# Financially Affordable Helmet Add-On for Concussion Prevention in High School Football

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## Introduction

Football is one of the largest sports in the United States of America. From the popularity of the National Football League and College Football, down to high school and youth football, the sport is the center of attention during the fall season year in and year out. With all this interest in the sport however, comes the increased awareness in the issues the sport brings, most notably, the risk of head injury and concussions. Concussions can be defined as "a type of traumatic brain injury—or TBI—caused by a bump, blow, or jolt to the head, or by a hit to the body that causes the head and brain to move rapidly back and forth." (CDC, 2019). These brain injuries have become very common in football with roughly 300,000 occurring from football each year (UCLA, 2021). While positive strides have been made in helmet innovation to help counteract this issue and make the game safer, there is still more work to be done to protect players. This project will explore how to develop a financially affordable football helmet add-on technology that helps decrease the risk of concussions in high school football, facilitating comprehensive protection for each player and allowing anyone to participate.

# SECTION I: BACKGROUND RESEARCH

## History of American Football

The earliest origin of American tackle football can be traced back to the late 19th century at two American institutions, Rutgers University and Princeton University. On November 6th, 1869, the two schools played a soccer-style match that also included elements of rugby (Fujita, 2023). It wasn't until the 1880's when Walter Camp, also known as the "Father of American Football", pioneered the rules of football that are followed today. Camp helped to eliminate the rugby 'scrum' as well as enforced downs, turnovers, and new positions for the 11 players (A&E, 2022). Football gained popularity when in 1920, the first professional football league was formed in Canton, Ohio, which would go on to become the National Football League. In the inaugural season, the Akron Professionals won the championship after an undefeated season (Fujita, 2023).

## History of Football Impact Protection

The history of football impact protection has seen significant developments and innovations over the years. In 1893, the earliest attempts at head protection emerged as the first leather skull cap was introduced to safeguard players' heads during the game. Fast-forward to 1939, when John Riddell made a groundbreaking contribution to helmet design by creating the first plastic helmet. This innovation marked a significant advancement in player safety. In 1955, another milestone was reached with the introduction of the facemask. This addition provided an extra layer of protection and became a standard feature on football helmets. The year 1975 witnessed a significant improvement as helmets were fully padded for the first time, offering increased comfort and protection for players (Smithsonian, 2012).

The next significant innovation in football helmets did not come until 2002, when Riddell once again played a crucial role in helmet evolution by introducing the Revolution helmet, which was the first football helmet design that was based on extensive concussion research (Riddell, 2023). In 2007, Schutt made an innovative move by designing the first shock-absorbing face mask. This development aimed to further reduce the impact of head collisions during play (Smith, 2018). A few years later in 2010, Guardian took a different approach by creating the Guardian Cap, which provided the first external padding for football helmets (Caitlin, 2020). Most recently, in 2021, the NFL took a significant step in promoting player safety by allocating $3 million in grants to support the development of better helmets (NFL, 2021). This initiative reflects ongoing efforts to continually improve helmet technology and protect the well-being of football players.

## User Insight and Product Classification

The focused user of this project will primarily be high school aged tackle football players. According to the National Federation of State High School Associations' high school athletics participation survey, nearly one million high school students in the United States played tackle football during the 2021-2022 season. This number is a decrease of over 12% from the 2008-2009 peak season. The decrease in participation has a strong correlation with the increase in concussion awareness and overall safety concerns (Gilligan, 2023). These players play multiple positions and use helmets that get refurbished and reused year in and year out. They are passionate about playing each snap like it's their last, and want to do whatever it takes to win the game. They are also worried about how cool they look when they play. They show prestige by having the newest and best equipment that the NFL and College players wear, and hate bulky

objects. When they use safety equipment, it needs to either be cool and flashy, or completely unnoticeable.

The purchaser of this product are the coaches and parents. Coaches and parents are passionate about their players safety over success, and they are very worried about brain injuries. They show prestige by buying their players the best equipment that is on the market. Parents find a lot about football off putting, with head injuries being so common, and the cost of safety equipment being so expensive, some do not want kids to play football at all. Figure 1 below shows the psychographic mood board for this project, highlighting the players, parents, and coaches concerns.


*Figure 1 – Psychographic Mood Board for the players, parents, and coaches*

At its core, this project is about reducing the risk of concussions while playing football and being affordable enough for anyone to be able to purchase it. The product is focusing on high school football as it is the largest population of football players, and it is the point in the game where parents pull their players out due to the fear of concussions.

## Product Rules

For this project, it is important to understand the rules and regulations surrounding football helmets. All helmets in the U.S. must meet the National Operating Committee on Standards for Athletic Equipment (NOCSAE) performance and protection standards. These helmet performance standards are created using scientific and medical data. They involve input from various experts such as physicians, researchers, coaches, trainers, and helmet manufacturers. The standards assess football helmet performance by testing them against multiple impact speeds and locations. Helmets are evaluated based on their ability to reduce impact forces to the head, measured by a Severity Index (SI) value. To pass the standard, helmets must significantly reduce these forces and score well below 1200 SI for all impacts. Importantly, NOCSAE standards are not biased towards any specific helmet design, allowing manufacturers the freedom to innovate and create helmets that meet the safety criteria. It is important to note that NOCSAE has standards for reconditioning helmets, which are very similar to the initial tests. This process happens after the helmets have been used for five years (NOCSAE, 2018). For this project, the add-on needs to be approved to be used in high school football games (Fischer, 2012).

## Competitor Product Analysis

While there is a plethora of options for football helmets on the market, the exterior helmet protection space is very minimal. There are only two companies that make exterior helmet padding: Guardian Innovations and SAFR Sports. Guardian makes two soft-shell caps, the XT model, and the NFL NXT model. Meanwhile, SAFR makes one foam shell called the

ProTech. Both of these competitor products will be analyzed for their product anatomy, materials, manufacturing, and jobs to be done.

*Figure 2 – SAFR ProTech (left), and Guardian Cap (right).*

In 2010, Guardian Innovations created the very first exterior helmet padding system. The Guardian cap is a soft-shell helmet attachment that covers the entire helmet and is loosely secured by four elastic straps to allow it to move independently, which allows it to shift at impact and redirect energy. This product is mainly used in practice, but is now game approved. The two models are the XT that costs $69.99, and the NFL NXT model at $125.00. The cap consists of three main parts, the padding, the exterior fabric, and the straps. The padding is made from medium density EVA foam, also known as ethylene-vinyl acetate copolymer foam. This EVA foam is closed-celled, and is compression molded into the specific shapes based on the area of the helmet (Glaunert, 2017).

The closed cell padding works as extra impact protection on the helmet and provides complete coverage all around the helmet. The exterior fabric of the cap is made from a nylon spandex blend, while the four straps are made from elastic and Velcro. The fabric is cut to pattern and bonded to the EVA foam. The Velcro elastic straps are cut to length, then sewn on to the fabric. Based on Guardians research, they claim this soft-shell layer on the outside of a hard-shell

football helmet that reduces impact forces up to 33%. This product has been approved by the NFL and is mandatory in their training camps (Guardian Sports, 2023). Images of the Guardian Cap and notes about the materials and manufacturing process, can be seen below in Figure 3.


## Guardian Cap

- Padding
  - Medium Density EVA foam (also known as Ethylene-vinyl acetate copolymer foam)
  - Closed cell foam that allows maximum impact protection with medium stiffness, padding is spread out along the shell for complete coverage
  - EVA is compression molded into the shapes specific to the area on the helmet
- Exterior Fabric
  - Nylon-Spandex blend and Velcro
  - Fabric covering allows the shell to stretch to fit all sizes of helmet, Velcro gives players adjustability on the helmet
  - Fabric is cut to pattern then bonded to EVA foam, Velcro is sewn on to fabric

*Figure 3 – Materials and manufacturing research for Guardian Cap, as well as jobs to be done for the padding and exterior fabric*

The only other exterior football helmet padding system on the market is made by SAFR sports. SAFR's ProTech helmet cover is a project birthed from the idea of the Guardian Cap but meant to increase safety and have better aesthetics. The ProTech is currently only used in high school and college football, most notably, it is used during games. The product is not sold individually, but when sold to football teams, it retails $165.00. Similar to the Guardian Cap, the ProTech is a soft foam outer shell that absorbs impact and dissipates impact forces. The shell is

made of polyurethane foam. The foam is poured into a vacuum formed mold and casted into a helmet shape, one half at a time (Pleiger, 2023). The benefits of this helmet cover are that it is an extremely lightweight foam that absorbs and dissipates energy caused by hits and is easily molded to fit specific helmets. The foam shell is attached to the helmet by aluminum hooks. The hooks are secured into the foam and can be pulled out and rotated to lock into helmet attachment points. SAFR claims that when their product is used with a top rated helmet, concussion risks are decreased by 77% (SAFR Sports, 2023). Images of the SAFR ProTech Helmet Cover, and information about the materials and manufacturing of the product, can be seen below in Figure 4.


