Development of the Design Requirements for a 'Smart' Baseball/Softball Backstop

A Major Qualifying Project Report

Submitted to the Faculty of

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In partial fulfillment of the requirement for the

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Abstract

The object of this paper was to facilitate a future team to create a smart backstop. The rationale is that consumers want more information on their pitching; a new backstop could capitalize on this trend. The methods used are market research with an AHP analysis of current backstops, an Axiomatic Design decomposition of a backstops job and financial analysis for future backstops. The results for the AHP analysis show the key factors for a current backstops, the Axiomatic Design decomposition extrapolates future key factors and a financial analysis helps future teams understand how to create the most valuable product. In conclusion, we have set up a design team to create a smart backstop with information on design parameters, functional requirements, and financial tools.

Chapter 1: Introduction

A baseball backstop keeps the baseball on the playing field or in the backyard. The backstop is designed to protect spectators from a wild pitch or a foul ball that could potentially cause injuries or return the baseball to the pitcher.

1.1 Problem Statement

The objective of this project is to prepare a design team with the functional requirements and potential commercialization plan for a smart backstop for youth baseball players. A smart backstop is a baseball backstop that also analyzes the pitch to provide more information to the pitcher, such as speed and location. Our approach takes a step back and examines the problem, not the specifically requested solution to the problem to define our value proposition: helping youth improve their pitching. The future designed smart backstop could be novel by reflecting the evolution of youth baseball from a pastime to college investment.

1.2 Project Goals and Objectives

We established the project goal as, to develop the functional requirements of a commercialization plan for a smart backstop.

In order to achieve our goal, we will be using the Axiomatic Design method to structure our project. The Axiomatic Design (AD) “conforms functional requirements (FR’s) to two axioms to ensure the design is effective and efficient” (Suh,2001). Key methods being used to reach our goal are, financial analysis, time value of money analysis, analytical hierarchy and market research. We developed a financial model to determine commercialization feasibility. These methods helped our team move in gathering information for a future design team to create a smart backstop.

1.3 Scope and Deliverables

The project deliverables for this project include developing a financial analysis report that will assess the viability and profitability of both the company and product for the future creation of the smart backstop. We will also include an Axiomatic Design decomposition of our project goal.

1.4 Project Timeline

This MQP project proposes a commercialization plan for a product that ultimately helps and prepares other MQP design teams with the necessary information required to design a smart backstop for youth baseball players. Our plan explores the economical and operational characteristics for a smart backstop.

Using an Axiomatic Design decomposition, our team will identify the most important factors of the smart backstop including key functional requirements, customer needs, and constraints. Finally, a market analysis will explore the economic potential of a new smart backstop, including potential marketization plans with a built-in time value analysis.

To complete all of our goals within the project, we used 2 7 week terms throughout the school year. We tried to follow our gantt chart, see appendix 4, to the best of our ability to fulfill our goals and requirements.

Chapter 2: Background

In order to understand the context of our project, we gathered market research of baseball backstops currently on the market. We also briefly introduce the main method of our project, axiomatic design.

2.1 Axiomatic Design

The Axiomatic Design method is a design procedure that was introduced by Nam Pyo Suh (Suh, 2001). It proposes a systematic approach for the design of products, processes, components, and softwares. The AD applies a scientific approach for designing products according to its customer needs. The process within the approach is “repeated until all parties are satisfied that the design accurately represents the components” (Brown, 2005).

The axiomatic design approach makes use of two axioms that govern the design process. Axiom 1, known as the ‘Independence Axiom’, maintains the independence of the functional requirements of the design. It states that the independence of the Functional Requirements (FRs) must be always maintained, “where FRs are defined as the minimum number of independent functional requirements that characterize the design goals” (Suh, 2001). Axiom 2, the ‘Information Axiom’, seeks to minimize the information content in a design. It also states that among those designs “that satisfy the Independence Axiom, the design that has the highest probability of success is the best design” (Suh, 2001).

2.2 Overview of Backstops on the Market

Human Alternative

Baseball backstop manufacturers continually try to address the customer need of improving youth pitchers. There is a small quantity of peer-reviewed research on smart backstops that explain their responsibilities. Through research, we found that the position of a catcher in baseball is a human alternative to a backyard backstop. In fact, “catchers are actually nicknamed “backstops” on the baseball field” (Baseball Reference, 2013). Some of the responsibilities they have in common are, keeping the baseballs in close proximity, keeping surroundings safe from wild pitches, and indicating what kind of pitch was thrown. The radar pitching trainer, largemouth hitting net, and galileo vinyl backstop are all possible examples of backstops on the market that are addressing the customer need of improving youth pitchers.

Figure 1

Figure 1 is an example of a catcher acting as a backstop. The catcher is waiting for the pitch to be thrown from the pitcher and will do their best to stop the pitch from possibly getting away from them.

2.2.1 Radar Pitching Trainer

Figure 2

The radar pitching trainer addresses a major area when compared to other backstops on the market. For all pitches in the strike zone, the device is designed to “calculate the pitcher's release speed for fastpitch baseball or softball” (Radar Pitching Trainer, 2020). The built-in virtual umpire determines whether a pitch will be a ball, strike, or walk. The device can also keep track of cumulative pitch count, balls, strikes, outs, and walks. However, in some aspects, the radar pitching trainer does not act like its human alternative, the catcher. It will not keep a baseball from flying off in a random direction. If the user throws a wild pitch, then whatever is in the background of the backstop has a chance of being fragmented. After the radar pitching trainer is set up in the backyard, all users have to do is throw pitches consistently at the target to generate statistics that will benefit them.

Price: $399.00 (Radar Pitching Trainer, 2020)

2.2.2 Galileo Vinyl Backstop

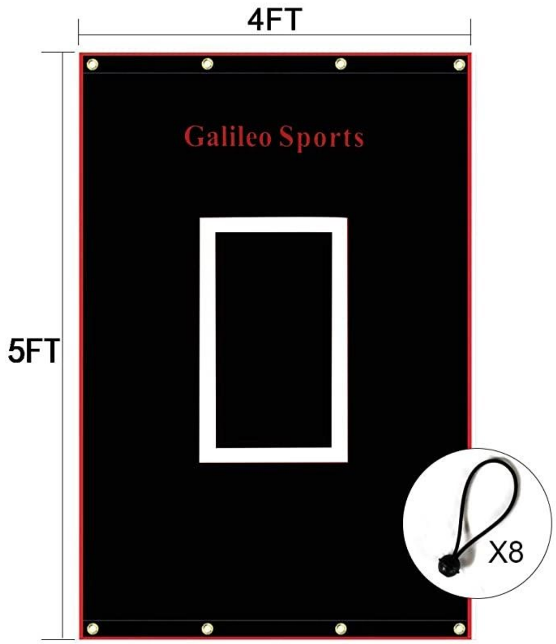

Figure 3

Galileo Sports has developed a heavy-duty 4 ft by 5 ft backstop that "stops the hardest pitched balls" (Galileo Sports, 2020). The main feature of this backstop is that it will keep wild pitches from damaging any property in the background. Since there is a strike zone in the middle of the backstop, users are able to see if their pitch was a ball or strike. The Galileo baseball/softball backstop "is made of high quality imported PVC material and, resistant to high temperature, strong light, will not be oxidized for a long time practice" (Galileo Sports, 2020). Unlike the radar pitching trainer, this backstop design does not detect strikes, balls, walks, or the speed of a pitch.

Price: $35.99 (Galileo Sports, 2020)

2.2.3 Backstop Discussion

Each backstop design tries to improve the users pitching, but their approach is different. The radar pitching trainer provides a smart backstop that uses technology to detect pitch speed and whether a pitch was a ball or strike. This backstop can be considered one of the "smartest" backstops on the market because it detects the speed and location of the pitch. The trainer is designed to "encourage backyard competition" (Radar Pitching Trainer, 2020). By calculating pitch speed, users can throw a pitch and identify who out of the group throws the fastest pitch. The company may fulfill the customer need of identifying how fast a pitch is thrown, but it does not fulfill the customer need of keeping the backyard safe. The Galileo vinyl backstop serves the main purpose of saving any property in the background from getting damaged. With the strike zone in the middle of the backstop, the user can identify with the eye whether a pitch was a ball or strike. The downfall of this backstop is that it can not detect the pitch speed like the radar pitching trainer can. Each backstop is successful in its own way. The radar pitching trainer is a modern-day smart backstop, while the Galileo Vinyl backstop is an old fashioned backstop with no technology.

2.2.4 Other Equipment

Large Mouth Hitting Net

Figure 4

Hit Run Steal has developed a 7x7 practice net with a bow frame and has become one of the "most reliable baseball training nets in the industry (Hit Run Steal, 2020)", see Figure 4. The main feature of the largemouth hitting net is that it is extremely durable for fast pitches.

Although they do not explicitly claim to serve as a backstop, the design shares the same responsibilities as a catcher. The wide netting allows for wild pitches to stay in the proximity if it hits the net. When pitched, the baseball will bounce off the net in a downwards angle into the ground.

Price: $159.97 (Hit Run Steal, 2020)

2.2.5 Pitching Statistics

This section identifies how well statistics pitchers need to perform in order to get into that respective college for pitching. Having fun, staying active, and eventually playing at a higher level are a few of the reasons to play childhood sports. This section breaks down divisional recruiting guidelines to give recruits and their families a better understanding of what will be expected of them at the pitcher position.

