Axiomatic Design of a Football Play-Calling Strategy

A Major Qualifying Project

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by

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Abstract

The purpose of this MQP was to design an effective play-calling strategy for a football game. An Axiomatic Design approach was used to establish a list of functional requirements and corresponding design parameters and functional metrics. The two axioms to maintain independence and minimize information content were used to generate a final design in the form of a football play card. The primary focus was to develop a successful play-calling strategy that could be consistently repeatable by any user, while also being adaptable over time. Testing of the design solution was conducted using a statistical-based computer simulator.

Acknowledgements

We would like to extend our sincere gratitude to the following people, as they were influential in the successful completion of our project. We would like to thank Professor Christopher A. Brown for his advice and guidance throughout the yearlong project and Richard Henley for sharing his intellect and thought process about Axiomatic Design and the role it could play in the game of football.

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1   Introduction

1.1 Objective

The objective of this work is to test the hypothesis that axiomatic design can be used to design an effective play-calling system for the game of football. This system is effective when it facilitates a positive point differential or wins games. A sub-objective of this work is to provide functional metrics of our functional requirements (FRs) (Henley, 2015). The scope of this work is in-game decisions, specifically play-calling via computer-simulated games.

1.2 Rationale

Football is a complex game that involves strategy and tactics. Like most aspects of life we interact with, the game of football follows a design. Two opposing teams compete against each other with set game plans or strategies. Football game strategy can be designed by manipulating varying inputs to get a desired output.

During the game there are a number of inputs and components that affect the outcome of a given play. Inputs are defined as anything that goes into the decision making process for each play. Inputs can be the given field position, the offensive or defensive formation, the offensive or defensive personnel, or the actual play called on either side of the ball. The inputs that each team tries to control for their desired output or result are what make their own strategy unique. These inputs act as measures to control the outcome of the game.

In order to improve the system in place, metrics are used. "Metrics are defined as quantifiable measures used to determine the degree of success of a system or process (Henley, 2015). Functional metrics can tell how well a FR meets a customer need (CN)

(Henley, 2015). It is important that metrics measure the system because as Lord Kelvin states, "If a system or process cannot be measured then it cannot be objectively improved." If axiomatic design (AD) can facilitate a successful winning strategy by helping select the best response to a given set of inputs with the help of functional metrics, it could also be used to solve complex societal problems.

If we can apply the principles of AD to improve the strategy of calling football games, we can administer them to important problems in our society. Areas such as military strategy, political campaigns, other sports, and education could all benefit from the applications of AD.

Successful designs in our nation's history have been consistent with AD, specifically in the Civil War. On March 9, 1862 two naval ships engaged in combat: the USS Monitor (Union) and the CSS Virginia (Confederacy). Before the Civil War era ships depended on wind to move. The customer need of ship captains, locomotion, was dependently bound or "coupled" with wind. Engineers found that steam power allowed ships to move independently of the wind, thus decoupling wind and movement of ships. While both these ships were steam powered, the CSS Virginia possessed multiple strategic advantages of the USS Monitor in size, speed, and firepower. However, the Monitor had one advantage over the Virginia that would make up for its other deficiencies: a swivel turret. This swivel turret decoupled the direction of travel and the direction of fire, so that it could place itself at a favorable 45 degrees from the broadside of the Virginia and still be able to fire back. Using the independence axiom, the USS Monitor was able to neutralize the faster, larger, and more heavily armed CSS Virginia.

The axioms of maximizing independence and minimizing information could be used to find solutions to other design problems in society such as political campaigns. A top level FR could be to win the presidency (FR0), with some lower level FRs being "Gain public support and spread influence" (FR1) and "Fund campaign" (FR2). The corresponding DP for these could be campaign advertisements and rallies. A common problem for many politicians is that they only have so much funding for these advertisements. AD could be used to find a campaign strategy design that maintains the independence of campaign funding and gaining support as well as minimizing the information in advertisements and rallies by finding what the most important factors and ideas gain public support, so that they can have more robust advertising and get rid of useless information.

Just as factories might need to adjust their process to create better products, football teams need to adjust their process to win games. Just as a manufacturing system has metrics to determine success, a football strategy must also have metrics to gauge success.

1.3 State-of-the-art

1.3.1 Prior Work Relating to Football

Before we took on this project, there had already been previous works of quantitative methodology in football. In 1971 Virgil Carter of the Cincinnati Bengals and Robert Machol of Northeastern University calculated the expected point values of offensive possession on first down and ten yards to go from various field positions (Carter and Machol, 1971). They discussed the strategic implications of these values and raised awareness of the importance of field position in relation to scoring. Later on they

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continued their work, looking specifically at fourth down and the decisions coaches made on whether or not to attempt to convert (Carter and Machol 1978). In 2001 Jess Boronico and Scott Newbert expanded on this work and looked closely at a strategy of first and goal scenarios for both offensive and defensive parties. They presented a mathematical model to help select first and goal plays by collecting data from over 1700 football plays from the Monmouth University football team and applying the results into a game-theoretical approach to try to maximize the probability of scoring a touchdown (Boronico and Newbert, 2001). Frank Frigo and Chuck Bower (2005) created a Monte Carlo based simulation model called ZEUS that uses a NFL statistics database, game theory, and computer programming and modeling, to provide coaches with a recommendation on play selection for critical plays (Patel 2012). All these works point to how many inputs go into the decision making for play calling in football games and how many different ways success can be quantified.

1.3.2 Functional Metrics and their Relation

One of the most powerful management disciplines is to make an organization's purposes tangible. Managers or CEO's do this by translating the organization's mission into a set of goals and performance measures that make success concrete for everyone. The bottom line for every organization is for the executives to answer the question, "Given our mission, how is our performance going to be defined?" (Magretta and Stone 2002). The general managers and coaches of a football team should focus on what aspects of the game determine their success. A metric is a verifiable measure, stated in either quantitative or qualitative terms and defined with respect to a reference point.

Metrics provide essential links between strategy, execution, and ultimate value creation (Melnyk et al. 2004).

1.3.3 Functional Metrics in Sports

Throughout the history of sports different strategies have been used to control the output of the sports game. The problem with these strategies is that they cannot prove which one works better than the rest. A way to determine if a strategy is better than another would be to apply functional metrics to improve the effectiveness of the sports teams program.

The 2002 Oakland Athletics are an example of a sports team applying functional metrics to their program. Baseball teams of the past decades have failed to find useful metrics. Statistical analysis showed that on base percentage (the percent of time a batter reaches base) had a higher correlation with runs scored than other statistics. The way to win a baseball game is simple: score more runs than your opponent. From this information, the 2002 Oakland Athletics were able to form a team designed behind the idea that getting on base would improve their winning percentage. That year the Athletics were able to win the most games of any MLB teams during the regular season, while paying the third lowest salary of all 30 MLB teams (Lewis 2004).

1.4 Axiomatic Design

Former head of Mechanical Engineering at Massachusetts Institute of Technology, Nam Suh, created Axiomatic Design in 1990 (Suh 1990). Suh's goal was to improve design process by determining what all good designs had in common. Axiomatic Design is helpful in the decision making process because the two axioms maintain the

independence of the variables whiles minimizing the information content. The design process can help improve quality, designs, and address complex problems. Axiomatic design can be used for manufacturing, software, hardware, materials, and organizational designs.

The axiomatic design process involves applying the two axioms to lead to an optimal solution for a design problem. This process consists of two axioms; axiom one being the independence axiom, and axiom two being the information axiom. Axiom one maintains the independence of the functional requirements while axiom two minimizes the information content of the design. Creating a solution using these axioms maximizes the value added, bringing the design closer to a robust solution. Minimizing the non-value-added time is important because wasteful tasks and activities don't contribute to fulfilling the functional requirement of the design solution.

Axiomatic design uses hierarchal design decomposition. Design decompositions exist in four different domains that respond to the goals of the design. The domains address the what and the how of the design. The domains used in the design decomposition are customer domain, functional domain, physical domain, and process domain.

The needs of the customer are identified and related to the customer domain. The customer needs can be a product, material, system, process, or anything else the customer needs. The ultimate goals of any manufacturing process are customer satisfaction and the fitness for use (Juran 1999). Customer needs should be met with every design and are utilized to determine functional requirements.

Functional requirements (FRs) and constraints characterize the functional domain.

FRs are what the designer identifies as the customer's need to fulfill the design

objectives. Due to the hierarchal design decomposition, each functional requirement is

decomposed into sub-functional requirements. In other words, for each parent FR there

must be a sum of children FRs that add up to the original FR. Each of these sub-

functional requirements must be unique in order to satisfy the independence axiom.

Designs also have constraints that limit the FRs because of potential impact on a FR's

independence. An important thing to note is that constraints do not have to be

independent from each other, unlike functional requirements.

The physical domain is the breakdown of the functional requirements and

constraints into physical properties. The physical properties consist of design parameters

(DPs). Design parameters answer "how" the design will fulfill the functional

requirements. DPs contribute to an item's physical design, its development through the

design process, and its cost.

The process domain consists of details of the design parameters. These details are

the way the design parameters can be made into a process, satisfying the physical

properties of the design. The process domain is used for the production of the design and

prototyping.

1.4.1 Acclaro Software

Acclaro® DFSS, created by Axiomatic Design Solutions, Inc., is a software

program used to manage a design hierarchy. This program is able to show the hierarchal

form of the functional requirements at all levels of analysis. New rows made up of sub-FRs can be seen as the "children" of each functional requirement. The design matrix in the program is used to determine if the design is coupled or decoupled. Acclaro® will show an "x" to show each design parameter interacts with a functional requirement. This program was utilized for this work's design process.

1.5 Approach

Axiomatic design is used to come up with the best, most efficient game calling strategy to win football games. Axiom 1 is used to maintain the independence of our FRs in order to increase winning percentage over the course of a season. Axiom 2 is used to minimize any unnecessary information to make our design more robust. While there have been previous models and strategies to determine success in a football game, Axiomatic Design has not been used to design a play calling strategy to improve a team's winning percentage in football. Our design solution attempts to aid coaches in difficult decision making in play calling, similar to Carter and Machol (1971, 1978). Our work looks at prior strategies implemented on first and goal scenarios; however, unlike Boronico and Newbert (2001), our design solution attempts to use functional metrics to improve strategies. Our design solution uses a NFL statistics database (PC Action Football) and game theory, but unlike Frigo and Bower (2005), the design solution uses a live simulator to test the effectiveness of each individual strategy. Statistical analysis is used to find correlations for useful metrics in relation to winning games, but unlike Lewis (2004) our scope specifically looks at in game play calls and won't consider off the field problems like salary or drafting players. Similar to Henley (2015), design solutions use functional metrics assigned to every FR in an attempt to facilitate the design of a collectively

exhaustive, mutually exclusive design solution. A design solution is obtained using a decomposition that has measurable metrics of the FRs and DPs. Acclaro software is used to assist the construction of the decomposition.

2   Design Decomposition

2.1 Statement of the Top level Functional Requirement- FR_0

The top level Functional Requirement, FR_0, is to have a positive point differential at the end of the game. The design parameter for this Functional Requirement is a strategy that wins games. Constraints to achieving the upper level requirements are inconsistencies and uncontrollable elements in the computer game system used.

2.2 Statement of the first level Functional Requirements- FR_1, FR_2, & FR_3

The goal of FR_1 is to facilitate number of points scored. The DP_1 for this is a play calling strategy for scoring the maximum number of points per game. Every time the offense possesses the ball, the object should be to score as many points as possible on that drive.

The goal of FR_2 is to inhibit number of points allowed. The DP_2 for this is a play calling strategy for limiting opponents points scored per game.

The goal of FR_3 is to enable system adaptability. The DP_3 for this is a play calling strategy that ensures a continued lead throughout the game. As the game and the season progress, the opponent catches on to consistencies in the play calling and adjusts their design to match ours. If we find a metric or play call that correlates to guaranteed success and gives us a competitive advantage over the opponent, the competition eventually catches on, applies the same strategy to their game plan, and levels the playing field. In order to ensure continued success and superiority of our design, our strategy must be able to adapt to change and continue to maintain that positive point differential.

