Additive Manufacturing Methods in Australian Rules Football Footwear:

An In-Depth Analysis of the Effects of Additive Manufacturing Processes and Digital Analytical Technologies on Athlete Performance

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Phase I: Research

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Introduction

For some time now, 3D printing has been used for footwear prototyping, a process that allows footwear professionals to craft test shoes before making their final products. In recent years, however, additive manufacturing technologies have become productive and cost-effective enough to be applied mass-scale in the footwear market, with this mode of manufacturing currently making up approximately 0.3% of global footwear market revenues, a figure that is set to rise to 1.5% of overall global footwear revenues by 2029. (SmartTech, 2019). As modern sports companies integrate these advanced technologies, some sports fall through the cracks and receive little to no attention. A prime example is Australian Rules Football [AF], the country's largest professional sports competition (Nicholson, 2021). Modern-day AF players are engaged in more frequent, high-intensity sprint efforts for more extended periods, with the ability to sustain performance across these intermittent, high-intensity activities being a paramount priority of the modern, elite AF player.

This research explores how we could apply these advancements in digital analytical technology, additive manufacturing, engineered lattice structures, and thermoforming processes to enhance AF boot design by creating a three-boot lineup that tackles the positional needs of Ruckman, Center-Forwards, and Rovers.

Professional Interests

My goal is to innovate within the product development process and improve athlete performance while redefining the boundaries of sport. Additive manufacturing is one of those innovations that has plenty to offer the footwear sector, and I aim to employ those qualities in my product intervention. I hope to translate the gathered athlete's feedback and data on their needs, into performance benefits as Australian Football and its athletes continue to evolve.

This capstone project will embody everything the Sports Product Design program has instilled in me and a glimpse of what I can achieve in the industry. I will showcase how I design functional footwear interventions using a data-driven approach and learn how innovations in other industries can be implemented into footwear. Working in conjunction with my mentors, who are active in the industry, will help me put into practice skills that professionals value and seek in teammates at these larger companies

Personal Strengths

Strengths are partly like a talent, partly like a skill. They can be improved and applied when relevant; nonetheless, they are the core toolbox for accomplishing goals. The top strengths I identify with are Achiever, Analytical, Activator, Ideation, and Deliberativeness. Some of these are more pronounced than others at different stages of projects. As we move forward with the thesis project, these strengths will help me

accomplish a distinguished capstone that highlights my professional goals. Using my Analytical and Ideation strengths will help me innovate in a direction that is well informed and explores multiple approaches to a solution. My Achiever and Activator strengths will aid me in connecting and forming a plan of attack for the different checkpoints over the subsequent terms, helping me complete tasks with a strong work ethic. Lastly, my deliberative strength will help me reduce risks and prevent problems through innate anticipation and careful thought.

Mentors

To better guide my research and design process, I will have a series of mentors advise me throughout the capstone project. These mentors will consist of various active members of the footwear or aligned industries. Currently, the team consists of two titular mentors: Nathan Schultze and Cesar Idrobo, with further mentors to be added depending on the stage of the capstone project.

Nathan Schultze is currently a footwear Designer at Women's Jordan and has previous experience with the Nike Innovation (NXT) and Nike Sports Wear (NSW) Running teams. Cesar Idrobo is the Head Pattern and Sample Maker for Footwear at Adidas' Yeezy.

Meetings will occur bi-monthly with each mentor to develop concepts, refine research, evaluate prototypes, and validate ideas.

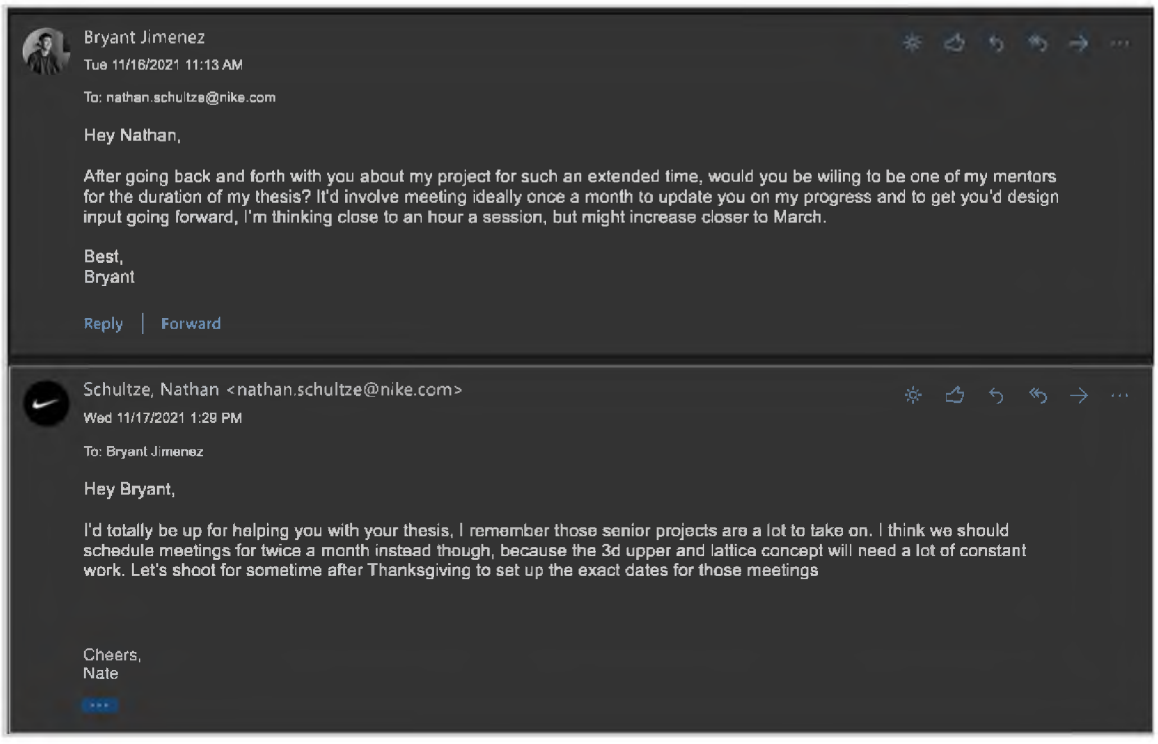


Image 1 Mentor e-mail confirmation from Nathan Schultze

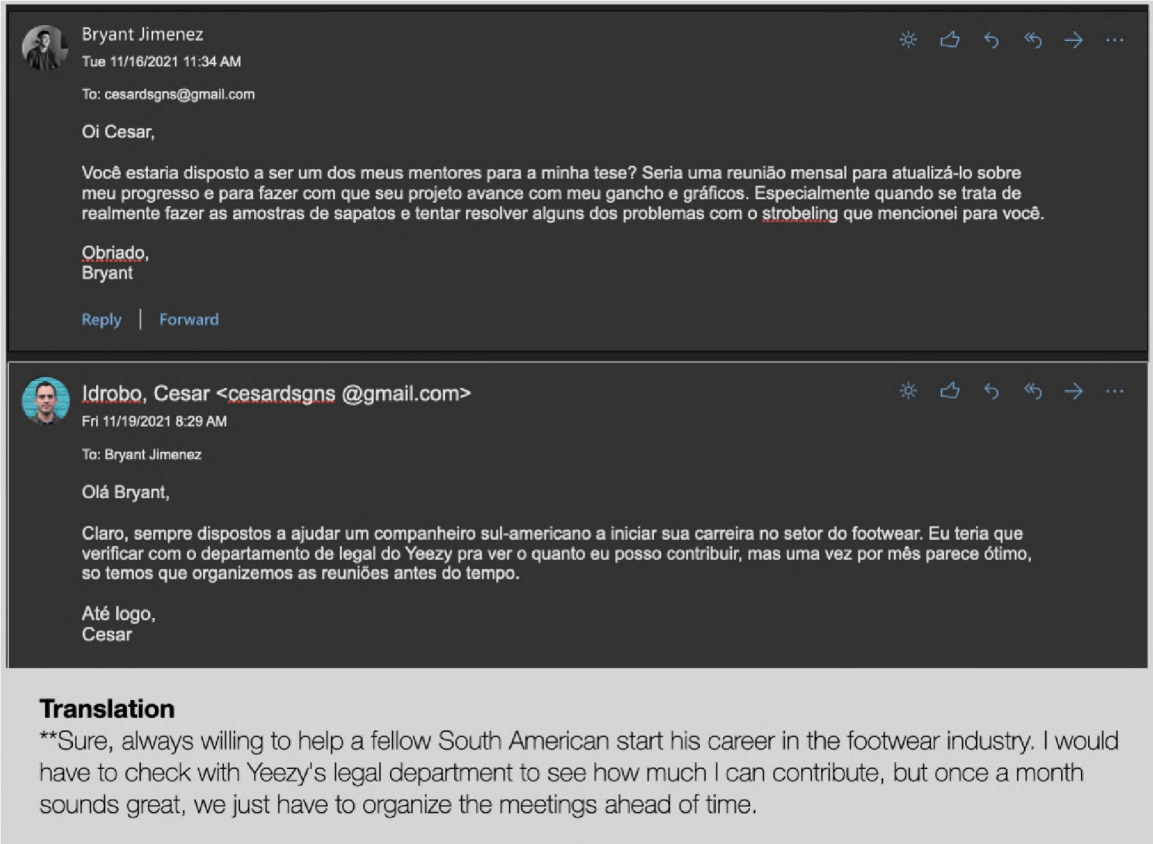


Image 2 Mentor e-mail confirmation from Cesar Idrobo

Product Classification

Footwear & Last Shapes, Football, Australian Rules

Sport History

Australian Rules football (ARF/Footy) has been played for over 160 years. Originating in Melbourne, the capital of Victoria, the code is the most popular winter sport (Marshall , 2019). Australian Football's first appearance in Melbourne in 1858 pre-dated the formal organization of soccer, rugby league, and American Football, giving it eminence (Richardson, 2011). The game quickly became popular amongst the different boroughs of Melbourne, where schools organized weekly competitions on unused cricket grounds. Spreading to the surrounding cities of Melbourne: Geelong, Notts Country, Stoke City, Carlton, and Nottingham Forest in that order (Blainey, 2010).

Thomas Wentworth Wills has the honor of being the game's pioneer and earliest umpire, who in the off-season of cricket in 1858 organized a famous scrimmage between Melbourne Grammar and Scotch College (Pascoe R. , 1995). In the city of Melbourne, these were the two best-known secondary schools; news of the proposed match reached the newspapers, and, on Saturday, August 7, 1858, The Melbourne Morning Herald reported the match (Blainey, 2010). The match between the schools has become

folklore, but it frames Australian rules football as a once-only invention; instead, it was an evolution of Gaelic Football amongst the youth of Australia. Just when secondary schools were becoming absorbed in Gaelic Football, young men and late teenagers were organizing matches which were to have more substantial effects on the development of Australian Football (Blainey, 2010). About a month before the notorious match, Thomas Wills had written a letter to the headmasters of Melbourne Grammar, asking for the organization of an off-season football team to keep cricketers in shape during the winter (Marshall , 2019).

The modern-day variant resembled and gained much inspiration from early Cricket, Gaelic Football, and Rugby forms. Almost at once, it was a distinctive game. So quickly did it move in its own direction under its own momentum, and so often did it devise or adopt rules and tactics that, within twenty years, it was far removed from the older rugby and new soccer and was still changing (Blainey, 2010). The resemblances of in-game traits were traced back to Thomas Wills, who ported over various attributes from the European competitions. Wills, as a youth, was sent to England to attend Rugby School, the birthplace of its' namesake football code, Rugby (Pennings, 2021). Particularly during his time in England, he became renowned for his ability in cricket, which proved to be pivotal for the sport. His desire to retain physical form during the off-season of cricket led to early versions of Australian football taking place across Melbourne upon his return to Australia in 1856.

Prior to his time in England, another outstanding inspiration that tied the game to genuine Australian culture was Wills' experience with Marn Grook—having lived in the early settlements of Lexington, Victoria, where he grew up with numerous aboriginal children, learning their language and, more importantly, their games for passing the time. Marn Grook, white European colonists, described a game featuring high kicking and leaping for a ball. 'The ball is kicked high in the air, not thrown up by hand as white boys do, nor kicked along the ground; there is general excitement who shall catch it' (Flanagan, 2008). The parallels to Marn Grook helped shape the unique forwarding system that quickly set it apart from the other football variants of the time.

Alongside Thomas, Thomas Henry Smith, William Josiah Hammersly, and James Bogue Thompson met to draw up a code of rules for the Melbourne Football Club on May 17, 1859 (Collins, 2011), proving to be the sport's first official milestone. The next significant jump came later the same year when the rules were amended to outline scoring criteria and announce the formation of several clubs within the city. This trend of constant rule amendments continued through the 1860s, where the most significant change came in the way of player contracts.

Prior to the 1860 season, players were not confined to any one club, a loophole notoriously seized by the Richmond club to field numerous stars from non-competing teams for their matches and tactic that won them two of the inaugural premiership titles. The dawning of the season 1866 saw the first published leaguewide code of rules,

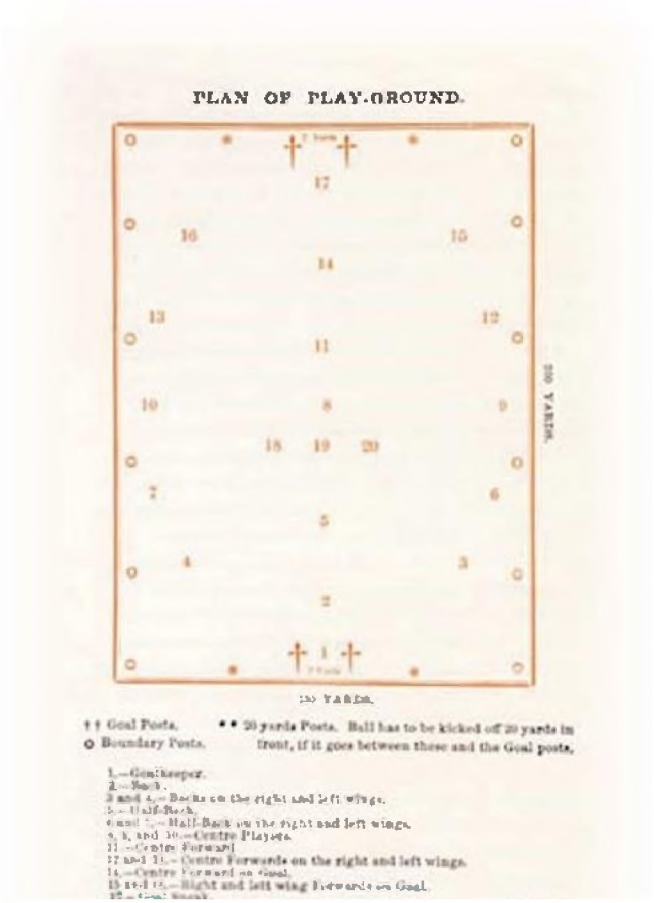


Figure 1 An Australian Rules football pitch as published in The Footballer of 1880 (Pascoe & Pennings, 2019)

which were adopted at a meeting of delegates from the principal clubs held in May (Power, 1875). A field requirement between goals expanded to 200 yards, along with instituting a bounce rule that regulated the distance a player could carry the ball without dribbling. The latter caused havoc, as previously players would adapt the rugby practice of tucking the ball under the arm and running to goal; the rule change outlined the need to bounce the ball every five or six yards to eliminate this practice.

Adding to its uniqueness Australian Football developed the mark, the same year as the field and bouncing statutes, more commonly known as a 'fair catch,' the rule allowed a player who caught the ball cleanly before it touched the ground to claim a 'free kick,' the right to kick the ball unimpeded by his opponents.

In 1877 the Victorian Football Association was established, where the stouter and financially backed clubs dominated the game. This trend lasted nearly two decades until

1896, when half of the clubs, including six of the strongest, seceded and formed the Victorian Football League (VFL) (Keenan, 2012). With its inaugural season, it brought several innovations, including a finals tournament and a formal establishment of a scoring system, in which six points were awarded for a goal and one point for a behind. The league quickly established itself as the premier competition in Victoria. It took nearly 40 years for the league to expand, from a nine to a twelve-team system in 1925. This era of VFL saw Collingwood set the standard as the only team in AFL history to win the premiership four consecutive times. The Melbourne team dominated during the following two decades, contesting a record seven straight grand finals from 1954 to 1960. At this time, perhaps one of the most distinctive divergences from English Football occurred in the lack of the offside rule (Pascoe R. , 1995). This lack of offside allowed attacking players to advance beyond the ball-carrier, and their opponents, at will and without restriction or penalty.

During this time, the league also opted not to allow games to be televised, as the league saw a steep decline in crowd turnout during the 1957 trial season, as well as building the first dedicated VFL mega stadium in Melbourne in 1970 to gain independence from the Melbourne Cricket Club that owned the Melbourne Cricket Ground (MCG) (Keenan, 2012). The hiatus from televised games ended in 1965 as many former players became commentators on pre-game preview programs and post-game review programs to the nation's ever-increasing audience. Nevertheless, it was not until the 1980s that there was a regular timeslot of VFL matches on Fridays, a tactic championed by North Melbourne. In 1986 the most significant merger in the sport took place, the unification of the Western Australian Football League, the Queensland Australian Football League, and the Victorian Football League, which in 1990 was renamed to the Australian Football League.

Image 3 The Victorian Football League's Previous Logo and Current Australian Football League Emblem (Australian Football League, 2021)

The league followed suit with many other world sporting organizations and signed a Collective Bargaining Agreement with the Australian Football League Players' Association (AFLPA). Since then, the league has added several expansion teams in Queensland, Gold Coast, and Western Sydney raising the league to an 18-team system. A national women's league followed suit in 2017, marking the most modern development to the AFL structure and history.

It became evident that Australian Rules was no longer a football variant but a genuine Australian invention; it captivated the whole continent and produced one of the utmost unique sports in modern athletics.

Environment

The arena of play that this paper will focus on will be the Melbourne Cricket Ground (MCG), regarded as Australia's premier sporting venue; the 'G' has played host to the country's prevalent cricket and Australian Rules Football matches, and many other significant sporting contests for over one hundred years (Cricket365, 2015). It was, in fact, even the centerpiece of the Olympic Games of 1956 (Pascoe & Pennings, 2019). Built in 1954, the MCG holds a capacity of 90,000 fans and hosts day and night competitions.

Image 4 Crowd sings national Australian anthem prior to starting the 2018 Grand Final in the Melbourne Cricket Ground (MCG) (globetrekimages, 2018)

The pitch itself is in Melbourne, Victoria, Australia; it is an oval field that is 165m long by 110m wide. The pitch includes four goalposts at the east and west ends, with 50m lines arching at each end (Australian Football League, 2021). The center is marked by a 5m circle within another 50m wide box (Tatz, 1983).

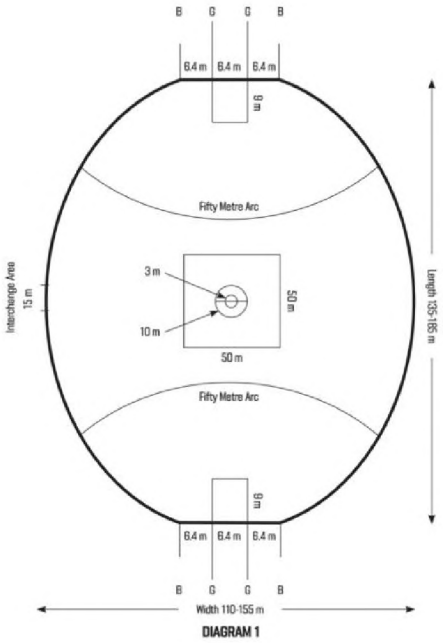


DIAGRAM 1

Due to the sport taking place during the Australian winter, temperatures vary from 6.5 - 14.2°C (43.7 - 57.6°F) for the grand final (Stern, 2008). The MCG is also a natural grass pitch that is hard-packed firm ground due to the lack of rain during the winter months. The humidity sustains a constant threshold of 50-62% due to Melbourne's proximity to the southern side of the equator (Stern, 2008). Although humidity is higher than average, rain is scarce during this part of the year

User – Target Athlete Demographic

The target athletes are elite Australian rules football players, 22-27 years old, across three key defined positions, Forward, Follower/ Rover, Ruck/Ruckman, who play in the premiership (Division 1) of the Australian Football League.

Market Size

There are 18 AFL clubs with approximately 40 players on each team's list; thus, approximately 720 professional AFL players in Australia. Another estimated 5,407 senior-level participants in other semi-professional club football leagues across Australia (Munro, 2019). Expanding to the world view, Australian football leagues have sprouted in numerous countries across the African, Asian, and Oceanic regions of the world. Leading to a further global estimated total of 921,439 registered participants that are playing Australian Football as of 2020, placing it behind cricket (1,311,184) and soccer

(1,188,911) (Commission, 2020). Participation continues to rise due to increasing support in western Sydney and a significant increase due to booming female participation brought on by the introduction of the AFLW (Commission, 2020).

Positional Needs

Australian Football, the most popular football code in Australia, is a contact sport played by two teams of 18 players who contest play over four 20-minute quarters; the game's object is to score the most points through goal kicking. (Flanagan, 2008)

An interview was conducted with former Australian Football academy player and current University of Oregon Punter, Tom Snee, to better understand the positional distinctions, needs, roles, and identification methods. His insights proved extremely valuable in ascertaining the positional targets of this research and gaining insight into how their footwear solutions might be better adjusted.

Forwards

This player style requires increased accuracy as they are often the leading goal scorers, using short bursts to accelerate past defenders and clear space to take a shot on the goal. Due to their responsibility of leading the scoring, they become the de facto offensive tempo makers that guide shifts and set plays. The average height of these players in the premiership is 6'0" to 6'4", with a frame that allows for quick sprints and powerful kicks. (Snee, 2021)

Followers/ Rovers

This player lurks around the center square during bounces and stoppages to receive the ball and complete a clearance towards a forward. Rovers are typically the smallest players on the pitch, usually in the 5'4"-5'11" range. These players will often cover the most ground, averaging under 18km, requiring increased traction and lightweight boots to keep up with their high stamina requirement (Snee, 2021)

Ruck-Man

The ruckman needs to be tall and active; the average height is 6'5"-7'2". The ruckman must follow the ball around the field and needs to get to every ruck contest to give the team the best chance at securing possession and feeding the ball to other midfielders. The main focuses for ruckmen are comfort and lockdown, as their frames put increased Strain on their feet and joints. (Snee, 2021)

Jobs to be done

The created footwear needs to function better than existing Australian football boots and lower weight with increased performance benefits. The shoe needs thoughtful striking zone considerations, and 3D printed features in the midsole and cleat outsole to keep the player comfortable during long games and better options than the existing

market. The shoe needs to be made from innovative materials to wear carefree throughout an entire game.

Sport Success

Success in this sport is gained by accumulating the highest number of points across the span of the game to win.

Biomechanical Needs

Drop Punt Kick | Check Side Kick

Goal-kicking forms an essential component of winning games in Australian Football (AF), as it provides the only means to score points. The drop punt is a complex multidimensional kicking action that successfully involves whole-body interactions. It is relatively reliable, simple to execute, and faster to perform when compared to other punting techniques, providing better ball stability and a more accurate outcome. The drop punt technique is of particular importance as it is the primary technique used during set-shot attempts, making up 62% of points scored during a game (Roberston, Back, & Bartlett, 2016). The drop punt kick involves the combined technical aspects of a running approach, the release of the ball from the hands, and a forceful impact with the foot of the kick-leg as it swings through in the direction of the goals, where more accurate kickers adopted a straighter approach line, dropped the ball in line with the kicking thigh and finished with the kick-leg pointing towards goals. (Blair, Roberston, Duthie, & Ball, 2020). The kicking action can be broken down into six-movement phases:

Phase of Movement	Start Point	End Point
Approach	Initiation of movement	Toe-off into kicking motion
Back Swing	Toe-off into kicking action	Maximum Hip Extension
Wind Up	Maximum Hip Extension	Maximum Knee Flexion
Forward Swing	Maximum Knee Flexion	Foot-to-ball Contact
Follow Through	Foot-to-ball Contact	Maximum Knee Extension
Recovery	Maximum Knee Extension	Maximum Hip Flexion

Table 1 The Six Phases of Movement in a Drop Punt Kick

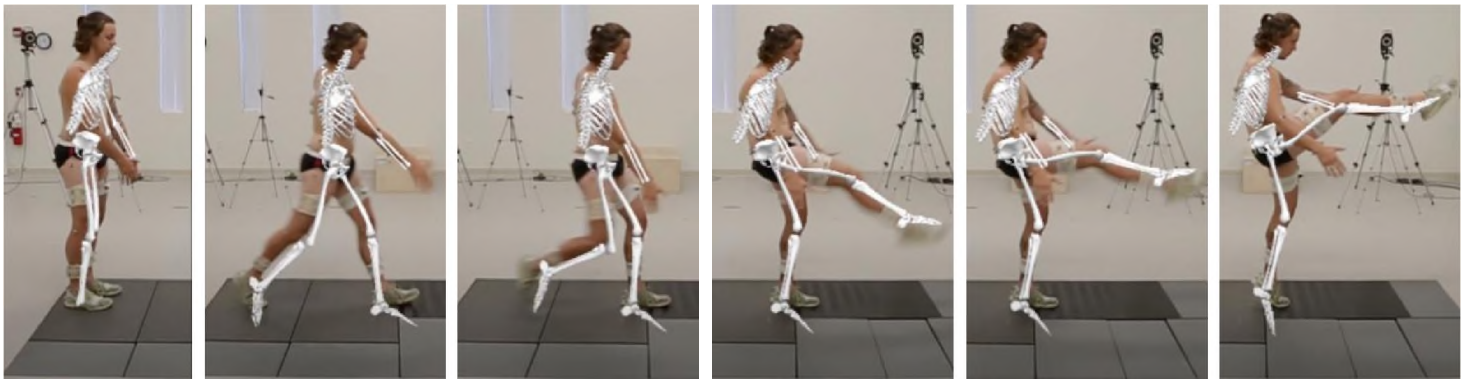


Image 5 Movement Sequence of a Drop Punt Kick (A) approach, (B) backswing, (C) wind-up, (D) forward swing, (E) follow-through, and (F) recovery. (Delaware, 2017)

To achieve an accurate drop punt, an appropriate force must be imparted onto the ball as a resultant function of generated foot velocity, effective striking mass, and the quality of foot-to-ball contact (Young, 2005). The correct kicking technique involves a series of well-timed and controlled whole-body interactions, particularly ball velocity, trajectory, limb coordination and control, foot position, stiffness, impact restitution, ball drop, contact position, joint flexibility, and range of motion.

Approach

The drop punt can be performed from a stationary position or using a predetermined approach strategy, which may vary based on length, speed, and approach angle. The two latter are the main components that substantially influence the kicking performance during the development of foot velocity and the rotational axis of the kicking leg (Hart, 2012). The approach phase is a preparatory movement that aims to accelerate the body into a selected velocity prior to planting the support leg as a mechanism to generate and transfer greater levels of initial velocity from the whole body through the sequential segmentation of the kicking leg and into the ball. A run-up approach achieves higher ball speeds than a stationary kick based on previously established momentum, allowing more significant lengthening of hip musculature, which subsequently enables them to perform more work over a greater distance (Hart, 2012).

Support Leg

As skilled kicking involves the complex interaction of many-body segments and requires footballers to adopt single-leg postures, the wholesome contribution of the support leg to the kicking motion is visibly significant (Blair, Roberston, Duthie, & Ball, 2020). The importance of the support leg is to allow athletes to manipulate and lower their center of gravity to provide greater athletic stability, balance, and control while also resisting torque developed by the kicking leg when powerfully striking the ball (Blair, Roberston, Duthie, & Ball, 2020).

Ball drop

Within the ball drop of both the drop punt and torpedo, players must guide the ball down with the guiding hand cradling the ball and with the release point being at the

time kicking foot leaves the ground, ultimately allowing the player sufficient time to generate power to kick the ball. The ball is released from hip level as the guiding hand controls the path and orientation of the ball. Throughout this stage, the non-guiding hand is removed from the front of the ball and swings up and back in an arc to provide balance and stability. In the final stages of the ball drop, it is crucial to ensure the ball is in a vertical position as it leaves the hand to allow the bottom third of the ball to reach contact with the foot. Ultimately resulting in the ball spinning backward, therefore, creating a more accurate kick (Hart, 2012)

Swing of Leg

During the swing phase, the leg has angular momentum. This is because any mass with velocity has momentum and because the leg has an angle, it, therefore, has angular momentum. As previously mentioned, for optimal power and acceleration of the leg's swing, we need to reduce the mass (shoes) or keep the mass close to the center of rotation. That is why we can see the leg swing remains relatively close to the body's center to generate power for the kick.

Foot Velocity

Foot velocity is a significant contributor to subsequent ball velocity and kicking distance achieved (Young, 2005); To develop high foot speeds, the kicking leg must produce a proximal-to-distal segmental sequence, commonly identified as a 'throw like movement pattern. In a chain reaction to maximize foot speed, the movement should commence with the proximal segments (the body and thigh) and progress through the linked chain to more distal segments (the shank and foot) so that each segment starts its motion at the preceding segments moment of most significant velocity.

Additional Factors involved in Kicking Sequence

Magnus Effect

The 'Magnus Effect' is a spinning ball 'grabs' the air that flows past it due to the friction between the air and the ball, and as a result, the air particles begin to spin with the ball (Blainey, 2010). The Magnus Effect influences the drop punt as the ball spins in a backward motion in a vertical position. Ultimately this creates an increased amount of air resistance and a greater level of friction. Therefore, the speed and velocity of the ball are significantly reduced because of form drag; however, it does provide an increased level of control and accuracy. As the ball spins, it creates a pressure difference, which moves from left to right, creating more control of how the ball moves throughout the flight pat.

In contrast to the drop punt, which achieves a high level of friction as it moves throughout the air, the torpedo kick is marginally influenced by friction and air resistance due to the way it travels throughout the air. The torpedo kick is a kick used to achieve large distances as it relies on a high amount of spin and rotates in a vortex position throughout the air for this to be successfully achieved. (Young, 2005).

Foot-to-ball Contact

Ball velocity, trajectory, and directionality rely upon the suitable generation of angular momentum transferred to the ball and angular impulse applied to the ball, as created by the kicking leg during the kicking action and impact phase (Young, 2005). Therefore, a limb with greater striking mass or greater peak velocity at impact will achieve more incredible ball velocity due to a longer contact time between the foot and the ball (Hart, 2012) where the collision between the foot and the ball is influenced by the deformation of the kicking foot and the location of ball contact with the foot surface during the striking motion.

Upper Body

The kicking action is a whole-body multi-joint movement, with skilled kickers using more significant trunk rotation and non-kicking arm extension and abduction to produce a more effective tension and pre-lengthening stretch through the musculature of the trunk and pelvis, assisting with force generation and velocity transfer (Blair, Roberston, Duthie, & Ball, 2020).

Physiological Needs

Body Structure

Mass, stature, and frame compositions are evident factors that distinguish different positions in Australian football. The average height of current elite Australian Football players is 1.87 m across all current AFL players (Gray & Jenkins, 2010). However, other studies have found substantial positional differences in height, with small forwards and small midfielders shorter than the mean height, while key position forwards/ backs and ruckmen are all taller (Pyne, Gardner, Sheehan, & Hopkins, 2006). On average, body mass ranges between 85 and 90 kg (187-200 lbs.) at the elite level in the AFL, with some key position players weighing more than 100 kg (Young, 2005). This weight spectrum outlines variable muscle mass between positions, where smaller players tend to be bulkier to compensate for constant collisions during possessions and ball contests changes. The most significant physical change needed to play in the AFL is increased body mass with proportionate increases in strength (Keogh, 1999). Table 2 will highlight in red the differences in height and body mass where Ruckman (Nomadic) players are 188±9cm & 86.8±8.9kg, Forwards are 186±10cm & 87±7.75kg, and Rovers (Backs) are 187±5cm & 87.7±7.5kg (Gray & Jenkins, 2010).

Maximal Oxygen Uptake

During the 20m shuttle run test at the draft combine workouts, players' maximal oxygen uptake (VO_2max) values ranged from 55 to 65mL/kg/min (Gray & Jenkins, 2010). Compared to other sports like soccer and field hockey, the study found that this VO_2max was marginally higher than the average across elite sports. When broken down by position, Ruckman (*Nomadic*) players had an endurance capacity of 61.6±3.5

mL/kg/min, Forwards had 57.8±5.1 mL/kg/min, and Rovers (*Backs*) had 61.1±3.5 mL/kg/min, highlighted blue in Table X (Gray & Jenkins, 2010).

