

February 12, 2023

Dr. Mike Hegedus  
Department of Engineering Science  
Simon Fraser University  
Burnaby, BC V5A 1S6

Re: ENSC 405W Requirements Specification for KickPro

Dear Professor Hegedus,

Within the attached document, you will find the requirement specifications for KickPro. KickPro is a soccer training mechanism that will analyze shot patterns and placements, and pass balls at the player - even when they are in motion. KickPro is meant to be a retrofit tool that can be added to any net that meets its criteria and will also provide training data to the player, whether they are training individually or with a coach.

KickPro will perform its functions through a physical ball-launcher system, a player tracking system, and a feedback system that records and analyzes the position of the ball as it crosses the goal line.

To verify this functionality, this document will define the general requirements, hardware requirements, software requirements, safety and sustainability requirements, and legal requirements our product must validate from the proof-of-concept, to the prototype, to the production version.

Our team is comprised of Jagpreet Grewal, who is in the computer discipline; Amirali Farzaneh, Tao Li, and Minh Phat (Henry) Tran, who are in the systems discipline; and Alon Singh and Zehui (Jeffrey) Lin, who are in the electronics discipline.

Thank you for considering our proposal. We look forward to hearing from you soon. Should you have any questions, comments or concerns, please reach out to our Chief Communications Officer, Jeffrey at [zla167@sfu.ca](mailto:zla167@sfu.ca).

Sincerely,



Alon Singh  
Chief Executive Officer  
IronFoot Technologies

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ENSC 405W  
REQUIREMENTS SPECIFICATION  
KICKPRO

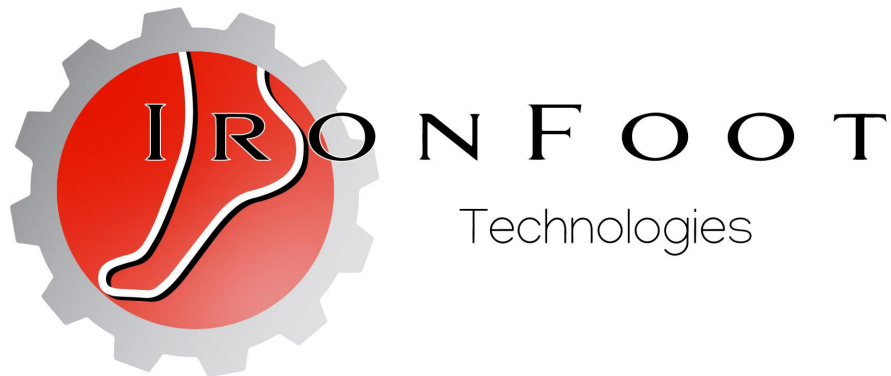
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A REQUIREMENTS DOCUMENT BY IronFoot Technologies

WRITTEN BY

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## Abstract

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This document goes into detail on the requirements that must be met in order to implement KickPro, a cutting-edge soccer training tool that analyzes shot patterns and feeds soccer balls to the player. Designed as a retrofit solution, it can be added to any suitable net and provides players with detailed training data. The mechanism operates through a physical ball-launcher system, player tracking system, and feedback system. However, the specific design details will be glossed over until the appointed time comes to present them. In short, there are five main categories of requirements this product must meet to satisfy the Engineering Standards of Simon Fraser University: general requirements, hardware requirements, software requirements, safety and sustainability requirements, and legal requirements. This document will examine all in depth. Lastly, the proof-of-concept test plan of this product that must be fulfilled by April 2023 will be defined and discussed.

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## Glossary

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| Term | Definition                                     |
|------|--|
| AC   | Alternating Current                            |
| CSA  | Canadian Standards Association                 |
| DC   | Direct Current                                 |
| EMC  | Electromagnetic Compatibility                  |
| GUI  | Graphic User Interface                         |
| IEC  | International Electrotechnical Commission      |
| ISO  | International Organization for Standardization |
| PCB  | Printed Circuit Board                          |
| PC   | Personal Computer                              |

**TABLE I: Definition of Glossary Terms**

# 1 Introduction

---

Soccer, with its widespread popularity and demanding nature, has become one of the most beloved sports in the world today. Whether played indoors or outdoors, the sport requires a remarkable level of finesse and accuracy, which can only be attained through consistent practice and improvement. It is for this reason that regular training has become an indispensable aspect of a soccer player's development. KickPro is a new and innovative tool that aims to take this training to the next level.