2.3 List of the 2nd level of Functional Requirements for FR_1

The requirement of $FR_{1.1}$ is to facilitate the total number of points scored per possession. Its corresponding $DP_{1.1}$ describes a play calling system for maximum efficiency per possession. $FR_{1.2}$ says to facilitate the number of possessions, and its $DP_{1.2}$ is a strategy for limiting turnovers and punts. We define a possession for a team as every play where they end up with possession of the ball at the conclusion of the play. This way we are able to relate a team's success to number of possessions. If we define a possession as the entire offensive drive, then both teams have an even number of possessions, because after every score, punt, or turnover from one team, the other team gets to reply with their own offensive possession.

2.3.1 List of Lower Levels of Functional Requirements for FR_1

[FR] Functional Requirements	[DP] Design Parameters	FR Meas
Facilitate Positive Point Differential	Strategy for winning games	Point D
1　Facilitate Number of Points Scored	Play calling strategy for scoring max number of points per game	Poi
1.1　Facilitate Total Number of Points scored Per Possession	Play calling system for maximum efficiency per possession	
1.1.1　Facilitate number of first downs/scoring plays per possession	Variety of short/med quick routes	
1.1.2　Improve starting field position	Punting ball in own territory, FG from opp 38-end zone.	
1.2　Facilitate number of possesions	Strategy for limiting turnovers and punts	
1.2.1　Limit number of turnovers	More short/quick routes that allows the QB to get rid of ball quicker	
1.2.1.1　Inhibit number of fumbles lost	More short/quick routes that allow QB to release ball sooner *(Can't control running back fumbles by play calling	
1.2.1.2　Inhibit number of interceptions turned over	Less high risk high reward plays and more short/quick routes that allow QB to release ball in less than 4 seconds	
1.2.2　Increase longevity of drives	Higher 1st down conversion rate	

Figure 1- FRs and DPs of FR_1

Under $FR_{1.1}$ is $FR_{1.1.1}$ and $FR_{1.1.2}$ as can be seen in the figure above along with their corresponding DPs. We decided that in order to control the number of points per possession we had to focus on gaining first downs and controlling the field position. We determined that the best way to gain first downs and scoring plays was to call both running plays and various short, quick routes (short/medium slants, crosses, outs, or hitches). These routes proved in the simulations to be the most effective way to move the

ball down the field. We can control the field position best by determining when to punt, go for it on 4th down, or kick a field goal based on field position. Generally you want to punt the ball in your own territory (the first 50 yards of the field furthest away from the end zone you are trying to reach) in order to avoid the opponent starting with the ball less than 50 yards to go if you fail going for it on fourth down. Anytime you cross into your opponent's territory you should go for it on fourth down, unless you are in field goal range (38 yard line or less) and you stand a better chance getting 3 points from a field goal than by going for it and potentially turning the ball over on downs.

2.4 List of the 2nd level of Functional Requirements for FR$_2$

The requirement for FR$_{2.1}$ is to inhibit the total number of points allowed per possession. Its corresponding DP$_{2.1}$ describes a strategy for effective defensive play calling. FR$_{2.2}$ says to facilitate the number of possession changes. DP$_{2.2}$ is a play calling strategy for forcing opponents' turnovers.

2.4.1 List of Lower Levels of Functional Requirements for FR$_2$

2	Inhibit Number of Points Allowed	Play calling strategy for limiting opponents points scored per game	Points al
2.1	Inhibit Total number of points allowed per possession	Strategy for effective defensive play calling	Poi
2.1.1	Inhibit number of opponents' first downs	Limited number of times opponent's offense acheives 10 yds in 4 downs through keying top receives, blitzes, and matching personel	
2.1.2	Inhibit number of opponents' scoring plays	Limited successful opponent's offensive plays by matching offensive personell, keying top targets, and mixing up blitzes	
2.2	Facilitate number of possesion changes	Play calling strategy for forcing opponents turnovers	Tot:
2.2.1	Facilitate number of opponent turnovers	Strategy for forcing turnovers	
2.2.1.1	Facilitate number of opponent's interceptions	Mix of blitzes and tight coverage	
2.2.1.2	Lessen opponents starting field position	Analysis of 4th down options based on current field position (Go for it in 4 down territory, Decipher whether to kick field goal or attempt to score based o	
2.2.1.3	Facilitate number of fumbles forced/recovered	High number of unpredictable blitzes (Can't control RB fumbles based on playcalling)	
2.2.2	Maximize number of opponents punts	Stopping opponent within their 4 downs by matching offensive personell (Base D unless 5+ recievers, in which case its Nickel/Dime) and bump and run	

Figure 2-FRs and DPs of FR$_2$

The requirement for FR$_{2.1}$ has two sub-requirements, FR$_{2.1.1}$ and FR$_{2.1.2}$. The requirement for FR$_{2.1.1}$ is to inhibit the number of opponents' first downs. FR$_{2.1.1}$'s corresponding DP$_{2.1.1}$ is a strategy that limits the number of times the opponent's offense

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achieves 10 yards in four downs by keying top receivers, blitzing, and matching opposing personnel. The requirement for $FR_{2.1.2}$ is to inhibit number of opponent's scoring plays. Its corresponding $DP_{2.1.2}$ is a strategy that limits successful opponent's offensive plays by matching offensive personnel, keying top targets, and mixing up blitzing schemes.

The requirement for $FR_{2.2}$ has two sub-requirements, $FR_{2.2.1}$ and $FR_{2.2.2}$. $FR_{2.2.1}$ has three sub-requirements $FR_{2.2.1.1}$, $FR_{2.2.1.2}$, and $FR_{2.2.1.3}$. The requirement for $FR_{2.2.1}$ is to facilitate the number of opponents' turnovers. Its corresponding $DP_{2.2.1}$ is a strategy for forcing turnovers. The requirement for $FR_{2.2.2}$ is to maximize the number of opponent's punts. Its corresponding $DP_{2.2.2}$ is stopping the opponent within their four downs by matching their offensive personnel (Base D unless 4+ receivers, in which case run Nickel, Dime, or Quarter) and bump and run coverage.

2.5 List of the 2nd level of Functional Requirements for FR_3

The requirement for $FR_{3.1}$ is to enable offensive system adaptability. Its corresponding $DP_{3.1}$ is a broad range of plays that stays ahead of opponents' adaptively. The requirement for $FR_{3.2}$ is to enable defensive system adaptability. Its corresponding $DP_{3.2}$ is a system that stays ahead of opponents' offenses by reacting to their tendencies.

2.5.1 List of Lower Levels of Functional Requirements of FR_3

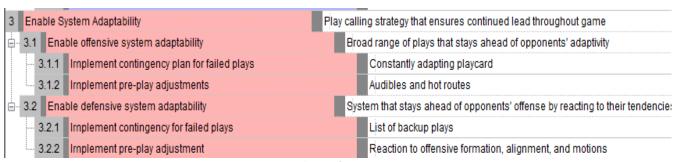| 3	Enable System Adaptability		Play calling strategy that ensures continued lead throughout game
	3.1	Enable offensive system adaptability	Broad range of plays that stays ahead of opponents' adaptivity
		3.1.1 Implement contingency plan for failed plays	Constantly adapting playcard
		3.1.2 Implement pre-play adjustments	Audibles and hot routes
	3.2	Enable defensive system adaptability	System that stays ahead of opponents' offense by reacting to their tendencies
		3.2.1 Implement contingency for failed plays	List of backup plays
		3.2.2 Implement pre-play adjustment	Reaction to offensive formation, alignment, and motions

Figure 3- FRs and DPs of FR_3

The requirement for $FR_{3.1}$ has two sub-requirements, $FR_{3.1.1}$ and $FR_{3.1.2}$. The requirement for $FR_{3.1.1}$ is to implement a contingency plan for failed plays. $FR_{3.1.1}$'s corresponding $DP_{3.1.1}$ is a constantly adapting play card. The requirement for $FR_{3.1.2}$ is to implement pre-play adjustments, and its corresponding $DP_{3.1.2}$ is audibles and hot routes.

The requirement for $FR_{3.2}$ also has two sub-requirements, $FR_{3.2.1}$ and $FR_{3.2.2}$. The requirement for $FR_{3.2.1}$ is to implement a contingency plan for failed plays. Its corresponding $DP_{3.2.1}$ is a list of backup plays. The requirement for $FR_{3.2.2}$ is implement pre-play adjustment. Its corresponding $DP_{3.2.2}$ is reaction to the offensive formation, alignment, and motions.

2.6 Completed Axiomatic Design Hierarchy

The completed decomposition is shown in Figure 4 below. It includes all of the Functional Requirements and Design Parameters.

Figure 4- FRs and DPs for Design Hierarchy

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2.7 Measurements

Figure 5- FRs and Functional Metrics for Design Hierarchy

As seen in Figure 5, we determined Functional Metrics for each FR of the design hierarchy. The Functional Metrics for each level of FRs will be discussed in the following sections.

2.7.1 Functional Metrics for Top Level FRs

The top-level metric for the design decomposition is Point Differential= Points Scored – Points Allowed. This metric is applied to FR_0 to satisfy a positive point differential. To successfully apply Functional Metrics to all of the sub-functional requirements from FR_0, all the metrics must sum to the top-level metric. Therefore, FR_1 and its sub-functional requirements relate to points scored while FR_2 and its sub-

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functional requirement relates to points allowed. This is because in order to maintain the Independence axiom we split FR_1 and FR_2 to relate to the offensive and defensive strategies respectively. FR_3's functional metric relates to point differential.

FR_1's functional metric is $Points\ scored = \#\ possessions \times \frac{points}{possession}$. As stated earlier, a possession is defined as every play where the team ends up with possession of the ball at the conclusion of the play. The reasoning behind this metric is that you don't score every time you possess the ball, so you must take the average of points you score per possession and multiply it by the total number of possessions.

FR_2's metric is $Points\ allowed = \#\ possessions \times \frac{points\ allowed}{possession}$

FR_3's metric is $Point\ differential = (f)\left(\frac{pts\ allowed}{\#\ possessions}\right)$.

2.7.2 Functional Metrics for Second Level FRs

We define the functional metric for $FR_{1.1}$ as the

$\frac{Points}{possession} = (f)(starting\ field\ position, first\ downs)$. We found that the amount of points scored is higher when teams score more first downs in addition to starting the drive closer to the end zone. The better teams start off with in field position, the more times they end up scoring.

Our metrics for $FR_{3.1}$ and $FR_{3.2}$ are similar for the offense and defense:

$Adaptability = (f)\left(\frac{points\ scored}{\Delta T}\right)$ and $Adaptability = (f)\left(\frac{points\ allowed}{\Delta T}\right)$

Our strategy must adapt with respect to time. On offense it must run plays that continue to drive the offense down the field over the course of a game. The defensive strategy must continue to inhibit the number of yards and points scored against as time goes on.

2.7.3 Functional Metrics for Lower Level FRs

Another metric that may need clarification is the one for $FR_{1.2.2}$: First down conversion rate is the number of plays resulting in first down on first down plus that same result on second down, third down, and fourth down. It is important for the life of the drive to maintain a high level of first down convergence on all four downs.

$FR_{2.1.1}$ requires inhibiting the number of first downs the opponent reaches. We decided the best metric to measure that would be to calculate the number of times the opponent punts. The more times they punt, the fewer amounts of times they are scoring or moving the ball down the field with first downs.

$FR_{3.1.1}$ requires the implementation of a contingency plan for failed plays, and the metric we decided was the best measurement of that was to measure the success rate of the new play calling strategy, which is the number of successes over the number of attempts. The best way we can tell if our strategy is adaptable and can constantly stay ahead of the competition is if the success rate continues to be a desirable percentage.

3   Testing of the Final Design

3.1 Methods

Using Axiomatic Design we designed a play-calling strategy for a football game. We applied this design to a computer-simulated game to test our final design. In the beginning of the design stage, we knew that we had one major goal: to score more points than the opposing team. Throughout the design process we made multiple revisions to the design decomposition, consisting of changing Functional Requirements, Design Parameters, and our Functional Metrics. Our first draft of the decomposition contained structural flaws. Not all of our FRs were in the imperative form. We also had single child FRs that did not sum to the parent FR. Some of our DPs had verbs in them, and we lacked solid Functional Metrics. Overall, the first decomposition contained gaps throughout it and still needed to be made into a design that was collectively exhaustive and mutually exclusive (CEME).