	Pitch Velocity	ERA	K per inning	Walks
Division 1	84 MPH consistently, up to 95 + MPH	Below 2.00	At least 1 K per inning	Less than 1 batter per 2 innings
Division 2	82 MPH - 90+ MPH	Below 3.00	Around 1 K per inning	Around 1 batter per 2 innings
Division 3 and NAIA	77 MPH - 82 MPH	Between 2.50 - 3.50	Strikeout to walk ratio 1:1	
Junior College	80 MPH consistently	Below 4.00	1 or less than 1 K per inning	

Table 1

ERA: Earned Run Average K: Strikeout

With this table of information available, users of the smart backstop will know their pitching velocity, and whether a pitch is a ball or a strike. This helps users know what aspect of their pitching they need to improve in order to reach the next level of going to college.

2.3 Market Analysis - Products on the Market

We previously discussed well-known backstops on the market. This section of the chapter discusses different products on the market that give more background on products that are involved in the making of a smart backstop.

Our market analysis found that there are a host of different ways to measure display and record a host of parameters for a baseball pitch. These parameters could include speed, location, spin, and even the full trajectory for the most expensive smart backstops. Additionally, there are lots of products that stop the baseball from going too far. One well-known example of a fully comprehensive analysis of a baseball pitch is the analytics provided by the MLB, Pitchf/x. While this technology is not available to everybody, other high-end consumer devices are available to the public. On the lower end, popup nets that vaguely indicate speed based on the recoil of the net and indicate location based on catching the ball in an array of nine pockets create an array for lower end backstops.

The four kinds of devices in the smart backstop industry are passive backstops, radar guns, video analytics, and smart balls. Passive backstops are usually simple nets on the amount of chain link fences in a specific area. Some of the nets have different holes so the pitcher knows where the ball went based on the hole the ball ended up in. Other kinds of passive backstops have a hard plate where the strike zone would be and netting all around so the pitcher can tell based on the sound if the pitch would or would not have been a strike. Most smart backstops either have their own passive backstop built-in or require a passive backstop to be complete.

Radar guns are a common way of tracking the speed of the pitch. Many radar guns are mounted onto a passive backstop and display the speed with a display and sometimes audio as well. Other radar guns are either handheld by another person or can be placed on the ground or a tripod behind a passive backstop sold separately.

One example of a radar gun on the market is the Bushnell Velocity Speed Gun. The speed gun displays the fastest speed once the trigger is released and can track the speed of a ball from 10 feet up to 110 MPH. It is also an easy point and “shoot speed gun with +/- 1.0 MPH accuracy” (Bushnell, 2020).

Figure 5

Video analytics is a cutting edge way of measuring a host of information, from spin to velocity and position. They make use of one or more video cameras to track the ball’s trajectory. The information is usually displayed on a computer, or a smartphone . An example of video analytics for pitching training is Trackman. (Trackman, 2020)

Smart balls measure the speed and spin of the ball when the pitcher throws it. They then upload the information to a computer or a smartphone (Bushnell, 2020)

Completing a market analysis gave our team and a future design team information about customers, industries, competitors, and other market variables. With the market analysis produced in this report, a future design team should be able to identify where they can penetrate the market. With our market analysis, we back up our business idea with data, figures and facts.

Chapter 3: Methods

This section briefly describes the methods our team used throughout our MQP. It begins with an analytical hierarchy, axiomatic design and the axiomatic decomposition of our project, and a financial analysis.

3.1 Analytical Hierarchy

An analytical hierarchy process (AHP) is a method developed by Thomas L. Saaty in the 1970's "for organizing and analyzing complex decisions, using math and psychology" (Passage Technology, 2018). Our judgment criteria includes price, setup time, ease of use, quality of data, and quality of the display. Rather than having a "correct" decision, the AHP will help a future design team find a decision that best suits their understanding of the smart backstop creation. This hierarchy could be particularly helpful if future teams decide to modify an existing backstop on the market and then license the technology to the current creator: an approach that our team believes would be the most risk-averse way to earn a return on investment. With this hierarchy, future teams could have a structured approach to knowing which backstops offer the best licensing deals.

Below is a visual representation of all the steps we have followed to complete the necessary analytical hierarchy process, see figure 6.

Example of Final Product for Analytical Hierarchy:

		Option 1 Scores		Option 2 Scores		Option 3 Scores		Total Points by
Category	Weight	Unweigh	Weighted	Unweighte	Weighted	Unweighte	Weighted	category
Ease of Use	30%	4	1.2	5	1.5	6	1.8	15
Setup Complexity	25%	2	0.5	6	1.5	7	1.75	15
Development Cost	20%	6	1.2	6	1.2	3	0.6	15
Confort and Entertaining	20%	6	1.2	4	0.8	5	1	15
Product Cost	5%	6	0.3	6	0.3	3	0.15	15
Total Score	100%		4.4		5.3		5.3	

Figure 6

The analytical hierarchy process informs the axiomatic design process by defining the decision problem and design goals. An evaluation method “of the design matrix that indicates the relationship between functional requirements (FRs) and design parameters (DPs) in AD is proposed in this study to provide a quantitative design method for AHP hierarchy structure design” (Cho, 2012). The AHP model calculates the weights of criteria and then helps the creation of the axiomatic design decomposition.

3.2 Axiomatic Design

We used the axiomatic design as a method to structure our project. The goal of Axiomatic Design is to “establish a scientific basis for a design and to improve design activities by providing a theoretical foundation based on logical and rational thought processes and tools” (Suh, 2001).

The diagram below shows how the different domains of Axiomatic design work together. However, building the smart backstop is not within the scope of our project, our project only focuses on the Stakeholders, Stakeholder domain, Functional Domain and Physical Domain. Constraints, Selection Criteria and Optimization criteria are also briefly touched upon.

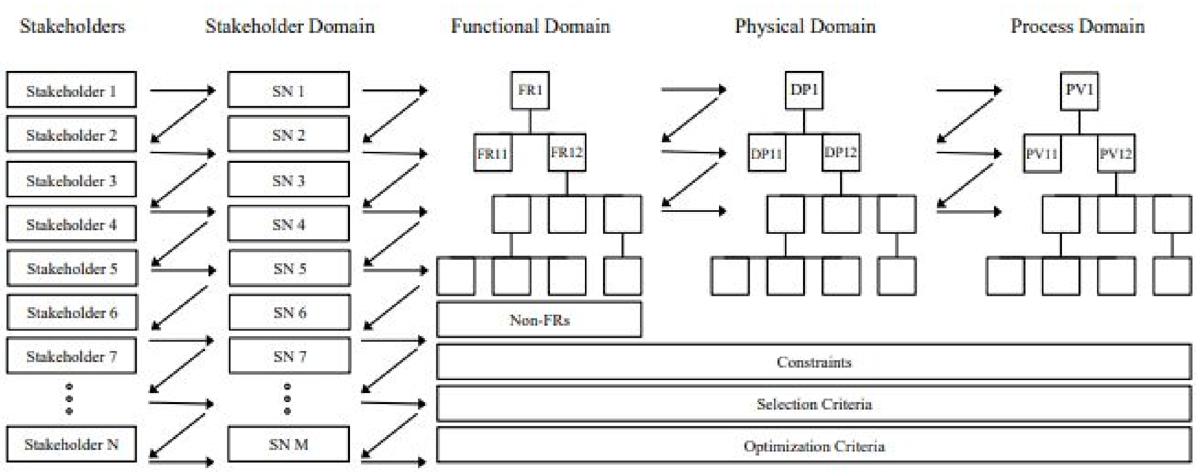

Fig. 1. Stakeholders, requirements categories, and their relations to the four domains of Axiomatic Design Theory.

Figure 7

3.2.1 Identifying Customer Needs

The main key to using the axiomatic design is to successfully understand the customer needs. By defining the problem we must solve, we can fulfill the customers' needs. Normally, when using the axiomatic design we would create and select a solution. However, a design team will actually be designing the physical backstop device so they will refer to one of the multiple solutions we develop in our results. There are two main customers in the smart backstop market, the people who will eventually use the product and the investor who might be financing the product. Without these two customers, the product will never be successful. The retail customer wants a new backstop that adds value to their practice performance results time for a reasonable price. To make the product successful, we must meet the customers' needs the most amount of times possible. The investor wants an investment that provides a high return on investment as a function of time.

Our project uses research to determine the customer needs for a new smart backstop. Market research is utilized initially to determine what is on the market. Further research regarding industry growth and changes is then considered with the market research to determine areas that current products fail to cover. Based on research discovered so far, growth in the youth sports industry seems to be strongly tied to the growth of sports scholarships. The direction for the youth sports industry guides our development for a new smart backstop. Using the axiomatic design matrix methods, we have analyzed the customer needs for others of the smart backstop and developed those into the functional requirements.

3.2.2 Identifying Functional Requirements

"Functional requirements are a minimum set of independent requirements that completely characterizes the functional needs of the product (or software, organizations, systems, etc.) in the functional domain. By definition, each FR is independent of every other FR at the time the FRs are established" (Suh, 2001). The functional requirements are the "what" in what we want to achieve. Each functional requirement has one or more design parameters and must be satisfied within the design range.

3.3 Financial Analysis

A financial analysis is the process of evaluating businesses, projects, budgets, and other finance-related transactions to determine their performance and suitability" (Tuovila, 2020) Since our financial analysis is being conducted internally, we have prepared a design team to make future business decisions regarding the creation of a smart backstop.

