normal[1]	100	-	500	Hz

[2] Normal test conditions mean that the test is conducted at ambient temperature +20°C, 65% RH, no direct sunlight. No wind. No precipitation. The device is powered by a lithium ion battery. A distance of 10 to 11 meters from the 100º FOV infrared camera.

3 - MEASUREMENT OF SUCCESS

An important concept we must consider when working on our project is measuring successful milestones. The following list will be the guideline that our team will be quantifying the project's success.

1. Circuitry and modules must fit in small compartments with shock-absorbent material surrounding them and be attached to the helmet in convenient and non-intrusive regions.
2. Must not compromise the integrity of the helmet's safety features
3. Must be able to accurately collect positional data via inertial navigation over 60 meters in distance with a percentage error of less than 10%
4. Latency should not exceed more than a few seconds
5. Maintain stable connection for constant high definition video broadcasting over 60 meters in distance
6. Battery life must support a minimum of 90 to 120 minutes of continuous usage, including video recording, streaming, and data collection.
7. Biometric sensors must be able to monitor players' real-time heart rates, and provide accurate readings within a 5% rate of error per minute during the game.
8. The total weight of the helmet after integrating all devices must not exceed 800 g to prevent negative effects on players' necks.
9. The microphone must capture clear audio in a noisy environment so that the broadcasting and streaming channel can have clear audio about the game.

4 - TEST PLAN

The number of tests performed will depend on the system's complexity, the specific project requirements, the components involved, and the need to validate functionality, accuracy, and user experience. Each component will undergo test cases to ensure the product meets necessary safety, performance, and usability standards.

Table 3: Test Plan

I.D.	Test Case	Description	Acceptance Criteria
TC-01	Device Frame Enclosure	Frame must be able to encase all modules and prevent any movement or shifting during use.	All internal modules must remain securely in place without any shifting or movement during a series of dynamic movements or impacts.
TC-02	Shock Absorption	Ensure the frame's ability to protect internal components	Endure damage when subjected to impacts from a height of 1 to 1 ½ meters as well as physical impact against another player
TC-03	Environmental Protection	Ensure frame's effectiveness against environmental factors	Frame must prevent water and dust ingress
TC-04	Thermal Management	Ensure that frame has proper heat dissipation of components	Frame must not exceed safe operating limits while in use
TC-05	Weight & Portability	Measure overall weight of frame to ensure ease of use	Total weight must not exceed the specified weight limit to ensure comfort
TC-06	Video Transmission	Ensure continuous video transmission without interruption	Video feed must remain continuous and stable for at least a full game duration with minimal signal and frame drops
TC-07	Tracking Efficiency	Measure the effectiveness of the tracking system in accurately locating the player's position	Tracking must maintain accuracy of at least 90% in a 26 x 60 meter area
TC-08	User Interface	Evaluate the usability and responsiveness of the UI for monitoring helmet data	Interface must allow users to access real-time data, navigate easily and display key parameters with little delay
TC-09	Latency	Measure delay between video capture and display on receiving device	Latency must not exceed more than a few seconds for real-time monitoring

5 - REVIEW OF EXISTING SOLUTIONS

5.1 - Introduction

In this review, we will be directing our attention to existing products that are similar in nature with our proposed project and identify their flaws, strengths, limitations, and areas for improvement. By analyzing their strengths and weaknesses, we aim to ensure our solution addresses these shortcomings while offering enhanced functionality and user experience.

5.2 - Existing Solutions

5.2.1 - XTADIUM [1]

The XTADIUM app would be an existing app that is native to the MetaQuest VR and already has a foothold in the sports industry when it comes to immersive POV experiences. Developed by the company "YBVR", XTADIUM allows users to watch live sports events with multiple camera angles, offering close-up, immersive perspectives. While the app delivers high-quality visual experiences, it lacks features for real-time player data integration or interactive elements, such as performance metrics or live tracking, which our project aims to incorporate, enhancing the overall user experience.