Upon restructuring our decomposition, we really looked into what our customer needs were and what we wanted the overall solution to look like. Our problem was to find a consistently repeatable process for a game calling strategy to win football games. This process aims to be able to be used by any team, regardless of their players and personnel. The intended customers of this design are football coaches (both offensive and defensive coordinators), football team owners and general managers, and anyone who is invested in the success of a given team. Their customer needs (CNs) are to win games. They need something simple that can successfully be applied to their own respective teams and that could repeatedly yield success. A critical component of this system needed

by our customers was the ability to adapt to the opponent. Throughout the design of the FRs we took into consideration how they would fulfill our customer needs.

The structure of our design started to take form when we took a zigzag approach to our decomposition. Initially all of our DPs were placeholders. For example, they would say "Strategy for…" which didn't offer much substance for what the design parameter would look like. To add more substance to the DPs we began to convert them at the lowest level into more specific DPs. For instance, we changed $DP_{1.2.1.2}$ from "Strategy for more conservative pass plays" to "Less high risk high reward plays and more short/quick routes that allow the quarterback to release the ball in less than 4 seconds."

However, there were still some DPs that couldn't be changed from these placeholders. $FR_{1.1.2}$ states, "Improve starting fielding position." Our corresponding DP was, "Strategy for obtaining most favorable starting field position," but there is no strategy we have control over that would allow us to obtain a desired field position. This shows that there are some problems within the design.

Figure 6- Design Matrix

In order to satisfy out independence axiom, we converted our decomposition into a design matrix, and as seen in figure 6 above, our design came out to a diagonal matrix. Each of our DPs satisfied its corresponding FR independently, so according to Suh (2001) in his book *Axiomatic Design: Advances and Applications*, this design was an uncoupled design. For example, if we look at DP_1, play calling strategy for scoring most amount of points per possession, we can see that it satisfies FR_1, facilitate total number of points scored per possession. It doesn't satisfy FR_2 or FR_3. Every other DP follows the same suit.

We tested our play-calling strategy using a computer simulator called Action! PC Football. This program is a stat-based football game that is designed to challenge the process you take while coaching a football team. Play results are determined by lineups, play calls and strategy. In this game you take the roll of the coach and have hundreds of strategy options available to you. This program uses every available published statistic as well as expert subjective analysis to rate each individual player. The program contains every season's statistics from 1920 on. The program also includes extensive player, team, and league statistical reports.

Action! PC Football is a detailed, comprehensive, and challenging football simulation that allows many different options for gameplay. You can relive past seasons as the coach of your favorite team; draft teams and play games in a league; let the computer manage all of the teams and watch the results; or set your coaching preferences for a specific team and let the computer play the season with your own specific coaching profile.

For our testing with this program, we played a complete 16-game regular season implementing our design strategy. We also tested our strategy against another design strategy that was designed using AD. The opposing AD strategy differed from our own and therefore was a good indication of how our strategy would fair against real life opponents.

3.1.1 Final Play-Calling Strategy

Upon completion of the design decomposition, there was a need for a tangible play calling strategy that could be repeatedly followed in order to play the game. A traditional way for coaches to call plays is by using a play card. A play card is a piece of

paper a coach may use on the sideline to call plays. They often contain a list of potential plays for all different aspects of the game. For our design decomposition we put together our own play card. Like other designs have visuals from CAD and other software programs, we use the play card as our visual representation for our design.

To maintain axiom one we divided the play card into offensive and defensive sections. The offensive and defensive plays can be seen for different scenarios of the game. There are options for 1st, 2nd, 3rd, and 4th down. Along with those downs there are different scenarios for the numbers of yards to go whether it be to the first down or the end zone. On the play card there is also a section for offensive audible calls in order to enable system adaptability. There are also inputs for play calls for special teams. A more in depth play call selection for special teams can be seen in the appendices.

The offensive play card can be seen in Figure 7. The way it is broken down is by formation followed by a list of plays that can be selected for the formation. For example, for second down and 5-10 yards to go the play card indicates to run 4 wide receivers and from that formation you can run the ball via off-tackle, dive, or trap. Another scenario for that same down and distance is to run 4 wide receivers and to run a short or medium pass.

Offense

1st 10+
4 Wide, Offtackle, Dive, or Trap
4 Wide, Short or Medium Pass
3 Wide, Draw, Offtackle, or trap
3 Wide, Short or Medium Pass
4 Wide 1 TE, Short or Medium Pass
Pro Basic, Offtackle, Dive, or Trap
Pro Basic, Short or Medium Pass
5 Wide, Short or Medium Pass

2nd 10+
4 Wide, Short or Medium Pass
3 Wide, Short or Medium Pass
4 Wide 1 TE, Short or Medium Pass
Pro Basic, Short or Medium Pass
5 Wide, Short or Medium Pass
Play Action Short or Medium Pass
3 Wide, Draw or offtackle
Pro Basic, Draw, dive, or offtackle

2nd 5-10
4 Wide Offtackle, Dive or Trap
4 Wide, Short or medium Pass
4 Wide 1TE, Short or Medium Pass
Pro Basic Short or Medium Pass
Pro Basic, Offtackle, dive, or trap

3rd 5-10
5 Wide Short slant or cross
5 Wide Medium slant, hitch, cross, or out
3 Wide 1 RB, Short or medium pass
Pro Basic, short or medium pass
Pro Basic Offtackle, draw, or trap
4 Wide 1TE, short or medium pass
4 Wide Play action short or medium pass
4 Wide, Short or Medium Pass
4 Wide Offtackle or Trap

2nd 0-5
Pro Basic, Offtackle, dive or trap
Pro Basic, Short slant, cross, or hitch
4 Wide, short out, cross, slant, or hitch
4 Wide, dive, trap, pitch, or offtackle

3rd 10+
5 Wide, Medium cross, slant, hitch or fly
4 Wide 1 TE, medium cross, slant, or fly
4 Wide, medium cross, slant, hitch, or fly
4 Wide, Draw or Screen
3 Wide 1 RB, Medium Pass

3rd 0-5
4 Wide, Draw, OffTackle, or Trap
4 Wide, Short Cross, Hitch, or Slant
4 Wide 1 TE, short cross or slant
Pro Basic, offtackle, dive, or trap
Play Action Short cross or slant
Pro Basic, Short slant, cross or hitch
3 Wide-1RB, Short Pass or Draw

Figure 7- Offensive Play Card

The defensive play card can be seen in Figure 8. It is broken down by down and distance just like the offensive play card. It also is broken down by formation and then a list of plays that can be called out of the formation. However, because the defense selects play second in Action! PC football the formations should be chosen to match up with the offensive personnel. For example, if the offense comes out in a 4 wide receiver set, it is in the defense's best interest to play a dime, nickel, or quarter coverage to properly defend the threat of pass. The defensive play card takes this into consideration and prepares for

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the offensive strategy accordingly. The entire play card including the offensive audibles and special teams aspect can be seen in the appendices.

Defense

1st and Short	1st and Long
4-3 Basic, Tight Man Pass	4-3 Basic, Tight Man Pass (can double)
4-3 Basic, Pass short	4-3 Basic, Tight Man Run (can key)
3-3 Nickel, Pass Short	4-3 Basic, Tight Man Basic, send blitz
3-3 Nickel Basic	3-4 Basic, Tight Man Pass
4-3 Basic, Basic, send blitz	4-2 Nickel, Man/Tight Man Basic
3-2 Dime, Short Pass	3-3 Nickel, Man Pass, send blitz
3-2 Dime, Basic	3-3 Nickel, Man/Tight Man Basic
3-4 Basic, key run	3-2 Dime, Tight Man Pass, send blitz

2nd and Short	2nd and Long
4-3 Basic, Tight Man Key Run	4-3 Basic, Man, Basic
-3 Basic, Tight Man Pass insid	4-3 Basic, Man, Key Run
-3 Basic, Tight Man Pass Shoi	4-3 Basic, Tight Man, Pass
3-3 Nickel, Tight Man Key Run	4-3 Basic, Man, Pass-short
3 Nickel, Tight Man Double Pa	3-3 Nickel Loose Man, Basic
	3-3 Nickel, Man Pass
	3-2 Dime, Loose Man Pass, Double WR
	4-1 Dime, Tight Man, Pass
	4-2 Nickel, Tight Man, Pass

3rd and Short
4-4 Stack, Key Run, send blitz
4-4 Stack, Tight Man Basic
4-3 Basic, Tight Man Run
4-3 Basic, Man Short Pass
4-3 Basic, Tight Man Key run

3rd and Long/4th and Long
3-3 Nickel, Loose Man Pass
3-3 Nickel, Man Pass
3-2 Dime, Loose Man Pass, Double
4-1 Dime, Man Pass
4-2 Nickel, Man Pass
3-3 Nickel, Loose Man Pass Long
3-2 Dime, Loose Man, Pass Long

4th Down/Goal Line
4-4 Stack, Key Run, send blitz
4-4 Stack, Tight Man Basic
4-3 Basic, Tight Man Run
4-3 Basic, Man Short Pass
4-3 Basic Tight Man, Key Run
5-3 Stack, Tight Man Key Run
6-2 Stack, Tight Man Key Run

Figure 8- Defensive Play Card

4   Results and Discussion

Throughout the gaming process, we gained a lot of valuable insights from the data collected. We would have gotten more useful data if we had run more simulations, but since we were pressed for time we got out of it what we could.

The gaming system used has some uncontrollable elements that skew the results we got. Penalties seem to be unpredictable, excessive at some points, and even completely unrelated to the selection of certain plays. They detract from the progress of any offensive or defensive possession. For example, after stopping our opponent on third down where they normally would have to punt, our defense got a personal foul penalty that gave the opposing offense 15 yards and an automatic first down. The text result from the play stated that we had stopped the play, but afterwards revealed the penalty. This type of penalty was completely unrelated to the type of play called on defense, and greatly hurt our chances of keeping the opponent from scoring. Similarly, on offense false start penalties and holdings plagued us at times, leaving us at a 2nd and 30 at one point in one of our simulations. Up to this point we didn't have a strategy for scenarios this long to go for a first down, and we had to adjust accordingly.

Another uncontrollable element in the game that deters progress on both sides of the ball is injuries. They occur frequently and on a much grander scale than in real life scenarios. Frequently players on both sides of the ball are sidelined for anywhere from a few plays at a time to up to 36 weeks. We have no control over these injuries, and it affects what capabilities our offense or defense has. Players are given a certain rating in the game from 1 to 10, and when a player with a higher rating gets injured and taken out of the game for 15-20 plays, he might get replaced by a backup with a much lower rating.

This allows us to adjust our strategy to exploit certain weaknesses. If there are lower ratings for the defensive backs on one side of the field, we would throw to that side. On the other side of the ball, if one of the opponent's higher rated receivers gets injured, we can key on other players that might be a threat and stop them.

For the season simulation that we ran against the computer as the New England Patriots, we ended up going 11-5. Below are some the common plays that we ran with their success percentage next to each play. Attached in the appendices are some of the box scores and play-by-plays of some of the games.
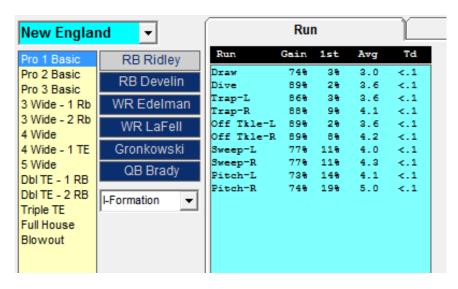

Figure 9- Run play percentage

As can be seen above, off tackle plays and dives yielded the best percentage for amount of times resulting in a gain, while sweep right had the highest average gain per times run.