*Figure 4 – Materials and manufacturing research for SAFR ProTech, as well as jobs to be done for the exterior shell and fastening system*

With an average of 50 players per high school football team, schools will have to pay around $3500 - $8500 extra just to reduce concussion risk for players. With my personal

experience of coming from a school with a very small budget, and after speaking with multiple coaches, there is a clear need for more financial affordability in the concussion prevention space.

## Intellectual Property

With just two exterior helmet padding systems on the market, research was done on the patents of each product. First is US patent number 8,776,727 titled ‘Helmet Cover’. This patent was created by Albert Straus and Frank Lytle, and was assigned to Protective Sports Equipment International, which eventually was given to SAFR Sports, where they call the product the SAFR ProTech Helmet Cover. This patent makes claims to a helmet cover comprising of an outer skin, an impact absorbing material, at least two vents, and one attachment feature. This dome-shaped cover is designed to be placed over a helmet, where its inner surface conforms to the helmet's outer surface and can be detachably attached using integral extensions with fasteners. The outer skin is made of a tougher material than the impact-absorbing layer inside it. The cover features multiple vents, including tapered and flared vents, enhancing ventilation. It may have inner surface flow enhancer features and outer surface flow channel features to optimize airflow. Additionally, the cover can accommodate interchangeable pads that fit within recesses, forming part of the helmet cover's outer surface. These pads can also contribute to the cover's edge (Straus, 2014). A drawing of this patent can be seen in the top of Figure 5.

The next patent is titled ‘Protective Helmet Cap’ and is US patent number 11,064,752. This patent was created by Erin and Wallace Hanson, who are the owners of Guardian Innovations, and the product is the Guardian Cap. The patented helmet cap offers a unique design with several distinctive features. Its outer shell is divided into multiple padded segments that are engineered to deform upon impact with an object. This outer shell is intended to be

attached to a helmet. The inner surface of the outer shell, when adjacent to the helmet's exterior, allows for sliding displacement of some portions upon impact, aiding in energy absorption. Notably, the padded segments revert to their original form after impact. The outer shell can consist of upper and lower sections, even if they were originally flat before assembly. Some segments deform upon impact, while others remain unimpacted. The helmet cap may include strap attachment points for attachment to a football helmet facemask. Additionally, the padded segments come in various shapes, like rectangular, trapezoidal, and some with convex edges that promote ventilation. An adjustable fastener, such as hook-and-loop fasteners, is included to modify the helmet cap's internal dimensions. Furthermore, a specific configuration of the outer shell has one portion attached to the helmet exterior while another portion remains unattached, forming a contact area with the helmet. This unattached portion is designed to be slidingly displaced upon impact with an object, while the first portion has a smaller total surface area than the second portion (Hanson, 2021). A drawing of this patent can be seen in the bottom image of Figure 5.

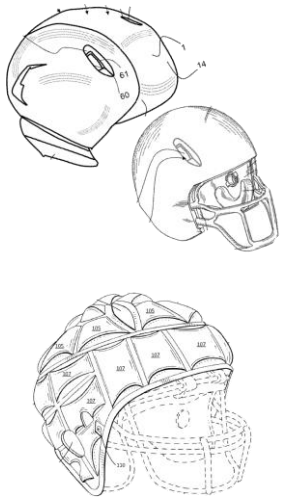


*Figure 5 – Patent illustrations for the helmet cover (top), protective helmet cap (bottom).*

## Trend Research

For this product, it is important to forecast current and future trends in color, silhouette, graphics, and branding. Guardian's color options stand out as they offer a selection of six different colors online, with a unique feature of customizing colors to match NFL team preferences. NFL players have expressed their opinions on the appearance of the Guardian Cap, with one player playfully noting that it might make them “look a bit goofy."(DiAmore, 2022). SAFR has cleverly seized upon this by branding their SAFR ProTech as a solution that is virtually unnoticeable when attached to helmets. Furthermore, SAFR's product can be personalized to match specific team colors and logos, giving teams the flexibility to use these protective caps in actual games without compromising their distinct branding. Figure 6 below highlights these examples.


*Figure 6 – Left: Guardian Cap with NFL colors. Center: NFL player making fun of Guardian Cap. Right: SAFR ProTech with Virginia Tech colors and logos.*

In recent years, the world of football helmet graphics has witnessed a noticeable shift. In college football, teams like the University of Oregon have embraced the practice of altering their helmet graphics for each game, showcasing a dynamic approach to design. Similarly, the NFL has adopted a more flexible policy, permitting teams to change their helmet graphics to reflect various themes, including throwback designs. This evolving trend in helmet graphics is likely to influence high school football as well, pushing new technologies to adapt and ensure that protective gear does not obscure or compromise these ever-changing and distinctive graphics. For the scope of this product, basic colors and graphics will be used.

Presently, helmet padding technology brands primarily emphasize safety in their products. Interestingly, two distinct companies have chosen to incorporate 'guardian' into their branding, a term that conveys the notions of defense, protection, and guardianship. SAFR, on the other hand, plays on the word 'safer,' yet it also stands as an acronym for Scientifically Advanced Force Reduction technology, underlining its commitment to advanced safety measures (SAFR Sports, 2023). Logo elements like footballs and shields are often integrated into these brand identities, providing a clear context of their focus on sports and protection. This can be seen in Figure 7 below. Looking ahead, it is anticipated that future logo and branding designs will continue to feature safety elements to reinforce their commitment to safeguarding athletes.


*Figure 7 – Company logos for exterior helmet protective systems.*

## Physiological Research

The exploration of helmet technologies plays a pivotal role in comprehending and mitigating the intricate physiological processes associated with concussions. These injuries arise from external forces that cause the brain to bounce and twist inside the skull, resulting in microscopic damage to brain cells and their membranes. This damage initiates abnormal movements of vital substances like calcium, potassium, and glutamate within the injured cells, disrupting their regular functions. Additionally, the brain's response to such injuries includes restricting blood flow to the affected regions, which is a critical element in this physiological cascade. Since blood serves as the brain's exclusive source of fuel, particularly glucose, brain cells confront a significant challenge. They experience an increased demand for fuel as they endeavor to repair themselves, leading to a mismatch between the supply and demand of fuel, exacerbating cell injury and dysfunction (NFHS, 2023). Understanding these mechanisms is imperative, as individuals who have suffered concussions are highly susceptible to aggravated symptoms following subsequent injuries, which can result in a severe condition known as second impact syndrome (Chea, 2017), as seen below in Figure 8. Consequently, research into helmet technologies is instrumental in developing effective measures to prevent and alleviate these intricate physiological processes, ultimately ensuring the well-being of athletes and individuals vulnerable to head injuries.

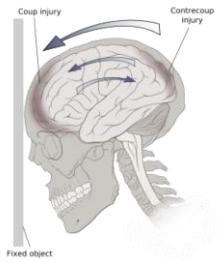



*Figure 8 – Representation of Second Impact Syndrome (Chea, 2017)*

## Biomechanical Research

Biomechanics research sheds light on the occurrence of concussions in football, often resulting from abrupt and forceful head impacts. These impacts can involve translational, rotational, or angular head acceleration, with the effects varying among individual players (AlQuran, 2021), this can be seen in Figure 9 below. However, it is well-established that a concussion typically transpires at forces ranging from approximately 90 to 100 g-forces, which can be equated to the impact of striking one's skull against a solid surface at speeds of approximately 20 miles per hour (Brogilo, 2012). Understanding the biomechanical factors at play in concussions is crucial for developing effective strategies to prevent and mitigate these injuries in football and related sports.

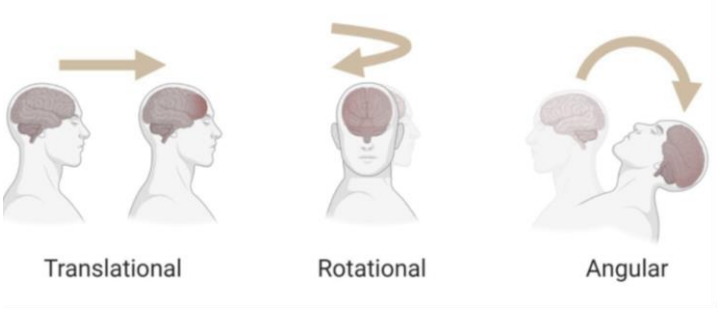



*Figure 9 - Types of impact motions on the brain (AlQuran, 2021)*

## Psychological Research

Psychological research highlights the intriguing relationship between player perception and safety measures in football. While some athletes turn to devices like the Q-Collar to enhance their safety, studies have demonstrated that this particular product has only a minimal impact on reducing head impact injuries. What's remarkable, however, is that players persist in wearing it due to their belief in its effectiveness (Futterman, 2022). This psychological factor proves to be a

critical consideration in the design of helmet technologies, as players confidence in a product significantly influences its adoption. Furthermore, it underscores the importance of players' concerns regarding their appearance and comfort on the football field, as these factors play a substantial role in their choices and behaviors related to safety equipment.

## Product Performance Goals

The performance goals that influenced the design and development of the Custom Cranium Coverage Football Helmet Add-On versus the competition can be seen in Figure 10 below.

