Strike League - DriveWise

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This document includes:

- *Graphical Abstract Version 4*
- *Executive Summary Version 5*
- *Project Scope Edition 5*
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- *Project Charter Edition 5*
- *Progress Review Meeting 1 & 2 Minute – Appendix*
- *House of Quality – Appendix Version 2*

Vision Statement: "To simplify swing improvement for golfers of all levels."

Signatures

Mobile Application Developer: Ryan Martin ________________________________ Date: 12/05/2025

Backend Engineer: Noah Kremler ______________________________________ Date: 12/05/2025

Computer Vision Specialist: Daniyar Umuraliyev _______________________________ Date: 12/05/2025

Wireless Communications Engineer: Hugo Kwon ________________________________ Date: 12/05/2025

Mechanical Engineer: Husain Kanthawala ____________________________________ Date: 12/05/2025

Electronics Engineer: Sungmin Lee ______________________________________ Date: 12/05/2025

Sponsor: Hugo Kwon _______________________ Date: 12/05/2025

Date

December 05, 2025

Project Title

DriveWise: Shelf-Ready AI Golf Launch Monitor

Authorization

This charter which is between Hugo Kwon (Project Sponsor) and the Technical Team sets the terms and conditions for implementation of this project.

Project Objective/Overview

To deliver an affordable & portable golf launch monitor that prioritizes actionable coaching feedback over raw numbers and metrics.

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Graphical Abstract

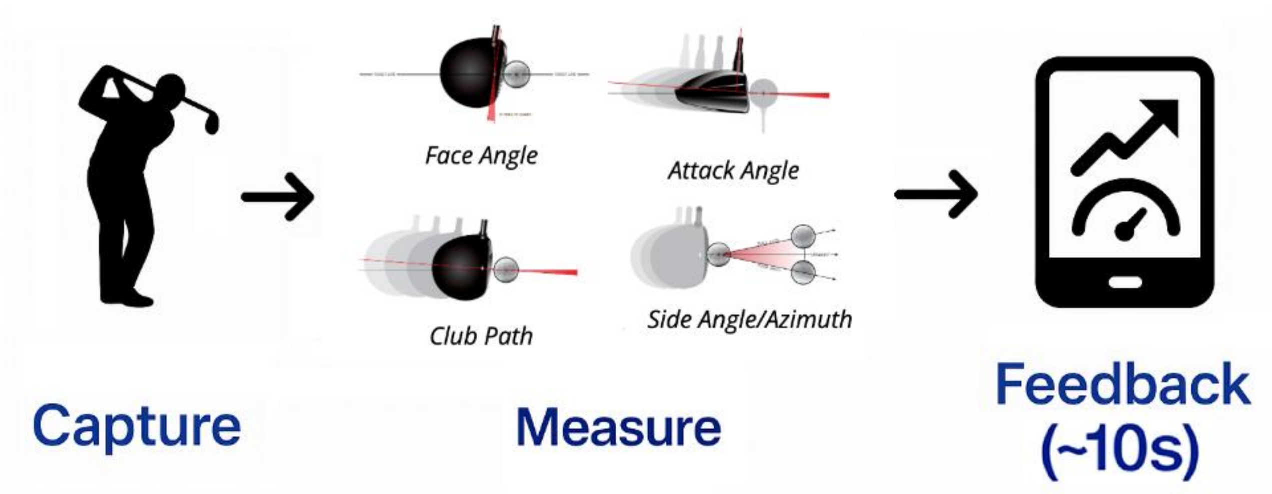

Fig. 1: *Graphical Abstract*

Executive Summary

Golf Launch Monitor for Developing Golfers

Strike League is a BC-based company comprised of Simon Fraser University undergraduate students, designing a coaching product within the golf-tech industry. The company designs and manufactures the product DriveWise, which is a portable golf launch monitor that provides its users with actionable feedback. The company is asking for $1100 to avoid cash flow negative and is seeking that from their university's funding and grants.

The Problem

Golf participation in Canada has reached record highs, with over six million active players. Yet novice and intermediate golfers lack training technology that helps them learn and improve. Existing launch monitors primarily display raw statistics such as ball speed, spin rate, or launch angle. While advanced players can interpret these numbers and connect them to swing mechanics, beginners struggle to understand how these figures translate into practical improvements. As a result, many developing golfers remain frustrated, unable to correct issues like slicing or inconsistency. What these players need is not just numbers, but interpretable coaching feedback that shows them what specific adjustments will lead to better swings and, ultimately, better results.

The Solution

DriveWise is an assistive golf launch monitor designed specifically for novice to intermediate golfers. It calculates four critical parameters: face angle, attack angle, swing path, and side angle, which directly influence ball direction and curve. A companion mobile application connects wirelessly to the launch monitor and translates the metrics into coaching tips such as "Face 3° open: rotate forearms earlier", delivered within 10 seconds of impact. This enables players to understand not just their statistics, but how to improve their swing immediately.

The Opportunity

The global golf equipment market exceeds $7.5 billion USD, with Canada alone valued at $450 million and growing at a CAGR of 6.3%, which is faster than both the U.S. and global averages. Yet within this growing *market, a gap remains for training tools that do more than report numbers. By focusing on providing actionable coaching to guide the user's improvement, DriveWise opens a path to capture a portion of Canada's six million players who are underrepresented. By targeting players early in their development, DriveWise has the potential to engage a large and expanding segment of golfers who are seeking not just performance data, but meaningful ways to improve their game.*

Competitive Advantage

The defining advantage of DriveWise is its actionable feedback. Unlike existing launch monitors that overwhelm users with raw statistics, DriveWise translates swing metrics into clear coaching prompts that developing golfers can apply immediately on the range. This bridges the gap between numbers and improvement, giving beginners the same kind of guidance that only experienced players or coaches can usually interpret. Also, DriveWise is built to be robust while maintaining a sleek, professional appearance. Its enclosure is engineered to include an integrated ramp to minimize ball impact, combining both durability and portability with a refined finish that reflects the aesthetics of modern golf equipment.