In Susumu Ogawa and Frank T. Piller's 2006 article "Reducing the Risks of New Product Development," the two professors suggest a few different ways to minimize risk when launching a new product: Postponement & Mass Customization and Collective Customer Commitment. With Postponement & Mass Customization, the company can learn what the customer wants by selling just a few of the products (Ogawa and Piller, 2006). While this approach results in a larger than normal work process, smaller batch sizes and added complexity, it gives the company the flexibility to change the product. Oftentimes, base products will be created and then slowly sold with changes such as added features as the company receives feedback from their customers.

A similar approach to minimizing product launch risk is Collective Customer Commitment (Ogawa and Piller, 2006). With this strategy, the products are marketed to potential clients and the company generates feedback. Next, a final design is promoted to the public and customers are asked to preorder the product with a down payment before production of the product. This approach gives the company early feedback from paying customers and is useful in gauging whether or not to take the product to market. If a certain number of preorders are not acquired before launching the product, the project is abandoned and if a large number of preorders are acquired, production scheduling can be efficiently adjusted (Ogawa and Piller, 2006).

Our team has prepared a future MQP team to use a combination of Postponement & Mass Customization and Collective Customer Commitment to identify the viability of a new backstop, giving investors the best information for moving forwards. Future MQP teams could create a prototype and sell the product to a test market. Preorders could be obtained from particularly keen customers or the product could be marketed to a test sample of clients. This information will be helpful in determining the value of the product.

3.3.1 Time Value of Money Analysis

The "time value of money (TVM) is the concept that money you have now is worth more than the identical sum in the future due to its potential earning capacity" (Chen, 2020). There are a few specific variations of the time value of money, net present value, present value, and future value. There are five factors in a TVM calculation, number of time periods involved, annual interest rate, present value, payments, and future value. We have evaluated the time value of a baseball backstop. The goal of the TVM method is to show graphically that the money the future design team puts into the backstop initially, will be greater in the future, due to the potential earning capacity.

3.3.2 Pilot Run Approach

Our team has created a calculator that helps future design teams to approximate the products worth with investors. This calculator could help the design team and investors understand how the different economic parameters of a new smart backstop affect the investment opportunity. The calculator approximates the profitability of the idea and the timeframe required to produce a return on investment based on a pilot run. Future MQP projects can focus on this pilot run and use the calculator to make sure that the product is being developed in a financially viable way, and that the product can be sold for a high profit later on.

The production team will need to create a prototype and produce production costs and retooling costs of the smart backstop. A marketing team would need to test the market by selling the prototype. For the pilot production run, it is important that the team markets the product to as few people as possible and attempts to achieve the highest conversion rate for a proof of concept for the whole market. Essentially, the marketing team for the first batch is trying to prove that they can sell the most products while reaching out to the smallest number of potential clients. If they are able to sell a product to each potential client contacted, then the idea will have a strong proof of concept. If a low percentage of potential customers contacted do not buy the backstop then the product could seem less favorable to potential clients.

Chapter 4: Results

4.1 Stakeholder Analysis & Customer Needs

There are two main stakeholders in our project: the smart backstop user and the design team. The smart backstop user's requirements focus mainly on the functionality of the device and the price. The design teams requirements focus mainly on the profitability of the device and the way they are going to design it. The customer need for our design team is to create a design that is profitable and also competitive with other smart backstops on the market. The main customer need for our users is to get better at baseball, specifically pitching, but because many athletes are trying to use baseball as a way of getting into college, one customer need is help getting recruited. (Gregory,2020)

4.1.1 The Sports Industry

A 2009 article in the International Journal of Sports Finance states that the consumer market expenditure for baseball and softball equipment totaled $372.4 million in the US alone. The chart depicted below shows the US's sporting goods expenditure per year. Together this data suggests that the market for backstops is large and growing.

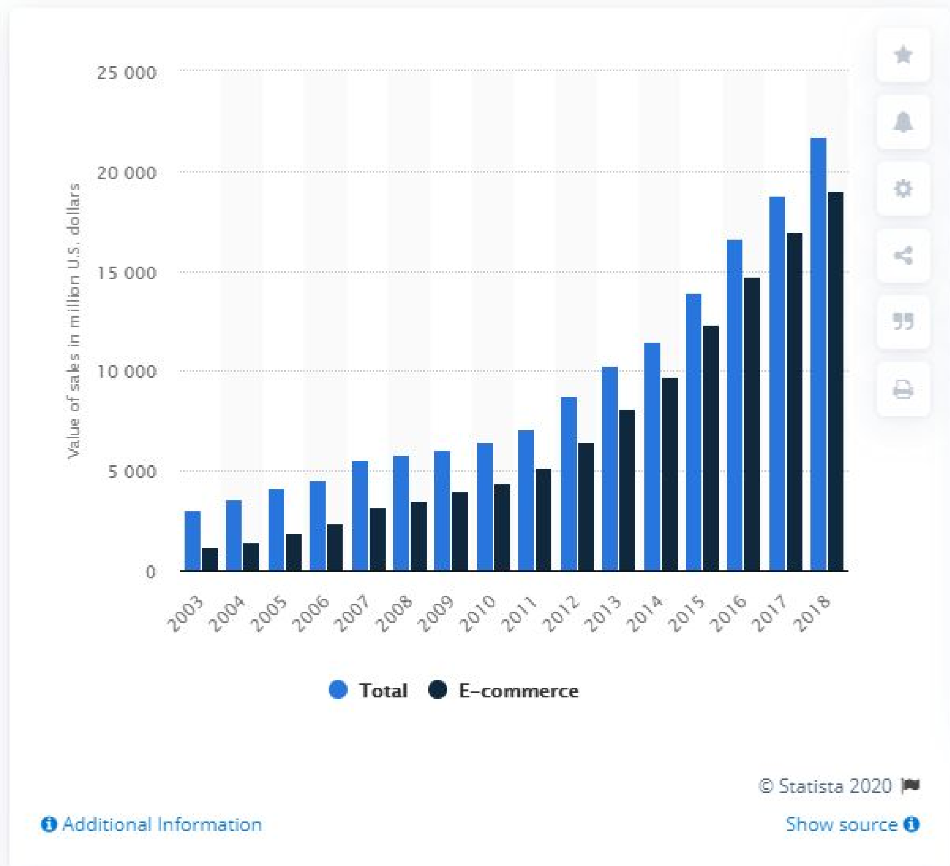

Figure 8

(Clement, 2020)

4.1.2 The Baseball Recruiting Industry

Coaches and college recruiters are looking for players for their team and understanding how the player performs is critical (Rush Soccer, 2006). Mallory Merda's 2020 article about recruiting during Covid-19 sheds light on the future of baseball recruiting. Merda focuses on the story of Joey Cuomo, a player and now recruiter who, in high school, was a "late bloomer." Cuomo didn't start the recruiting process until well after his peers, but by using video footage was able to get recruited. After majoring in applied mathematics and statistics, Cuomo used that knowledge to help recruit players by taking a data analytics approach. Cuomo's head coach Matt Jones is quoted by Merda saying "Their increased use of these technologies is here to stay, even when the pandemic ends. The human side of recruiting will continue to be important, but the pandemic has forced the Raiders to adopt technology for recruiting at a faster rate. Jones doesn't see that going away." While Jones reiterates the importance of seeing recruits perform in person, he admits that data from smart devices is becoming more important and does not anticipate the importance of these devices diminishing after Covid-19. (Merda, 2020)

4.2 Market Research: AHP Analysis

4.2.1 Devices Rated

Some of the products were not backstops, but just data collection and display devices, like a radar gun. To make all of the different options comparable, our team added $60 to the cost of each device that did not stop the baseball. Our team chose $60 because that was the cheapest "dumb" backstop we could find on Amazon. The four products we compare are CrankShooter LaxRadar, Radar Pitching Trainer Varsity, Pocket Radar and the F5 Sports pitchLogic Ball.

The Crankshooter LaxRadar is a small radar gun in a box that sits on the ground and measures speeds from 3-150 mph. It is extremely portable and has both a visual and audio display. The CrankShooter LaxRadar costs $110, but does not stop the ball so a backstop costing $60 for baseball could be required to use the device: this extra cost was factored into our analysis.

The Radar Pitching Trainer Varsity is a backstop that senses speed and the difference between strikes and balls. It does not require any extra parts because the radar gun is built into a backstop and costs $300.

The Pocket Radar Smart Coach is a handheld radar gun that can be mounted to a tripod and linked to a smart device like a smartphone. It measures the speed with one device and can use the camera from another smart device to give video and speed recordings of a pitch. It does not have a backstop so it's $400 price had $60 added to it for the backstop cost. It also requires a person or a tripod to hold the radar gun. Like the Crankshooter LaxRadar, it has a voice display with the speed and does not measure accuracy at all.

The Pitch Logic by F5 Sports is a smart baseball that measures a large number of factors from the pitchers throw. The smart baseball measures speed, spinn on all three axes, and the forwards and backwards motion of the pitcher as he or she throws the ball. The ball connects to an app which runs on both IOS and Android devices. It costs $250 but does not have a backstop so $60 was added to the cost. The device only requires one person to use it, so no extra people are necessary.