5.2.2 - Zebra MotionWorks™ Sport: Real-Time Player Tracking [2]

Zebra MotionWorks™ Sport is a comprehensive real-time player tracking solution designed for professional sports teams. This technology utilizes RFID sensors placed on players and within venues to capture precise movement data. While it provides detailed insights into player performance, including speed, distance covered, and positional analytics, it does not emphasize immersive viewing experiences for fans. Our project seeks to integrate similar tracking capabilities with a more engaging and interactive interface for spectators.

5.2.3 - Catapult Sports [3]

Catapult Sports offers advanced performance analytics and wearable technology designed for athletes in various sports. Their devices track a range of metrics, including heart rate, speed, and movement patterns. While Catapult Sports provides valuable insights for coaches and athletes to enhance performance, it lacks the immersive viewer experience and real-time data visualization features for fans that our project intends to deliver, creating a more engaging atmosphere during games.

5.2.4 - VEO [4]

Veo provides an AI-powered camera solution that automatically records sports games and matches. The platform allows teams to analyze performance through game footage, highlighting key moments and player movements. Although Veo is excellent for performance analysis, it does not offer interactive or immersive viewing experiences for spectators. Our project aims to bridge this gap by providing real-time insights and immersive perspectives for fans while maintaining the analytical features of platforms like Veo.

5.2.5 - Hawk-Eye Innovations [5]

Hawk-Eye Innovations is renowned for its optical tracking systems and decision support tools used in sports such as tennis and cricket. Their technology provides accurate ball trajectory analysis and enhances officiating through replay systems. However, Hawk-Eye primarily focuses on officiating and performance analysis rather than delivering a fan-centric experience. Our project intends to incorporate real-time data and immersive visuals to enhance viewer engagement, moving beyond traditional tracking systems.

5.2.6 - NACSport [6]

NACSport is a video analysis tool aimed at coaches and athletes, enabling them to review game footage and improve performance through detailed tagging and event analysis. While it offers significant advantages for post-game analysis, NACSport lacks real-time engagement features for fans during live events. Our project strives to merge these analytical capabilities with an immersive viewing experience, providing spectators with real-time insights and performance metrics as they enjoy the game.

6 - ALTERNATIVES

The main signal transmission method we have chosen for this project is via wifi through a wireless adapter. However, there are many alternative solutions for position tracking/triangulation, and some of the suitable ones are listed below:

- **Radio signal**: using radio frequency signals in bands such as high and ultra-high frequency. Commonly, the radio signal is known for transmitting analog or digital signals. It is known to provide greater range than Wi-Fi but is still limited to line-of-sight. The quality and range of the radio signal are heavily influenced by the antenna used and the power of the transmitter.
- **SATCOM (satellite communications)**: This method of communication is extremely reliable as well as having a wide range of coverage. However, the equipment is very space-consuming, expensive, and requires a lot of power input. For a commercial product that focuses on sports captures, this method of signal transmission is not suitable.
- **UWB1000 (Ultra Wide Band)**: This method involves using beacons/transponders that will communicate with the module and track its position by calculating the helmet's velocity, acceleration, and distance.
- **Cellular**: The two most common communication as of now are 4G and 5G. Although its coverage and reliability heavily depend on the location as well as the antenna model, it has advantages such as ultra-low latency and enhanced data rates. 5G signal specializes in bandwidth-intensive applications such as streaming high-definition video. However, it requires a large coverage of antenna to transmit long-distance signals.