The Team

Strike League is a team of six senior engineering students at Simon Fraser University: Daniyar Umuraliyev (Computer Engineering), Ryan Martin (Computer Engineering), Husain Kanthawala (Electronics Engineering), Hugo Kwon (Computer Engineering), Noah Kremler (Computer Engineering), and Sungmin Lee (Electronics Engineering. Collectively, the team brings experience from industry co-ops in software development, testing, and system integration.

Ask

We are seeking $700 of funding which will be dispensed for:

1) *Raw material purchase (approximately $450)*
2) *Performing field testing (approximately $100)*
4) *Prototype Manufacturing and 3D Printing (approximately $100)*
5) *Physics-based verification of derived metric's accuracy (approximately $50)*

High-Level Project Description, Boundaries, and Key Deliverables

Description

- *Develop a single, high-performance golf swing analysis device ready for customer use*
- *Build on proof-of-concept prototype with refined hardware, software, and reliability*
- *Capture accurate golf swing and ball flight data using advanced computer vision*
- *Provide real-time feedback through a mobile app with wireless connectivity*
- *Deliver a polished, customer-ready unit suitable for demonstration or sale*

Boundaries

In scope:

- *Polished hardware design, power management, and enclosure*
- *Detect the face angle, club path, side angle, and attack angle of a golf swing*
- *Validate the accuracy of computer vision and metric algorithms for club and ball tracking*
- *Coaching feedback catered towards beginner golfers*
- *Mobile app for real-time data display*
- *Display device status on enclosure*

- *Automatic swing detection after the start button is triggered*
- *Calibration indicator to simplify set-up for accurate shot detection*
- *Field testing in real-world golf environments*
- *User documentation and setup guides*

Out of scope:

- *Mass manufacturing or large-scale production processes*
- *Retail marketing campaigns*
- *Multiple device models or variants*
- *Integration with third-party golf hardware/software or services*
- *Support for left-handed golfers (can still use the device, but will not receive tailored feedback)*
- *Tracking training history over multiple sessions*
- *Detection/algorithms for different club types (putters, drivers, etc.)*

Key Deliverables

Final Prototype Unit

- *Fully integrated, reliable hardware device*
- *Durable, portable enclosure*
- *Optimized power and battery management*
- *Device status indicators*

Computer Vision System

- *Accurate ball and club tracking*
- *Robust performance in varied lighting conditions*
- *Rule-based feedback engine for actionable swing analysis*

Mobile Application

- *Real-time swing metrics*
- *Wireless pairing*
- *User-friendly interface*

Documentation

- *Setup and usage documentation*
- *Test cases and results*

Project Scope

Product Scope Description	
The project delivers a portable golf launch monitor that provides built-in swing feedback for novice golfers seeking accessible training tools. The device measures and processes face angle, swing path, side angle, and attack angle, then translates these into clear, actionable feedback displayed on a mobile app. The swing detection will be designed to repeatedly detect swings after the start button is pressed on the app. The physical system consists of a lightweight enclosure housing an embedded platform for accurate data capture and real-time analysis. The enclosure is designed to withstand errant golf shots and includes a laser pointer to guide the user in setting up the shot. The enclosure will also indicate the status of the device through LED indicators. The system is paired with our companion app that displays the measured metrics, coaching feedback, a visual indicator of the shot type (push, pull, slice, etc.), and visual description of the metric itself. The app also includes additional features to improve the user experience such as a calibration button that dynamically changes the exposure value of the camera based on lighting conditions.	
Scope Details	
In Scope	*Must (M), Should (S), Could (C), Won't (W)*
• *(Electrical) Power system using rechargeable battery* • *(Electrical) Sensor to capture ball and club movement* • *(Electrical) The enclosure must have LED indicators that represent the device status* • *(Electrical) One power button and charger controls the entire system* • *(Mechanical) Enclosure with passive/active thermal management to operate at high temperature computer working conditions.* • *(Mechanical) Enclosure securely contains all components of the system* • *(Mechanical) Device mass light enough for single hand carry with legs to account for slope* • *(Mechanical) Enclosure must withstand impact from errant golf shots and protect components inside* • *(Mechanical) Physical indicators (lasers, markers, etc.) are used to help the users set up the golf ball* • *(Mechanical) All components are housed inside the enclosure* • *(Software) Mobile app to display swing metrics and provide personalized coaching feedback* • *(Software) Mobile app and device connect wirelessly* • *(Software) Swing is detected repeatedly without user input on the app or embedded system*	*Must (M):*
• *(Software) Provide picture/shot path of the type of golf shot taken on the app.* • *(Software) Accuracy within ±2 degrees of validated testing* • *(Software) Mobile app receives metrics and feedback within 20 seconds after the shot is taken*	*Should (S):*