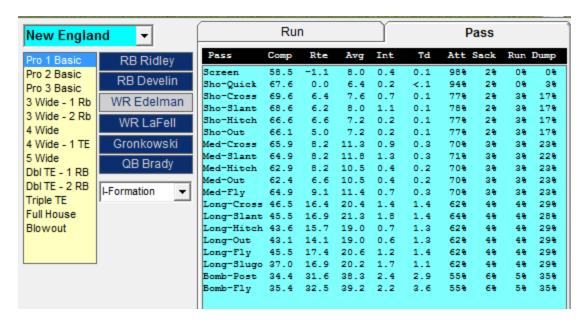| Pass	Comp	Rte	Avg	Int	Td	Att	Sack	Run	Dump
Screen	58.5	-1.1	8.0	0.4	0.1	98%	2%	0%	0%
Sho-Quick	67.6	0.0	6.4	0.2	<.1	94%	2%	0%	3%
Sho-Cross	69.6	6.4	7.6	0.7	0.1	77%	2%	3%	17%
Sho-Slant	68.6	6.2	8.0	1.1	0.1	78%	2%	3%	17%
Sho-Hitch	66.6	6.6	7.2	0.2	0.1	77%	2%	3%	17%
Sho-Out	66.1	5.0	7.2	0.2	0.1	77%	2%	3%	17%
Med-Cross	65.9	8.2	11.3	0.9	0.3	70%	3%	3%	23%
Med-Slant	64.9	8.2	11.8	1.3	0.3	71%	3%	3%	22%
Med-Hitch	62.9	8.2	10.5	0.4	0.2	70%	3%	3%	23%
Med-Out	62.4	6.6	10.5	0.4	0.2	70%	3%	3%	23%
Med-Fly	64.9	9.1	11.4	0.7	0.3	70%	3%	3%	23%
Long-Cross	46.5	16.4	20.4	1.4	1.4	62%	4%	4%	29%
Long-Slant	45.5	16.9	21.3	1.8	1.4	64%	4%	4%	28%
Long-Hitch	43.6	15.7	19.0	0.7	1.3	62%	4%	4%	29%
Long-Out	43.1	14.1	19.0	0.6	1.3	62%	4%	4%	29%
Long-Fly	45.5	17.4	20.6	1.2	1.4	62%	4%	4%	29%
Long-Slugo	37.0	16.9	20.2	1.7	1.1	62%	4%	4%	29%
Bomb-Post	34.4	31.6	38.3	2.4	2.9	55%	6%	5%	35%
Bomb-Fly	35.4	32.5	39.2	2.2	3.6	55%	6%	5%	35%

Figure 10- Pass play percentage

In the summary of the pass play percentage shown above, short crossing patterns yield the highest completion percentages. Medium crosses and slants, while slightly lower completion percentage, result in a higher average gain.

In the simulations against a human opponent using a similar strategy as ours, we are able to get a different insight. Since we were both using similar strategies, we saw a convergence in play results. The same strategies we used to beat the computer didn't work as well against the human opponent. We both had a very good offensive strategy, utilizing short/medium crossing routes mixed with a well rounded run game. When we faced off, it became very difficult to stop each other on offense at times. We found short crossing and slant routes to be almost unstoppable overall. Even when we would key certain receivers on pass plays and set up a pass defense, our opponent would still end up making a play with that same receiver. Another thing we discovered is that it is easier to cover one highly rated player on the field at a time, than it is to cover 3 decent players. This way the defense doesn't know which player to key on, since they all pose an equal

threat. This makes the process consistently repeatable and more reliable. One drawback we found out that detracted from the use of crossing patterns was the risk it posed to certain players. When you send receivers over the middle it leaves them more vulnerable and makes them more susceptible to dropping the ball.

We found through experience and looking through the game manual regarding audibles that we have a less likely chance to succeed in calling one than the same play called in the huddle. If we didn't use them in the right situations, we would be better off not even using an audible. We could be fooled by deceptive defenses that show blitz and then drop back into coverage, luring the offense into back audibles. If audibles are used too aggressively, smart defenses can catch on and exploit our tendencies.

When we were presenting our poster, we were asked a certain question that got us thinking to how we could compare our process to actual Mechanical Engineering design problems. If you are trying to manufacture a certain part, you take into account certain inputs like sharpness of tool, material, cut depth, etc. While you need to design the best way to manufacture this part, these things never change. They stay constant. However, in our game, the opponent constantly adjusts its strategy to counter you. They adapt and continuously force you to think of a different design process. A way that the mechanical engineering field forces the manufacturer to adjust and adapt is competition in the marketplace. If you view rival companies as enemies, you have to constantly refine your process to stay ahead of them.

5   Conclusions

This work showed that Axiomatic Design could be applied to create an effective play calling strategy for the game of football. The work met the definition of an "effective" strategy by maintaining a positive point differential for a 16-game regular season and producing a winning percent of .687 (11 wins) over the course of the season. The system also succeeded against a real life opponent, although it did show some predictably. Although our design did meet the definition of "effective" the results may still be inconclusive. The game statistics and outcomes do suggest that the strategy worked, but they do not prove that this strategy is better than another. If more simulations were completed for multiple seasons, more data could be collected and analyzed to show whether or not the strategy continued to be effective long-term. Another improvement to the testing would be to test multiple seasons as a high ranked team, multiple seasons as an averaged rank team, and multiple seasons as a poorly ranked team to see if the strategy held consistent for all three teams. The design decomposition succeeded in providing functional metrics for each FR, but there may be better metrics to be used than the ones selected in this work. Overall, this work showed that Axiomatic Design can be applied to a complex game, such as football, to objectively improve the design strategies of the game.

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7   Appendices

Appendix A- Action PC Football Plays in detail

Action! PC Football Special Teams Play Selection

1. Punts
   a. Punt deep (own 40 yard-line or less)
   b. Punt Sideline (own 41 yard-line to opponent 38 yard-line)
   c. Pooch Punt (never)
   d. Fake run (4th and inches, 4th and 1, own 45 yard-line to opponents 40 yard line)
   e. Fake Pass (never)
2. Punt Return
   a. Punt block (opponent kicking from own 15 or in)
   b. Watch Fakes (4th and less than 2, opponents own 40+)
   c. Fair Catch (anytime ball should land inside 15 or there is excellent coverage)
   d. Let roll (anytime ball should land inside 10 or less)
   e. Punt return (anytime there is good coverage or no coverage description is provided)
3. Kickoffs
   a. Kick deep (any time when tied or leading in the game)
   b. Kick angle (when attempting to prevent a runback)
   c. Squib kick (with less than a minute left in a half)
   d. Onside kick (when trailing past 4 minutes in the 4th quarter)
4. Kick Returns
   a. Return (always return in non-onside scenarios, always kneel it when given the option)
   b. Watch Onside (when leading with less than 4 minutes left in the game, at the beginning of the half)
5. Field Goals
   a. Kick (opponents 33 yard line or less, 4th and more than 2)
   b. Holder Run (never)
   c. Kicker Run (never)
   d. Holder Pass (never)
6. Field Goal Defense
   a. Block (4th and more than 3)
   b. Watch Fakes (4th and 2 or less where opposing team trails by more than 3)

1. **Calling Defensive plays**
    a. Three steps in calling defensive plays:
        i. Set formation to be used. If no huddle is being used, the list will be grayed out as no personnel changes can be made.
        ii. Set any specific play options and assignments. These can include coverage depth and mode, keyed runners, doubled receivers, blitzers, match-ups, defensive line play, deception tactics, and more. As many options as desired can be used on a play, and each have their own strengths and weaknesses as they relate to players on the field and game situations.
        iii. Call a play. Play call determines the mindset and behavior of the defense as a whole. Plays include basic, run, pass, prevent, and goal line.
2. **Defensive Formations**
    a. Fifteen formations are available. Each formation is a different arrangement and number of defensive linemen, linebackers, and defensive backs. Personnel used in a formation may be set from the team roster screen. Any changes made during a game will not be saved for future games. Changes may also be made by clicking a player's name on the playing field and selecting a substitute from the quick sub form. Checking the "global substitutions" box will replace the player in every formation, while leaving it unchecked will only change the current formation.
    b. To view the overall ratings of the chosen formation, select the "Line" tab. Ratings appear below the lineup. A range of ratings is used for the sack rating, since it varies according to which players are blitzing. The formation also influences what play calling options are available. For example, run defenses cannot be used when five or more defensive backs are in the game, while pass defenses require at least four. The match-ups created by different formations also affect the ability to double cover receivers, blitz, and move the free safety into run support, among other things.
    c. **Types of Formations:**
        i. **4-3 Basic:** A standard set including four linemen, three linebackers, and four defensive backs.
        ii. **3-4 Basic:** Standard set including three down linemen and four linebackers. The 3-4 is effective for teams with good linebackers, and usually relies on at least one blitzing linebacker to create a pass rush.
        iii. **5-2 Basic:** Basic package for teams with five good defensive linemen. May be vulnerable to short passing, and may give up more big runs.
        iv. **3-3 Nickel:** A pass oriented defensive formation with five defensive backs, 3 linemen, and 3 linebackers.

     v. **4-2 Nickel:** A nickel formation that may be effective for teams with good pass rushing linemen or weak linebackers.

    vi. **5-1 Nickel:** A nickel formation using five down linemen to create a pass rush, and only one linebacker. Teams with good linemen may be able to produce sacks, but vulnerable to big plays.

   vii. **3-2 Dime:** Standard dime formation with six defensive backs. Matches up well against four wide receiver sets.

  viii. **4-1 Dime:** A dime set with four down linemen and one linebacker.

    ix. **3-1 Quarter:** A pass defense platoon using seven defensive backs. Can be effective prevent defense.

     x. **5-3 Stack:** A run defense formation useful in short yardage situations. Because only three defensive backs are used, it is vulnerable to passing..

    xi. **5-4 Stack:** Designed for short yardage situations, but very vulnerable to passing plays with only two defensive backs on the field.

   xii. **6-2 Stack:** Similar to 5-3 stack, but it can be used effectively by teams with six good linemen.

  xiii. **6-3 Stack:** Similar to the 5-3 stack, but it can be used effectively by teams with six good linemen.

  xiv. **4-3 Basic B:** An alternate 4-3 basic formation. By default, this lineup is filled with backups, and is best used in blowout situations to protect important players from being injured.

   xv. **3-4 Basic B:** An alternate 3-4 basic formation.

3. **Defensive Play Calls:**
   a. Play call occurs after selecting coverages, keyed runners, blitzers, or other defensive options. Play call determines the mindset and behavior of the defense as a whole on a play.
   b. **Basic:** Standard, balanced defensive play. Will generally be used more than any other, as it has no specific strengths or weaknesses.
   c. **Run:** Lowers opponent's rushing average, increases the chance of lost yardage, decreases the chance of a big gain, and increases the chance of a fumble on running plays. More vulnerable to passing plays. Must be no more than four defensive backs on the field to call.
   d. **Pass:** Lowers the effectiveness of the passing game, while making the defense more vulnerable to running plays. Must be at least four defensive backs on the field.
   e. **Prevent:** Designed to prevent a big play. Offense will be able to move the ball with short passes or runs, but will be ineffective on long and deep passes and will rarely break a big gain. Deep zone coverage is selected automatically when playing prevent defense.
   f. **Goal line:** Bring everyone up to the line to stop the offense in short yardage situations. Usually most effective play at the goal line, but is very risky in non goal line situations. Breakaways and big gains are very likely on both passes and runs. The offense always gets a chance to audible when the defense plays goal line defense outside of the red zone.