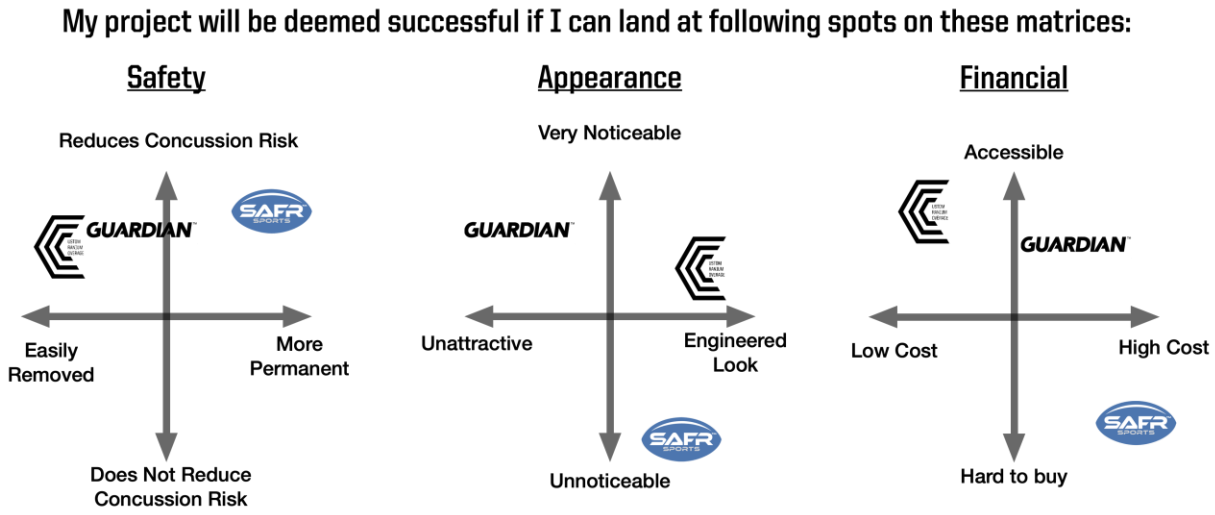
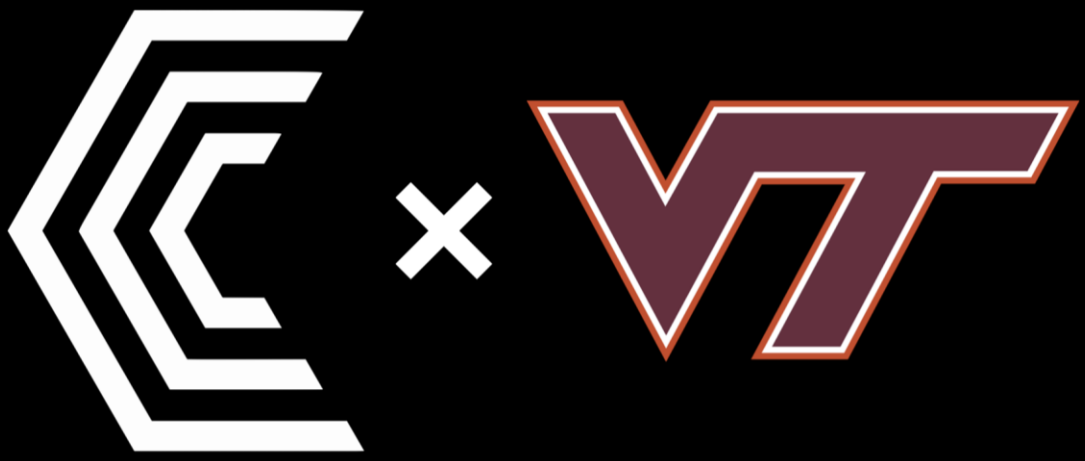


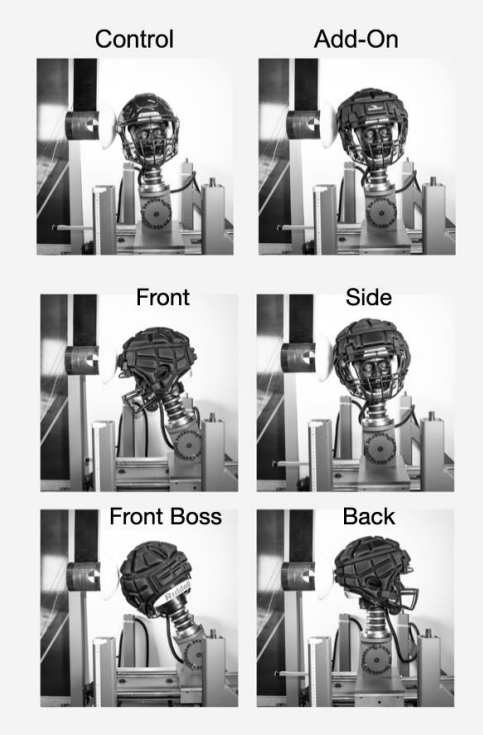

*Figure 10 - Product Performance Goals*

## SECTION II: PRODUCT IDEATION AND DEVELOPMENT



## Foam Ideation and Testing

Through the help of my mentor Barry Miller, the pendulum impactor test was conducted at Virginia Tech's Helmet Testing Lab to help analyze the effects that impact forces have on the user when playing football. Employing a head accelerometer, the helmet undergoes impacts in four distinct locations: front, back, side, and front boss, at varying speeds of 3.1, 4.9, and 6.4 meters per second. The control helmet utilized for the assessment was a Riddell SpeedFlex. The objective of the test is to determine the extent to which my foam ideations, and the final product, reduce the risk of getting a concussion when playing football..




During the foam ideation process, various foam density and geometric combinations were experimented with extensively, aiming to explore a wide array of possibilities. First, the cross hatch design was found to have excessive negative space, hindering its effectiveness. Consequently, the Triple C concept required streamlining, ultimately converging into a singular hexagonal shape. The final selection of samples for testing prioritized criteria such as hardness, geometry, and tactile feel, ensuring a comprehensive evaluation process. The foam samples tested at the Virginia Tech lab can be seen in Figure 11.

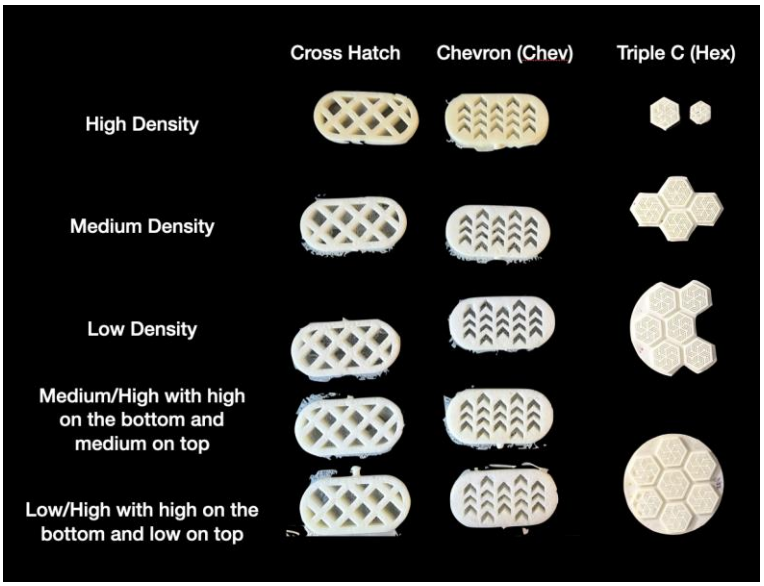
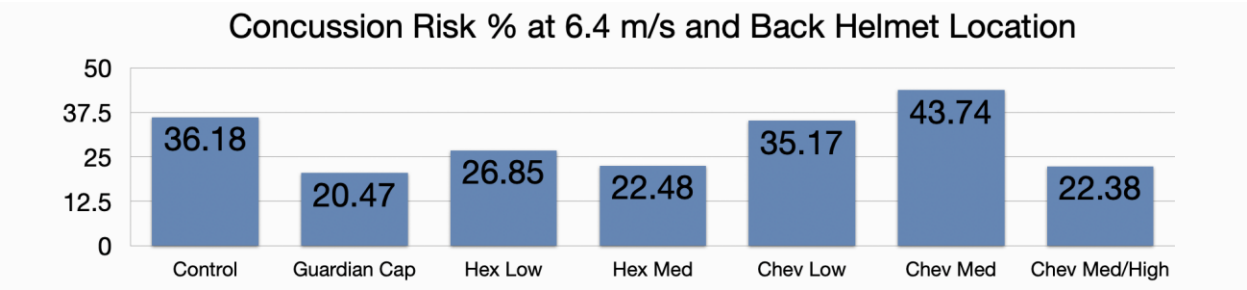



*Figure 11 - Foam and geometric ideation process*

Testing was done on individual samples on the back location of the helmet and at 6.4 m/s the speed where most concussions occur from. In this specific location and speed, the helmet by itself was shown to have a 36.18% chance of concussion, whereas the Guardian Cap was shown to only have 20.47% chance. While the Chevron Med/High tested the closest to the Guardian Cap, it was determined that the pad would be too heavy to move forward with. The Triple C (Hex Med) was chosen to move forward with as it had the next best testing and degraded the least.