7 - PROJECT PLANNING & SCHEDULE

Table 4: Project Planning and Schedule

Event	Deadline/Time
Phase 1 (Selection and Planning) ● Project selection and team formation ● Group Meeting ● Group Meeting with Professor WeiPing Zhu ● Group meeting ● Proposal Completed ● Project Approval by Supervisor ● Group meeting ● Meeting with Space Concordia ● Group meeting ● Phase 1 presentation	 September 6 September 8 September 10 September 11 September 15 September 16 September 29 October 1 October 5 October 7
Phase 2 (Design) ● All group meeting plan ● Final Design Approval ● Software Acquisition ● Hardware Acquisition ● Phase 2 Report Submission ● Phase 2 Presentation	ALL TBD Phase 2 report and presentation will be held on end of November to beginning of December
Phase 3 (Prototype) ● All group meeting plan ● Begin Prototype Implementation ● Testing and Troubleshooting of Prototype ● Phase 3 In lab-demo	ALL TBD from January to February in 2025
Phase 4 (Final Product) ● All group meeting plan ● Final design implementation ● Verification and testing ● Phase 4 In-Lab Demo ● Phase 4 Report Submission ● Phase 4 Final Poster Presentation	ALL TBD from March to April in 2025

8 - TEAM FORMATION

The formation of teams was done by finding team members with field of studies, experiences and competencies adequate for our project. The following is a summary of the team member's qualifications.

Table 5: Team Formation

Team members	**Field of study/Competency/Experience**
GuanFeng Wu	ELEC, EMC and EMI compatibility method, 3D modeling, Circuit design, ECAD software (Altium, CAD-SPICE), Confluence, JIRA, C, C++, Java.
Haoyu Wang	COEN, has experience in coding projects, is familiar with Windows/Linux systems. Programming languages: Android, Matlab, C++, Java, Assembly, Python.
Rongmin Gan	COEN, has project experience with FPGA, developing project with various language as follows: C, C++, VHDL, Assembly (x86、MIPS、ARM), JAVA
Shahin Khalkhali	ELEC, experience in custom PCB design, electrical wiring, embedded control systems, LTSpice, Assembly drawing, electrical testing, Verilog, Wireshark, Cisco Packet Tracer, modeling and simulation, Python, product testing.
Samson Kaller	COEN, DEC in Computer Engineering Technology Embedded Software Development, Windows/Linux Console App Development, Graphics Programming, Software Debugging, Network Protocols, Soldering Programming Languages: C/C++ - Python - Java - Assembly (x86, ARM, MIPS, PIC)
Tien Vu	ELEC, electrical wiring, embedded control systems, LTSpice, Assembly drawing, electrical testing,Wireshark, HTML, database, C++, MATLAB.

9 - TASKS BREAKDOWN

In terms of task allocation, tasks will be divided based on professional fields and general research areas (COEN and ELEC). Therefore, ELEC students will be assigned tasks more closely related to the hardware components of the project, which can further be subdivided and allocated into smaller tasks. Similarly, COEN students will be assigned tasks more relevant to the computer hardware/software aspects of the project, which can also be further divided and assigned into smaller tasks.

On a team basis, all student members will also conduct background research related to the technologies that will be used, as well as documentation associated with these technologies. Additionally, all student members will design and code any applications in hardware and software during the project.

Table 6: Tasks Breakdown

Task ID	Task Description	Allocation
Hardware-1	3D camera and microphone configuration for streaming program	ELEC
Hardware-2	Pulse oximeter, Brain Wave Sensor, and thermo sensor for vital monitoring program.	ELEC
Hardware-3	IMU, infrared LED, and infrared detecting camera configuration for motion and positioning program.	ELEC & COEN

Hardware-4	Wireless transmission system configuration for the transmitting module of the device, and its corresponding receiver to receive the signal.	ELEC
Hardware-6	Battery selection and power module management for device operative longevity and device safety.	ELEC
Software-1	VR Application: Using Oculus SDK Meta, Quest Developer Hub, Unity (C++) to develop the graphical application for streaming the match.	COEN
Software-2	Server Software: Create a server that can accept incoming data from the device, store it and transmit it to the VR application. SQL, Python/C++.	ELEC & COEN
Software-3	Embedded Software: Raspberry Pi 4 Model B programming, creating a program that streams camera video through an IP address. Creating a subprogram that transmits collected vital data of the user. Creating a subprogram that controls the flash rate of light intensity for the indoor positioning program.	COEN
Software-4	Fusion 360 to make the case and frame of the device	ELEC
Software-5	Altium to design the PCB for the later phase of project development.	ELEC