4.2.2 Rating Criteria

The four products were rated on the following criteria: Price, Setup Time, Ease of Use, Quality of Data, Quality of Display and Cost of modification. The weights for each criteria was determined by our team based on the level of importance that each criteria carried. Quality of data was considered the most important criteria because it would give any added on program the most data to use. Cost of modification was given the next greatest weight because the cost of modifying the product would determine the investment required to create the product. Price, setup time and ease of use were considered the less important criteria because users of the newest technology are generally tolerant of extra cost and hassle if they can get the best product. Quality of display was given the lowest weight because our product would provide its own display. The raw scores seen in green were given out on a scale of 1-5, with 5 being the most desirable score and 1 being the least desirable score. The raw price score seen in orange is the inverse of the actual price. Weighted scores were then calculated by multiplying the raw score by the weight and dividing by the total raw score for the given category. The sum of weighted scores for all the categories were added to produce a final score for each product (seen in yellow).

4.2.3 AHP Analysis

		LaxRadar By CrankShooter		Radar Pitching Trainer		Pocket Radar Smart Coach		F5 pitchLogic Ball	
Category	Weight	No Weight	Weight Score	No Weight	Weight Score	No Weight	Weight Score	No Weight	Weight Score
Price	15%	0.006	0.217	0.003	0.123	0.004	0.142	0.003	0.119
Setup Time	15%	3.000	0.120	4.000	0.160	3.000	0.120	5.000	0.200
Ease of Use	15%	3.000	0.120	4.000	0.160	3.000	0.120	5.000	0.200
Quality of Data	25%	3.000	0.231	3.000	0.231	3.000	0.231	4.000	0.308
Quality of Display	10%	3.000	0.080	4.000	0.107	4.000	0.107	4.000	0.107
Cost of Modification	20%	4.000	0.267	4.000	0.267	2.000	0.133	2.000	0.133
Total Score	100%		1.034		1.047		0.852		1.067

Table 2

4.2.4 AHP Analysis Discussion

Our analysis suggests that the F5 pitchLogic Ball is the best choice, followed by Radar Pitching Trainer, LaxRadar and then Pocket Radar coming in last for the devices analyzed. While these results are helpful to choosing the best option, there could be important parameters not included. Initially, the backstop team should focus on companies that are likely to make licensing deals. As a product using new technology, the F5 company, creator of pitchLogic Ball could be particularly open to opportunities to expand and grow their product offerings. While there were cheaper options very similar to the F5 pitchLogic Ball, they lacked the accuracy of the F5 pitchLogic Ball.

The AHP Analysis is an excellent tool to use before axiomatically decomposing the function of a smart backstop because it helps the user identify key aspects of products currently on the market. Essentially, an AHP Analysis starts with what exists on the market and identifies the importance of these features to the user, while an Axiomatic Design Decomposition starts with the stakeholders and identifies what features the user would need.

4.3 Axiomatic Design Decomposition for the smart backstop

The axiomatic design decomposition is broken into a few sections; those sections are explained in detail below. The coupling matrix below shows the main interactions between the functional requirements and design parameters. Because this project is in its infancy, these couplings are extremely rough estimates assumed by our team.

#	[FR] Functional Requirements	[DP] Design Parameters
0	Develop Commercialization Plan for a Smart Backstop	Commercialization Plan for Smart Backstop
1	Determine the Economic Characteristics of a Smart	Economic Characteristics of Smart Backstop
1.1	Create Going to Market Plan	Going to Market Plan
1.1.1	Identify Target Customer	Target Customer
1.1.2	Create Monetization Strategy	Monetization Strategy
1.2	Project Return on Investment	Return on Investment
1.2.1	Create Budgets & Timeline	Budgets & Timeline
1.2.2	Create Financing Plan	Financing Plan
2	Determine the Operational Characteristics of a Smart	Operational Charecteristics of a Smart Backstop
2.1	Develop Pitch Analysis	Pitch Analysis
2.1.1	Collect Trajectory Data	Trajectory Data
2.1.1.1	Measure Vertical Speed	Vertical Speed Measurement
2.1.1.2	Measure Horizontal Speed	Horizontal Speed Measurement
2.1.1.3	Measure Orthagonal Speed	Orthagonal Speed Measurement
2.1.1.4	Measure Pitch Rotation	Pitch Rotation Measurement
2.1.1.5	Measure Yaw Rotation	Yaw Rotation Measurement
2.1.1.6	Measure Roll Rotation	Roll Rotation Measurement
2.1.1.7	Measure Impact Location	Impact Location Measurement
2.1.2	Analyze& Display Data From Pitch	Analysis and Display of Pitch Data
2.2	Collect Balls	Ball Collection

Figure 9

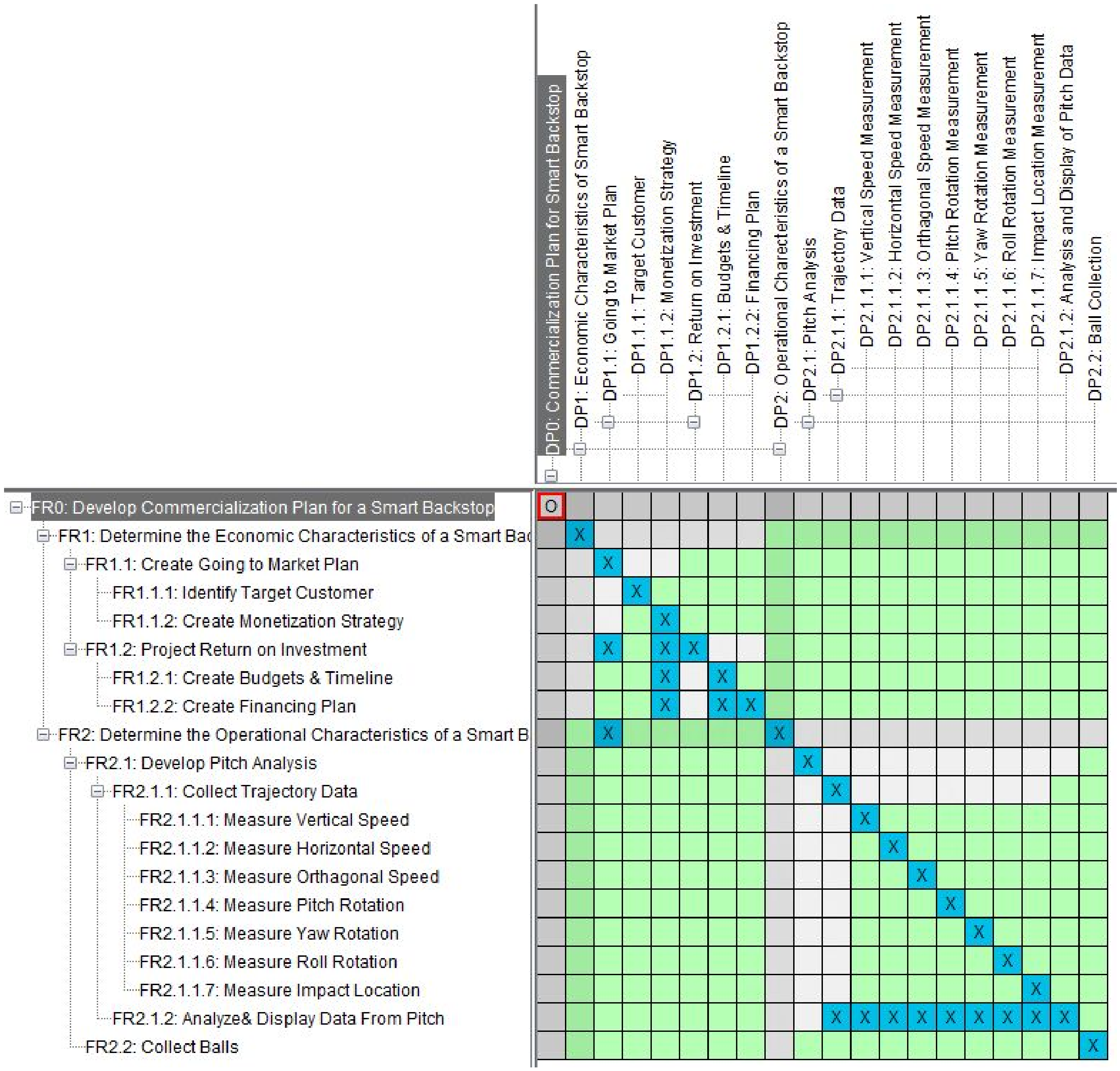

Figure 10

4.3.1 Determine the Operational Characteristics of a Smart Backstop

4.3.1.1 Develop Pitch Analysis

4.3.1.1.1 Collect Trajectory Data

The trajectory of the ball can be broken down into the six degrees of freedom, three for displacement and three for rotation. A smart backstop could measure either the velocity of displacement or map the location of the ball as a function of time. While having the location and times of the ball is more information, it is not particularly helpful. Most smart backstops focus on the velocities and rotation speeds, not tracking the exact position of the ball. As in the case of a knuckleball, all of the degrees of freedom can interact with each other as the ball moves from the pitcher to the batter. A knuckleball is a kind of pitch where spin is minimized. The result of this low spin is that the seams of the ball cause the horizontal and vertical velocities to behave unpredictably to the batter. (& Mandarino, 2016)

For speed, there are three speeds, vertical, horizontal and orthogonal, or the straight line speed from the pitcher to the batter. While most of the speed is in the orthogonal direction, vertical and horizontal velocities play a key factor in good pitching. Because of the way that radar guns work, most backstops measure speed in the orthogonal direction only. This type of analysis is helpful for comparing fastball pitches but fails to take vertical and horizontal speed into account. The graph below was found from baseballsavant.com and shows the total displacement of the ball in horizontal and vertical direction from pitchers in the MLB. Because the ball is moving no more than 15 inches vertically and horizontally on it's 60.5ft trip from the batters mound to home plate, the total velocity will change very little. If a pitch was traveled 15 inches in both the vertical and horizontal direction (21 inches total), the difference between the true speed and orthogonal speed of the ball would be less than .05%. (Savant, 2020)

