BM1R 3513
PRODUCT DESIGN AND MANUFACTURING
SEMESTER 2 2024/2025

PROPOSAL FOR INTEGRATED DESIGN PROJECT (IDP)

Project Title
G-Sense

Project Cluster:
Cluster 1 Detection and Localization System

Programme:
Bachelor of Industrial Engineering
(BMIF)

Project ID:
14F

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EXECUTIVE SUMMARY

Golf driving ranges currently face inefficiencies in ball tracking, particularly under challenging conditions such as poor lighting, dense traffic, or obstructed zones. Manual observation methods and existing detection systems fail to deliver consistent and real-time data, leading to inaccurate performance analysis, and affects coaching insights and training results. Motivated by these challenges, the team decided to design and develop a product that enhances ball tracking and localization using an intelligent sensor-camera system. G-Sense, which is a ceiling-mounted sensor-camera system designed to detect and estimate the landing zones of golf balls in real-time. It maps ball concentration across predefined zones, enabling staff to prioritize high-density areas and optimize the collection route. This improves operational efficiency, reduces manual scanning time and supports data-driven coaching insights. The system's fixed top-down coverage ensures wide visibility with minimal blind spots, while integrated software provides live monitoring for immediate feedback and system diagnostics. The main users targeted by G Sense include golfers who seek accurate performance feedback, coaches who rely on precise shot tracking to guide performance and driving range staff and managers, who benefit from improved ball collection workflows and data-supported decision-making. During the initial development phase, the team completed field visits and stakeholder interviews and a thorough analysis of existing market solutions. Through the survey and interviews, key user needs were identified. Users consistently requested accurate localization, real-time tracking and ease of use. The most significant issues included ineffective ball detection and overreliance on manual ball collection. Besides that, the team developed and evaluated ten conceptual sketches, culminating in a finalized solution based on overhead camera tracking combined with motion estimation algorithms using projectile physics. Engineering analysis and CAD modelling supported the concept's technical feasibility, while concept screening and scoring revealed it as the most practical, scalable, and user-accepted option. The current prototype includes an aluminum frame and ball-joint mounted webcam, with development focused on system durability, precision, and ease of assembly. In future, the team will fabricate the camera system, integrate the detection software, and validate the prototype through field testing. The team targets to achieve at least 90% accurate detection and full zone coverage without blind spots. Feedback from test users will inform further refinements before final deployment. Overall, G-Sense is expected to reduce undetected balls, minimize manual effort, enhance coaching insights, and introduce a data-driven approach to training at driving ranges which provide a cost-effective solution that aligns with the growing demand for smart sports technologies.

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TEAM ORGANIZATION

This section outlines the internal structure of the project team which included clearly defined roles and responsibilities through Key Responsibility Areas (KRAs). Each member is assigned specific tasks that align with the project's development phases to ensure progress, accountability and collaboration. A detailed project plan, along with a timeline and defined milestones was developed to guide weekly activities and evaluate progress at key checkpoints. To maintain effective communication, the team adopted a communication plan involving meeting with supervisor and shared digital platforms for updates and document management. This structured approach ensures smooth project execution and alignment with overall objectives.

Organization Structure

Figure 1 shows the organization chart of the team.

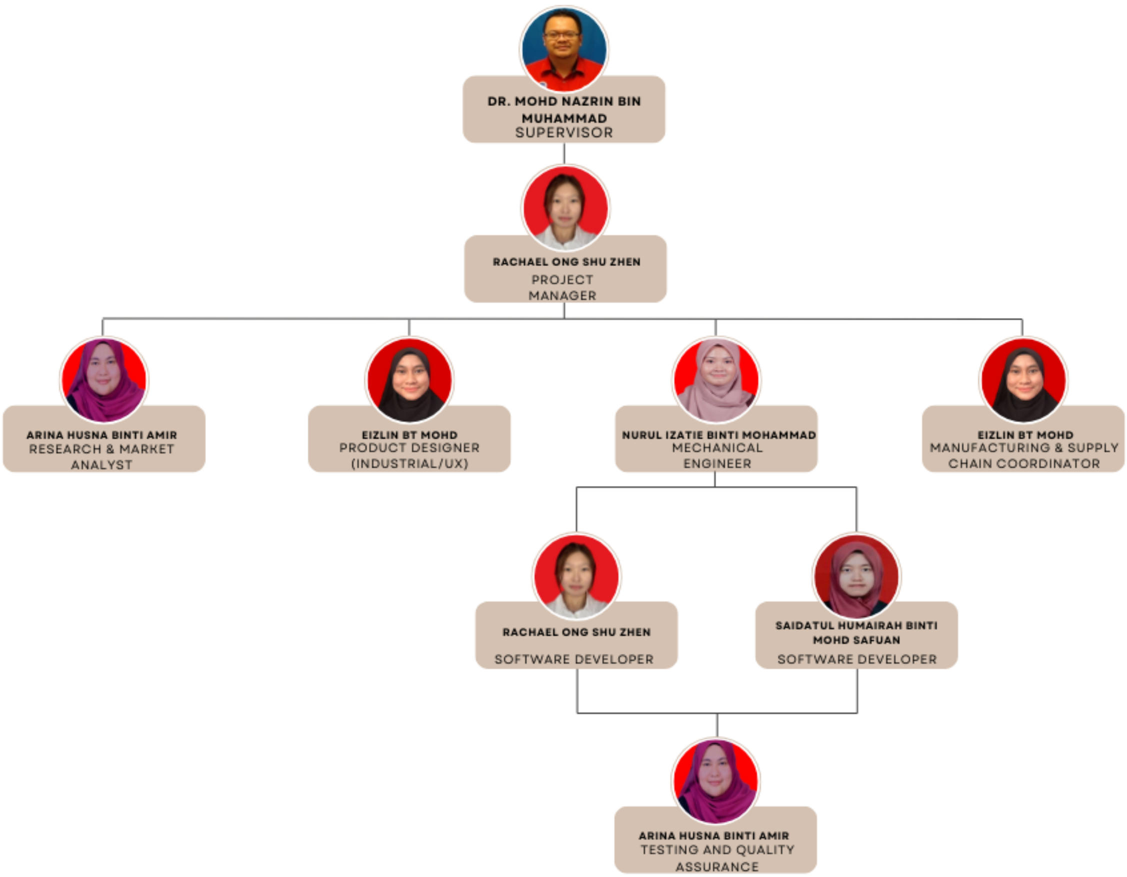


Figure 1:Organizational chart

Key Responsibility Areas (KRAs)

Table 1 shows the Key Responsibility Areas (KRAs) for each member.

Table 1: Key Responsibility Areas (KRAs)

No	Team Member Name	Role	Key Responsibilities
1	Rachael Ong Shu Zhen	• Project Manager	• Plan and oversee the entire project timeline and workflow • Assign tasks, coordinate meetings and ensure all the milestone are meet
		• Software Developer	• Focus on implementing algorithms to estimate the golf ball's trajectory based on the tracked data. • Analyze the ball's motion parameters
2	Arina Husna Binti Amir	• Research & Market Analyst	• Conduct market research to identify user needs, competitor analysis, and product feasibility.
		• Testing and Quality Assurance	• Analyse customer preferences and feedback. • Identify potential improvements and trends for product innovation • Develop test plans to assess the accuracy and reliability of the tracking system • Identify defects or areas for improvement in the tracking system. • Optimize the system for better tracking precision and usability.

3	Eizlin Bt Mohd	• Product Designer (Industrial/UX)	• Create concept sketches and design prototypes that align with product vision. • Develop aesthetic designs while ensuring ease of use and functionality. • Collaborate with engineering teams to refine product design and user experience. • Test and iterate on designs based on user feedback to improve usability.
		• Manufacturing & Supply Chain Coordinator	• Oversee production schedules, manage supply chain logistics, and ensure timely product delivery.
4	Nurul Izatie Binti Mohammad	• Mechanical Engineer	• Lead the design and development of the system's structural components. • Ensure mechanical reliability and accuracy of moving or load-bearing parts. • Collaborate with the designer and software developer to align hardware with system requirements. • Support prototyping, assembly, and hands-on testing of the system.
5	Saidatul Humairah Binti Mohd Safuan	• Software Developer	• Design and implement the software modules for golf ball tracking and trajectory estimation.

			• Write and test code related to image processing, motion tracking, or AI models. • Integrate different software components into a unified system. • Debug and optimize code for efficiency and accuracy. • Support user interface development if needed for visualizing tracking results.

Project Planning

Table 2 shows the key members to each project phase which includes key person-in-charge and supporting team members per phase.

Table 2: Key members to each project phase

Phase		RACHAEL	IZATIE	SAIDATUL	HUSNA	EIZLIN
Phase 1: Research and Ideation	Project kick off and team formation	✅	/			
	Problem identification and market research	/	/	/	✅	/
	Concept ideation and brainstorming	/	/	/	/	✅
	Initial sketch and design Concepts				/	✅
Phase 2: Concept Development and Design	3D modelling and CAD Design				/	✅
	Material selection and design refinement	/	✅	/	/	/
	Preliminary prototyping	/	✅	/		
Phase 3: Engineering & Prototyping	Prototype Fabrication	/	✅	/		
	Programming and Functional Integration	✅		✅		
	Prototype Testing and Refinement	/	/	/	✅	/
Phase 4: Testing and Validation	Product Testing and Performance analysis	/	/	/	✅	/
	User testing and feedback collection	/			✅	/
	Safety and compliance check	/			✅	/
Phase 5: Finalization &	Design Optimization and final adjustment	/	/	/	✅	/

Commercial Strategy	Manufacturing and cost analysis			/		✅
	Marketing and business model development			/		✅
	Pitch deck and report compilation	✅	/	/	/	/
Phase 6: Final Presentation & Submission	Final report presentation	✅	/	/	/	/
	Product demonstration	/	/	✅	/	/
	Final report and documentation submission	✅	/	/	/	/

Note:
✅ Key person-in-charge
/ Supporting team member

Project Timeline and Milestones

a) Gantt Chart

Figure 2 and 3 show the Gantt chart which display project tasks and milestones to be executed until the end of Semester 2 2025/2026 (week 28).

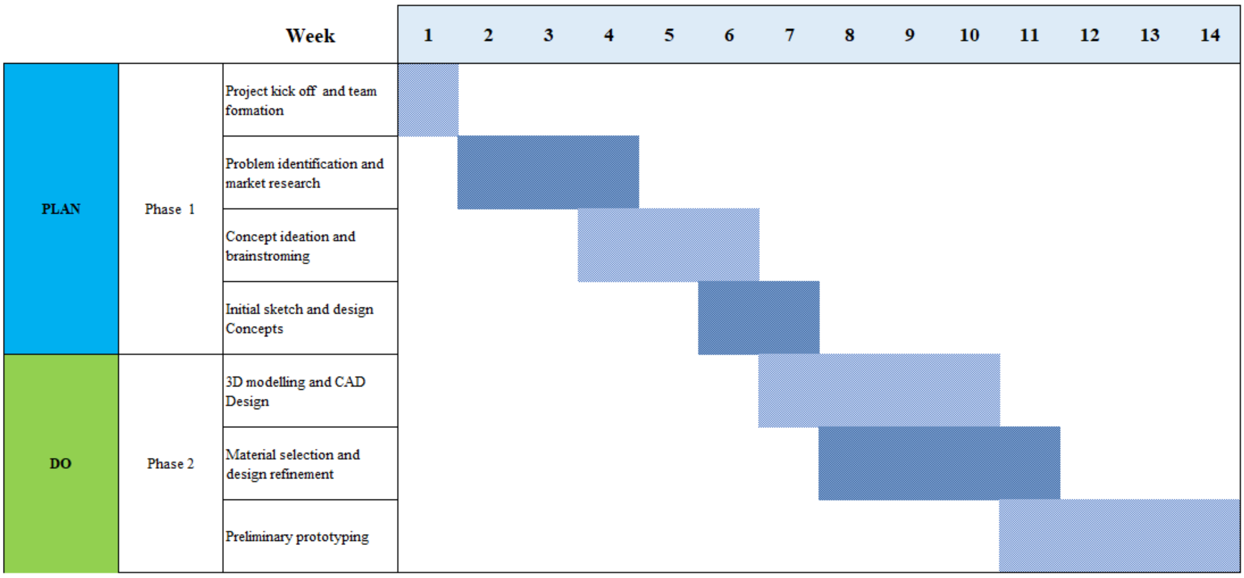


Figure 2 : Gantt chart for Semester 2 2024/2025

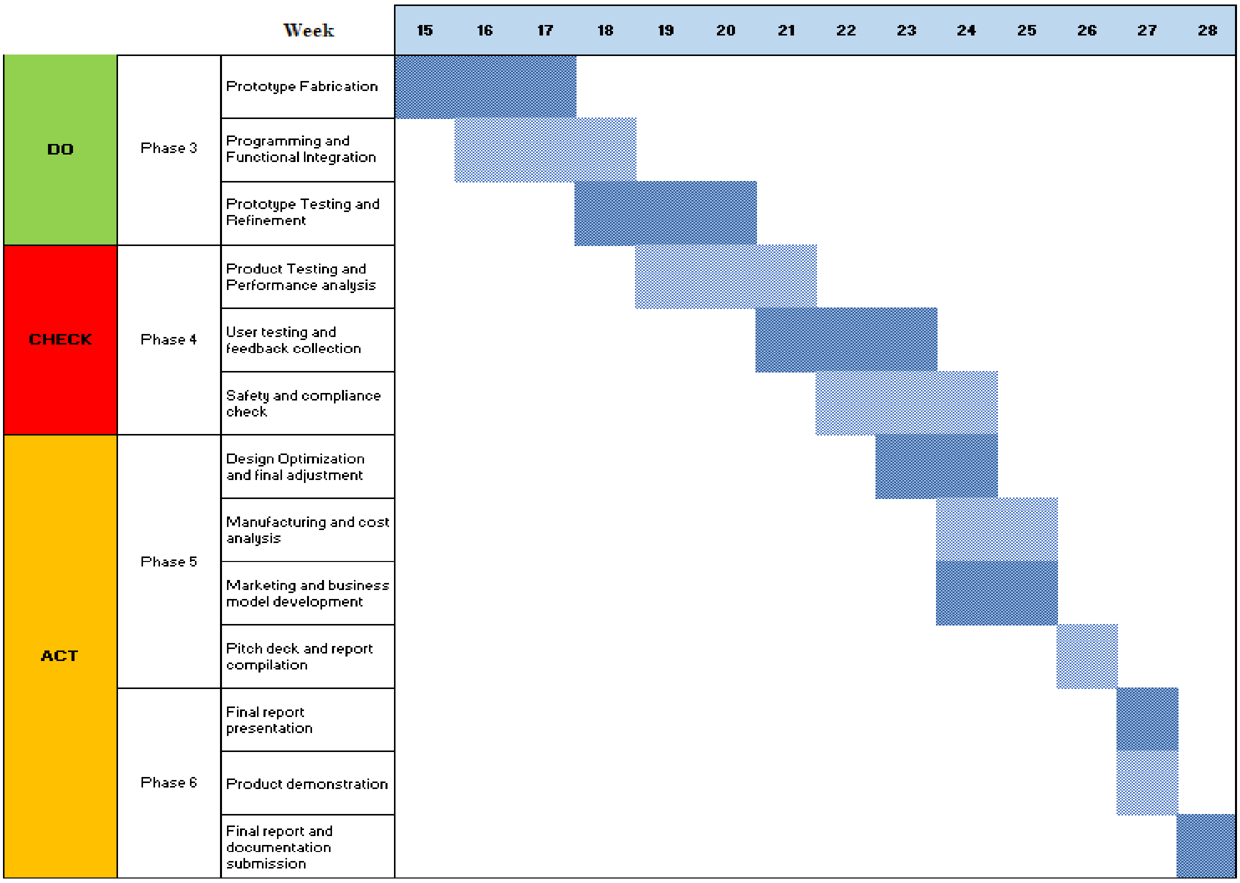


Figure 3: Gantt chart for Semester 1 2025/2026

b) Project Milestone

Table 3 shows the project milestone which detailing critical progress checkpoints along with their respective deadlines and assigned team members.

Table 3:Project milestone

Milestone	**Description**	**Deadline**	**Responsible Team Member(s)**
Phase 1: Research and Ideation	Identify the core problem and conduct market research	Week 4	Research analyst
	Generate initial ideas through brainstorming and sketches.	Week 7	Product designer
Phase 2: Concept	Translate ideas into early design concepts using 3D modelling and CAD tools	Week 10	Product designer

Development and Design	Refine the design through material selection and create preliminary prototypes.	Week14	Mechanical Engineer
Phase 3: Engineering & Prototyping	Fabricate the prototype, integrate programming and key functionalities	Week 20	Mechanical Engineer
Phase 4: Testing and Validation	Perform iterative testing to refine the working model, evaluate product performance through rigorous testing, gather user feedback and ensure the system complies with safety and industry standards.	Week 24	Testing and Quality Assurance
Phase 5: Finalization & Commercial Strategy	Optimize the design	Week 24	Testing and Quality Assurance
	Analyse manufacturing and cost factors, develop a marketing plan and business mode	Week 25	Manufacturing & Supply Chain Coordinator
Phase 6: Final Presentation & Submission	Present the final report, demonstrate the product, and submit all required documentation to conclude the project.	Week 28	Project Manager

Communication Plan

To ensure smooth collaboration and efficient workflow, the team adopted a structured communication strategy supported by digital tools and regular meetings. This approach has enabled effective task delegation, consistent progress tracking, and timely resolution of challenges throughout the early stages of the project. Below are the communication and collaboration tools used by the team:

a) Microsoft Planner

Used as the main project management tool, Microsoft Planner allows the team to track tasks, set deadlines and monitor the overall timeline of the project. Tasks are divided according to project phases, and each team member is assigned specific responsibilities, ensuring clarity and accountability.

b) WhatsApp

This platform serves as the team's primary communication tool for quick updates, reminders and informal discussions. It supports real-time responses, which is essential for day-to-day coordination and fast decision-making.

c) Microsoft Teams

Employed for formal discussions and online meetings, Microsoft Teams provides a platform for structured dialogue, progress presentations, and shared access to important files. It is particularly useful during discussions with the project supervisor, as it allows screen sharing and organized documentation.

PRODUCT DEVELOPMENT PROGRESS

PHASE 1: RESEARCH AND IDEATION

This phase marks the foundation of the product development journey. The team focus on identifying the core problem, understand the user needs and explore the potential solutions. Through research, brainstorming, site visits and stakeholder engagement, the team gathered essential insights to shape a clear project direction and concept.

Problems Identification

The first phase of the project starts with problem identification, which is crucial to understanding the core issues that need to be addressed. During this phase, the team conducts brainstorming sessions and engages with stakeholders to validate the problem. Through these efforts, the team gains a comprehensive understanding of the challenge and begins to explore potential solutions. This phase sets the stage for the ideation process, where various ideas are generated, assessed, and refined to form the basis of the project's development.

a) Problems Register

Table 4 shows the potential problems related the project cluster which identified through brainstorming session in the initial phase.

Table 4: List of problems

List of Problems		Proposed by:
1	Grass, dirt and other objects on the range can confuse sensors detection.	Rachael
2	Inadequate detection or tracking of golf balls can lead to unreliable data.	Rachael
3	Many detection or localization systems face a trade-off between conserving energy and maintaining accuracy, especially in mobile or battery-powered devices.	Izatie
4	In cooperative systems, different devices may have inconsistent detection or localization capabilities which will complicating data fusion	Izatie
5	Gathering and processing the data needed for accurate localization such as video footage and location data may face regulatory limitations.	Izatie

6	Limited tracking range – Sensors may struggle to detect golf balls over long distances.	Husna
7	Environment factors like grass cover, terrain variations and lighting conditions complicated the balls location detection.	Saidatul
8	Lack of real-time on real time information on ball location which reduce productivity.	Saidatul
9	High-speed balls may be difficult to track immediately after being hit.	Eizlin
10	Frequent maintenance or calibration is required to ensure sensor accuracy, which can increase downtime and operational costs.	Eizlin

b) Problems Register Assessment

Table 5 shows an evaluation for each identified problem based on its criticality and team's capability to resolve it. The assessment uses a scoring system to determine the feasibility of implementing solutions.

Table 5: Problems register assessment

List of Problems		Criticality	Capability	Total
1	Grass, dirt and other objects on the range can confuse sensors detection.	3	3	6
2	Inadequate detection or tracking of golf balls can lead to unreliable data.	4	3	7
3	Many detection or localization systems face a trade-off between conserving energy and maintaining accuracy, especially in mobile or battery-powered devices.	4	2	6
4	In cooperative systems, different devices may have inconsistent detection or localization capabilities which will complicating data fusion	3	2	5
5	Gathering and processing the data needed for accurate localization such as video footage and location data may face regulatory limitations.	4	2	6
6	Limited tracking range, sensors may struggle to detect golf balls over long distances.	4	5	9

7	Environment factors like grass cover, terrain variations and lighting conditions complicated the balls location detection.	5	2	7
8	Lack of real-time on real time information on ball location which reduce productivity.	3	3	6
9	High-speed balls may be difficult to track immediately after being hit.	3	2	8
10	Frequent maintenance or calibration is required to ensure sensor accuracy, which can increase downtime and operational costs.	3	4	7

c) Problems Shortlisting

To prioritize the identified problems, a Capabilities-Criticality Matrix was established as shown in Figure 4. This matrix helps in visualizing and shortlisting problems based on its criticality and team's capability to resolve it. By mapping each problem accordingly, the team can focus on high-impact issues that are realistically solvable within the project's scope and resources.

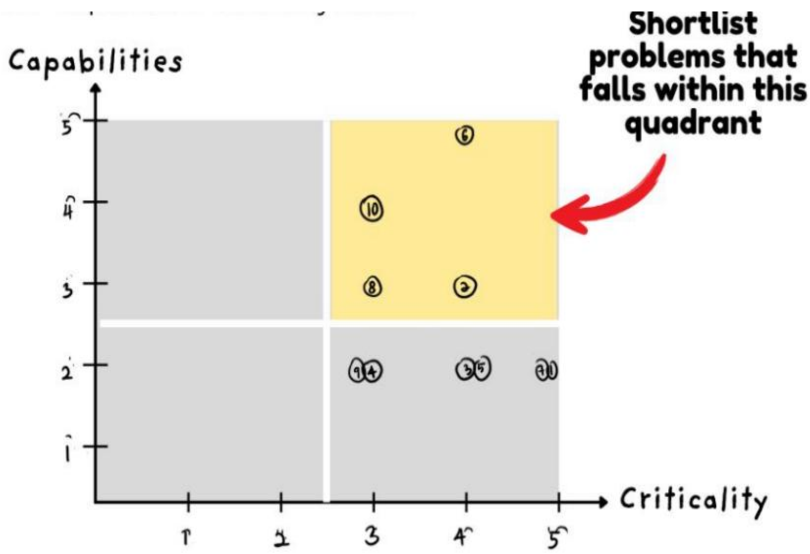


Figure 4: Capabilities-Criticality Matrix

The problems that fall within the yellow area are known as shortlisted problems which are listed in Table 6.