10 - COMMUNICATION PLAN

In terms of communication, various platforms will be used by the team and stakeholders to stay in contact for the duration of the project. For inter-team communication the selected platform is Discord, where a custom server has been created for the project with all team members included. For communication with stakeholders like our Supervisor, Coordinator, Technical Coordinator, Evaluator, and ELSEE Lecturer, in-person presentations will be held for important milestones, or the Zoom platform will be used to host online presentations and meetings for the project.

Additionally, email services will be used to communicate with University Faculty to ask small questions and set up Zoom meetings when discussion is needed. Furthermore, the Azure DevOps platform will be used with Azure Boards for project planning and tracking, and an Azure Repos Git repository for version control and collaboration on the software aspects of the project.

The following sections will provide more details about the communication mediums we will be employing, the frequency of meetings, and finally other miscellaneous communications necessary for the project.

<u>Communication Mediums:</u>

Table 7: Communications Mediums

Discord:	Discord provides many features for communication including text, voice, and video chat, screen sharing, and the ability to send files and images for any document, screenshot, schematic, or diagram related to the project. Within the project server, channels can be created to organize discussions around different topics and aspects of the project. Communications on this platform

	are persistent, so the team may review relevant chats and information at their discretion. *Primary communications medium between team members.*
Zoom:	Zoom provides an online environment for meetings with easy-to-use features for voice, video, and text chat, while also including screen sharing capabilities. Meetings can be scheduled for a specific time and participants can be invited by sharing the meeting code and password. Communications on this platform are not persistent, and so a recording of the meeting or notes must be used to save important information. *Primary communications medium between team members and the Faculty.*
Azure DevOps:	Azure DevOps provides many features for Agile Development, including Azure Boards for project planning and tracking. A Backlog can be created to organize tasks to complete the project, and Sprint planning can be used to assign tasks to team members and track progress. A retrospective meeting at the end of each sprint can help highlight pros and cons encountered, which can be discussed and resolved for optimal efficiency over the next sprint. Azure Repos can also be used to host a Git repository for the project, allowing version control and team collaboration for the project software. Azure Pipelines can additionally be used for continuous integration, allowing automated software builds and testing for detecting bugs and problems with the code. *Primary communications medium for project planning, tracking, and software development.*

Meeting Frequency:

Table 8: Meeting Frequency

Participants	Frequency	Topic
- Team Members	- One to two times a week - Scheduled according to member availability using When2meet app (www.when2meet.com)	Project Development, Planning, Documentation, etc.
- Supervisor - Team Members	- Once a week - Scheduled through email with the Supervisor based on their availability	Project Progress, Questions, Feedback
- Technical Coordinator - Team Members	- Once a week or as needed - Scheduled through email with the Technical Coordinator based on their availability	Technical Questions
- Supervisor - Technical Coordinator - Evaluator - Team Members	- At the end of each project phase - Scheduled by email with ECE reception depending on all member availabilities	Project Presentations

Other Communications:

In terms of other communications, email messages will be used to ask small questions, set up meetings, and otherwise communicate with anyone not on the Discord server for the project. Care must be taken to specify an appropriate subject line for the email, specifying course code, team number, and the matter. Ex: 490-13-Meeting Request. Google Docs will be used for project documentation and all documents will be stored on a Sharepoint that team members can access and work on collaboratively. Finally, report submission for evaluation will be through the course Moodle page for COEN/ELEC-490, where pages will be available for uploading the reports at the end of each phase of the project.