This retrofit solution, which is applicable to any suitable net, functions by loading multiple balls into a launcher. This device is modeled after the ones already in use among the sport, but with a significant difference: it swivels automatically. Paired with a tracking system that operates through a camera, the system is able to calculate the angle to return the ball to the player. On its own, this stands to be a much-loved tool for training drills. However, the product also comes with a training analyzer which provides players with real-time data on their positions on the field, placement of their shots and their progress throughout the session.

Idealistically, KickPro has the potential to revolutionize the way soccer players train.

## 1.1 Background

---

Automatic ball launchers are well-known in not just soccer, but in many other sports such as baseball, basketball and lacrosse. While convenient, such products fail to address a core deficiency in how players are trained today - the accumulative time-wasting that arises from manually adjusting the angle and speed of the launcher. Additionally, these launchers lack the capability to accurately pass balls to moving targets, necessitating more involvement from a player or staff. KickPro aims to address this short-coming by automating this tedious labor so that both the players and coaches can focus more on the training and hard-work that makes up the heart of the game. As well, KickPro will also provide its own analysis and feedback throughout the course of a session.

## 1.2 Scope

---

The product development of KickPro will occur in three phases: the proof-of-concept, the engineering prototype, and the production version. The functional requirements for each phase will be different, with the proof-of-concept having the most laxity and the production version burdened with the most strict validations. These requirements will include the general requirements, requirements for each subsystem, and other important requirements such as safety, sustainability, and legality.

The main challenges we expect to face are constructing the ball launcher to a reliable standard and achieving sufficient accuracy towards moving targets. IronFoot Technologies takes pride in its products and as such, we wish to construct our device so that it works as intended every time.

As might be expected, achieving this level of sophistication and integration can be difficult. Even designing a camera that swivels and tracks users can easily be worth over a thousand dollars [1]. And our scope is much greater than that.

### 1.3 Intended Audience

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This document is intended to serve as the functional requirements for KickPro to IronFoot Technologies, its potential customers, Dr. Mike Hegedus, and the teaching assistants for ENSC 405W. When operating this product, please follow the (upcoming) user manual and take all reasonable precautions for the safety of every user and passerby.

### 1.4 Requirements Specification

---

The requirements in this document will use the following system:

**R.X.Y.Z V**

The definitions for the encoding are as such:

| Encoding | Definition         |
|----------|--------------------|
| X        | Section            |
| Y        | Subsection         |
| Z        | Requirement Number |
| V        | Product Stage      |

**TABLE 1.4.1: Definition of Convention**

The versions for the product stages are abbreviated as follows:

| Version | Product Stage         |
|---------|-----------------------|
| A       | Proof-of-concept      |
| B       | Engineering Prototype |
| C       | Production Version    |