Table 6: Shortlisted problem

Shortlisted Problem	
2	Inadequate detection or tracking of golf balls can lead to unreliable data.
6	Limited tracking range – Sensors may struggle to detect golf balls over long distances.
8	Lack of real-time on real time information on ball location which reduce productivity.
10	Frequent maintenance or calibration is required to ensure sensor accuracy, which can increase downtime and operational costs.

d) Problems Validation

Following the shortlisting process, the selected problem was validated through analysis, observation, and stakeholder input. This validation ensures that the problem is both relevant and solvable within the scope of the project. Table 7 presents the validated problem along with its description, supporting data and the associated design opportunity.

Table 7:Problems validation

Shortlisted Problem		Description	Supporting Data	Design Opportunity
2	Inadequate detection or tracking of golf balls can lead to unreliable data.	Detection systems often struggle to distinguish golf balls from surrounding elements, especially when impacted by grass, dirt, or rainy conditions.	Visual test trials show misidentification in 3 out of every 10 cases under rainy or muddy conditions; accuracy drops by 25% in poor lighting.	Implement multi-sensor systems (e.g., radar + camera + infrared) to improve object differentiation and tracking accuracy.
6	Limited tracking range – Sensors may struggle to detect golf balls over long distances.	Current sensors have a limited detection radius, especially in large open ranges, leading to missed tracking beyond 50 meters.	In Ayer Keroh Country Club, bush area balls are collected manually. Buggy with roller has limited range and is under maintenance,	Upgrade sensor hardware or deploy multiple sensor nodes to expand coverage and enable full-range localization.

			increasing manual workload	
8	Lack of real-time on real time information on ball location which reduce productivity.	Without real-time tracking, ball collection becomes inefficient and uncoordinated, leading to delays in range operations.	Ayer Keroh staff currently collect balls manually and place them in baskets. No fixed schedule. Manual collection takes significantly longer. No collection at night. Delay in ball collection compared to buggy car	Develop an IoT-based live ball mapping system (RFID) for real-time display on mobile apps or control panels.
10	Frequent maintenance or calibration is required to ensure sensor accuracy, which can increase downtime and operational costs.	Sensors used in outdoor environments often require regular maintenance due to weather effects, dirt, or sensor drift	At Ayer Keroh, the buggy collector is under maintenance. Without automation, staff rely on manual collection, increasing fatigue and downtime.	Design a self-calibrating sensor module or enclosure with weatherproof, low-maintenance materials to extend service life.

e) Project Theme Selection

From the shortlisted problems, only one main issue was selected to drive the direction of the innovation project. The decision is made based on the impact or significance, feasibility and cost. To objectively evaluate each problem, a weighted score method was used. Each criterion was assigned a different weight based on its importance. Team members rated each problem on a scale from 1 to 5 for each criterion and the weight score were calculated to determine overall priority. By applying these criteria, the team ensures that the chosen problem not only addresses a real need but is also achievable with the available resources and time frame. Table 8 shows the assessment of each shortlisted problem using key decision-making criteria to identify the most suitable issue to drive the innovation project.

Table 8: Evaluation of project theme selection

Shortlisted Problem		Impact/ Significance (x2)	Feasibility (x3)	Cost (x4)	Total	Rank
2	Inadequate detection or tracking of golf balls can lead to unreliable data.	4 x 2 = 8	5 x 3 = 15	2x4=8	31	1
6	Limited tracking range – Sensors may struggle to detect golf balls over long distances.	4 x 2 = 8	2 x 3 = 6	4x4=16	30	2
8	Lack of real-time on real time information on ball location which reduce productivity.	5 x 2 = 6	3 x 3 = 9	3x4=12	27	3
10	Frequent maintenance or calibration is required to ensure sensor accuracy, which can increase downtime and operational costs.	3 x 2 = 6	2x 3 = 6	3x4=12	24	4

The team refined the problem by using the 5W1H method, which helped to identify the specific issues. This approach allowed us to transform a vague statement into a clear, detailed and actionable problem description.

Problem statement: Inadequate detection or tracking of golf balls can lead to unreliable data.

i. What?

The detection and tracking system for golf balls fails to capture accurate data.

ii. Who?

Affected the coaching staff, facility managers and possible golf players relying on performance analytics.

iii. When?

Especially when multiple balls are hitting.

iv. Where?

Across the entire driving range, particularly in shaded or obstructed zones.

v. Why?

Sensors may have blind spots, poor calibration, or limitations in identifying multiple simultaneous trajectories.

vi. How?

Tracking system miss fast-moving or overlapping causing data gaps or errors.

Refined problem statement:

Inadequate detection and tracking of golf balls across the driving range, particularly in shaded or obstructed zones and during periods when multiple balls are in motion which resulting in data gaps and inaccuracies. These issues are caused by sensor blind spots, poor calibration or limited tracking capabilities, negatively impacting coaching staff, facility managers and players who rely on accurate performance analytics.

f) Target Setting

Setting clear and measurable targets is a crucial step in the problem-solving process. It ensures that the proposed solutions can be assessed effectively and remain aligned with both project goals and industry expectation. To ensure that targets are practical and effective, the SMART criteria is applied. SMART is an abbreviation that stands for specific, measurable, achievable, realistic, and time bound. It is a widely used framework that helps teams and individuals set clear objectives and monitor progress effectively.

- Specific
  The target should be well-defined, clear, and unambiguous to avoid any confusion about what is to be achieved.
- Measurable
  The goal must include specific criteria that can track progress and confirm when the target has been met.
- Achievable
  The objective should be realistic and attainable, considering the team's current skills, tools, and available resources.
- Realistic
  The target must be practical, aligned with project goals, and relevant to the context of the challenge being addressed.
- Time-bound
  A clear timeline, including a start and target date, should be established to maintain focus and create a sense of urgency.

Based on the project objectives and analysis of the root causes, the two target settings are established using the SMART criteria:

i. To reduce the number of lost golf balls
   - Specific: Implement visual detection system by using sensor camera
   - Measurable: Reduce lost golf balls by 65% during field testing
   - Achievable: Technology is available and has been successfully used in other sports.
   - Relevant: Important to reducing cost and improving player experience

- Time-bound: To be implemented by week 12 of the semester

ii. To spot every ball landing coordinates

- Specific: Install smart camera and sensor
- Measurable: Minimum 70% detection accuracy during field testing
- Achievable: Already available and has been successfully used in another sport.
- Relevant: Ensuring ball efficiency and detection tracking
- Time-bound: Within 12 weeks of the project timeline

g) Root-Cause Analysis

Another method causes and effect diagram as shown in Figure 5 also used to identify the root cause of problem statement.

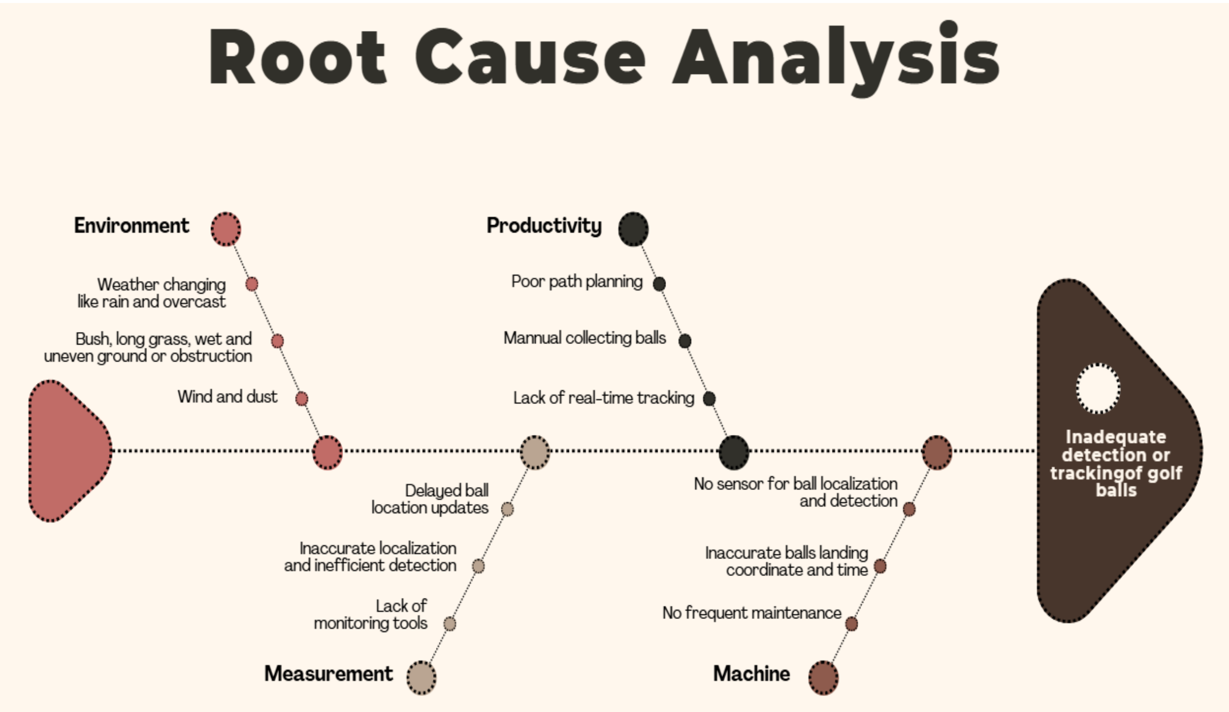


Figure 5: Cause and effect diagram

h) Opportunity for Improvement

To encourage innovative and strategic thinking, the team focused on generating potential solutions as shown in Table 9. This approach allowed for open discussion and exploration of various ideas based on the root causes.

Table 9: Opportunity for improvement

Root Cause		**Opportunity for Improvement**
Environment	Weather changing like rain and overcast	Implement weather-resistant housing for components and integrate adaptive sensor algorithms that auto-calibrate under varying light and moisture conditions.
	Bush, long grass, wet and uneven ground or obstruction	Enhance object detection with terrain-adaptive machine vision
	Wind and dust	Add protective filters and enclosures to sensors, and incorporate data smoothing
Measurement	Delayed ball location updates	Use a faster camera and sensors that can send updates quickly, so the system always knows where the ball is in real time.
	Inaccurate localization and inefficient detection	Refine detection algorithms for better precision, improve contrast-based techniques, or adjust camera angles and field-of-view to reduce blind spots and false positives.
	Lack of monitoring tools	Develop a simple dashboard or log-based monitoring system to track detection success, or errors rate, and environment situation in real-time or post-run analysis.
Productivity	Poor path planning	Implement a path planning algorithm that utilizes sensor or vision input feedback to dynamically adjust the route and minimize travel time.
	Manual collecting balls	Improve the layout or workflow of the collection area to make manual collection faster and more

		organized such as using guided lanes, collection zones, or clearly marked drop-off points.
	Lack of real-time tracking	Incorporate real-time tracking using a continuous feedback loop from camera or sensors to allow immediate position updates and reactive adjustments during navigation as they change.
Machine	No sensor for ball localization and detection	Integrate basic vision sensors or proximity sensors to enable automated ball detection and localization for more precise and reliable retrieval.
	Inaccurate balls landing coordinate and time	Use timestamped sensor or camera input to log ball landing events, allowing for coordinated and timely retrieval paths based on actual landing data.
	No frequent maintenance	Establish a routine maintenance schedule and integrate simple self-check features (e.g., sensor health checks, mechanical calibration alerts) to ensure consistent machine performance.

Market / Background Study

This section provides an overview of current technologies and commercial solutions in the field of golf ball tracking systems. It evaluates some competitors such as TrackMan4, Rapsodo MLM2Pro and FlightScope by analysing their strengths and limitations.

a) Competitive Benchmarking

An analysis was conducted between the competitors to evaluate their strengths and weakness. Table 10 summarized the key features and limitations of the systems.

Table 10: Competitive Benchmarking

Product	Feature	Limitation
TrackMan4  	• Real-time tracking • Mobile app integration • High accuracy	• Expensive • Mainly for professional-grade facilities
Rapsodo MLM2Pro 	• Mobile launch monitor • Visual feedback via app	• Designed for individuals • Not scalable to large ranges
FlightScope 	• Radar-based tracking • Portable setup • Detailed analytics	• Limited range coverage • High cost for full-field use

b) Technical Benchmarking

To evaluate the current market offerings for golf ball tracking systems, a technical benchmarking analysis was conducted. Table 11 focuses on key performance criteria such as localization precision and tracking accuracy.

Table 11: Technical benchmarking

Criteria	TrackMan	Rapsodo MLM 2Pro	FlightScope
Localizatioon precision	Dual radar and camera system	Good within short-range, mobile setup	Good within short-range, mobile setup
User friendly	Requires training and setup	App-based, beginner-friendly	App-based, beginner-friendly
Easy impplementation	Requires professional setup and calibration	Plug-and-play mobile unit	Plug-and-play mobile unit
Maintenance requirement	Software updates, calibration, power needs	Minimal maintenance	Needs sensor care and updates
Tracking accuracy	Tour-level precision	Good for casual/pro use	Strong data capture and launch metrics
Speed of detection processing	Real-time feedback and analytics	App displays shot data instantly	Real-time processing
Adaptability to environmental conditions	All-weather capable	Works well outdoors, lighting-sensitive	Performs well indoors and outdoors

User Needs Analysis

a) Stakeholders Identification

To ensure the system meets actual user needs and expectations, a Voice of Customer (VOC) analysis was conducted. This process involved identifying key user requirements and preferences related to golf ball tracking systems. Table 12 shows VOC gathered from potential stakeholders.

Table 12: VOC

Stakeholder	VOC (User Need)
Ground staff	I get exhausted quickly when I have to collect balls in the heat.
Ground staff	I want to optimize my time and avoid the inefficiency of searching for the balls at midnight.
Ground staff	I want accurate location of the balls.
Technician	I want good lighting and terrain.
Technician	I want machine easy to use.
Technician	There should be an integration option with GPS, RFID or scanning device.
Golfer	I want to see exactly where my ball lands without searching all over.
Golfer	The tracking technology should be simple and quick to use.
Manager	I want my customers and staff to enjoy their tasks and golf with ease
Manager	I don’t want ground staff to spend too much time locating balls manually.

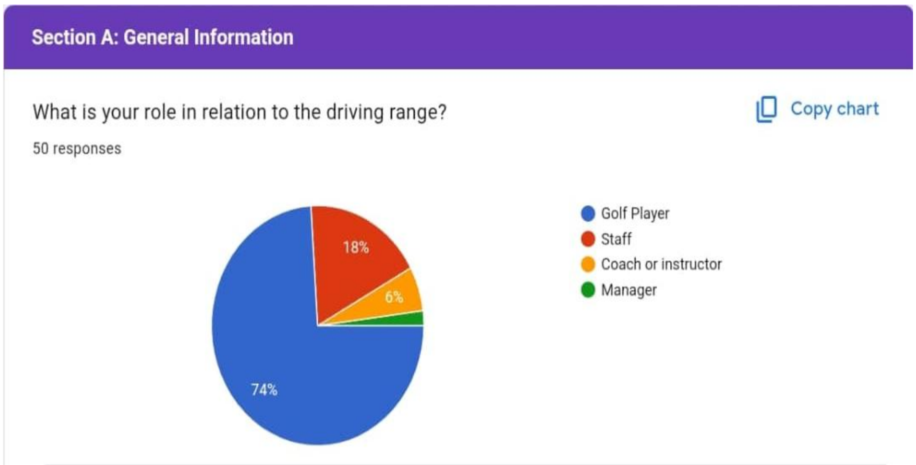
b) Data Collection

i. Survey

To support the development of an intelligent detection and localization system for tracking golf balls on driving ranges, a survey was conducted to gather feedback, insights, and suggestions from golf players and other relevant stakeholders. The primary aim of this study is to identify existing challenges, understand user expectations and explore opportunities for improving the efficiency of golf ball retrieval operations. The survey comprises three main sections. Section A: General Information, Section B: Observation and Experience and Section C: Feedback and New Concepts. The data collected will inform the design and implementation of a more effective and user-oriented tracking solution.

Section A: General information

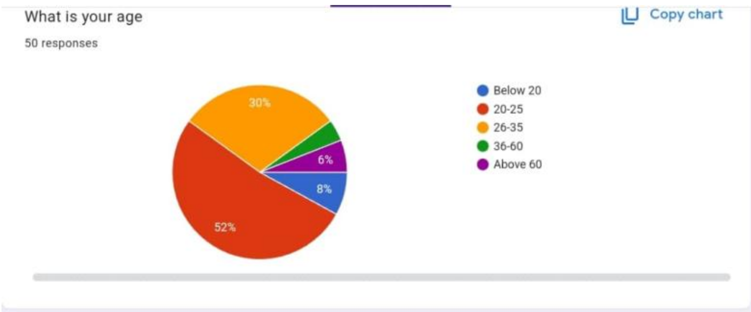
- Respondent Details

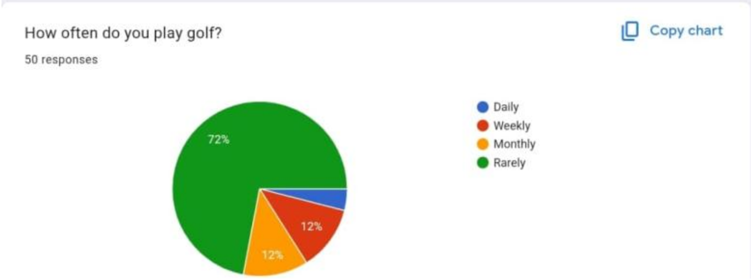


A total of 50 individuals participated in survey, providing diverse perspectives on golf ball localization and retrieval systems

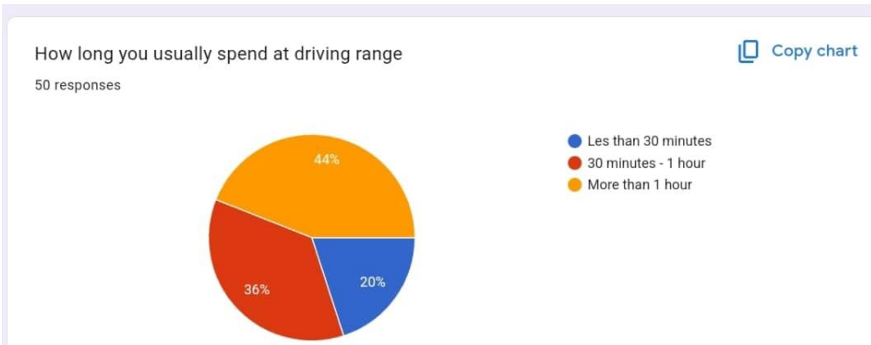
- Respondent Background

The participants include a diverse range of individuals involved in various aspects of golf course operations. The majority group, providing valuable firsthand experiences with detection and tracking challenges is Golf Players (74%). For responsible for day-to-day operations and retrieval, offering operational insights Staff (18%). Another role in relation Coaches/Instructors (6%) and Managers (2%).



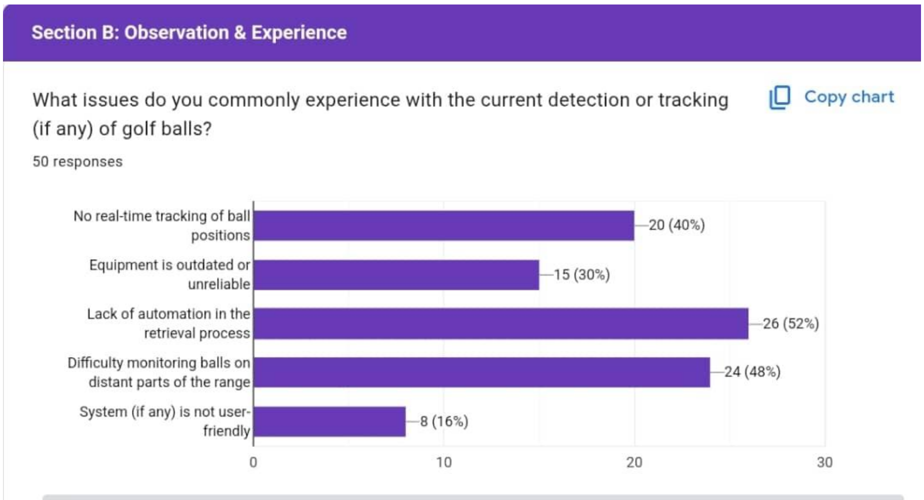


Most respondents are young adults (20-25 years old). However, most participants 72% rarely play golf. Only 4% play daily, while 24% play occasionally. This suggests that golf is more of a casual activity for this group rather than a regular sport. Any golf detection system should focus on ease of use and accessibility for casual players.

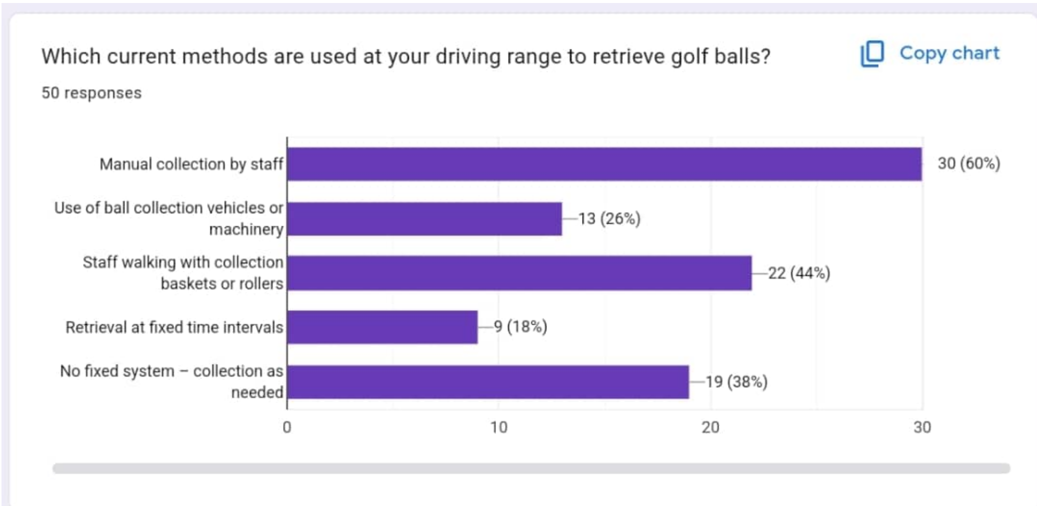


The pie chart shows respondents typically spend at a driving range. The largest group (44%) spends more than 1 hour, followed by 30 minutes to 1 hour (36%). A smaller portion (20%) spends less than 30 minutes. This suggests that most golfers prefer longer practice sessions, likely to refine their skills.