The chosen material for the project is an open cell, medium high density polyurethane foam. This foam is crafted into a hexagonal shape featuring six C-shaped cutouts; this geometry allows for maximum impact absorption, with the C-shapes collapsing in on each other. The final manufactured version of this foam will be die-cut from large sheets to ensure product affordability. Figure 12 shows the details of this padding.

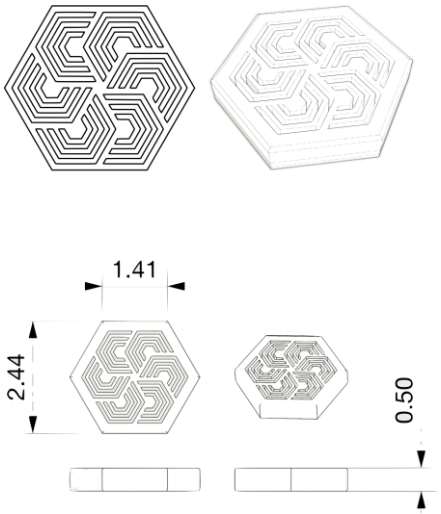



*Figure 12 - Triple C foam pads*

## Product Prototyping

Once a final foam density and geometry were chosen, the final product needed to be created. The initial prototyping phase consisted of patterning the add-on using a tape and cut method on a football helmet shell, followed by creating the final foam. The foam was created from a casting method for sake of ease and repeatability of this method. Next, the foam was arranged, then added to an initial fabric panel. This can be seen in Figure 13.

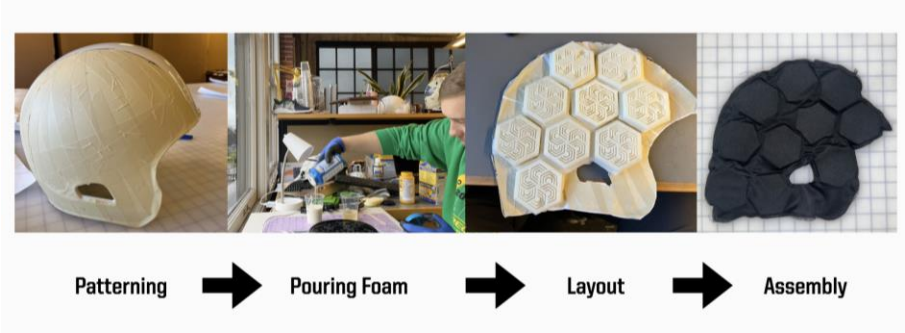



*Figure 13 - Initial Prototyping Phase*

The final prototyping phase followed, where a full prototype was created by sewing two side panels and one rectangular middle panel together, then adding individual foam pads and sewing around them. Next the attachment was ideated on, and a hook and loop system was added to the prototype. It was determined that the sewing method did not provide enough of a sleek and engineered look, and that the hook and loop attachment was not working and needed to be scrapped. A g-hook attachment was then added, which proved to work much better. The final prototype was created with that attachment system, then instead of sewing around each pad, glue was added, and the final panels were boded together giving the prototype an engineered aesthetic. The progression is exemplified in Figure 14 below.

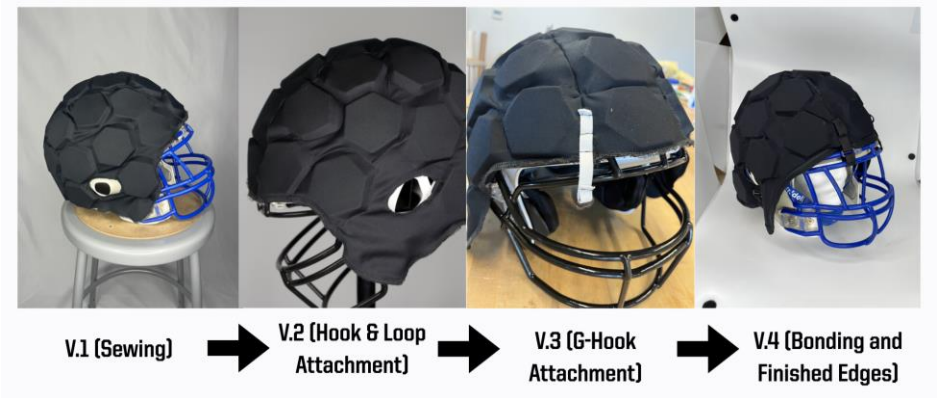



*Figure 14 – Final Prototyping Progression*

## Features and Benefits

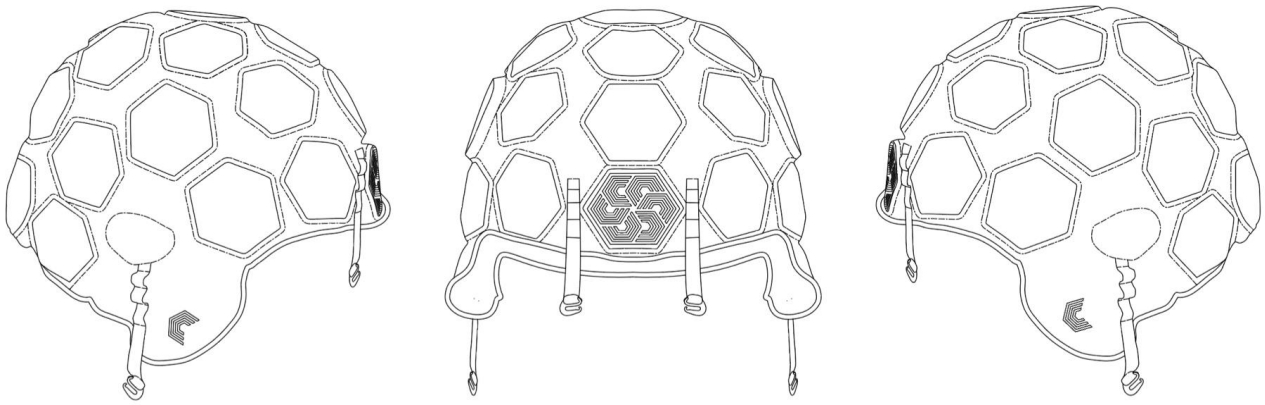


*Figure 15 - Technical Drawings of Product*

The final prototype has the before mentioned g-hook strap system at 4 different connection points for quick and efficient donning and doffing. For the final construction, edge binding is added for a more finished look. The bonded logo on front centric pad shows off the shape of the foam technology, but is also on the interior pads to add friction to helmet shell. The overall silhouette has less volume on top of helmet compared to competitors, giving it a more sleek look when in use. The final materials breakdown can be seen in the detailed exploded view in Figure 16.

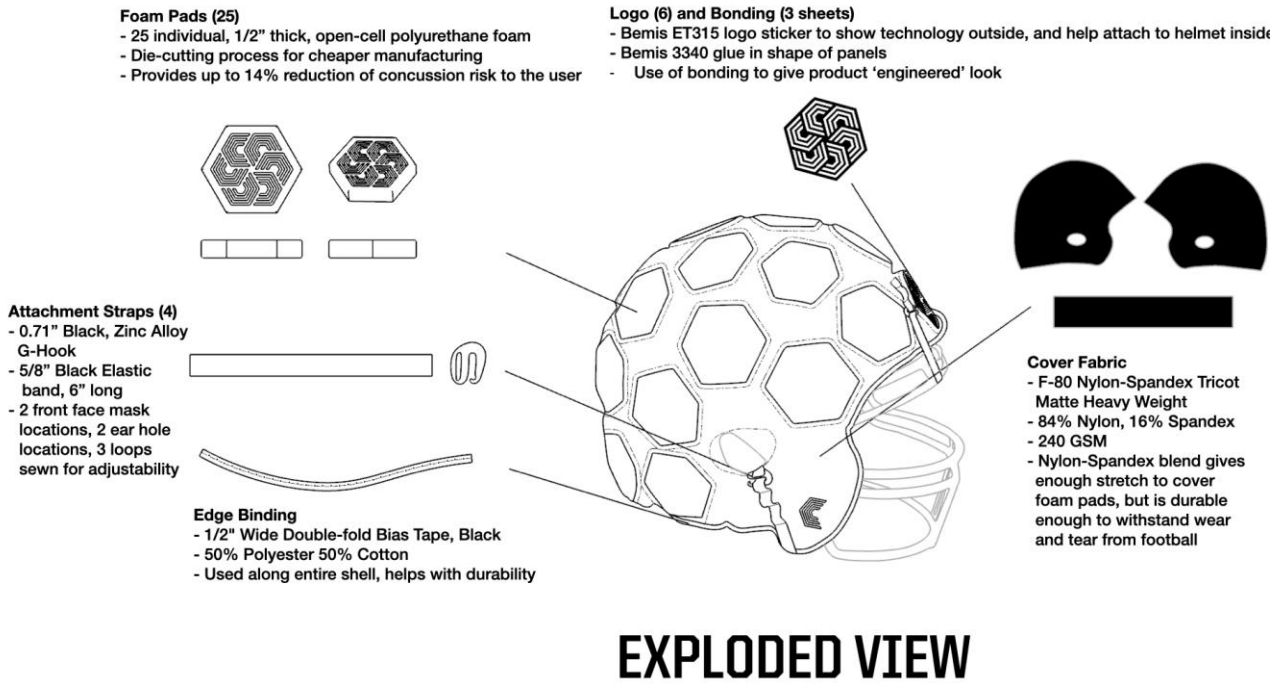



*Figure 16 - Detailed Exploded view of Product with Material Breakdowns*


*Figure 17 - Final Photography of Product*

## Cost Breakdown

The final cost of the prototype is a major feature of the product, as it is very important for it to be financially affordable so that more high schools are able to afford concussion protection. After considering the cost of each material used to create the prototype, as well as considering known manufacturing costs from Chinese factories, an estimated per unit cost came out to $11.40 to make. The full breakdown can be seen below in Figure 18.