Muscular Endurance

Tackling, colliding, and 'wrestling' with opposition players during a mark or loose ball contests requires high upper and lower body strength levels. This strength can vary based on position due to the frequency of player involvement in contests and clashes. A bench press and leg press exercise used a three-repetition maximum to identify the upper body and lower limb strength across player categories. Highlighted green in Table 2, it reflects that forward and backs possess slightly greater upper and lower body strength than elite midfielders (Young, 2005). Measures of leg power and upper body strength ability assessed are higher for Australian Football players than for rugby league players (Duthie, 2003)

Table V. Physiological characteristics of Australian Football players[a]

	Study							
	Buttifant[31]	Keogh[33]	Pyne et al.[34]	Pyne et al.[35]	Young et al.[32]			Young and Pryor[36]
Year of data collection	1993–7	1999	1999–2001	1999–2004	2004			2005
No. of players	18	29	283	495	38			177–200
Level of competition	AFL (elite)	State U/18	AFL draft camp	AFL draft camp	AFL (elite)			State U/18
Age (y)	22.7 [1993]–26.8 [1997]	15.9	17–18	17–18	22.6±2.9			16–18
Positions	All	All	All	All	Nomadic	Forwards	Backs	All
Anthropometry								
height (cm)	186	180.2±7.2	186±6.62	187±6.6	188±9	186±10	187±5	183.9±6.9
body mass (kg)	85.7 [1993]–90.5 [1997]	74.6±8.3	80.5±7.82	81±7.6	86.8±8.9	87±7.75	87.7±7.5	79.8±8.3
skinfolds (mm)	55.4 [1993]–63.6 [1997][b]		56±3.4[b]	55.3±12.6[b]	47±7.8[c]	59.7±16[c]	53.3±12[c]	
Endurance capacity								
20 m shuttle run (VO_{2max}; mL/kg/min)	53.6 [1993]–59.2 [1997]	57.7	57.8±3.4	57.8±3.4	61.6±3.5	57.8±5.1	61.1±3.5	57.3±3.5
yo-yo IR2[d] test (m)					747±123	656±128	743±142	
Speed and acceleration								
5 m (s)			1.09±0.06					1.12±0.05
10 m (s)	1.83 [1993]–1.66 [1997]		1.81±0.07		1.9±0.06	1.93±0.1	1.88±0.07	
20 m (s)	3.06 [1993]–2.92 [1997]		3.04±0.09	3.04±0.09				3.13±0.09
40 m (s)	5.37 [1993]–5.40 [1997]							
Flying 30 m split (s)					3.46±0.11	3.6±0.15	3.49±0.06	
Strength								
3RM bench press (kg)		63.8±10.7			97.9±11.9	93±10.4	98.8±8.4	
3RM leg press (kg)					399±46	348±64	410±44	
3RM chin ups (kg)					109±10	103±12	106±5	
Leg power								
concentric squat jump (W/kg)					68.3±6.2	70.5±7.4	68.1±7.1	
countermovement squat jump (W/kg)					70.2±8.8	65.1±9.4	69.1±7.8	
Jumping ability								
countermovement jump (cm)		55.2±7.9	60.1±5.76		62.3±3.7	58.4±5.1	63.4±2.4	
absolute running vertical jump (cm)			322±11.1	322±10.9				
Flexibility								
sit and reach test (cm)		10.7±6.4						8.8±7.5

a Performance and anthropometric values are expressed as mean±SD.

b Sum of seven skinfolds.

c Sum of eight skinfolds.

d There are two yo-yo protocols: level 1 and level 2. Level 2 is reported here and has higher initial running speeds.[37]

AFL – Australian Football League; **IR2** – intermittent recovery level 2; **RM** – repetition maximum; **U/18** – under 18 y age group; **VO_{2max}** – maximal oxygen uptake.

Table 2 Physiological Characteristics of Australian Football Players

Speed and Repeated Sprint Ability

The ability to outrun defenders and 'find space' or chase down opponents is integral to Australian Football; players require swift acceleration and sprint ability in all positions

during their high-speed and very high-speed runs. The time to cover an observed distance during a 10-meter sprint and a 30-meter flying sprint was recorded to document and emphasize these differences during a previous study. The study showed that the Nomadic and Forward players (1.9±0.06s & 1.93±0.1s) took 0.2 seconds longer on average to cover a 10-meter area compared to Backs (1.88±0.07s) from a standstill (Young, 2005). While Nomadic and Back players (3.48±0.11s & 3.49±0.06s) held an edge over Forward players (3.6±0.15s) during a flying 30-meter sprint (Young, 2005). These results show that players can accelerate to over 80% of their maximal velocities in just a few seconds, a desirable quality at the elite level. Repeated sprint ability is becoming increasingly important for players, as the game's pace has accelerated within the last decade. Using a 6 x 30m sprint protocol (on a 20-second cycle), the mean total time of all six sprints be 25.83 – 0.6 seconds (Pyne, Gardner, Sheehan, & Hopkins, 2006).

In summary, compared with players in other positions, midfielders are consistently found to spend the most time at higher intensities, complete more high-intensity efforts, sustain them for longer and have shorter recovery periods between high-intensity exercise bouts. 'Ruckmen' have similar but less intense running profiles, while forwards and backs generally have less game involvement but have a more intermittent running profile (Delaney, Burgess, Dascombe, Dascombe, & Duthie, 2017)

Psychological Needs

Athletes need to train physically and mentally and face a variety of pre-game, in-game, and post-game factors that may affect their athletic performance. These external influences can alter their mindset and preparedness leading up to games and practices and deter entire seasons.

Pre-Game

Mental rehearsal, winning imagery, and positive visualizations are aids that sports psychologists practice with athletes to prepare them for success. These cognitive devices and wellness techniques are taught and reinforced before a player touches any court or pitch, yet this mental aspect might have the most significant impact on players during the off-season where they are subject to scrutiny or face the possibility of having to fight for a roster spot. The success visualization method allows players to project successful implementations of fundamental and trivial skills to increase the likelihood of in-game execution at an elite level (Perry & Erdal, 2008). Another pre-game aspect that affects players is their rituals, superstitions, or routines they perform before they go out to play. These are built over years of games and practices. Athletes must have their superstitions with them; it brings good luck and ease of mind (Neil, 1982).

In-Game

Some factors that afflict the psyche of an athlete are tied to elements that are only present in-situ or in-game. These can include simple body interactions with footwear land equipment, from cushioning and the proper fit of boots to their gear's sensory feedback and weight. A player will often want to feel the most comfortable while playing and go to great lengths to have the best gear with them when on the court (Foster, Weigand, & Baines, 2006). The gear players use helps them achieve maximal performance output if their footwear, uniform, and equipment check off their boxes. Appropriate equipment will increase sensory attenuation as they see direct feedback on using the items (Foster, Weigand, & Baines, 2006). Another subtle aspect of athletic gear is the weight or level of technology woven into the construction of the equipment, where users interpret less weight with being quicker and targeted technology with being able to ascend to a higher performance threshold.

Post-Game

The last phase of psychological consideration is after the final buzzer has rung, and players have reason to celebrate, deal with a dreary result or tend to an injury. The latter has the most considerable impact on a player's mentality. If they know they are not 100% athletically, it becomes difficult to perform at a high level or even believe they can ascend to a previous threshold (Neil, 1982). This pressure to remain healthy leads players sometimes to hide injury or neglect to seek assistance, which may cause aggravated injuries or suboptimal performances come game-time. Another modern component of the post-game phase is image and media, where players are subject to extreme criticisms and slander from sports analysts and team fandoms (Gao, Wang, & Liu, 2021). The media's effect on players has risen with social media, where players can be tagged and directly attacked with reproach based on sub-par performance or an act deemed derogatory or offensive. This off-field pressure can lead players to perform how they would otherwise not.

Product Anatomy

AF is regarded as a physically and technically demanding sport. The physical demands of an AF match vary considerably between playing positions, with global positioning system (GPS) analysis revealing players typically cover 11,000 to 17,000 meters during a match (Janetzki, Bourdon, Norton, Lane, & Bellenger, 2021). Australian Football footwear needs support, flexibility, stability, lockdown, and comfort features. These features enable modern-day AF players to engage in more frequent, high-intensity sprint efforts, kicking contests, and sustain athletic performance across these intermittent periods of the games quarter system (Snee, 2021).

The state-of-the-art AF boot comprises four core components: the upper, midsole, soleplate, and the last. The upper is comprised of textile combinations that house the foot during wear. It serves various functions depending on the specific region and material makeup.

Upper

An upper can have designated Drive, Touch, Volley, Pass, and Curve zones that affect its interaction with the ball. The upper encompasses the boot's heel collar, which can vary in silhouettes from low, mid, semi-mid, and high cuts, where the increasing heights restrict the ankle's range of motion and have the most significant degree of ankle lockdown potential. Comparatively lower cut options provide more flexibility and better pivoting capacity. Specific state-of-the-art uppers also have dedicated Strike zones that increase precision and focalize power onto the ball. Uppers have also developed either a laced or laceless system to cater to specific fits and actions of the foot. Additional upper components include the tongue, heel counter, vamp, lacing system, and textural elements. The latter can be integrated or fused to the exterior of the upper's material. Many brands have proprietary lacing systems and engineered knits. However, kangaroo leather is the closest condition to the preferred fitting (Olaso Melis, Priego Quesada, Lucas-Cuevas, González García, & Puigcerver Palau, 2016).

Midsole

The midsole is an out-of-norm component for most football boots, as AF is one of the few sports that incorporate a developed midsole. This component provides the principal cushioning element of the boot, absorbing the heavy forces of running and jumping (Saleem, 2018). Typically, the midsole is located between the upper and the outsole; some high-tech midsoles are made with non-foam technologies, such as airbags or gel pods, to increase protection and durability. AF boots in specific have a silhouette that more closely resembles a wedge designed to increase forefoot propulsion in explosive movements. Not all AF boots offer a midsole, as it is a component that is typically omitted due to manufacturing cost.

Soleplate

The soleplate is the final component of the boot; it is made up of the soleplate itself, the studs, and the critical configurations of studs. There are several classifications, but the three main categories are Firm Ground, Soft Ground, and Artificial Ground (Olaso Melis, Priego Quesada, Lucas-Cuevas, González García, & Puigcerver Palau, 2016).

Firm Ground (FG)

Firm Ground soleplates are designed for natural grass surfaces, typically solid ground, and require a more significant amount of penetration for a stable footing, leading to more blade-like studs. The studs are usually molded as part of the plate itself and have the same material composition (Barr, 2017). Nowadays, to reduce weight, brands like the Nike Tiempo and the Adidas Copa Sense.1 have a split soleplate construction covering just the forefoot and the rearfoot, all supported by an internal chassis.

Soft Ground (SG)

Soft Ground soleplates are relatively heavy compared to the other two; since wet and muddy pitches usually require the most penetration possible, SG soleplates have screw-in holes for elongated metallic studs (Barr, 2017). The screw-in configuration means studs of SG soleplates are replaceable. Certain brands have also developed a hydrophobic layer to repel mud and prevent an accumulation of dirt between studs.

Artificial Ground (AG)

Lastly, Artificial Ground soleplates house more studs than the FG soleplate, with the studs being mainly conical in shape. This is because artificial pitches, while built to replicate natural surfaces, are more rigid and denser, allowing less penetration and requiring more pressure distribution to be comfortable. Like those in FG, the studs are also molded and take up the material of the base plate.

Stud Shape

The studs come in varying shapes; three general stud shapes are Triangular/Bladed, Conical, and Hybrid. Bladed studs provide traction when a player pushes from the side of their foot during a cut move. In comparison, conical studs provide stability and rotational traction during a wide range of movements. Hybrid studs are semi-altered triangles and conical shapes that attempt to balance rotational traction and propulsion (Barr, 2017). Different sports product companies have boot designs that cater to specific positional needs across many football variants. Mainly to provide targeted traction, zoning, and control details for those positional needs.

Last Form

The final component is one of the aims of this research, the last. Last shape and design are one of the aims of this research as the last shape has a substantial influence on sprinting performance, kicking accuracy, and influences maximum kicking velocity (Hennig & Sterzing, 2010). Lasts are three-dimensional forms that mimic the design form of the boot and give the upper its shape and volume. Anatomical lasts are more contoured to match the foot's shape, while generic lasts are based on morphological averages. Additionally, the last's footbed can profoundly impact player performance, as it delivers optimal support shape between the player's foot and the soleplate (Liebeskind, 2011).m Depending on positional proclivities, these last shapes are adjusted to aid player performance.

Product Landscape

In the realm of competitive footwear for AF, only one large-scale manufacturer, Asics, has a dedicated lineup for the sport; however, the provided solutions do not adequately target positional needs. Alongside Asics, smaller companies target specific game

attributes like kicking and comfort without applying the solutions in an aimed method. Apart from these specifically designed boots, AF players will routinely sport soccer and rugby boots as improvisations; this external use creates a wide variety of boot options across pricing, last shapes, features, and graphics.

An important consideration is that the Product Landscape analysis is restricted to Kangaroo Leather (K-Leather) variant boots where the primary upper material is either entirely kangaroo leather or incorporates a combination of synthetic leathers alongside k-leather.

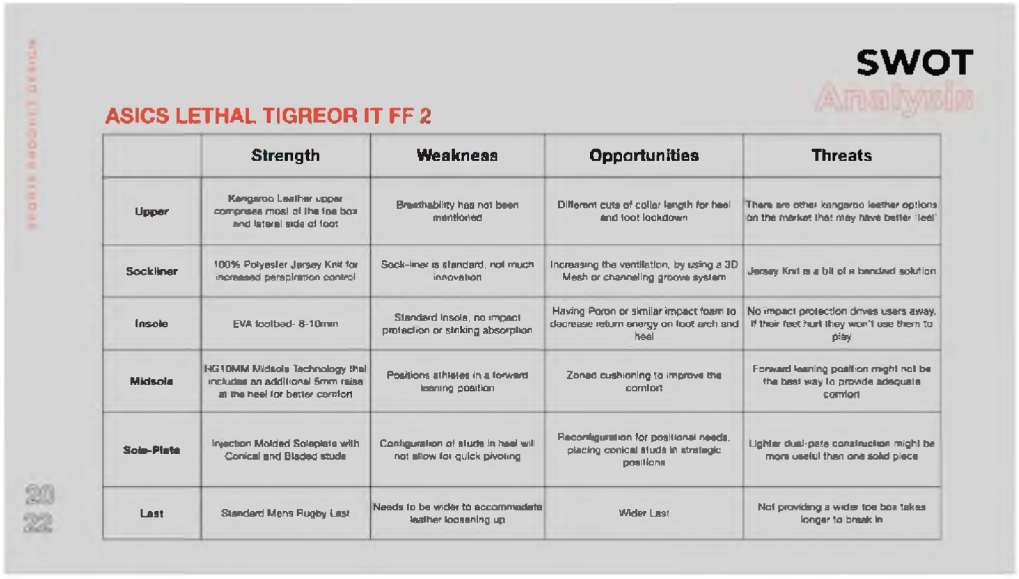
The highlighted boots are Asics's Lethal Tigreor FF2, Concave's Halo + Hulk Firm Ground Cleat, Nike's Tiempo Legend 9 Elite Firm Ground boots, and Adidas's Copa Sense.1 Firm Ground Cleats.

Product	Image	Price	Sport	Features & Benefits
Asics Lethal Tigreor IT FF 2		MSRP $240	Australian Football	• HG10mm Heel Gradient to reduce Strain on lower limbs • Lightweight comfort for faster momentum and directional changes • Revamped upper design for lockdown in heavy playing conditions • Kangaroo leather • FLYTEFOAM cushioning
Concave Halo + Hulk FG		MSRP $280	Australian Football	• AccuStrike Railing System for increased grip and control • Dual anti-torsion bars soleplate for ultimate grip and traction on firm ground surfaces • Texturized synthetic upper for ultimate stability while enhancing feel • Neoprene inner • hybrid stud configuration
Adidas Copa Sense.1 FG		MSRP $225	Soccer	• Low-Profile Design for increased ankle range of motion • Touch pods for absorbing impact energy of incoming passes • Sense pods for creating a seamless connection between boot and foot • Kangaroo & Synthetic leather upper for perfect ball feel • Redesigned soleplate to stabilize user's gait
Nike Tiempo Legend 9 Elite FG		MSRP $285	Soccer	• Low-Profile design • Upper has raised textures for precise dribbling • Soft foam pods for exceptional comfort • Kangaroo leather • Adaptive mesh tongue to reduce bulk • Redesigned soleplate to provide traction for quick cuts and sudden stops

Table 3 lists and compares the price, sport, and features of several top market boot alternatives for AF, image rights: players (Adidas, 2021) (Asics, 2021) (Concave, 2021) (Nike, 2021)

Competitor Landscape SWOT Analysis

To better understand the possible design interventions with the proposed footwear solution of this research, a thorough SWOT analysis details at an anatomical level the top three competitors in the Australian Football boot market.

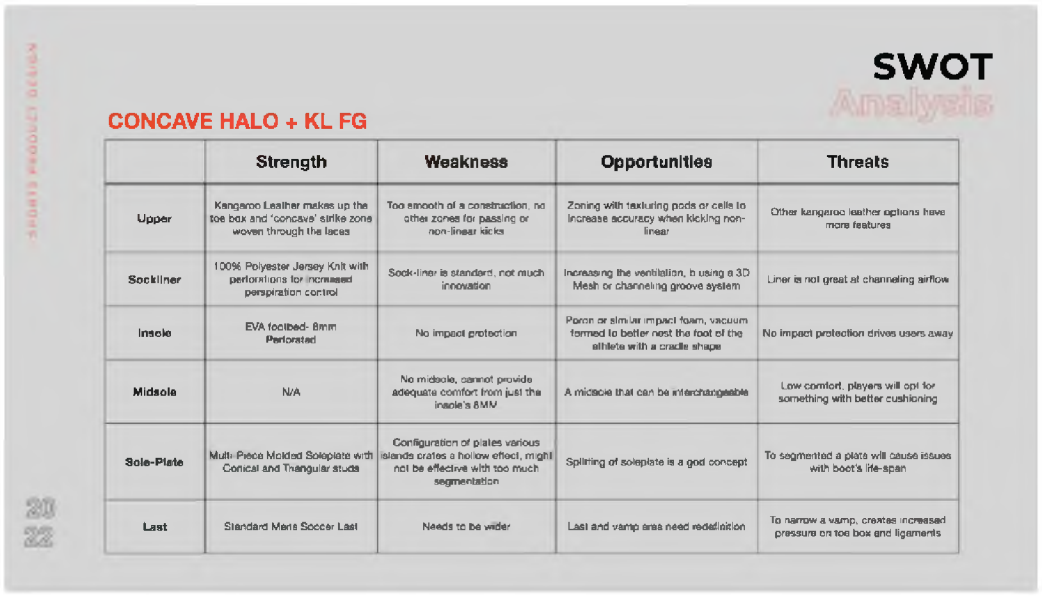


SWOT Analysis

ASICS LETHAL TIGREOR IT FF 2

	Strength	Weakness	Opportunities	Threats
Upper	Kangaroo Leather upper compress most of the toe box and lateral side of foot	Breathability has not been mentioned	Different cuts of collar length for heel and foot lockdown	There are other kangaroo leather options on the market that may have better 'feel'
Sockliner	100% Polyester Jersey Knit for increased perspiration control	Sock-liner is standard, not much innovation	Increasing the ventilation, by using a 3D Mesh or channeling groove system	Jersey Knit is a bit of a standard solution
Insole	EVA footbed- 8-10mm	Standard insole, no impact protection or striking absorption	Having Poron or similar impact foam to decrease return energy on foot arch and heel	No impact protection drives users away, if their feet hurt they won't use them to play
Midsole	HG10MM Midsole Technology that includes an additional 5mm raise at the heel for better comfort	Positions athletes in a forward leaning position	Zoned cushioning to improve the comfort	Forward leaning position might not be the best way to provide adequate comfort
Sole-Plate	Injection Molded Soleplate with Conical and Bladed studs	Configuration of studs in heel will not allow for quick pivoting	Reconfiguration for positional needs, placing conical studs in strategic positions	Lighter dual-pate construction might be more useful than one solid piece
Last	Standard Mens Rugby Last	Needs to be wider to accommodate leather loosening up	Wider Last	Not providing a wider toe box takes longer to break in

Image 6 SWOT Analysis of Asics Football Boot - Competitor 01

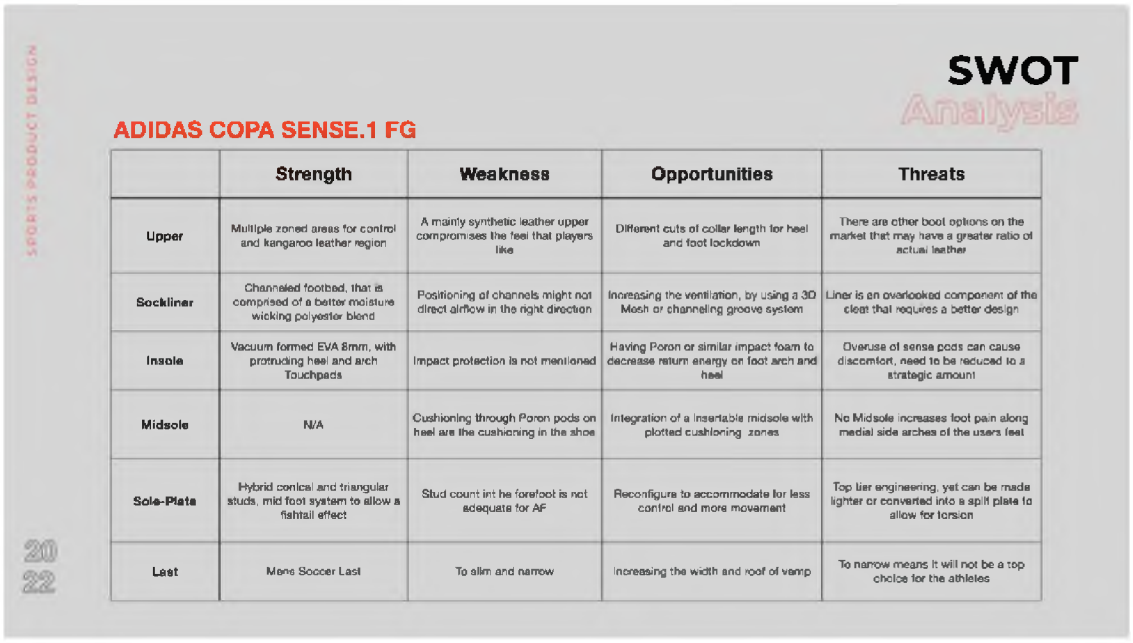


SWOT Analysis

CONCAVE HALO + KL FG

	Strength	Weakness	Opportunities	Threats
Upper	Kangaroo Leather makes up the toe box and 'concave' strike zone woven through the laces	Too smooth of a construction, no other zones for passing or non-linear kicks	Zoning with texturing pods or cells to increase accuracy when kicking non-linear	Other kangaroo leather options have more features
Sockliner	100% Polyester Jersey Knit with perforations for increased perspiration control	Sock-liner is standard, not much innovation	Increasing the ventilation, b using a 3D Mesh or channeling groove system	Liner is not great at channeling airflow
Insole	EVA footbed- 8mm Perforated	No impact protection	Poron or similar impact foam, vacuum formed to better nest the foot of the athlete with a cradle shape	No impact protection drives users away
Midsole	N/A	No midsole, cannot provide adequate comfort from just the insole's 8MM	A midsole that can be interchangeable	Low comfort, players will opt for something with better cushioning
Sole-Plate	Multi-Piece Molded Soleplate with Conical and Triangular studs	Configuration of plates various islands creates a hollow effect, might not be effective with too much segmentation	Splitting of soleplate is a god concept	To segmented a plate will cause issues with boot's life-span
Last	Standard Mens Soccer Last	Needs to be wider	Last and vamp area need redefinition	To narrow a vamp, creates increased pressure on toe box and ligaments

Image 7 SWOT Analysis of Concave Football Boot - Competitor 02



	Strength	Weakness	Opportunities	Threats
Upper	Multiple zoned areas for control and kangaroo leather region	A mainly synthetic leather upper compromises the feel that players like	Different cuts of collar length for heel and foot lockdown	There are other boot options on the market that may have a greater ratio of actual leather
Sockliner	Channeled footbed, that is comprised of a better moisture wicking polyester blend	Positioning of channels might not direct airflow in the right direction	Increasing the ventilation, by using a 3D Mesh or channeling groove system	Liner is an overlooked component of the cleat that requires a better design
Insole	Vacuum formed EVA 8mm, with protruding heel and arch Touchpads	Impact protection is not mentioned	Having Poron or similar impact foam to decrease return energy on foot arch and heel	Overuse of sensa pods can cause discomfort, need to be reduced to a strategic amount
Midsole	N/A	Cushioning through Poron pods on heel are the cushioning in the shoe	Integration of a insertable midsole with plotted cushioning zones	No Midsole increases foot pain along medial side arches of the users feet
Sole-Plate	Hybrid conical and triangular studs, mid foot system to allow a fishtail effect	Stud count int he forefoot is not adequate for AF	Reconfigure to accommodate for less control and more movement	Top tier engineering, yet can be made lighter or converted into a split plate to allow for torsion
Last	Mens Soccer Last	To slim and narrow	Increasing the width and roof of vamp	To narrow means it will not be a top choice for the athletes

Image 8 SWOT Analysis of Adidas Football Boot - Competitor 03

State-of-the-Art Materials

AF boots uppers are traditionally composed of k-leather or a combination of k-leather and other synthetic leathers. Certain brands substitute leather for engineered knits that restrict or encourage specific movements. These uppers will often have hot melts made from PU, Poron, or TPU films to increase textural qualities and enhance the boot's longevity, using the stitching patterns as texturing (Olaso Melis, Priego Quesada, Lucas-Cuevas, González García, & Puigcerver Palau, 2016). Brands like Nike and Adidas will have their proprietary knits and textured designs; these knits are combinations of polyester and nylon weaved in an engineered fashion. The midsoles traditionally comprise Ethyl vinyl acetate (EVA) or Polyurethane (PU) foam, but each company will have a patented combination or formula for this foam. The soleplate is usually injection molded and casts both the studs and plate in one piece, customarily made of either PU, Nylon, Styrene-butadiene, or Butyl. Some brands like Asics also incorporate a thin carbon fiber plate in the midsole to increase energy return to the athlete, while other companies have experimented with castor beans. These soleplates can also have removable metal studs depending on the stud configuration.

State-of-the-Art Manufacturing

The manufacturing process of making the boot's upper consists of laser-cutting each upper component and stitching the ensemble together, however prior to this process, the leather or engineered knit is embossed or printed with any decorative elements, and the stitch-line patterns are also etched on (Motawi & Motawi, 2017). After it has been assembled, the upper is skived, and a succession of workers hammer down the edges. Next, the upper goes through the lasting process where the edges are wrapped around

and beneath the last form through a thermoforming and hydraulic pressing machine. Afterward, the uppers are then buffed down using a small sanding tool that will rough the bottom edges of the upper, providing a clean area for the bonding cement to adhere. Primer and cement are applied to the upper and are reactivated with a UV heat treatment to allow for better bonding between materials. To achieve optimal shape retention, the soleplate and upper, with the last form still inserted, are left in a hydraulic press for 20 minutes to 24 hours while the leather cures to its new shape. Lastly, any rivets that might be needed are inserted, and additional glue is applied to the edge of the plate to maximize the seal to the leather upper

Rules and Regulations

The Australian Football league has prohibited the use of boot studs, plates/cleats, or any Protective Equipment (other than Protective Equipment approved by the Controlling Body) unless the field Umpire is satisfied that the item does not constitute a danger or increase the risk of injury to other Players competing in the Match (Australian Football League, 2021).

As well as outlining that, under apparel,

I. Not to wear boots that have exposed metal stops (i.e., stops may internally contain metal or be metal at the end which screws into the boot, but no exposed surface of the stop that may potentially meet the turf or other player may be metal)
II. Not to wear boots with stops that are plastic or any other material that have sharp or pointed edges (Australian Football League, 2021).

A breach of either regulation can result in a sanction of $40,000, along with a suspension pending the gravity of the violation (Wu, 2020).

Along with the rules outlining restrictions, it is worth noting the scoring system that applies during a game of AF. There are two methods to score a point(s) in AF; the primary method is kicking a ball through the two center uprights, resulting in 6 points awarded to the kicking team; the other method is scoring a behind, which is when the ball passes between the uprights on either side of the center gap, this will give the team 1 point (Snee, 2021). The Australian Football League outlines both methods like the following:

> 16.1.1 Scoring a Goal
>
> Subject to Law 16.2, a Goal is scored when the Football is Kicked completely over the Goal Line by a Player of the Attacking Team without being touched by any other player, even if the football first touches the ground.
>
> 16.1.2 Scoring a Behind
>
> Subject to Law 16.2, a Behind is scored when any of the following occurs:
>
> (a) the football passes entirely over the Behind Line;

(b) the football touches or passes over the goal post or touches the padding or any other attachment to the goal post;

(c) a Player of the Attacking Team Kicks the Football over the Goal Line, but before completely passing over the Goal Line, the football is touched by another player;

(d) a Player from the Attacking Team Handballs, knocks, or otherwise takes the football over the Goal Line, other than kicking the ball described in clause 16.1.1;

(e) a Player from the Defending Team Kicks, Handballs, knocks, or otherwise takes the football over the Goal Line or Behind line; or

(f) if a defending Player plays on from behind the Goal Line or Behind line and subsequently changes direction before entering the Playing Surface.

(Australian Football League, 2021)

The last fundamental regulations concern Free Kicks and Marks, as these stoppages significantly affect scoring opportunities by allowing the player to kick an uncontested direct kick towards goal with the opponent a specified distance from the kicking player.

18.1.3 When a Free Kick May be Awarded

A Free Kick may be awarded when the football is or is not in play, between when a field umpire starts and ends a quarter. However, a Free Kick may also be awarded:

(a) if an infringement occurs on the arena before the commencement of a quarter, in which case the Free Kick shall be taken at the Centre Circle or in accordance with Law 18.1.2, whichever is the more significant penalty against the offending team; and

(b) after a score has been recorded or play has ended, in the circumstances described in Laws 16.4, 16.5, and 16.6.

15.1 Marking the Ball

A Mark is taken if, in the opinion of the field Umpire, a Player catches or takes control of the football:

(a) within the Playing Surface;

(b) after it has been Kicked by another Player a distance of at least 15 meters; and

(c) which has not touched the ground or been touched by another Player.

17.3 Protected area

Other than the player bringing the football into play, all Players must make every endeavor to vacate the Protected Area described in Figure 3 immediately.

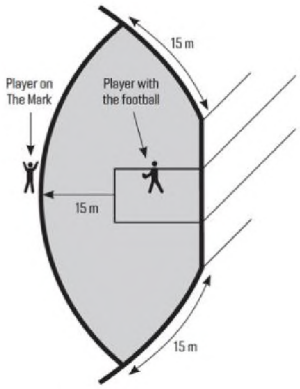


Figure 2 Illustrates the Protected area designated for a Free kick (Australian Football League, 2021)

Intellectual Property

This research's relevant intellectual property includes methodology, manufacturing, and assembly of footwear products with incorporated additive manufacturing, lattice structures, and footwear with a cleated soleplate.

Relevant Patents include:

US20190232591A1 | method for forming three-dimensional structures with different material portions- Yoav Sterman, Todd A. Waatti

> *A system and method for forming 3D printed structures includes printing an outer shell portion and filling an interior of the outer shell portion to form an inner portion. The outer shell portion and an inner portion may have different material properties. The outer shell portion may be anchored to the base component* (USA Patent No. US 20190232391A1, 2019)

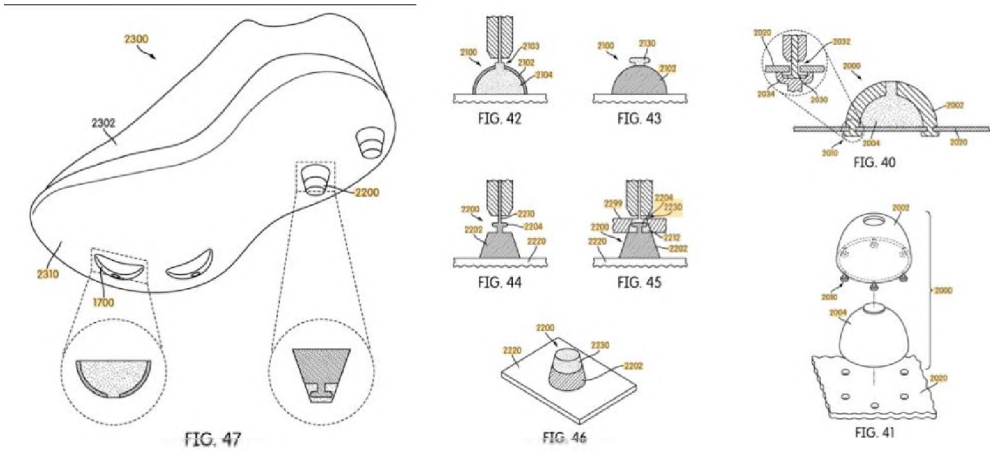


Figure 3 illustrate the applications of the patent towards 3D-printed cleats

US6763611B1 | Footwear sole incorporating a lattice structure- Ciro Fusco

The invention is an article of footwear with a sole that incorporates a lattice structure. The lattice structure includes a plurality of connectors joined by a plurality of masses and may be configured to attenuate and distribute ground reaction forces in a specific manner. In addition, the connectors and masses may be configured to vibrate at a specific frequency or exclude vibrations at another frequency (USA Patent No.