4. **Coverage and Match-up Options:**
    a. **Coverage Type:**
        i.   **Man Coverage:** Each Player matches up against an offensive player in pass coverage. Slightly more effective than zone defense, but weak defenders may be exploited by good receivers. More vulnerable to breakaways and big gains, as well as certain routes such as slants and crosses. Scrambling QBs will run more effectively against man defense, and it is more susceptible to being beaten by trick plays like reverses and end arounds. Any players who are not assigned to a man-to-man match up and are not designated to another assignment will play a zone.
        ii. **Zone Coverage:** Each defender is given an area of some field to cover, rather than a specific player. Zone defense can sometimes "hide" poor defenders but also minimize the positive impact of great defensive backs. Zones usually give up a slightly higher completion percentage and average gain, but are less susceptible to big gains and deep passes. More effective against certain routes, such as slants and crosses, but are worse against hitches, medium and long fly routes and posts. Works well against running QBs. Less likely to be caught out of position by trick plays. Double coverages cannot be used in zone.
    b. **Coverage Depth:**
        i.   **Tight/short Coverage:** Brings defensive players closer to the line of scrimmage. Makes defenders more effective at defending short passes, but leaves them vulnerable to long passes. Runs are slightly more likely to be stopped for a loss or a short gain, but are more likely to result in breakaways and big gains if they get behind the tight coverage.
        ii. **Loose/Deep coverage:** Moves defenders away from the line of scrimmage to better defend deep passes. Short passes are much more effective, but breakaways are less likely. Long and bomb passes are less effective. On running plays, the average gain is higher, but the chance of a long gain is reduce.
    c. **Inside and Outside Coverage:** When playing inside or outside coverage, defenders will adjust their zones or shade their man coverage to better defend an area of the field. Outside coverage helps pass defense near the sidelines, and can be effective at stopping out routes and fly patterns. Often good coverage style against a two minute offense that is throwing sideline passes in an effort to get out of bounds and stop the clock. More vulnerable to the middle of the field, where crosses and slants are run. Shifts defenders towards the middle of the field to defend against routes like crosses and slants, while leaving outside routes open more often.
    d. **Show Coverage:** Allows the defense to play one coverage depth, but disguise it at the line of scrimmage as another. For example, the defense could show tight coverage, and then back off into normal coverage as the play begins. Pass defense is slightly less effective overall when showing

coverage, since defensive backs are not in their ideal position to start the play. However, by using deception at the right times, the offense can be lured into making bad audible calls that can work to the defense's advantages.

  i. Showing tight or loose coverage is available when playing normal coverage, and results in a significant chance that the offense is given an audible opportunity (usually about 70%). Showing normal coverage is available when playing tight or loose coverage, and greatly reduces the chance of an offense reading the actual coverage and getting an audible chance. By showing tight coverage but playing normal coverage, the defense could lure the offense into believing that a deep pass audible is a good call. By balancing the use of deception with actual coverage changes, a defensive coach can limit the use and effectiveness of offensive audibles, and turn the offense's ability to audible against itself.

e. **Match Ups:** Match ups can be set by position. Preferred match ups may be set to cornerback, safety, or linebacker. Specific player matchups will be assigned in order of pass defense ratings. For example, if three offensive players are designated to be guarded by cornerbacks, the best receiver of the three will be matched up against the best cornerback. If only two cornerbacks are on the field, the lowest rated receiver will be matched up with a safety instead.

  i. An example of the usefulness of the match up preferences could be when facing a RB who often catches passes. The RB could be matched up against a safety to limit his effectiveness. On the other hand, the RB could be matched up against a linebacker in situations where he is not a threat, such as long yardage, in order to free up a safety for support coverage.

  ii. The check box for "Rotate Coverage when Blitzing LBs and Safeties" determines how match-ups are assigned when coverage players are designated to blitz. When checked, the next best cover player is rotated up to guard the blitzing player's assignment, with his assignment being covered by the next best, and so on. When the box is unchecked, the best available player without an assignment is used. If no player is available, and the box is unchecked, he will be unguarded. Coverage is never rotated when blitzing corners, so it is important that a defender is free to pick up the blitzing corner's assignment.

  iii. Match up box also allows a free safety to be designated for the current formation. The free safety will be the last defensive back to be assigned coverage. This means that he will be "free" more often to blitz, double cover, play run support, or simply to play zone defense.

f. **Zone Defensive Backs:** When playing man-to-man coverage, any defensive backs who are not assigned a primary coverage responsibility will play zone defense. These defensive backs support the others in

coverage, and play an important role in defending against deep passes and preventing breakaways. Defensive backs can be freed up by assigning players to be guarded by linebackers using the match-ups box. Number of zone defensive backs can also be set for a specific play by selecting the "Zone DBs" number, located below the coverage box.

    g. **Swap Corners:** "Swap corners" switches the assignments of the top two cornerbacks on the field. Can be useful against teams with two receivers of near equal ability, especially when they have different skill sets. For example, the best corner could match up on the best deep threat in long yardage situations, and against the better overall pass catcher in others. Swapping corners occasionally can also force the offense to throw to different receivers, rather than throwing against the best match-up all game. The chance of an audible opportunity for the offense increases when the defense swaps corners.

5. **Keys and Doubles:**

    a. **Keyed Runners:** Keying a running back correctly reduces his average by the amount of his "keyed" rating, which can be viewed on the team roster and player form. Keying correctly also increases the chance of a stuff in the backfield, increases the chance of a fumble, and decreases the chance of a breakaway run. Runners who carried the ball more often and more effectively in real life are less affected by run keys, because they are assumed to have been keyed more in real life. Keying incorrectly slightly increases the chance of a gain. Short and medium pass plays are more effective when a runner is keyed, since the linebackers give more attention to defending the run. Screen passes are less likely to gain yardage when thrown to a keyed runner. Run keys can not be used when five or more defensive backs are in the game, when playing a pass or prevent defense, or when double covering a receiver.

    b. **Doubled Receivers:** Double covering a receiver reduces the completion percentage on passes to that receiver by his "doubled" rating, which can be viewed on the team roster and player form. The chance of a pass being attempted to a double receiver is reduced, often significantly, with the QB dumping the ball of to secondary receivers instead. Average gain and breakaway chance are also reduced when throwing to the doubled receiver, and interception chance is increased. Double covering a receiver increase the effectiveness of other receivers, and slightly increases the average on running plays. Defenders will be used in order of their pass coverage rating. Double coverage is not available when fewer than four defensive backs are on the field, or when playing run or goal line defense. The effectiveness of double coverage is reduced when more than one is used. Double covering two receivers does not reduce each receiver's effectiveness as much as if they were the only one. Receivers who are not double become even more effective, since there are fewer defenders in support coverage.

6. **Blitzes:** Can create pressure on the QB, causing more sacks, incompletions, and interceptions. On the other hand, they tend to give up bigger gains and more

breakaways, and vacate areas of the field that can be targeted by the offense. Short passes and screens can be very effective at beating the blitz, especially when they are thrown towards the blitzing players. Offenses should be alert to where the best pass rushers are located, and throw short passes and screens in their direction when a blitz is expected, or when the defense shows blitz. Blitzes by the cornerbacks and safeties are the most aggressive, bringing potential risks and rewards. A good pass rusher coming from a corner position is especially difficult to pick up, but can leave a significant weakness on his side of the field. When blitzing a corner or safety while playing man-to-man coverage, make sure that another defensive back is available to guard his match-up assignment. Even when another player is available to cover, passes thrown in the direction of the blitz are much more effective. Against the run, blitzes are more likely to shut down plays in the backfield, especially when the run is in the direction of the blitz. However, average per carry and breakaway chance are increased. When a run defense is called along with a blitz, it is considered a run blitz. In this case, average gain and gain percentage are decreased, while breakaway chance is increased. Blitzing increases the chance the offense will have an opportunity to audible.

    a. **Show Blitz:** Showing blitz is a fake blitz, designed to cause the offense to react with audibles that work in favor of the defense. Showing blitz presents an audible opportunity to the offense. Any defense that blitzes often should also include some fake blitzes to keep the offense from exploiting the blitz with audibles. This could also be combined with a key on a running back who an audible screen pass might go to, or a double coverage on the side of the field that the blitz usually comes from. Also has negative effects. Fake blitzers need to adjust from their blitz position to their assignment for the play. Both pass and run defenses are negatively impacted. This can be offset in the short term by causing poor audibles, and in the long term by keeping the offense suspicious enough to decline good audible opportunities later in the game.

    b. **Delay Blitz:** Calling a delayed blitz instructs blitzing players to remain in their normal positions before the snap, hiding their intention to blitz. Greatly reduces the chance of a blitz being detected and exploited with an audible. Because blitzers have further to go, the blitz is less effective at creating pressure but still has many of the negatives of a normal blitz.

7. **Additional Defensive Options**:

    a. **QB Spy:** A QB spy's job is to follow the QB and limit his ability to run. Can significantly decrease the effectiveness of running QBs. The spy's ability in pass and run coverage is decreased, resulting in increased average gains and completion percentages.

    b. **Aggressive vs. Conservative Defense:** Setting the defense to aggressive or conservative affects the overall mindset of the defense. Aggressive defenses will go for strips and attempt to jump in front of routes for interceptions. This results in more fumbles and interceptions, but increases average gains and breakaways. Aggressive defenses also commit more penalties. Conservative defenses do not attempt to create turnovers. They

yield higher average gains and completion percentages, but greatly reduce the chance of big gains and defensive penalties. In general, aggressive defense is best used when attempting to come from behind and a turnover is needed, and conservative defenses are often a good strategy when protecting a large lead.

c. **Free Safety Run Support:** To bring the free safety "into the box" for run support, click the "Run-FS" label below the blitz list. This brings the free safety closer to the line of scrimmage to defend against the run. Effectiveness of the running game is reduced according to the free safety's run defense rating. An extra player in the box can stop run, but opens up the free safety's area of the field to passing plays and increases the chance of breakaways on both passes and runs. Pass defense is especially hurt on long passes and bombs. Rum support is not available when the free safety has another assignment.

d. **Defensive Line Play:** Defensive line can be set to rush straight ahead or to slant left, right, or outside. Slanting the line in one direction reduces the effectiveness of runs in that direction, but increase the effectiveness of runs in the other direction. Slants are best used against teams that are strong in one area of their offensive line. Being alert to the offensive coach's run direction tendencies over the course of a game and season will give clues as to how often and in which direction to slant the line.

8. **Preventing and Influencing Audibles:** QB's have the ability to read a defense and create opportunities for audible calls. It is important that the defense understand what types of calls are more likely to result in these chances. The chance of an audible opportunity is shown at the bottom right of the defensive play call screen and changes as defensive options are selected. Include the following:

a. **Defensive Personnel:** Formations do no closely match the offensive personnel are more likely to result in audible chances. For example, putting six defensive backs on the field against a pro basic formation, or a 4-3 defense against a four wide receiver set, will increase the chance for an audible.

b. **Coverage Depth:** Playing tight or loose coverage increases the chance of an audible by about 10 percent. Deception can be used by showing a different coverage than is actually being played, in order to either prevent an audible from being called, or to try to lured a bad audible call.

c. **Swap Corners:** Switching the match-ups of the top two corners increases the chance of an audible opportunity.

d. **Blitz:** The more blitzers that are selected, the better the chance of an audible opportunity. This chance can be minimized by delaying blitz, at the expense of reducing the effectiveness of the blitz. It can also be increased by showing (faking) a blitz, to try to lure the offense into a poor audible.

Action! PC Football Offensive Plays

- **Draw:** Works well against pass defense. Run defense will not be fooled. Slow developing run, more likely to be stopped in backfield for loss.
- **Dive:** Conservative run play that can be effective at picking up short gains. Rarely produce significant lost yardage and rarely produces large gains.
- **Trap:** Run in between guard and tackle. Trap blocking technique by lineman opens up holes for the RB. Effective against slanting defensive lines.
- **Off Tackle:** Run behind either the left or right tackle of the offensive line. Most standard yardage distribution for running plays. Moderate chance of a breakaway run and moderate chance of a loss.
- **Sweep:** Outside handoff where typically a lineman "pulls", getting outside in front of the RB to block. Good chances for breakaways, but also result in more losses since they take longer to develop.
- **Pitch:** Outside running play where the ball is tossed to the running back. Similar to sweeps, but result in slightly more breakaway runs. Carry more risk, including an increased chance of a fumble or a loss in the backfield.
- **Short Cross:** Six to nine yard route run over the middle of the field. Higher completion percentage because they are a shorter throw for the quarterback. Throwing over the middle increases the chance of interception due to more defenders in the vicinity. Produce a moderate chance for a breakaway, slightly better at beating man-to-man coverage.
- **Short Slant:** Quick angled route over the middle of the field. Slants produce the best chance for yards after the catch because the receiver catches the ball running up field. Slightly higher completion percentage than the average pass. Because the route is run over the middle, interceptions are more likely and receivers are more susceptible to hits that could cause fumbles. Slightly more effective against man-to-man coverage.
- **Short Hitch:** Conservative, six to nine yard "curl" route. Produce reliable gains, with very little chance of significant yards after the catch. Completion percentage is slightly lower, but interceptions and fumbles after the catch are significantly reduced. Hitch routes are slightly more effective against zone defense.
- **Short Out:** Six to nine yard route run towards the sideline. Completion percentage is lower, since the pass generally has to be thrown further to reach the receiver. Throwing away from the middle of the field results in fewer interceptions and fumbles after the catch. Good routes for getting out of bounds to stop the clock. Breakaways occur less.
- **Short Quick:** Immediate throw to a receiver or tight end at the line of scrimmage. Effective against loose coverage, can be used successfully as an audible. Less effective against normal coverage than other routes, especially ineffective against tight coverage. Receivers who can run after the catch will be able to produce the best gains.
- **Short Flat:** Run out of the backfield to the flat on either side of the field. Usually caught near the line of scrimmage, relies on the running back's ability to gain yards after catch. Good way to get the ball to a good pass catching running back.