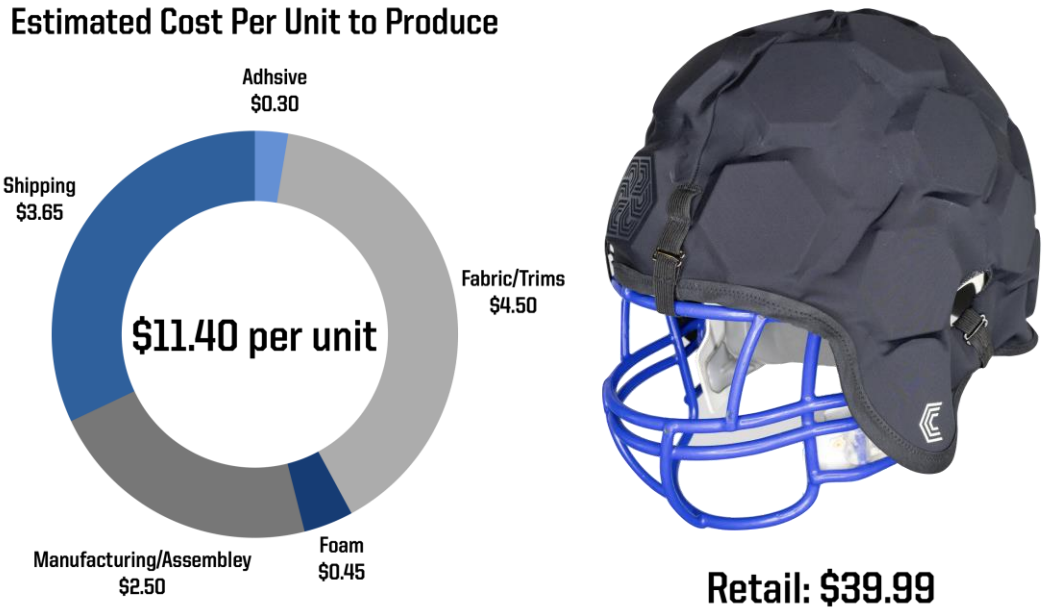



*Figure 18 - Estimated Cost Per Unit to Produce, and Final MSRP of Product*

The final total is calculated assuming 4,000 units will be made, enough for 100 high schools to be equipped with the product. The retail cost of final product will account for quality assurance, marketing, etc., but will still be a significantly lower price point than the competition at $39.99 MSRP.

## Final Testing

Final testing was completed on the Custom Cranium Coverage Football Helmet Add-On at Virginia Tech using the pendulum impactor, and same testing methods as mentioned previously. On average the product reduces concussions by 14% when taking on a head impact compared to only wearing a helmet. Other notable findings compared to control include: 30% reduction in concussion risk on the side hit, 18% reduction linear acceleration on the front, and 20% reduction in rotational acceleration on the front boss.

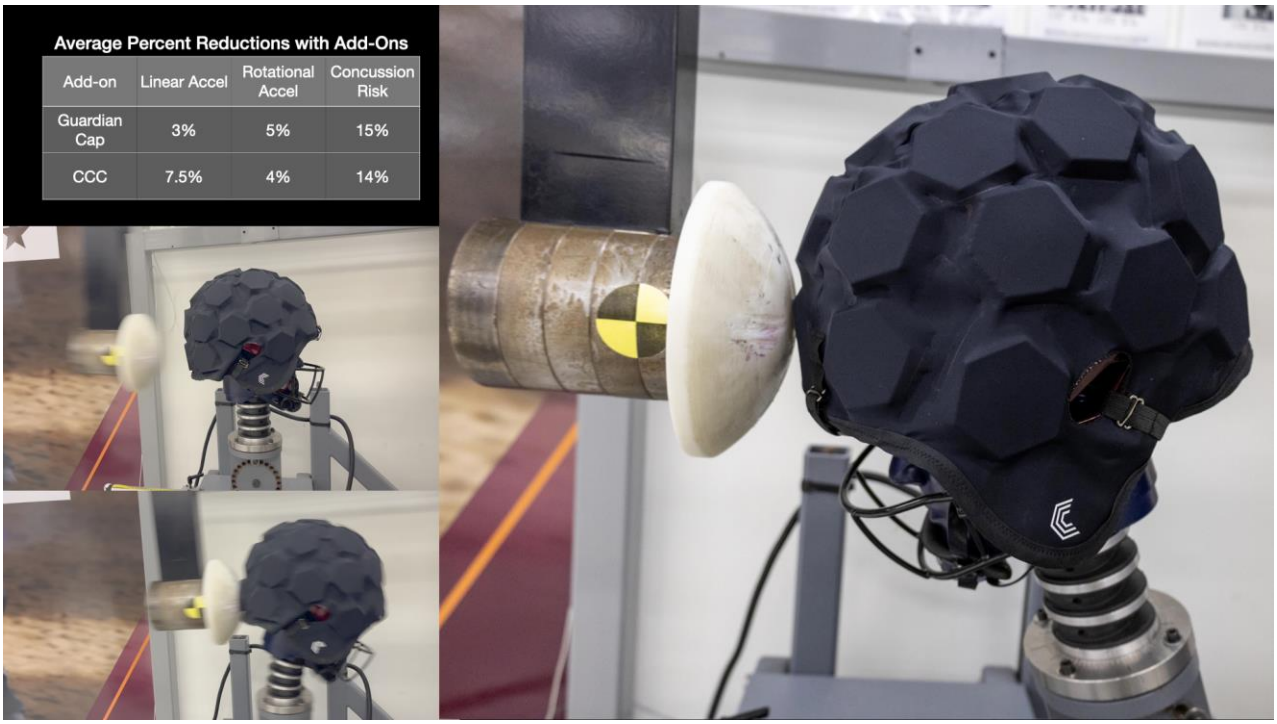



*Figure 19 – Pendulum Impactor Test being conducted on the Custom Cranium Coverage Football Helmet Add-On*

## Summary

Even with the positive strides that have been made in football helmet innovation and design to help counteract the large issue that is concussions, there is still an evolution that needs to occur to protect players more. The Custom Cranium Coverage Football Helmet Add-On is a financially affordable football helmet add-on technology that helps decrease the risk of concussions in high school football, facilitating an evolution in safety for players and the parents and coaches who care for them. The product reduces the risk of a concussion on high impact hits by an average of 14% compared to only wearing a helmet, has less volume on top of helmet compared to competitors giving it a more sleek and engineered look, and retails at $39.99 making it the lowest price point of any other football helmet add-on that is on the market. In the future, this product could be diversified into other sports such as lacrosse and hockey, and could be offered in multiple colorways to match the helmet it is on. Overall, the Custom Cranium Coverage Football Helmet Add-On provides a decrease in concussion risk at a financially affordable price.

## Professional Statement

As a child, I overcame a brain tumor and was told I couldn't play full-contact sports. Now, I'm determined to help kids facing similar challenges enjoy these sports safely. With a background in material science, engineering, and design, I aspire to be a sports product innovator, addressing brain injury concerns through cutting-edge equipment in all contact sports. This thesis project will serve as a springboard for my future pursuits as a helmet designer, with a primary objective of eradicating concussions in football.