11 - CONTINGENCY PLAN

11.1 - Introduction

Given the high-impact nature of hockey and the complex sensitivity of the equipment involved, even with thorough design and testing measures in place to prevent device malfunctions, instances of defects or failures can still occur. These malfunctions can range from minor defects to severe accidents, potentially leading to anything from mild inconvenience to serious injury, or even fatal outcomes for the user. The purpose of this contingency plan is to outline safety measures and solutions for such incidents.

The objectives and mission of this contingency plan are as follows:

- Define the goals, required resources, and procedures of the contingency plan.
- Identify product weaknesses and vulnerabilities to develop appropriate responses.
- Assess the precise level of risk for each scenario, including worst-case outcomes.
- Investigate all possible solutions for each issue and implement the most effective one.
- Test, refine, and ensure the contingency plan functions as intended.

11.2 - Application

The contingency plan should comprehensively address all aspects of the product. Given the nature of the device, the plan can be divided into two distinct components: Software and Hardware. Each of these areas requires specialized expertise for effective design and execution, meaning the approaches and potential solutions will vary significantly between the two.

- First, it’s important to outline situations where the contingency plan will not apply:
    - Emergencies arising from medical conditions or unforeseen incidents unrelated to the device.
    - Emergencies caused by unpredictable or unavoidable external factors (e.g., natural phenomena such as earthquakes or tsunamis).
    - Incidents resulting from the user's failure to follow instructions or safety measures outlined in the manual.
    - Misuse, unauthorized modifications, or tampering with the device.
- For the software aspect, the contingency plan will be implemented in the following scenarios:
    - **Situation 1**: Errors or malfunctions occurring within the software code.

      Solution: frequent updates of the main code to fix potential problems as well as a backup code to pull if needed.

    - **Situation 2**: Delays or interruptions caused by weak or lost signal connections.

      Solution: provide a stable second connection if the main signal gets disrupted.

- **Situation 3**: Issues arising from pending updates or updates that are compatible with the system.

  Solution: Frequency backup of the source code as well as thorough testing of all the updates before launch.

- **Situation 4**: Code failures under specific circumstances or conditions.

  Solution: Frequency backup of the source code.

- For the hardware aspect, the contingency plan will be applied in the following scenarios:
  - **Situation 1**: Errors or malfunctions occurring within the hardware components.

    Solution: Replacement of the whole device or a component is always available.

  - **Situation 2**: Common incidents arising from the user environment that expose hardware vulnerabilities (e.g., collisions on the hockey field).

    Solution: thorough testing of the device as well as available replacement.

  - **Situation 3**: Injuries that may occur even when the device is used correctly.

    Solution: Provide a clear user manual as well as emergency contact information.

  - **Situation 4**: Quality control issues affecting individual products.

    Solution: Quality control during the production.

  - **Situation 5**: Concerns related to the durability of components over time.

    Solution: provide guarantee and customer support for the user.

11.3 - Security & Safety Hazards

First of all, the integration of electronic components such as cameras, microphones, and biometric sensors into a hockey helmet would bring a series of potential risks to the players. For example, electronic devices may collapse when there is physical confrontation between the players, and might be harmful to the players. To address this, both the helmet and the device must undergo serious tests to ensure the strength. The design should also make sure that all parts are not loose during the games.

Secondly, to support real-time video and data transmission, the device must count on a battery to provide electricity. However, implanting a battery inside a helmet also has safety hazards such as overheating, electrical malfunction or even battery leakage. To address this, the design should incorporate high-quality, temperature-resistant batteries, and use waterproof materials inside the helmet to prevent the leakage of electricity.

Thirdly, adding new staff onto helmets of the players may cause the player to be uncomfortable. Because some of the players choose to customize their own equipment for their daily usage. Thus introducing new parts to their equipment will add more weight to their helmet and may affect the players' performance or even become a source of injury to the players. To address this, the consent of the players must be considered before introducing it to the players.