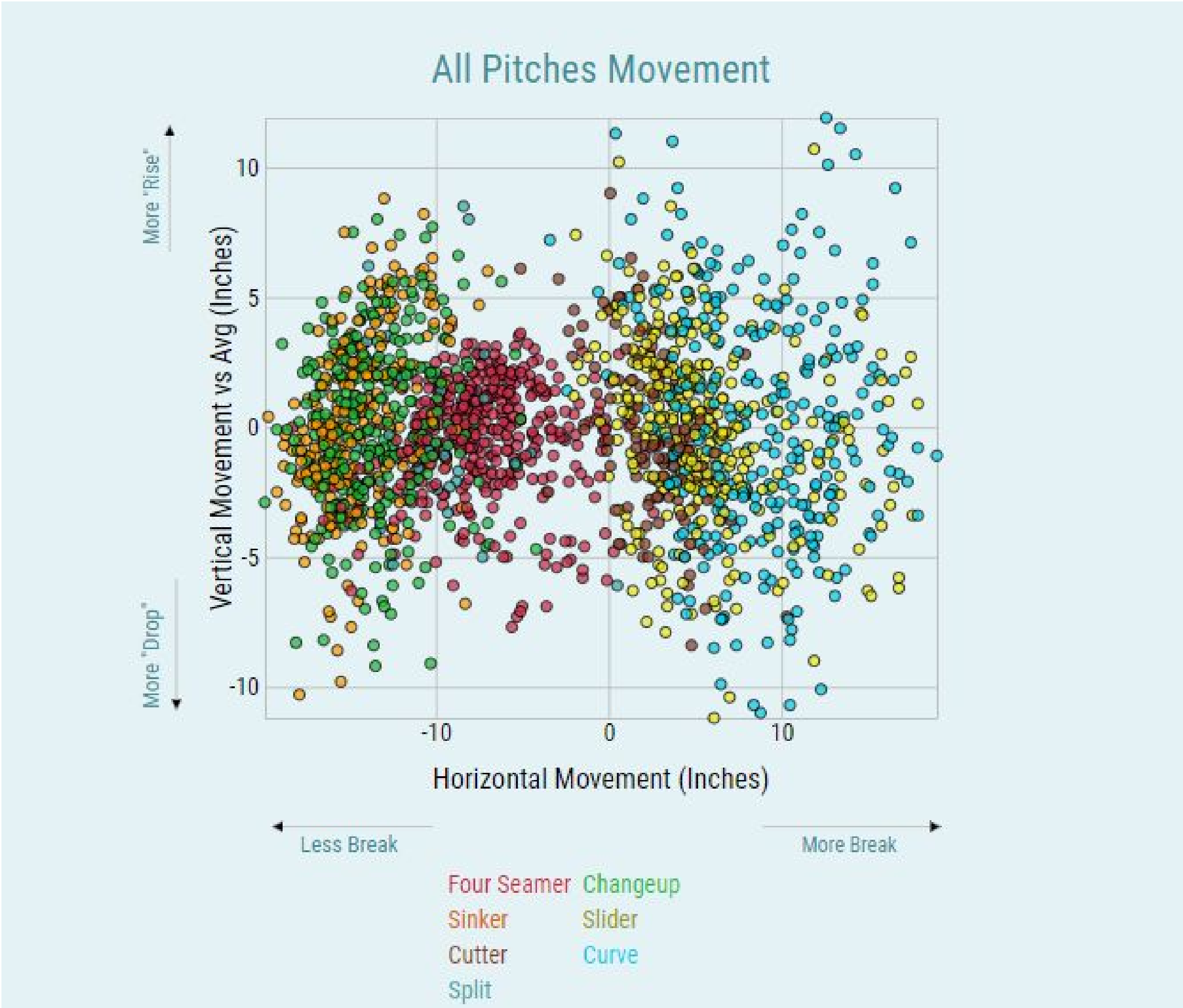

Figure 11

For rotation, there are three axes about which the ball can rotate. A combination of these three rotations defines the overall rotation of the ball. The axis are generally defined relative to the direction of travel of the ball, which is roughly the orthogonal direction discussed previously.

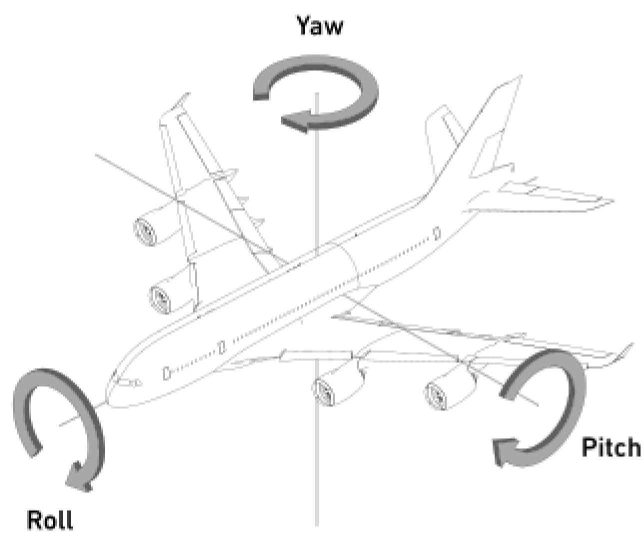

Figure 12

Finally, a smart backstop can tell the user where the ball ends up hitting. This is particularly important information because the final location of the pitch is indicative of whether or not the pitch would have been a strike. (Aashmango4793)

4.3.1.1.2 Analyze and Display Data from Pitch

One of the most important differentiators between backstops is the analytics display of the pitch. Ultimately the user only interacts with the display analytics making that a critical factor. This analysis display should be tailored to the exact needs of the customer. One example of a disconnect between current customer needs and current analytic displays on the market is the recruitment implications that come with the pitch. Our team believes that youth pitchers would want to know how their pitches stack up to other recruits, letting them constantly gauge where they stand on the recruitment spectrum.

4.3.1.2 Collect the Balls

Lastly, a smart backstop should be able to collect the balls. This aspect of the smart backstop is notably coupled from all of the other factors and can be dealt with mostly separately from all of the other functions.

4.3.2 Determine the Economic Characteristics of a Smart Backstop

4.3.2.1 Create Going to Market Plan

4.3.2.1.1 Identify Target Customer

We suggest that our target customer be youth hoping to get recruited to college through baseball. Our team thought that kids sports equipment could be a lucrative market because the kids sports equipment industry is the largest it has ever been and is continuing to grow. According to Sean Gregory's 2020 Times Article "How Kids Sports Turned Pro," parents are spending more on their kids sports than ever before in hopes of their kids getting recruited for college level sports. Baseball is no exception. (Gregory, 2020)

Gregory's article points out that money is not the only sacrifice parents make. As one Sandiego soccer mom put it "It's definitely taken over everything," when referring to the financial cost but also the nights and weekends spent at tournaments, causing the family to miss birthday parties and weddings. Gregory cites the $3 billion a year awarded in NCAA scholarships as the motivation behind the youth's sports oriented lifestyles. Many would consider the $3 billion of scholarships awarded in sports to be an excellent opportunity to give kids a great opportunity in life, but Tom Farrey, executive director of the Aspen Institute's Sports & Society program hilights a silver lining: "That's a lot of chum to throw into youth sports, it makes the fish a little bit crazy." More worrying still, Gregory concludes that "For most, a savings account makes more sense than private coaching [to get your child through college]."

4.3.2.1.2 Create Monetization Strategy

Our team believes that the best monetization strategy is creating a rudimentary pilot run to demonstrate a proof of concept and then using our projections to secure a licensing deal. This strategy limits the financial investment and relies heavily on time investment from MQP teams. With this monetization strategy, our team believes that risk will be minimized on the end of a sponsor.

4.3.2.2 Project Return on Investment

4.3.2.2.1 Create Budget & Timeline - Time Value Analysis of Project

Because the product has not yet been created, most of the factors required for an investment analysis are unknown. A customized calculator will help future teams and investors understand the value of the investment opportunity based on their own numerical inputs. While the project is still being run by MQP teams, the time value analysis is simple. Because there are few if any costs associated with running MQP's, there is nothing to be lost by continuing the project within WPI. From an investment standpoint, there is no limit to the number of MQP's or time spent doing MQP's that will make this project a poor investment assuming some sort of return is feasible. As the project continues, MQP teams should consider whether or not there is even a small possibility of turning a profit. If it is determined that there is virtually zero chance of creating a profitable product, the project should be abandoned; if there is still some chance of creating a profitable product, the project should be continued. As the project continues, our team believes the probability of being first to market (a key factor in product profitability) goes down, but until a product that is similar to our project reaches the market the project will likely have potential of being profitable.

Our team created a time-value analysis for other companies who might want to license the product. The graph is a rough estimation of the predicted profitability as a function of time. The graph is based on a calculator which can use an input from a pilot run to project sales. The calculator has a number of inputs which at this stage in the process are approximations made by our team with little to no data supporting these approximations.