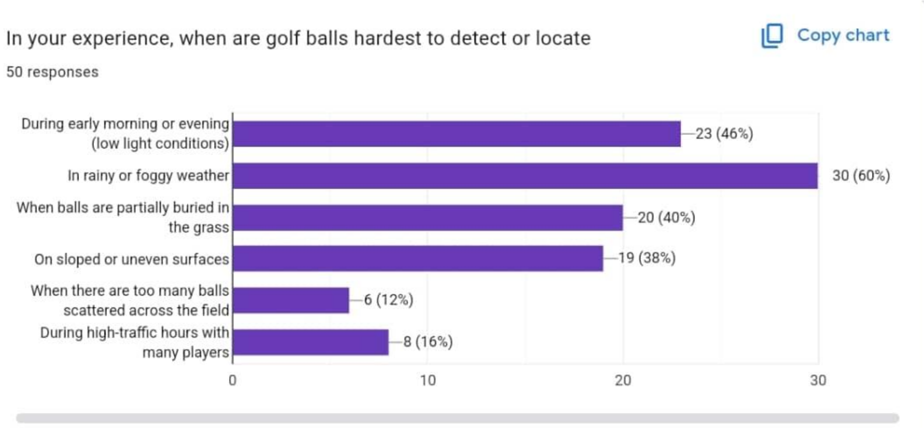
Section B: Observation and Experience



The survey results indicate several key issues in golf ball detection systems. The most frequently reported problem is the lack of automation in the retrieval process, affecting 52% of users, followed by difficulty monitoring balls on distant parts of the range (48%). Additionally, 40% of respondents find that there is no real-time tracking of ball positions, which impacts their playing experience. 30% of users encounter outdated or unreliable equipment, and 16% find the system not user-friendly. These insights highlight the need for an improved, automated, and more precise tracking system to enhance user experience and efficiency in golf ball detection.

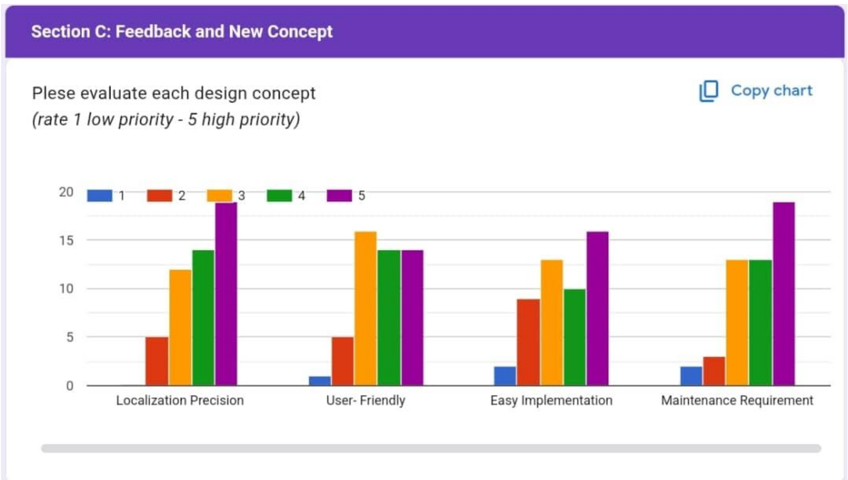


The survey results reveal that manual collection by staff is the most common method for retrieving golf balls, with 60% of respondents using this approach. Additionally, staff walking with collection baskets or rollers is reported by 44% of participants. 38% of respondents stated that retrieval is done as needed, while 26% rely on ball collection vehicles or machinery. Only 18% follow a system where balls are retrieved at fixed time intervals. These findings indicate that manual collection methods still dominate driving ranges, despite the presence of automated solutions. Improving automation and efficiency in ball retrieval systems could enhance the user experience and reduce the workload for staff.



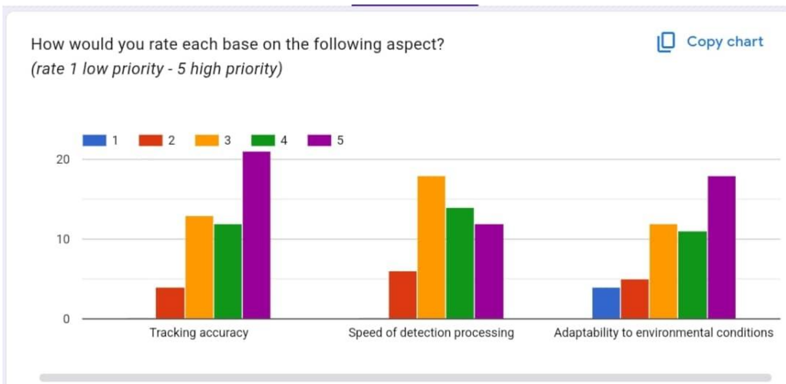
The survey results indicate that rainy or foggy weather poses the greatest challenge for golf ball detection, with 60% of respondents struggling in such conditions. Low-light environments, such as early morning or evening, also present difficulties for 46% of participants. Additionally, 40% find detection challenging when balls are partially buried in the grass, while 38% encounter issues on sloped or uneven surfaces. Interestingly, factors such as high-traffic hours (16%) and too many balls scattered on the field (12%) are less commonly reported issues. These findings suggest that improvements in visibility, terrain adaptability, and real-time tracking could enhance detection systems.

Section C: Feedback and New Concept



For sections feedback and new concept. This aimed to evaluate the feasibility and user perception for a golf ball detection and localization system. Respondents were asked to rate four key design concepts on a scale of 1 (low priority) to 5 (high priority). For the first design concept a localization precision is a most highly rated criterion, with the majority of respondents assigning a score of 5. This indicates strong confidence to deliver precise localization, which is essential for tracking golf balls accurately. The second design concept is user-friendliness, from survey that received mostly 3 and 4 ratings. It suggests that are relatively user-friendly, there is for improvement, especially for users with less technical background.

Next, is easy implementation, the respondents generally rated this between 3 and 5, with a notable number choosing 5. This shows that implementation is considered manageable and within reach for most users, especially those with some technical expertise. Lastly, for design concept a maintenance requirement, that received a significant number of 5 ratings. If interpreted as "low maintenance requirement. However, this should be clarified to ensure consistent interpretation. The survey results indicate is well-regarded for use in a golf ball detection and localization system. High scores in localization precision and ease of implementation suggest that it is a technically sound and practical choice. While user-friendliness and maintenance perceptions vary, overall sentiment is positive.



From responses the functional performance evaluation, were then asked to rate three functional aspects of the system, the first is tracking accuracy that received the most 5 ratings across all categories, underlining its critical importance. A capability in this area appears to meet expectations very well. Next, performance is speed of detection processing, the responses varied, with a significant cluster at 3, 4, and 5. This suggests that while the speed is generally acceptable, some users may have concerns about performance in real-time conditions.

The last performance is adaptability to environmental conditions from survey leaned toward 4 and 5, showing that users believe are resilient across different lighting, weather, or terrain conditions a valuable trait for outdoor sports applications. The overall survey data supports the development of a golf ball detection and localization system. The platform scores exceptionally high in precision and tracking, and is seen as robust and adaptable. While user-friendliness and implementation ease are generally positive, targeted improvements could enhance accessibility for a broader range of users.

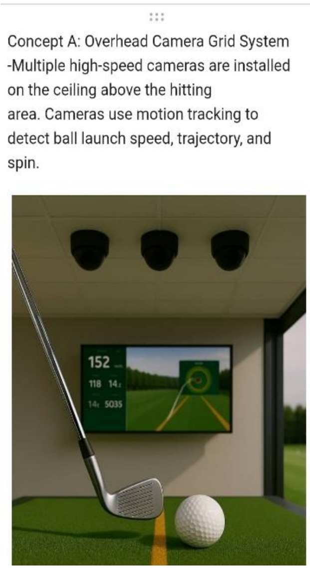


Figure 6: Concept A

Figure 7: Concept B

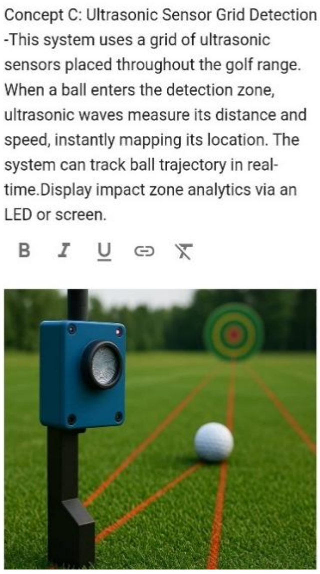
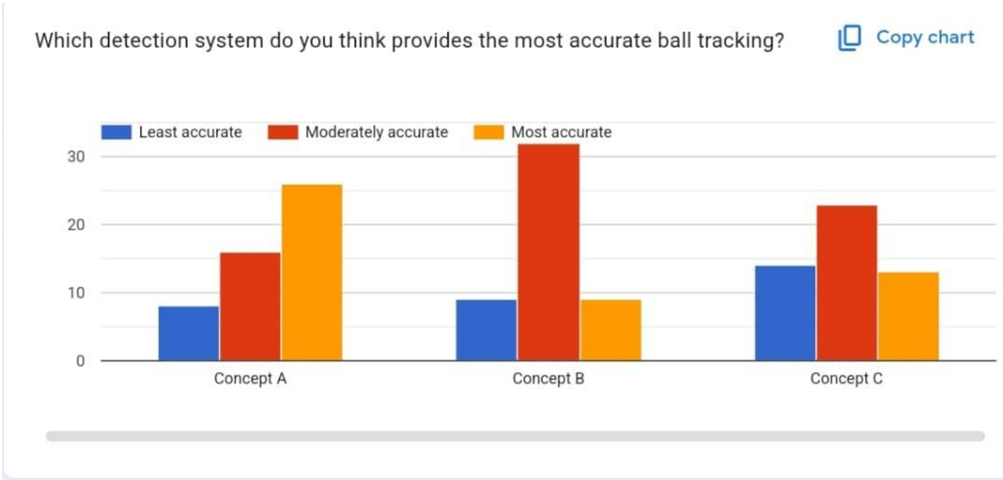
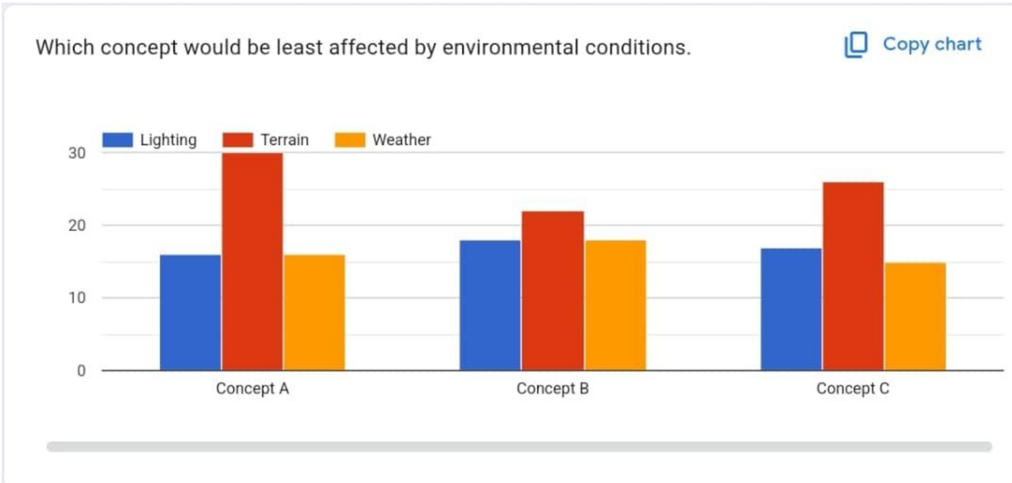


Figure 8: Concept C





For this part the comparison of ball tracking concepts, have three design concepts for ball tracking were presented:

- Concept A: Overhead Camera Grid System.

Utilizes multiple high-speed overhead cameras to capture ball data (launch angle, speed, spin). Responses rated most frequently as moderately accurate, though a fair number selected it as the most accurate option.

- Concept B: Pressure Sensor Grid System.

  Employs a grid of pressure-sensitive sensors beneath the turf to calculate impact location and force. From the survey responded, received the highest count of most accurate ratings, suggesting participants trust this method's precision and reliability.

- Concept C: Ultrasonic Sensor Grid Detection

  Uses ultrasonic sensors to detect and map ball trajectory in real time, displaying results via LED or screen. Mostly responded rated as moderately accurate, with some respondents considering it the least accurate

Concept B (Pressure Sensor Grid) was rated the most accurate by the majority of participants. While Concept A is also trusted, it appears to be viewed as less precise than the pressure-based system. Concept C, although technologically unique, is seen as less reliable in terms of tracking precision.

Environmental Impact on Detection Systems

1. Terrain Effects

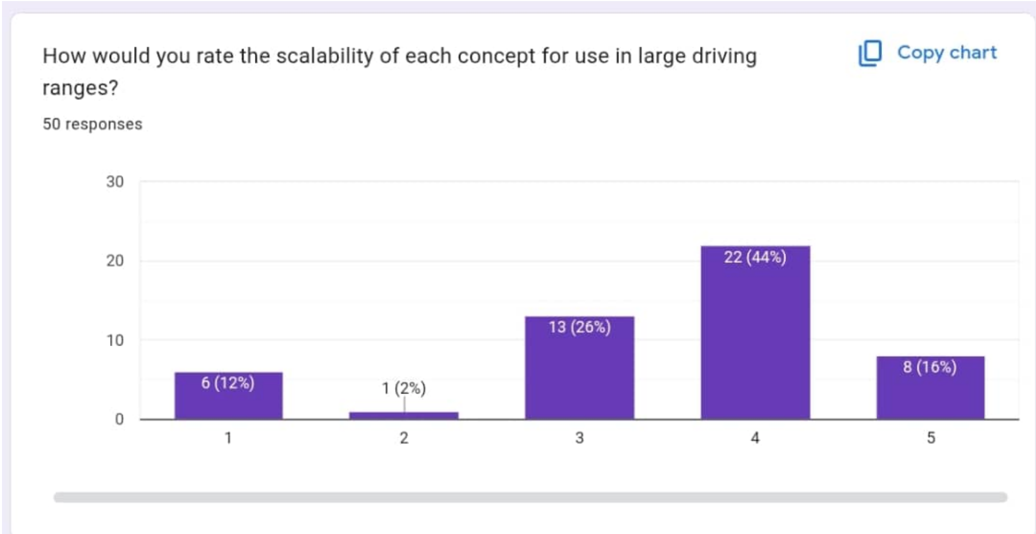
   Concept A is most affected by terrain conditions (30) compared to Concept B (20) and Concept C (25). Suggests that Concept A may struggle with uneven surfaces or varying ground textures.

2. Weather Influence

   Concept A (20) experiences more weather-related impact than Concept B (15) and Concept C (15). Indicates that Concept A's detection performance may fluctuate due to environmental changes like rain or wind.

3. Lighting Considerations

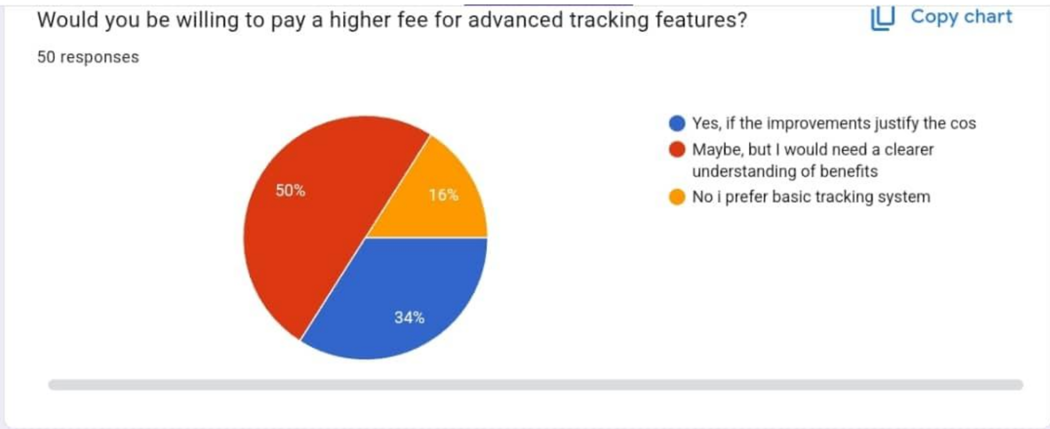
   Concept C (20) is most affected by lighting conditions compared to Concept A and Concept B (both at 15). This could suggest that Concept C depends heavily on visibility-based tracking, such as camera-based systems.

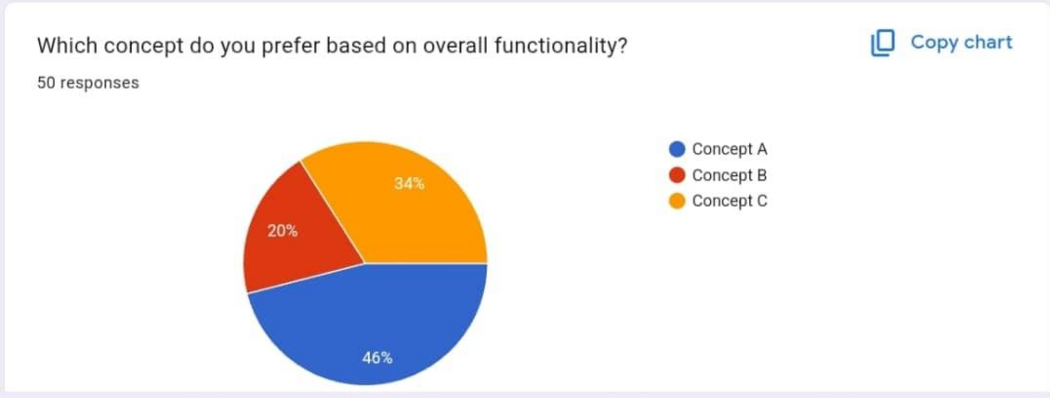


The bar chart you provided shows how respondents rated the scalability of different concepts for use in large driving ranges. Here are the key takeaways

- Most Common Rating 4 is (44%) - Indicates that the majority of respondents found the concept to be fairly scalable.
- Moderate Rating 3 is (26%) Suggests a significant portion saw room for improvement in scalability.
- High Rating 5 (16%) – Some respondents rated the concept as highly scalable, though this is a minority.
- Low Ratings 1 (12%) and 2 (2%) – A small percentage felt the concept lacked scalability.

The responses indicate that the system has moderate to high scalability for large driving ranges. Factors like ease of deployment, adaptability to terrain, and cost efficiency may need further optimization to enhance scalability.





Based on the responded survey, user preferences and willingness to invest in advanced golf ball tracking systems. That is for 50% isare undecided, stating they need a clearer understanding of benefits before committing. Next, for 34% of respondents would pay a higher fee if the improvements justify the cost. Last, for 16% is prefer a basic tracking system* and are unwilling to pay more. From 3 concept, responses prefer choose a concept A because 46% in the most favored design. Next, for concept C response choose it by 34%. Lastly the less choose is 20% for concept B.

ii. Interviews and Site Visit

To support the development of a golf ball localization and tracking system, informal observations and discussions were conducted at Ayer Keroh Country Club. The main respondent was the driving range manager, who provided valuable insights into the current ball collection practices and operational routines.

The discussion focused on understanding how golf balls are collected, when the collection typically occurs, and whether the process involves manual or automated methods. The manager explained that ball collection is primarily done using a roller device pulled by a buggy to retrieve balls from the open field. However, as the buggies are currently undergoing repairs, the task is temporarily being carried out manually by ground staff, typically twice a day once in the morning before the range opens and again in the evening. In areas with dense vegetation or uneven terrain, where buggies cannot access, balls are collected entirely by hand.

The manager also clarified that no fully autonomous or automated ball collection system is currently in use, mainly due to cost limitations and the challenging landscape. The current approach still depends heavily on manual labor and visual inspection, highlighting a clear opportunity for technological enhancement through systems such as ball localization and tracking.

Figure 9 : Buggy car with roller system is under maintaenance

Figure 10: Collecting the ball golf with manualy

Figure 11: Site visit with manager in Ayer Keroh Country Club

c) Data Interpretation and Organization

Table 13 below shows the summarization of user needs and potential design solutions to address functional, operational, and environmental challenges of the G-Sense System

Table 13: Summarization of user needs and potential design solutions

Category	User needs	Potential design solutions
Tracking Performance	• Need for real-time tracking (40%) • Difficulty monitoring distant ball positions (48%)	Incorporate high-precision localization, wide-range visibility and instant feedback
Environmental Factors	• Rain, fog, uneven terrain, and poor lighting significantly affect current detection systems	Design must be resilient to weather, terrain variations and low-light conditions
System Usability	• Casual golfers and ground staff need a user-friendly system that doesn't require technical expertise.	Develop intuitive interfaces, integrate basic tutorials or mobile app guides
Maintenance & Reliability	• Current equipment is outdated or unreliable (30%) • Ground staff prefer low maintenance requirements	Ensure low-maintenance hardware, modular components for easy servicing
Scalability	• Systems must work well in both small and large driving ranges.	System should be modular and cost-effective to scale for both small and large ranges
User Preferences	• 46% prefer Concept A (camera-based) • High scores for tracking accuracy	Prioritize Concept A while improving its environmental adaptability and ease of use
Willingness to Pay	• 50% unsure without clear benefits • 34% will pay more if justified	Tiered pricing model with clearly defined features and benefits

d) Design Requirements and Product Specifications

Table 14 below shows the technical requirements and technical specifications.