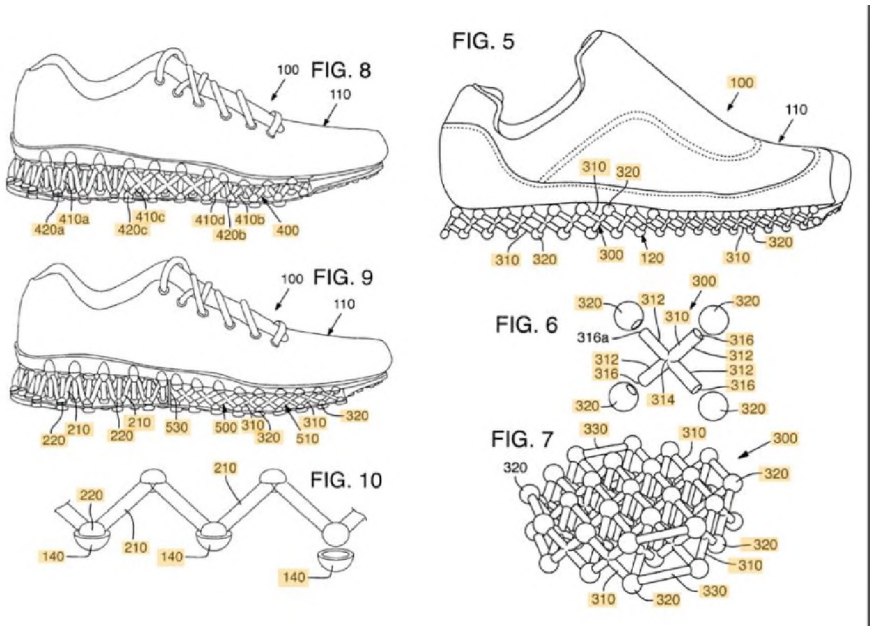


Figure 4 Footwear sole incorporating a lattice structure

US6763611B1 , 2004)

US20140020192A1 | Footwear Assembly Method With 3D Printing - David P. Jones, Ryan Larson

Methods and systems are disclosed for apparel assembly using three-dimensional printing directly onto fabric apparel materials. Disclosed is a method and system for direct three-dimensional printing and assembly of an article of apparel, including designing a three-dimensional pattern for printing, positioning at least a portion of the article on a tray in a

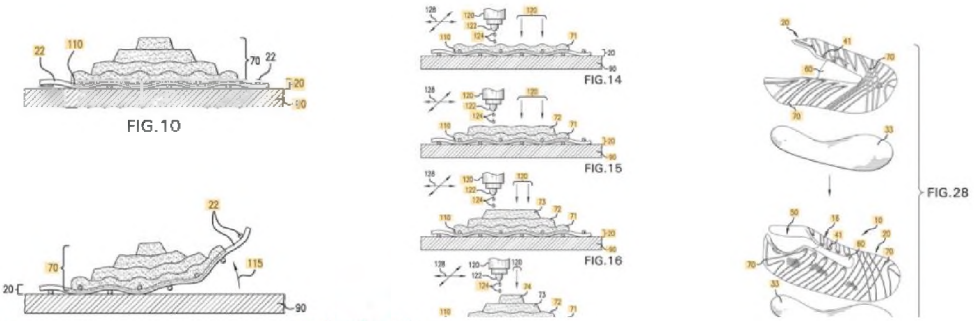


Figure 5 Footwear Assembly Method with 3D Printing

three-dimensional printing system, the portion being positioned substantially flat on the tray, printing a three-dimensional material directly onto the article using the designed pattern, curing the printed material, and removing the article from the three-dimensional printing system (USA Patent No. US20140020192A1, 2015)

US20140020192A1 | Footwear midsole with warped lattice structure and method of making the same- Jacques Perrault, Derek Andrew Luther, Berin Skye B, Marco Florian Kormann, Pradeepan INDRA KUMAR Florian Josef FICK, Felix Braun, Yuehong TU, Andrew Jacob SCHNEIDER, Christian Siegl, Brendan Epley

A midsole for an article of footwear including a three-dimensional mesh including interconnected unit cells and methods of making the same. The interconnected unit cells each include a plurality of struts defining a three-dimensional shape. The interconnected unit cells are connected at nodes having a valence number defined by the number of struts connected at that node. The valence number of the nodes may vary to provide customized characteristics to zones or portions of the midsole. The plurality of interconnected unit cells may be organized in a warped cubic lattice structure. The warped cubic lattice structure and the size/shape of interconnected unit cells may vary to provide customized characteristics to zones or portions of the midsole. The three-dimensional mesh may be customized based on a biometric data profile for an individual or group of individuals. The midsole may be manufactured using an additive manufacturing process (USA Patent No. US10932521B2, 2019)

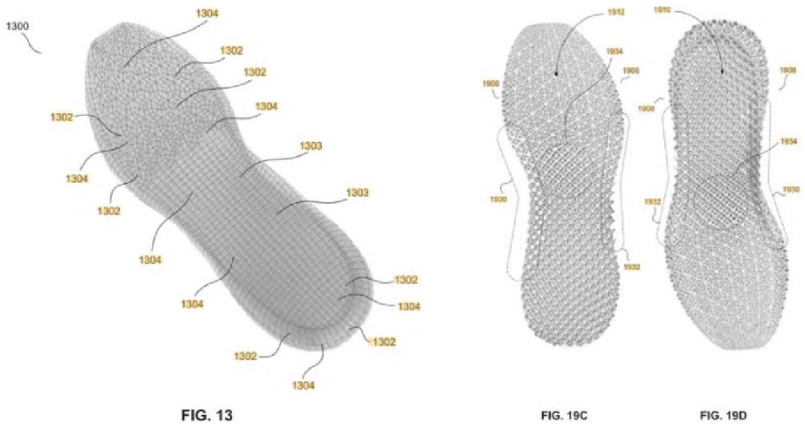


Figure 6 Footwear Midsole with a warped lattice construction

US20160374431A1 | Systems and Methods for Manufacturing of Multi-Property Anatomically Customized Devices- Adam P. Tow

Systems and methods for using a three-dimensional fabrication device, like a 3D Printer, for novel automation and additive manufacturing techniques in manufacturing medical devices such as orthotics, customized for a particular person. The systems and methods may use a plurality of work surfaces on the three-dimensional fabrication device. The systems and methods may use a plurality of materials or a plurality of fabrication tools

and processes to manufacture the customized product (USA Patent No. US20160374431A1, 2016)

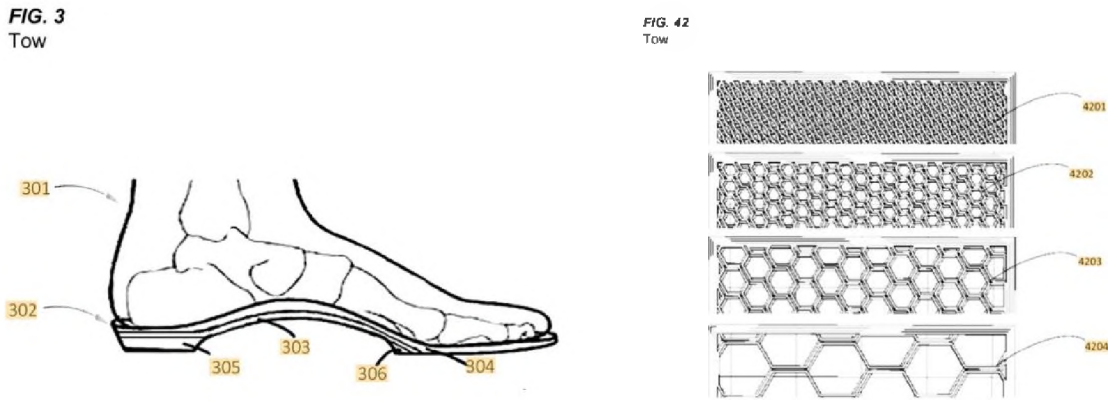


Figure 7 Multi-Property Anatomically Customized Device

Product Trends

Color Trends

Trend research focuses on the spring and summer seasons (S/S) of 2022-23, based on the proposed innovation timeline and intended launch. With a close to the earth palette, grounded by richly pigmented clay, intensely colored vessels evoke the arid landscape of the aboriginal homeland (Palmer, 2021). A palette that includes primary colors of deep greens (#F2C230 | 17-5912 TCX) and rich deep oranges (#8C5320 | 18-1250 TCX), with accent colors of maroon (#73324A | 19-1528 TCX), yellow (#F2C230 | 19-1528 TCX), orange (#F25D27 | 19-1528 TCX), and ivory (#D7D7D9 | 11-0103 TCX).

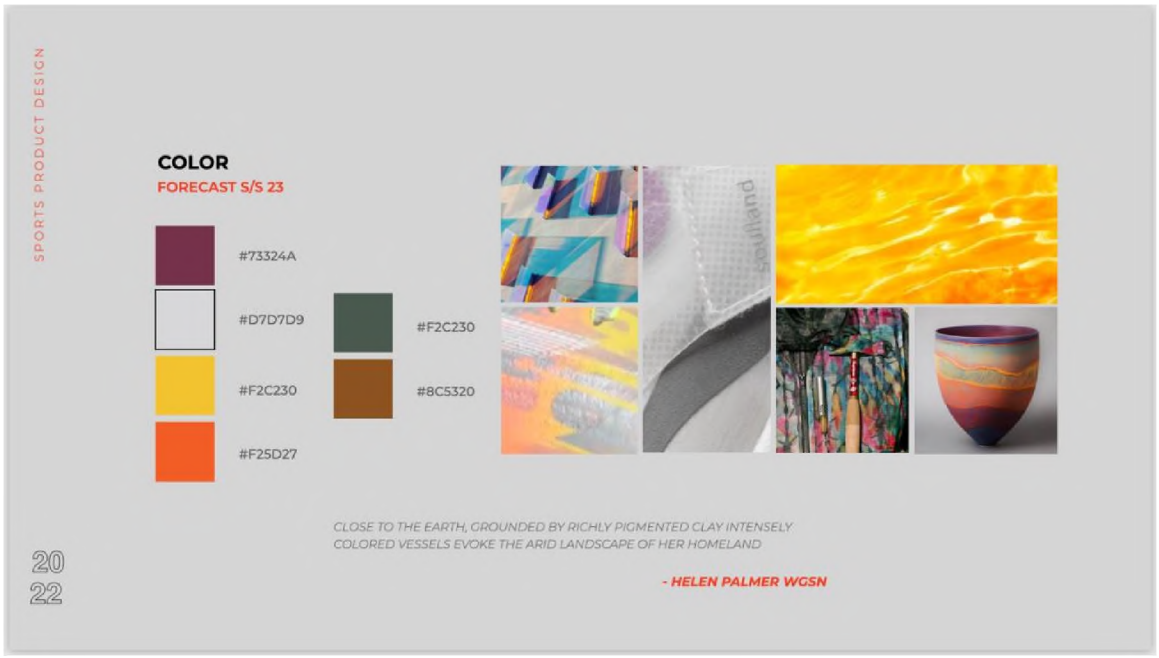


Image 9 Color Trend Recap from in-class Presentation

Graphic Trends

3D-printed lace, embossed pattern, and sleek forms, the computational craft is becoming even more refined in intricate and filigree material forms & the metaverse inspires transformative color and materials in both digital and physical contexts (Saldana, 2021). These trends use color and texture to provide a sense of protection and comfort while creating visual depth with layering and transparency.

Image 10 Graphic Trend Recap from in-class Presentation

Branding Trends

Transformative, super-natural materials to emit dazzling visuals in real and virtual realms with a responsive or gradient color of real and digital skins to products and spaces… (Saldana, 2021). Using TPU overlays, reflective tapes, embossments, and screen prints display logos, branding, and additional decals or text, either informing use or as part of the overall design.

Image 11 Logo/Branding Trend Recap from In-class Presentation

Athlete Questionnaire

A survey was sent out to various athletes, coaches, and biomechanists to determine athletes' positional needs, characteristics, and potential design interventions associated with Australian Rules Football. Using this information will verify that the proposed footwear intervention is warranted or needs modification prior to going into the design and prototyping phase of the capstone project. Several sections had "outs" to avoid irrelevant feedback once the athlete's responses extended beyond their expertise or experience. The link to the survey and snapshots of the survey will be attached below.

https://forms.gle/AyTdPvc9KZB1wxqNA

Section 1 of 5

Australian Football Footwear Questionnaire

My name is Bryant Jimenez; I am a Sports Product Design graduate student at the University of Oregon, USA. I am looking to gain insight into Australian Football players' footwear and habits, to better understand and design footwear solutions for the sport.

Your name.

Short answer text

Do you play Australian Rules Football? *

- Yes
- No

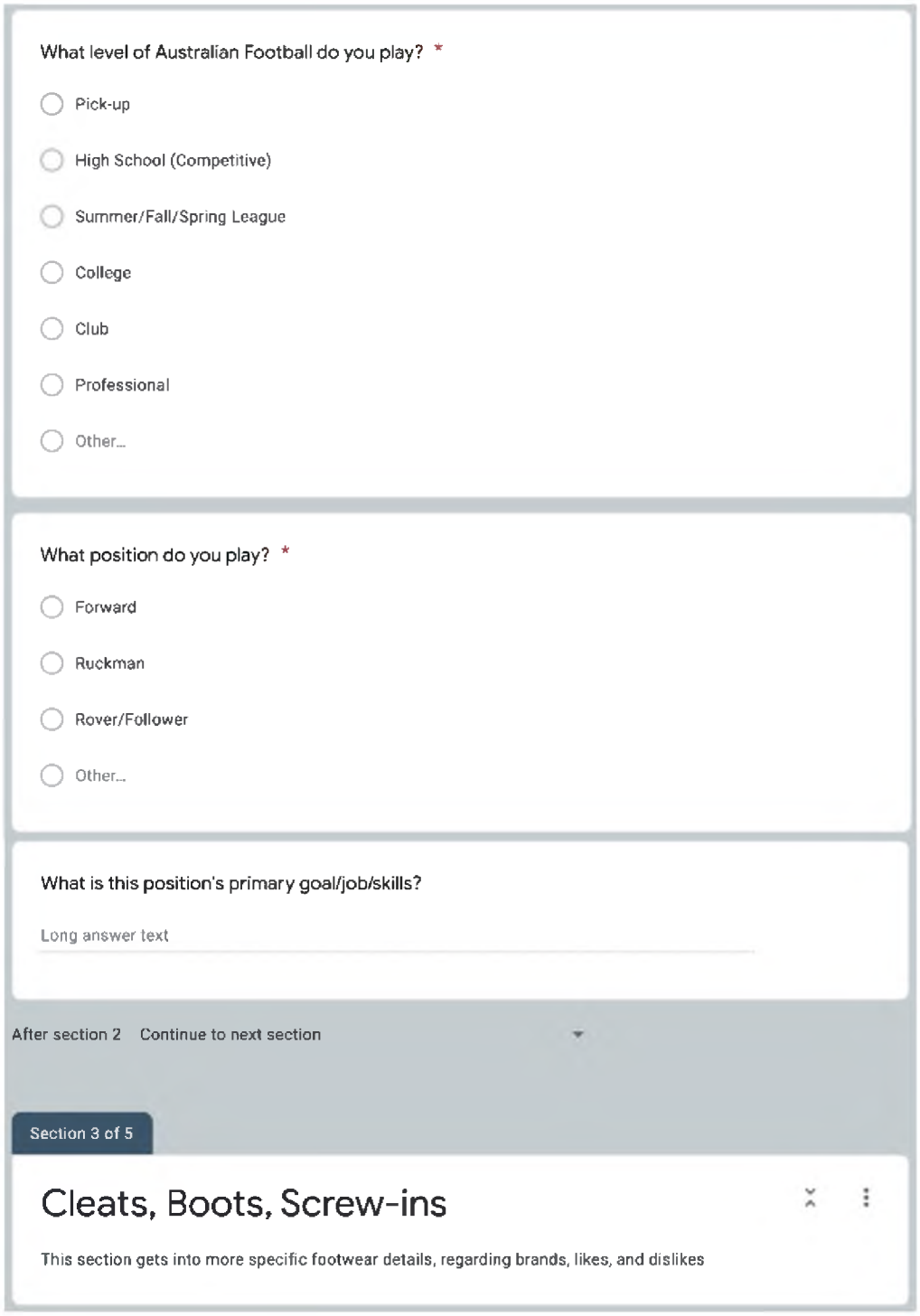
Section 2 of 5

Sport Background

This section will ask about your experience, involvement, and positional background information

How long have you played the sport? *

- 0-1
- 2-5
- 5-10
- 10<


What level of Australian Football do you play? *
Pick-up
High School (Competitive)
Summer/Fall/Spring League
College
Club
Professional
Other...
What position do you play? *
Forward
Ruckman
Rover/Follower
Other...
What is this position's primary goal/job/skills?
Long answer text
After section 2 Continue to next section
Section 3 of 5
Cleats, Boots, Screw-ins
This section gets into more specific footwear details, regarding brands, likes, and dislikes

What cleats, boots, footwear do you currently wear during matches? *

- Adidas
- Asics
- Concave
- Nomis
- Mizuno
- New Balance
- Nike
- Puma
- Under Armour
- Umbro
- X Blades
- Other...

Model

Short answer text

Boots original sport *

1. Football [Soccer]
2. American Football
3. Rugby
4. Other

What do you like most about these cleats?

Long answer text

What do you like least about these cleats?

Long answer text

How long do your cleats typically last?

Short answer text

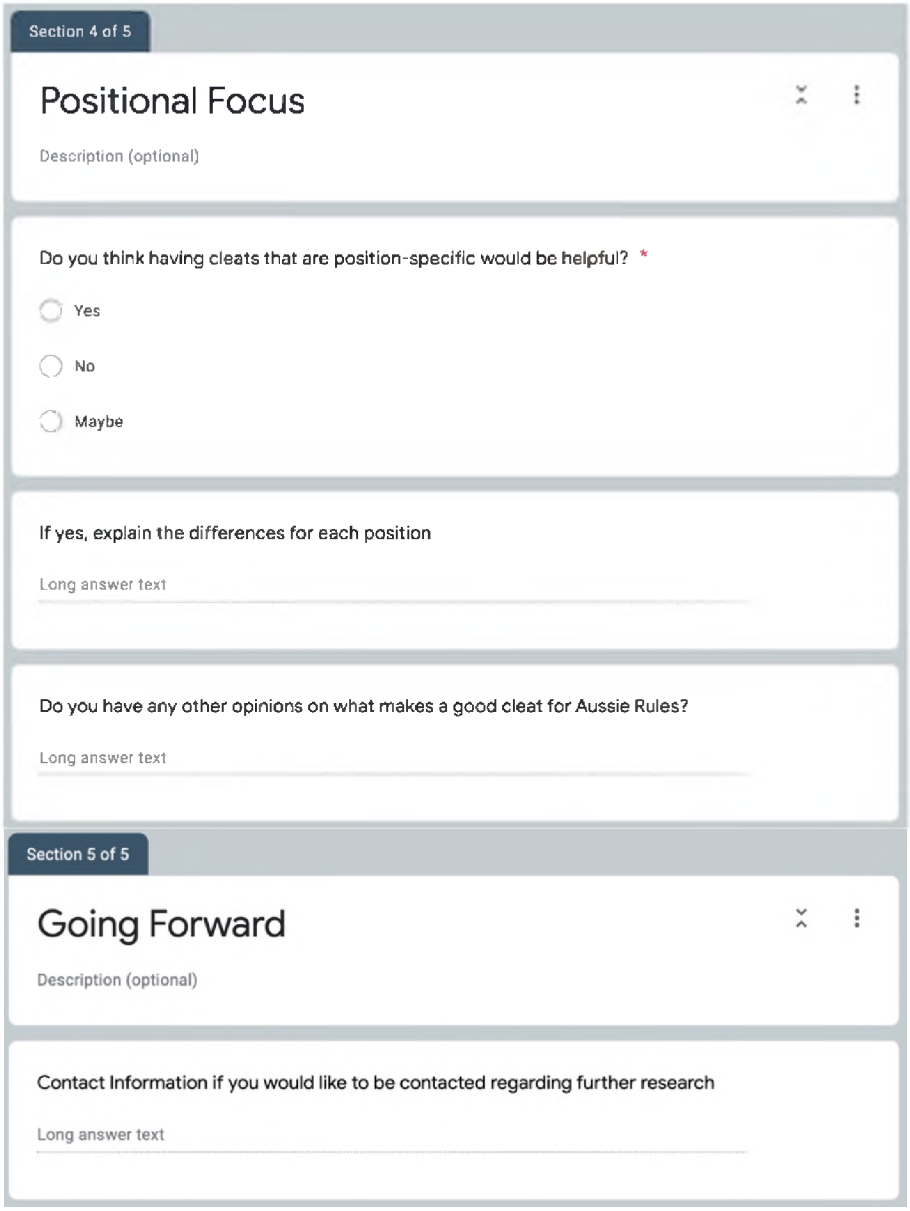


Image 12 An accumulation of screenshots that show the athlete survey sent out

Performance Testing

The proposed footwear competitors will be tested and analyzed to determine a baseline. Three competitor products will be analyzed, Asics Lethal Tigreor, Concave Halo, and Adidas Copasense.1 FG. The selected footwear represents the top-rated kangaroo leather competitors that this research's intervention aims to surpass. The attached slides outline a detailed process of the types of tests and methodology that the competitor footwear will be submitted to. Approximately three athletes will be recruited as wear-testers. These athletes will be males spanning the different positions identified in the positional focus section of this research.

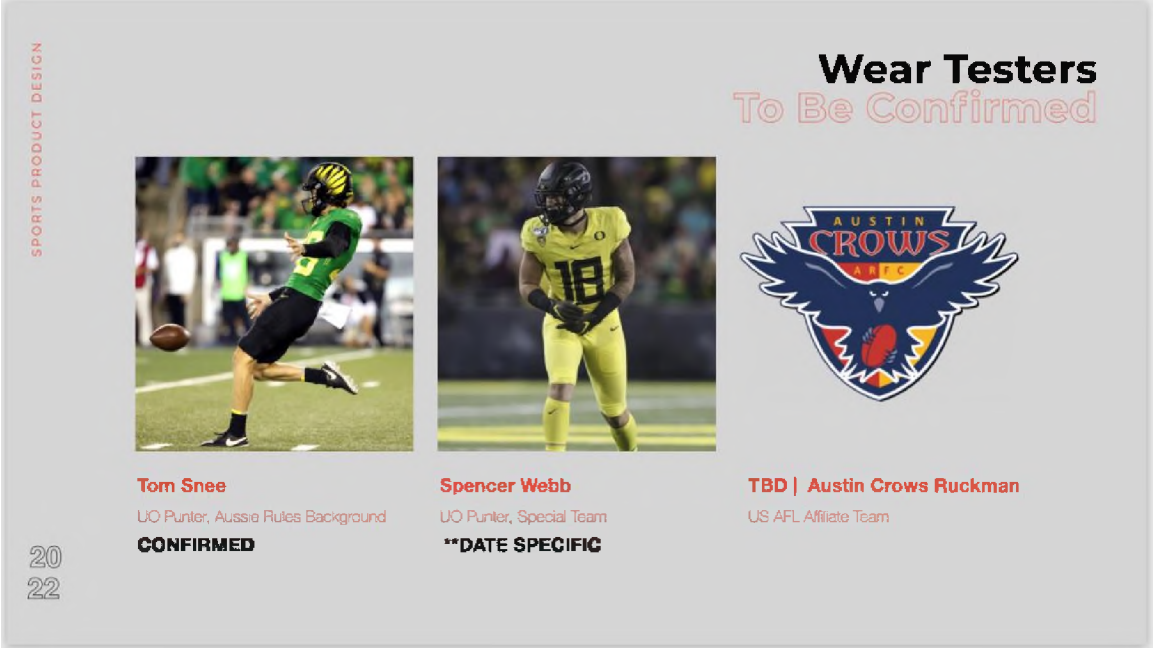


Image 13 Tom Snee and Spencer Webb are the two confirmed wear testers for the Winter term validation and testing analysis

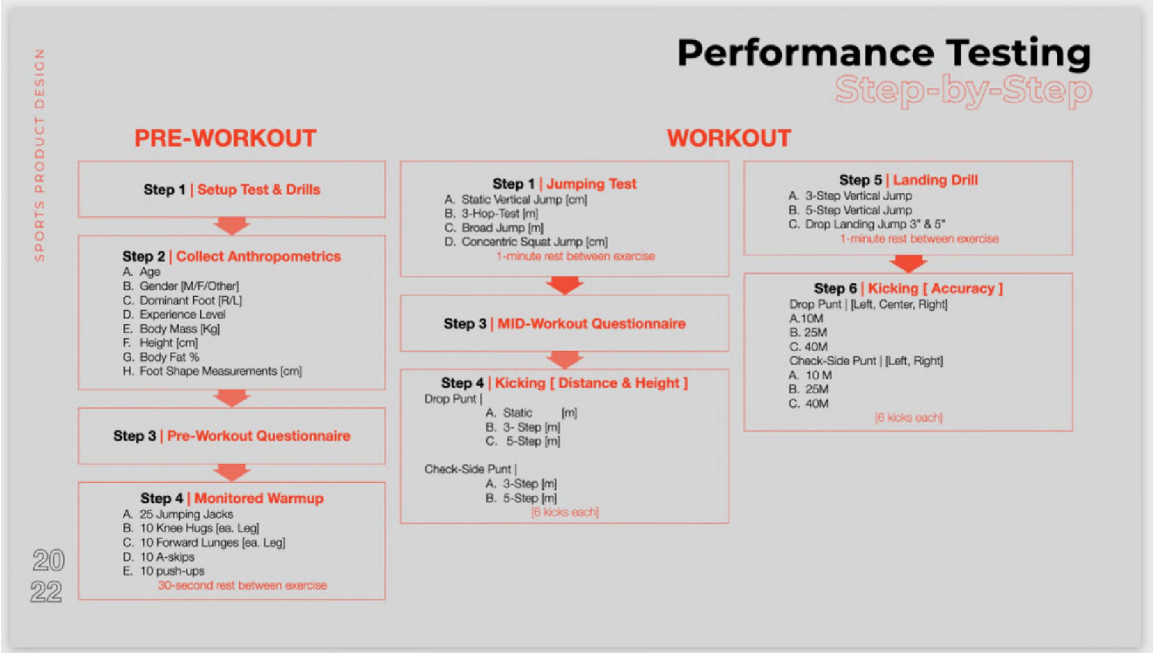


Image 14 Performance testing program breakdown

Proof of Concept Presentation

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HAVOC

THESIS 2022

- ~~The font on slide 7 is not showing up anywhere else, change it out.~~
- ~~Your argument for additive manufacturing is still not strong. You will need to answer to questions that challenge - cost effectiveness, ease of manufacturing, durability, color, etc~~
- ~~If you move away from the clear filament, you will need to update your mood board - unless you will move to white?~~
- ~~It may be worth reaching out to the filament maker and see if they have ideas to stabilize the material color under UV and other handling. This is a problem in the footwear indu~~ ~~and companies add stabilizes in their materials, so they don't yellow too quickly. Also reach out to Proto Pasta and see if they have ideas too.~~
- ~~Explain what the last features are and why you used certain parts.~~
- ~~Lacing is missing or is not so attractive for your uppers - get that figured out. Also label medial/lateral views.~~
- ~~Missing features and benefits for all your footwear designs.~~
- How can you improve your traction performance?
- How can you improve your kicking accuracy performance?
-

BRYANT JIMENEZ, 24

UO Graduate with degrees in Architecture, Digital Arts and Romance languages

I WANT TO INNOVATE AND IMPROVE ATHLETE PERFORMANCE IN SPORTS

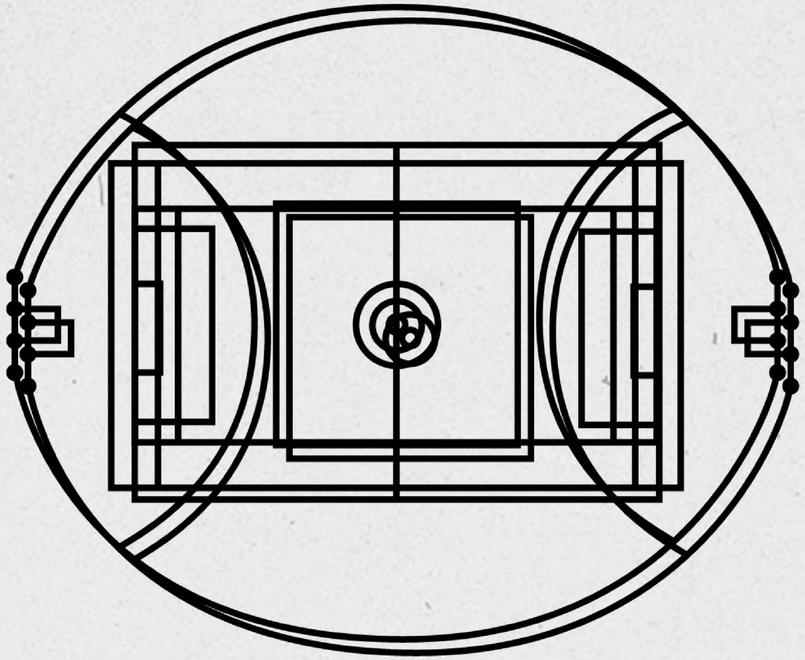
POST GRADUATION

I want to pursue Footwear Design through sample making or 3D Footwear Design in the cleated field or adjacent

HAVOC

THESIS 2022

WHAT IS AUSTRALIAN RULES FOOTBALL?



WHY IS IT IMPORTANT ?