• *(Software) Display a model of the golf club and ball at contact on the app* • *(Software) Swap rule-based inference with a lightweight LLM for advanced feedback.* • *(Software) Expanded export formats (e.g., Excel).* • *(Software) Performance tuning (e.g., response <100ms) beyond baseline thresholds.* • *(Software) Data collection with swing history sessions and deletion.* • *(Software) UI features for different club types and loft angles.* • *(Software) History graphs and retained session data in later app iterations.*	*Could (C):*
Out of Scope	*Must (M), Should (S), Could (C), Won't (W)*
• *Integration with indoor simulator ecosystems (e.g., E6 Connect, GolfZon) in initial prototype.* • *Cloud-based swing database or multi-user profiles (local device storage only in scope).* • *AI-driven personalized coaching beyond rule-based and vision-based inference.* • *Development of custom hardware SoCs beyond Raspberry Pi + COTS sensors.* • *Full compliance with commercial safety certifications (e.g., FCC, CE) for initial capstone prototype.* • *UI features to account for left-handed players.*	*Won't (W):*

Table 1: *Scope Details*

High-level requirements

- *Measure face angle, swing path, side angle, and attack angle*
- *Provide results in under 20 seconds of impact*
- *Detect swings repeatedly after start button is pressed*
- *Transfer data and feedback wirelessly to mobile app*
- *Be portable with ample battery runtime for a single practice session*
- *Mobile application with visuals to help beginners understand the metrics*
- *Calibration tool to make it easy to set up golf ball for the shot*
- *Enclosure is designed to withstand errant golf shots*
- *Enclosure size minimized to reduce the chance of getting hit*

Key Performance Indicators

Technical KPIs – Software

Objective: Ensure Measurement accuracy and consistency and UI responsiveness

KPI	***Definition***	***Target/Metric***
Detection time	*The amount of time it takes to identify the motion window and process ball and club frames.*	*< 30 seconds*
Metric display reliability	*The percentage of successful swing captures displayed on the app.*	*75+%*
Metric accuracy	*The accuracy of the measured metrics compared to the true metrics (verification)*	*+/- 2 degrees*
Mobile App Connectivity	*Successful BLE connection during 20-min sessions.*	*> 95%*

Table 2: *Software KPIs*

Technical KPIs – Hardware

Objective: Achieve power efficiency and structural reliability

KPI	***Description***	***Target/Metric***
Status Indicator Latency	*How fast the system can identify the state (detect ball, analyzing swing, etc.) and change the LED color.*	*< 1s*
Enclosure Durability	*Test the state of the enclosure after getting hit by 5 high-speed golf balls.*	*100% functional after the impact*
Battery Runtime	*Continuous operation on full charge*	*≤ 2 hours*

Table 3: *Hardware KPIs*

Schedule KPIs

Objective: Complete all testing and validation on schedule to refine the project

KPI	***Definition***	***Target/Metric***
Computer vision reliability	*Finish testing the frames detected, detection time, and overall reliability of swing detection.*	*November 7, 2025*
Metric validation	*Complete metric validation and achieve the targeted results.*	*November 12, 2025*
Usability testing	*Process and refine the project based on the feedback reported by user testing.*	*November 16, 2025*
System testing	*Finish conducting full system tests at the golf range.*	*November 21, 2025*

Table 4: *Schedule KPIs*

Financial KPIs

Objective: Maintain total unit costs and expenses within launch monitor target market range

KPI	***Definition***	***Target/Metric***
Total Prototype Cost (Per Unit)	*The total material/component cost to produce one prototype.*	*< $500 CAD*
Electronics Component Cost	*The total cost of the Raspberry Pi 5, Camera, Battery, Cooling.*	*< $400 CAD*
Mechanical Cost	*The total cost of the enclosure, screws, washers, and laser.*	*< $90 CAD*

Table 5: *Financial KPIs*

House of Quality

See the HoQ Appendix at the end of the document for more information.