Table 14:Technical requirements and technical specifications

User needs	Technical Requirements	Technical Specifications
I get exhausted quickly when I have to collect balls in the heat.	Automated ball retrieval system	The system must autonomously collect at least 1,000 golf balls per cycle across a large field. It should operate continuously for 6 hours in temperatures up to 40°C, avoid obstacles, unload into storage easily, operate safely around people, and emit noise under 60 dB.
I want to optimize my time and avoid the inefficiency of searching for the balls at midnight.	Nighttime ball detection and retrieval	System must use infrared or night-vision technology to detect and collect at least 1,000 balls per cycle in low-light or dark environments. Must function reliably for 6 hours at night and cover the full field with minimal supervision.
I want accurate location of the balls.	Real-time ball location tracking	System must provide real-time location of golf balls with ±0.5m accuracy using GPS, RFID, or computer vision. Must update every second, operate under all lighting/weather conditions, and present data on an easy-to-use interface.
I want good lighting and terrain.	Safe and accessible maintenance	Field must include uniform

	workspace	lighting of at least 300 lux and weatherproof fixtures. Terrain should be level, hazard-free, and well-drained with clearly marked access paths for technicians and equipment.
I want machine easy to use.	Simple and user-friendly operation	The machine must have a user-friendly design with simple, intuitive controls that require minimal training. It should feature a clear interface like labeled buttons or touchscreen, quick start-up, and easy-to-follow operation steps. The system must include basic instructions on the device and require no more than 30 minutes of initial training for a technician to operate confidently.
There should be an integration option with GPS, RFID or scanning device.	Integrated system	System must support real-time tracking via GPS, RFID, and barcode/QR scanning. Must display location data on a dashboard, support wireless connectivity, and scale to thousands of balls with a refresh rate $\leq$ 1 second.
I want to see exactly where my ball lands without searching all over.	Real-time ball tracking	Tracking system must show real-time flight and landing data with $\pm$0.5m accuracy. Must use GPS, radar, or computer vision, and display

		results on a user-accessible app or screen instantly after the ball lands.
The tracking technology should be simple and quick to use.	Fast setup and effortless tracking	Tracking system must allow full setup in under 10 minutes, have one-button activation, and show real-time ball location updates every second. Must require no technical skills and include clear usage instructions.
I want my customers and staff to enjoy their tasks and golf with ease	User-friendly golf course management system	System must provide mobile/desktop access to booking, payment, performance tracking for golfers, and scheduling/inventory for staff. Interface must be intuitive, require minimal training, and enhance overall experience.
I don’t want ground staff to spend too much time locating balls manually.	Automated ball tracking and retrieval	System must reduce manual search time by 80% through GPS, RFID, and sensor-based automation. Must collect balls into central storage, operate for 6 hours per charge, and require minimal user input and maintenance.

i. Rating of the VOC

To prioritize the technical specifications based on user needs, table 15 below shows the importance rating can be collected from interview and survey with stakeholders.

Table 15:Rating of VOC

User Need	Unnecessary	Less needed	Needed	Desirable	Critically desired
I get exhausted quickly when I have to collect balls in the heat.			/		
I want to optimize my time and avoid the inefficiency of searching for the balls at midnight.					/
I want accurate location of the balls.					/
I want good lighting and terrain		/			
I want machine easy to use				/	
There should be an integration option with GPS, RFID or scanning device.				/	
I want to see exactly where my ball lands without searching all over.					/
The tracking technology should be simple and quick to use.					/
I want my customers and staff to enjoy their tasks and golf with ease				/	
I don't want ground staff to spend too much time locating balls manually.					/

ii. Relative importance

Table 16 shows the result of the relative importance and priority rank for user needs based on interview and survey with stakeholders.

Table 16:Relative importance and priority rank for the user needs.

User need	Relative importance	Priority
I get exhausted quickly when I have to collect balls in the heat.	3	3
I want to optimize my time and avoid the inefficiency of searching for the balls at midnight.	5	1
I want accurate location of the balls.	5	1
I want good lighting and terrain	2	4
I want machine easy to use	4	2
There should be an integration option with GPS, RFID or scanning device.	4	2
I want to see exactly where my ball lands without searching all over.	5	1
The tracking technology should be simple and quick to use.	5	1
I want my customers and staff to enjoy their tasks and golf with ease	4	2
I don't want ground staff to spend too much time locating balls manually.	5	1

iii. House of Quality (HoQ).

In Phase 1 of the House of Quality (HoQ), the G-Sense development team focuses on translating customer needs into measurable and actionable product specifications. This begins with the identification of key customer requirements, which include:

- User friendly
- Easy implementation
- Maintenance requirement
- Tracking accuracy
- Speed of detection processing

These represent the most critical expectations of users, gathered through surveys and interviews.

To address these needs, the team defines a set of functional requirements, which are the technical features or design elements that can fulfill the customer expectations. These include:

- Real-time location tracking with ±0.5m accuracy
- Tracking system refresh rate ≤ 1 second
- Real-time flight and landing data display
- Infrared or night-vision detection capability
- User interface

These technical responses are chosen for their potential to be quantified, tested, and improved throughout the development process.

These specifications are then translated into clear, measurable product targets that guide the development process. At this stage, customer needs are also prioritized to focus on the most critical features, ensuring that the final product aligns with user expectations while remaining feasible in terms of cost and technical capability.

In addition, products identified through market research and background studies are treated as competitors within HoQ 1. Including these competitor products enables benchmarking and helps the team compare how well existing market solutions address the same customer requirements. This comparative analysis highlights performance gaps and supports the setting of more competitive and realistic design targets.A House of Quality for Phase 1 is developed to illustrate this structured process, as shown in Figure 12.

Quality Function Deployment

Project title:	G-Sense
Project leader:	
Date:	1/5/2025

Correlation:

+	.	-
Positive	No correlation	Negative

Relationships:

9	3	1	
Strong	Moderate	Weak	None

	1: low, 5: high	Desired direction of improvement (↑,0,↓)						Competitive evaluation (1: low, 5: high)			
	Customer importance rating	Functional Requirements (How's) → Customer Requirements - (What's) ↓	Real-time location tracking with ±0.5m accuracy	Tracking system refresh rate ≤ 1 second	Real-time flight and landing data display	Infrared or night-vision detection capability	User interface	Weighted Score	Competitor rating 1	Competitor rating 2	Competitor rating 3
1	5	Localization precision	9	3	9	9	1	155	9	3	3
2	3	User friendly	3	1	1	1	9	45	3	9	9
3	5	Easy implementation	0	0	1	0	9	50	1	9	9
4	5	Maintenance requirement	0	1	1	3	3	40	1	3	1
5	5	Tracking accuracy	9	9	9	9	1	185	9	3	9
6	3	Speed of detection processing	3	9	3	1	1	51	9	9	9
7	5	Adaptability to environmental conditions	9	0	0	3	2	70	9	3	9
8								0			
9								0			
		Technical importance score	153	95	112	126	110	596			
		Importance %	26%	16%	19%	21%	18%	100%			
		Priorities rank	**1**	**5**	**3**	**2**	**4**				

Figure 12:HoQ1

Explanation for HoQ1:

Once the relationships between customer and functional requirements are mapped in the HoQ matrix, the team assesses how strongly each technical feature contributes to fulfilling each customer's need. This is done using relationship scores which 9 for strong, 3 for moderate, 1 for weak, and 0 for none. For example, localization precision has a strong relationship with real-time location tracking, real time flight and landing data display, and infrared or night-version detection capability, all of which are essential for precise ball positioning. Tracking accuracy, one of the highest priority needs, shows strong relationships with all technical features, emphasizing its central role in product success.

Conversely, requirements like user friendliness rely heavily on the user interface, while easy implementation and maintenance requirements are more influenced by infrared detection and interface simplicity. Speed of detection is most impacted by the tracking refresh rate, which ensures real-time responsiveness.

The roof of HoQ analyzes the correlations between the technical requirements to identify how changes in one feature may affect others. In the G-Sense project, most technical requirements show positive or no correlation, indicating a well-aligned design strategy. For example, there is a strong positive correlation between real-time location tracking and the tracking system refresh rate, as a faster refresh rate enables more accurate and timely tracking. Similarly, infrared or night-vision detection capability positively supports both real-time tracking and flight and landing data display, especially in low-light environments, enhancing the system's adaptability and precision.

Another positive relationship exists between real-time flight and landing data display and the user interface, since a well-designed interface improves how effectively users can view and interpret tracking data. However, some relationships are neutral, such as between the user interface and infrared detection, or between the tracking refresh rate and the user interface, since these systems operate independently. Notably, there are no significant negative correlations among the technical requirements, suggesting that improving one area is unlikely to hinder another. This insight allows the development team to proceed confidently with enhancing multiple features simultaneously without compromising overall system performance. The roof of the HoQ therefore plays a crucial role in guiding balanced design decisions, ensuring technical harmony among the features while supporting the customer-driven goals defined earlier in the matrix.

In phase 2 of HoQ, it takes the prioritized product targets from phase 1 and breaks them down further into specific system components or subsystems that will achieve those targets. The engineering characteristics identified in phase 1 are mapped to the physical components or subsystems responsible for achieving them.

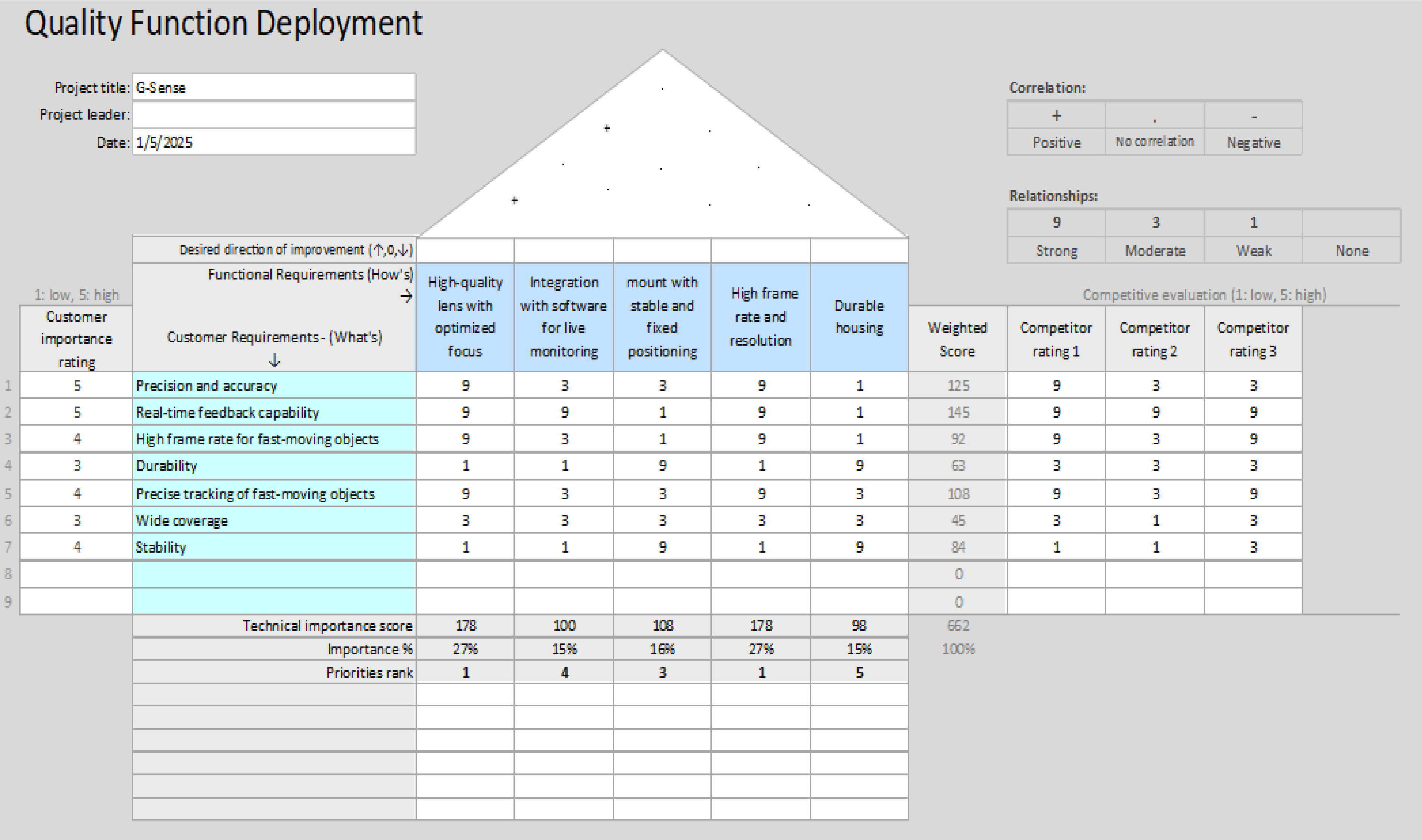
A second matrix is developed as shown in Figure 13, which visualizes the relationships between product targets and component characteristics, helping to ensure a systematic and traceable design process. This matrix identifies how each part characteristic contributes to the desired part targets.
show HoQ2.

Part target:

- Precision and accuracy
- Real-time feedback capability
- High frame rate for fast-moving objects
- Durability
- Precise tracking of fast-moving objects
- Wide coverage
- Stability

Part characteristics:

- High-quality lens with optimized focus
- Integration with software for live monitoring
- mount with stable and fixed positioning
- High frame rate and resolution
- Durable housing



Quality Function Deployment

Project title:	G-Sense
Project leader:	
Date:	1/5/2025

Correlation:

+	.	-
Positive	No correlation	Negative

Relationships:

9	3	1	
Strong	Moderate	Weak	None

Competitive evaluation (1: low, 5: high)

	Customer importance rating (1: low, 5: high)	Customer Requirements - (What's) / Functional Requirements (How's)	High-quality lens with optimized focus	Integration with software for live monitoring	mount with stable and fixed positioning	High frame rate and resolution	Durable housing	Weighted Score	Competitor rating 1	Competitor rating 2	Competitor rating 3
		Desired direction of improvement (↑,0,↓)									
1	5	Precision and accuracy	9	3	3	9	1	125	9	3	3
2	5	Real-time feedback capability	9	9	1	9	1	145	9	9	9
3	4	High frame rate for fast-moving objects	9	3	1	9	1	92	9	3	9
4	3	Durability	1	1	9	1	9	63	3	3	3
5	4	Precise tracking of fast-moving objects	9	3	3	9	3	108	9	3	9
6	3	Wide coverage	3	3	3	3	3	45	3	1	3
7	4	Stability	1	1	9	1	9	84	1	1	3
8								0			
9								0			
		Technical importance score	178	100	108	178	98	662			
		Importance %	27%	15%	16%	27%	15%	100%			
		Priorities rank	1	4	3	1	5				

Figure 13:HoQ2

Explanation for HoQ2:

The team assesses how well each technical feature contributes to fulfilling the customer requirements. For example, real-time feedback capability has a strong relationship with nearly all the functional requirements, particularly with software integration, frame rate and lens quality, reflecting the critical role these features play in delivering live and accurate information. Similarly, precision and accuracy also rely heavily on these same features, particularly the lens quality, mounting stability, and high frame rate, since these directly affect the system's ability to capture and display accurate visuals in real time. Precise tracking of fast-moving objects also shows strong dependencies on frame rate, lens focus and software, confirming the need for high-performance optical and processing systems. Lower-rated customer needs such as durability, coverage and stability show weaker or more selective relationships, mostly tied to durable housing and mount stability.

From these relationships, weighted scores are calculated to prioritize customer needs. Real-time feedback emerges as the top priority with a weighted score of 145, followed by precision and accuracy and tracking of fast-moving objects. These scores indicate which needs have the most influence over technical decision-making. On the technical side, the high-quality lens with optimized focus and high frame rate and resolution has the highest technical importance scores, making them the most impactful features to invest in. These are followed by mounting stability and software integration, both of which moderately contribute to fulfilling key requirements.

Additionally, the HoQ includes a competitive evaluation, comparing G-Sense against three existing products on a scale of 1 to 5. The competitors perform strongly in core areas such as real-time feedback, precision, and tracking, all scoring 9 in these domains. This benchmarking highlights that the market already offers high-performing systems, and G-Sense must either match or exceed these performance levels to be competitive. Lastly, the triangular roof section of the HoQ, although not fully detailed, would typically illustrate the correlations among technical features—for example, showing positive interdependencies between lens quality and frame rate, or identifying potential trade-offs, such as between durability and system weight or complexity.

In conclusion, this HoQ analysis helps the team identify the most critical engineering targets, prioritize resources, and set development goals that are aligned with both user needs and market expectations. The matrix provides a structured approach to decision-making, ensuring that the final product delivers high performance, usability, and competitive value.

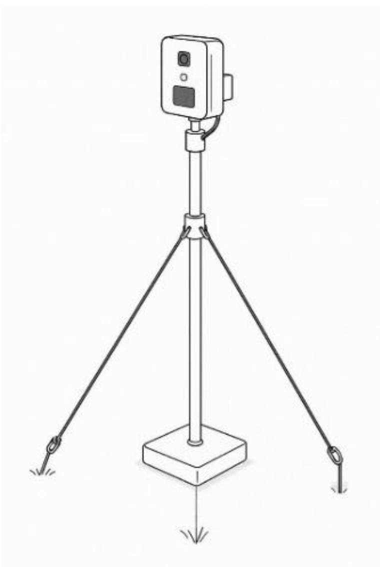
PHASEE 2: CONCEPT DEVELOPMENT

Initial Conceptualization

i. Ceiling-mounted camera

This ceiling-mounted camera system is well-suited for golf ball retrieval monitoring at driving ranges, offering high accuracy through its stable overhead position that ensures precise tracking of ball movements and retrieval equipment. Its fixed installation allows for consistent, clear visuals without the need for constant repositioning, while the high - quality lens and downward angle provide excellent clarity for observing golf ball paths and collection processes. Real-time feedback is achievable when integrated with monitoring software, allowing range staff to efficiently oversee operations and respond promptly to equipment issues or obstructions. With a frame rate likely sufficient to capture fast-moving golf balls like typically 30 to 120 fps. This system can effectively document rapid retrieval cycles. Its durable mount and protected design make it ideal for long-term use in an active driving range environment, where reliability and minimal maintenance are key.

ii. Portable camera



The camera shown in the image appears to be a precision measurement or monitoring device, likely used in applications such as surveying, construction, or environmental monitoring. Its accuracy is typically high, often within millimeter or sub-degree ranges, ensuring precise data collection essential for tasks like alignment, levelling or mapping. The design, featuring a sturdy tripod base with tension cables for stability, indicates ease of use even in outdoor or uneven terrains, as it minimizes vibrations and movement that could affect readings. Additionally, such cameras often provide real-time feedback through an integrated display or connected app, allowing users to immediately assess data quality, make on-the-spot adjustments, and ensure optimal setup without needing post-processing, thereby improving efficiency, and reducing errors during operation.

iii. Stand-able camera

The camera depicted in the image, likely designed for outdoor surveillance or sports performance tracking, offers impressive accuracy in capturing detailed movements or activities over long distances, making it suitable for monitoring environments like driving ranges or sports fields. Its clarity is enhanced by a high-resolution lens and possibly advanced features like autofocus and low-light compensation, ensuring sharp, detailed images even in challenging lighting or weather conditions. Built with robust, weather-resistant housing, the camera demonstrates excellent durability, capable of withstanding prolonged exposure to rain, wind, and varying temperatures, which ensures reliable performance and minimal maintenance needs in demanding outdoor settings.

iv. Portable 360 vision camera

The camera shown in the image, labeled “360 Vision,” is likely a high-performance 360- degree camera designed for sports analysis, such as monitoring golf swings, and offers exceptional accuracy in capturing motion from all angles, ensuring no detail is missed in performance tracking. Its ease of use is enhanced by a compact, tripod-mounted design that allows for quick setup and adjustment, making it user-friendly even for individuals without technical expertise. The clarity of the camera is impressive, delivering sharp, high-resolution video that captures fine details such as ball trajectory, body movement, and environmental context, which is essential for precise feedback and improvement. Furthermore, its high frame rate capability ensures smooth video playback without motion blur, even during fast swings or rapid movements, making it ideal for detailed slow-motion analysis and enhancing the overall user experience in both practice and competitive settings.