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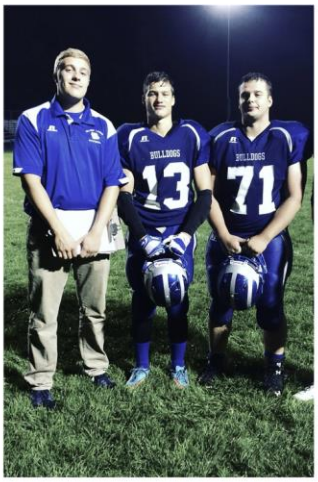
**Appendix A: Final Presentation**

USTOM
RANIUM
OVERAGE

# Financially Affordable Helmet Add-On for Concussion Prevention in High School Football

Sky Bunker - SPD Thesis Project

## ABOUT ME



- Cancerous brain tumor at one years old causing me to never be able to participate in full-contact sports due to the likelihood of brain injuries such as concussions
- Statistician and equipment manager for my high school varsity football team
- Interested in researching and designing new equipment that protects the brain from injury in full-contact sports so that others like me can participate

# THE RISK OF CONCUSSIONS IN FOOTBALL

Concussions are a form of traumatic brain injury resulting from a forceful impact to the head or body, causing the head and brain to move rapidly

**300,000**
Concussions per year across all levels of football

**1,000,000**
High School Football Players in the US

**12%**
Decrease since 2008-2009 due to concussion awareness

# THE COST OF SAFETY

To help decrease the risk of concussions, teams have incorporated the use of helmet add-ons, which add padding to the exterior of a helmet

With an average of 50 players per team, schools pay around $3500 - $8500 extra to reduce concussion risk for players

Coaches call for better product affordability and accessibility, while players want something that looks cool

GUARDIAN | CAPS

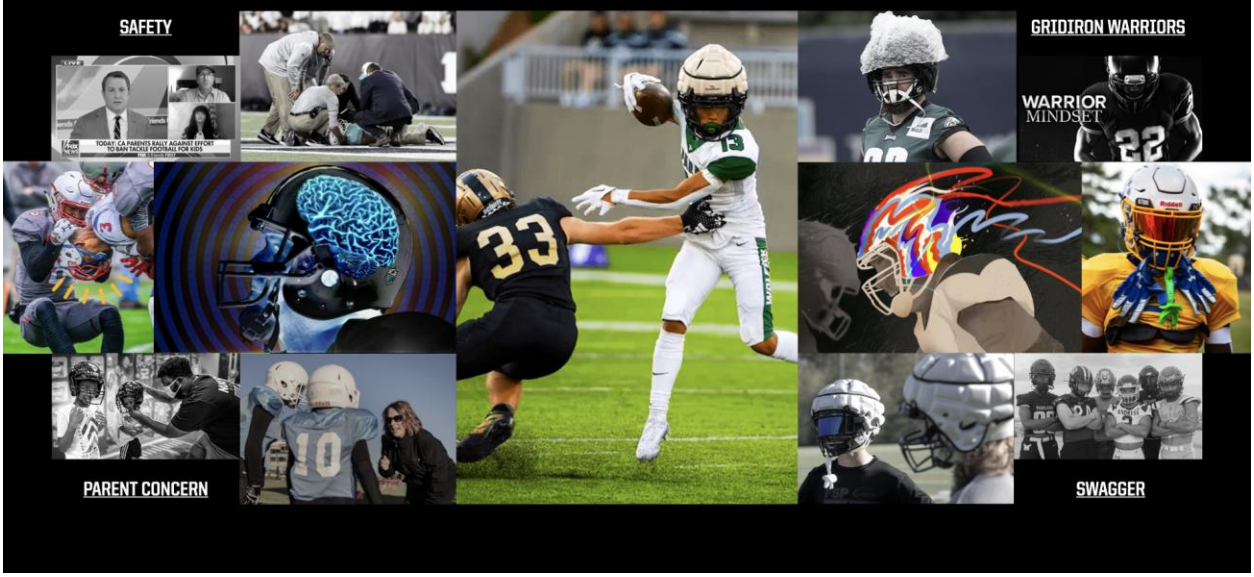
- Guardian Cap XT - $69.99
- Most commonly used add-on
- Closed cell foam with Nylon Spandex cover
- Used mostly in practice and is now game approved
- Available on Amazon


- SAFR ProTech - $165.00
- Very uncommon, only available in wholesale
- Can be used in games
- Provides up to 77% reduction in risk of concussion

## PROBLEM STATEMENT

How could we develop a financially affordable football helmet add-on technology that helps decrease the risk of concussions in high school football, facilitating comprehensive protection for each player and allowing anyone to participate?

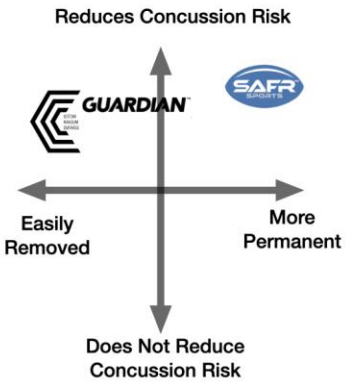
## PSYCHOGRAPHIC MOOD BOARD



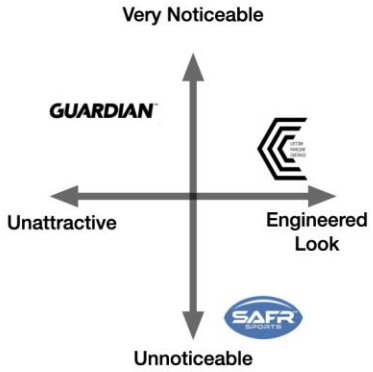
# PRODUCT PERFORMANCE GOALS

My project will be deemed successful if I can land at following spots on these matrices:

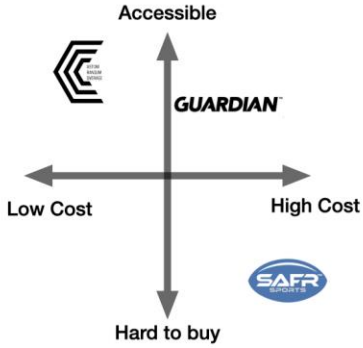
**Safety**

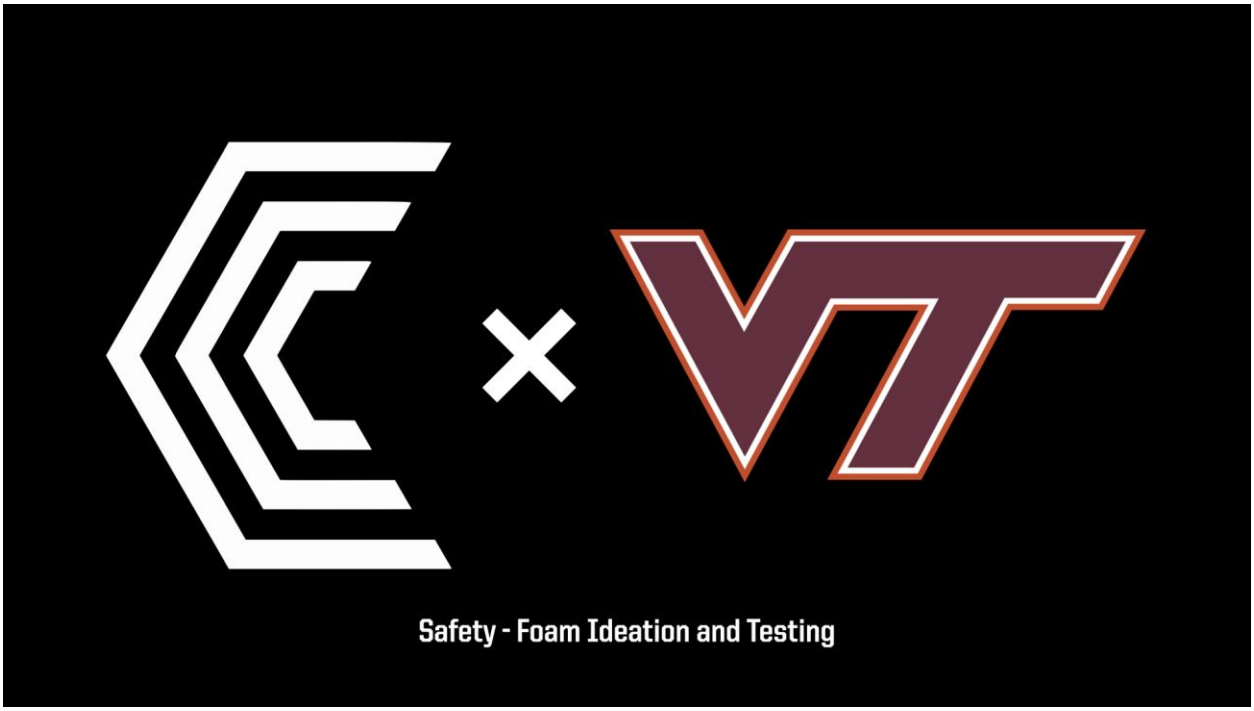


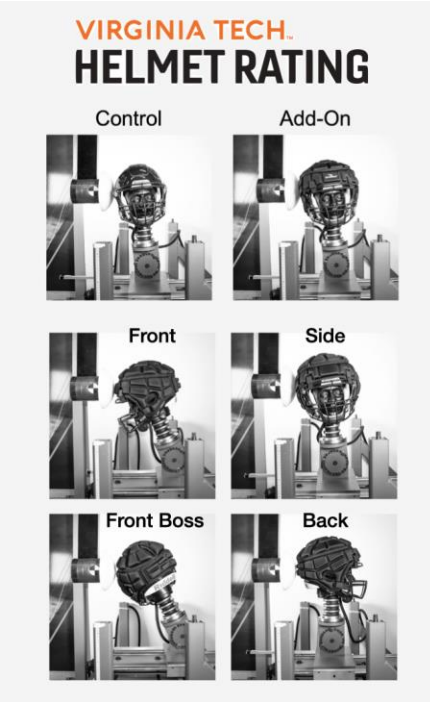

**Appearance**




**Financial**





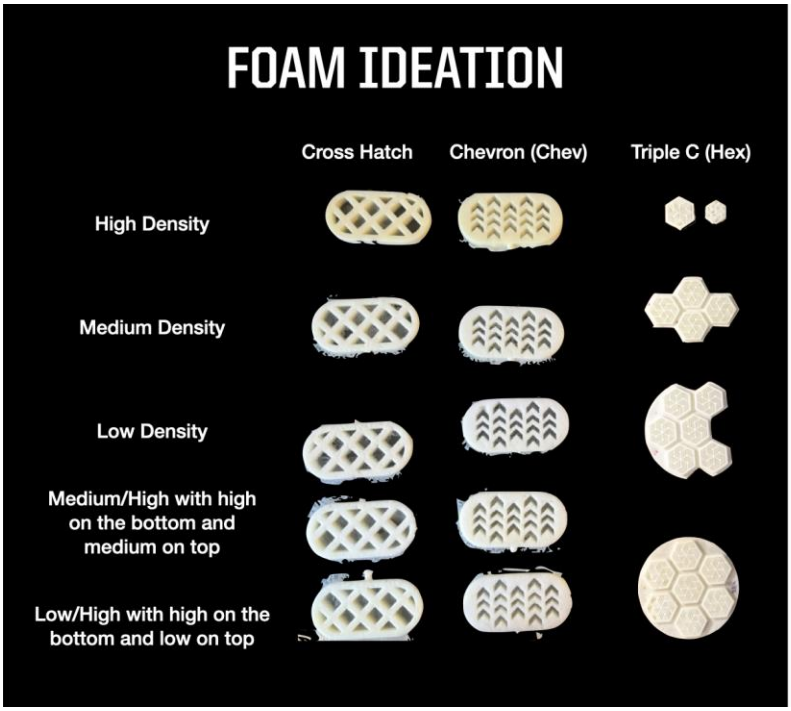

## PENDULUM IMPACTOR TEST

Test completed at Virginia Tech's Helmet Testing Lab on individual pads and add-on

Control helmet is a Ridell SpeedFlex

Using head accelerometer, the helmet is hit in four locations; front, back, side, and front boss. And at three speeds; 3.1, 4.9, 6.4 m/s

Calculates how much add-on decreases the risk of a concussion



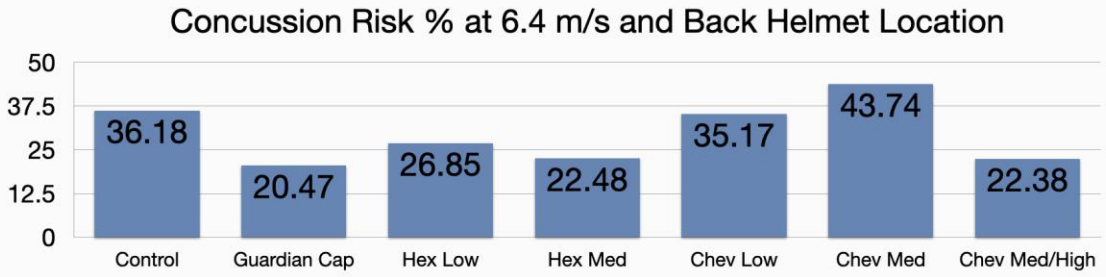

Created many foam density and geometric combinations

Cross hatch seemed to have too much negative space

Triple C needed to be simplified into a singular hexagonal shape

Final samples sent for testing were selected based on hardness, geometry and feel

# FOAM TESTING RESULTS



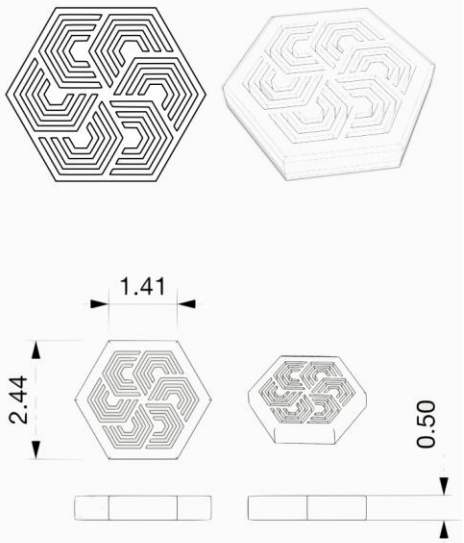

- Testing was done on individual samples on the back location of the helmet and at 6.4 m/s the speed where most concussions occur from
- In this specific location and speed, the helmet by itself was shown to have a 36.18% chance of concussion, where as the Guardian Cap was shown to only have 20.47% chance
- While the Chevron Med/High tested the closest to the Guardian Cap, it was determined that the pad would be too heavy to move forward with
- The Triple C (Hex) Med was chosen to move forward with as it had the next best testing and degraded the least

# TRIPLE C FOAM PADDING

Open cell, medium high density polyurethane foam

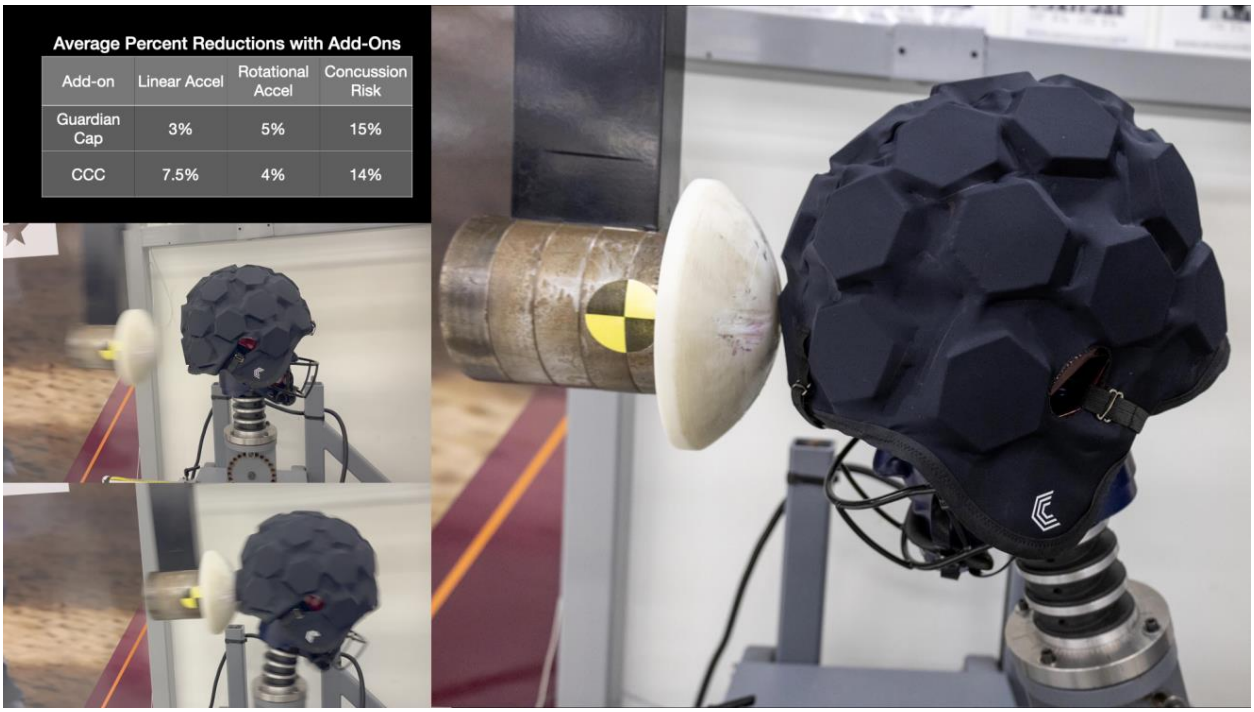
Hexagonal shape with 6 C-shaped cutouts

Geometry allows for maximum impact absorption, with C-shapes collapsing in on each other



**Average Percent Reductions with Add-Ons**

| Add-on | Linear Accel | Rotational Accel | Concussion Risk |
|---|---|---|---|
| Guardian Cap | 3% | 5% | 15% |
| CCC | 7.5% | 4% | 14% |