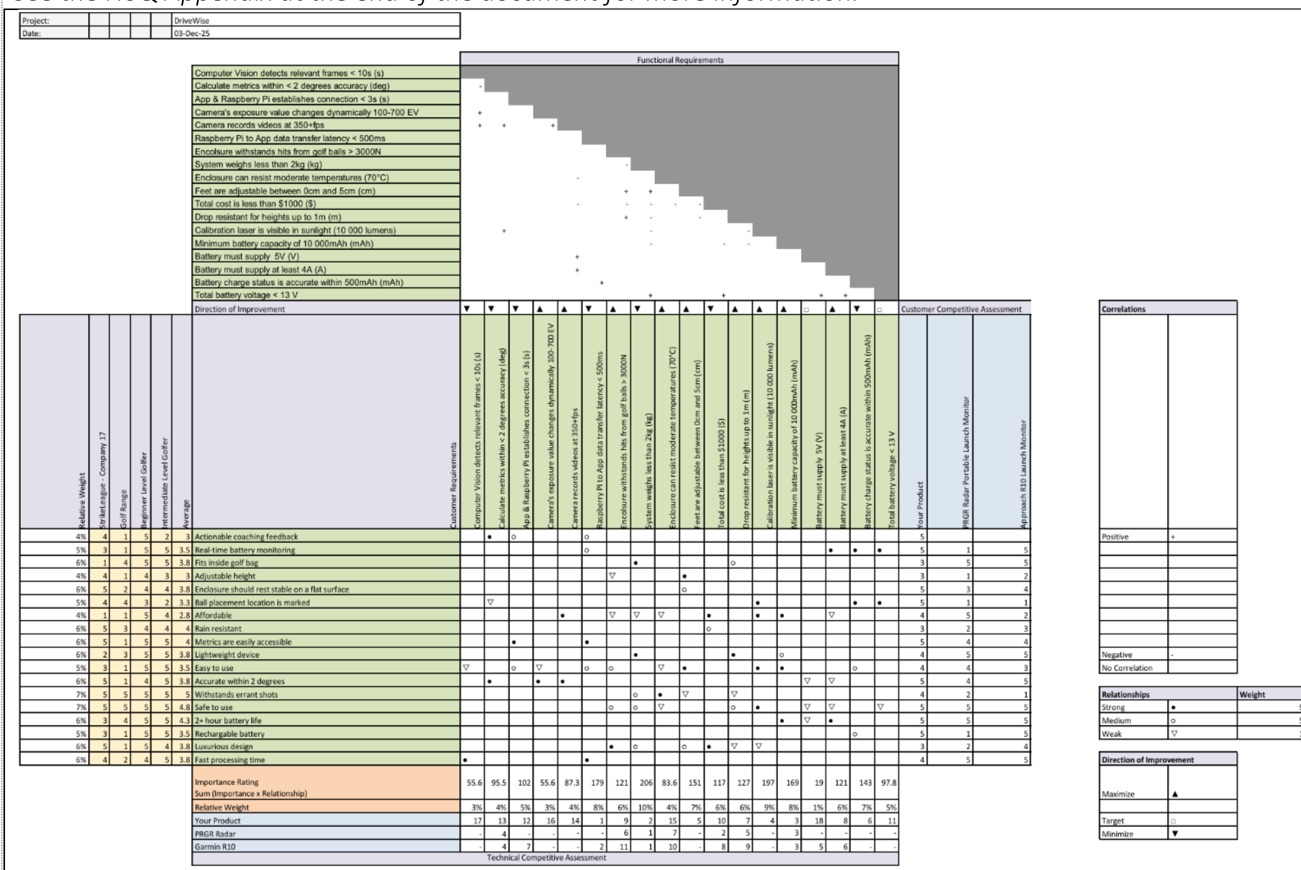

Fig. 2: *House of Qualities*

Project Budget

Item		Budget
1	Sensors	$120
2	Microcontroller	$150
3	Battery	$80
4	Enclosure	$150
5	Miscellaneous	$50
6	Testing	$150
Total		**$700**

Table 6: *Project Budget*

Summary Schedule

Milestone		Completion Date
1	Functional Prototype Refinement (PoC to stable, reliable prototype with all core features)	2 weeks (09/20/2025)
2	Performance Optimization & Field Testing (real-world feedback)	4 weeks (10/20/2025)
3	Final Hardware & Software Integration (single, polished version of device and software)	4 weeks (11/15/2025)
4	Customer Readiness (meets all safety and usability standards, user manual)	2 weeks (11/30/2025)
5	Final Demonstration	0.5 weeks (12/4/2025)
Total		**12.5 weeks**

Table 7: *Summary Schedule*

Risk Assessment

Risk Event		Probability	Impact	Response	Contingency Allowance ($)
1	Enclosure/System damage during testing	High	High	Test enclosure durability independently with no critical components inside	$150
2	Supply delays	Medium	High	Dual-source, buy early, buy high-speed shipping	$50
3	Thermal/power integration	Medium	Medium	Buy heat sink/fan, thermal design review	$50
4	Model accuracy not meeting target	Medium	Medium	Expand dataset, staged metric gates	$25
5	Circuit Design Errors	Low	High	Test all electronic components on DMM before connecting to the system	$50
6	Test-range access limitations	Low	High	Find multiple testing sites, contact owners early	$100
Total					**$425**

Table 8: *Risk Assessment*

Roles & Responsibilities

Mobile Application Developer – Ryan Martin
Responsible for building the user-facing mobile application for device interaction and data visualization.

- *Designs and develops the mobile app for both iOS and Android platforms*
- *Creates a clean, intuitive UI/UX for real-time swing metrics and session summaries*
- *Implements wireless connectivity via BLE to pair with the launch monitor hardware*
- *Optimizes performance for low-latency updates during live tracking sessions*
- *Maintains and updates the app based on user feedback and new feature requests*

Backend Engineer – Noah Kremler
Handles data processing, storage, and interfaces between hardware, app, and cloud.

- *Integrates backend APIs to display ball-flight data and analytics*
- *Optimizes backend performance to support low-latency data transmission from the device*
- *Develops a rule-based feedback engine to provide actionable swing insights*
- *Integrates detection output with backend systems for analytics and visualization*

Computer Vision Specialist – Daniyar Umuraliyev
Focuses on ball and club tracking, swing analysis, and feedback algorithms.

- *Designs and trains YOLOv8-based models for high-speed ball and club detection*
- *Implements real-time tracking algorithms optimized for the Raspberry Pi 5 hardware*
- *Tunes computer vision models to handle varied lighting, angles, and golf environments*
- *Collaborates with backend and wireless engineers to ensure synchronized data capture*

Wireless Communications Engineer – Hugo Kwon
Responsible for connectivity between the device and external systems for real-time data transfer.

- *Develops reliable Bluetooth protocols for device-to-app communication*
- *Optimizes data transmission for minimal latency during live tracking sessions*
- *Designs a robust pairing and connection process for user-friendly setup*
- *Handles error detection and recovery for dropped or unstable connections*
- *Works with the backend engineer to ensure seamless API data flow*

Mechanical Engineer (Hardware + Enclosure) – Husain Kanthawala
Oversees the physical components, circuitry, enclosure design of the device.