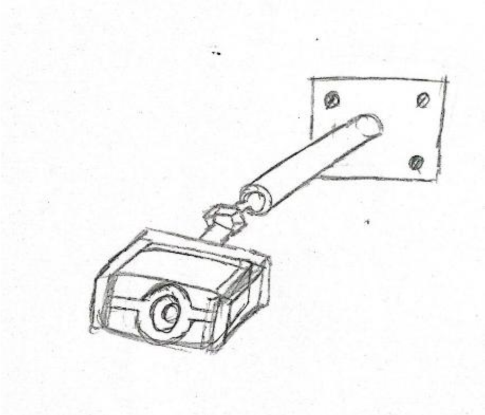
v. GolfEye pro camera

The GolfEye camera that with its compact and sturdy design, is well-suited for golf ball retrieval monitoring at a driving range, offering excellent accuracy in tracking golf balls across the range and ensuring precise detection of their locations for efficient collection. Its ease of use is reflected in its simple installation, user-friendly interface, and potential integration with mobile or desktop applications, allowing staff to monitor activity and ball distribution effortlessly. The camera provides outstanding clarity, delivering sharp, high-resolution video that clearly captures the movement and resting spots of golf balls, which is critical for optimizing retrieval operations. Built with durability in mind, its robust housing can withstand the occasional impacts, vibrations, and environmental conditions typical of a busy driving range. Moreover, its high frame rate enables smooth and uninterrupted tracking of fast-moving golf balls, ensuring no movement is missed and supporting both real-time monitoring and effective post-session analysis to improve operational efficiency.

vi. Range vision 360

The camera shown in the image, with its dome design and ceiling mount, is highly suited for golf ball retrieval at driving ranges, offering exceptional accuracy in tracking ball movement and pinpointing locations across wide areas, which greatly enhances retrieval efficiency. Its ease of use comes from its fixed overhead installation and automated pan- tilt-zoom (PTZ) capabilities, which allow operators to monitor large sections of the range effortlessly through intuitive controls or integrated software. The camera delivers outstanding clarity, capturing high-resolution images and video that ensure even fast- moving golf balls are visible and trackable under varying lighting conditions. With real- time feedback, staff can immediately observe ball dispersion and retrieval progress on connected devices, enabling quick decision-making and operational adjustments. Its durable build is designed to withstand continuous operation in both indoor and semi- outdoor environments, resisting dust, vibrations, and temperature changes. Additionally, the high frame rate ensures smooth, lag-free video streams, allowing accurate tracking of rapid ball movement and guaranteeing that no action is missed during busy periods.

vii. G-Sense camera

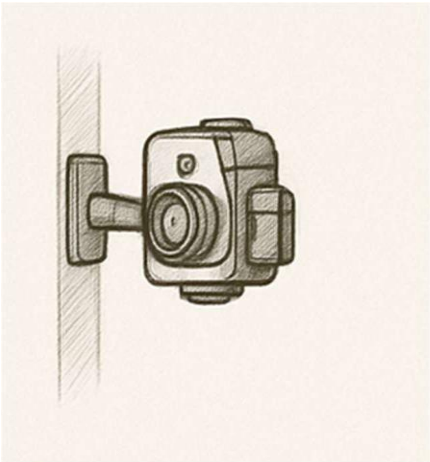


The G-sense is designed to deliver reliable and precise monitoring, offering good accuracy with its focused lens that helps clearly detect and identify objects or movement. It is easy to use, featuring an adjustable arm and secure wall mount that allow users to quickly install and position it exactly where needed. The camera provides clear, sharp images, ensuring important details are visible even in different lighting conditions. It also offers real-time feedback by streaming video instantly, enabling live monitoring and quick responses. With a standard frame rate that ensures smooth, steady video without blurring during motion, G-sense is well-suited for effective tracking. Additionally, its durable construction and stable mounting system ensure it can withstand long-term use.

viii. LiveView Pro camera

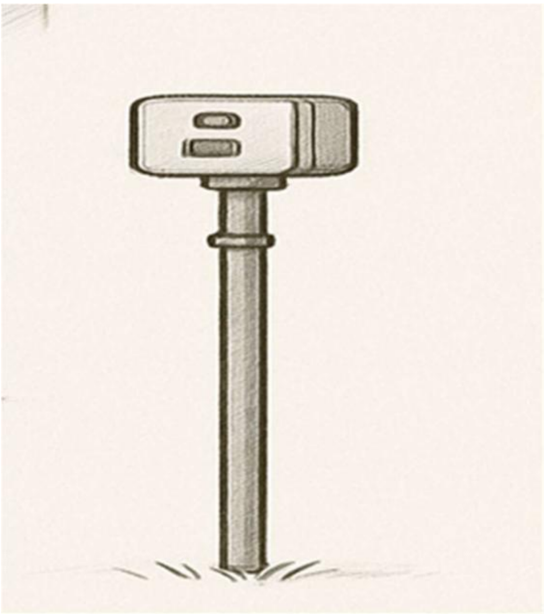
The LiveView Pro camera depicted in the image is designed to deliver outstanding clarity, providing crisp, high-resolution video that captures fine details essential for applications such as sports training, motion analysis, or live demonstrations. Its precision optics and image sensors ensure that even subtle movements or expressions are recorded with sharpness and minimal distortion, making it ideal for both real-time feedback and post- session review. Additionally, the camera’s high frame rate capability allows it to record smooth, fluid video even during fast-paced actions, reducing motion blur and ensuring that every moment is captured accurately and clearly, which is particularly valuable for slow-motion playback and detailed performance analysis.

ix. Go Pro camera



This driving range golf swing camera is designed to deliver accurate and clear video capture of a golfer’s swing, providing real-time feedback that helps improve technique. With its high frame rate, it ensures smooth, detailed recordings that allow golfers and coaches to analyze motion with precision, while its wide-angle lens guarantees full swing coverage without distortion. The camera is built for ease of use, typically requiring minimal setup, and integrates seamlessly with display systems or analysis software. Its durable, weather-resistant housing ensures long-lasting performance in outdoor conditions. Together, these features can work in harmony, making the camera a reliable and valuable tool for both amateur and professional golf training.

x. Golf shot cam



This driving range golf camera is designed for ease of use, featuring a simple setup and automatic recording that allows golfers and coaches to quickly capture and analyze swings without technical hassle. Its high frame rate ensures smooth, detailed video that accurately captures fast movements, enabling effective slow-motion playback and precise swing analysis. However, the camera lacks durability, as its design does not appear to include weatherproofing or impact-resistant housing, making it vulnerable to rain, dust, and accidental damage, and therefore better suited for indoor or sheltered driving range use rather than prolonged outdoor exposure.

Concept Screening and Scoring

a) Concept Scoring

Table 17 shows the Concept Scoring for 10 designs in initial conceptualization.

Table 17: Concept Screening

Selection Criteria	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Concept 6	Concept 7	Concept 8	Concept 9	Concept 10
Accuracy	++	+	+	+	++	-	++	++	0	0
Ease of Use	+	++	0	++	+++	0	0	0	0	+
Clarity	+	-	+	0	+	+	++	+	0	0
Real-time Feedback	-	+	-	+	0	0	+	+	0	0
Frame Rate	+	0	+	+	+	+	++	+	0	+
Durability	++	+	++	++	-	0	+	+	0	-
Sum of +	7	5	5	6	7	2	8	6	0	2
Sum of 0	3	2	1	1	1	4	1	1	6	4
Sum of -	1	1	2	0	2	1	0	2	0	1
NET SCORE	6	4	3	6	5	1	8	4	0	1
RANK	2	6	7	3	4	9	1	5	10	8
CONTINUE?	YES	NO	NO	COMBINE		NO	YES	NO	NO	NO

Relative Performance	Rating	Previous Method
Much worse than reference	1	--
Worse than reference	2	-
Same as reference	3	0
Better than reference	4	+
Much better than reference	5	++

+ “better than”

0 “same as”

-“ worse than”

After evaluating all the proposed design concepts based on key criteria such as accuracy, ease of use, and real-time feedback, the following decisions were made:

• Concept 1

Selected to proceed to the next stage due to highest net score.

• Concept 7

Demonstrated strong potential and was chosen to continue independently.

• Combined Concept (4 + 5)

These two concepts were found to have complementary strengths and were merged to form a more robust and comprehensive solution.

• Concepts 2, 3, 6, 8, 9, and 10

These concepts were screened out due to lower performance against the selection criteria.

b) Concept Scoring

Table 18 below shows the concept of scoring by using the result of Table 17.

Table 18: Concept scoring

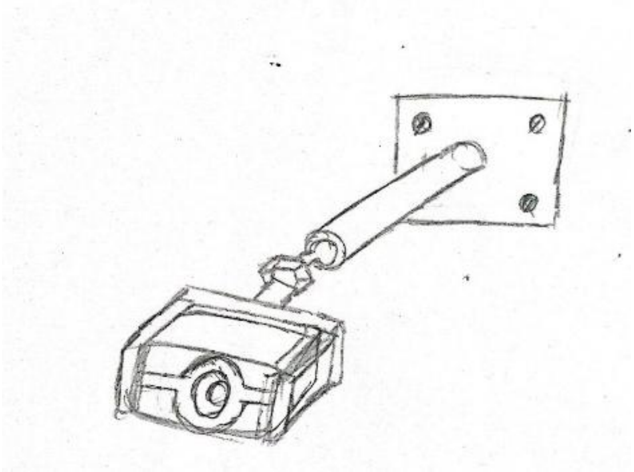
Selection Criteria	Weight (%)	Concept					
		Concept 4&5		Concept 1		Concept 7	
		Rating	Weight Score	Rating	Weight Score	Rating	Weight Score
Accuracy	25	5	1.25	5	1.25	5	1.25
Ease of use	5	3	0.15	3	0.15	5	0.25
Clarity	20	3	0.6	5	1	4	0.8
Ral-time feedback	10	4	0.4	5	0.5	4	0.4
Frame-rate	25	4	1	5	1.25	4	1
Durability	15	4	0.6	4	0.6	3	0.45
TOTAL	100	4		4.75		4.15	
RANK		3		1		2	
CONTINUE?		NO		YES		NO	

In concept scoring, the shortlisted concepts were evaluated in greater detail using a weighted scoring method. Criteria such as accuracy, ease of use, and real-time feedback were assigned weights based on their importance. Each concept was then scored accordingly. The rating for each criterion was derived through a structured design review process, where cross-functional team members including design and user experience representatives individually assessed each concept against predefined performance benchmarks. Scores were given on a standardized scale, for example from 1 to 5, and team discussions ensured consistency by aligning on the interpretation of scoring guidelines. Weightings for each criterion were set during the planning phase of the design process, based on user research, project objectives, and risk analysis, to reflect what aspects mattered most for the target application. The weighted scores were then calculated by multiplying each criterion score by its assigned weight and summing the results to get a total score for each concept. This systematic approach ensured transparency, repeatability, and alignment with best practices in product design and manufacturing decision-making.

Concept 1 achieved the highest total weighted score, showing consistently strong performance across all major evaluation areas. It stood out particularly in terms of accuracy, clarity, and real-time feedback. These strengths make it highly suitable for further development, with strong potential to fulfil user needs and project objectives effectively. In contrast, Concept 7 and the Combined Concept (Concept 4 + 5), while demonstrating innovation and certain desirable features, did not perform as well in key areas. Their lower scores in clarity and durability raised concerns about potential user confusion and long-term reliability. As a result, they were deemed less favorable for advancement at this stage.

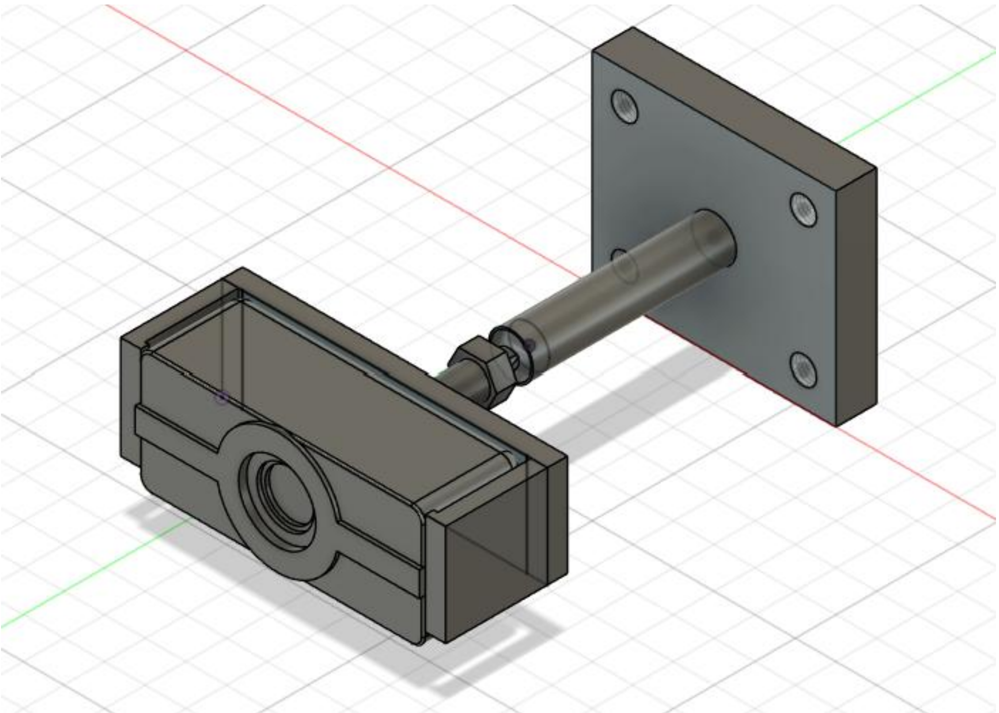
In conclusion, Concept 1 is the most viable and best option, meeting both technical and user expectations effectively.

PROPOSED PRODUCT DESCRIPTION



The G-sense is a precision-mounted camera or sensor system designed for reliable monitoring and tracking applications, integrating features that prioritize accuracy, ease of use, clarity, real-time feedback, high frame rate, and durability. The design includes an articulated mounting arm secured to a stable wall plate, enabling precise angle adjustment and flexible positioning (up, down, left, and right) to maximize coverage and ensure the sensor can be aligned optimally for its environment. This ease of use is further supported by a straightforward installation system, likely with universal screw fittings and tool-free adjustments that make it accessible even to less experienced operators. In terms of accuracy, the prominent lens suggests an advanced optical system capable of high-resolution imaging with minimal distortion, essential for security, motion tracking, or industrial inspection tasks that demand reliable identification and measurement. Clarity is enhanced through careful attention to lens design, with potential for anti-reflective coatings and low-light or infrared capabilities to maintain crisp, detailed images even in challenging lighting conditions. Additionally, the G-sense is designed to provide real-time feedback, supporting live monitoring with minimal latency, enabling immediate responses to detected motion or anomalies, and integrating easily with networked systems or cloud-based analytics for automated alerts and continuous surveillance. The expected frame rate is another critical aspect for standard security use or higher rates for specialized applications like analyzing fast-moving objects in driving range or manufacturing quality control, ensuring smooth, blur-free capture of dynamic scenes. Finally, the durability of the G-sense is evident in its robust construction, with a solid housing and mounting system intended to withstand mechanical stress, weather exposure, dust, and temperature variations, making it suitable for both indoor and outdoor use in demanding environments. Overall, the G-sense represents a professional-grade solution that balances technical sophistication with practical design, delivering dependable, high-quality performance essential for modern monitoring and security needs.

DETAILING CAD MODELLING

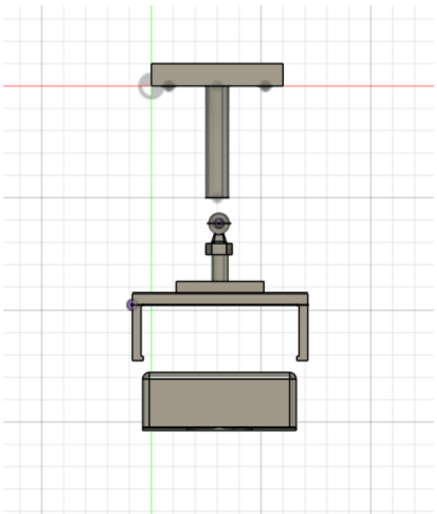
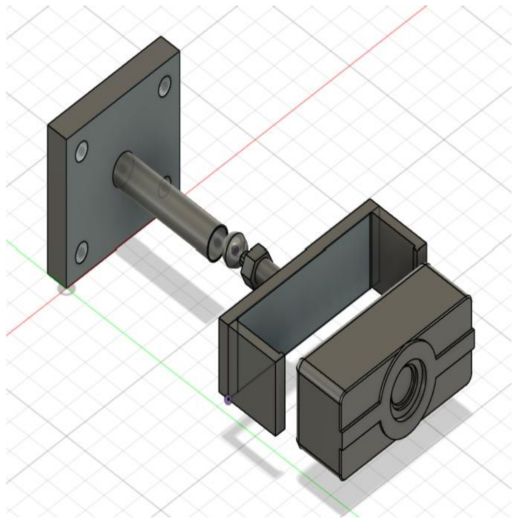
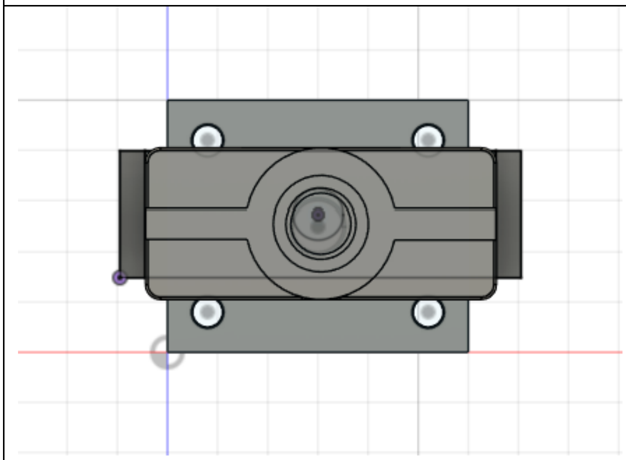
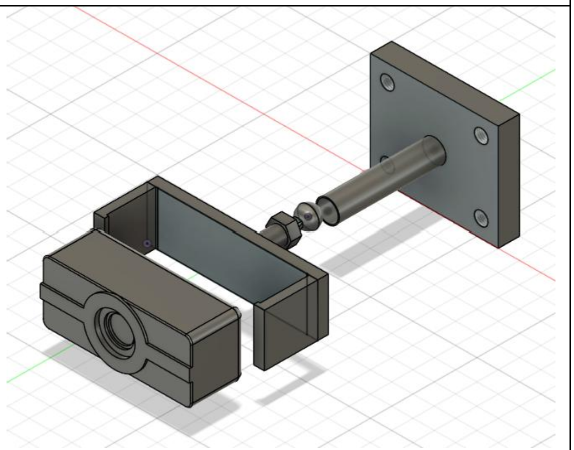


The 3D model of the G-sense device illustrates a thoughtfully engineered surveillance or sensing unit featuring a rectangular housing mounted on an articulated support arm fixes to a wall plate, chosen specifically to meet the demanding criteria of precision monitoring applications. This concept was selected because it delivers a practical, reliable, and highly adaptable design solution, critical for ensuring accuracy in positioning and measurement. For example, the articulated arms allow fine-tuned angular adjustment so the camera or sensor can be precisely aimed to cover the required field of view without blind spots, reducing setup errors and ensuring consistent data capture. The ease of use is emphasized through the simple yet effective mounting system, with a flat base plate including the four holes of screw for stable the installation on variety of surfaces, while the adjustable joint allows users to quickly align or reorient the device without specialized tools, making maintenance and redeployment straightforward.

On the other hand, the rectangular holder itself offers a well-defined, protective cradle that securely fixes the camera in place, supporting the clarity by maintaining the correct alignment and shielding the camera body from impacts or environmental contamination, which helps preserve consistent image quality. Moreover, this stability directly benefits real-time feedback, ensuring that live video or sensor data streams remain steady and reliable without disruptive shifts or vibrations that could introduce errors and blur. The design also supports maintain a high frame rate, since secure mounting prevents camera shakes that could degrade the quality of fast-motion capture, then making it suitable for tracking moving objects or real-time analysis in driving range contexts.

Furthermore, durability is another important factor that addressed by this concept such as the arm and the holder are designed for robust mechanical performance, with materials and connections that can withstand environmental exposure and repeated adjustment over time. Overall, this concept was chosen because it offers a practical and user-friendly for safely holding and precisely positioning a camera unit in demanding monitoring applications, ensuring accurate, clear, and reliable performance while remaining easy to install, adjust and maintain in the field.

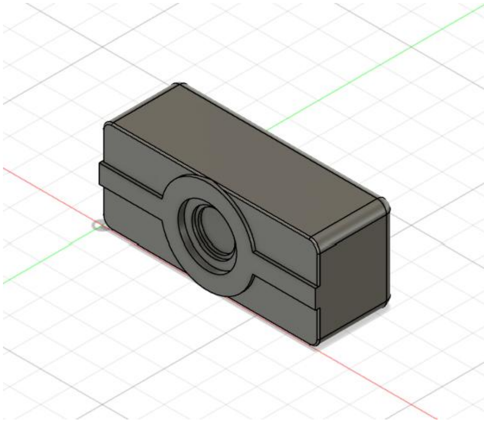
a) The View of the 3D Design

 Top view	 Left view
 Front view	 Right view

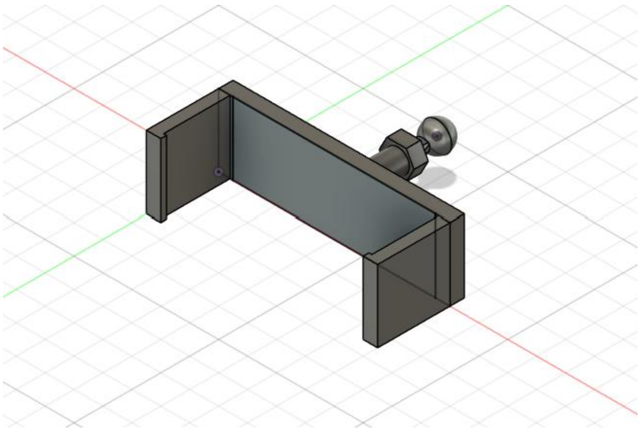
The mechanical assembly, viewed from multiple angles, reveals a camera mounting system optimized for precision, stability, and adaptability. The top view emphasizes a symmetric and well-balanced design, ensuring accurate alignment along the central axis and ease of integration with real-time feedback systems. The left view showcases the modular support structure, highlighting the cylindrical rod, adjustable ball joint, and U-shaped frame that securely holds the camera. This is all for reliable performance under repeated adjustments. The front view confirms the minimal vibrations, which are essential for consistent image capture. Then, the right view reinforces the assembly's mechanical simplicity and functional strength, revealing the full mounting path from base plate to the camera. Taken together, the design reflects a well-rounded solution that balances accuracy, clarity, durability, and user control on making it highly suitable for driving range.