12 - TOOLS REQUIRED

This section provides a broad overview of the hardware and software tools that will be required to complete the project. Hardware tools include general purpose items like a computer, circuit diagnostic tools like an oscilloscope and multimeter, embedded programming tools like a programmer/debugger, and prototyping tools like a soldering iron and 3D printer. Software tools include applications that will be used to develop the project software, for example the VR app and embedded software, other tools like Matlab and PSpice for simulation and design, and documentation tools like the Office Suite for creating reports and presentations. Hardware and Software lists are provided below for more details on how these tools will be used in the context of the project.

12.1 - Hardware

- Computer : project development, team communication, etc.
- Smartphone : smartphone app development and testing
- VR Goggles : VR app development and testing
- Oscilloscope : circuit testing, verification, and debugging
- Multimeter : circuit testing, verification, and debugging
- Power Supply : circuit testing, verification, and debugging
- Programmer/Debugger : programming and debugging embedded system
- Soldering Iron : prototyping
- 3D Printer : prototyping
- Router : WIFI communications

12.2 - Software

- Unity Editor : VR app development
- Android Studio : smartphone app development
- Visual Sudio Code : embedded software development
- Matlab : simulation and testing
- PSpice : circuit design and analysis
- Autocad Fusion360 : 3D modeling
- Altium/Cadence : PCB design software
- Office Suite : documentation with Word, Excel, PowerPoint, etc.

13 - BUDGET ESTIMATION

Table 9: Budget Estimation for Components

Name	Item	Weight(g)	Units	Price(CAD)
Triangulation RF Module	SX1280IMLTRT	0.251	1	6.00
MCU	Raspberry Pi Compute Module 4	12	1	80.00
IMU (Inertial Measurement Unit)	MPU-6050	0.15	1	3.00
3D Camera	Global Shutter 3D Stereo VR Camera Module	86	1	92.00
Pulse oximeter module	MAX30102	1.1	1	4.00
Infrared LED	SFH 4715AS	0.215	1	6.00
Infrared Camera	Raspberry Pi Wide Angle NoIR Camera	N/A	1	27.00
Microphone	1063 Electret Microphone Amplifier	18	1	13.00
Electroencephalography	TGAM Development Board EEG Module	15	1	27.00
Galvanic Skin Response	SEEED STUDIO 101020052	28	1	15.00
Wireless transmission module	VONETS VM5G 1200M	5	1	60.00
Total		**165g**		**333.00$**

DESIGN COST ESTIMATION:

For budgeting the engineering and design fees among the team of six students, we consider several factors, including the estimated time commitment, hourly rates for engineering students, and the complexity of the work. Here's a rough way to estimate:

Given an hourly rate of $30 and a time commitment of 400 hours per student over two semesters, here's the updated budget calculation:

- **Hourly rate**: $30

- **Hours per student**: 400

- **Total hours for 6 students**: 6 × 400 = 2400 hours

- **Total labor cost**: 2400 hours × 30 $/hour = 72,000 $

So, the estimated cost for engineering and design work for the 6 students over two semesters would be **$72,000**.

14 - REFERENCES

[1] “About Us,” *YBVR°*. https://ybvr.com/about/

[2] “Sports Player Tracking | Zebra,” *Zebra Technologies*, 2024. https://www.zebra.com/gb/en/products/location-technologies/sports-player-tracking.html (accessed Oct. 06, 2024).

[3] “Athlete Monitoring,” *Catapult*. https://www.catapult.com/solutions/athlete-monitoring

[4] “About us I Veo,” Veo Sports Camera. https://www.veo.co/about-us

[5] Hawk-Eye, “Hawk-Eye,” Hawkeyeinnovations.com, 2018. https://www.hawkeyeinnovations.com/about

[6] “Getting Started with Nacsport Hub Live,” Nacsport.com, 2023. https://www.nacsport.com/blog/en-gb/News/nacsport-hub-live-tutorial (accessed Oct. 06, 2024).

[7] “UAV & Drone Communications”

https://www.unmannedsystemstechnology.com/expo/drone-communications/#:~:text=The%20most%20common%20method%20of,of%2Dsight%20(LOS)