- *Selects components for power efficiency, performance, and cost optimization*
- *Develops power management systems, including battery integration and charging circuits*
- *Builds and tests prototypes to ensure reliable operation in real-world conditions*
- *Designs the physical enclosure for durability, portability, and thermal management*

Electronics Engineer (Firmware + Enclosure) – Sungmin Lee
Responsible for the circuit and enclosure design of the physical UI of the device

- *Optimizes the enclosure design to contain LEDS, calibration equipment, and an improved battery*
- *Develops firmware to send a compact battery's status to the app*
- *Designs solutions for force mitigation to improve the durability of the enclosure*
- *Builds the circuitry and firmware to control LED indicators for device status*

Test Plan

Functional Testing

Test: Consecutive Shot Measurement Test	Time:	Date
Testing Procedure: 1. Connect and calibrate the device by following the operation manual 2. Once the ball is placed and calibrated, press 'Begin Session' and check the LEDs 3. Once the LED is green, take a swing 4. Wait for the LED to change from green to red to confirm the swing was detected 5. Wait until the LED changes from red to yellow, then analyze results on the app 6. Once the LED is yellow, place a new ball on the marked spot 7. Repeat steps 3-6 five times 8. Count the number of successful swing captures on the app		
Expected Outcome: At least 4/5 swings are captured with reasonable metrics		
Observed Outcome:		
Comments:		
☐ Pass ☐ Fail	Tester Signature: ______________________	

Test: Battery Life Test	Time:	Date
Testing Procedure: 1. Fully charge the system before taking it to the golf range 2. Use the system for a 1–2-hour practice session 3. Monitor the battery level at the end of the session		
Expected Outcome: The battery should last at least 2 hours without any technical failure		
Observed Outcome:		
Comments:		
☐ Pass ☐ Fail	Tester Signature: ______________________	

Test: App Connectivity Testing	Time:	Date
Testing Procedure: 1. Open the app and connect to the device through BLE 2. Operate the device for 10 minutes 3. Close the app 4. Repeat steps 1-3 on phones with different operating systems and release dates		
Expected Outcome: All phones with BLE are able to connect to the device with connection issues less than 95% of the time		
Observed Outcome:		
Comments:		
☐ Pass ☐ Fail	Tester Signature: ______________________	

Performance Testing

Test: Enclosure Impact Durability Test	Time:	Date
Testing Procedure: 1. Power on the device and confirm normal operation 2. Position the device at a driving range or controlled hitting area 3. Place the ball ~1.3m away from the device and hit the enclosure with a full-speed golf ball 5 times 4. After the 5th impact, inspect the enclosure and internal components for physical damage 5. Restart the device and confirm that all functions operate normally		
Expected Outcome: The system should fully function after the enclosure is hit with 5 full-speed golf balls		
Observed Outcome:		
Comments:		
☐ Pass ☐ Fail	Tester Signature: _______________________	

Test: Validation of Metrics	Time:	Date
Testing Procedure: 1. Prepare the validation device with a calculated face angle and club path 2. Place the ball in the validation device and align it with the launch monitor 3. Release the validation device and record the path of the ball after 1.3m 4. Calculate the expected face angle, club path, and side angle using the validation device and measured ball path 5. Compare the expected results to the results produced by the launch monitor 6. Repeat steps 1-5 with different angles		
Expected Outcome: The launch monitor displays metrics within 2 degrees of the actual values		
Observed Outcome:		
Comments:		
☐ Pass ☐ Fail	Tester Signature: _______________________	

Test: Swing Latency Test	Time:	Date
Testing Procedure: 1. Connect and calibrate the monitor by following the operation manual 2. Once the ball is placed and calibrated, press ‘Begin Session’ and check the LEDs 3. Once the LED turns green, take a swing 4. Once the LED turns red, begin the stopwatch 5. Once the LED turns yellow stop the stopwatch and check the metrics on the mobile app		
Expected Outcome: The delay between swing analysis (yellow LED) and the beginning of the next swing (red LED) is <30s		
Observed Outcome:		
Comments:		
☐ Pass ☐ Fail	Tester Signature: _______________________	

Test: App Navigation Efficiency Test	Time:	Date
Testing Procedure: 1. Connect the app to the launch monitor via BLE 2. From the home screen, navigate to the "Calibrate Lighting" button 3. Repeat step 2 for the "Begin Session" button, "Swing Analytics" screen, and "Settings" screen		
Expected Outcome: Each major section of the app should be navigable within three 'clicks' or 'presses'		
Observed Outcome:		
Comments:		
☐ Pass ☐ Fail	Tester Signature: ________________________	

Usability Testing

Test: LED Indicator Test	Time:	Date
Testing Procedure: 1. Connect and calibrate the monitor by following the operation manual 2. After calibration, remove the ball off the marker then press 'Begin Session' 3. Record how long it takes for the yellow LED to turn on 4. Place a ball on the marker and record how long it takes for the green LED to turn on 5. Take a swing 6. Record how long it takes for the LED to change from green to red 7. Record how long it takes for the LED to change from red to yellow 8. Check to see if the swing was detected properly 9. Repeat steps 3-8 five times		
Expected Outcome: LEDs correctly change color in less than 1s 90% of the time		
Observed Outcome:		
Comments:		
☐ Pass ☐ Fail	Tester Signature: ________________________	

Test: State Cancellation Test	Time:	Date
Testing Procedure: 1. Connect the app to the launch monitor 2. Calibrate the monitor and press "Begin Session" to start the camera 3. Once the LED turns yellow, press the "Cancel" button on the mobile app 4. Press "Begin Session" on the mobile app 5. Once the LED turns yellow, position the ball and wait for the LED to turn green 6. Once the LED turns green, press the "Cancel" button on the mobile app 7. Press "Begin Session" on the mobile app and ensure the yellow LED turns back on		
Expected Outcome: Each time the cancel button is pressed, all the LEDs should turn off		
Observed Outcome:		
Comments:		
☐ Pass ☐ Fail	Tester Signature: ________________________	