- **Screen:** Short Pass, usually to a RB, in which the pass rush is allowed to get behind the play before the pass is thrown. Lineman release up field to block. Screens are especially effective against blitzing defenses. Rarely intercepted, but when they are the result is often a big return.
- **Medium Cross:** 10 to 15 yard route over the middle of the field. Crossing routes have a high completion percentage because they are effectively a shorter throw for the quarterback. Throwing over the middle generally means more defenders, increasing chance of interception. Crossing routes produce a moderate chance for a breakaway, slightly better at beating man-to-man coverage.
- **Medium Slant:** 10 to 15 yard route angled over the middle of the field. Receiver catches the ball going up field, producing the best chance of yards after the catch. Slightly higher completion percentage than the average pass. An interception is more likely, as well as fumbles. More effective against man coverage.
- **Medium Hitch:** 10 to 15 yard "curl" route. Produce reliable gains, little chance of significant yards after the catch. Completion percentage is slightly lower than average, but interceptions and fumbles are significantly reduced. Hitch routes are slightly more effective against zone defense
- **Medium Out:** 10 to 15 yard route run towards the sideline. Completion percentage is lower, since the pass is generally thrown further to reach the receiver. Throwing away from the middle of the field results in fewer interceptions and fumbles after the catch. Good patterns for getting out of bounds to stop the clock. Breakaways occur less often.
- **Medium Fly:** 6 to 15 yard straight pass. Pass is slightly more effective against zone defense. Yardage varies more than the typical pass, because the QB will attempt to throw the pass in a window rather than to a specific distance.
- **Long Cross:** 20-30 yard route over the middle of the field. Higher completion percentage than other routes. Increased chance of interception. Produces moderate chance of a breakaway, and slightly better at beating man-to-man coverage.
- **Long Slant:** 20 to 30 yard angled route over the middle. Produces best chance for yards after the catch. Higher completion percentage than the average pass. Interceptions are more likely, as well as fumble. Slightly more effective against man coverage.
- **Long Hitch:** 20 to 30 yard "curl" route. Slightly more effective against zone. Little chance for YAC. Completion percentage lower than average, but interceptions and fumbles less likely.
- **Long Out:** 20 to 30 yard route towards sideline. Completion percentage lower. Results in fewer interceptions and fumbles. Less often breakaways.
- **Long Fly:** 20 to 30 yard straight pass. Slightly more effective against zone. Yardage varies.
- **Bomb Fly:** Deep 40 to 50 yard route run straight up the field. Most effective against man coverage.
- **Bomb Post:** Deep 40 to 50 yard angled route across the middle of the field. Slightly higher completion percentage than fly routes. Also have a slightly higher interception chance and lower big gain after the catch. Most effective against zone defense.

- **Combo Pass:** Pass play allows up to four receivers to be selected to run short, medium, long, or bomb routes. The QB will throw to each receiver about evenly, except in certain defensive situations. (For example, if the defense is playing tight coverage, passes are less likely to go to short routes. If one receiver is doubled covered, he less likely to be thrown to.) Can be used effectively against coaches who aggressively adjust coverages from play to play. Combo passes are slightly less effective than standard pass calls, so it is important that they are used in the right situations.
- **Dive Over the Top:** Quick hand off to a running back who attempts to dive over the line of scrimmage in an effort to gain short yardage. Consistently will yield between zero and one yard. Effective way to convert a first down/TD with inches to go against a goal line defense.
- **Stretch:** Outside hand off to the strong side of the field, in which the QB sprints outside to make the hand off and the offensive line "stretches" in the direction of the run.
- **Quick Pitch:** Play to the weak side of the field. Effective against aggressive defenses, or against defensive lines that are slanting towards the strong side of the field. More risk of lost yardage than standard pitch plays.
- **End Around:** Outside hand off to a wide receiver or tight end. Good way to get the ball into the hands of a good running receiver. Risk lost yardage but may also produce a gain. The play becomes somewhat less effective when trick plays have already been run in the game.
- **Reverse:** Outside handoff to RB, who then hands the ball to a wide receiver running in the opposite direction. Reverses can produce big gains if the defense over pursues the initial hand off and is left out of position on the reverse. However, when the defense stays home the play will often go for a significant loss. Aggressive defenses, or defensive line slants in the direction of the original hand off, are especially likely to be fooled, while conservative defenses rarely will. Zone defenses are much less likely to get caught out of position on reverses than man-to-man. This play is less effective once trick plays have already been run in the game.
- **QB Bootleg:** A fake inside hand off to a RB, followed by an outside run by the QB. Not effective in short yardage situations, since they are often stopped for a loss. Can produce good gains when used with a running QB. A defense that keys primary running back may be more susceptible to bite on the fake hand off.
- **Delay Draw:** Draw play with an exaggerated delay before the hand off. Can produce large gains against pass defenses, but also get stopped due to the slow development. Rarely will have any success if the defense does not anticipate a pass.
- **Double Reverse:** A reverse play with a third hand off. Extremely risky, and often loses significant yardage as each hand off moves further behind the line of scrimmage. Against aggressive defense, there is a chance that the defense will be fooled and big play could result. Zone defense are less likely to be fooled. Less effective once a trick play has already been called.
- **Statue of Liberty:** Similar to both a draw play and an end around. QB fades back to pass, and then hands the ball to a wide receiver on an outside run. Play can be

effective against defenses that are expecting a pass, but will also often be stopped for a loss against basic run defenses. Less effective when other trick plays have been called.

- **Shovel Pass:** Quick screen pass in the middle of the field to a RB. Lower completion percentage than typical screen passes, but can also produce slightly larger gains. Most effective against aggressive, blitzing defenses, especially when the blitz comes from inside linebackers.
- **Corner Fade:** Lob pass into the corner of the end zone. Only available inside the 20-yard line. Completion percentage is lower than a typical pass, but it is consistently thrown to the primary receiver, and will always result in a touchdown if completed. Fade attempts to isolate a one-on-on match up, therefore it is particularly effective against a favorable man-to-man match up, while good defenders can shut down the play.
- **Long Slant & Go:** Initially looks like a short slant, but the receiver then breaks straight up the field on a long fly route. Defenses playing tight, aggressive coverage are likely to jump the short route and the be beaten deep. Sacks and dump-offs are more likely since the primary route takes longer to develop. More effective against man defense than zone.
- **Hook & Ladder:** Medium hitch pass, followed by an optional pitch to a receiver headed down field. Pass is slightly less effective than a standard medium hitch. If the pitch is made, it can result in an additional big gain. However, it also carries a significant risk of a fumble. This play is less effective if a trick play has already been run in the game.
- **Flea Flicker:** Ball is first handed off to a RB who starts up the middle. He then stops and pitches the ball back to the QB, who throws a long pass to a designated receiver. Can be especially effective against defenses that are expecting the run. They often result in sacks since they take a long time to develop, and will often result in interceptions and incompletions against defenses who do not fall for the fake run. Less effective once trick plays have already been run in the game.
- **Hail Mary:** Desperation, deep pass thrown as far as the QB can throw. No primary receiver is targeted and the pass usually ends up being a jump ball in the end zone. Chance for a completion is low, and the chance of an interception is very high. It is, however, the best chance of scoring on one play against a prevent defense
- **Trick Pass:** Trick passes are thrown by a player other than the QB. It is usually a hand off to the passer, who then throws the a medium or long pass. Very high chance of a sack or interception, but also potential for a big play if the defense is fooled. Most likely to be successful when the defense suspects run, or keys the passer. Less effective once other trick plays have been called.
- **Run-Pass Option:** The QB rolls out and has the option of either throwing a short to medium pass or running. The QB will choose between running and passing about equally, except in certain situations. Each option is slightly less effective than if it were called the standard way, but because the option that is taken depends partially on the defensive call, it can be an effective play for a team with the right players.

- **Option:** QB carries the ball outside with the option to pitch to the running back who trails behind him. The preferred option is selected. Defensive play calls effect which option will be taken. For example, if the RB is keyed, the QB will be more likely to run the ball himself. Option plays are less effective against pro teams.
- **Triple Option:** Option play with an additional option to hand off to the fullback up the middle. The preferred option is selected. Defensive play calls can also effect which option will be taken. Less effective against pro teams.
- **QB Sneak:** Quick run up the middle by the QB. The play will consistently yield between zero and one yard, making it an effective way to convert a first down or TD with inches to go against a goal line defense.
- **Quick Kick:** Quick kick is a trick punt play. QB lines up in the shotgun and punts the ball. The defense will not have a player deep, therefore returns are generally very short when the kick is returned at all. Because of the short snap, the fact that the QB is not usually a punter, there is a greater risk of the punt being blocked.

Appendix B- Complete Play Card

Offense			Scripted Plays	Defense	
1st 10+	**2nd 10+**			**1st and Short**	**1st and Long**
4 Wide, Offtackle, Dive, or Trap	4 Wide, Short or Medium Pass	1		4-3 Basic, Tight Man Pass	4-3 Basic, Tight Man Pass (can double)
4 Wide, Short or Medium Pass	3 Wide, Short or Medium Pass	2		4-3 Basic, Pass short	4-3 Basic, Tight Man Run (can key)
3 Wide, Draw, Offtackle, or trap	4 Wide 1 TE, Short or Medium Pass	3		3-3 Nickel, Pass Short	4-3 Basic, Tight Man Basic, send blitz
3 Wide, Short or Medium Pass	Pro Basic, Short or Medium Pass	4		3-3 Nickel Basic	3-4 Basic, Tight Man Pass
4 Wide 1 TE, Short or Medium Pass	5 Wide, Short or Medium Pass	5		4-3 Basic, Basic, send blitz	4-2 Nickel, Man/Tight Man Basic
Pro Basic, Offtackle, Dive, or Trap	Play Action Short or Medium Pass	6		3-2 Dime, Short Pass	3-3 Nickel, Man Pass, send blitz
Pro Basic, Short or Medium Pass	3 Wide, Draw or offtackle	7		3-2 Dime, Basic	3-3 Nickel, Man/Tight Man Basic
5 Wide, Short or Medium Pass	Pro Basic, Draw, dive, or offtackle	8		3-4 Basic, key run	3-2 Dime, Tight Man Pass, send blitz
		9			
2nd 5-10	**3rd 5-10**		**Audibles Offense**	**2nd and Short**	**2nd and Long**
4 Wide Offtackle, Dive or Trap	5 Wide Short slant or cross		3-2 Dime= Offtackle/Dive	4-3 Basic, Tight Man Key Run	4-3 Basic, Man, Basic
4 Wide, Short or medium Pass	5 Wide Medium slant, hitch, cross, or out		4-3 Basic Show Blitz= Pass	-3 Basic, Tight Man Pass inside	4-3 Basic, Man, Key Run
4 Wide 1TE, Short or Medium Pass	3 Wide 1 RB, Short or medium pass		Blitz= Medium Fly or quick short	-3 Basic, Tight Man Pass Shor	4-3 Basic, Tight Man, Pass
Pro Basic Short or Medium Pass	Pro Basic, short or medium pass		3-3 Nickel show bltiz= short pass	3-3 Nickel, Tight Man Key Run	4-3 Basic, Man, Pass-short
Pro Basic, Offtackle, dive, or trap	Pro Basic Offtackle, draw, or trap		Quarter= trap/dive/offtackle	3 Nickel, Tight Man Double Pa	3-3 Nickel Loose Man, Basic
	4 Wide 1TE, short or medium pass				3-3 Nickel, Man Pass
2nd 0-5	4 Wide Play action short or medium pass			**3rd and Short**	3-2 Dime, Loose Man Pass, Double WR
Pro Basic, Offtackle, dive or trap	4 Wide, Short or Medium Pass			4-4 Stack, Key Run, send blitz	4-1 Dime, Tight Man, Pass
Pro Basic, Short slant, cross, or hitch	4 Wide Offtackle or Trap			4-4 Stack, Tight Man Basic	4-2 Nickel, Tight Man, Pass
4 Wide, short out, cross, slant, or hitch				4-3 Basic, Tight Man Run	
4 Wide, dive, trap, pitch, or offtackle	**3rd 10+**			4-3 Basic, Man Short Pass	
	5 Wide, Medium cross, slant, hitch or fly		**Special Teams**	4-3 Basic, Tight Man Key run	**3rd and Long/4th and Long**
	4 Wide 1 TE, medium cross, slant, or fly		Always Kick Deep		3-3 Nickel, Loose Man Pass
3rd 0-5	4 Wide, medium cross, slant,hitch, or fly		Onside Kick-under 2 mins if losing	**4th Down/Goal Line**	3-3 Nickel, Man Pass
4 Wide, Draw, OffTackle, or Trap	4 Wide, Draw or Screen		Let Punt Roll inside 5 yd line	4-4 Stack, Key Run, send blitz	3-2 Dime, Loose Man Pass, Double
4 Wide, Short Cross, Hitch, or Slant	3 Wide 1 RB, Medium Pass		Punt Return	4-4 Stack, Tight Man Basic	4-1 Dime, Man Pass
4 Wide 1 TE, short cross or slant			Fair Catch With Good Coverage	4-3 Basic, Tight Man Run	4-2 Nickel, Man Pass
Pro Basic, offtackle, dive, or trap			Return Kick	4-3 Basic, Man Short Pass	3-3 Nickel, Loose Man Pass Long
Play Action Short cross or slant			Kneel Kick if 2+ yds in endzone	4-3 Basic Tight Man, Key Run	3-2 Dime, Loose Man, Pass Long
Pro Basic, Short slant, cross or hitch			Attempt FG 38 yds or under	5-3 Stack, Tight Man Key Run	
3 Wide-1RB, Short Pass or Draw			Block Kick	6-2 Stack, Tight Man Key Run	