b) Part

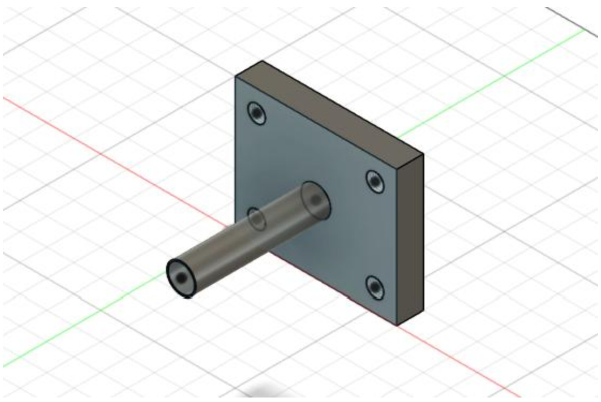
i. Camera



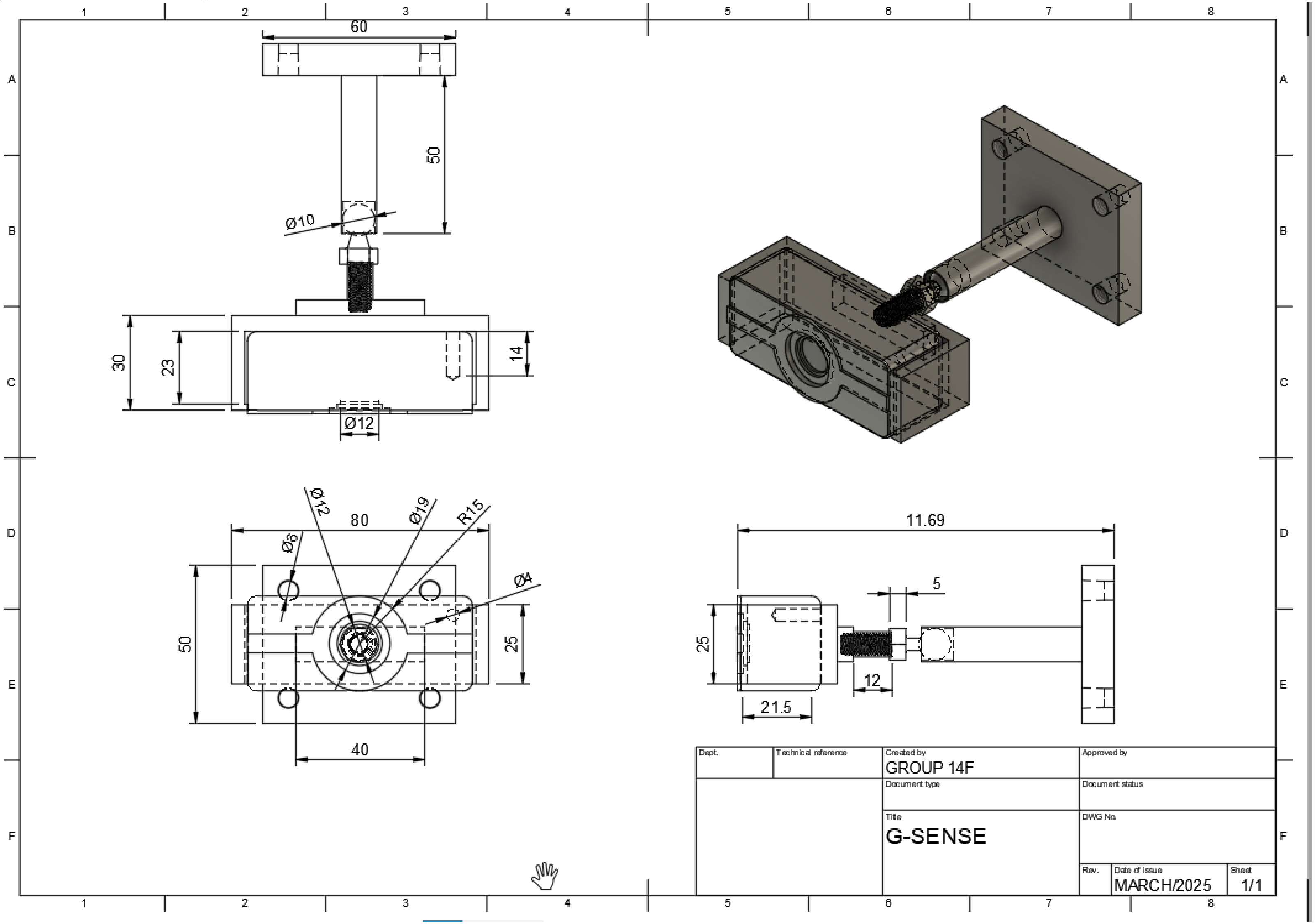
ii. Holder with the ball joint



iii. Base plate with the rod



c) Technical Sketching



PHASE 3: ENGINEERING ANALYSIS

Mechanical Analysis

a) Design Concept Overview

This design provides real-time monitoring and supports both coaching and operational efficiency. The proposed system consists of a camera mounted securely on a mechanical frame or mast positioned strategically around the golf range. The camera will support by a mechanical frame designed for stability against wind load and vibrations. This camera is programmed with a vision-based detection algorithm capable of recognizing golf balls at various distances across the range.

The primary purpose of this system is twofold:

i. To assist coaches and players in analysing consistency by showing where the balls are landing and supporting performance analysis and technique improvement.

ii. To support workers by allowing them to quickly identify the high-density areas for efficient ball retrieval, while saving time and effort, improve comfort of the job for the workers also for the new recruits.

To achieve the purpose, the system must require:

i. Identifies and locates golf balls in real-time using object (golf ball) detection algorithms such as YOLO and OpenCV.

ii. Generates a colour coding map display using consistency fundamental of golf ball predicted will fall.

- Red zones show where there are many golf ball (high golf ball quantity).
- Yellow zones represent moderate quantity golf ball areas.
- Green highlighted low quantity areas.

b) Engineering Assumptions

In designing the camera mounting and ensuring the structure is safe and reliable. Assumptions ensure that the calculations remain conservative and that the structure should withstand more than the expected loads without risk of failure. Then, certain assumptions are made:

i. The combined mass of the camera and housing together approximately is about 2kg (typically for industrial outdoor cameras.

ii. The frame or mast height is 3m, high enough to provide a good angle for monitoring without obstructing play.

iii. The system will be exposed to maximum wind speeds of 20m/s, which is common for outdoor design conditions (storm winds).

iv. The frame is made from steel, which widely available and offers a good balance of strength and cost. Its yield is 250MPa.

A factor of safety (FOS) of at least 2.5 is targeted, meaning for all structure components should withstand more than twice the expected loads without risk of failure

c) Structural Analysis

The main structural consideration is the ability of the frame to withstand wind forces without failure of excessive deflection that could affect camera alignment.

Wind Force Calculation

We calculate the force acting on the camera due to wind. Wind exerts a drag force depending on the wind speed, air density, exposed area and shape of the object which represents the horizontal load acting at the camera's height. Using the standard drag force formula:

$$F = \frac{1}{2}\, pv^2\, AC_d$$

p = air density

v = wind speed

A = frontal area of the camera housing

C_d = drag coefficient (object)

$$F = \frac{1}{2}\,(1.225kg/m^3)(20^2)(0.05m^2)(1.2)$$

$$F = 14.7N$$

Bending Moment at Base

This moment represents the torque that the base of the frame must resist to prevent tipping or failure.

$$M = F \times h \times g$$

M = moment

F = wind force

h = height of frame from base

g = gravity

$$M = 14.7N \times 3 \times 9.81$$

$$M = 433Nm$$

Stress in Frame/Holder

To check the frame's strength, we calculate the stress:

$$\sigma = \frac{\mathrm{M}}{\mathrm{Z}}$$

σ = stress

M = moment

Where,

Z = section modulus of the frame (depends on cross-section shape)

Assuming for a 85mm x 10mm with 10mm thickness, Z = $8.5 \times 10^{-6} m^3$

$$\sigma = \frac{433\text{Nm}}{8.5 \times 10^{-6} m^3}$$

$$\sigma = 51MPa$$

This means the stress in frame(holder) due to the wind is 51MPa.

Factor of Safety

This formula is intentional for outdoor equipment to ensure long-term reliability and resistance to unexpected conditions like gusts or minor impacts.

$$FOS = \frac{yield\ strenght}{\text{calculated stress}}$$

$$FOS = \frac{250MPa}{51\text{MPa}}$$

$$FOS = 5$$

∴ This FOS (5) shows that the structure is strong enough for normal outdoor conditions.

Ball Detection and Retrieval Calculations

i. Assuming the camera cover a field area: 50m x 50m = 2,500m^2
ii. The camera's field of view (FOV) generates an image of 1920 x 1080 pixels (Full HD)

$$Area\ per\ pixel = \frac{field\ area}{FOV}$$

$$Area\ per\ pixel = \frac{2500m^2}{1920 \times 1080pixel}$$

$$Area\ per\ pixel = 0.006m^2/pixel\ \ @\ \ 6mm^2/pixel$$

A golf ball has an area of about 143mm2 (based on its 42.7mm diameter). This resolution is good enough of occupying one full pixel of golf ball.

Ball Count Per Zone

To determine how much field each colour zone cover for colour-coded map:

- Coordinate - x = 5
- Coordinate - y = 25
- Total = 5 x 25 = 125

$$Zone\ area = \frac{total\ field\ area}{\text{number of zones}}$$

$$Zone\ are = \frac{12500}{125}$$

$$Zone\ area = 100m^2$$

∴ The zone can be divided into minimum each $100m^2$ of $12500m^2$ field for colour-coded map.

Ball Density Calculation

To decide colour coding for retrieval map:

$$Ball\ density = \frac{\text{ball count}}{zone\ area}$$

$$Ball\ density = \frac{\text{3000 balls}}{125\ zones}$$

$$Ball\ density = 24\ \text{balls per zone (min)}$$

The result above just assumption for min of balls for every zone, but the reality is not every zone has the same number of balls. It can be like this:

Zone	Number of balls
1	30
2	6
3	25
…	…
125	10

Time Saved

To measure efficiency for workers:

$$Time\ saved = \frac{\text{area reduction}}{speed}$$

- Without camera, workers search entire area of $12500m^2$.

- With camera, workers can focus on red (high ball density area) and yellow (moderate ball density area) zone. If the area is 40% of total, then he just needs to collect the ball in 5000m^2 before continuing to the green (low density of ball).

In average retrieval speed of 1m^2/sec

$$Without\ camera\ system: \frac{12500}{1} = 12500\,\text{sec} = 3.47hr$$

$$With\ camera\ system: \frac{5000}{1} = 5000sec = 1.39hr$$

∴ Time saved = 7500 seconds (2.08 hr per cycle).

Coaching Consistency Calculation

For coaching, we calculate the spread consistency of ball landings by collect (x,y) coordinates of detected balls:

Mean Position (x,y):

$$\bar{x} = \sum x_i \qquad \bar{y} = \sum y_i$$

Landing Spread Radius

Standard deviation to quantify player shot consistency:

$$\sigma = \sqrt{\frac{1}{N}\sum((x_i - \bar{x})^2 + (y_i - \bar{y})^2)}$$

N = Number of balls

Example for 5 balls:

Ball	x_i (m)	y_i (m)
1	50	20
2	52	22
3	48	18
4	51	19
5	49	21

$$\bar{x} = \frac{1}{N}\sum x_i$$

$$\bar{x} = 50 + 52 + 48 + 51 + 49 = \frac{250}{5} = 50$$

$$\bar{y} = \frac{1}{5}\sum y_i$$

$$\bar{y} = 20 + 22 + 18 + 19 + 21 = \frac{100}{5} = 20$$

$$d_i^2 = (x_i - \bar{x})^2 + (y_i - \bar{y})^2$$

Ball	d^2_i
1	0
2	8
3	8
4	2
5	2

$$\sigma = \sqrt{\frac{1}{N}\sum((x_i - \bar{x})^2 + (y_i - \bar{y})^2)}$$

$$\sigma^2 = \frac{1}{N}\sum d_i^2$$

$$\sigma^2 = \frac{1}{5}(0 + 8 + 8 + 2 + 2) = \frac{20}{5} = 4$$

$$\sigma = \sqrt{4} = 2m$$

∴ The spread radius (standard deviation) is 2 meters. This means on average, the balls landed about 2 meters from the center point of the group.

d) Performance Analysis

The system's performance in terms of camera detection. To ensures both coaching value (consistency tracking) and retrieval efficiency (workers can quickly focused on high quantity ball areas) was evaluated through simulation:

- Detection accuracy

The programmed algorithm is simulated by using Python + OpenCV can correctly identify and count golf balls with 95% accuracy within a 50 meters range when lighting is good.

- Processing speed

The detection system processes video at 30 frames per second (FPS), ensuring smooth and real-time operation.

- Colour coding map response

The system generates and updates the color-coded in under 100 milliseconds, giving workers and coaching up-to-date information on ball distribution.

Failure Modes and Effects Analysis

To ensure robustness of the system, a Failure Modes and Effective Analysis is conducted as summarized and show in Table 19.

Table 19: Summary of FMEA for robustness of the system

Failure Mode	Cause	Effect	Severity	Occurrence	Detection	RPN	Mitigation Action
Camera housing failure	Corrosion and impact damage	Loss of detection	8	3	5	120	• Use corrosion-resistant coating • Schedule regular inspection.
Detection algorithm	Poor lighting and ball occlusion	Missed ball detections	7	4	4	112	• Improve range lighting • Consider infrared support • Enhance algorithm
Power loss	Power supply failure	System stops working	9	2	3	54	• Provide uninterruptible power supply (UPS) backup
Frame structural failure	Extreme wind load	Camera misalignment or damage	9	1	7	63	• Strengthen design • Include additional bracing • Routine maintenance

Colour map	Software bug or error in visualization	Worker confusion and inefficient retrieval	6	3	3	54	• Implement rigorous software validation and user interface testing

For further understanding, the structural robustness of the system means that the mechanical frame was intentionally designed to be stronger than necessary. With a factor of safety greater than 20, the frame can easily handle wind forces that are much stronger that what would normally be expected at the golf driving range. This ensures the camera remains stable and reliable even in harsh weather conditions.

Since this is outdoor equipment, it is exposed to rain, sun and other environmental factors that can cause corrosion or damage over time. To protect the system and reduce the need for frequent maintenance, we would like to use corrosion-resistant materials or apply protective coatings that extend the lifespan of the equipment.

For the system reliability, a power backup (such as a UPS) needs to be included to ensure the camera keeps working even if there is a power cut. In addition, the software is designed with checks and backups so that errors in detecting golf balls are minimized. This help ensure the system provides consistent, and accurate results.

The colour-coded map offers immediate and clear feedback to workers. By showing red areas for high ball concentration, yellow for moderate and green for low consistency. Workers can quickly identify where to focus their efforts by time. This will save time and reduces the effort needed for ball collection.

The camera system for golf ball detection is mechanically sound and operationally efficient. The structural analysis confirms it can endure environmental conditions safely. The detection algorithm performs effectively in recognizing golf balls and providing real-time colour coding maps. The risk analysis identifies potential failure points and provides clear mitigation strategies to ensure consistent and reliable performance in coaching and ball retrieval operations.

PHASE 4: DESIGN ITERATION AND OPTIMIZATION

In this phase, the system underwent critical refinement to enhance functional performance, cost-efficiency and environmental sustainability. By incorporating key principles of Design for Manufacturing and Assembly (DFMA), alongside continuous sustainability evaluations, the team implemented several design improvements to ensure the product remain viable for real-world deployment at driving ranges. The integration of engineering analysis, design iteration and feedback from early prototypes allowed for a thorough evaluation and optimization of both the mechanical structure and embedded system.

Design For Manufacturing Assemble

The implementation of Design for Manufacturing and Assembly (DFMA) principles was crucial in evolving the G-Sense product from a basic conceptual sketch to a refined, optimized solution ready for prototyping and manufacturing. This approach significantly improved the ease of production, reduced cost, and enhanced the serviceability of the product.

Table 20 shows a structured comparison of how DFMA was applied, showing the transformation from the initial design to the finalized concept.

Table 20: Structured comparison of DFMA

Aspect	Initial Concept	Finalize concept
Part count	Single body or integrated form with undefined modularity.	Clear segmentation into base, rod, holder and webcam module. Fewer parts optimized for manufacturing.
Component modularity	Fixed configuration, all parts appear permanently attached.	Modular assembly allows independent replacement of components such as holder or camera module.
Adjustability	Lack adjustability which is a fixed angle mounting system.	Ball joint mechanism provides multi directional adjustability without requiring extra parts or tools.
Assembly complexity	Limited accessibility to internal parts, therefore	Tool-friendly design with standard fasteners and

	special tools or disassembly steps is required.	clear part orientation, simplified one- directional assembly.
Ease of Disassembly	Integrated structure would be difficult to open or service.	Integrated structure would be difficult to open or service.

Sustainability Aspects

In addressing sustainability, the G-Sense project team placed significant emphasis on environmentally responsible engineering practices throughout the design refinement process. Material selection was a primary consideration, with a focus on using recyclable and lightweight materials such as aluminum alloys and high-density polyethylene (HDPE), both of which offer durability while reducing environmental impact. These materials ensure longevity under harsh conditions and support ease of disassembly and recyclability at the end of the product's lifecycle. The design also incorporated energy-efficient components, including low-power processors and camera modules that are optimized for minimal energy consumption during extended real-time tracking, particularly valuable for outdoor and unmanned deployments.

From a lifecycle perspective, the system was developed with a modular design approach that supports easy upgrades and repairs, effectively extending its usable life and reducing electronic waste. Non-toxic, RoHS-compliant materials were chosen wherever possible to minimize environmental harm during disposal or recycling. The weather-resistant enclosure and mounting structure help reduce maintenance frequency and material replacements, thereby conserving resources over time. Additionally, the design process emphasized minimizing part count and selecting materials that require less energy-intensive manufacturing processes, which contributes to a lower carbon footprint during production. Collectively, these strategies ensure that the G-Sense system is not only functionally robust but also aligns with modern sustainability principles, balancing high performance with long-term environmental responsibility.

Iterative Design Improvements Based on Analysis

The iterative design process for the G-Sense system was driven by findings from engineering analysis, DFMA principles, and sustainability assessments. Initially, the design consisted of a monolithic ceiling-mounted camera with a fixed vertical rod, which lacked adjustability and modularity, limiting both its functionality and maintainability. Engineering analysis revealed that the structure needed enhancements to withstand environmental conditions such as wind load and potential corrosion, prompting the adoption of stronger materials and protective coatings. The system's mechanical frame was redesigned for improved structural resilience, achieving a factor of safety greater than 20, and ensuring reliable operation even in storm-like conditions. At the same time, Design for Manufacturing and Assembly (DFMA) principles guided the transformation from a complex, hard-to-service assembly into a simplified, modular design. This included segmenting the system into four key components—base plate, adjustable rod, holder with a ball joint, and protective camera housing—each optimized for ease of production, assembly, and maintenance

From a sustainability standpoint, further improvements were introduced to allow for easy disassembly and end-of-life recyclability, addressing the shortcomings of the initial design which did not support responsible disposal or upgrades. Energy efficiency was enhanced by selecting low-power infrared sensors and processors, minimizing consumption during continuous operation. The modular camera holder was improved with a ball joint mechanism, allowing multi-directional adjustment without extra tools, which was a critical enhancement based on DFMA analysis. These changes also addressed issues such as obstructed views and alignment limitations observed in the early prototype. Finally, usability feedback and real-world deployment scenarios were integrated to refine the software interface and detection algorithms, ensuring the system could deliver accurate, real-time feedback under varying light and environmental conditions. Collectively, these iterative refinements resulted in a technically sound, sustainable, and user-centered design, ready for prototyping and future field validation.

FUTURE PLAN

PHASE 5: ENGINEERING AND PROTOTYPING

Bill of Material (BOM)

The next phase of the project will concentrate on systematically developing the design, followed by prototyping, testing, and refinement. Our aim is to create a reliable and effective camera-based system for tracking and identifying golf balls in a driving range environment. The plan includes the following key components design development, material selection, fabrication and cost estimation. Table 21 shows the BOM for the product.

Table 21: Bill of Materials (BOM)

No	Component	Quantity	Description	Function
1	Wall anchor screw	4	1cm x 2cm	Helps the screw grip better in concrete or brick walls.
2	Wall bracket	1	Flat bracket 6cm x 5cm x 1cm	Holds the aluminium rod tightly and connects it to the wall.
3	Aluminium Rod	1	Ø1 cm length 4 cm	Works as the main support pole for the whole webcam mount.
4	Ball Joint Swivel	1	Ø1 cm length 3.5 cm	Allows the webcam to pan (side to side) and tilt (up or down)
5	Aluminium hose adapter joiner	1	Approximately equal to diameter of the ball	Acts as the socket to hold the ball joint so it can rotate smoothly.
6	Screw	4	1 cm x 2 cm	Used to fix the wall bracket
7	Aluminium plate	1	7cm x 3cm x 2.5cm	Supports the webcam and connects to the top of the ball joint.
8	Webcam T-WOLF WC15	1	A small USB webcam with an HD lens	The main device that track and estimate the location of the golf balls

Proposed Materials and Justification

The materials selected for this prototype are depending on the factors such as mechanical dependability, easy to use, cost-effective, and compatibility with basic workshop fabrication equipment. The frame of the product, including the rod, hose adapter, and webcam holder plate, is created using aluminium, which known for its great strength to weight ratio. Aluminium is easy to cut, drill, and weld, making it ideal for custom modifications and precise assembly. Its natural resistance to corrosion is also beneficial for long-term durability, especially in environments where humidity or temperature variation may occur.

The ball joint swivel is made of steel or hardened alloy to ensure it can endure repeated movement without significant wear. The design ensures the webcam stays firmly in place without sagging or shifting out of alignment. To keep everything stable, the wall bracket and fasteners are made of steel, giving the setup a solid anchor and reducing any vibrations or movement during use. Plastic wall anchors are also used to make sure the screws grip securely into concrete or brick especially important in outdoor or semi-outdoor sports facilities.

We chose the T-WOLF WC15 webcam because it’s affordable and delivers clear video quality. It also comes with a built-in threaded mounting hole, which made it easy to attach to the holder plate without needing a lot of extra modifications. Since we were looking for a rare, budget-friendly option that still performed well, this camera was a great fit for both our product and testing needs.

Suggested Fabrication Methods and Processes

To build the prototype that is related to the intended design, we pursue a series of practical fabrication steps. The production process started with fabrication steps like cutting the aluminium rod into right dimension by using a hacksaw. This rod acts as the main vertical support between the wall bracket and the ball joint socket, so it is important to get the right size for the alignment and stability

Once cut, we moved on to drilling. Mounting holes were drilled into both the rod and the bracket so they could be fixed together using screws. With that done, we attached the aluminium hose adapter to the top of the rod. This part was welded securely to form the upper socket where the ball joint would sit.

The ball joint itself, made of steel, was inserted into the hollow adapter. To stop it from popping out while still allowing it to move freely, we applied a layer of solder around the rim of the socket. After checking that the ball could still rotate and tilt, we welded a small aluminium plate to the top of the ball. This plate serves as the webcam holder.

Finally, an overall assembly attached onto the wall by using screws and wall plugs. There is a standard screw hole under the component for the webcam so it can be fitted to the holder plate, which completing the structure of it. The webcam holder will be used in this prototype functions same as to a basic smartphone clamp holder. It includes two side arms or bars one on the left and another on the right which securely hold the sides of the webcam to grip it firmly in position. The holder was fitted to the swivel top of the ball joint, which permitted the webcam to move through tilt or rotation as required. This step-by-step approach helped ensure parts fit together, move as planned, and function properly under mechanical stress that is light.