Unlike other popular cleated sports, **only two boot manufacture produce a dedicated boot design**

Fastest growing sport in the Oceanic region

Global Estimated **921.000 participants,** with **720 premiership players** and another 5.400 senior players across other leagues

Despite being a **1.2 billion dollar industry** players have to **resort to sporting football cleats as workarounds**

AUSSIE RULES FOOTBALL

How can we apply **additive manufacturing and engineered lattice** structures **to address the positional needs** of Australian Football athletes

With 18 positions, the key roles observed are:

RUCKMAN
ROVER
FORWARD

RUCKMAN

Defensive Giants

Average Height 6’5” +

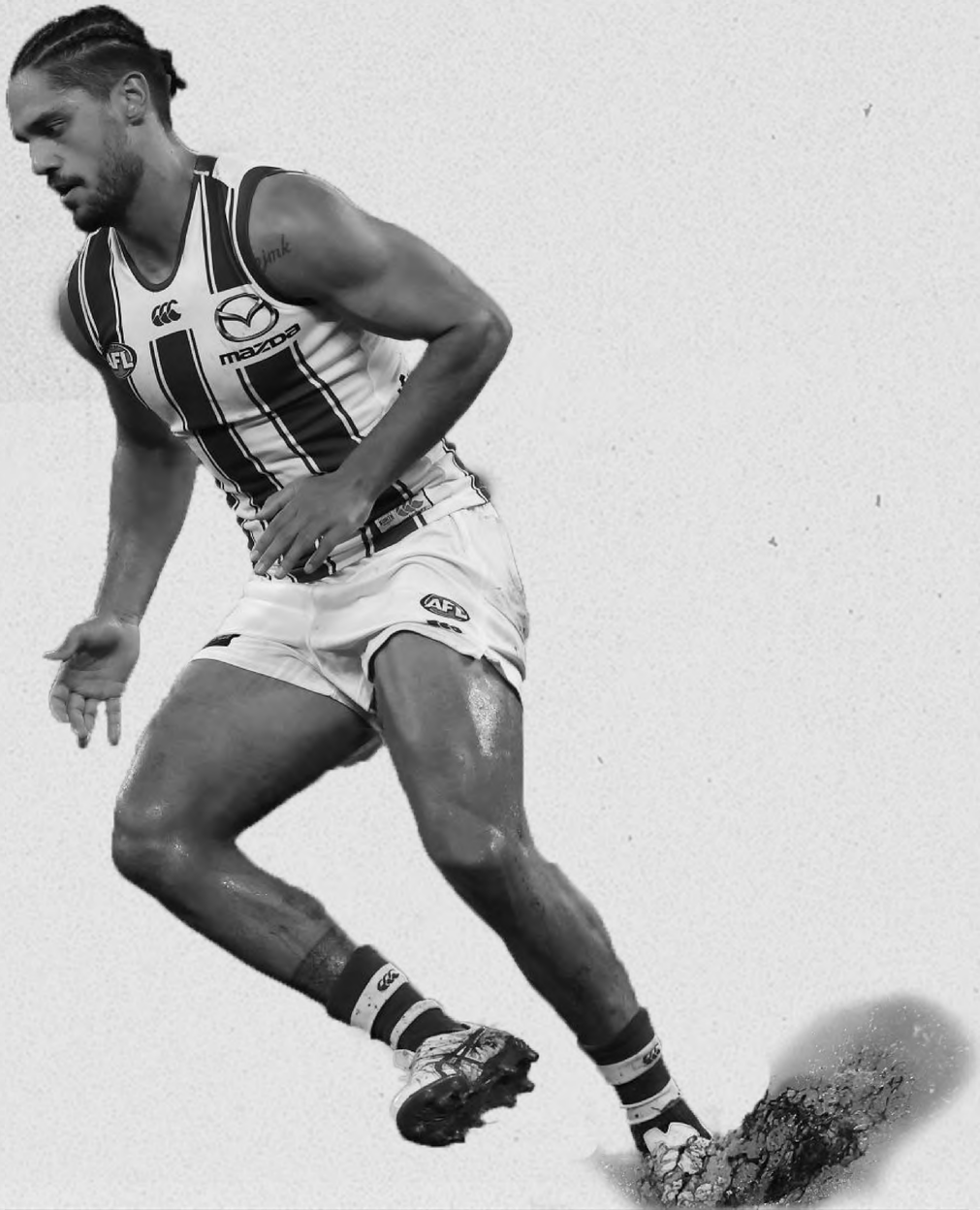
Aerial Collisions

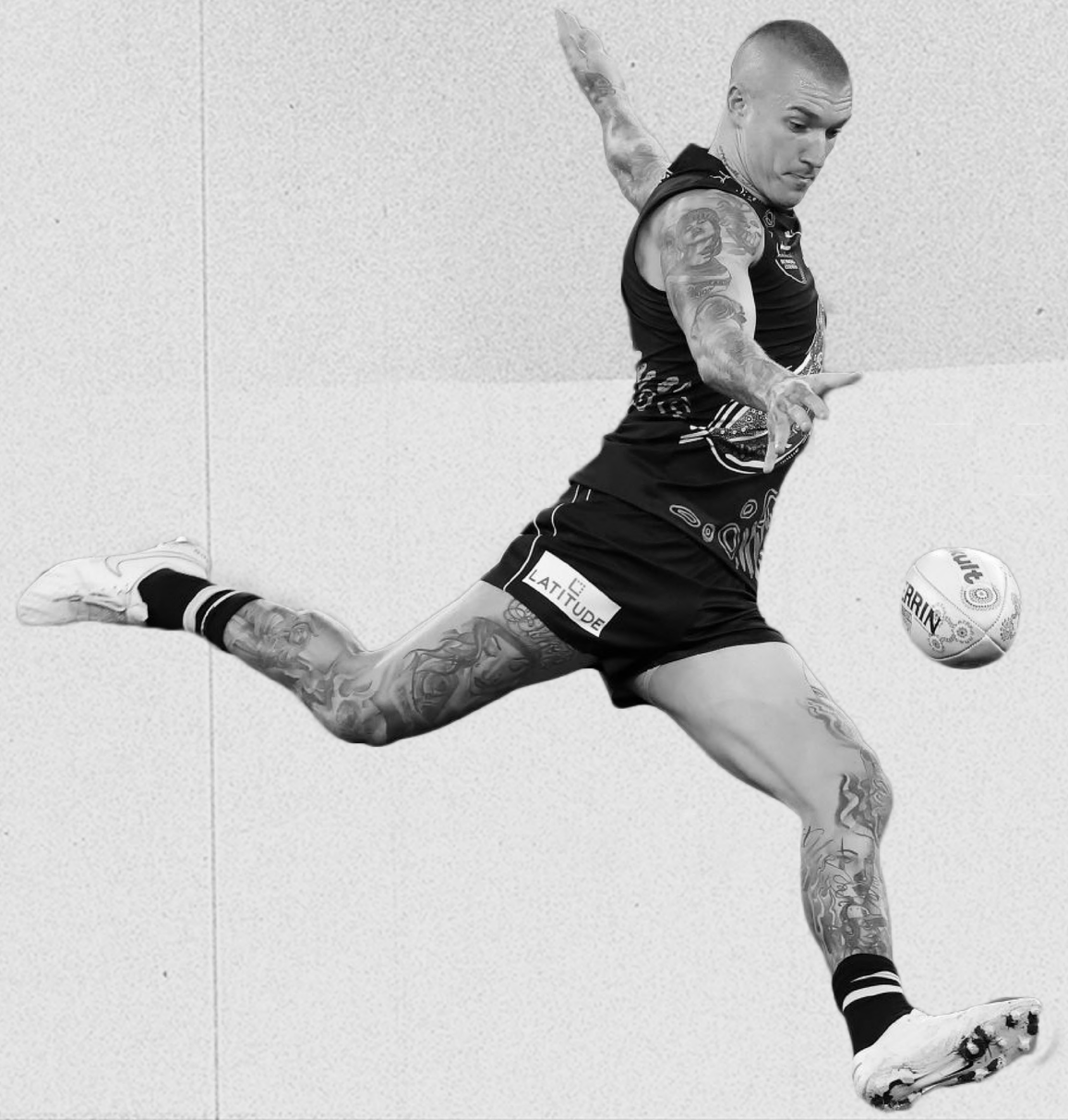
ROVER

Recovers possession

Longest Average Game Distance

Most Versatile Movement





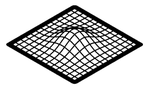
FORWARD

Primary Goalscorer

Most Dynamic Movement

Sprints between 30-60M

POSITIONAL NEEDS



LIGHTWEIGHT

Using 3D printed upper components and 3D lattice midsole to allow for easier acceleration

ROVER / FOLLOWER

FORWARD

RUCK / RUCK-MAN

TRACTION

Developing new stud configurations and shapes to improve forward momentum and reduce foot strain

ROVER / FOLLOWER

RUCK / RUCK-MAN

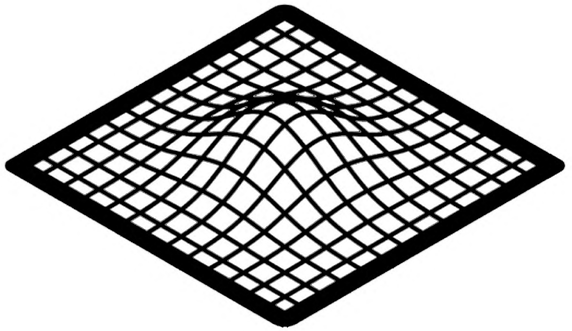
ACCURACY

Redesigning the upper construction to improve kick distance and accuracy with new ball shape

FORWARD

HAVOC PRINT	Upper + Last Form + Lacing System	30% REDUCED WEIGHT
BLR SOLEPLATE	Soleplate + Studs	WITHIN 10% TRACTION OF COMPETITORS
PRCSN-STRIKE	Tongue + Upper	WITHIN 15% ACCURACY

WHY ADDITIVE MANUFACTURING?



WEIGHT
A synthetic material achieves the same amount of durability at a fraction of the weight

MOLDABILITY
Synthetic materials require less break-in time for optimal fit in the toe box

WEATHERING
Less time is needed to dry out the boots if they become wet or are washed

COST
On average the cost of a pair while be a fraction of the cost of genuine leather counterparts

COLOR
TPU and TPE can be manufactured into any color or graphic in a fraction of the time needed for dying leather

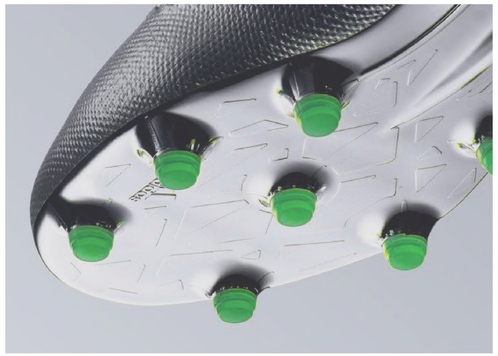
PROGRAMABILITY
Synthetic materials allow for the combinations of numerous technologies onto a boot, which might be impossible with leather as a base upper material

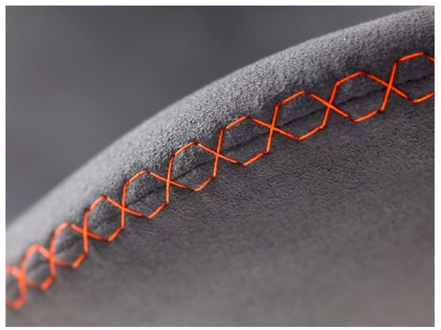
HAVOC COLLECTION

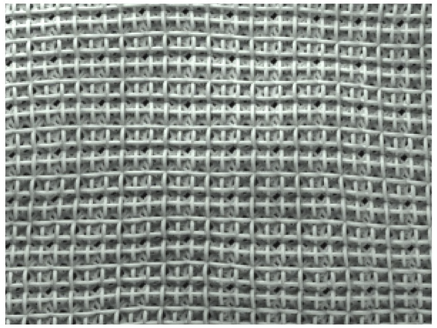
THESIS 2022

MOOD BOARD

Textures & Silhouettes
Aesthetically Details







COLOR PALETTE

Primary Colors &
Secondary Colors

 # 1C181C

C 0 M 8 Y 0 K 89
R 28 G 24 B 28

 # F26B1D

C 0 M 53 Y 84 K 5
R 242 G 107 B 29

 # 63B597

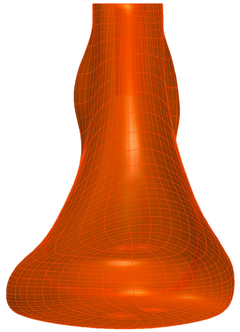
C 32 M 0 Y 12 K 29
R 99 G 181 B 151

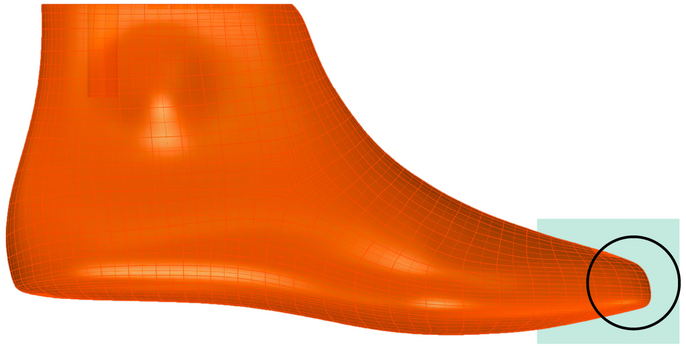
LAST REDESIGN

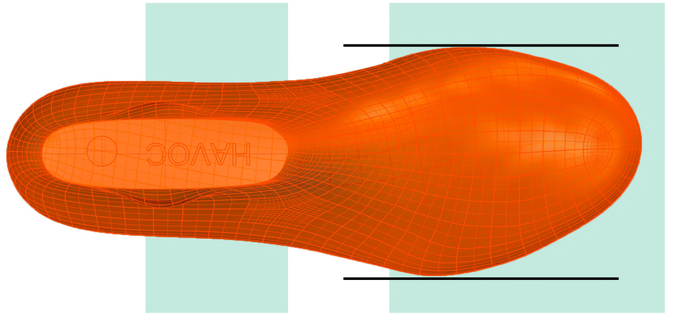
Last Creation
Since there is no precedent last, I created a last shape from similar anthropometric features of American Football , Soccer and Running Last

Last Features
Widened Toe Box - A better fit based on Aussie Rules' player foot morphology
Dorsiflexed MidFoot - Creating a 'propelled' stance similar to a track spike
Reduced Toe Spring - With no driven ball striking, the toe's spring can be relaxed
Widened Metatarsal Angle - Reshaping the toe box for a wider planting base

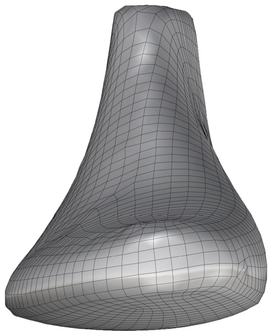
HAVOC LAST

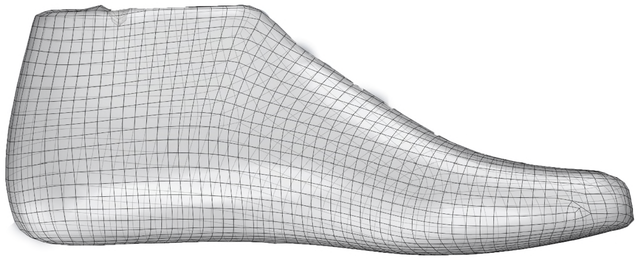


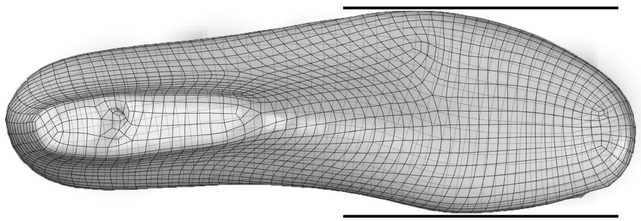




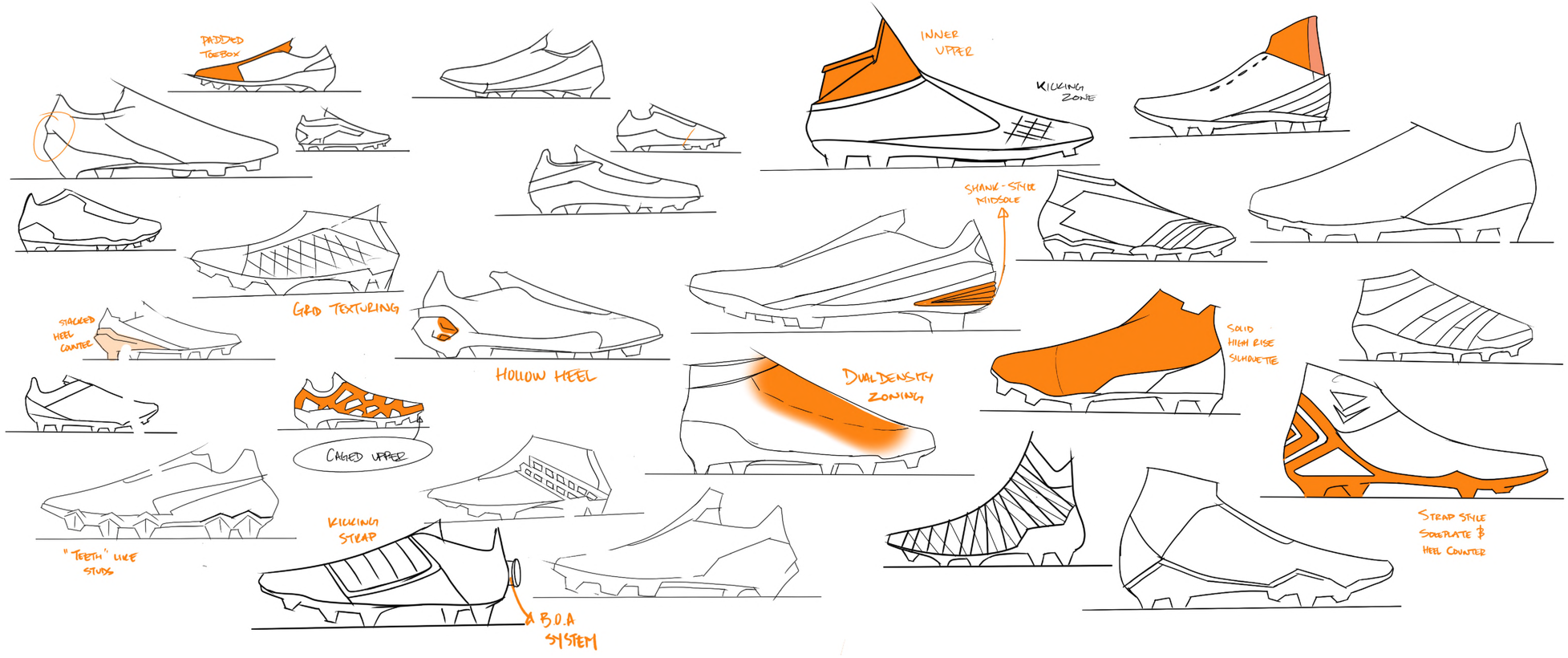
SOCCER LAST

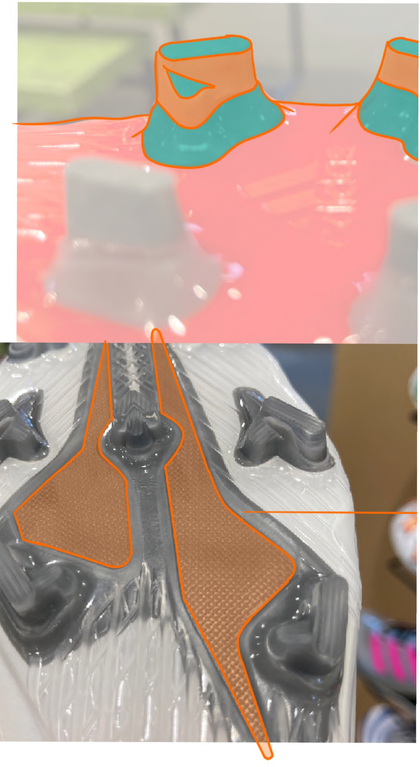




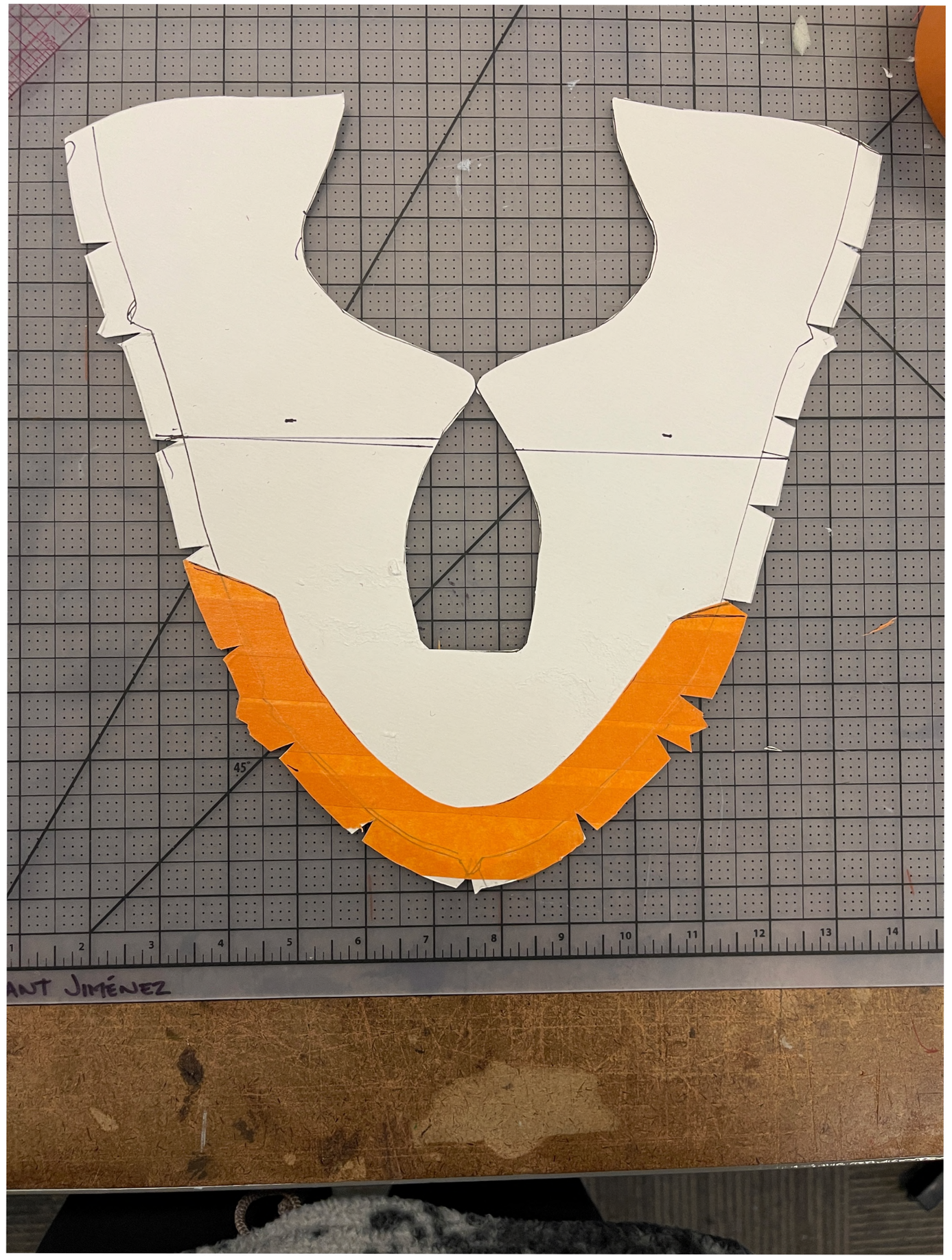


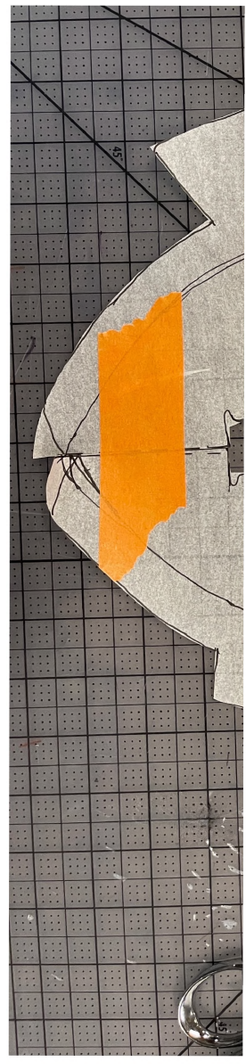
IDEATION

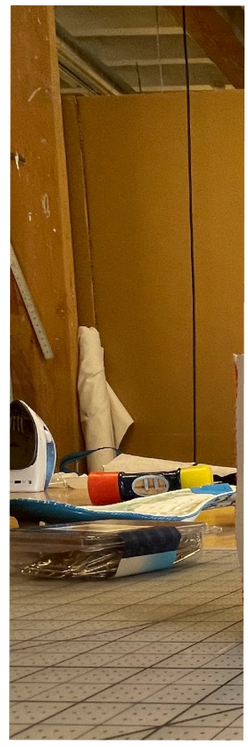

PADDED TOEBOX
INNER UPPER
KICKING ZONE
SHANK - STYLE MIDSOLE
GRID TEXTURING
STACKED HEEL COUNTER
HOLLOW HEEL
DUAL DENSITY ZONING
SOLID HIGH RISE SILHOUETTE
CAGED UPPER
"TEETH" LIKE STUDS
KICKING STRAP
B.O.A SYSTEM
STRAP STYLE SOLEPLATE & HEEL COUNTER



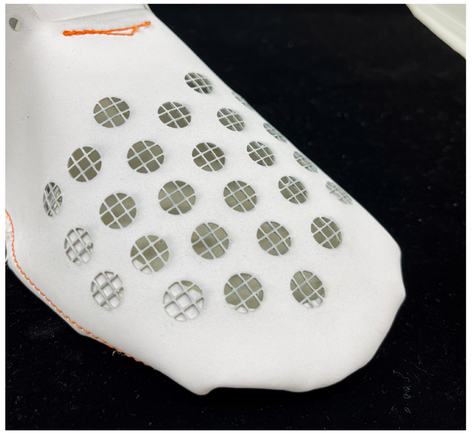
PATTERNING

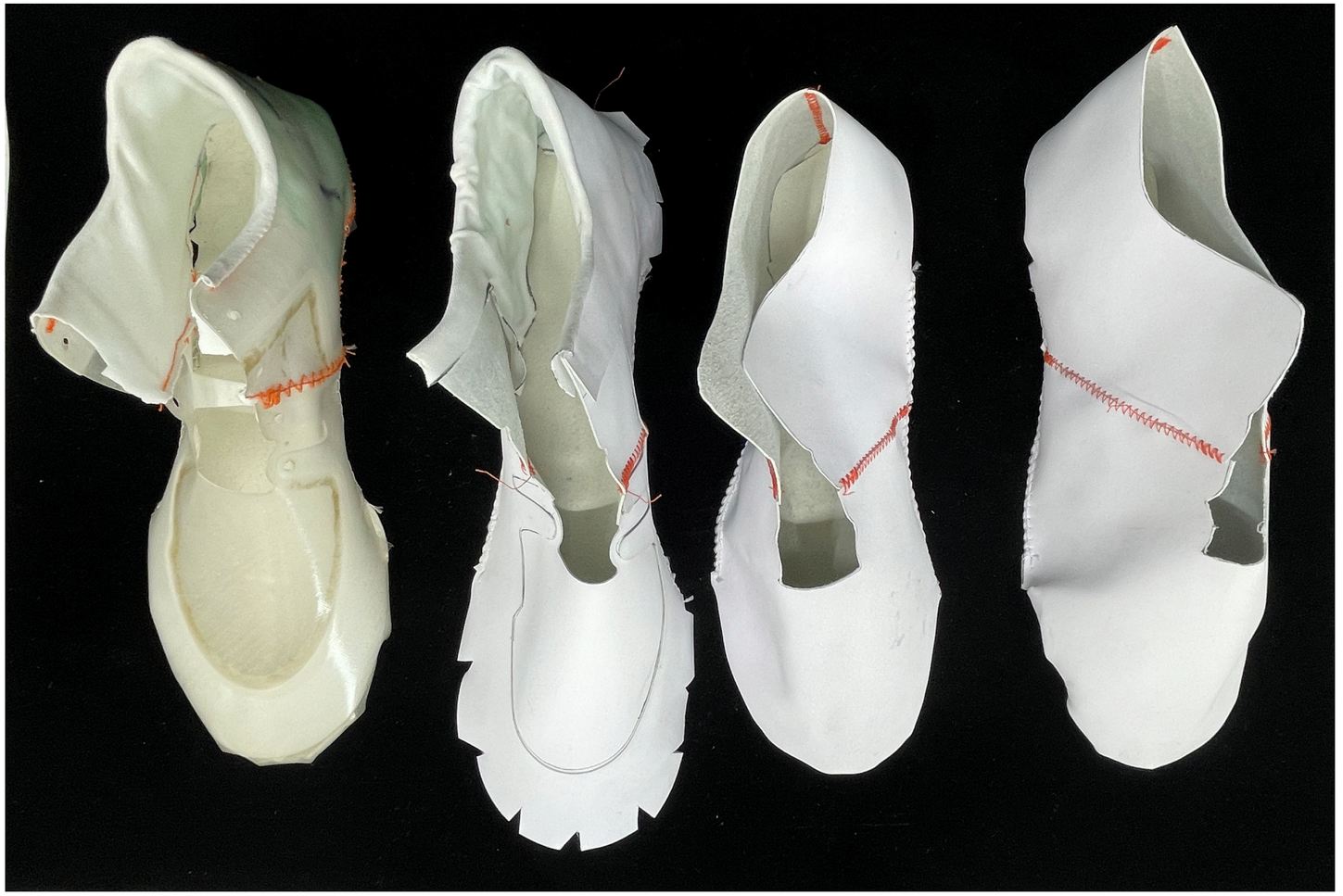






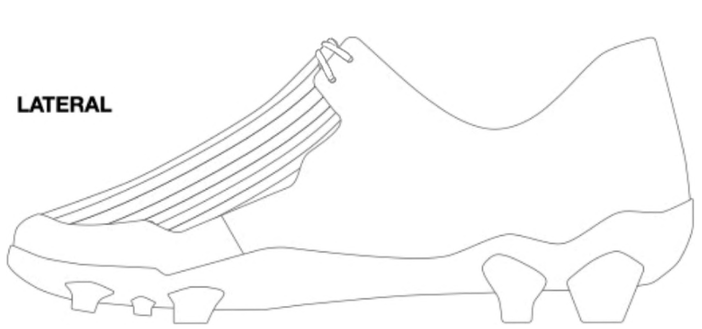
PROTOTYPING

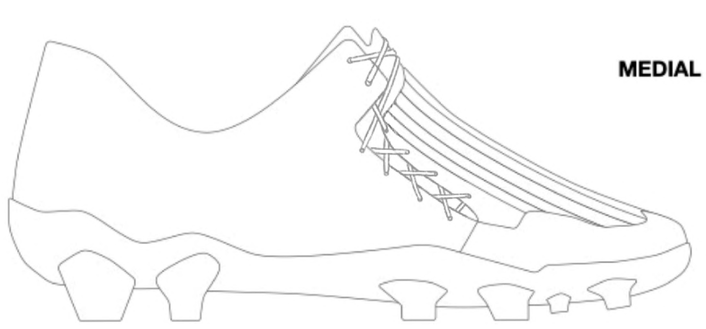




UPPER DESIGNS

ROVER

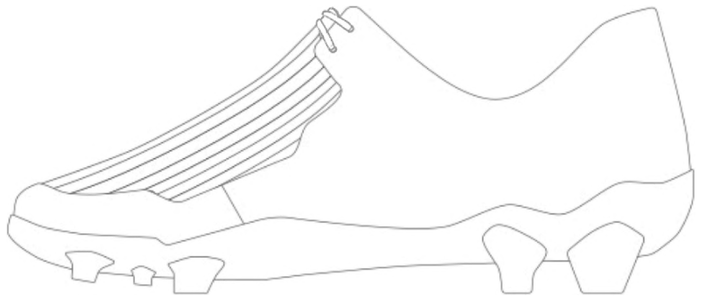


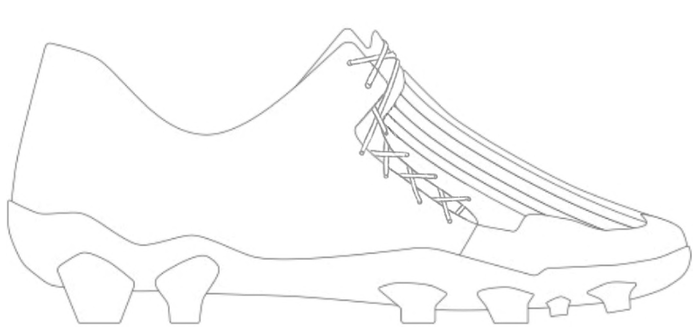


FORWARD

RUCKMAN

FEATURES & BENEFITS





ROVER

3D Textile Construction— A multi-filament upper, for a lightweight and easily modified upper
Internal Cage- Using a two layer system for increased stability
Lattice Midsole Insert- A cushioned insole provides exceptional comfort
Redesigned Cleatplate - For improved traction during dynamic movement

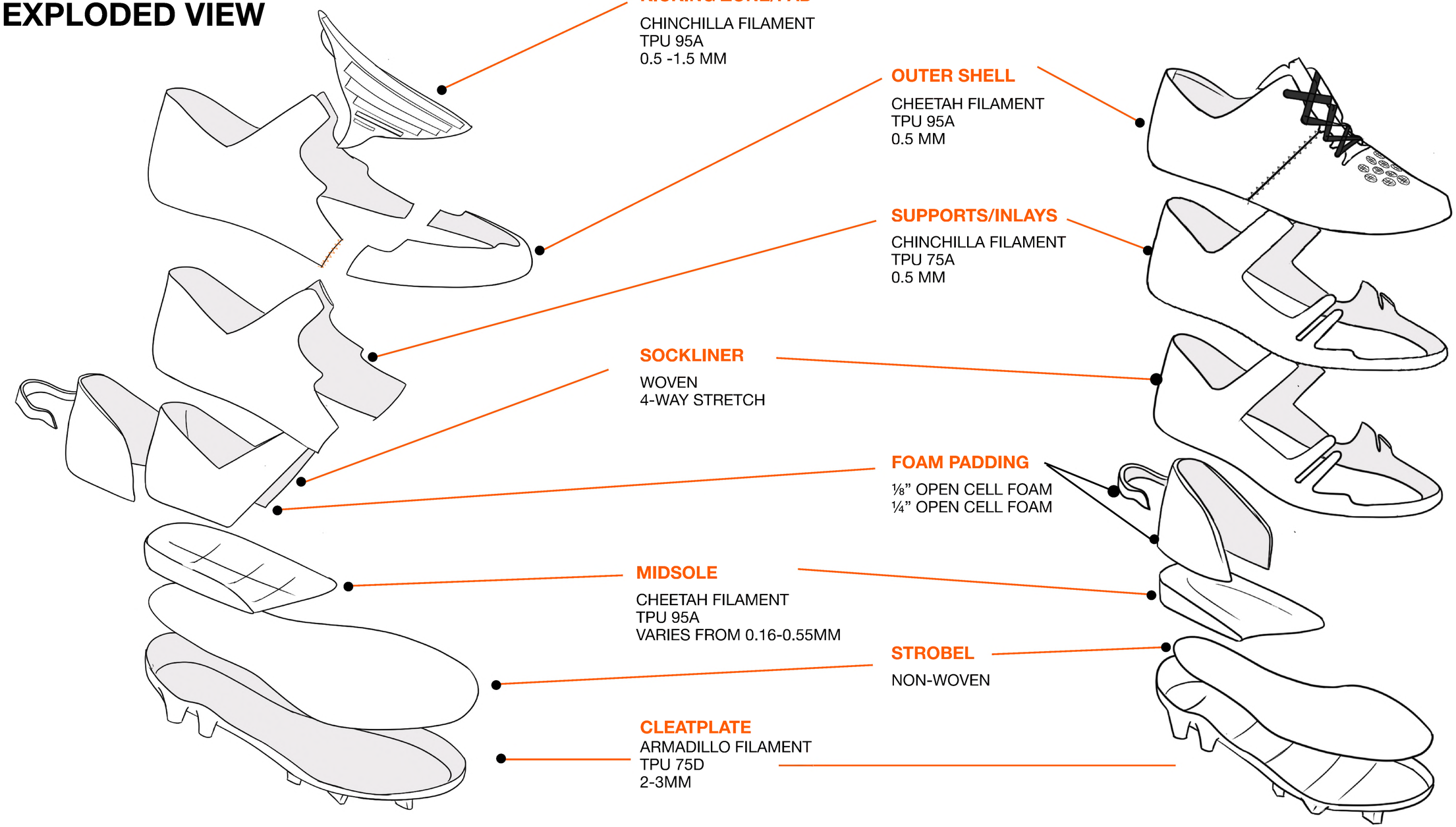
FORWARD

Impact Absorbing Kicking Pad — A targeted filament component for increased accuracy and reduced foot strain
Sideways Lacing- Unique lacing system for maximizing the kicking surface along the vamp and top of foot
Targeted Construction- Using a combination of filaments to provide stretch or impact absorption
Redesigned Cleatplate - For improved traction during dynamic movement