Compatibility Testing

Test: Club Compatibility Test	*Time:*	*Date*
Testing Procedure: 1. *Attach markers to the club face* 2. *Set up the launch monitor for normal operation (Scan, connect, calibrate)* 3. *Press "Begin Session" on the mobile app* 4. *Take five swings with the golf club* 5. *Press "Cancel Session" on the mobile app and analyze the results of the swings* 6. *Repeat steps 1-5 with golf clubs made by different brands*		
Expected Outcome: 8/10 swings are detected with each golf club		
Observed Outcome:		
Comments:		
☐ *Pass* ☐ *Fail*	*Tester Signature: ______________________*	

Test: Range Location Compatibility Test	*Time:*	*Date*
Testing Procedure: 1. *Find an open spot on the first floor of the golf range* 2. *Set up the launch monitor for normal operation (sticker, scan, connect, calibrate)* 3. *Press "Begin Session" on the mobile app* 4. *Take five swings with the golf club* 5. *Press "Cancel Session" on the mobile app and analyze the results of the swings* 6. *Repeat steps 2-5 on different floors or unique locations in the golf range*		
Expected Outcome: 8/10 swings are detected at each location		
Observed Outcome:		
Comments:		
☐ *Pass* ☐ *Fail*	*Tester Signature: ______________________*	

Lessons Learned Register – Proof-of-Concept

Category	*Issue*	*Problem/Success*	*Impact*	*Recommendation*
Technical Team	*System Integration*	*It took longer than anticipated to combine the computer vision, embedded device, and data processing.*	*High*	*Start early and integrate the system with all involved team members present to identify bugs.*
Instructional	*High-Level Requirements Specification*	*Our group focused on solutions before defining requirements. Resulted in backtracking during later documentation and development.*	*Med*	*Define high-level requirements and consult instructional team before proceeding with solution stage.*
Financial	*Invest in high-quality solutions to prove concept*	*We prioritized saving money over buying high-quality sensors, resulting in added development and testing difficulty*	*High*	*To prove concept, use components that have a high probability of succeeding, and look for places to save cost later.*

Technical Team	Overcomplicating and over-optimizing design	We attempted to optimize some non-critical parts of our design early in the development phase, leading to wasted time.	Low	Keep things simple, and first ensure that your basic concept works, meaning that your design should first fulfill its initial proposal.
Technical Team	Physical design and 3D printing	The learning curve for 3D modeling and creating a printer-ready design was higher than expected. Resulting in failed print attempts and delays in full system testing.	High	Begin the iterative design process early. Research the tolerances of the printers being used.
Technical Team	Choosing a computer vision model	We stubbornly stuck to one computer vision model in the beginning without heavily researching or considering alternatives. Resulted in back tracking and unnecessary additional testing/validation.	Med	Heavily research the available options and weigh the pros and cons of each to find the optimal model for the projects early in development.

Table 9: *Proof-of-Concept Lessons Learned*

Lessons Learned Register – Final Demonstration

Category	Issue	Problem/Success	Impact	Recommendation
Technical Team	Field Testing	The computer-vision pipeline was designed using shots recorded in the lab and a few simple outdoor clips with good lighting. At the driving range, we saw how much more the background, plain white objects, lighting changes, and ball marks affected detection than we expected.	Med	Create designs and conduct testing for the intended place of use even if it increases development costs.
User Experience	Clear feedback of device status	When an error or something unexpected happened to device, we moved on to the next state without informing the user. The users that helped us with functional testing highlighted confusion from the lack of feedback/indicators.	Med	Don't assume the user understands the minor details and protocols within the device. Give clear instructions and indicators when there's an issue with the product.
Technical Team	Software and Mechanical Integration	Minor differences in design ideas caused issues during system integration. This resulted in backtracking for the communication protocol, computer vision, and mechanical design which delayed the final product.	Low	Ensure all group members are working with the same designs in mind. Communicate often and updates the relevant teammates on progress made.
Technical Team	Camera Alignment	Due to the high frame rate required by our scope, the resolution that the camera was capturing was very small. This made it	Low	Finalize all design decisions with the user in mind. The average user experience is

		difficult for users to place the golf ball in the correct place if the laser was misaligned. Although a temporary software fix was created, a more reliable laser or improved calibration method would eliminate this issue.		*greatly different from the developers' usability.*
Technical Team	*3D Printing*	*Beyond the learning curve of 3D printing, the importance of small details like tolerances, different printers, and different materials all affected the final print. Conducting proper research on these variables could have reduced the total number of prints.*	*High*	*Heavily research 3D printing early to understand all the available printing options. The research will also help reduce errors in tolerance, durability, and more.*
Technical Team	*Testing Environment*	*Until the app and BLE was fully developed, it was complicated to validate the functionality of the integrated components of our project.*	*Med*	*Set up an easy-to-use testing procedure and environment to make future validation and testing more efficient.*

Table 10: *Final Demonstration Lessons Learned*

Agreement

We the undersigned hereby agree to the terms and conditions set out in this charter. No changes can be made to the charter without the agreement of all parties.

Project Sponsor	Hugo Kwon	*Hugo Kwon*
Mobile Application Developer		*Ryan Martin*
Backend Engineer		*Noah Kremler*
Computer Vision Specialist		*Daniyar Umuraliyev*
Wireless Communications Engineer	Hugo Kwon	*Hugo Kwon*
Mechanical Engineer	Husain	*Husain Kanthawala*
Electronics Engineer		*Sungmin Lee*

Appendix 1 -- Meeting Minutes

Progress Review Meeting 1 Minutes

Date: *2025-09-18*
Meeting Time: *3:01pm - 3:51pm*
Location*: ASB 10703*
Attendees:

- *Dr. Shervin Jannesar, P.Eng*
- *Usman Ahmed Edhbal*
- *Hugo Kwon*
- *Noah Kremler*
- *Ryan Martin*
- *Daniyar Umuraliyev*
- *Husain Kanthawala*