4.3.2.2.2 Time-Value Analysis of Prototype Pilot Run

Before a product is created and tested on the market, a calculator helps a sponsor or investor determine whether or not a pilot run is a wise investment. Pre Orders and prepayment could be used to ensure that all of the product created is sold, eliminating most risk from the investment. The numbers in green are parameters that the design team should determine as the project progresses.

Batch size indicates how many products will be produced in the pilot run. Setup costs are the amount of money needed for tools and other one time costs and was approximated at 0 because WPI already has a lot of tools. Securing a patent could increase the setup cost's value but would also have a negative impact on the investment profitability of the pilot run. Manufacturing costs are approximated as the cost of buying a backstop to modify. Depending on the backstop chosen and other parts needed for the new backstop, this parameter could change but $400 was a common cost of a smart backstop. Average Wholesale price is another parameter which could be adjusted based on pre orders acquired. Lastly, the ROI is the estimate for the pilot run, but the main point of the pilot run is to demonstrate proof of concept. A key factor of the pilot run strategy is that the work in process inventory can be limited to one. If individual devices are bought, modified and sold, the initial investment will only be $400 for the first device and investment could be repaid after 4 units have been sold.

Pilot Run Model			
Batch Size	10		
Total Batch Expenses	$4,000.00		
	Setup Costs		$0.00
	Manufacturing Costs	$400.00	$4,000.00
Total Batch Revenue	$5,000.00		
	Average Wholesale Price	$500.00	$5,000.00
Predicted ROI for batch	125.00%		
Units Sold to Break Even	4		

Table 3

The capital gains evaluation model uses data collected by running the pilot run to project national sales. The number of schools contacted and months spent selling the pilot run products are used in tandem with figures from the pilot run to create projections for national expansion. Most of the numbers in the capital gains evaluation model would be discussed with a sponsor and licensee to make more reasonable estimates. These numbers would be the foundation for licensing negotiations, so maximizing the performance of the pilot run (having the best possible numbers in our pilot run) is critical.

Capital Gains Evaluation Model		
From Batch Model		
	Schools Contacted	100
	Time Required (Months)	0.5
Expected Sales	2,400	
	Potential Customers (US Highschools)	24,000.00
	Expected Market Share	10.00%
Profit Per Unit	$250.00	
	Predicted Average Wholesale Price	$500.00
	Predicted Average Production Cost	$250.00
Upfront Costs	$20,000.00	
	Licensing Cost	$10,000.00
	Retooling & Inventory Cost	$10,000.00
Profit	$580,000.00	
ROI	2900.00%	
Years of Sales	10	
Units Sold to Break Even	80	
Months to Break Even	4	

Table 4

The graph below projects the return on investment of the smart backstop, the current expected return on investment if the same amount of money was invested in the SPY ETF Trust, and the difference between these two investments. The expected return on investment from the smart backstop is based off of an estimate made by our team. When the cash on hand was negative, the projection includes interest rates on the money approximated at the SPY Index, so a 12.11% interest rate on the loan. When the cash on hand was positive, we assumed the cash on hand was earning 12.11% interest.

The SPY ETF Trust return estimate was based on the State Street SPDR figures. As of September 29,2020, the estimated growth per year for the next 3-5 years was 12.11%. This figure means that if you put money in the SPY ETF, you can expect to multiply that money by 1.11211 every year you leave your money in the SPY ETF. The SPY ETF was chosen because our team considered it to be a “normal” investment.

Finally, Backstop outperformance indicates the difference in profit between the two investments. According to our current estimations, investing $20,000 in our backstop could yield just under $600,000 in 20 years, or beat the SPY ETF by just under $400,000. (State Street Global Advisors, 2020)

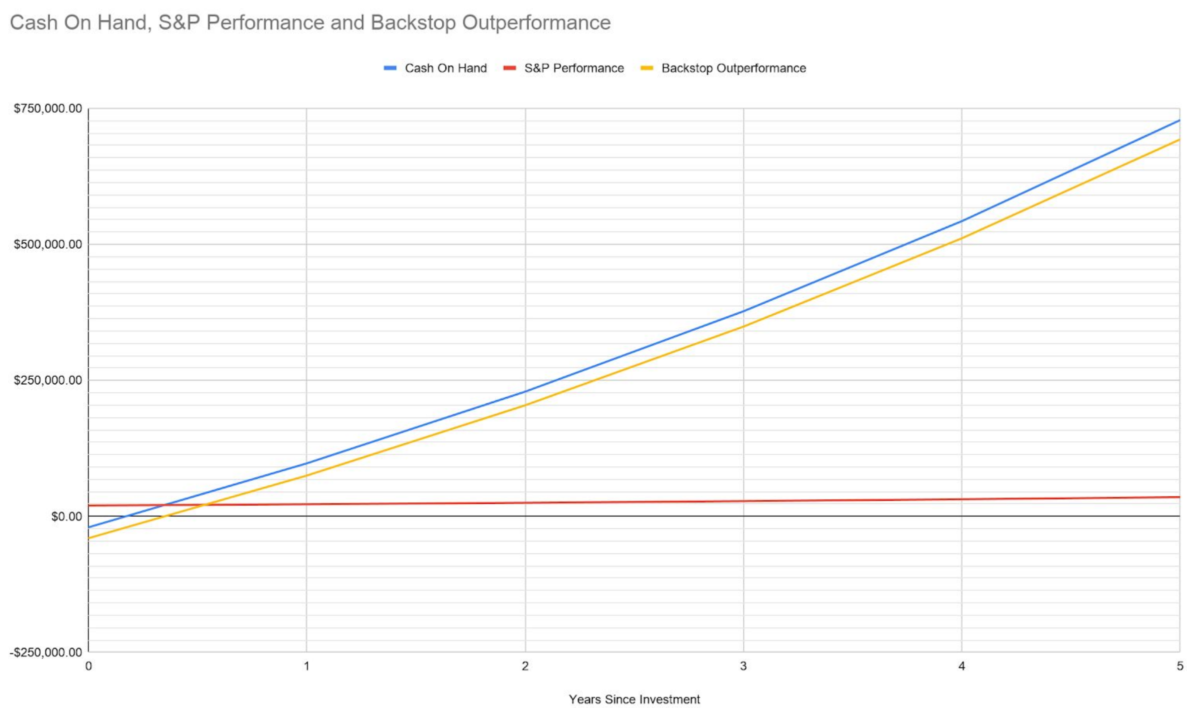

Figure 13

One likely incorrect assumption that the graph above makes is that the cost of producing the backstop will remain constant. The average production cost was used for the entire model but it is more likely that the price of producing the product will decrease with time. More likely, the company will have to learn efficiency as it grows. The chart below shows how the company becomes increasingly efficient as time progresses. The chart lacks numbers because the operations are a function of all of the factors in the calculator above but the graph does highlight the initial negative cash flow after the initial investment due to poor operations. The bottom of the curve shows when the product begins to actually make money.

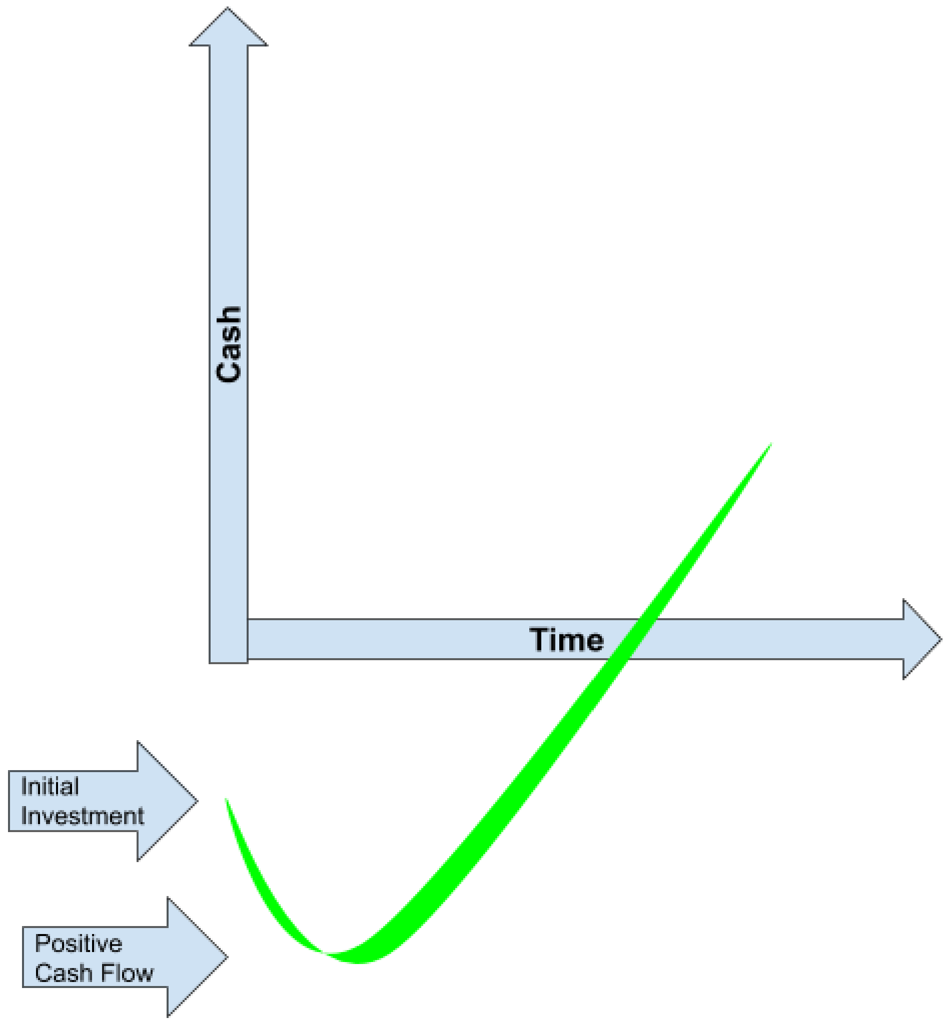

Figure 14

4.3.2.2.3 Create Financing Plan

If this project utilizes the pilot run and licensing strategy to go to market, there would need to be two rounds of funding. The first round of funding would be for the pilot run. This funding could be attained through prepaid pre-orders or by a sponsor. The second round of funding would be funded by the licensor. By minimizing our work in process inventory, the investment from a sponsor could be limited to the cost of a smart device which we would modify, one at a time. Once modified and sold, the revenue for the first device could fund the second sale. Our projections for the graph above demonstrate the financial benefits to the licensing company.