RUCKMAN

3D Textile Construction— A multi-filament upper, for a lightweight and easily modified upper
Mid-Height— A taller silhouette allows for more lockdown for the ankle and base of the foot
Lattice Midsole Insert- A cushioned insole provides exceptional comfort
Redesigned Cleatplate - For improved traction during dynamic movement

EXPLODED VIEW



KICKING ZONE/PAD

CHINCHILLA FILAMENT
TPU 95A
0.5 -1.5 MM

OUTER SHELL

CHEETAH FILAMENT
TPU 95A
0.5 MM

SUPPORTS/INLAYS

CHINCHILLA FILAMENT
TPU 75A
0.5 MM

SOCKLINER

WOVEN
4-WAY STRETCH

FOAM PADDING

⅛” OPEN CELL FOAM
¼” OPEN CELL FOAM

MIDSOLE

CHEETAH FILAMENT
TPU 95A
VARIES FROM 0.16-0.55MM

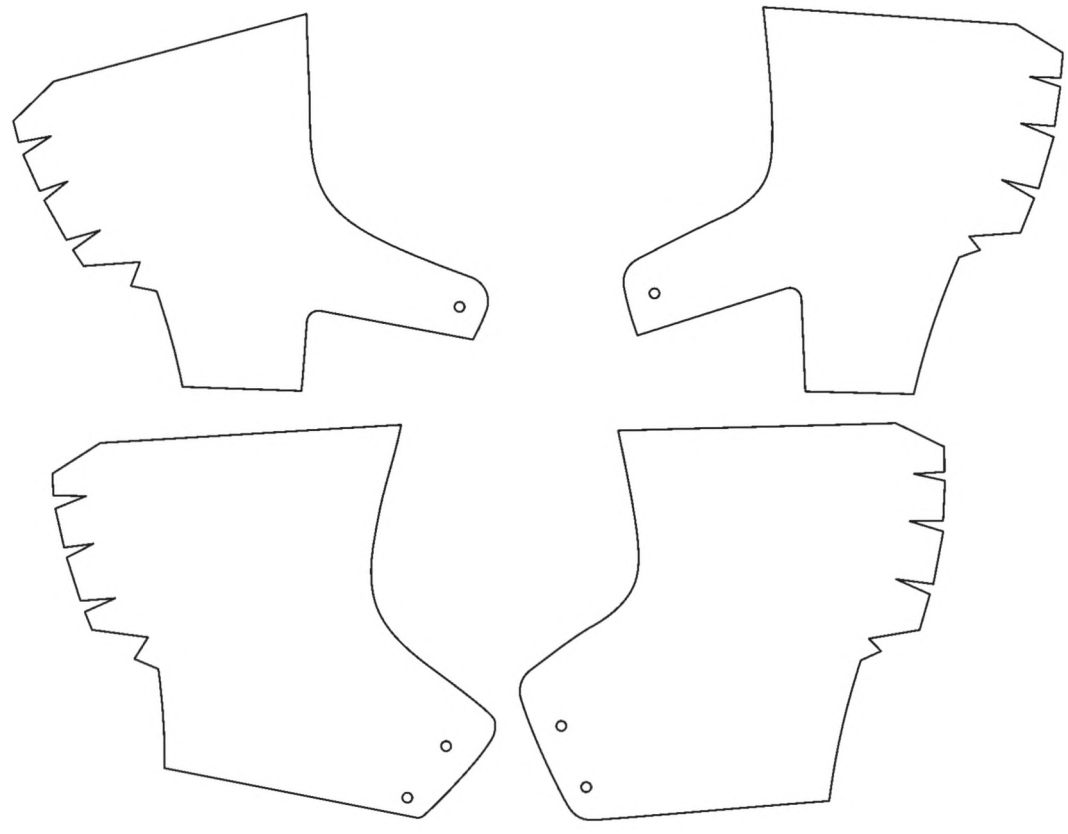
STROBEL

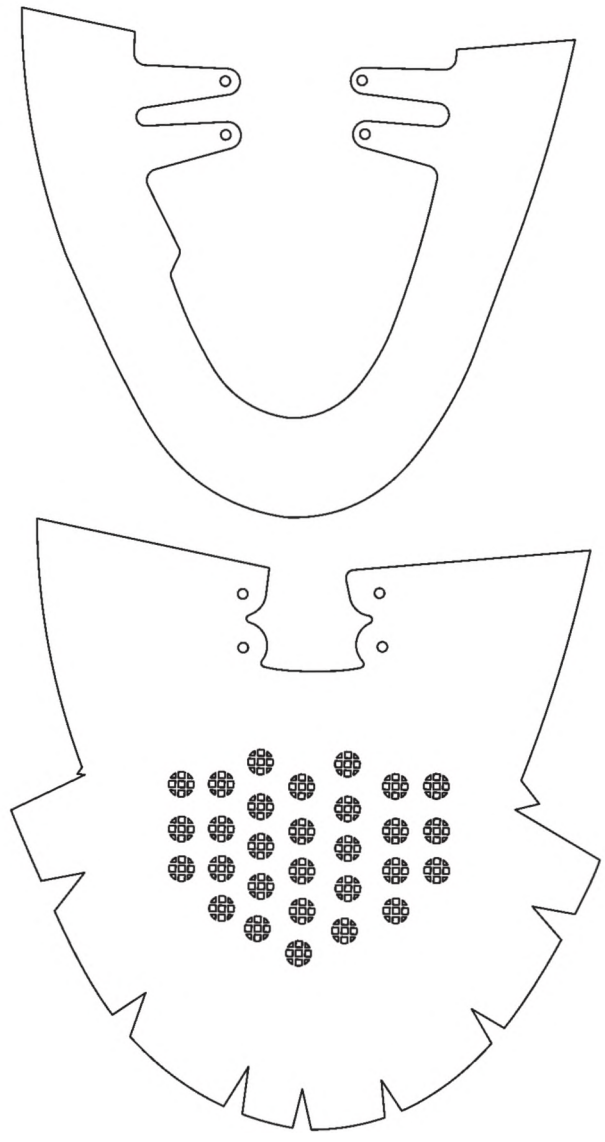
NON-WOVEN

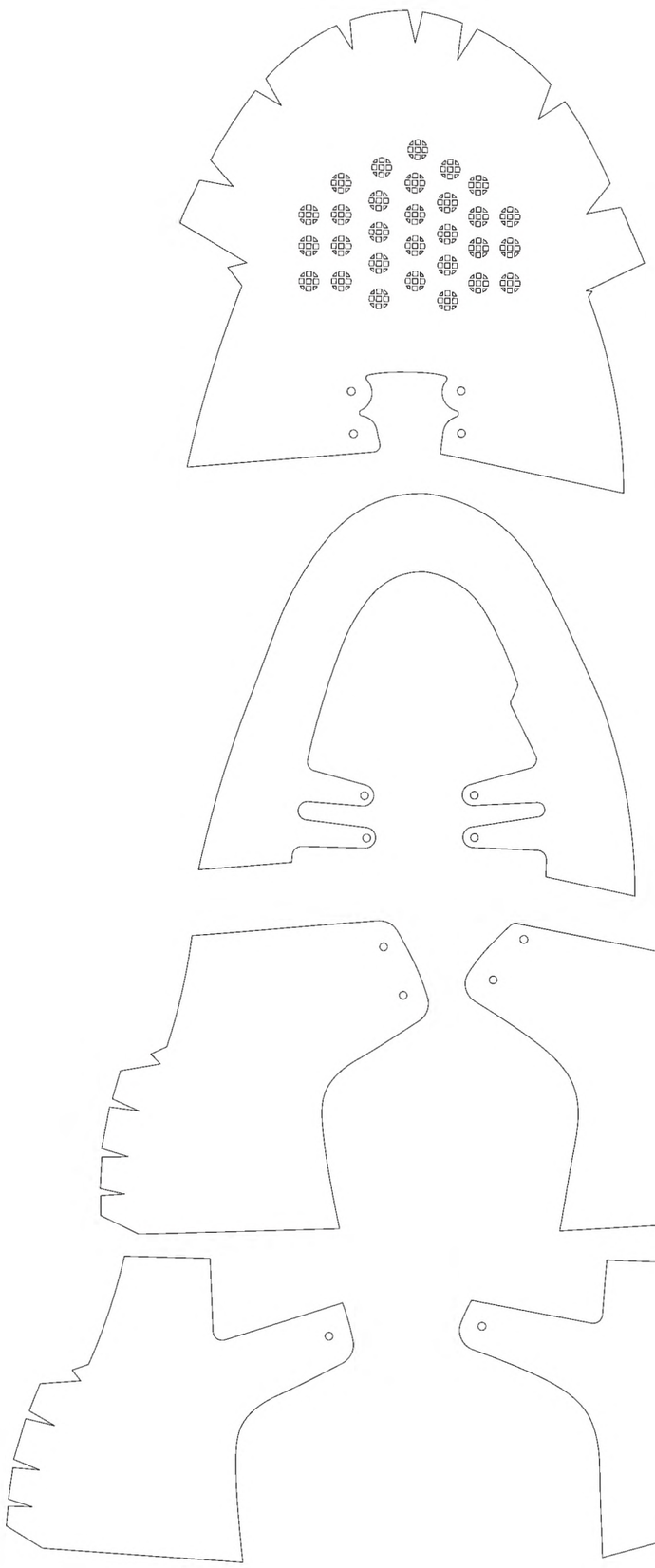
CLEATPLATE

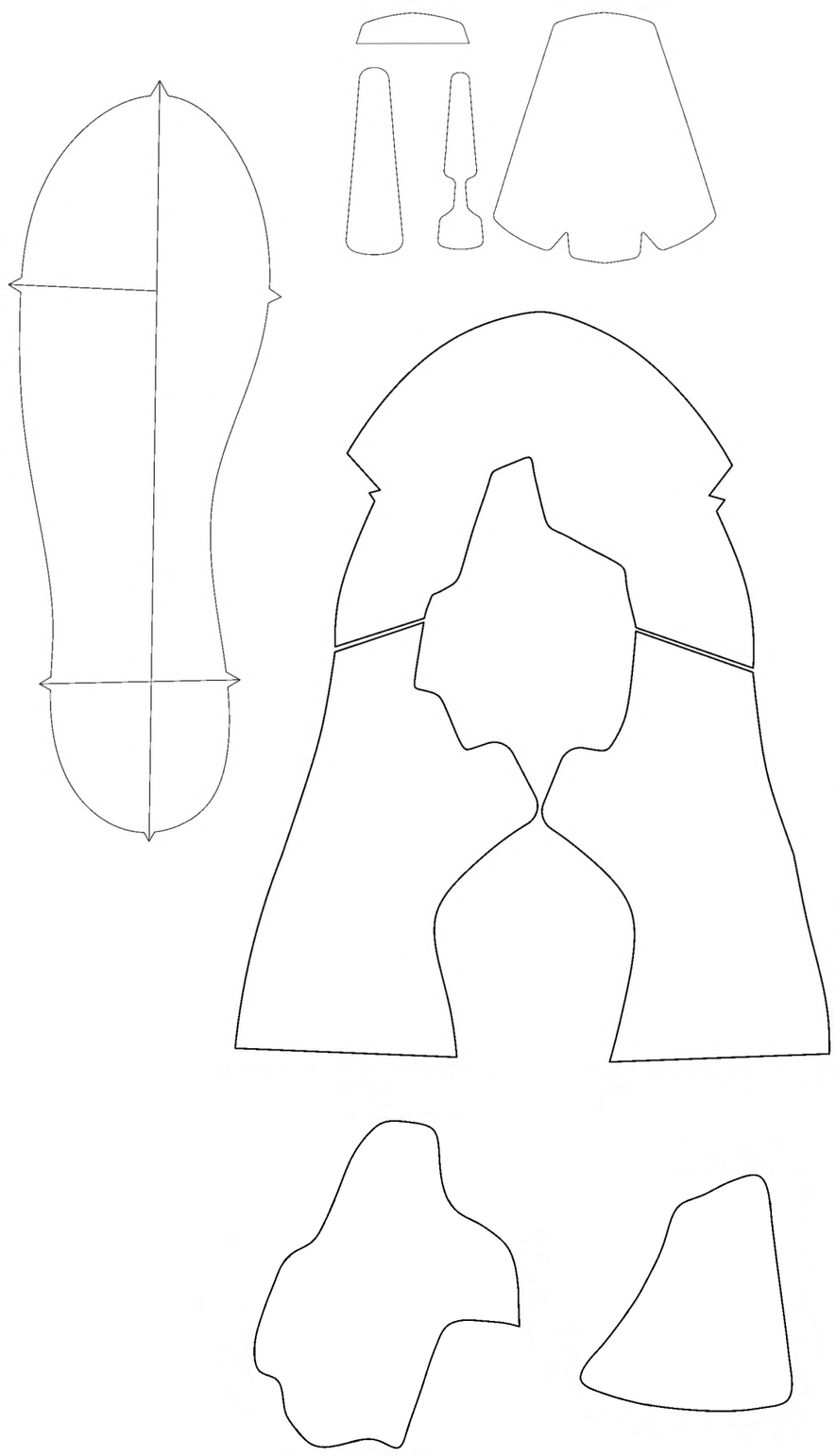
ARMADILLO FILAMENT
TPU 75D
2-3MM

UPPER BUTTERFLY PATTERNS

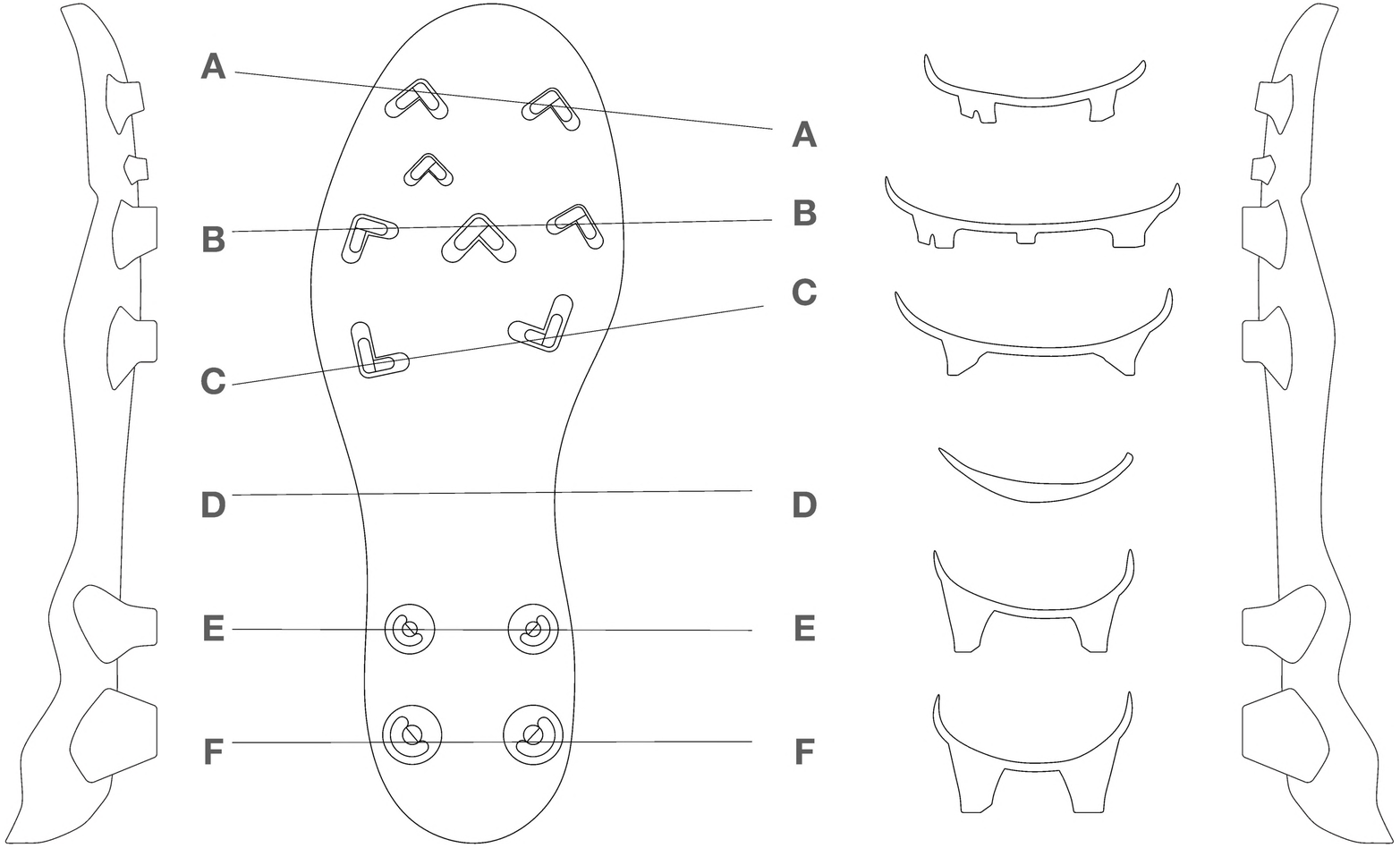


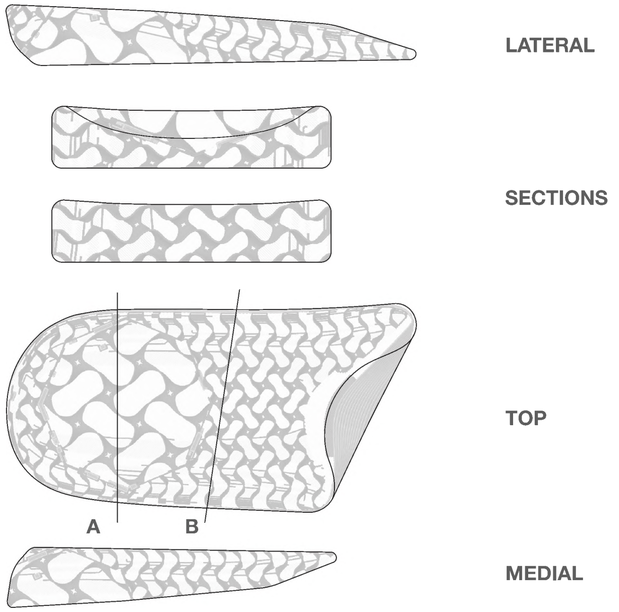




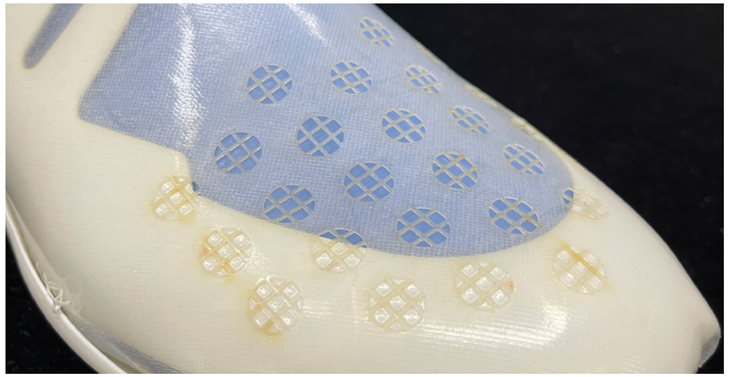


BLR SOLEPLATE & MIDSOLE SHANK





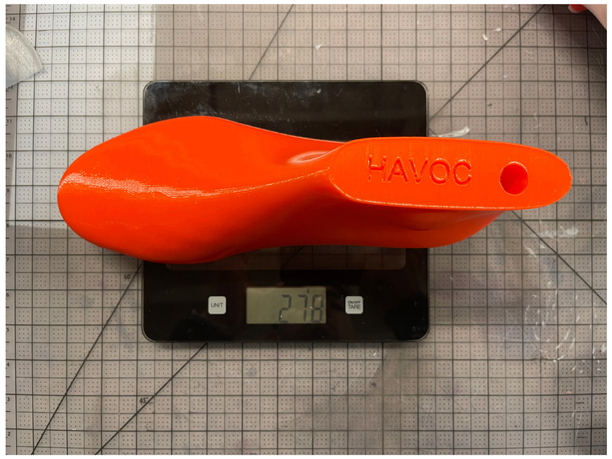
PROOF OF CONCEPTS

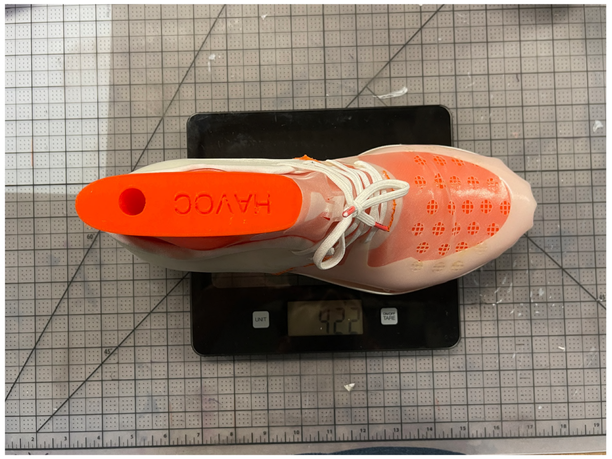


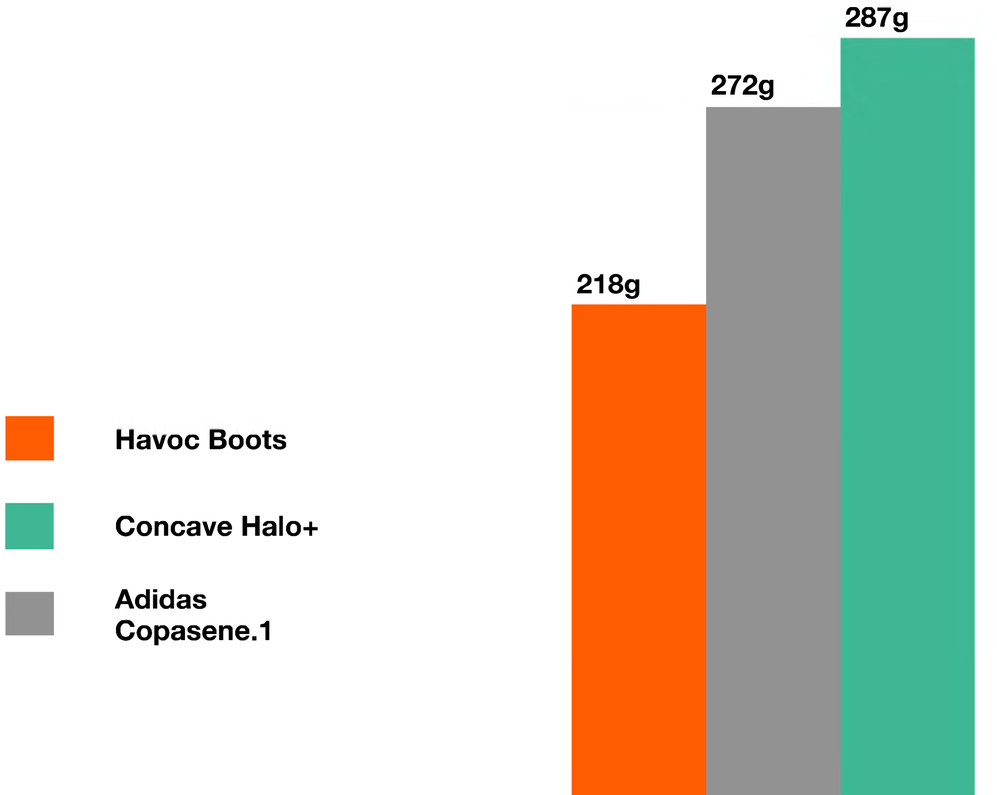
PERFORMANCE TESTING

WEIGHTS

The cleats were weighed out-of-box, with insoles and laces

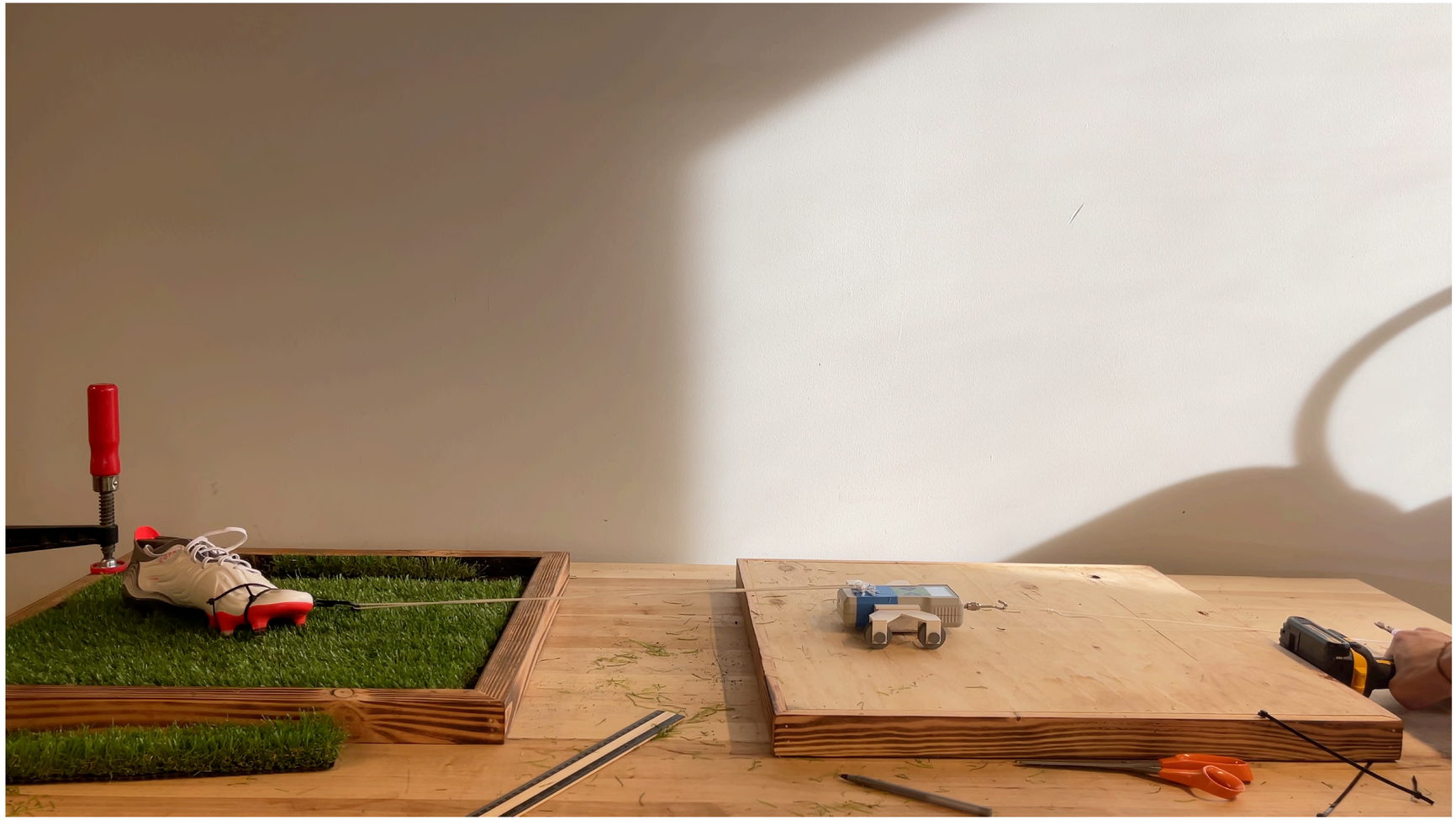






TRACTION TESTING

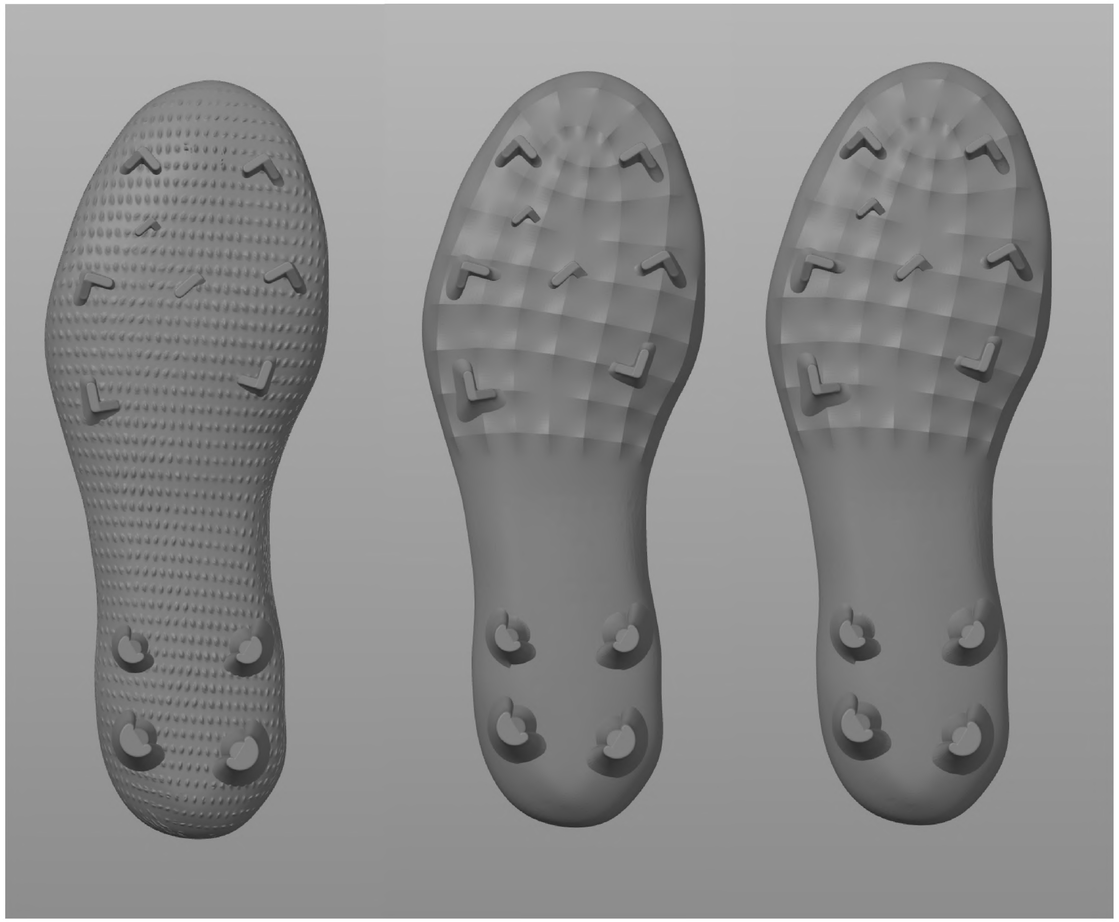
Traction Resistance
Cleats were draped using a pull -system, with a force gauge measuring the necessary resistance to drag along a surface



TRACTION RESULTS

		Adidas Copasense.1	Concave Halo +	Havoc Boot
Direction	Condition	Average	Average	Average
Forward	Dry	17.3 N	15.8 N	16.8 N
	Wet	15.8 N	15.2 N	15.3 N
Right Angled	Dry	33.7 N	31.8 N	32.1 N
	Wet	18.6 N	17.0 N	17.7 N
Left Angled	Dry	31.5 N	30.8 N	30.3 N
	Wet	27.3 N	26.6 N	26.8 N

TRACTION TESTING



Micro-Texturing—Using additional micro textures along the length of the soleplate, additional traction can be extracted from the BLR soleplate