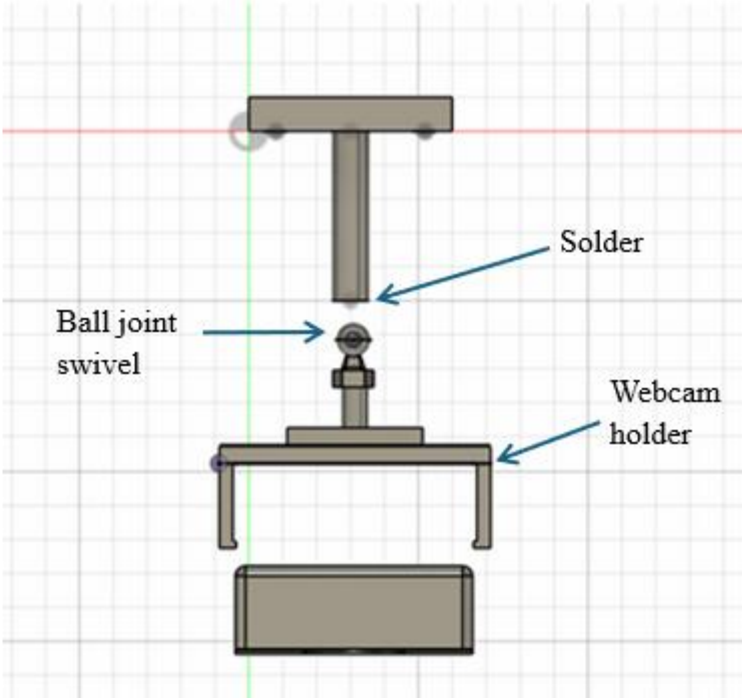


Figure 14: Fabrication

Cost Estimation and Breakeven Analysis

This section presents that the cost estimation for producing the Ceiling-mounted sensor-camera system based on actual component prices from local sources. Since the system is assembled manually without outsourcing fabrication or incurring labor charges, there are no fixed costs, F. Therefore, the total cost reflects only variable costs per unit. The breakeven analysis shows at what quantity of units the project becomes profitable. Table 22 below shows the cost estimation for producing the Ceiling-mounted sensor-camera system.

Table 22: Cost Estimation Table

No	Component	Quantity	Unit Price (RM)	Total (RM)
1	Wall anchor screw	4	1.27	5.08
2	Wall bracket	1	10.00	10.00
3	Aluminium Rod	1	14.00	14.00
4	Ball Joint Swivel	1	11.02	11.02
5	Aluminium hose adapter joiner	1	21.29	21.29
6	Screw	4	0.50	2.00
7	Aluminium plate (webcam holder)	1	5.00	5.00
8	Webcam T-WOLF WC15	1	19.31	19.31
Total cost per unit				87.70

a) Revenue and Profit Analysis

Table 23 below shows the revenue and profit analysis for G-sense system.

Table 23: Revenue and Profit Analysis

Description	Total (RM)
Selling price	130.00
Cost per unit	87.70
Profit per unit	42.30

b) Breakeven Analysis

This breakeven analysis is done by assuming that we will sell 10 products.

- Total Revenue (R) = RM 130 x 10units = RM 1300
- Total Cost = 10 x (RM 87.70 + RM 0) = RM 877
- Profit = RM 1300 – (RM 87.70 x 10) = RM 423

So, if 10 products are sold at RM130 each, the total expected net profit is RM423.00.

Timeline and Task Distribution

This part explains the G-senses' semester-long development timeline and task allocation planning. The project is classified into phases for research, design, fabrication, integration, testing, and final evaluation during the course. Roles and responsibilities assigned to each team member to maintain effective collaboration and balance workload.

Table 24 shows key phases of the project across the two semesters overall, specifying the timeline and major activities completed during each phase.

Table 24: Timeline and Task Distribution

Phase	Week(s)	Activities
PHASE 1 PLAN	Week 1 – Week 4	Project started, set the problem statement, target setting, identify stakeholders and vision of the project.
PHASE 2 DO	Week 5 – Week 11	Develop design concept, CAD design, 3D modelling, material selection, and design refinement.
PHASE 3 DO	Week 12 – Week 17	Prototyping structure, hardware assembly, enclosure equipment, and presentation of the project mechanism.
PHASE 4 CHECK	Week 18 – Week 20	Functional and product testing, performance analysis including feedback response, and safety verification
PHASE 5 ACT	Week 21 – Week 24	Manufacturing and cost optimization, after effect study, final testing for product performance
PHASE 6 FINAL	Week 28	Final report, product demonstration, pitch preparation, presentation, and documentation submission

Table 25 shows each member's role and the main responsibilities they need to fulfill throughout the development cycle. Each member needs to plan and do their job wisely in order to produce a better finalized product.

Table 25: Role and Responsibilities Table

Team Member	Role	Main Responsibilities
Rachael	Project Leader and Planner	Oversee planning, manage development flow, supervise progress, and ensure milestone delivery, report compiler
Saidatul	Product performance	Doing calculations in engineering/mechanical analysis, comparison in the market
Eizlin	Hardware and Prototyping	Handle 3D modelling and detailing by using design software like SolidWorks and Fusion 360, fabrication structure

Izatie	Analysis and Documentation	Prepare BOM, conduct material selection, generate cost analysis, safety consideration
Husna	Testing and Safety	Test full system, collect feedback, perform final review, lead presentation

Safety Consideration

In this part, we need to focus on ensuring that safety during the design, assembly and procedure of G-sense is important to protect users, maintaining component durability, and complying with the basic engineering standards. This point outlines the safety aspects addressed throughout the development and recommendations for safe usage in future used.

Table 26 explains the main safety practices applied during product development and assembly to reduce potential challenges or risks such as electrical hazards.

Table 26: Safety Practice

Category	Safety Practice
Electrical Safety	Ensure low-voltage USB webcam operation, check for proper insulation of wires, verify no exposed live contacts.
Mechanical Safety	Secure fasten brackets and rods to prevent falls, use proper torque on screws, inspect for sharp edges or burrs
Structural Integrity	Test wall anchors and brackets with the maximum load before use, make sure no cracks or deformation in aluminium parts.
Assembly Precautions	Use protective gloves and goggles when drilling or handling metal components, perform assembly on a stable surface
System stability	Verify that the ball joint swivel can reliably hold position without slipping, and make sure the webcam cable routing does not cause strain
Environmental Safety	Check that metal component is corrosion-resistant if installed in humid environments

Table 27 outlines a qualitative risk assessment of the potential risks associated with the product and presents a mitigation strategy that can be used to prevent hazards

Table 27: Qualitative Risk Assessment

Potential Hazard	**Risk Level**	**Mitigation Strategy**
Sharp edges on aluminium rods or brackets	Medium	Debugger and smooth sharp edges, and wear protective gloves during assembly
Bracket or screw failure causing webcam to fall	High	Perform load testing on anchor and bracket, use quality hardware, and inspect before installation
Electrical shock from faulty webcam cable	Low	Use properly insulated, certified cables and verify with continuity testing
Pinch injuries from ball joint swivel during adjustment	Medium	Educate users on safe adjustment technique such as by warn the finger adjustment
Overheating of webcam	Low	Verify manufacturer ratings, ensure ventilation, and avoid prolonged continuous use
Corrosion of aluminium parts in humid environment	Medium	Apply corrosion-resistant coatings or use anodized aluminium

PHASE 6: TESTING AND VALIDATION

The testing and validation phase is a critical step in the development of the G-Sense prototype, a camera-based golf ball tracking system designed using Fusion 360. This prototype aims to solve the problem of inconsistent golf ball detection and tracking in driving ranges, particularly under fast motion. The system integrates a ceiling-mounted camera and real-time software to accurately map ball locations within designated zones. To ensure the system performs as intended in real-world scenarios, rigorous testing must be carried out to assess its accuracy, responsiveness, durability, and safety. This phase is essential to verify that the 3D-designed components, including the camera mount and structural frame modeled in Fusion 360, function correctly during operation and meet the required engineering specifications. The outcomes from this phase will determine whether the prototype fulfills its objectives and is ready for practical deployment or further refinement.

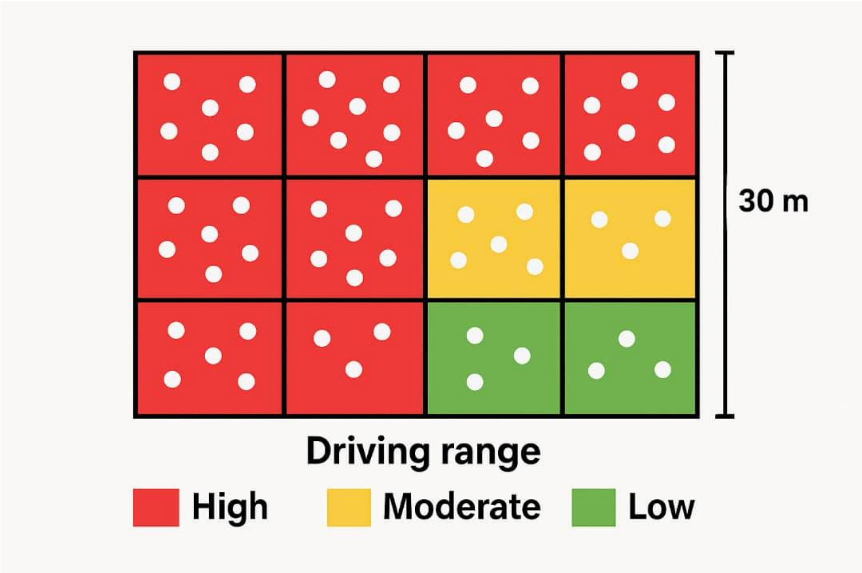


Figure 15: Driving range

Key performance parameters to be tested

a) Detection Accuracy

Detection accuracy refers to the system's ability to correctly identify and display the specific zone where a golf ball lands. Since the G-Sense system is designed to track golf balls in real-time, especially in high-density and fast-paced environments, high detection accuracy is essential. Accurate detection ensures reliable data for performance analysis and coaching feedback. This parameter will be evaluated by comparing the actual zone (where the ball physically lands) to the zone reported by the system, aiming for a minimum of 90% accuracy.

b) Speed of Detection

Speed of detection measures how quickly the system can recognize a ball's movement and display the corresponding zone on the interface. A fast detection response is critical in real-time tracking environments like driving ranges, where multiple balls may be in play simultaneously. Delays in detection can lead to confusion, missed data, or overlapping signals. The goal is for the system to complete detection and display within one second of ball launch, providing timely feedback for both operators and players.

c) Range and Coverage

Range and coverage evaluate whether the system can monitor the entire intended area without blind spots. Since the G-Sense sensor is ceiling-mounted for a top-down view, it must be capable of scanning all predefined zones uniformly. If any part of the field is not visible to the sensor, detection errors may occur. This parameter ensures that the system can cover the full detection grid, regardless of the ball's landing position, enabling more efficient collection planning and accurate heat mapping.

d) Software Integration

Software integration assesses how well the hardware system (camera and sensor) communicates with the software interface for live video feeds and zone mapping. The integration must be seamless so that detection results are instantly and accurately reflected on the user interface. A well-integrated system enhances user interaction, reduces manual work, and allows staff to make quick decisions. The parameter will be evaluated by observing real-time feedback and checking if the mapping interface reflects the ball's position without delay or mismatch.

Proposed testing methods or procedures

a) Zone-Based Detection Test

This test involves hitting golf balls into clearly defined zones and verifying if the system correctly identifies and maps the zone of each landing. It directly evaluates detection accuracy, which is critical for reliable performance data and feedback. By repeating the test multiple times in each zone, inconsistencies or blind spots in the system can be identified. This test also helps to calibrate the system for better zone recognition.

b) Time Response Test

Using high-speed cameras or precise timestamps, this test measures the latency between the moment a ball is launched and when its position is displayed on the system. The goal is to determine if the system responds in real-time, ideally within 1 second or less. A fast response is vital for real-time feedback and for enabling staff to make quick operational decisions on the driving range.

c) Environmental Stress Test

This test checks the system's stability under varying lighting conditions it ensures that the system can maintain consistent performance regardless of external environmental factors, which is crucial for open or semi-open golf driving ranges where such changes are common. Performance under poor lighting will reveal if additional camera settings or filters are needed.

d) Multi-Ball Scenario

In this procedure, multiple balls are launched within short intervals to test the system's ability to differentiate and accurately detect each one. This test mimics real-world conditions during peak hours, where several players may be hitting balls simultaneously. The system can maintain accuracy without confusion or overlap between detections. This is especially important for preventing data misinterpretation during busy usage

e) Endurance Test

This long-duration test involves running the system continuously for several hours or even days. It evaluates the system's long-term reliability, checking for software crashes, overheating, data loss, or sensor fatigue. The test aims to ensure the system is suitable for commercial settings where it may need to operate daily for extended periods. Successful completion without performance degradation would indicate the system is robust and dependable.

Tools or equipment required for testing

G-Sense prototype testing requires key tools such as golf balls and launchers to simulate real use, and a high-speed camera or stopwatch to measure response time. A computer with G-Sense software is used for real-time tracking and display, while the ceiling-mounted setup. Data logging tools like spreadsheets are used to record and analyze results efficiently. Table 28 below lists the tools or equipment required for testing, along with their corresponding descriptions.

Table 28: Tools or equipment required for testing

Tool	Description
Golf Balls & Launch Tools	-Simulate real usage conditions. -Manual or automatic launcher ensures consistent ball trajectory. -Useful for accuracy and repeatability in tests.
Stopwatch or High-Frame-Rate Camera	-Runs the detection and tracking software. -Displays real-time results and zone mapping.
Computer with G-Sense Software	-Runs the detection and tracking software.

	-Displays real-time results and zone mapping.
Tripod or Ceiling Mount Rig	-Simulates the actual ceiling-mounted setup of the system. -Provides a stable top-down view for accurate coverage.

Validation criteria

To ensure the G-Sense prototype meets its design goals and performs reliably in real-world conditions, a set of clear validation criteria has been established. These criteria define the minimum acceptable performance standards the system must achieve during testing. By comparing actual test results against these benchmarks. Table 29 shows the key parameters including detection accuracy, response time, stability, zone coverage, software performance, and overall system reliability.

Table 29: Key parameters

Parameter	Pass Criteria	Fail Threshold	Objective Comparison
Detection Accuracy	More that 90% correct detection rate	Less than 70% detection accuracy	Ensures reliable zone tracking for accurate feedback
Response Time	Detection less than 1 second when the golf ball is launched	Detection more than 1 second when the golf ball is launched	Supports real-time tracking and fast decision-making
Stability	Consistent over 10 test cycles	Inconsistent or erratic performance	Validates system under repeated and variable inputs
Range/Coverage	100% visibility from left-right diving range	Any undetected zone or blind spot	Confirms full tracking area without coverage gaps
Software Performance	Less than 5% error margin in real-time mapping	More than 5% mapping error	Ensures precise zone identification for data integrity
Reliability	No malfunction during 12+ hour operation	Crashes, lags, or system interruptions	Demonstrates system readiness for long-term daily use

Data collection plan and how results will be analyzed

To evaluate the performance of the G-Sense prototype effectively, a structured data collection and analysis plan is essential. This process ensures that all testing outcomes are data, analyzed, and used to validate system reliability, accuracy, and responsiveness. By collecting consistent data across various test scenarios, the team can identify strengths, weaknesses, and areas for improvement in the prototype. Table 30 shows the components of G-Sense prototype testing.

Table 30: Components of prototype testing

Component	Description
Data Logging	-Launch angle and ball speed - Calculate distance and estimated landing grid - Actual grid detected by the camera -Time between launch and detection
Zone Detection	Camera identifies and highlights the golf ball landing grid zone -Red zone : high ball density -Yellow zone : moderate ball density -Green zone: Low ball density These color code help identify which zones have the most ball after repeated launches
Accuracy Calculation	Calculate the percentage of correct grid detections -Formula: (correct Detection / Total launches) X 100%
Response Time	Measure latency between golf ball launch and camera-based grid detection
Failure Analysis	Identify failed detections and categorize them based on cause: -Angle estimation errors -Incorrect grid mapping or overlapping ball tracks
Ball Count by Zone	System counts how many balls are detected in each zone using camera input -Camera updates zone color based on ball accumulation -Ball count is also verified manually

Safety protocols during testing activities

To ensure a safe and controlled environment during the G-Sense prototype testing, specific safety protocols must be followed. These measures help protect all team members, prevent accidents, and maintain the integrity of the testing process. Table 31 outlines the key safety practices to be implemented throughout the testing phase.

Table 31: Safety measure for G-sense

Safety Measure	Purpose
Testers wear safety goggles	Protect eyes from flying golf balls or fragments. This is especially important during live launch scenarios.
Use test enclosure or net	A safety net or enclosed test area should be set up to capture balls and prevent ricochets. This reduces the risk of injury and ensures balls don’t hit sensitive equipment or bystanders.
Secure system on ceiling mount	This ensures stability and prevents the camera or components from falling, which could damage the system or harm testers.
Electrical Safety Measures	All wiring must be safely insulated, with no exposed or loose wires during operation. Equipment should be properly grounded to avoid electrical hazards such as shocks or fires during prolonged testing.
Emergency Equipment On-Site	A fire extinguisher and first aid kit must be available nearby to handle any emergencies promptly
Restricted Access to Test Area	Only trained and authorized personnel should be allowed in the test area. This minimizes distractions, prevents accidents, and ensures that safety protocols are consistently followed.

SUMMARY

The G-Sense project was developed to address the inadequate detection or tracking at driving ranges. The team adopted a structured and systematic product development approach that began with VoC, where customer needs were identified and prioritized through surveys and market research. These needs included localization precision, real-time feedback and easy implementation. Using HoQ, these customer requirements were translated into specific, measurable technical specifications, forming the foundation for the product's functional design.

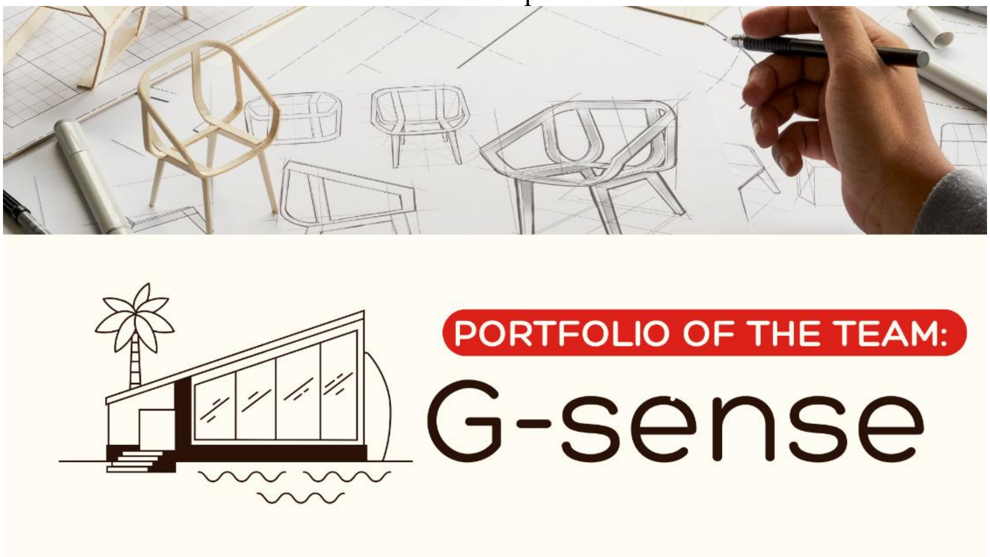
In Phase 2 and 3, the team conducted in-depth engineering analysis and concept development. Multiple design alternatives were generated, and their feasibility was assessed in terms of cost, functionality and performance. The chosen design which is a ceiling-mounted camera system with a modular support frame was further refined using DFMA principles to reduce part count, simplify assembly and improve maintainability. Sustainability was a major consideration in Phase 4, where material choices such as aluminum alloy and HDPE were selected for their durability, recyclability, and lightweight properties. Low-power components were integrated to minimize energy usage during continuous real-time operation, and the modular design supports lifecycle extension through easy disassembly, repairs, and upgrades.The next stage of the project involves prototyping and field testing. A functional prototype will be fabricated and tested under simulated and real driving range conditions. This will allow the team to evaluate system performance, including image capture accuracy, real-time processing speed and environmental adaptability. Further software enhancements will also be explored, particularly algorithm optimization using computer vision tools like YOLOv8 and OpenCV to improve tracking precision.

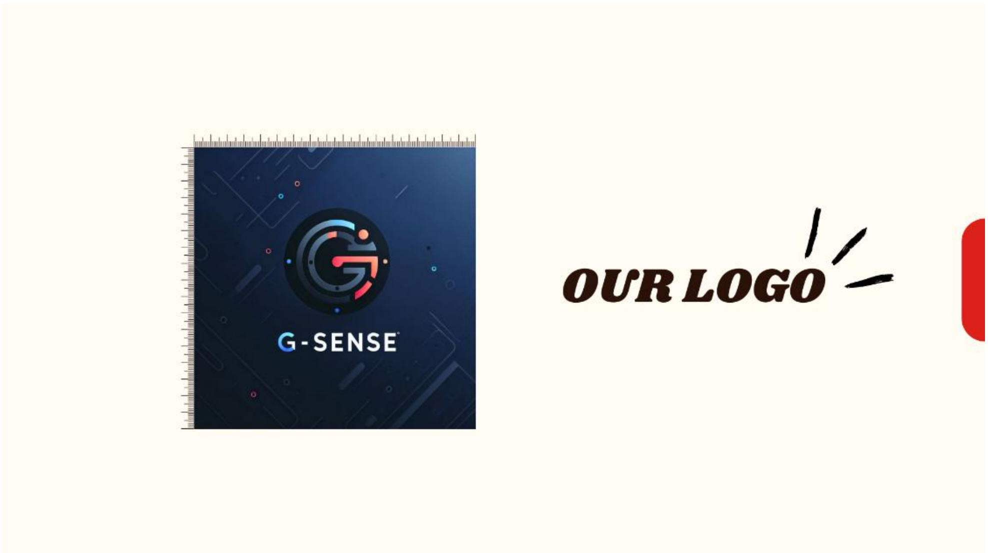
Despite the structured approach, several potential risks and challenges have been identified. These include camera calibration errors, inaccurate object detection in extreme lighting, delays in real-time feedback, hardware wear under prolonged exposure to heat and humidity and potential misalignment due to vibrations or structural instability. To mitigate and control these risks, the team has implemented several strategies such as incorporating a ball-joint mechanism for easy camera angle adjustment and integrating modular software updates that allow rapid response to user feedback and performance issues. Routine calibration protocols and preventive maintenance checklists will also be introduced to ensure long-term system stability.