**TABLE 1.4.2: Abbreviation of Product Stages**

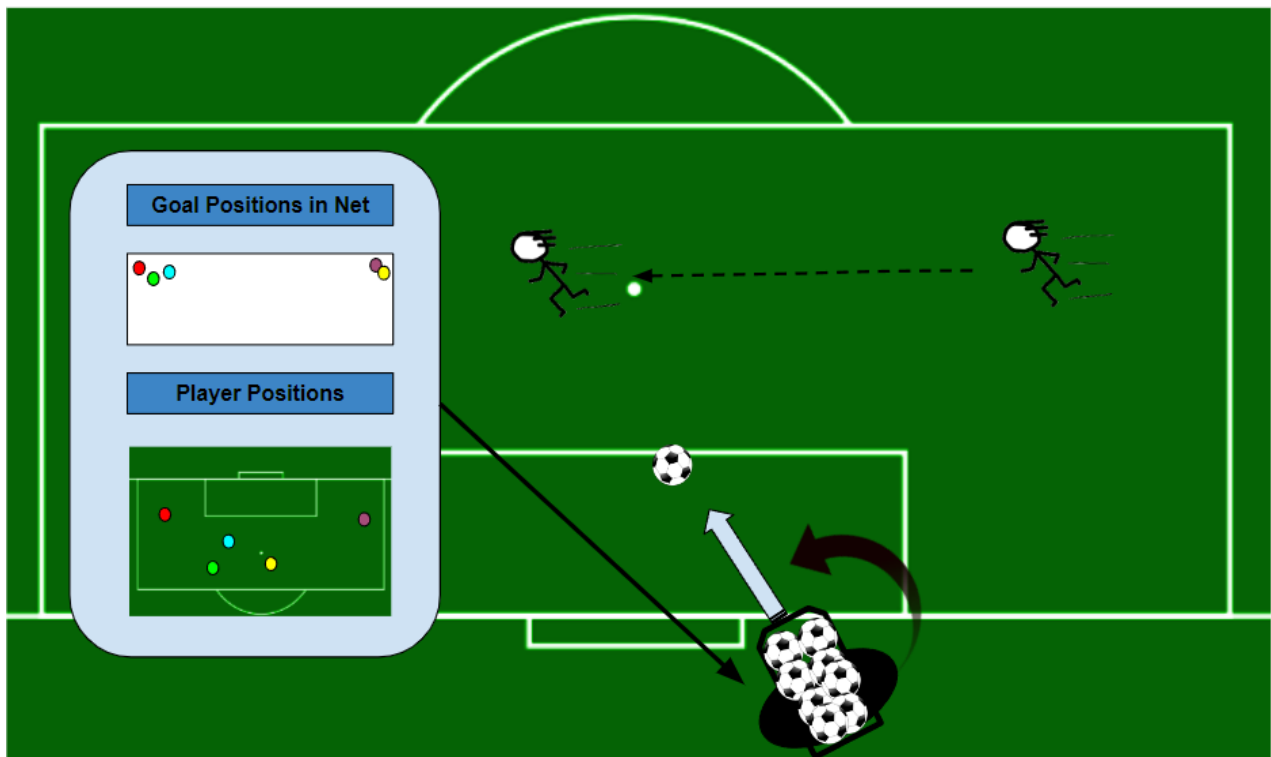


## 2 Systems Overview

---

KickPro is a state-of-the-art soccer training mechanism that provides players with advanced training data to improve their performance. A ball-return system will be implemented through two motor launchers, a swivel system, and a wooden framework. A feedback system will be implemented as well through multiple sensors attached to the goalposts and a screen to display the data. Furthermore, the ball-return system will interface with a tracking system, which will be created through an AI human detection algorithm in Python that obtains data from a camera.

KickPro will also have a training feedback suite to provide players with real-time analysis on their shots. This feedback system will be implemented through a mixture of sensors, circuits, and a Raspberry Pi. An algorithm in Python will record the position of each shot that passes through the goal line then analyze it. As well, a GUI will be designed to allow players to intuitively operate the machine and access the feedback data.