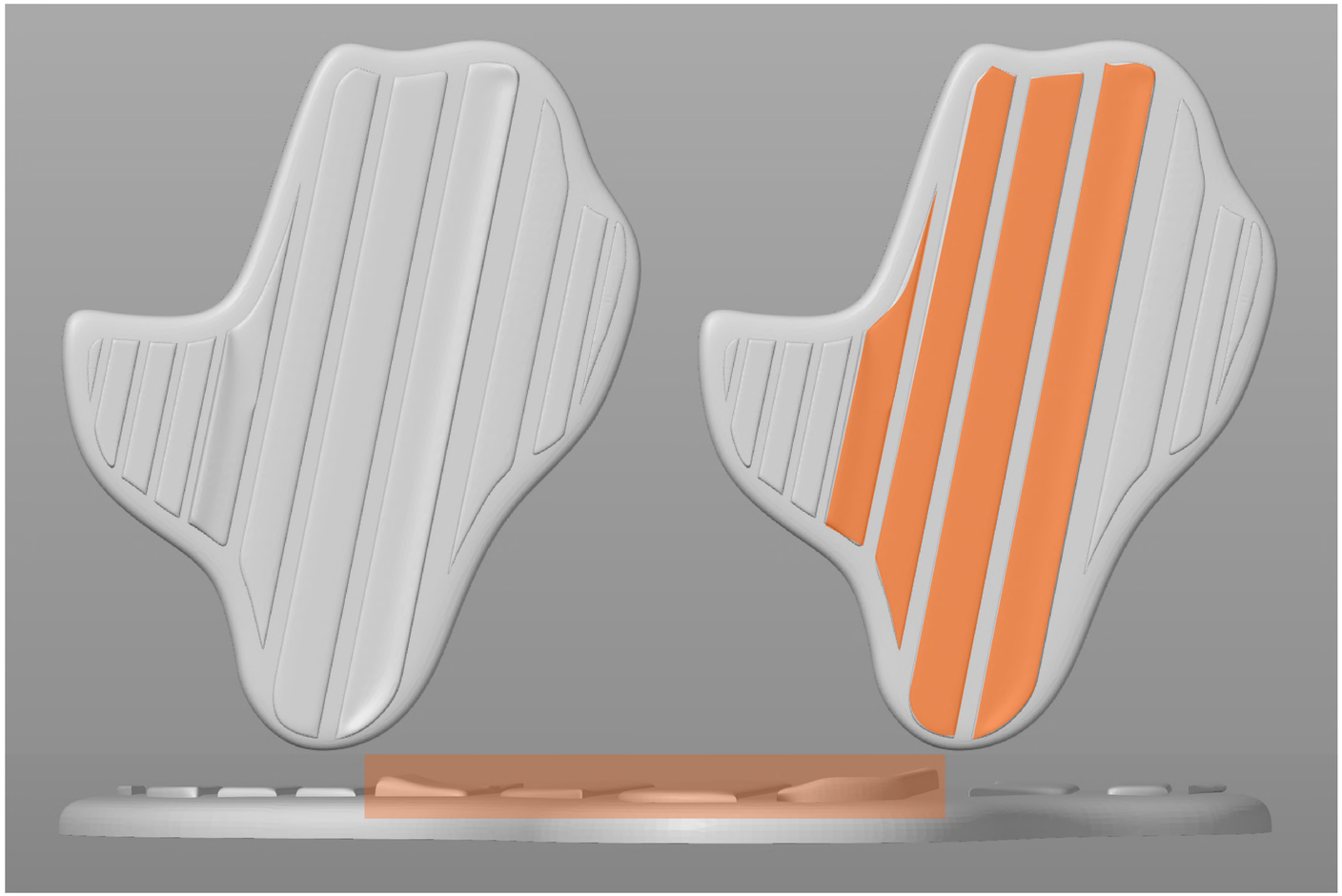
ACCURACY

Drop Ball Test
With a Last Placed inside of the boot, a Sherrin ball was dropped from 2-feet above the lace/kicking zone of the boot

ACCURACY RESULTS

	Adidas Copasense.1	**Concave Halo +**	**Havoc Kicking Boot**
Height	Deviation R/L	Deviation R/L	Deviation R/L
1-Foot	~20 ° RIGHT	~5° LEFT	~10° LEFT
3-Foot	~15° RIGHT	~5° RIGHT	~5° RIGHT

ACCURACY



Reengineering Kicking Pad —By using non-uniform height pads, a flatter and more accurate kicking surface can be constructed

REFLECTIONS

ORDER OF OPERATIONS
The order of adhesive, laser cutting and heat press use can be optimized to reduce yellowing and scorching

COLORWAY
Using a darker material will allow for less visible scoring, as well as the appeal compared to transparent

LEAD TIME
The material takes time to print in sheets, and being limited by the bed size constraint has had unforeseen benefits in patterning

STROBEL APPROACH
Redesigning the patterning to allow for a full strobel will solve puckering issue at the toe of the cleats

ADHESIVES
Since most of these materials are TPU or TPE based not all adhesives will adhere the fabrics together, leading to unforeseen curing and bonding times

CUTTING
Shifting to using a Cricut to cut the patterns from the sheets of filament to eliminate scoring or yellowing

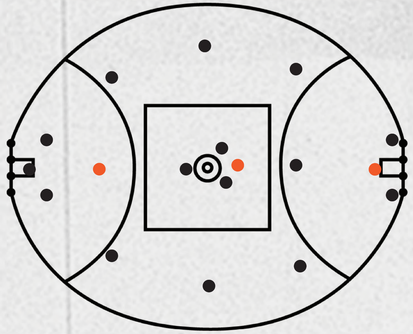
Thank You!

THESIS 2022


25% OF SLAVES ARE CHILDREN
57.000*
ACG.01 KURT
FOAM
DORTMUND

AUSSIE RULES FOOTBALL

HOW CAN WE INTEGRATE ***ADDITIVE MANUFACTURING AND ENGINEERED LATTICE*** STRUCTURES ***TO ADDRESS THE POSITIONAL NEEDS*** OF KEY AUSTRALIAN RULES FOOTBALL PLAYERS?



PITCH

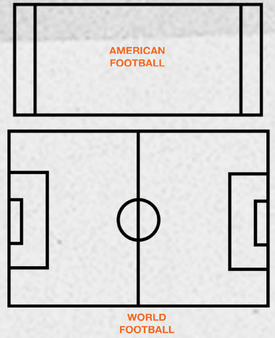
150-180M

18 PLAYERS

SCORING

6
TRY

1
CONVERSION



FORWARD

PRIMARY GOALSCORER
MOST DYNAMIC MOVEMENT
SPRINTS BETWEEN 30-60M
DIRECT GAME TEMPO

ROVER

RECOVERS POSSESSION
LONGEST AVERAGE DISTANCE RUN
MOST VERSATILE MOVEMENT PATTERN
HIGH STAMINA

RUCKMAN

DEFENSIVE GIANT
AVERAGE HEIGHT 6'5"<
AERIAL COLLISIONS
COORDINATE DEFENSE

TECHNOLOGIES

LIGHTWEIGHT

Using 3D printed upper components and 3D lattice midsole to allow for easier acceleration

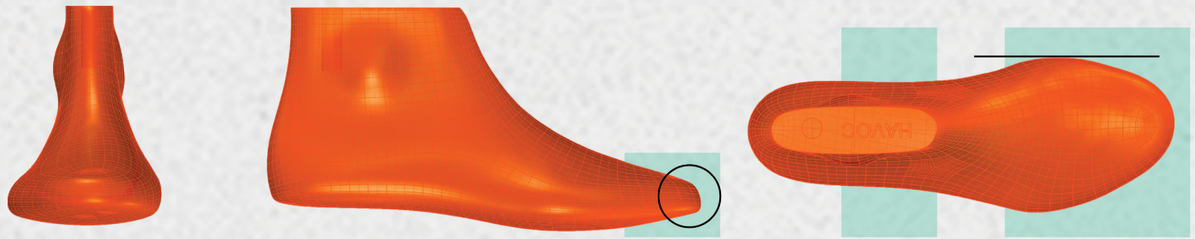
TRACTION

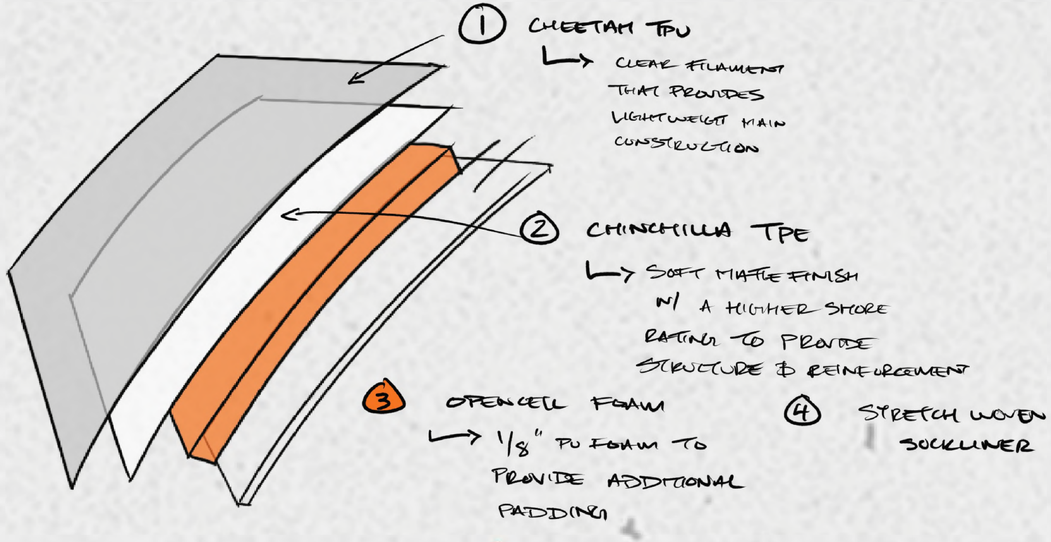
Developing new stud configurations and shapes to improve forward momentum and reduce foot strain

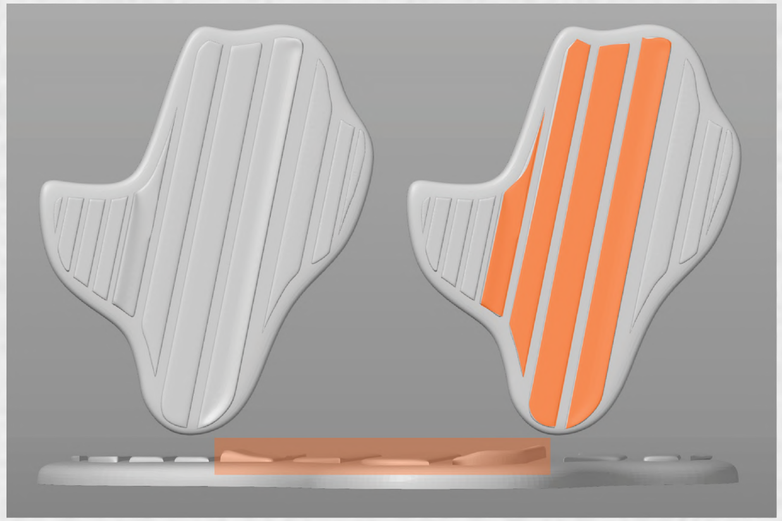
ACCURACY

Redesigning the upper construction to improve kick distance and accuracy with new ball shape

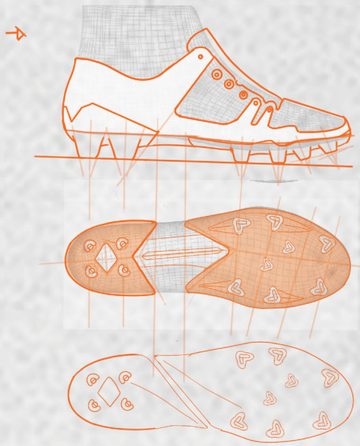
HAVOC LAST

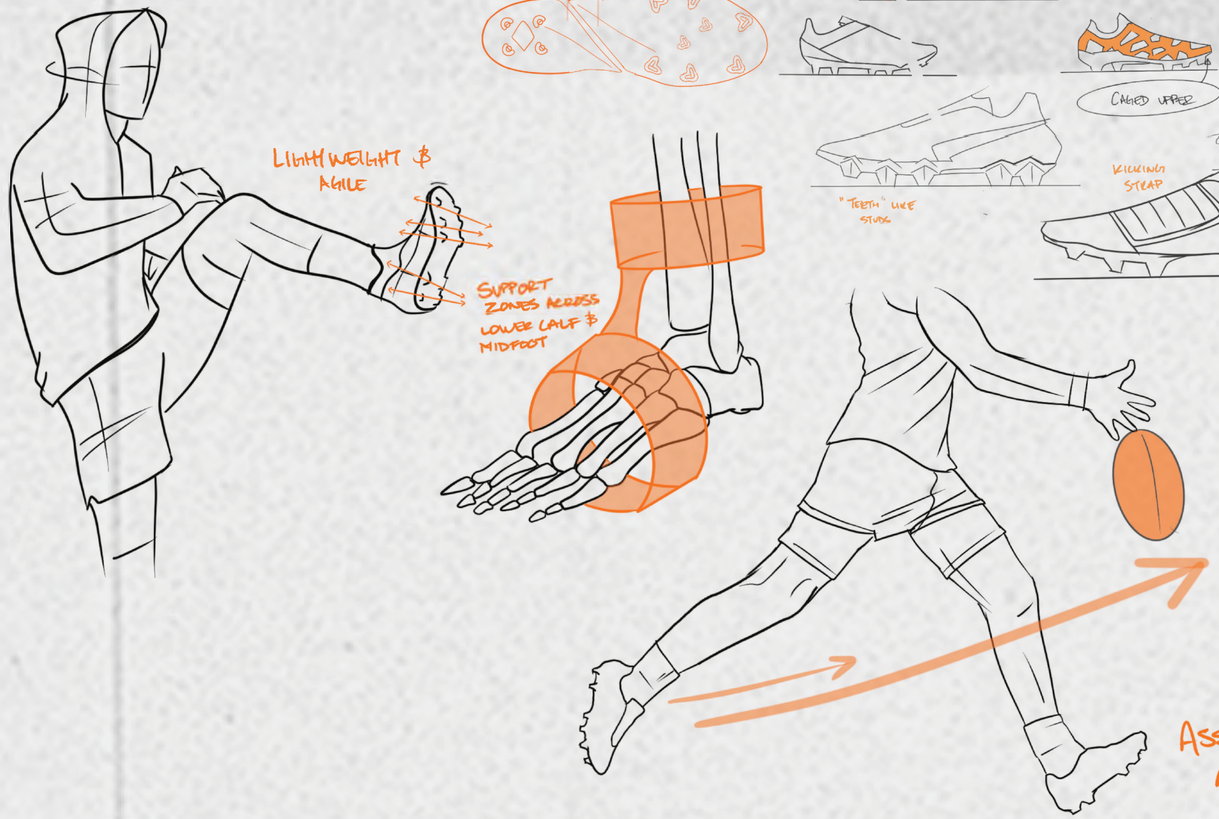


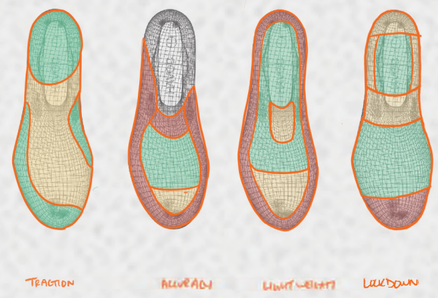


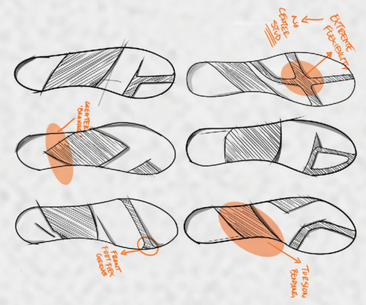


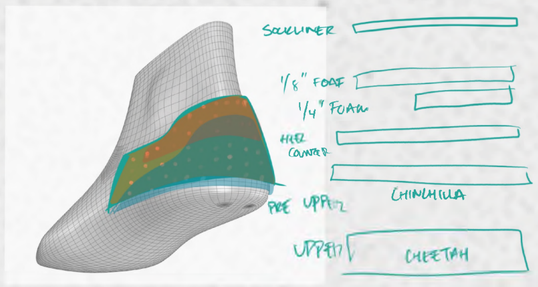
EARLY IDEATION

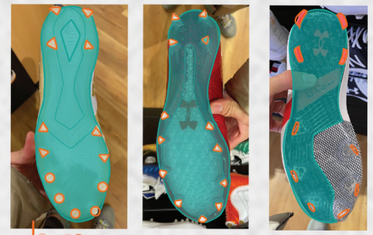




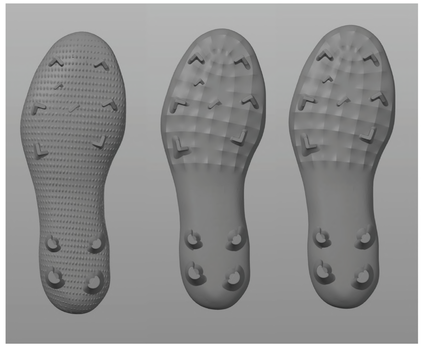




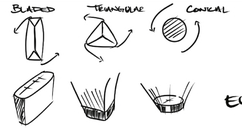


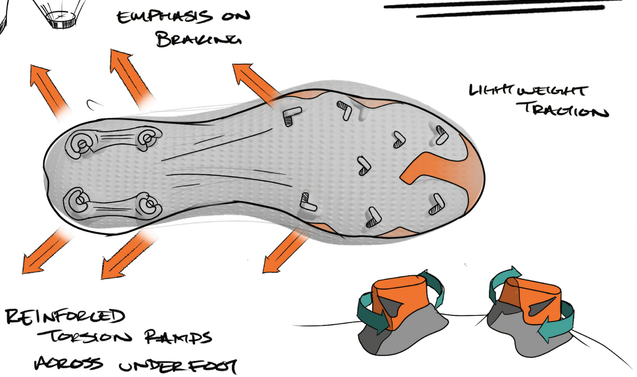


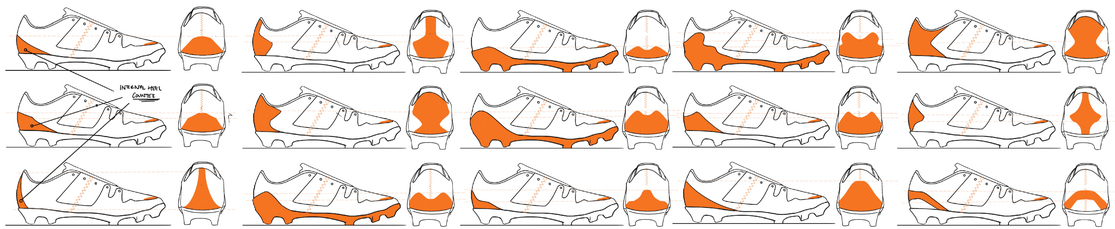
BASEBALL CLEAT CONFIGURATION
FOR 'PITCHING' CLEATS // ONLY ONE HAS METAL BLADES → ~53 STUDS AROUND TOE W/ PLATE MAP 4 ZONES

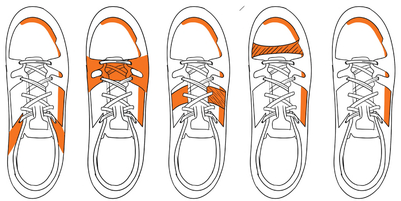


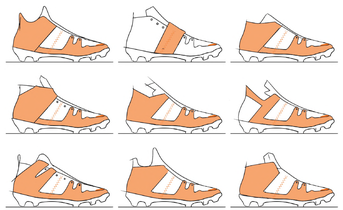

SUPPORT
ACROSS
ANKLE + BRIDGE


BLADED
TRIANGULAR
CONICAL


SOLEPLATE DESIGN
EMPHASIS ON
BRAKING
LIGHTWEIGHT
TRACTION
REINFORCED
TORSION RAMPS
ACROSS UNDERFOOT
MULTI-DIRECTIONAL
STUDS ALLOW FOR
ROTATION + BLADE


INTERNAL HEEL
COUNTER

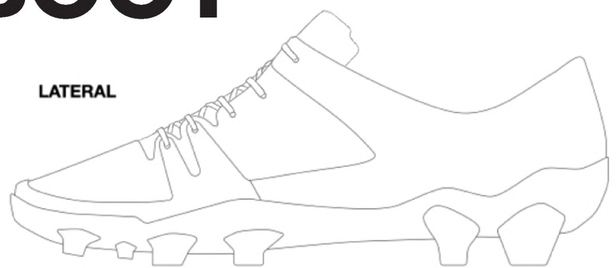





#1C181C
#F26B1D
#63B597
#CCC3BD
#939AB2
#57BDBE
#4E4E4E
#D9D9D9
#357152

LIGHTWEIGHT BOOT

LATERAL



MEDIAL

ROVER

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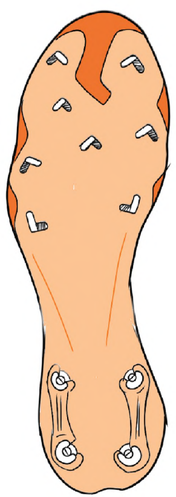
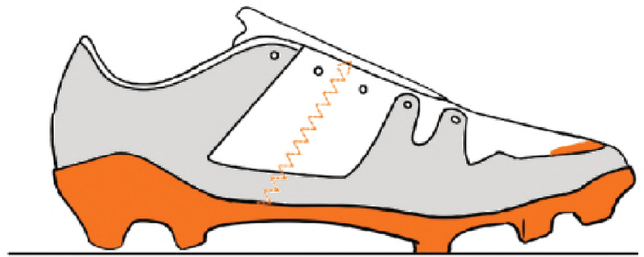
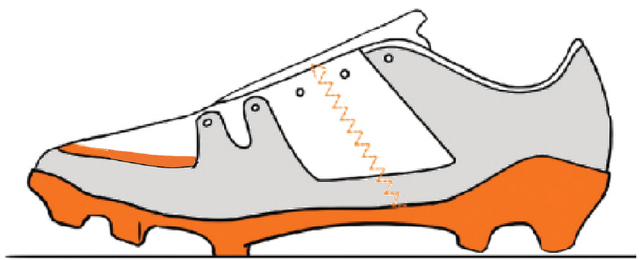
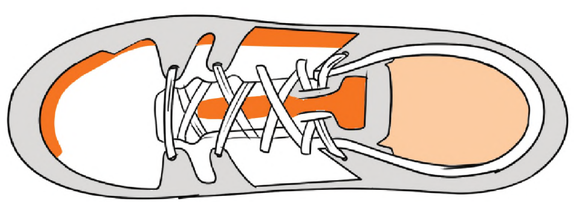
Internal Cage- Using a two layer system for increased stability
Lattice Midsole Insert- A cushioned insole provides exceptional comfort
Redesigned Cleatplate - For improved traction during dynamic movement



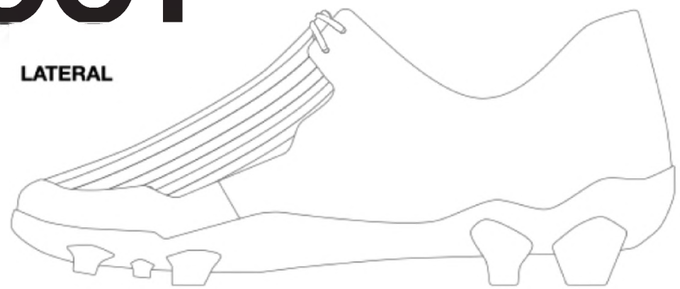




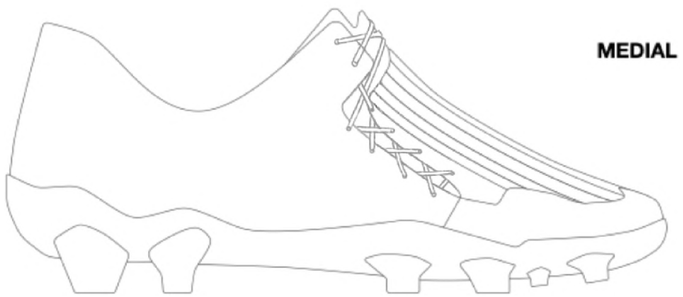


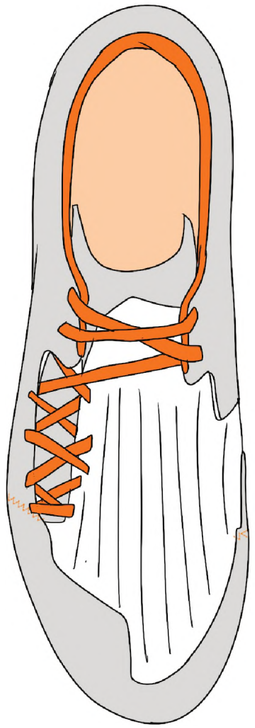
KICKING BOOT

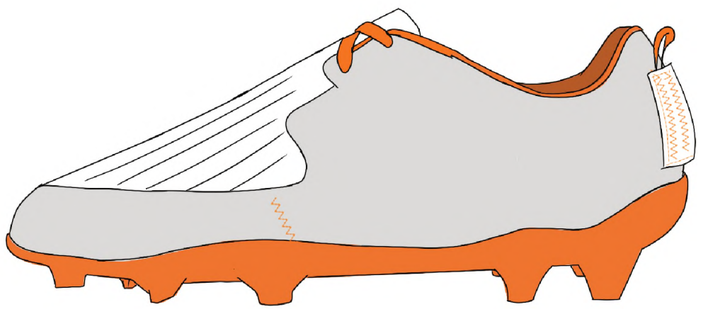
LATERAL



MEDIAL



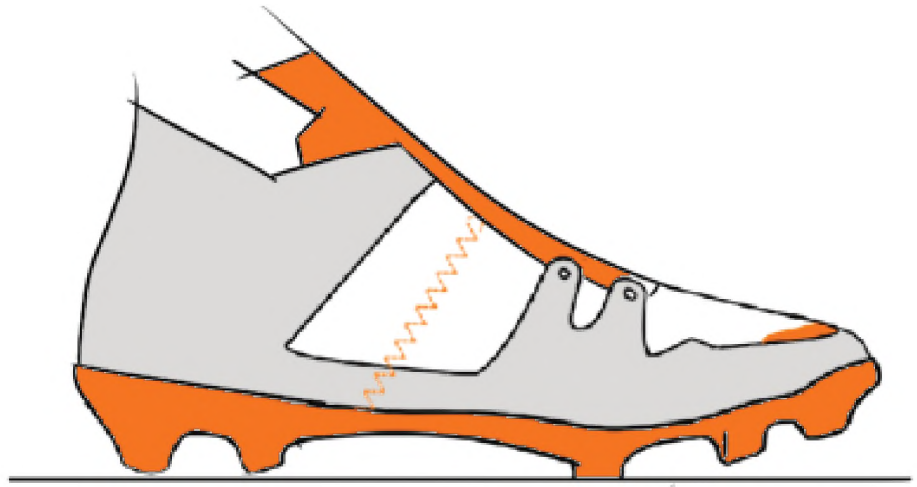


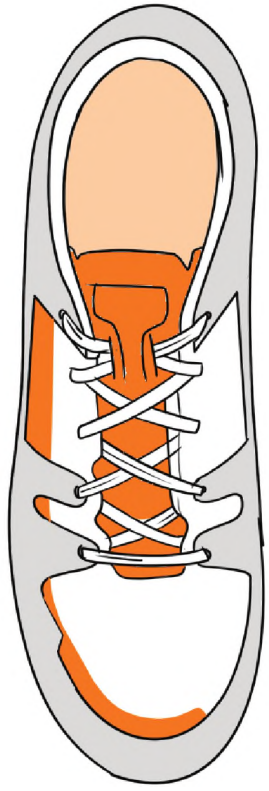


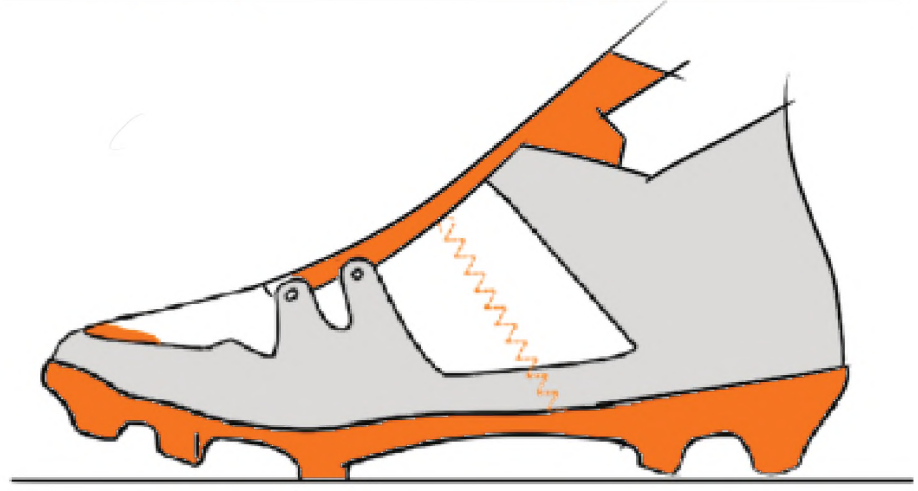
FORWARD

Impact Absorbing Kicking Pad — A targeted filament component for increased accuracy and reduced foot strain
Sideways Lacing- Unique lacing system for maximizing the kicking surface along the vamp and top of foot
Targeted Construction- Using a combination of filaments to provide stretch or impact absorption
Redesigned Cleatplate - For improved traction during dynamic movement

MID-TOP BOOT

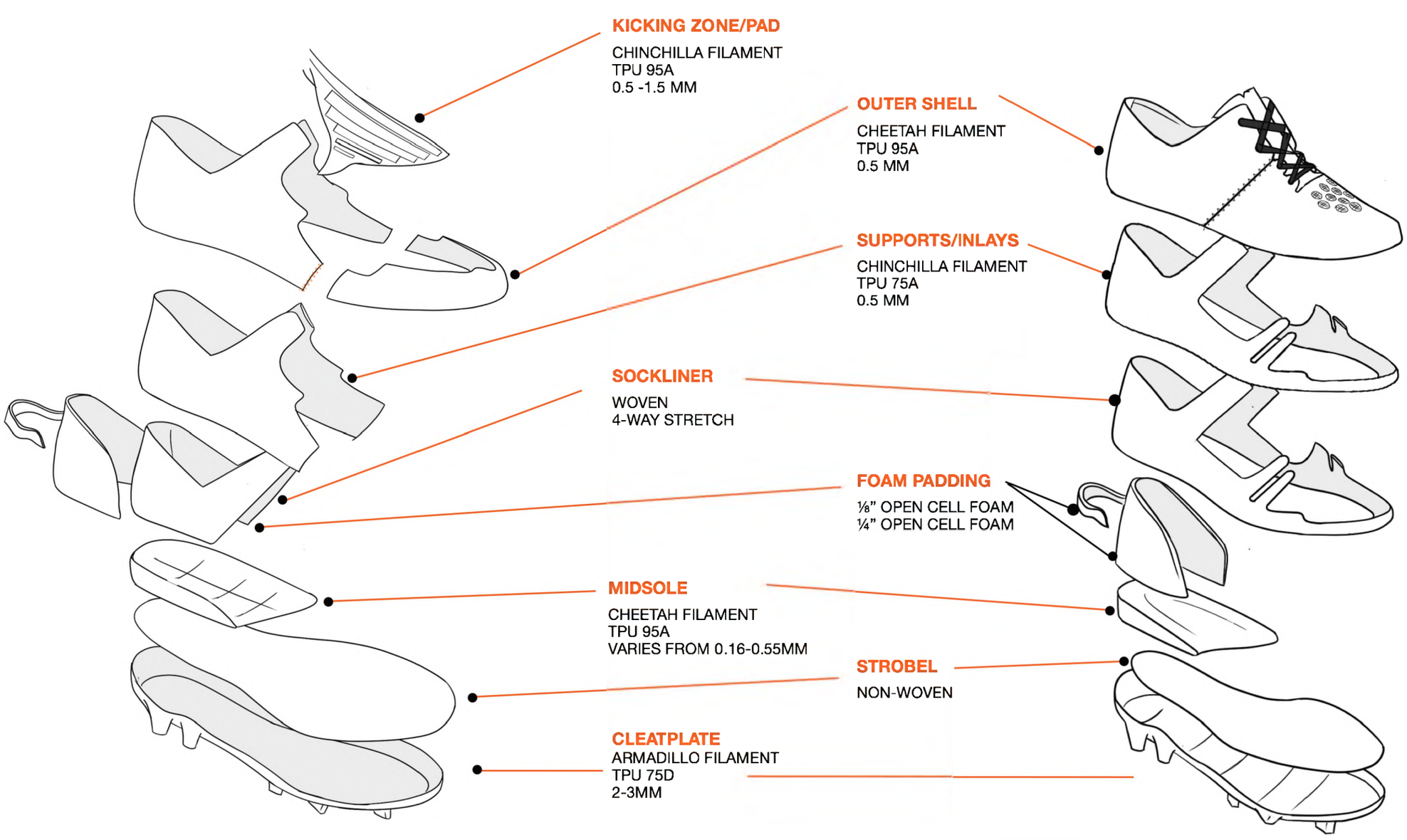


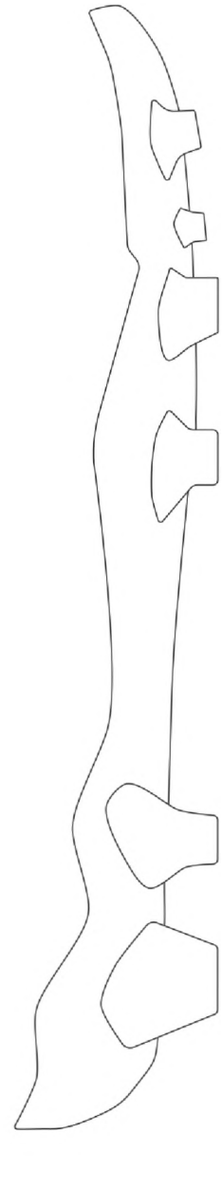




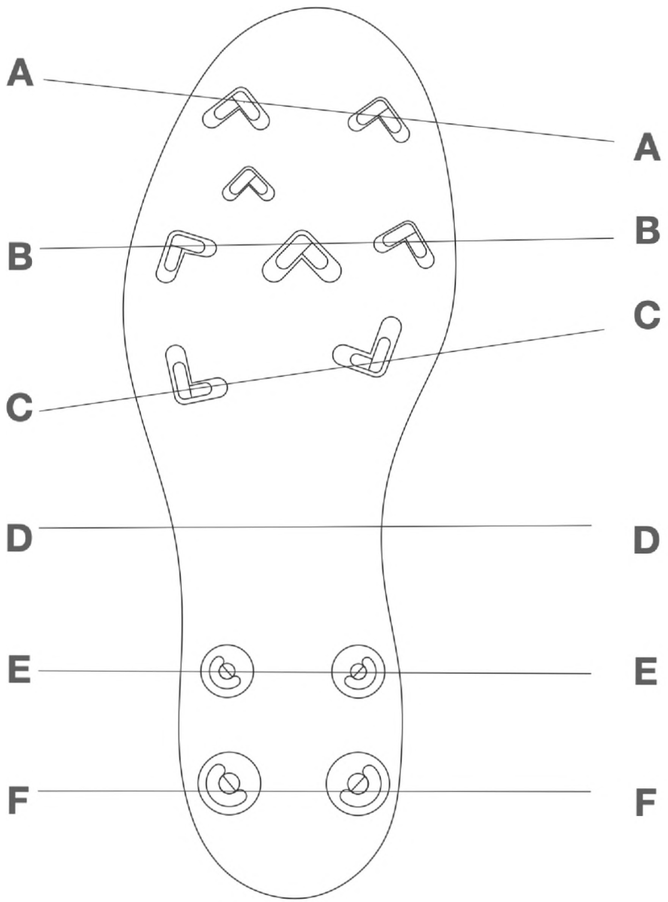
3D Textile Construction— A multi-filament upper, for a lightweight and easily modified upper
Mid-Height— A taller silhouette allows for more lockdown for the ankle and base of the foot
Lattice Midsole Insert- A cushioned insole provides exceptional comfort
Redesigned Cleatplate - For improved traction during dynamic movement