Absentees:

- *None*

Purpose: *Introduce the project to the ENSC440 teaching team, and set the goals and expectations for the final product.*
Meeting Agenda:

1. *Project Introduction*
    - *Hugo introduced the problem statement and Company 17's solution*
    - *Ryan explained the system overview and technical specifications*
    - *Noah summarized the proof-of-concept design and recent progress*
    - *Husain spoke about the company's goals for the semester*
    - *Daniyar showcased the computer vision model in action*
    - *A video example of the project was demonstrated*
2. *Dr. Shervin Jannesar's Questions and Comments*
    - *Design Considerations*
        - *The product should not sit directly on the ground; tripod/adjustable legs are necessary.*
        - *The lock/slide mechanism must align perpendicular to the force direction.*
        - *Concrete design parameters and justification should be defined by referencing HoQ*
        - *The product should be higher-end to target a wealthy, older target market*
    - *Project Goals and Deliverables*
        - *Technical details come after ensuring the product reliability and meets user needs.*
        - *ENSC 440 should focus on producing a shelf-ready product (luxurious box, user manual, complete app, no laptop required for demo).*
        - *Calibration, enclosure, and refinement are mandatory tasks, not optional extras.*
        - *App UI and project design should reflect a luxury product and provide clear, beginner-friendly training feedback.*
    - *Other Comments*
        - *Limit the product to right-handed players.*
        - *If too many performance metrics are included, attack angle can be dropped.*
        - *Team should prioritize hard work early in the project to avoid last-minute rushing.*

3. *Usman Ahmed Edhbal's Questions and Comments*
   - *Product and Viability Cost*
     - *Clarify the estimated shelf cost and account for manufacturing considerations.*
     - *Ensure verification of numbers and system performance.*
   - *Design and Functionality*
     - *Confirm how accurate the system will be.*
     - *Consider whether measuring from the side instead of the front would simplify the design.*
     - *Justify the use of machine learning in a computer vision–based project.*
   - *Durability and Safety*
     - *The design must be impact resistant.*
     - *Explore rubber materials for shock absorption; if metal is used, perform stress testing on the PCB.*
     - *Include strategies to mitigate impact forces on the device.*
   - *Verification and Testing*
     - *A personal meeting will be required to demonstrate verification of metrics.*
     - *The method for choosing ball location must be defined and justified.*
     - *Focus on verification early to stay on track.*

Action Items:

- *2025-09-21: Weekly company meeting*
- *2025-09-21: Upload phone app to Play Market*
- *2025-09-22: Finish the House of Quality and other documentation*
- *2025-09-23: Define and document test method for verification*
- *2025-09-25: Book meeting with Usman to review verification and project design*
- *2025-09-27: 3D-print the new case*
- *2025-09-27: Improve swing detection by leveraging ball detection*
- *2025-09-30: Retrain and improve TFLite model at 144×144 resolution*
- *2025-10-02: Order adjustable legs for the case*
- *2025-10-03: Update mobile app UI to reflect our luxury target market*
- *2025-10-04: Add calibration functionality to the phone app*
- *2025-10-07: Fix BLE update bug*

Progress Review Meeting 2 Minutes

Date: *2025-10-23*
Meeting Time: *11:01am - 11:58am*
Location*: ASB 10703*
Attendees:

- *Dr. Shervin Jannesar, P.Eng*
- *Usman Ahmed Edhbal*
- *Hugo Kwon*
- *Noah Kremler*
- *Ryan Martin*
- *Daniyar Umuraliyev*
- *Husain Kanthawala*
- *Sungmin Lee*

Absentees:

- *None*

Purpose: *Update the ENSC 440 teaching team on the project's current progress and discuss design decisions and timelines for the final demonstration.*
Meeting Agenda:

1. *Project Progress Update*
    - *Hugo discussed the key feedback from Progress Review Meeting 1*
    - *Daniyar spoke about the introduction and the computer vision progress*
    - *Ryan summarized the embedded and mobile application progress*
    - *Sungmin outlined the electrical progress and his contributions as a new member*
    - *Husain reviewed the enclosure/mechanical changes*
    - *Noah presented the validation video and described the validation approach*
2. *Dr. Shervin Jannesar's Questions and Comments*
    - *Design Considerations*
        - *Using a tripod is simpler and more stable than 3D-printed feet*
        - *Add pictures or visuals on mobile application to help illustrate the metrics being measured*
        - *Feet should have an attachment to the enclosure to keep the device secure in position*
        - *Use a sliding or locking mechanism for the feet interface*
        - *Mount the laser inside the enclosure to protect it from weather and impact*
        - *Use a single master power button to control the entire system including the laser*
        - *Ensure the inclined face does not obstruct camera view*
        - *Avoid making the laser removable or optional to the user*
    - *Project Deliverables and Timeline*
        - *The deadline for the project is latest December 2, and the project should be completed at least one week prior to the deadline to allow time for full system-testing.*
        - *The final demonstration is expected toward the end of November*
        - *Don't focus on battery or other technical additions, instead focus on resolving current issues*
        - *Schedule an informal meeting to provide a clearer overview of project*

3. *Usman Ahmed Eghbal's Questions and Comments*
    - *Design and Functionality*
        - *Implement automatic shot detection since the swing motion is repeatable*
        - *Provide both Manual and Automatic operation modes*
        - *Manual operation mode risks the user missing their swing window*
    - *User Interface and Experience*
        - *Replace button trigger with a hands-free intuitive alternative*
        - *Use a large, coloured LED to cue the user when to swing*
        - *Use the LED to indicate the device status*
    - *Next Steps and Follow Up*
        - *Schedule an informal meeting to demonstrate verification of metrics*
        - *Don't worry about the computing time of the system*