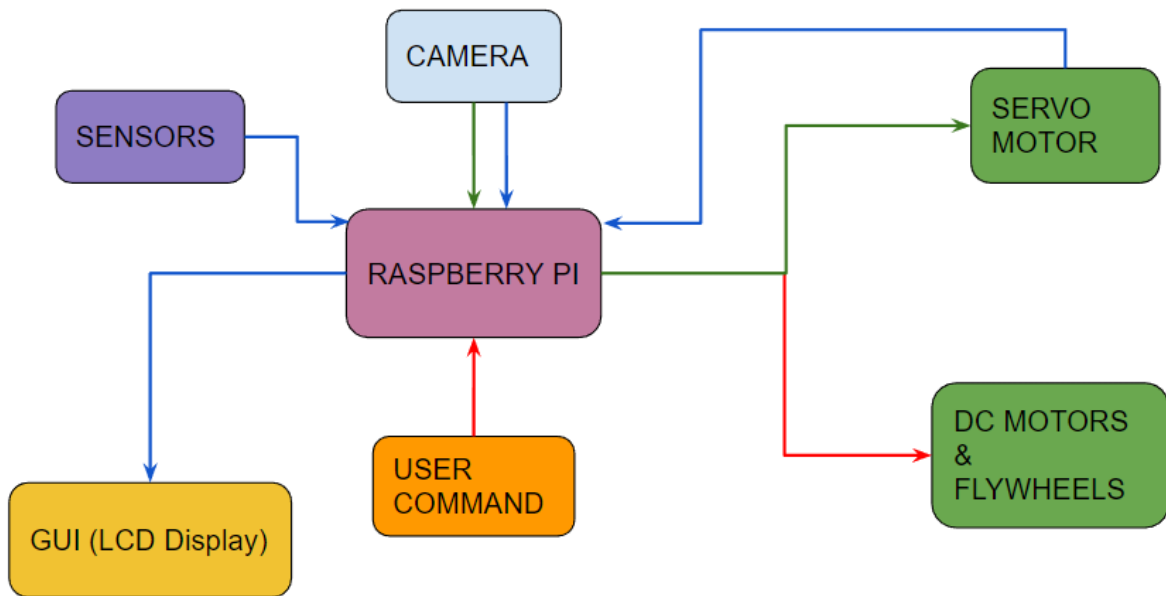


**Figure 1: Functional concept as well as the concept for the training feedback GUI design**

A similar product to KickPro named “Ball Launcher Pro”, is used to train goalkeepers on the market [2]. This product comes with a rechargeable battery and is able to launch the ball at various angles. However, KickPro includes more advanced features to adapt customer’s demands such as providing performance feedback, player tracking for automated passing drills, and a ball feeding mechanism. In ENSC 405W, KickPro will likely be functional but rudimentary. However, ENSC 440 will necessitate a much more aesthetically pleasing and streamlined product.



*Figure 2: The Ball Launcher Pro - Soccer Ball Delivery Machine [2]*



*Figure 3: The Block Diagram Overview of the system*

### 3 General Requirements

---

Our KickPro will be designed and developed based on considered requirements such as systems requirements, functional requirements and economic requirements. This section details the system, functional, economic, and documentation requirements for each version of our product.

#### 3.1 System Requirements

---

| Requirement ID | Requirement Description  |
|----------------|--|
| R.3.1.1 A      | The system consists of a microcontroller, launching mechanism, ball storage/feeding, and various sensors.        |
| R.3.1.2 A      | The system will track the player, transmit that information to the ball launcher, and send a ball to the player. |
| R.3.1.3 A      | The system will record the position of the balls in the net as they go in.                                       |
| R.3.1.4 A      | The system will require a PC to display the collection of data.  |
| R.3.1.5 A      | The various sensors will be wired and require some electronics knowledge.  |
| R.3.1.6 B      | The system will additionally record the positions of the player when the shots are taken                         |
| R.3.1.7 B      | The various sensors will be wireless and require minimal electronics knowledge.                                  |
| R.3.1.8 B      | The system will adapt from a stationary PC to a portable tablet for displaying data.                             |
| R.3.1.9 B      | The system will include a GUI and display module for user interaction.   |
| R.3.1.10 B     | The system will withstand various outdoor weathers.  |

**TABLE 3.1: System Requirements**

## 3.2 Functional Requirements

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| Requirement ID | Requirement Description  |
|----------------|--|
| R.3.2.1 A      | The system will launch balls to players at appropriate speed and distance. |
| R.3.2.2 A      | The ball launching system's actions will be controlled remotely.           |
| R.3.2.3 B      | The system will launch the balls at adjustable intervals automatically.    |

**TABLE 3.2: Functional Requirements**

## 3.3 Economic Requirements

---

| Requirement ID | Requirement Description                |
|----------------|--|
| R.3.3.1 A      | The system will cost less than \$600.  |
| R.3.3.2 B      | The system will cost less than \$900.  |
| R.3.3.3 C      | The system will cost less than \$1200. |

**TABLE 3.3: Economic Requirements**

## 3.4 Documentation Requirements

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| Requirement ID | Requirement Description   |
|----------------|---|
| R.3.4.1 A      | The system will come with a user manual.                                    |
| R.3.4.2 A      | All sources will be clearly identified and listed in the reference section. |

**TABLE 3.4: Documentation Requirements**

## 4 Hardware Requirements

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The hardware aspect of KickPro is considered to be one of the most essential as it represents the product's first impression to the user, which can be affected greatly by its mechanical design. It also is the backbone of the product's functionality and durability, which can be directly affected by how the electrical and power system is designed. In this section, detailed requirements in the mechanical and electrical spectrum for each stage of the design will be listed below.

