TAU TRAINERS

SENSOR-EQUIPPED, PERFORMANCE RUNNING FOOTWEAR FOR FEMALE DISTANCE RUNNERS

GABI LORENZO
2022 CAPSTONE THESIS
U.O. M.S. SPORTS PRODUCT DESIGN

TABLE OF CONTENTS

INTRODUCTION

WHAT IT'S ALL ABOUT

GABI LORENZO

MECHANICAL ENGINEER & SPORTS PRODUCT DESIGNER

I AM ENERGIZED BY SOLVING COMPLEX PROBLEMS.

I BELIEVE THAT GREAT DESIGN CAN ALWAYS BE IMPROVED.

FUNDING SOURCE

Wu Tsai Human
Performance Alliance

TAU

HOW CAN WE HELP FEMALE DISTANCE RUNNERS REACH THEIR PEAK PERFORMANCE USING SENSOR-EQUIPPED FOOTWEAR?

REAL-TIME FEEDBACK OF SHEAR FORCES AT THE FOOT-SHOE INTERFACE CAN HELP THE ATHLETE CORRECT HER GAIT TO RUN FASTER & RUN LONGER

PROJECT IMPORTANCE

WHAT IS SHEAR?

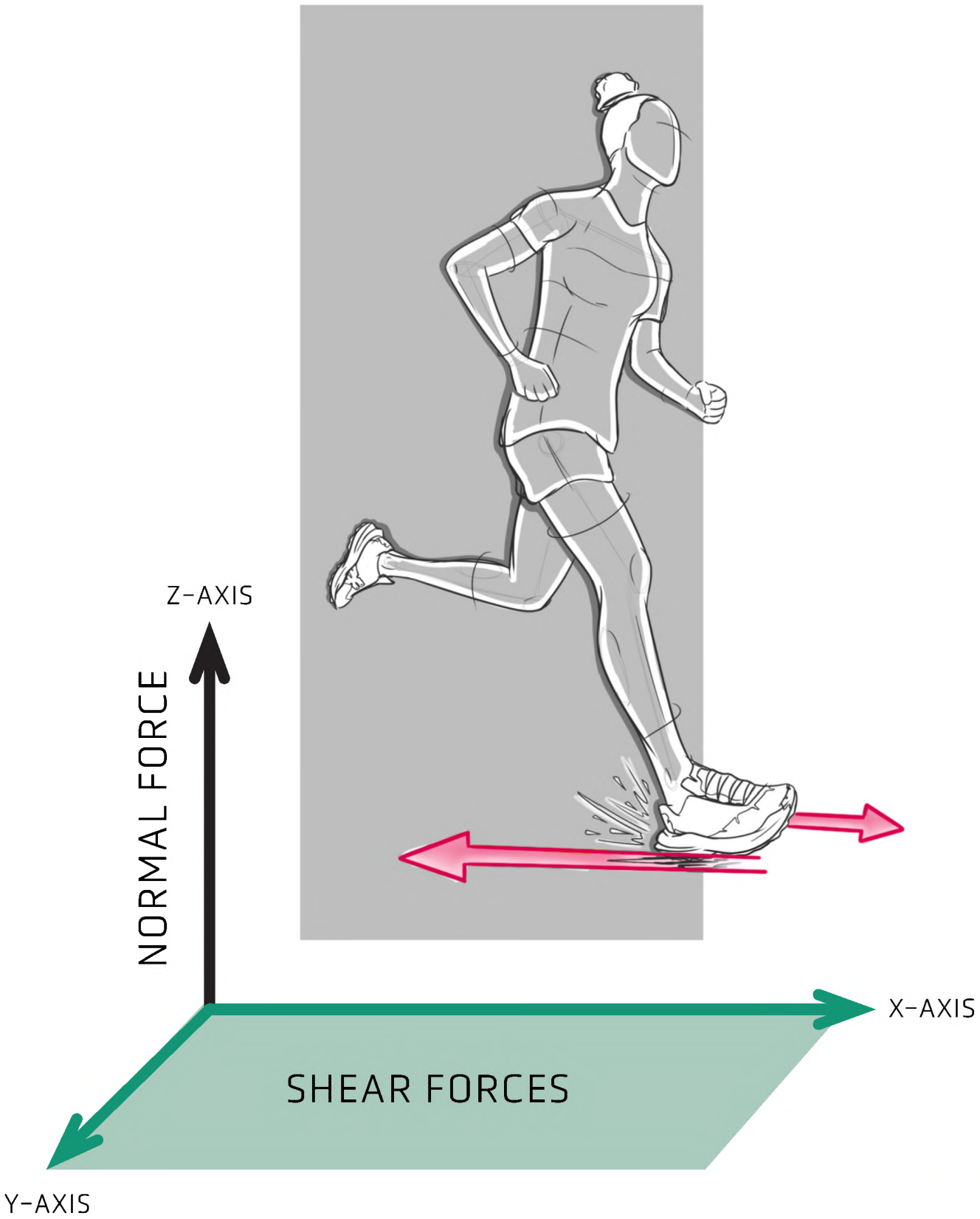
- Shear makes up 2/3 of the ground reaction forces that occur while running
- These forces allow an athlete to propel themselves forward, brake, or change direction; without shear, we could only jump upwards

IS SHEAR NEW?