EXPLODED VIEWS | CAD

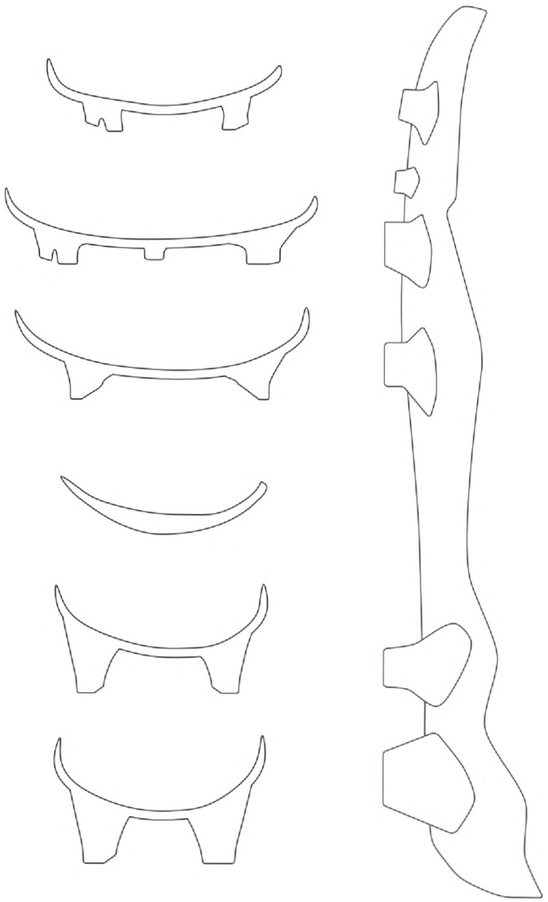




MEDIAL

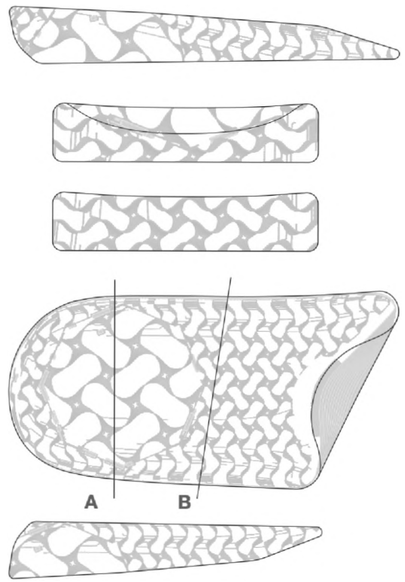


BOTTOM



SECTIONS

LATERAL



LATERAL

SECTIONS

TOP

MEDIAL

HAVOC

BRYANT JIMÉNEZ |THESIS 2022

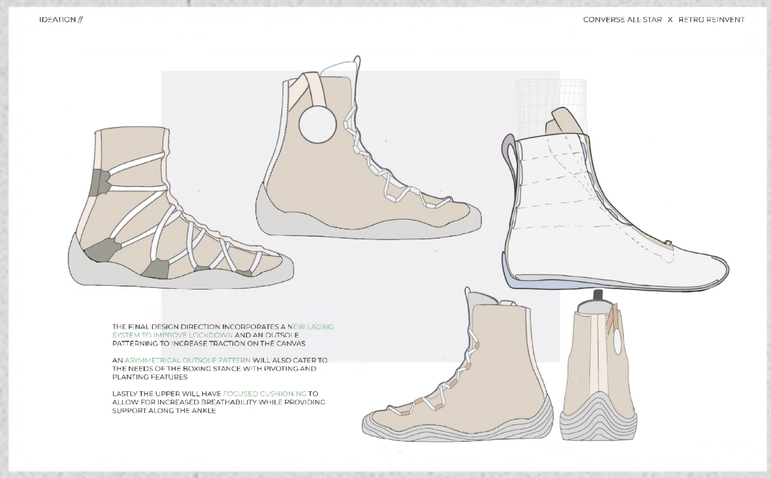
BRYANT JIMÉNEZ

UO Graduate with degrees in Architecture, Digital Arts and Romance languages

I WANT TO INNOVATE AND IMPROVE ATHLETE PERFORMANCE IN SPORTS

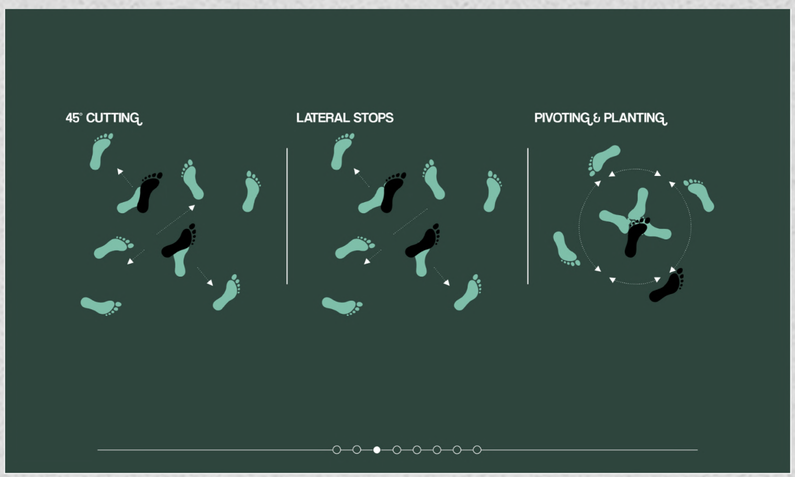
POST GRADUATION

I want to pursue Performance Footwear Design either through sample making or 3D Footwear Design



CONVERSE REINVENT

COPA SPEEDHACK

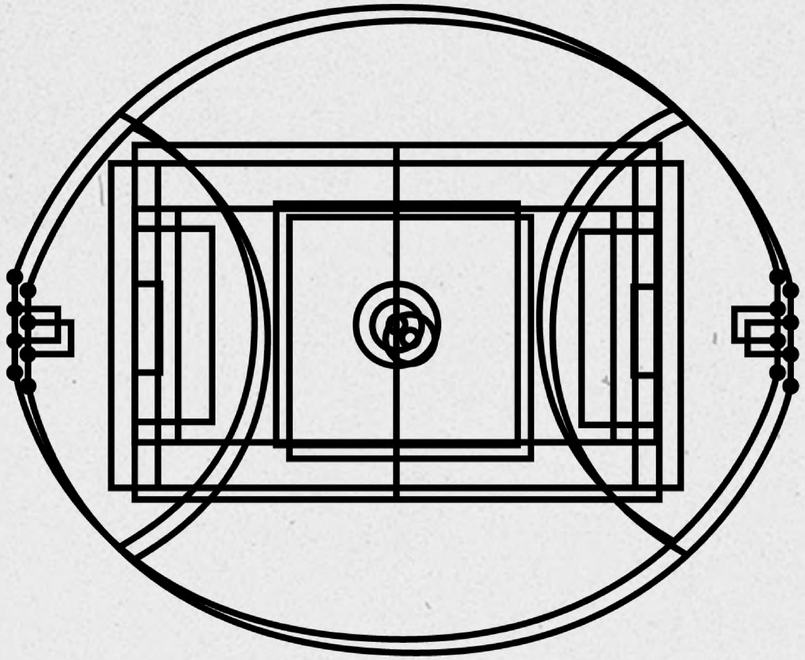


FUTSAL TRACTION

HAVOC

BRYANT JIMÉNEZ |THESIS 2022

WHAT IS AUSTRALIAN RULES FOOTBALL?



RUCKMAN

Defensive Giants

Average Height 6’5” +

Aerial Collisions

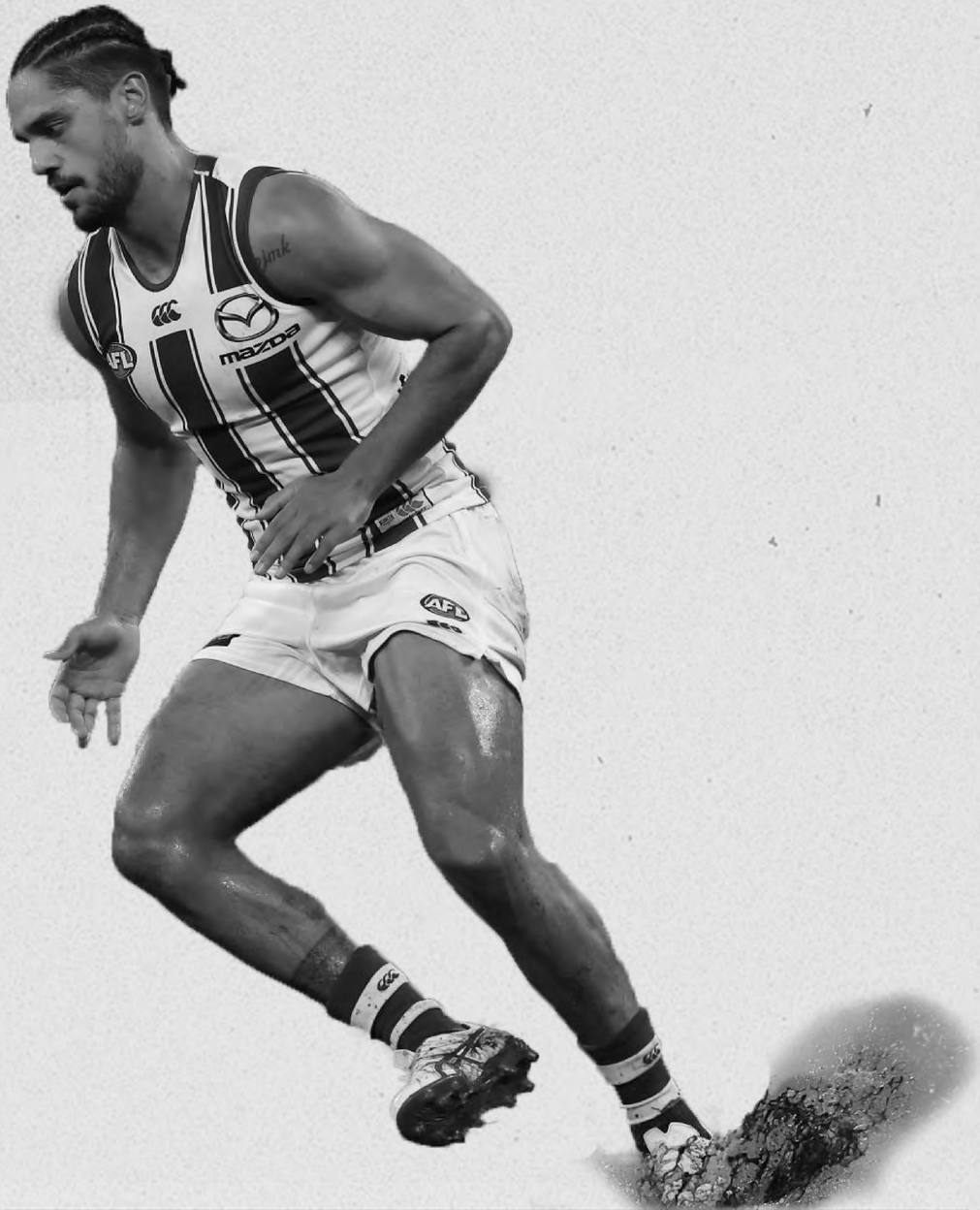

CAR 13 3 81 Q3
MEL 9 7 61 01:30
AFL .COM.AU
Life Insurance

ROVER

Recovers possession

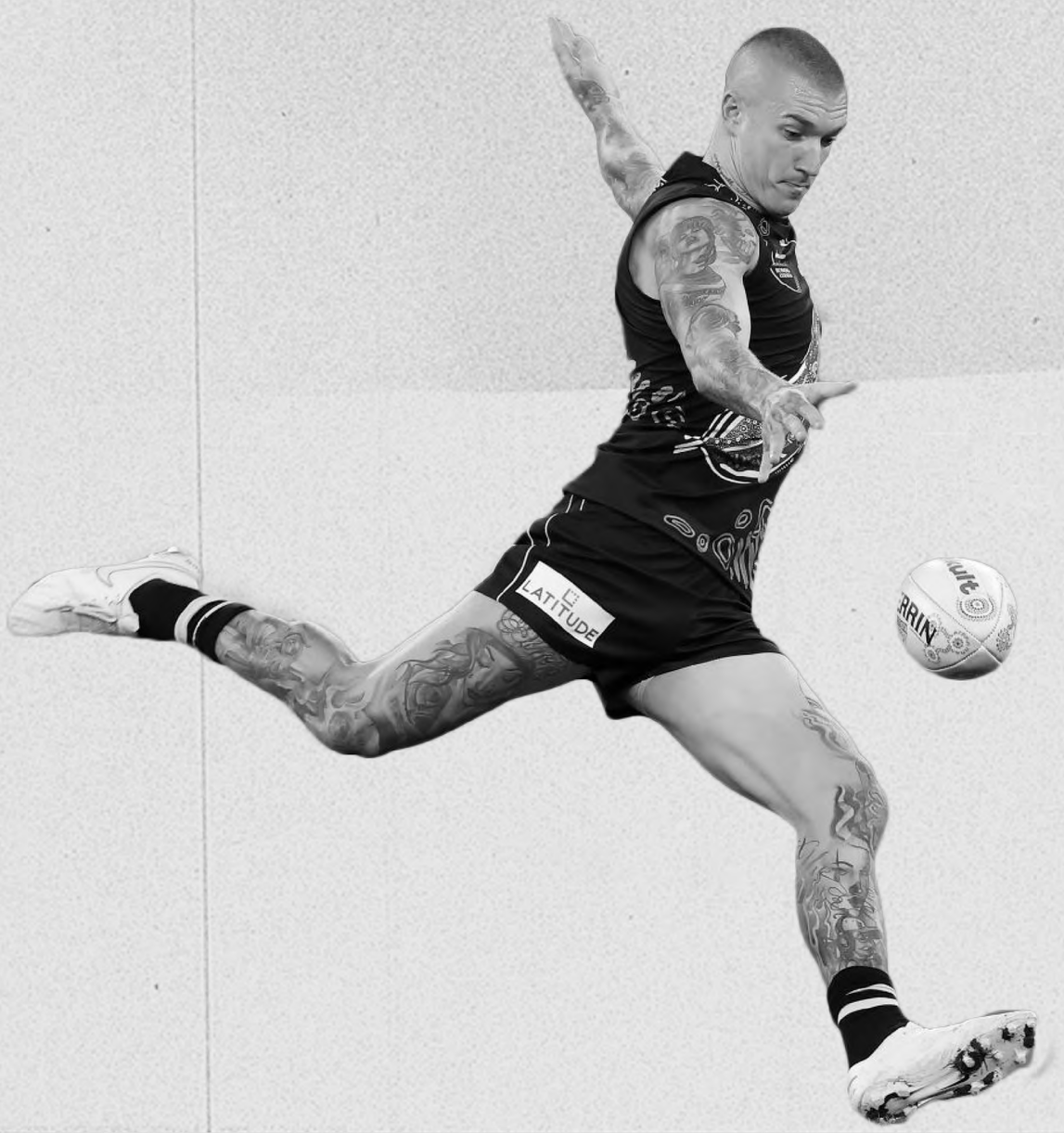
Longest Average Game Distance

Most Versatile Movement



CAR	13	3	81	Q3
MEL	9	7	61	01:07


WB 3 6 24 Q2
BRI 6 3 39 14:01
KENNEDY
KENNEDY
AFL
.COM.AU



FORWARD

Primary Goalscorer

Most Dynamic Movement

Sprints between 30-60M

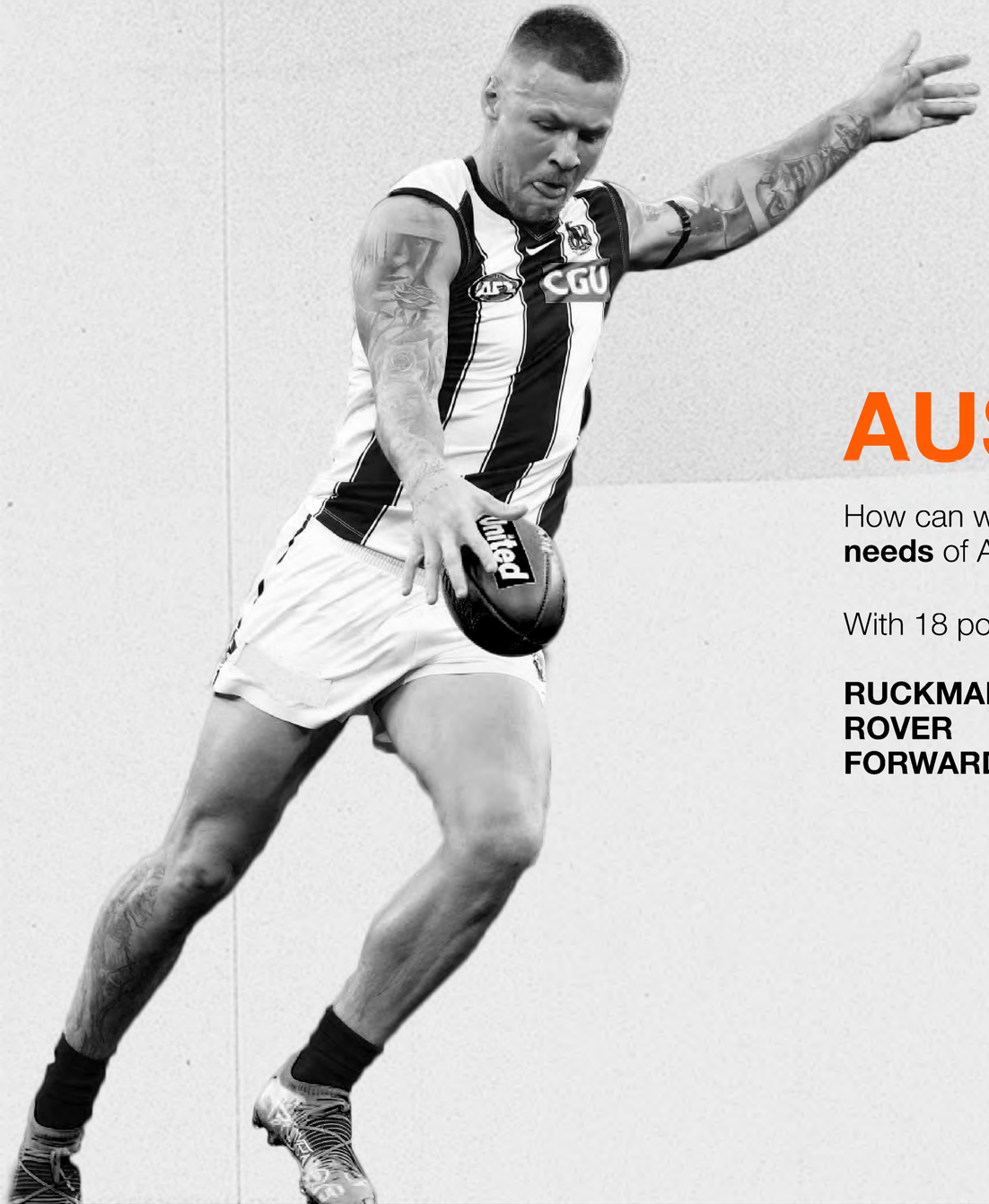

SYD 4 5 29 Q2
NM 1 2 8 10:30

CURRENT PROBLEMS

Unlike other popular cleated sports, **only two boot manufacture produce a dedicated boot design**

Despite being a **1.2 billion dollar industry** players have to **resort to sporting football cleats as workarounds** due to available solutions not meeting their performance needs

With **only 152 players in the Australian Premiership** is prime for concept runs of cleated footwear



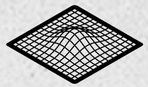
AUSSIE RULES FOOTBALL

How can we apply **additive manufacturing to address the positional needs** of Australian Football athletes

With 18 positions, the key roles observed are:

RUCKMAN
ROVER
FORWARD

POSITIONAL NEEDS



LIGHTWEIGHT

Using 3D printed upper components and 3D lattice midsole to allow for easier acceleration

ROVER / FOLLOWER

FORWARD

RUCK / RUCK-MAN

TRACTION

Developing new stud configurations and shapes to improve forward momentum and reduce foot strain

ROVER / FOLLOWER

RUCK / RUCK-MAN

ACCURACY

Redesigning the upper construction to improve kick distance and accuracy with new ball shape

FORWARD

HAVOC PRINT	Upper + Last Form + Lacing System	30% REDUCED WEIGHT
BLR SOLEPLATE	Soleplate + Studs	WITHIN 10% TRACTION OF COMPETITORS
PRCSN-STRIKE	Tongue + Upper	WITHIN 15% ACCURACY

ATHLETE INSIGHTS

Tom Snee
6’4”
198 Lbs.
11-11.5 US
R-Foot Dominant
Footy Copa Mundial
Football Nike Tiempo

Jeff Melanson
6’2”
178 Lbs.
11-11.5 US
R-Foot Dominant
Adidas Predator

Race Malhum
6’3”
190 Lbs.
11.5 US
R-Foot Dominant
Nike Mercurial

Joshua Rambert
5’9”
180 Lbs.
9.5 US
L-Foot Dominant
Flyknit Mercurial

Will Hutchinson
6’4”
197 Lbs.
11 US
R-Foot Dominant
Nike Tiempo

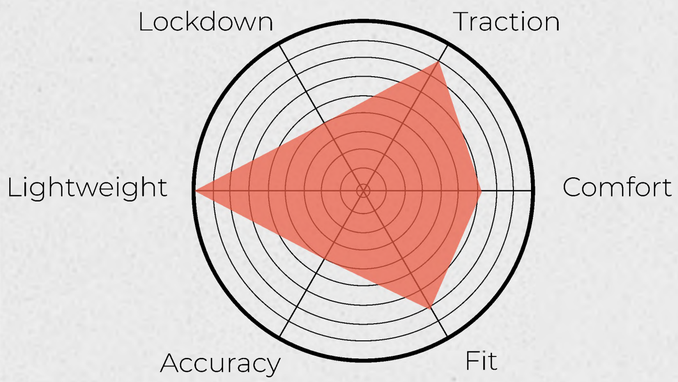
Haki Woods Jr.
6’5”
200 Lbs.
11.5 US
R-Foot Dominant
Nike Vapor

01 FIT/SIZING
02 AESTHETICS
03 TRACTION
04 KICKING ZONE
05 COMFORT

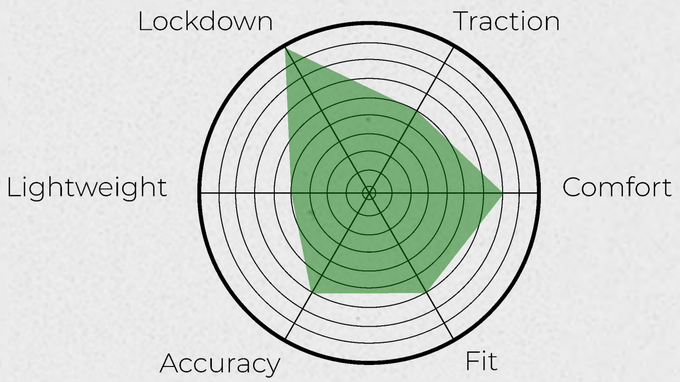
“THERE’S NOT MANY OPTIONS BESIDES FOOTBALL BOOTS…BUT THEIR TOO NARROW FOR US BIGGER GUYS”

ALL OF THE SYNTHETIC OPTIONS LACK PADDING IN THE TOE BOX

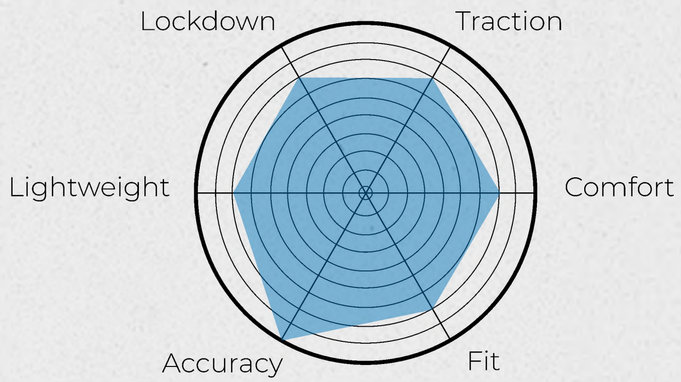
ALL THOSE TEXTURES DON’T DO ANYTHING FOR US, WE’RE NOT DOING FANCY TRICKS WITH OUR FEET