Appearance - Construction and Features

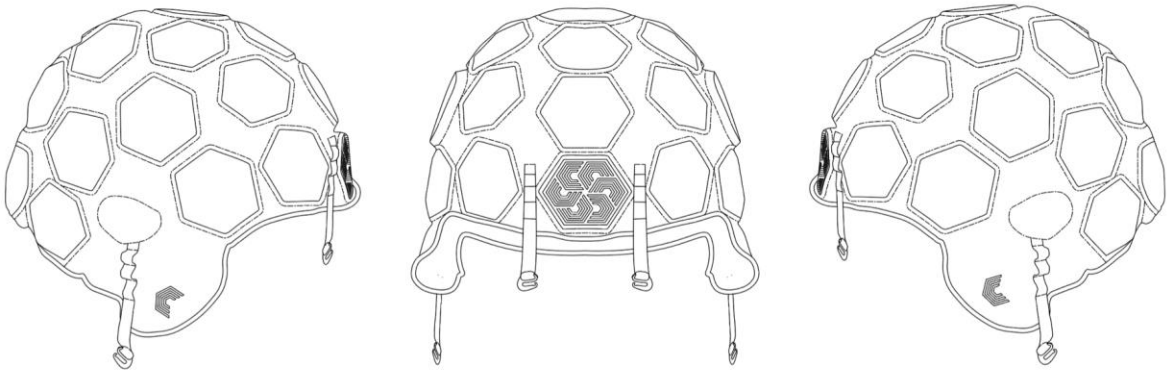
## MAKING PROCESS

Patterning → Pouring Foam → Layout → Assembly

## MAKING PROCESS

V.1 (Sewing) → V.2 (Hook & Loop Attachment) → V.3 (G-Hook Attachment) → V.4 (Bonding and Finished Edges)

# TECHNICAL DRAWINGS



Attachment: G-hook strap system at 4 different connection points for quick and efficient donning and doffing

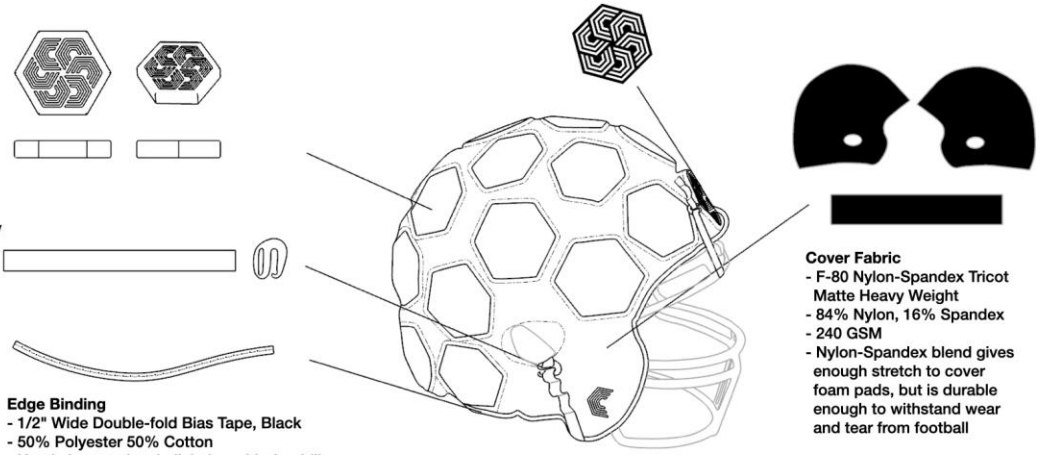
Logo: Bonded logos on front centric pad to show off shape of foam technology, and inside to add friction to helmet

Construction: Bonding each pad to give more 'engineered' look, and edge binding for better finish

Silhouette: Less volume on top of helmet compared to competitors, giving more sleek look when in use

**Foam Pads (25)**
- 25 individual, 1/2" thick, open-cell polyurethane foam
- Die-cutting process for cheaper manufacturing
- Provides up to 14% reduction of concussion risk to the user

**Logo (6) and Bonding (3 sheets)**
- Bemis ET315 logo sticker to show technology outside, and help attach to helmet inside
- Bemis 3340 glue in shape of panels
- Use of bonding to give product 'engineered' look



**Attachment Straps (4)**
- 0.71" Black, Zinc Alloy G-Hook
- 5/8" Black Elastic band, 6" long
- 2 front face mask locations, 2 ear hole locations, 3 loops sewn for adjustability

**Edge Binding**
- 1/2" Wide Double-fold Bias Tape, Black
- 50% Polyester 50% Cotton
- Used along entire shell, helps with durability

**Cover Fabric**
- F-80 Nylon-Spandex Tricot Matte Heavy Weight
- 84% Nylon, 16% Spandex
- 240 GSM
- Nylon-Spandex blend gives enough stretch to cover foam pads, but is durable enough to withstand wear and tear from football

# EXPLODED VIEW

USTOM
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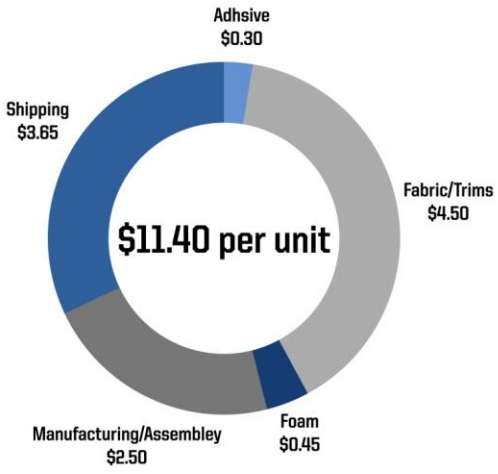
OVERAGE

Cost - Pricing Breakdown

# COST BREAKDOWN

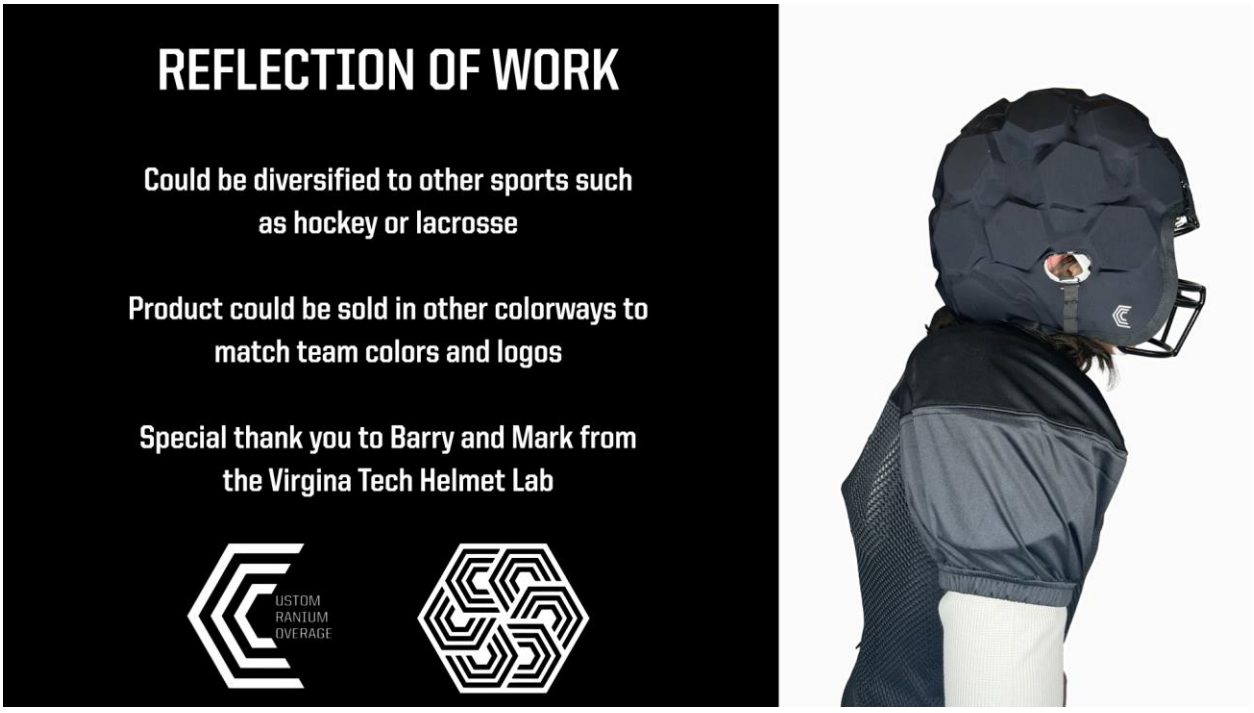
## Estimated Cost Per Unit to Produce




- Total cost per unit is estimated from multiple material quotes, as well as estimated quotes from Chinese factories
- Total is calculated assuming 4,000 units will be made, enough for 100 high schools
- Retail cost of final product will account for quality assurance, marketing, etc, but will still be a significantly lower price point than the competition

**Retail: $39.99**


FEATURES AND BENEFITS
Reduces the risk of a concussion on high impact hits by an average of 14%
Less volume on top of helmet compared to competitors, giving more sleek and engineered look
$39.99 - Lowest price point of any other football helmet add-on that is on the market


REFLECTION OF WORK
Could be diversified to other sports such as hockey or lacrosse
Product could be sold in other colorways to match team colors and logos
Special thank you to Barry and Mark from the Virgina Tech Helmet Lab
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OVERAGE


THANK YOU
Riddell