### 4.1 Overall Hardware Requirements

---

| Requirement ID | Requirement Description   |
|----------------|---|
| R.4.1.1 A      | The system will be generally portable and able to be set up by one person.  |
| R.4.1.2 B      | The structure and its internal systems will withstand hits by soccer balls. |

**TABLE 4.1: Overall Hardware Requirements**

### 4.2 Mechanical Requirements

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| Requirement ID | Requirement Description   |
|----------------|---|
| R.4.2.1 A      | The system will be able to store multiple soccer balls (approx. 5).                   |
| R.4.2.2 A      | The ball-launching function will obtain an adequate launch speed and launch distance. |
| R.4.2.3 A      | The system's swiveling actions will obtain adequate response time to input signals.   |
| R.4.2.4 A      | The system's swivel angles will be precise with an acceptable tolerance.              |
| R.4.2.5 A      | The system will be secured to the ground when in operation.                           |
| R.4.2.6 B      | The system will be able to store 10 balls.  |

**TABLE 4.2: Mechanical Requirements**

## 4.3 Electrical Requirements

---

| Requirement ID | Requirement Description   |
|----------------|---|
| R.4.3.1 A      | The system will have circuit protections for all sub-systems in the case of electrical failure. |
| R.4.3.2 A      | The system will have properly assembled PCBs.   |
| R.4.3.3 A      | All wiring connections are properly insulated.  |
| R.4.3.4 A      | The system will be plugged into a 120V AC wall outlet when in operation.                        |
| R.4.3.5 A      | The system will receive enough power to all sub-systems via one supply.                         |
| R.4.3.6 B      | The system will be compatible with extension cords for outside use.                             |
| R.4.3.7 C      | The system will have a portable battery life of 10 hours.                                       |
| R.4.3.8 C      | The PCBs will be properly compliant to EMC standards.   |

**TABLE 4.3: Electrical Requirements**

## 5 Software Requirements

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The software application will offer players functions to evaluate the shooting performance and give them feedback. Because our project will take advantage of Raspberry Pi and Python has been available and already set up in Raspberry Pi, the software and graphic user interface will be designed and developed in Python with assistance from its available package such as Tkinter.

### 5.1 Overall Software Requirements

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| Requirement ID | Requirement Description  |
|----------------|--|
| R.5.1.1 A      | The system will be able to run on desktop platforms.                       |
| R.5.1.2 A      | The system will determine the ball's position as it crosses the goal line. |
| R.5.1.3 A      | The system will handle exception cases without undefined behavior.         |

**TABLE 5.1: Overall Software Requirements**

## 5.2 Detection Requirements

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| Requirement ID | Requirement Description   |
|----------------|---|
| R.5.2.1 A      | The system will detect a player within the penalty box.                   |
| R.5.2.2 B      | The system will detect a player from slightly outside of the penalty box. |
| R.5.2.3 B      | The system will detect and record the position of a player on the field.  |
| R.5.2.4 C      | The system will predict the position of a moving player.                  |

**TABLE 5.2: Detection Requirements**

## 5.3 Performance Requirements

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| Requirement ID | Requirement Description   |
|----------------|---|
| R.5.3.1 A      | The system will work in real-time with low latency.                           |
| R.5.3.2 B      | The system will have minimal jitters and latency when interacting with users. |

**TABLE 5.3: Performance Requirements**

## 5.4 Feedback Requirements

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| Requirement ID | Requirement Description  |
|----------------|--|
| R.5.4.1 A      | The system will provide feedback to any laptop/desktop it is plugged into.                     |
| R.5.4.2 A      | The system will provide feedback in the form of statistics.                                    |
| R.5.4.3 B      | The system will provide feedback in the form of graphs and other illustrations. (See Figure.1) |
| R.5.4.5 C      | The system will provide feedback to a tablet it comes with and it will be                      |

|  |                                |
|--|--------------------------------|
|  | displayed on a designated GUI. |
|--|--------------------------------|