4.4 Coupling Matrix

The following section discusses the coupling matrix derived from the Axiomatic Decomposition.

4.4.1 Coupling the Economic Characteristics of a Smart Backstop

As demonstrated by the Pilot Run Model and Capital Gains Evaluation Model, most of the economic characteristics of the backstop are coupled at a certain level. Most notably the return on investment is essentially coupled to everything. The financing plan however is most closely tied to the monetization strategy (probably licensing) and timeline. This coupling matrix is a very rough approximation of the interactions between the different functional requirements and design parameters.

4.4.2 Coupling the Operational Characteristics of a Smart Backstop

Decoupling the operational characteristics of the smart backstop is difficult because we have not yet designed the backstop, but the notable decoupling is the Analysis and display decoupled with the trajectory data. Currently, some smart backstops such as the F5 PitchLogic Ball collect virtually all data and display it to the user. This information however might not be necessary to determine the key elements that define what makes a good pitch, and whether or not that pitch could get you into college. A farther coupling could identify the key components to getting into college, and then couple only those factors to the analysis. This simplification would minimize the information displayed to the user, a key component of Axiomatic design. To help the user get better at pitching, the same logic could be utilized: collect only the important data coupled to helping pitchers get better and analyze that data in a way the pitcher could use for improvement.

4.5 Conclusion

4.5.1 Stakeholder Analysis & Customer Needs

Research suggests that the demand for backstops is growing and that consumers are willing to spend more money on sports equipment like backstops than ever before. This growth may be attributed to the rise in college scholarships. Additionally, due to the Covid-19 epidemic, much of recruiting is becoming more data driven than in person. Our research suggests that the customer needs a product that facilitates recruitment as well as training for the user.

4.5.2 Market Research: AHP Analysis

Market research and AHP Analysis showed that there is a diversity of smart backstops available in the $300 price range. Some of the more advanced backstops provide velocities on all six degrees of freedom: displacement and rotation. Other backstops offer either no information or only the speed in the orthogonal direction.

4.5.3 Axiomatic Design Decomposition

The axiomatic decomposition outlines the key factors required to bring the product to market including creating the product. Continual development of this decomposition is critical to project continuation and will help each MQP team build on the previous teams work.

4.5.4 Coupling Matrix

Most of the aspects of the backstop, both functional and financial are coupled. A notably coupled aspect is the ball acceleration function, which could even be excluded from the final product. All of the other aspects appear to be coupled and iteration will likely be required before more helpful couplings can identify order of adjustment.

4.5.5 Cash Flow

In conclusion, our projections suggest that the investment would be worthwhile and yield a positive cash flow, but the numbers are estimated. Using the current calculator, future teams could establish better estimates based on input from the sales of a pilot run. Additionally, the profit margins will likely be difficult to maintain in initial pilot runs as well as the beginning of the product launch because of the learning curve involved in creating the product. Ideally, there would also be added value not accounted for in our estimations. If our product gains traction with recruiters, the licensor of the product would be perfectly positioned to capitalize on the growing trend of data in recruitment.

Chapter 5: Recommendations

The following list outlines our specific recommendations for moving forwards with the product:

1. Interview Stakeholders
    1.1. Project Sponsor
    1.2. Users
    1.3. Potential licensees
2. Determine functional requirements for pitch analysis

5.1 Interviews

5.1.1Interview Sponsors

Critical to the success of the project is the ultimate investment of a sponsor. Many WPI projects have sponsors and gaining a sponsor would help the project get some early funding. The purpose of an interview with a sponsor is to make sure the project is going in the right direction. If a sponsor has specific expectations for a return on investment or willingness to take risk, these expectations should be discussed. Additionally, if a sponsor has requests or requirements that have not yet been determined, these points should be noted early on. For this interview, the ideas explored in this MQP could be used as a foundation for moving forward with the project. The potential interview needs to go through WPI by filling out the IRB form that will grant access to the interview or survey.

5.1.2 Interview Product Users

The purpose of interviewing product users is to learn about what baseball players and coaches desire in a smart backstop. Pitch speed and location are the two most obvious and important factors when designing the backstop. We wanted to use interviews to specify exactly how they would like to know the speed and location and identify any other benefits they could possibly derive from an ideal smart and efficient backstop. Beyond just the backstops that current players and coaches use, interviews will consider the reason that the coaches and players are putting greater emphasis than ever before on youth sports like baseball.

Hosting interviews should be a primary focus for a future team to complete the project. Interviews “are an appropriate method when there is a need to collect in-depth information on people's opinions, thoughts, experiences, and feelings” (Easwaramoorthy & Zarinpoush, 2016). The in-depth information that we will be collecting will revolve around smart backstops. We created a set of predetermined questions in hopes that the respondents will answer in their own words, see appendix 1 for our predetermined questions.

5.1.3 Potential Licensees

This MQP has explored the possibility of licensing a product to companies that are already in the backstop industry. Interviews with each of these potential licensees could shed light on the likelihood of a licensing deal, the terms of the license, requirements, capabilities and willingness to invest.

5.2 Determine Functional Requirements for Pitch Analysis

While this project has outlined the functional requirements for a smart backstop and analyzed the industry to determine gaps in the market, the outline and analysis must be brought together more closely. Our Axiomatic Design focuses on the functional requirements of all smart backstops, but does not outline how our market research will shape a new product, as well as it's axiomatic decomposition. Specifically, the analysis of the pitch should be expanded upon. While our decomposition breaks down all of the factors of a pitch, the important factors should be identified. This is demonstrated by our coupling matrix, where our team assumed that all six degrees of freedom are required for an analysis. This assumption may be incorrect and requires further research.

Chapter 6: Project Discussion

6.1 Challenges

Covid-19 has taken the world by storm and all humans have been affected in some type of way from this global pandemic. Every challenge we have faced through this MQP was intensified because of Covid-19.

6.1.1 Communication

Throughout this MQP, the professors and our team have not had one physical face-to-face interaction due to Covid-19. All of our meetings over E and A term have been via zoom. During a normal school year we would be able to meet on campus throughout the term to talk about our MQP. Covid-19 has caused us to have less interaction overall with people outside of the people we live with, and we spend more time on Zoom talking about the project. This has caused us to communicate more often via text, phone and Zoom.

We learned that even though physical face to face interactions is helpful in building a relationship, it is not a necessity. Throughout our project, our team has built a lifelong friendship through zoom meetings and phone calls.

6.1.2 Project Timeline

Staying up to speed was a challenge for us because of the other priorities we had over the summer. Originally we wanted to finish this project over the summer, but as we continuously missed our own deadlines we knew that we would have to use another term to complete our MQP. The gantt chart in Appendix 5 details the initial plan for the timeline. Both of us worked a job over the summer, so balancing our jobs with our project was a key in finishing the MQP in A term.

We learned from our timing issues that defining the problem is a massive part of the project and that until the problem is properly defined, a schedule can be difficult to follow. In the beginning of the project, a poorly defined problem statement yielded scope creep and created confusion in the project because there were so many different ideas that were poorly connected. By the end of the project, we were simply rearranging these ideas about a central theme (the recruiting industry growth) turning an incoherent group of paragraphs into a coherent project. Finding the main point about which to adhere the thoughts, or the problem statement, was not accounted for in our timing.

Additionally, we learned the importance of consistently working on the project and continuing to push forwards even when things did not go according to plan. Our advisors changed multiple times even before the project had begun there was much confusion.

6.1.3 Axiomatic Design

Prior to this project, we had no idea what the axiomatic design was. Before the project started we were tasked with learning the basics of the axiomatic design. We achieved this task by completing weeks of research, quizzes, and meetings with professor Towner. Covid-19 caused us to conduct quality research and quizzes on our own versus being able to meet in person and talk things out. Because we had no prior knowledge of AD it took us a while to find the direction of the project that we wanted to take. We had a number of meetings with professor Towner and professor Brown discussing the direction of the project and the way to go about it.

6.2 Lifelong Learning Impact

We chose this project wanting to be able to give back to the youth and also gain knowledge about a design process (axiomatic design) that we will use for the rest of our life.

6.2.1 Youth Sports Industry

Our team enjoyed diving deep into the specifics regarding baseball and learning how we could help youth choose their own path. Kahleb, a basketball player noted that he enjoyed playing basketball much more than the recruiting process, but both aspects were necessary for him to enjoy his time in college. Our team learned the pleasure of trying to help individuals through the tough parts of a fun overall experience. From getting the kids out of the house to getting athletes into college, we learned that the decompositions and financial models ultimately help baseball pitchers do what they love: throw around a baseball.