Action Items:

- *2025-10-26: Weekly company meeting*
- *2025-10-26: Implement new/automatic timing system for computer vision*
- *2025-10-26: Research a new laser*
- *2025-10-26: Research adjustable feet for the enclosure*
- *2025-10-27: Order adjustable feet and modify 3D model to accommodate*
- *2025-10-28: Order new laser*
- *2025-10-29: Change 3D enclosure to contain new laser inside*
- *2025-10-29: Create circuit logic to power the new laser with current battery*
- *2025-10-29: Add information pages for each metric in the mobile application*
- *2025-10-30: Informal meeting with Shervin during office hours/lecture time*
- *2025-10-31: Update the enclosure based on the feedback from informal meeting*
- *2025-11-03: Thorough testing of face angle and club path with validation device*
- *2025-11-03: Durability and impact testing*
- *2025-11-04: Create validation testing to guarantee azimuth/side angle*
- *2025-11-05: Print the new enclosure with LED indicators and internal laser*
- *2025-11-06: Test and validate azimuth/side angle*
- *2025-11-08: Schedule informal meeting with Usman to review proof of metrics*
- *2025-11-10: Book sessions at the golf range for field testing*

Final Project Demonstration Meeting Minutes

Date: *2025-11-25*
Meeting Time: *11:03am - 11:51am*
Location: *Burnaby Mountain Golf Course & Driving Range*
Attendees:

- *Dr. Shervin Jannesar, P.Eng*
- *Usman Ahmed Edhbal*
- *Meesh Bono*
- *Mershad Azizinia*
- *Curtis Huang*
- *Joseph Wen*
- *Hugo Kwon*
- *Noah Kremler*
- *Ryan Martin*
- *Daniyar Umuraliyev*
- *Husain Kanthawala*
- *Sungmin Lee*

Absentees:

- *None*

Purpose: *Demonstrate the shelf-ready version of DriveWise, Company 17's golf launch monitor.*
Meeting Agenda:

- *Dr. Shervin Jannesar's Final Demonstration Instructions*
- *Dr. Shervin Jannesar requested the company's test plans and KPIs*
- *Dr. Shervin Jannesar announced his expectations for the demonstration*
    - *Begins with sales pitch and negotiation of price*
    - *Testers follow the test plan and instruction manual while the company silently watches*
    - *Teaching team evaluates the results of the demonstration*
- *Company 17's Sales Pitch*
- *Sales Pitch (Noah Kremler)*
    - *Described the metrics that the launch monitor measures*
    - *Explained the LEDs and Laser additions to enhance user experience*
    - *Pitched the importance of the app and coaching feedback displayed on there*
- *Negotiation*
    - *Company 17's initial offer was $800*
    - *Both parties agreed on a price of $775*
- *Tester's Product Demonstration*
- *Functional Testing*
    - *The testing team successfully connected the launch monitor to the mobile device*
    - *The launch monitor successfully displayed the LEDs and laser marker*
    - *The testing team installed the provided sticker on the club face*
    - *The launch monitor successfully captured normal swings and provided metrics and coaching feedback*
    - *The enclosure withstood direct impact from a golf ball*

- *Edge Cases*
    - *The launch monitor occasionally detected golf balls when white objects (shoes/clothes) were in the background*
    - *The launch monitor only detected the last ball to leave the frame when two balls were initially placed*
    - *The laser became misaligned after a golf ball was thrown at the top of the enclosure*
- *Dr. Shervin Jannesar's Feedback*
    - *Discussed areas where the product design could be improved*
        - *Improve safety of laser*
        - *Stop using laser after calibration*
        - *Secure laser/enclosure from all sides*
    - *Expectations for the rest of the course*
        - *Refine the document*
        - *Recreate the HoQ to reflect the final design*
        - *Final video*
            - *Get a golf coach or player's testimony*
        - *Peer Review*

Action Items

- *2025-11-26: Complete and submit peer review*
- *2025-11-26: Submit the updated operation manual to Activity 7*
- *2025-12-02: Complete course survey*
- *2025-12-05: Complete and submit Activity 9*
- *2025-12-05: Complete and submit the final video*
- *2025-12-05: Complete and submit the copyright license*

Appendix 2 -- House of Qualities Appendix

The House of Quality (HoQ) was used to weigh the importance of customer requirements to guide the design choices in our product. Because coaching feedback was one of the most important customer requirements, DriveWise uses a camera-based system instead of radar. This change provides more accuracy in club and ball accuracy metrics. Another major design choice identified was the use of a rechargeable battery rather than replaceable ones, which improves convenience and long-term sustainability. The addition of adjustable feet was also highlighted as an advantage, giving users more flexibility when positioning the device on uneven surfaces, something both competitors lack.

The HoQ made it clear which factors are most valued by customers and how technical choices affect those priorities. The strongest relationships were tied to usability, portability, enclosure durability, and battery capacity. A responsive app was found to be essential for real-time feedback, as users expect minimal delay between data collection and display. The trade-off between a lightweight and durable enclosure was another key consideration, since our device is placed directly in front of the golf swing. Battery capacity was also emphasized, as a larger rechargeable unit ensures continuous operation during long practice sessions.

These findings directly guided the design priorities for DriveWise. The team focused on optimizing Bluetooth Low Energy communication for fast and stable app connectivity, using reinforced but lightweight materials for the enclosure, and integrating a high-capacity battery with precise charge monitoring. Overall, the HoQ helped the team balance performance, portability, and reliability, ensuring that engineering decisions reflect what customers value most in a portable golf launch monitor.