**TABLE 5.4: Feedback Requirements**

## 6 Safety, Sustainability, and Legal Requirements

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| Requirement ID | Requirement Description   |
|----------------|---|
| R.6.0.1 A      | The ball launcher motor mechanism will be properly concealed so that it is not exposed to a user's contact. |
| R.6.0.2 A      | All electrical sources will be insulated to prevent electrical fires and harm to users.                     |
| R.6.0.3 C      | Trademarks and copyrights will be registered.   |
| R.6.0.4 C      | Software development will follow ISO standards. [3]   |
| R.6.0.5 C      | The product will be compliant to CSA C22. 1:21. [4]   |

**TABLE 6: Safety, Sustainability, and Legal Requirements**

## 7 Conclusion

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There are no similar products available that try to achieve the same scope as KickPro; we have the potential to tap into a Blue Ocean market. Our tool is meant to be a cutting-edge training mechanism that provides soccer players with real-time data and analysis, alongside enabling a limited type of soccer drills by accurately launching balls at players in motion. As this product is intended to be a retrofit solution, it will be user-friendly, intuitive, and simple to install. Thus, our upcoming design will have an emphasis on minimalism and simplicity while providing valuable feedback and services. IronFoot Technologies has written this document to outline the requirement specifications needed to satisfy the safety and convenience of all clients and stakeholders. This report also includes the specific phase of development we expect to satisfy each of those requirements. Lastly, our team has included a test plan for the proof-of-concept stage in the appendix.



## 8 References

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[1] “SWIVL - the robotic cameraman,” *Edtechs*. [Online]. Available: <https://www.edtechs.com.au/collections/swivl-the-robotic-cameraman>. [Accessed: 11-Feb-2023].

[2] “The ball launcher – Soccer Ball Delivery Machine,” *Net World Sports*. [Online]. Available: <https://www.networldsports.ca/the-ball-launcher-soccer-ball-delivery-machine.html>. [Accessed: 11-Feb-2023].

[3] “ISO Standards in Software Engineering”. [Online]. Available: <https://www.geeksforgeeks.org/iso-standards-in-software-engineering/> [Accessed: 11-Feb-2023].

[4] “Product,” *CSA Group*, 17-Sep-2022. [Online]. Available: <https://www.csagroup.org/store/product/CSA%20C22.1:21/>. [Accessed: 12-Feb-2023].

## 9 Appendix

### 9.1 Proof-Of-Concept Test Plan

The functionalities that will be presented for the proof-of-concept during the 405W poster presentation are below:

| Deliverable  | Test Procedure   | Validation   |
|--|--|--|
| R.3.1.1 A, R.3.2.1 A, R.3.2.2 A, R.5.3.1 A<br><br>The product should launch a ball directly to the player when a certain button is pressed on a remote-controller. This system should take into account the position and velocity of the player so the ball does not go behind or in front of them.            | Ensure the system is turned on and there is a clear area around the launcher and designated player. The designated player should jog around the area. When they press a button on the remote, the ball-launcher should pass the ball directly to them - the system will pass the ball to where they were, it will not try to intercept them. | The ball is passed to the player within a reasonable tolerance. This reasonable tolerance is defined as being able to catch the ball with one's foot without having to move more than one foot in any direction. |
| R.3.1.2 A, R.5.1.1 A, R.5.1.2 A, R.5.4.1 A, R.5.4.2 A<br><br>The product should record the position of each ball as it crosses the goal line, alongside the player, and rate each shot. The rating will also account for the position of the player. The data will be in text format for the proof-of-concept. | Ensure the system is turned on and there is a clear area around the launcher and designated player. The designated player should kick multiple balls into the net, one at a time, at different locations. Afterwards, a team member should pull the data from the system and determine if it is accurate.                                    | The data, in the form of statistics, shows the position of the balls - and shooter - as they crossed the goal line with sufficient accuracy. Furthermore, each shot is rated.                                    |

**Table 9.1: Proof-Of-Concept Test Plan**