Appendix C- Box Scores and Play-by-Play Results

New England Patriots vs. Seattle Seahawks 04-24-2016
Gillette Stadium Temp:63 Wind:10-20 *Internet* No Line MVP:Brady HFA:OFF

	1	2	3	4	Tot
2014 Seattle	7	7	0	7	21
2014 New England	7	3	10	3	23

Scoring Summary   0
1 8:15 Seattle   TD Wilson 3 pass to Harvin (Hauschka) (15-83-6:38)   7-0
15

1 3:42 New England   TD Brady 21 pass to LaFell (Gostkowski) (10-80-4:33)   7-7
27
2 13:34 Seattle   TD Wilson 9 pass to Richardson (Hauschka) (10-80-5:08)   14-7
40
2 0:00 New England   FG Gostkowski 54 (4-13-1:00)   14-10
86
3 10:13 New England   TD Brady 10 pass to LaFell (Gostkowski) (11-76-4:40)   14-17
98
3 5:12 New England   FG Gostkowski 30 (10-40-4:01)   14-20
116
4 10:50 Seattle   TD Wilson 9 pass to Kearse (Hauschka) (5-47-3:01)   21-20
141
4 7:06 New England   FG Gostkowski 50 (8-48-3:37)   21-23
153

Drive Summary
 1 Seattle   Sea 17 15 plays 83 yards 6:38   Touchdown, Sea 7 NE 0
2
 1 New England   NE 20 10 plays 80 yards 4:33   Touchdown, Sea 7 NE 7
18
 1 Seattle   Sea 20 10 plays 80 yards 5:08   Touchdown, Sea 14 NE 7
30
 2 New England   NE 26 11 plays 58 yards 5:52   Turnover on downs
43
 2 Seattle   Sea 16 6 plays 12 yards 2:51   Punt   54
 2 New England   NE 30 3 plays 17 yards 1:33   Punt   62
 2 Seattle   Sea 23 4 plays -3 yards 0:42   Punt   0
 2 New England   NE 36 3 plays 6 yards 0:14   Punt   72
 2 Seattle   Sea 20 3 plays -13 yards 0:33   Punt   77
 2 New England   Sea 49 4 plays 13 yards 1:00   Field Goal, Sea 14 NE 10
82
 3 New England   NE 24 11 plays 76 yards 4:40   Touchdown, Sea 14 NE 17
88
 3 Seattle   Sea 20 3 plays 6 yards 0:49   Punt   101
 3 New England   NE 48 10 plays 40 yards 4:01   Field Goal, Sea 14 NE 20
105
 3 Seattle   Sea 20 12 plays 22 yards 5:18   Punt   118
 4 New England   NE 7 3 plays -3 yards 0:49   Punt   132
 4 Seattle   NE 47 5 plays 47 yards 3:01   Touchdown, Sea 21 NE 20
137
 4 New England   NE 20 8 plays 48 yards 3:37   Field Goal, Sea 21 NE 23
144
 4 Seattle   Sea 16 5 plays 7 yards 2:30   Punt   155

4 New England   NE 36 9 plays 56 yards 4:19 Turnover on downs
161
 4 Seattle   Sea 8 1 plays   7 yards 0:04 Game Over   174

                Sea   NE
First Downs   20   24
Rushes   17-73   29-162
Passes   38-25-199 38-18-219
Sacked   6-42   0-0
Fumble   1   0
Penalties   6-45   7-58
Turnovers   0   0
Missed Tackles   10   3
Dropped Passes   1   1
Bad Passes   3   1
Passes 25+   0   0
Runs 10+   2   7
Blitzes   45   27
Time   28:30   31:30
Third Down   5-12   5-14
Fourth Down   2-2   1-3
Red Att/Td/Fg   7/5/1   6/2/1
Net Offense   230   381

Seattle   New England

Passing	Att	Cmp	Yds	25	In	Td	Sk	Rate	Passing	Att	Cmp	Yds	25	In	Td	Sk	Rate
Wilson	38	25	199	0	0	3	6	105.0	Brady	38	18	219	0	0	2	0	83.1

Rushing	Att	Yds	Avg	FD	10	Lg	TD	Rushing	Att	Yds	Avg	FD	10	Lg	TD
Lynch	13	40	3.1	1	0	6	0	Ridley	17	81	4.8	4	2	17	0
Wilson	4	33	8.3	2	2	20	0	Vereen	8	55	6.9	2	3	18	0
	17	73	4.3	3	2	20	0	Brady	3	26	8.7	2	2	15	0
								Blount	1	0	0.0	0	0	0	0
									29	162	5.6	8	7	18	0

Receiving	No	Dp	Att	Yds	Avg	FD	25	Lg	TD	Receiving	No	Dp	Att	Yds	Avg	FD	25	Lg	TD
Harvin	8	0	12	52	6.5	4	0	15	1	LaFell	6	0	11	79	13.2	6	0	21	2
Kearse	7	0	11	77	11.0	5	0	17	1	Gronkowski	4	1	9	51	12.8	4	0	19	0
Baldwin	4	1	6	31	7.8	4	0	10	0	Edelman	3	0	8	35	11.7	3	0	14	0
Richardson	4	0	7	28	7.0	2	0	14	1	Develin	1	0	1	9	9.0	0	0	9	0
Lynch	1	0	1	4	4.0	0	0	4	0	Amendola	1	0	2	6	6.0	0	0	6	0
Lockette	1	0	1	7	7.0	0	0	7	0	Thompkins	1	0	3	11	11.0	0	0	11	0
	24	1	37	192	8.0	15	0	17	3	Tyms	1	0	2	23	23.0	1	0	23	0

```
                Vereen       1 0  1  5 5.0 0  0  5 0
                Ridley      0 0  1  0 0.0 0  0  0 0
                        18  1  38 219 12.2 14  0 23  2
```

Fumbles   No Rec TD   Fumbles   No Rec TD
Wilson   1 1 0

Kick Returns No Yds Avg Lg TD   Kick Returns   No Yds Avg Lg TD
Richardson   2 32 16.0 17 0   Amendola   2 45 22.5 25 0

Punt Returns No Fc Yds Avg Lg TD   Punt Returns   No Fc Yds Avg Lg TD
Walters   0 2 0 0.0 0 0   Edelman   2 2 23 11.5 15 0

Kicking   Fg Lg Xp Pts   Kicking   Fg Lg Xp Pts
Hauschka   0-0 0 3-3   3   Gostkowski   3-3 54 2-2   11

Punting   No Yds Avg Tb 20 Bk Lg   Punting   No Yds Avg Tb 20 Bk Lg
Ryan   6 264 44.0 0 1 0 51   Allen   3 111 37.0 0 1 0 43

New England Patriots vs. Seattle Seahawks 04-22-2016

CenturyLink Field Temp:74 Wind:5-15 *Internet* Line:Sea by 9 MVP:Hightower
HFA:OFF

```
                    1  2  3  4     Tot
2014 New England        3 14  7  3     27
2014 Seattle           0 14  0 10     24
```

Scoring Summary   0
1 2:41 New England   FG Gostkowski 43 (10-36-4:09)   3-0
31
2 11:31 Seattle   TD Lynch 3 run (Hauschka) (11-80-6:10)   3-7
45
2 8:10 New England   TD Brady 7 pass to Gronkowski (Gostkowski) (3-15-0:49)   10-7
57
2 4:17 Seattle   TD Wilson 3 pass to Lynch (Hauschka) (7-88-3:45)   10-14
66
2 1:24 New England   TD Brady 15 pass to Edelman (Gostkowski) (9-80-2:45)   17-14
78
3 2:10 New England   TD Ridley 1 run (Gostkowski) (6-55-2:18)   24-14
125
4 10:22 Seattle   FG Hauschka 37 (16-61-6:44)   24-17   148