ROVER



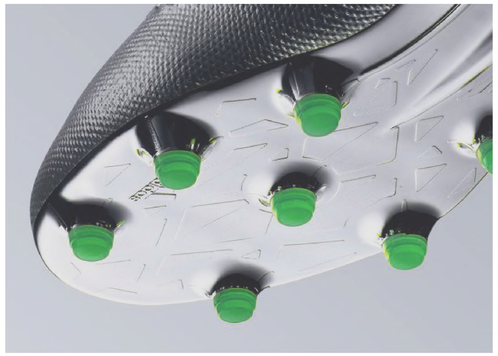
RUCKMAN

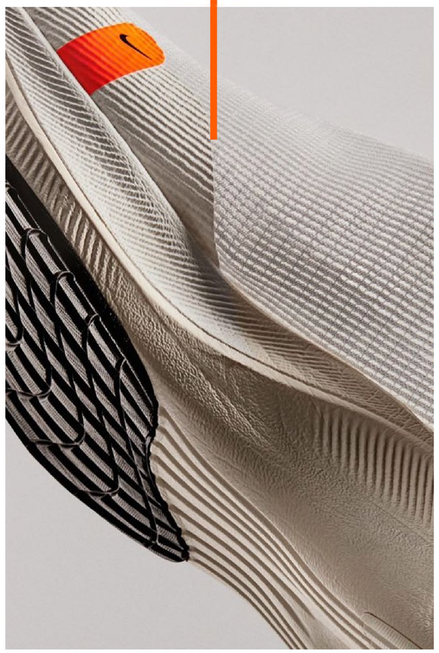


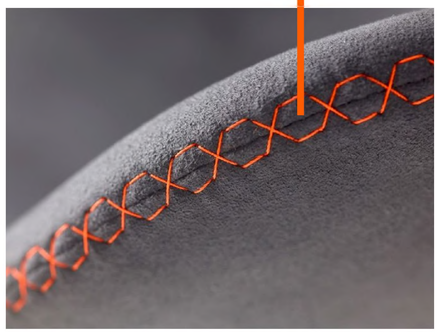
FORWARD

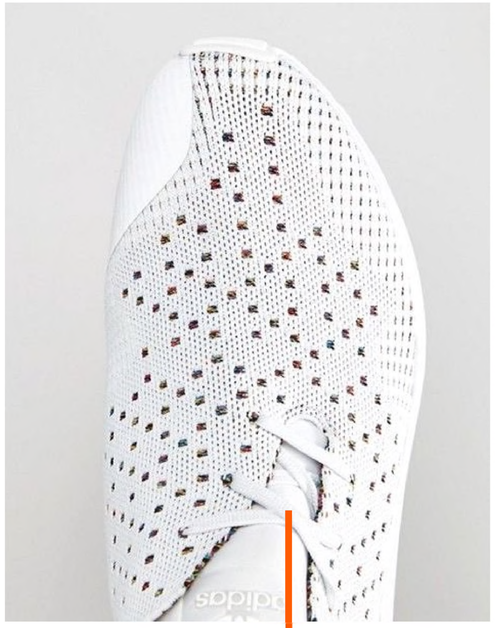
SPOT COLOR

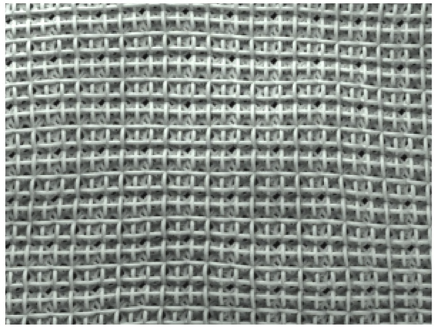
STITCHING ACCENT





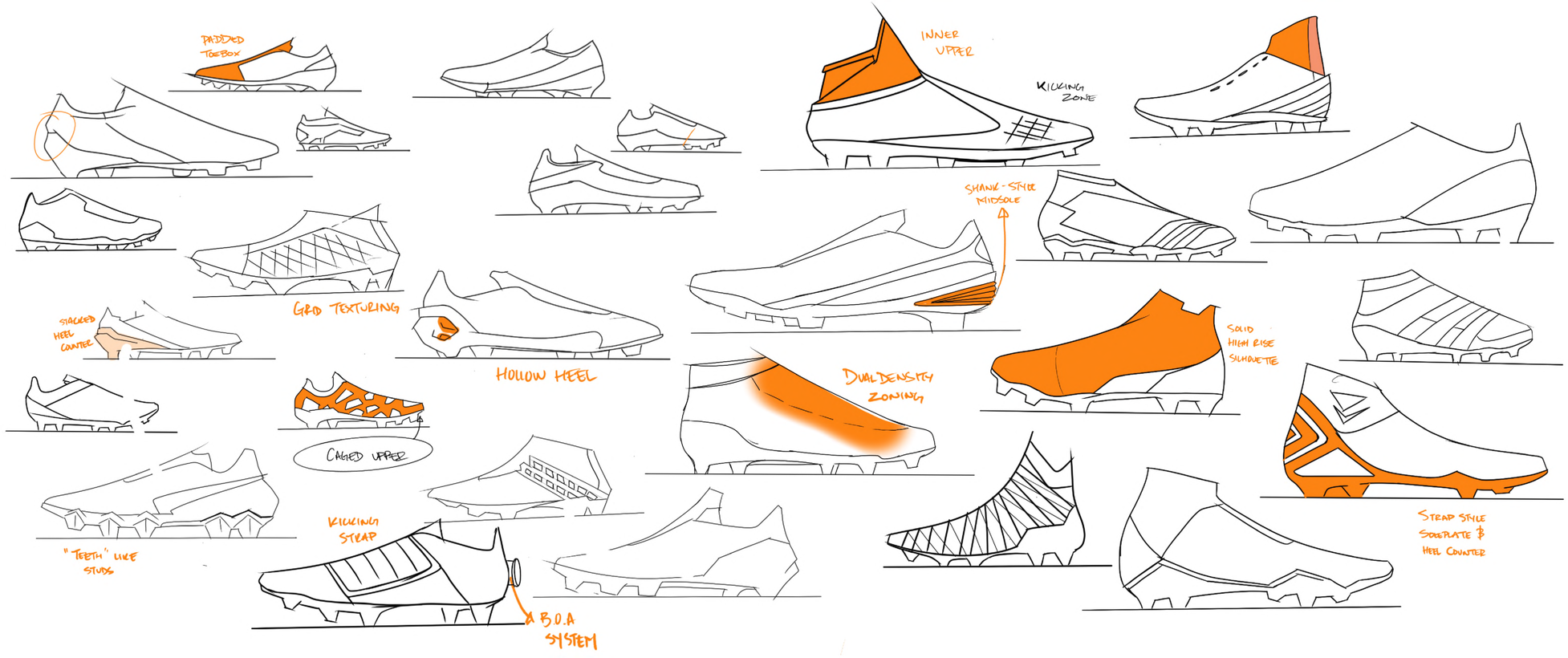


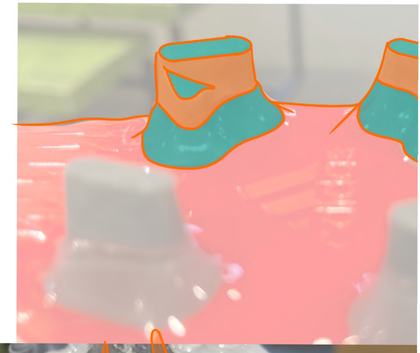


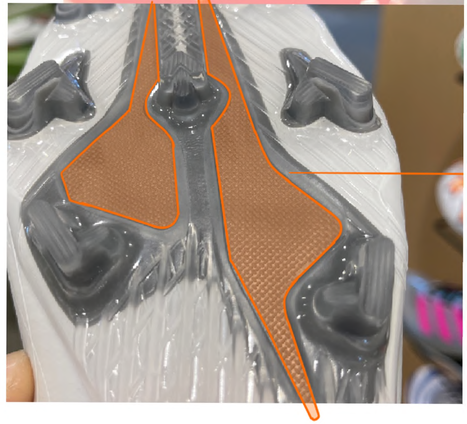


PERFORATIONS

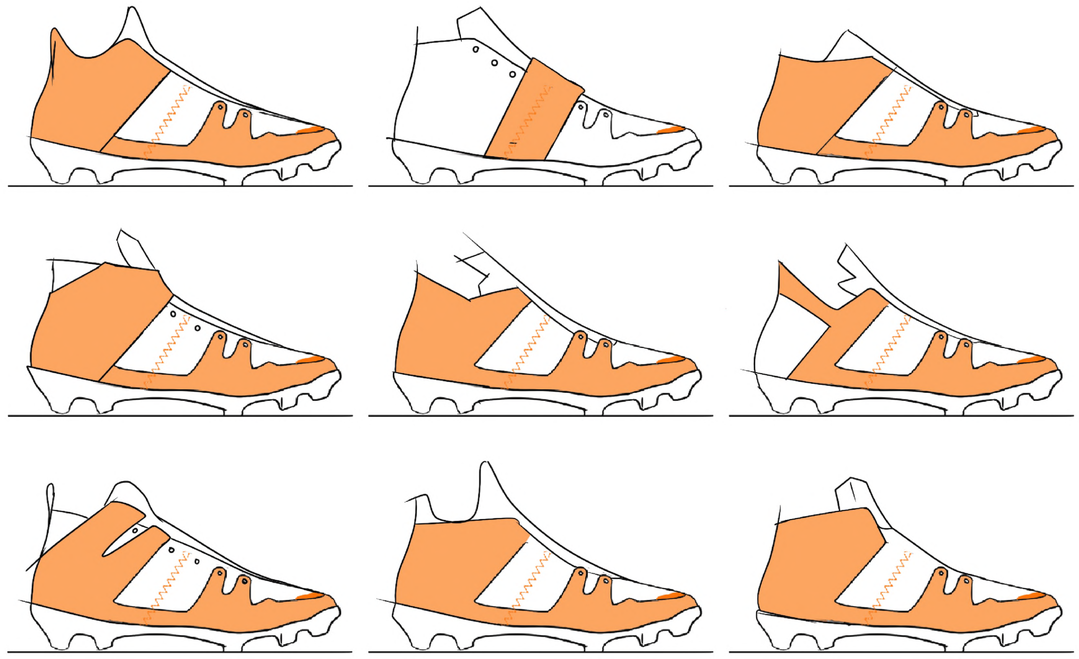
TRANSPARENCY

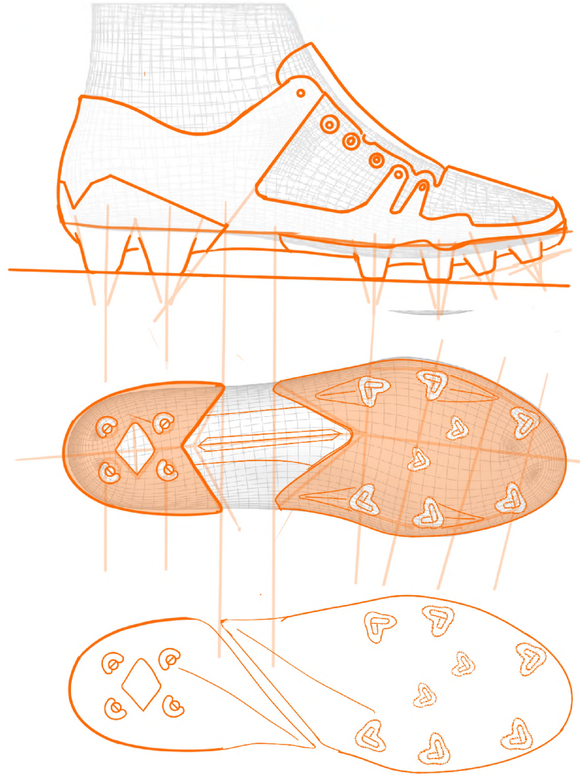

PADDED TOEBOX
INNER UPPER
KICKING ZONE
SHANK - STYLE MIDSOLE
GRID TEXTURING
STACKED HEEL COUNTER
HOLLOW HEEL
DUAL DENSITY ZONING
SOLID HIGH RISE SILHOUETTE
CAGED UPPER
"TEETH" LIKE STUDS
KICKING STRAP
B.O.A SYSTEM
STRAP STYLE SOLEPLATE & HEEL COUNTER

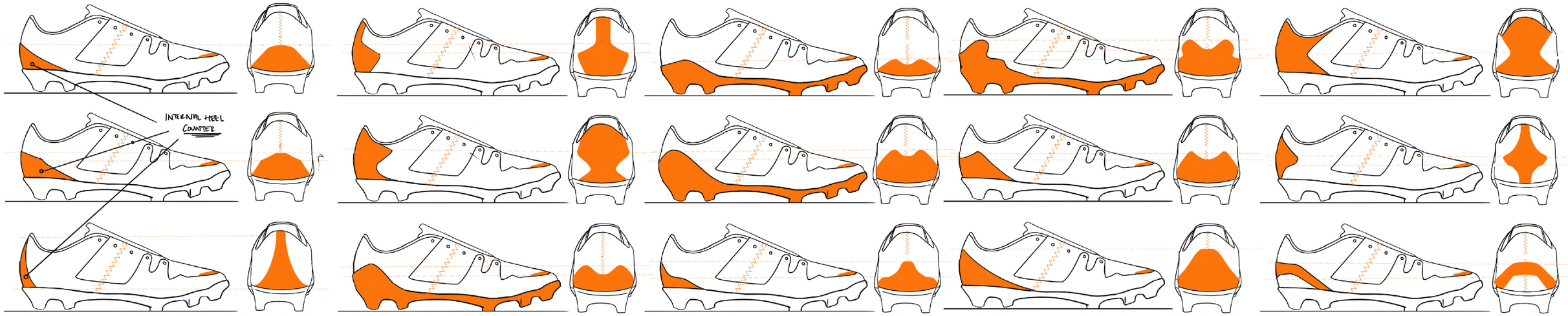




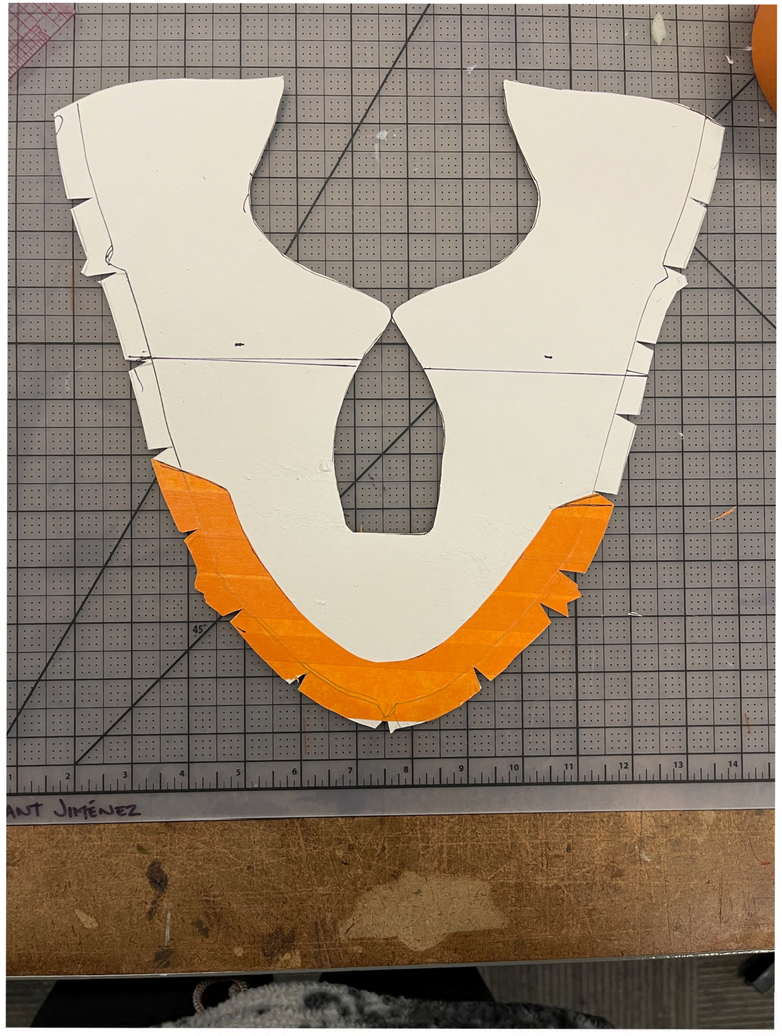

SUPPORT
ACROSS
ANKLE + BRIDGE

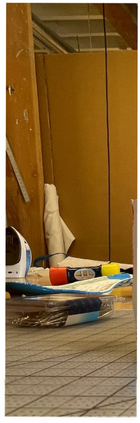




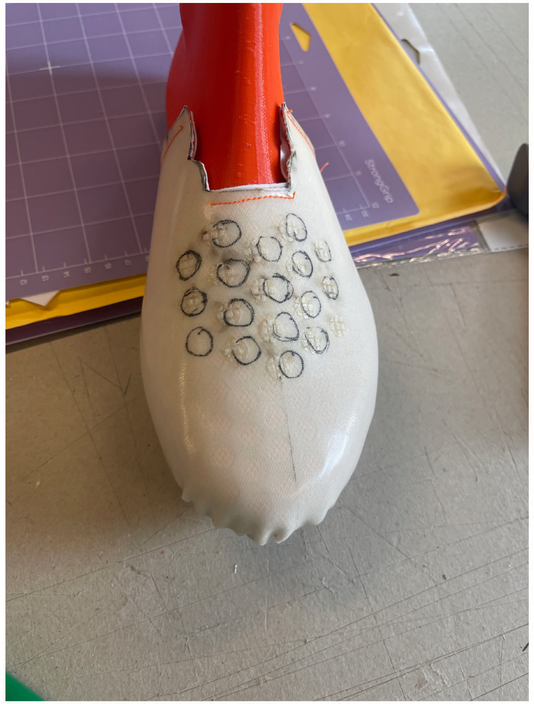

INTERNAL HEEL
COUNTER

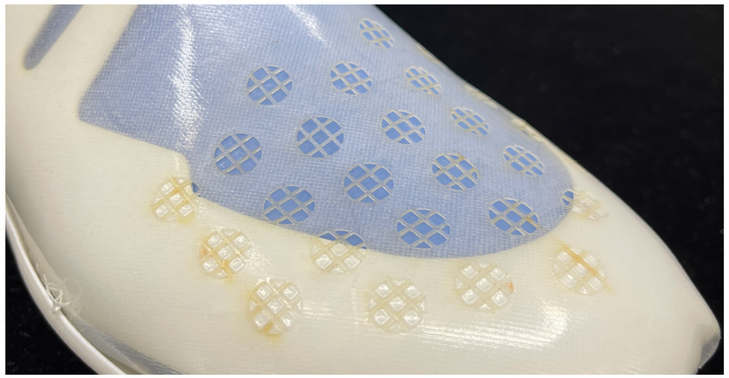
PROTOTYPES



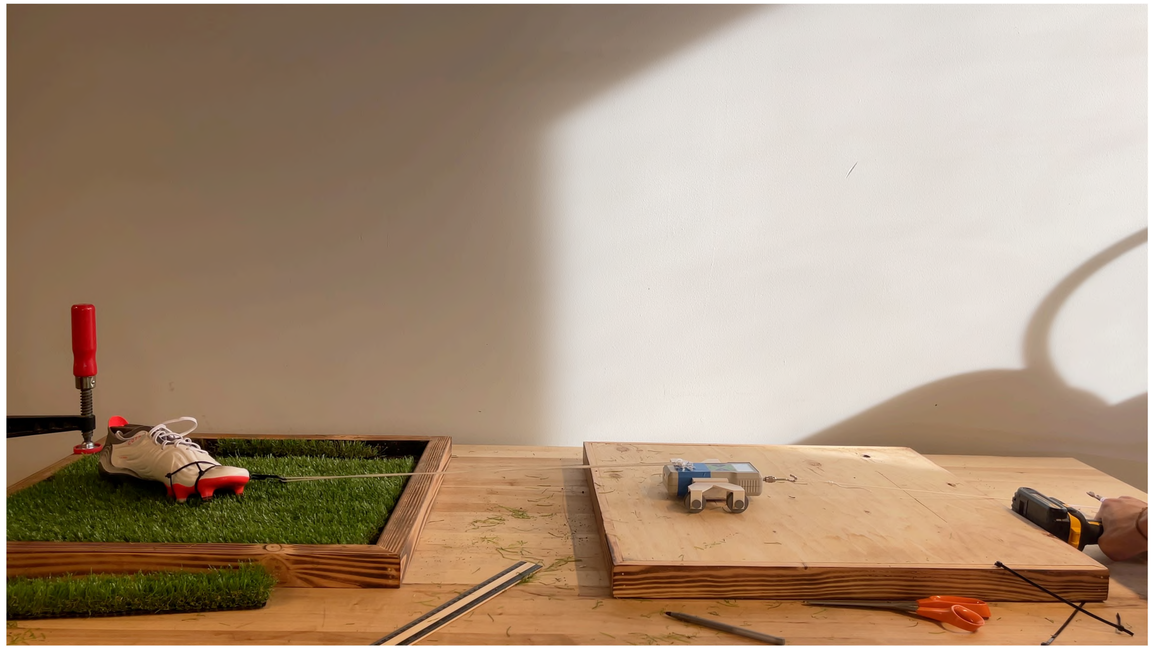


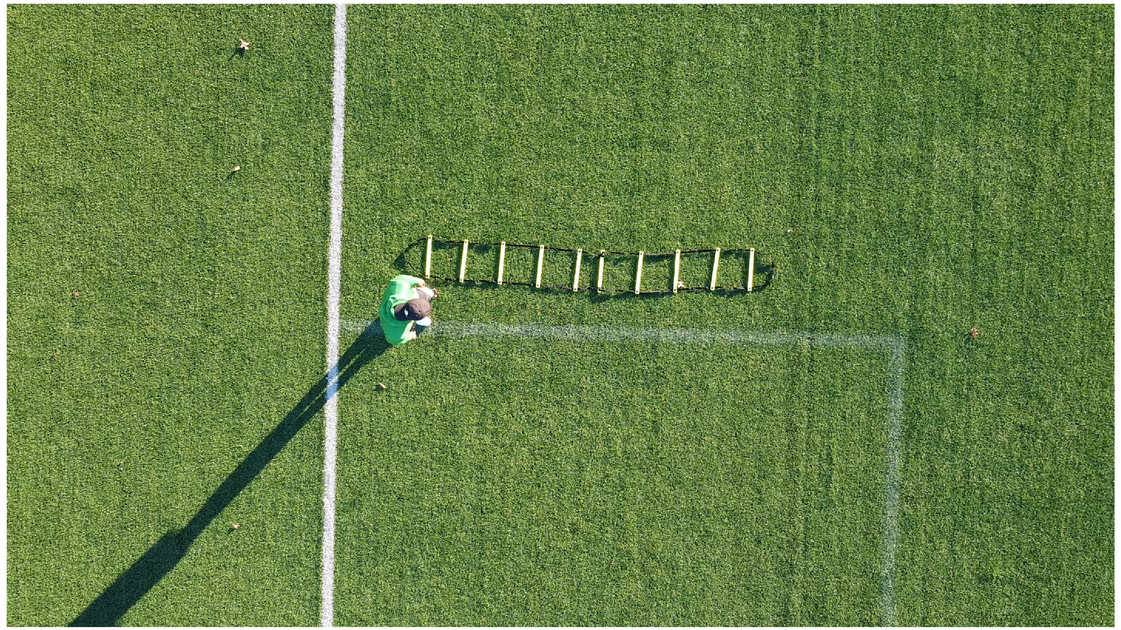

9E
AMERICAN FOOTBALL

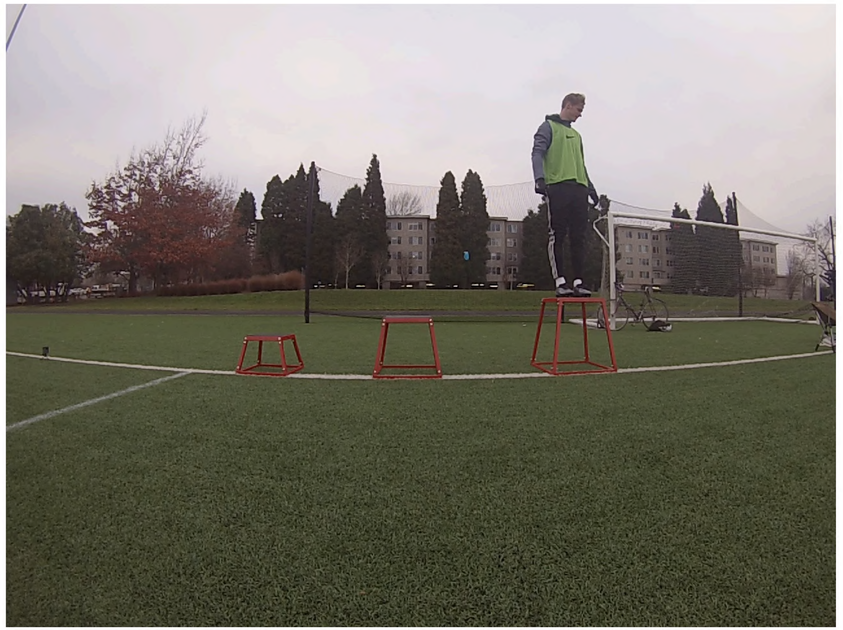




TESTING







KEY OUTCOMES

SILHOUETTE

MULTI DIRECTIONAL TRACTION

PERFORATIONS

PADDING

AMELIA ARUNDALE

BIOMECHANIST/PLAYER

Wrote a dissertation on the biomechanics of Aussie Rules Football and then worked with the AFL-W League

“THE IMPACT ABSORPTION FROM THE KICKING PAD … WOULD ALLEVIATE THE STRESS SEEN FROM DROP PUNT STYLE KICKS…THE SILHOUETTES ALLOW FOR DYNAMIC MOVEMENT AND THE RUCK MANS LANDINGS”


RUCKMAN
HAVOC

ROVER

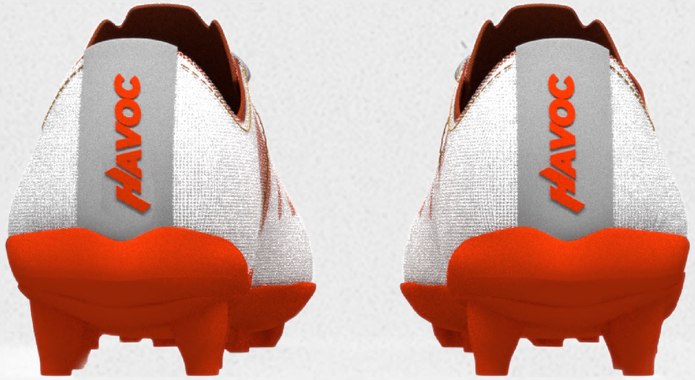
REINFORCED PADDING ON TONGUE
FOR ENHANCED KICKING
PERFORMANCE

INTERNAL FOAM LINER
FOR INCREASED PROTECTION

VAMP PERFORATIONS
FOR INCREASED BREATHABILITY

TPU OUTER SHELL
FOR BETTER FIT

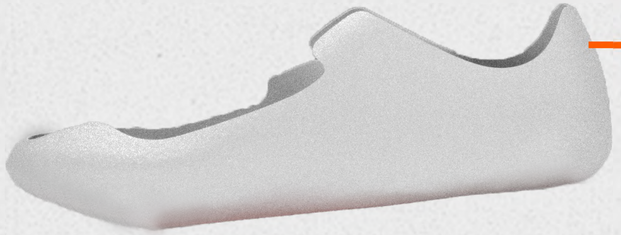
TPE INNER UPPER
FOR INCREASED STRUCTURE AND
LOCKDOWN



FORWARD

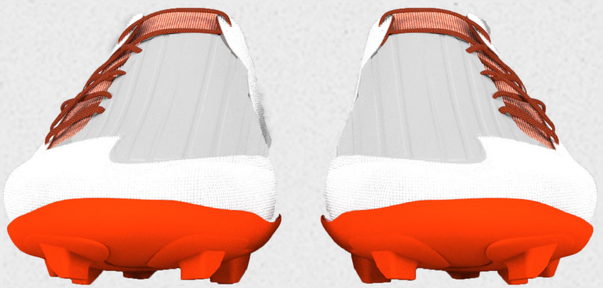
TPE ENGINEERIEDKICKING PAD
FOR MORE POWERFUL AND PRECISE
SHOT ON TARGET

TPE INNER UPPER
FOR INCREASED STRUCTURE



TPU OUTER SHELL
FOR BETTER FIT

INTERNAL FOAM LINER
FOR INCREASED PROTECTION



RUCKMAN

MID TOP SILHOUETTE
FOR INCREASED LOCKDOWN

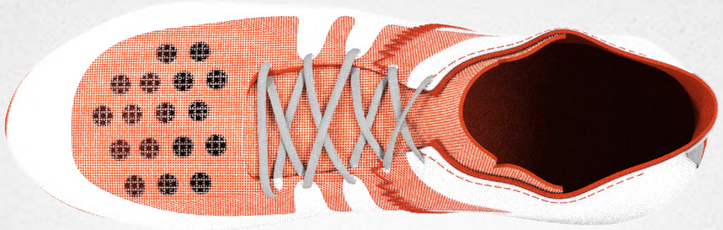
REINFORCED PADDING ON TONGUE FOR
ENHANCED KICKING PERFORMANCE

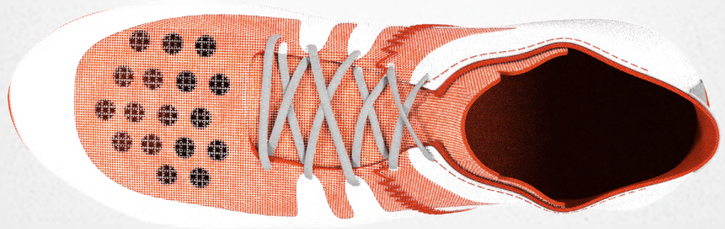
VAMP PERFORATIONS
FOR INCREASED BREATHABILITY

TPU OUTER SHELL
FOR BETTER FIT

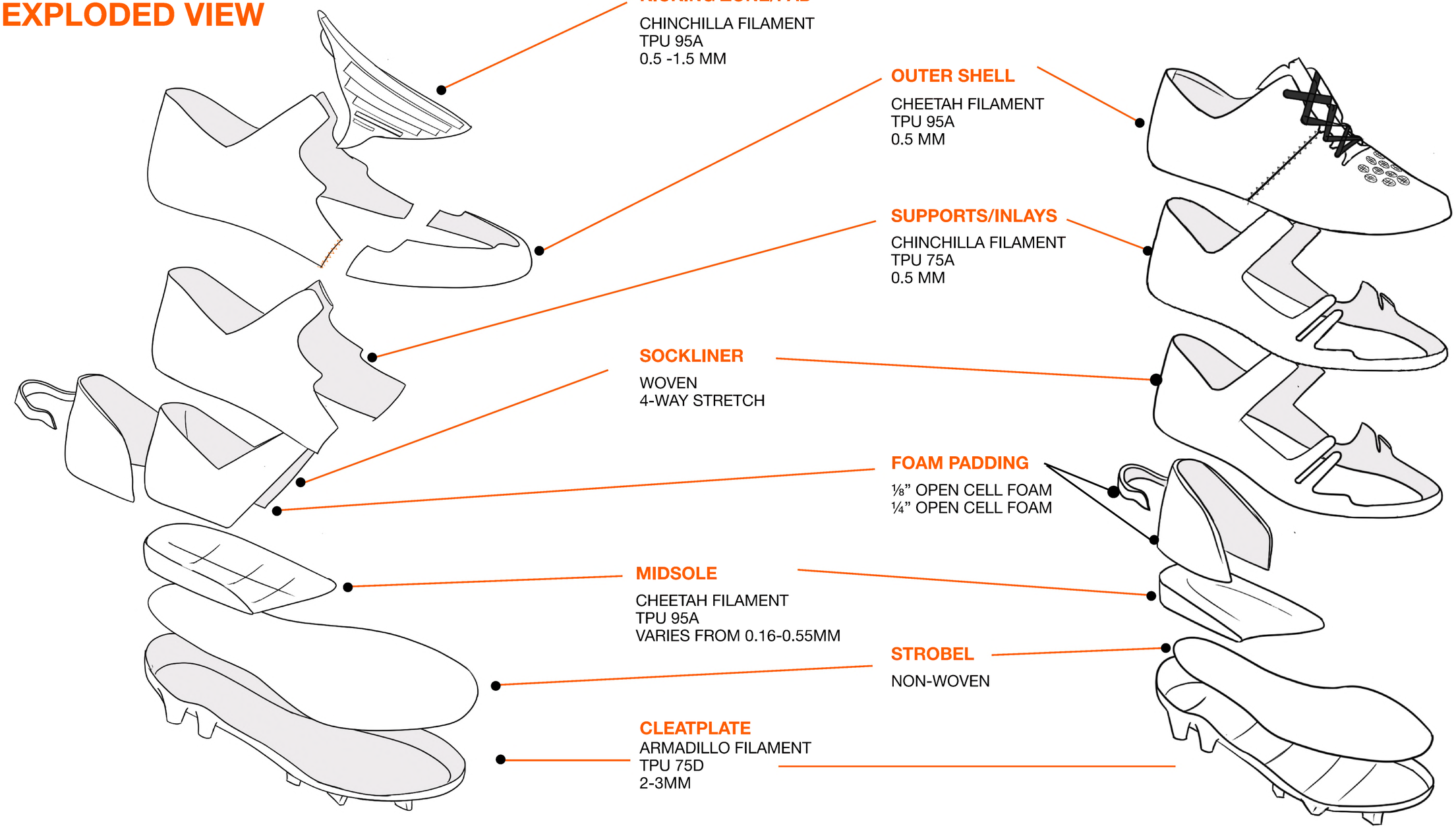
TPE INNER UPPER
FOR INCREASED STRUCTURE AND
LOCKDOWN

INTERNAL FOAM LINER
FOR INCREASED PROTECTION





EXPLODED VIEW



KICKING ZONE/PAD

CHINCHILLA FILAMENT
TPU 95A
0.5 -1.5 MM

OUTER SHELL

CHEETAH FILAMENT
TPU 95A
0.5 MM

SUPPORTS/INLAYS

CHINCHILLA FILAMENT
TPU 75A
0.5 MM

SOCKLINER

WOVEN
4-WAY STRETCH

FOAM PADDING

⅛” OPEN CELL FOAM
¼” OPEN CELL FOAM

MIDSOLE

CHEETAH FILAMENT
TPU 95A
VARIES FROM 0.16-0.55MM

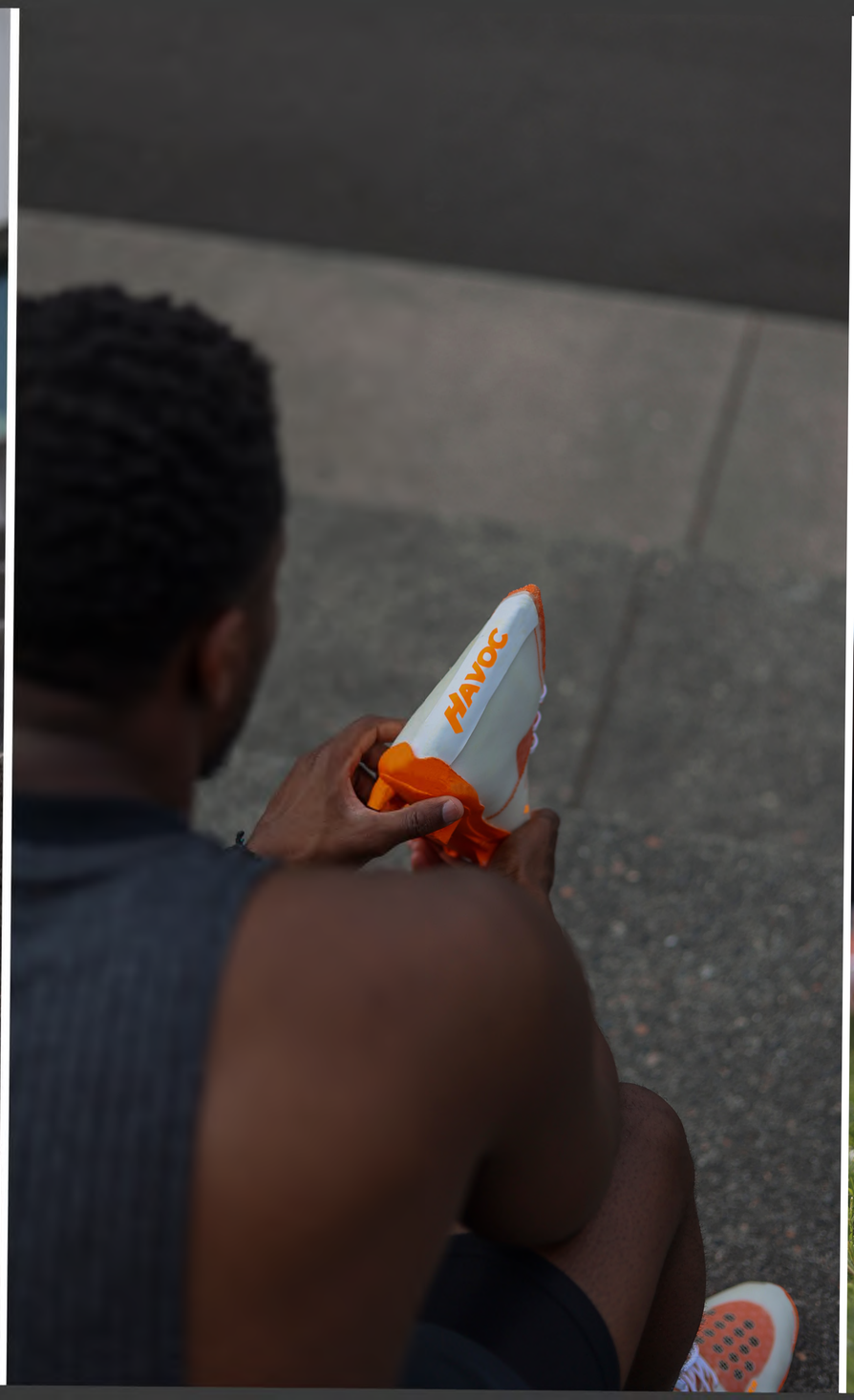
STROBEL

NON-WOVEN

CLEATPLATE

ARMADILLO FILAMENT
TPU 75D
2-3MM


RUCKMAN


HAVOC


BUCKAA

THANK YOU

SPECIAL THANKS

NATHAN SCHULTZE
AMELIA ARUNDALE