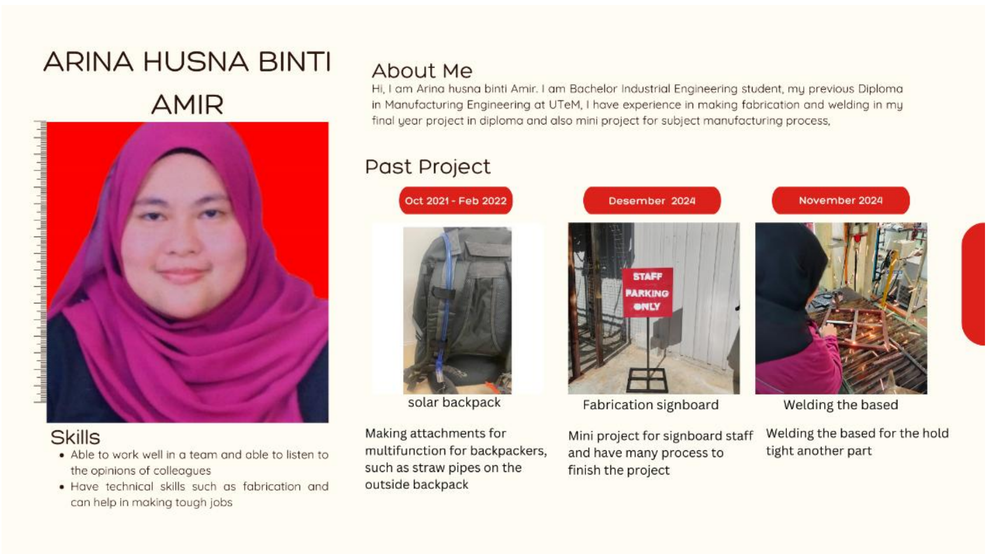
By integrating customer feedback, technical analysis, and sustainable design practices, the G-Sense project demonstrates a balanced approach to product innovation. The development process emphasizes functionality, efficiency, environmental responsibility, and user-centered engineering. With ongoing iteration, field validation, and a strong risk management framework, the team is confident inbringing a high-performance solution to market that addresses real-world challenges in golf ball tracking and retrieval.

APPENDIX A

Team members' portfolio







EIZLIN BINTI MOHD

About Me

Hello, I am Eizlin binti Mohd, an engineering student currently pursuing my bachelor's degree in Industrial Engineering. I am passionate about industrial engineering and i am excited to apply my knowledge to the real-world problems. I have experience and enjoy working on hands-on projects. I'm always looking for new opportunities to learn and grow in the field of engineering.

Past Project

Oct 2021 - Feb 2022

Fabrication project

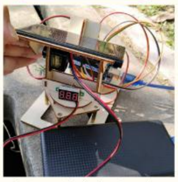
This fabrication project involves the process of designing, manufacturing, and assembling components or structures from raw materials.

March 2023 - Jul 2023

CNC Milling Project

By using CNC milling machine to create a high precision, multi-functional cardholder prototype. The final product is a versatile cardholder that can also function as a phone clip or pen holder.

March 2023 - Jul 2023



Automatic Solar Tracker

This project focuses on the development of an automatic solar tracker, which optimizes solar energy production. It's unique approach to using the sun's position as a guiding source enhances solar efficiency, promoting a sustainable energy future.

Skills

- Quickly learning new tools, technologies and adapting to changes in project requirements.
- Ability to think critically, analyze data and draw conclusion.
- Experience managing projects, including creating schedules, and ensuring deadlines are met.
- Technical proficiency in engineering Software: AutoCAD, Solidworks, Fusion360, CNC machines and simulation, Excel, Word, Powerpoint and Canva.

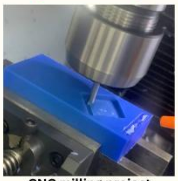
NURUL IZATIE BINTI MOHAMMAD

About Me

Hi, I'm Nurul Izatie binti Mohammad, a passionate student who currently pursuing my study in bachelor's degree of industrial engineering. Throughout my academic journey, I have directed my intention toward designing, fabricating, and implementing innovative solutions that merge functionality with aesthetics.

Past Project

JUNE 2023



CNC milling project

This project made me think outside the box because I had to do coding for the cnc machine and design as well.

JUNE 2023

Portable and multifunction bathtub table

This bathtub project for my diploma has been an incredible learning journey. It has significantly enhanced my knowledge and honed my skills across various domains, including design, laboratory tool usage, and problem-solving.

JANUARY 2024

3D design

During my internship, I was asked to do a house project for a client using the Sketch-up and AutoCAD applications.

Skills

- A creative thinker, able to conceptualize innovative solutions for complex issues
- Skilled in decision making, conflict, resolution and strategic planning

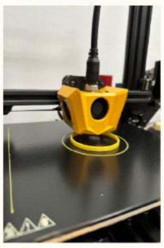
RACHAEL ONG SHU ZHEN

About Me

Hi, I'm Rachael Ong Shu Zhen, who currently pursuing my bachelor's degree in Industrial Engineering at Universiti Teknikal Malaysia Melaka (UTeM). My academic journey has fueled my passion for optimizing processes, enhancing efficiency, and solving real-world challenges.

Past Project

May 2023



3D printing

Using the 3D printing to produce the component for the diploma project

June 2023

CNC milling

Generate and simulate CNC programs on CNC Simulator Pro for making a multi-function cardholder

June 2023

Speedy Ginger Fibre Extractor (SGFE)

My Dipolma project achieved Top 9 in Diplma Project Exhibition

Skills

- Team work and collabration
- Communocation skills
- Time management
- Quickly adjusting to new challenges and learning new skills
- Attention to details

SAIDATUL HUMAIRAH BINTI MOHD SAFUAN

Skills

- Passionate and has good teamwork
- Can receive negative comments
- CNC machines (milling, lathe, and fabrication)
- CNC programming (milling and lathe)
- AutoCAD, CATIA, and Fusion
- Can hands-on (welding, cutting material using any cutting tools, and grinders)

About Me

Hi, my Name is Saidatul Humairah Binti Mohd Safuan, B142320177, a year 3 Bachelor of Industrial Engineering (BMIF) from Faculty Engineering Industrial and Technology and Manufacturing (FTKIP). I am looking forward the next experience I can achieve from this project. I really hope this IDP project will bring me more acknowledges and skills for my future carrier.

Experience & Achievement

2021 - 2024 **Diploma of Manufacturing Engineering, UTeM**

2023 - 2024 **Internship at VAT Manufacturing, Penang**
- Assemble and repair valves

2024 **Join JBSB Programmed by UTeM at The Ships Campus and The 12 Waves, Penang**
- Collect and arrange data from warehouse

Past Project

2022 **PORTABLE MULTI-FUNCTION HAIR DRYER**

This product was created with dwi-function hot and cold. The user can blow the dryer using their own perspectives.

Past Project

2023 **PORTABLE AND MULTI-FUNCTION BATHTUB TABLE**

Aims for adult especially parents who have baby below 1 years-old. This product is expressing ergonomics design to avoid Hazard like Musculoskeletal Disorder (WMSD).

APENDIX B

Survey Form - User Needs Survey for Golf Ball Tracking and Collection System

User Needs Survey for Golf Ball Tracking and Collection System

20 responses

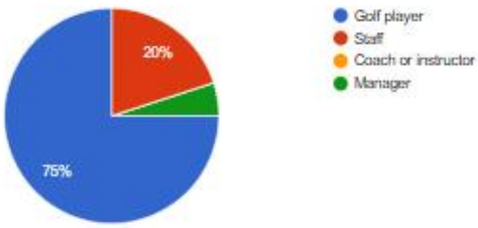
Publish analytics

Section A General information

What is your role in relation to the driving range?

Copy

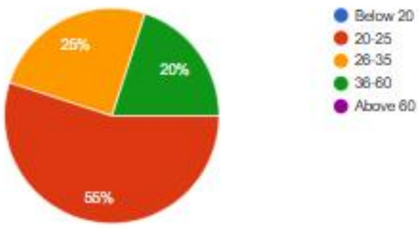
20 responses



What is your age?

Copy

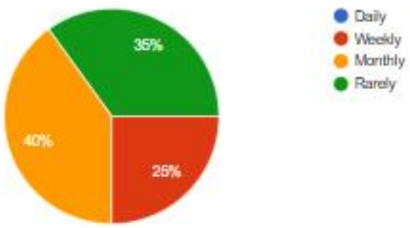
20 responses



How often do you paly golf?

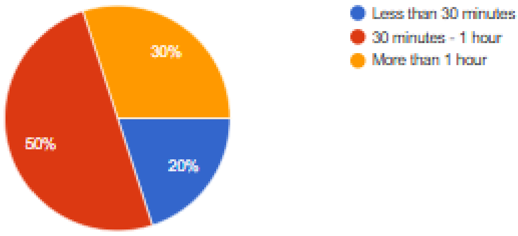
Copy

20 responses



How long usually spend at driving range?

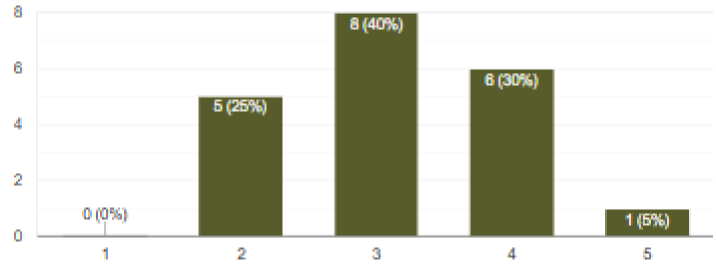
20 responses



Section B User Needs Analysis

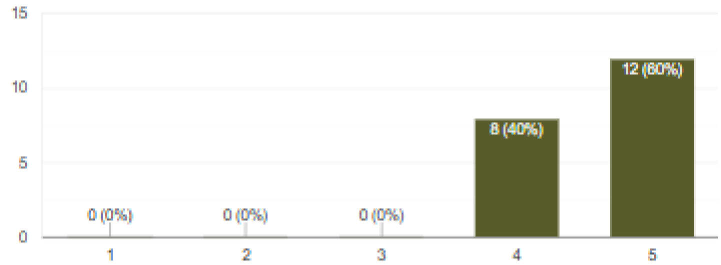
I get exhausted quickly when I have to collect balls in the heat.

20 responses



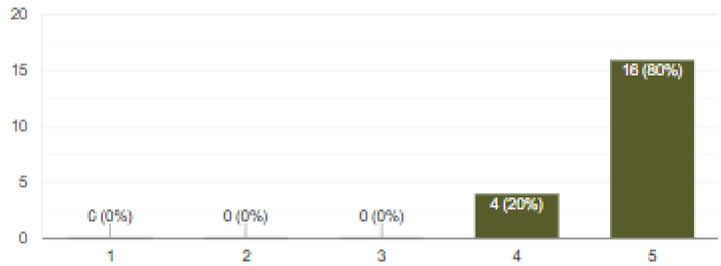
I want to optimize my time and avoid the inefficiency of searching for the balls at midnight.

20 responses



I want accurate location of the balls.

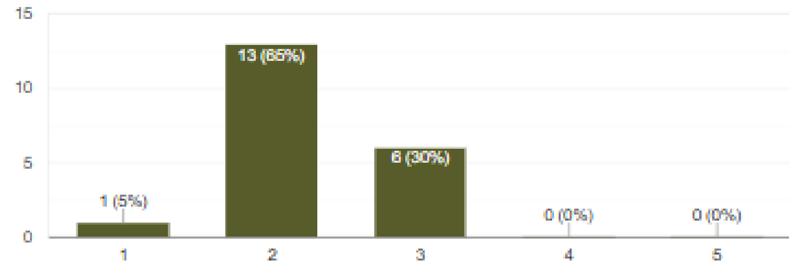
20 responses



I want good lighting and terrain.

Copy

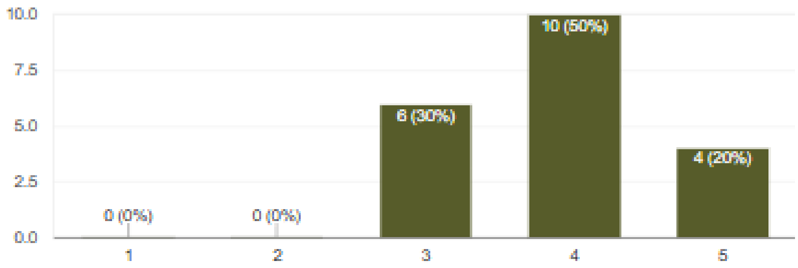
20 responses



I want machine easy to use.

Copy

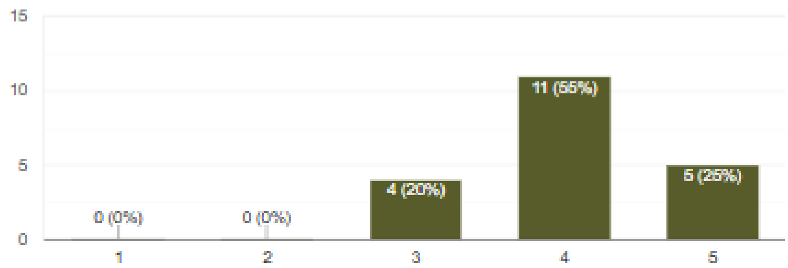
20 responses



There should be an integration option with GPS, RFID or scanning device.

Copy

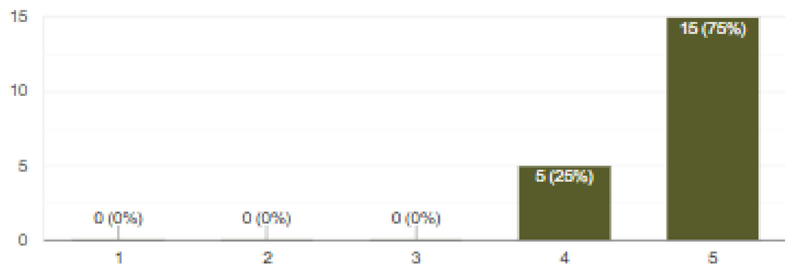
20 responses



I want to see exactly where my ball lands without searching all over.

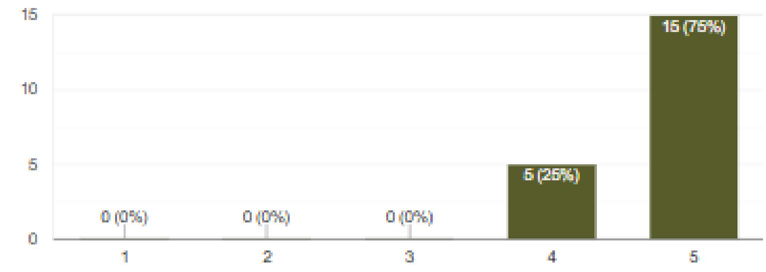
Copy

20 responses



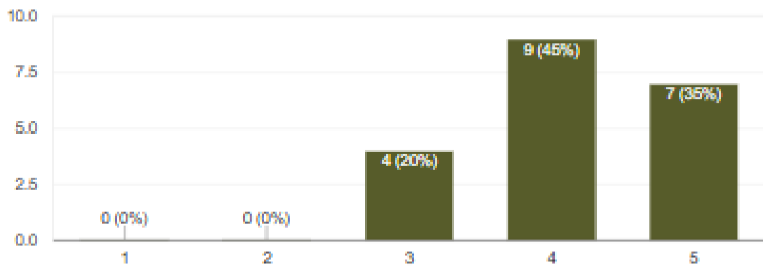
The tracking technology should be simple and quick to use.

20 responses



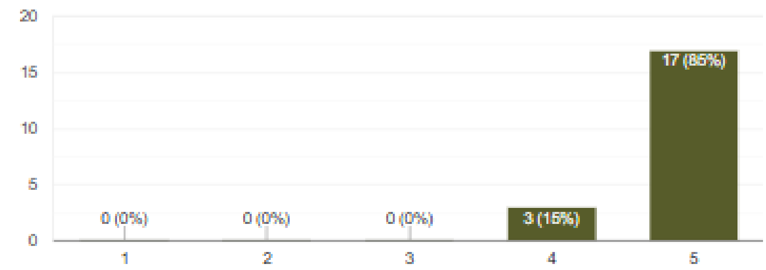
I want my customers and staff to enjoy their tasks and golf with ease

20 responses



I don't want ground staff to spend too much time locating balls manually.

20 responses



Survey Form- Golf Ball Detection and Localization System

Golf Ball Detection and Localization System

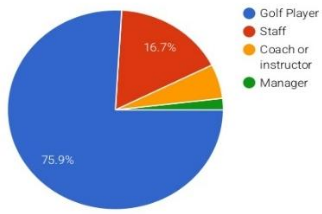
54 responses

Publish analytics

Section A: General Information

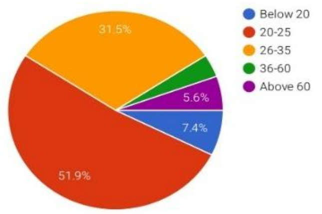
What is your role in relation to the driving range?

54 responses



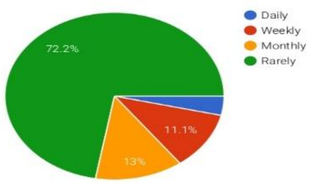
What is your age

54 responses



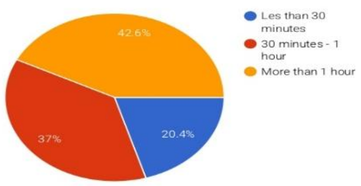
How often do you play golf?

54 responses



How long you usually spend at driving range

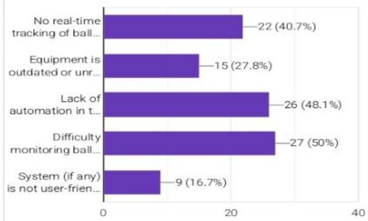
54 responses



Section B: Observation & Experience

What issues do you commonly experience with the current detection or tracking (if any) of golf balls?

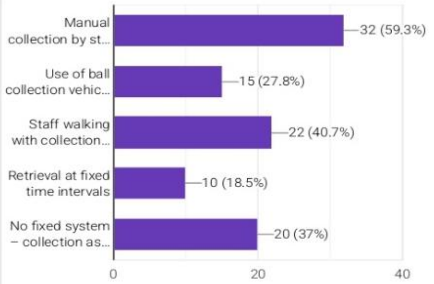
54 responses



Which current methods are used at your driving range to retrieve golf balls?

Copy

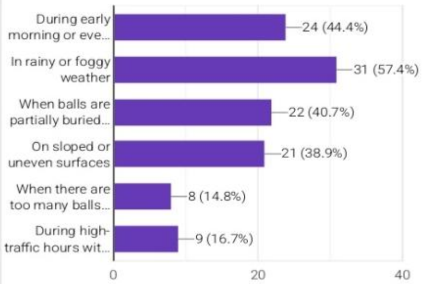
54 responses



In your experience, when are golf balls hardest to detect or locate

Copy

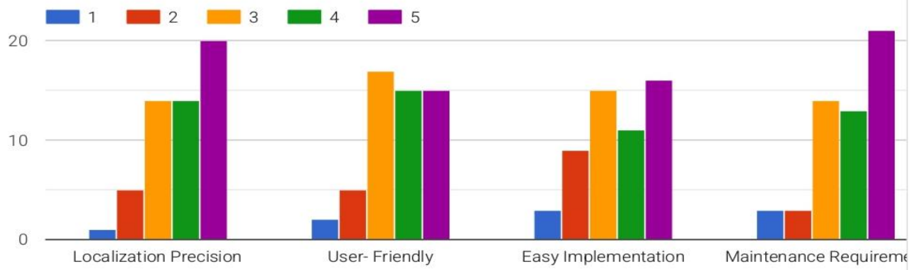
54 responses



Section C: Feedback and New Concept

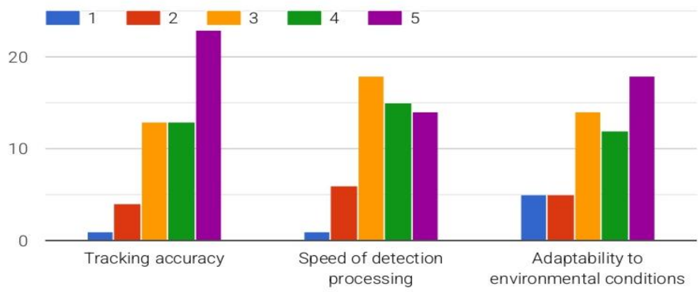
Plese evaluate each design concept
(rate 1 low priority - 5 high priority)

Copy

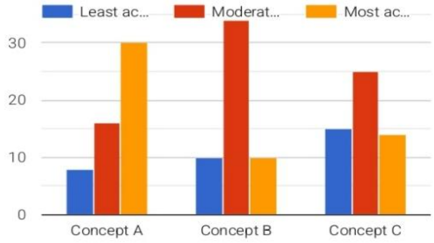


How would you rate each base on the following aspect?
(rate 1 low priority - 5 high priority)

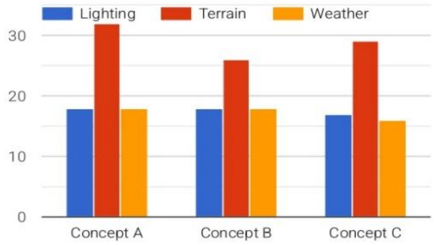
Copy



Which detection system do you think provides the most accurate ball tracking?

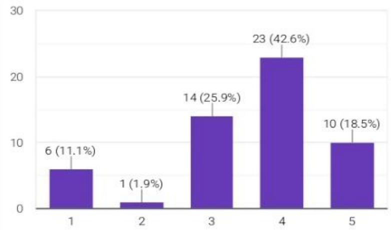


Which concept would be least affected by environmental conditions.



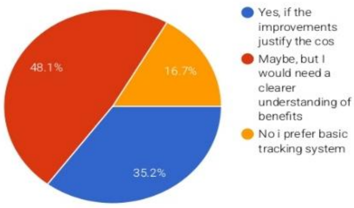
How would you rate the scalability of each concept for use in large driving ranges?

54 responses



Would you be willing to pay a higher fee for advanced tracking features?

54 responses



Which concept do you prefer based on overall functionality?

54 responses