6.2.2 Financial Analysis

When considering the financial aspect of a new smart backstop, we began by studying the needs in the industry. From this study, we were able to empathize with the struggles that athletes face in baseball: the recruitment process. By identifying this common problem, we were able to find a huge market that was ripe for innovation. Simply put, we began by focusing on value creation and let that value creation guide our finances. We learned that market size is ultimately a product of two factors: how much value you create and for how many people that are willing to help you in return (buy your product). The number of dollars is simply a quantification of that product. When creating models for investors, the ultimate question was, can the creation of this product be a mutually beneficial deal for all stakeholders.

In this project, we learned that the financial aspect of the smart backstop starts with helping everybody. We learned that generating profit is evidence of value creation and that a sound financial plan is a numerical expression of empathizing with peoples struggles and helping them overcome these struggles together, in a mutually beneficial way. Our team has learned that this concept extends beyond just smart backstops and is true of all financial interactions.

6.2.3 Axiomatic Design

As previously stated, we had no prior knowledge of the function of Axiomatic Design. We now have a better understanding of the Axiomatic Design framework and are able to apply it to everyday situations in future projects and life. Having the axiomatic design as a tool will help us in the future when we are tasked with solving problems. We also learned that the more we consider Axiomatic Design, the more we realize that we already use the framework in some senses. Our team has used Axiomatic Design to help us clear our heads in confusing situations and apply the concepts in every aspect of our lives. Simply put, Axiomatic Design helps us make better decisions and live better lives.

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Appendix

Appendix 1: Interview Questions

Interview Questions for Coaches:

Introduction

Thank you for taking the time to speak with us today. We are a WPI team trying to help youth improve their pitching. As you may know, youth sports are becoming an increasingly common way to help kids get into college and the incentive to improve their abilities is increasingly important. This interview aims to help our project team understand how we can best help youth baseball players improve their pitching.

1. Can you tell me a little about yourself? (Icebreaker Question)
2. What sport do you coach?
    a. What level do you coach at?
3. What is your role in the community?
    a. Baseball coach?
    b. Little League Coordinator?
4. What do you spend the most time doing as a coach?
5. How do your players practice in baseball?
    a. How do you practice pitching?
    b. Do they use a backstop?
    c. What type? Brand?

d. What do you love about your players using the backstop?

e. What do you hate about your players using the backstop?

6. What is a target price when shopping for a backyard backstop/pitchback?

7. What do you look for when purchasing a baseball backstop/pitchback?

a. Price?

b. Consistency?

8. From a coaches point of view, what are some benefits of having your player use the baseball backstop?

9. What do you find most effective about your recently purchased baseball backstop?

10. What are some improvements/features you would like to see in a backstop design?

a. How much would you be willing to pay for it?

11. Is there anything else you would like to tell us that we missed discussing in the interview?

12. Would you be available for some follow-up questions, if we think of something important we missed today?

Interview Questions for Player:

Introduction

Thank you for taking the time to speak with us today. We are a WPI team trying to help youth improve their pitching. As you may know, youth sports are becoming an increasingly common way to help kids get into college and the incentive to improve their abilities is increasingly important. This interview aims to help our project team understand how we can best help youth baseball players improve their pitching.

1. Can you tell me a little about yourself? (Icebreaker Question)
2. What sport do you play?
    a. What level do you play that sport at?
    b. What position do you play in baseball?
3. What do you spend the most time doing to practice?
4. Do you practice pitching?
    a. How do you improve?
5. Do you use a baseball backstop?
    a. Why do you use a baseball backstop model?
    b. What do you love about your baseball backstop?
    c. What do you hate about your baseball backstop?
6. From a players perspective, what are some benefits of owning and using a backstop?
    a. Speed?

b. Pitch location?

7. What improvements or features would you like to see in a backstop design?

a. How much would you be willing to pay for it?

8. Is there anything else you would like to tell us that we missed discussing in the interview?

9. Would you be available for some follow-up questions, if we think of something important we missed today?

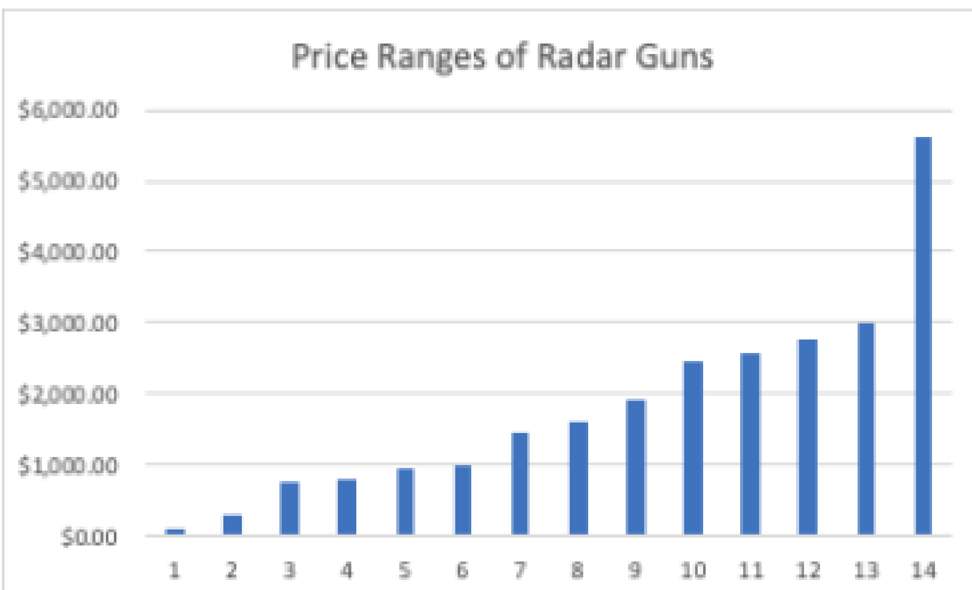
Appendix 2: Participant Recruitment Email

Hi NAME,

I am part of an MQP team exploring ways to help pitchers train. We were wondering if we could interview you on your experiences practicing pitching. The questions will explore...

Appendix 3: Price Range of Radar Guns

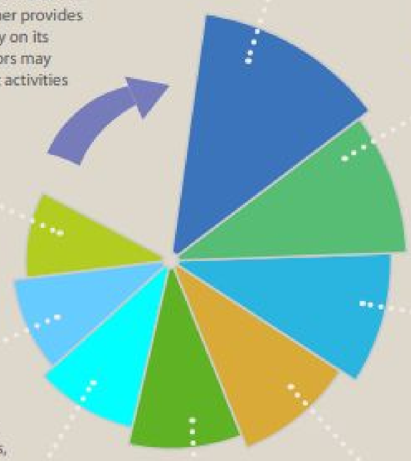
On the radar guns website in our references, there are a total of 14 radar guns that display the speed of a pitch on a display board. The price of the radar guns range from $119.99 - $5,599.00. The average price of radar guns on the market is $2,859.945. Below is a graph displaying the prices of each radar gun.



Appendix 4: The 8 steps of technology commercialization

OFFICE OF
Technology
Commercialization
THE UNIVERSITY OF TEXAS AT AUSTIN

The 8 steps of technology commercialization



1 Research

Observations and experiments during research activities often lead to discoveries and inventions that may have commercial applicability.

2 Disclosing an invention

The discoveries and inventions are formally disclosed by the inventors submitting a confidential Invention Disclosure form to OTC. (See *www.otc.utexas.edu/InventorForms.jsp*.)

3 Market assessment

OTC assesses a disclosed invention and develops a preliminary commercialization strategy. Based on this assessment, OTC determines whether to assert the university's rights in the disclosed invention. The assessment and determination is performed in conjunction with inventors, outside counsel, and/or advisors as appropriate.

4 Patenting and other legal protection

If the university's rights are asserted in an invention that appears suitable for patenting, OTC will engage outside counsel to pursue patent protection for the invention. When appropriate, the university may utilize copyright, trade secret, or trademark rights to commercialize university inventions or works of authorship.

5 Prospecting

OTC proactively approaches companies, entrepreneurs, and investors who have been identified as potentially suitable partners to bring the technology to market. OTC also showcases available technologies online and at appropriate conferences. In addition, faculty publications, presentations, or academic renown may result in third-party licensing interest.

6 Negotiation/due diligence

Marketing activities may result in one or more parties requesting an in-depth examination of the technology. This can involve signing a non-disclosure agreement and additional discussions with the inventors. Interested prospects will present a plan for commercialization and negotiate business terms with OTC.

7 Licensing

When the university and the commercialization partner are ready to move forward, OTC prepares legal agreements to reflect the business terms negotiated. When the agreements are signed by both parties, the startup or licensee has the right—and obligation—to commercialize the invention. Compensation varies and may involve fixed fees, milestone fees, royalties, equity, and other forms of consideration. Compensation is shared with inventors in accordance with university policy.

8 Commercialization and revenue

The path to commercial markets will vary, depending on the nature of the invention, the market it is addressing, and the invention's stage of development. Under the terms of the agreement, the commercialization partner provides regular progress reports to the university on its commercialization activities. The inventors may continue to be involved in development activities with the commercialization partner.

Appendix 5: Gantt Chart

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
	6/15	6/22	6/29	7/6	7/13	7/20	7/27	8/3	8/10 -8/17
Proposal									
Introduction									
Background									
Methods									
Results									
Recommendations									
Discussion									