                                52
```

4  5:30  New England    FG Gostkowski 51 (8-47-4:47)                    27-17
158
4  1:11  Seattle        TD Lynch 1 run (Hauschka) (12-79-4:14)          27-24
172


Drive Summary
 1 Seattle       Sea 8  6 plays  28 yards  3:13   Punt                              3
 1 New England   NE 15  4 plays  12 yards  2:11   Punt                              11
 1 Seattle       Sea 16  3 plays  -2 yards  2:05   Punt                             17
 1 New England   NE 39 10 plays  36 yards  4:09   Field Goal, NE 3 Sea 0
21
 1 Seattle       Sea 20 11 plays  80 yards  6:10   Touchdown, NE 3 Sea 7
33
 2 New England   NE 32  4 plays  15 yards  2:13   Punt                              48
 2 Seattle       Sea 7  1 plays  0 yards  0:07   Interception                       54
 2 New England   Sea 15  3 plays  15 yards  0:49   Touchdown, NE 10 Sea 7
55
 2 Seattle       Sea 12  7 plays  88 yards  3:45   Touchdown, NE 10 Sea 14
60
 2 New England   NE 20  9 plays  80 yards  2:45   Touchdown, NE 17 Sea 14
69
 2 Seattle       Sea 20  6 plays  74 yards  1:24   End Half                        81
 3 New England   NE 43  6 plays  9 yards  1:09   Punt                              92
 3 Seattle       Sea 5  3 plays  -2 yards  1:25   Punt                            100
 3 New England   NE 45  4 plays  26 yards  2:15   Interception
104
 3 Seattle       Sea 16 11 plays  47 yards  5:21   Missed Field Goal
108
 3 New England   NE 45  6 plays  55 yards  2:18   Touchdown, NE 24 Sea 14
121
 3 Seattle       Sea 20 16 plays  61 yards  6:44   Field Goal, NE 24 Sea 17
128
 4 New England   NE 20  8 plays  47 yards  4:47   Field Goal, NE 27 Sea 17
150
 4 Seattle       Sea 21 12 plays  79 yards  4:14   Touchdown, NE 27 Sea 24
160
 4 New England   NE 44  2 plays  -2 yards  1:05   Game Over
175


             NE     Sea
First Downs     20     26
Rushes      20-75    26-132
Passes    30-17-222  38-25-413
Sacked       1-6      8-52

Fumble            2        1
Penalties      5-45    11-95
Turnovers        1        1
Missed Tackles     11        3
Dropped Passes     1        1
Bad Passes        0        3
Passes 25+        1        3
Runs 10+         2        5
Blitzes        56       28
Challenges      1-1      0-2
Time        -13:31    72:29
Third Down      3-10     7-15
Fourth Down      0-0      2-2
Red Att/Td/Fg   7/3/1     8/4/3
Net Offense     291      493


New England                          Seattle

| Passing | Att | Cmp | Yds | 25 | In | Td | Sk | Rate | Passing | Att | Cmp | Yds | 25 | In | Td | Sk | Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brady | 30 | 17 | 222 | 1 | 1 | 2 | 1 | 88.5 | Wilson | 38 | 25 | 413 | 3 | 1 | 1 | 8 | 100.0 |

| Rushing | Att | Yds | Avg | FD | 10 | Lg | TD | Rushing | Att | Yds | Avg | FD | 10 | Lg | TD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ridley | 14 | 48 | 3.4 | 3 | 1 | 18 | 1 | Wilson | 7 | 94 | 13.4 | 5 | 4 | 39 | 0 |
| Vereen | 1 | 21 | 21.0 | 1 | 1 | 21 | 0 | Lynch | 19 | 38 | 2.0 | 5 | 1 | 15 | 2 |
| Develin | 3 | 6 | 2.0 | 0 | 0 | 4 | 0 | | 26 | 132 | 5.1 | 10 | 5 | 39 | 2 |
| Brady | 2 | 0 | 0.0 | 0 | 0 | 1 | 0 | | | | | | | | |
| | 20 | 75 | 3.8 | 4 | 2 | 21 | 1 | | | | | | | | |

| Receiving | No | Dp | Att | Yds | Avg | FD | 25 | Lg | TD | Receiving | No | Dp | Att | Yds | Avg | FD | 25 | Lg | TD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LaFell | 7 | 0 | 11 | 107 | 15.3 | 6 | 1 | 26 | 0 | Richardson | 6 | 0 | 9 | 86 | 14.3 | 2 | 1 | 30 | 0 |
| Edelman | 4 | 1 | 9 | 45 | 11.3 | 2 | 0 | 15 | 1 | Harvin | 5 | 0 | 8 | 51 | 10.2 | 2 | 0 | 17 | 0 |
| Gronkowski | 3 | 0 | 5 | 36 | 12.0 | 3 | 0 | 15 | 1 | Lynch | 4 | 0 | 4 | 38 | 9.5 | 3 | 0 | 18 | 1 |
| Amendola | 2 | 0 | 3 | 20 | 10.0 | 1 | 0 | 11 | 0 | Kearse | 4 | 0 | 4 | 59 | 14.8 | 1 | 0 | 24 | 0 |
| Thompkins | 1 | 0 | 1 | 14 | 14.0 | 1 | 0 | 14 | 0 | Baldwin | 2 | 0 | 5 | 65 | 32.5 | 1 | 1 | 58 | 0 |
| Develin | 0 | 0 | 1 | 0 | 0.0 | 0 | 0 | 0 | 0 | Lockette | 2 | 0 | 3 | 75 | 37.5 | 2 | 1 | 58 | 0 |
| | 17 | 1 | 30 | 222 | 13.1 | 13 | 1 | 26 | 2 | Norwood | 1 | 0 | 1 | 15 | 15.0 | 0 | 0 | 15 | 0 |
| | | | | | | | | | | Miller | 1 | 1 | 4 | 24 | 24.0 | 1 | 0 | 24 | 0 |
| | | | | | | | | | | | 25 | 1 | 38 | 413 | 16.5 | 12 | 3 | 58 | 1 |

| Fumbles | No | Rec | TD | | Fumbles | No | Rec | TD |
|---|---|---|---|---|---|---|---|---|
| Brady | 2 | 1 | 0 | | Wilson | 1 | 0 | 0 |
| Ridley | 0 | 1 | 0 | | Unger | 0 | 1 | 0 |

| Kick Returns | No | Yds | Avg | Lg | TD | | Kick Returns | No | Yds | Avg | Lg | TD |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

```
Amendola      2 53 26.5 31 0        Richardson    2 33 16.5  19 0
Slater     1  1 1.0  1 0        Harvin      1 14 14.0 14 0
White,C     1  0 0.0  0 0


Punt Returns  No Fc Yds  Avg Lg TD      Punt Returns   No Fc Yds  Avg  Lg TD
Amendola     1 0  1 1.0  1 0      Walters      1 1  0 0.0  0 0
Edelman      0 1  0 0.0  0 0


Kicking      Fg Lg Xp  Pts       Kicking       Fg Lg  Xp  Pts
Gostkowski   2-2 51 3-3  9        Hauschka     1-2 37 3-3   6


Punting    No Yds  Avg Tb 20 Bk Lg    Punting     No Yds  Avg Tb 20 Bk Lg
Allen      3 136 45.3 0  2 0 47    Ryan      3 139 46.3 0  1 0 49
```

New England Patriots vs. Kansas City Chiefs 04-27-2016
Arrowhead Stadium Temp:77 Wind:10-20 No Line MVP:Edelman HFA:ON(3)

```
                  1  2  3  4     Tot
2014 New England (2-2)     7  0 14 10     31
2014 Kansas City (2-2)     14  0  0  3     17
```

```
Scoring Summary                                     0
1 12:27  Kansas City     TD Smith 43 pass to Bowe (Santos) (6-80-2:25)      0-7
7
1  8:37  New England    TD Edelman 92 punt return (Gostkowski)        7-7
19
1  3:30  Kansas City     TD Smith 26 interception return (Santos)      7-14
30
3  9:53  New England    TD Gray 7 run (Gostkowski) (9-62-5:00)        14-14
94
3  0:02  New England    TD Brady 9 pass to LaFell (Gostkowski) (13-70-7:42)   21-14
114
4 10:57  Kansas City    FG Santos 25 (8-73-4:03)            21-17         124
4  3:14  New England    FG Gostkowski 20 (12-73-5:09)        24-17
147
4  1:10  New England    TD Brady 1 run (Gostkowski) (5-26-0:56)       31-17
162
```

```
Drive Summary
 1 Kansas City    KC  20  6 plays  80 yards  2:25  Touchdown, NE 0 KC 7
2
 1 New England    NE  20  3 plays  1 yards  2:03  Punt                10
```

1 Kansas City   KC 38 4 plays   7 yards 1:27   Touchdown, NE 7 KC 7
15
1 Kansas City   KC 30 5 plays 19 yards 3:29   Punt   22
1 New England   NE 13 3 plays   6 yards 1:28   Touchdown(Int), NE 7 KC 14
28
1 New England   NE 20 8 plays 32 yards 3:37   Punt   33
2 Kansas City   KC 20 8 plays 66 yards 3:37   Interception   42
2 New England   NE 3 13 plays 41 yards 5:52   Punt   52
2 Kansas City   KC 17 8 plays 48 yards 3:17   Punt   68
2 New England   NE 5   5 plays 21 yards 1:55   End Half   79
3 New England   NE 38 9 plays 62 yards 5:00   Touchdown, NE 14 KC 14
86
3 Kansas City   KC 20 3 plays   7 yards 2:04   Punt   97
3 New England   NE 30 13 plays 70 yards 7:42   Touchdown, NE 21 KC 14
101
3 Kansas City   KC 20 8 plays 73 yards 4:03   Field Goal, NE 21 KC 17
117
4 New England   KC 48 4 plays 10 yards 1:27   Turnover on downs
126
4 Kansas City   KC 38 3 plays -6 yards 0:48   Punt   131
4 New England   NE 25 12 plays 73 yards 5:09   Field Goal, NE 24 KC 17
135
4 Kansas City   KC 20 7 plays   6 yards 1:08   Turnover on downs
149
4 New England   KC 26 5 plays 26 yards 0:56   Touchdown, NE 31 KC 17
156
4 Kansas City   KC 24 5 plays 46 yards 1:05   Game Over   165

	NE	KC
First Downs	25	15
Rushes	45-202	28-215
Passes	23-16-122	23-12-125
Sacked	1-3	2-15
Fumble	1	0
Penalties	6-51	7-56
Turnovers	1	1
Missed Tackles	6	7
Dropped Passes	1	0
Bad Passes	1	2
Passes 25+	0	1
Runs 10+	6	5
Blitzes	4	45
Challenges	0-0	1-1
Time	35:47	24:13

```
Third Down       4-14      2-11
Fourth Down       2-3       0-1
Red Att/Td/Fg    4/3/1     2/0/1
Net Offense       321       325


Injury Report
4  7:19 NE  Ridley     Out 17 Weeks     4  8:42 KC  Allen      Out 31 Weeks
*     NE  Jones       Out 4 Weeks     *      KC  Thomas     Out 3 Weeks


Not Available Due To Injury:
 NE: Blount, Butler, Siliga
 KC: DeVito
```

New England									Kansas City								
Passing	Att	Cmp	Yds	25	In	Td	Sk	Rate	Passing	Att	Cmp	Yds	25	In	Td	Sk	Rate
Brady	23	16	122	0	1	1	1	78.5	Smith,A	23	12	125	1	1	1	2	64.6

Rushing	Att	Yds	Avg	FD	10	Lg	TD	Rushing	Att	Yds	Avg	FD	10	Lg	TD
Ridley	30	121	4.0	8	3	19	0	Charles	16	120	7.5	4	3	48	0
Gray	12	80	6.7	6	3	18	1	Davis	9	68	7.6	3	1	53	0
Brady	1	1	1.0	1	0	1	1	Smith,A	1	26	26.0	1	1	26	0
Vereen	2	0	0.0	0	0	0	0	Sherman	1	1	1.0	0	0	1	0
	45	202	4.5	15	6	19	2	Thomas	1	0	0.0	0	0	0	0
									28	215	7.7	8	5	53	0

Receiving	No	Dp	Att	Yds	Avg	FD	25	Lg	TD	Receiving	No	Dp	Att	Yds	Avg	FD	25	Lg	TD
Edelman	6	0	7	54	9.0	2	0	16	0	Kelce	5	0	9	29	5.8	0	0	10	0
LaFell	4	0	8	37	9.3	2	0	13	1	Charles	2	0	4	13	6.5	1	0	10	0
Develin	2	0	3	7	3.5	0	0	4	0	Avery	2	0	4	10	5.0	1	0	7	0
Gronkowski	1	1	2	5	5.0	0	0	5	0	Avant	1	0	2	10	10.0	1	0	10	0
Dobson	1	0	1	10	10.0	0	0	10	0	Bowe	1	0	1	43	43.0	1	1	43	1
Ridley	1	0	1	4	4.0	0	0	4	0	Wilson	1	0	2	20	20.0	1	0	20	0
Vereen	1	0	1	5	5.0	1	0	5	0	Santos	0	0	1	0	0.0	0	0	0	0
	16	1	23	122	7.6	5	0	16	1		12	0	23	125	10.4	5	1	43	1

Fumbles	No	Rec	TD	Fumbles	No	Rec	TD
Brady	1	1	0				

Kick Returns	No	Yds	Avg	Lg	TD	Kick Returns	No	Yds	Avg	Lg	TD
Amendola	1	32	32.0	32	0	Davis	2	52	26.0	30	0
White,C	1	0	0.0	0	0						

Punt Returns	No	Fc	Yds	Avg	Lg	TD	Punt Returns	No	Fc	Yds	Avg	Lg	TD

Edelman   2 0 93 46.5 92 1   Thomas   2 0 17 8.5 9 0

Kicking	Fg	Lg	Xp	Pts		Kicking	Fg	Lg	Xp	Pts
Gostkowski	1-1	20	4-4	7		Santos	1-1	25	2-2	5