- Measuring shear stress at the foot-shoe interface is extremely difficult & has not been done before
- Currently, only normal forces can be easily measured (1/3 of the forces that occur)

BENEFITS OF MEASURING SHEAR

- Understanding how shear changes throughout a run will provide opportunities to improve performance efficiencies & biomechanics


Z-AXIS
NORMAL FORCE
X-AXIS
SHEAR FORCES
Y-AXIS

ATHLETE & ENVIRONMENT

FEMALE DISTANCE RUNNERS

- 20 to 35 years old
- Specializing in 10k to marathon distances

ELITE ATHLETES

- Women who run at a high level & strive for constant improvement
- Athletes who trust technology

SPRING IN PORTLAND, OREGON

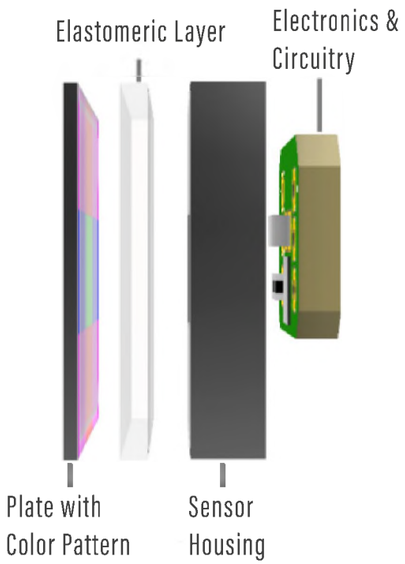
- Designed for unpredictable precipitation & slick surfaces

ROAD & TRAIL

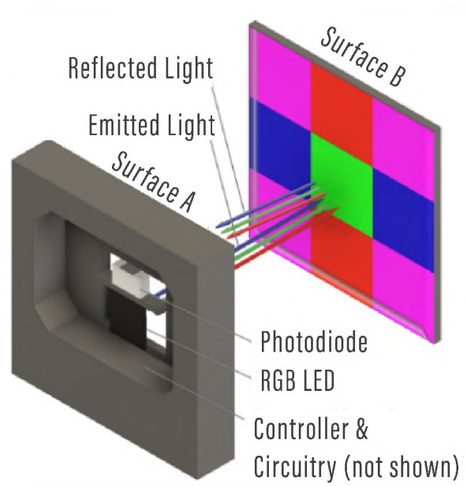
- Two versions for however she wants to train

THE SENSOR

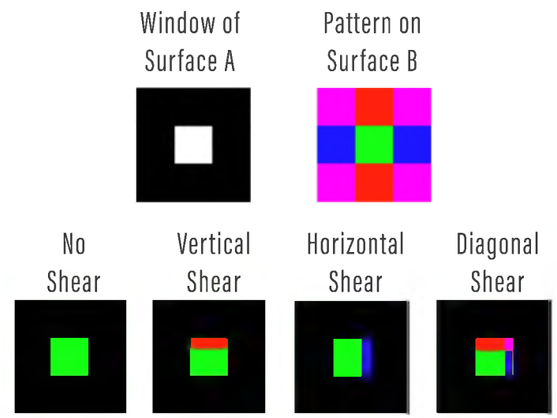
SENSOR ARCHITECTURE



SENSOR FUNCTION



VISUALIZATION OF SHEARING



SENSOR CONSTRAINTS

- PLANE OF ZERO DISPLACEMENT TO MEASURE DISPLACEMENT FROM
- SENSOR IS RIGID BUT NEEDS TO BE IMPERCEPTIBLY INTEGRATED INTO A DEFORMABLE BODY
- DEFORMABLE BODY NEEDS TO SHIFT ACROSS THE COLOR PATTERN

DEVELOPMENT TEAM

BIOMECHANICS
BOWERMAN SPORTS SCIENCE CENTER

MIKE HAHN

BIOMECH. & ENGR.
BSSC & KNIGHT CAMPUS

MICHAEL MCGEEHAN

ELECTRICAL ENGINEERING
KNIGHT CAMPUS

GHEE KEAT ONG

AREAS OF INNOVATION

TAU-TECH

- Sensor that accurately measures multi-axial shear stress at the foot-shoe interface
- Records real-time feedback via Bluetooth to an app

IMPULSE INTEGRATION SYSTEM

- Sole unit construction that imperceptibly integrates the sensor with no plantar pressure hot spots
- Provides high-energy return with dialed-in flexibility & impact attenuation

ACTIVO-ARCH

- Medial cage designed to provide the athlete with the perception of support & increase lockdown on declines
- Arch activiation & support is especially important for female athletes

TOTALIS TRACTION

- Trail & road traction patterns that provide confident grip in wet conditions

RESEARCH
TESTING BENCHMARK PRODUCTS

BENCHMARK PRODUCTS

TORIN IQ $220

ALTRA, MEN'S 7

- Collects data on impact force & location, contact time, & cadence to improve efficiency
- Interfaces with an app via Bluetooth for on-the-run feedback with live coaching
- Replaceable internal battery for usability
- The first commercially-available "smart shoes" released in 2017, no longer available from Altra

PEGASUS TRAIL 3 $160

NIKE, WOMEN'S 8

- Gore-Tex layer to keep water out & feet dry
- Dynamic fit band system through the midfoot for secure support & lockdown
- Increased traction at the heel & toe for grip going uphill or downhill
- Nike React tech is lightweight & durable while offering a smooth, responsive ride

PEGASUS 38 $120

NIKE, WOMEN'S 8

- Mid-level cushion for tons of energy return & comfort on runs of any length
- Mesh upper for ultimate breathability
- Air Zoom unit at the forefoot to create a responsive bounce
- Comfortable midfoot webbing to keep the foot snug & secure throughout the gait cycle

SWOT ANALYSIS

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
UPPER	- Soft sandwich mesh with thick, looped eyelets that provide great lockdown without hot spots - **Conforms well to the foot & provides stability** - Gusseted tongue for better lockdown - Non-slip laces with improved lock down through throat geometry	- **Plush tongue padding & sandwich mesh trap heat & sweat** - Sometimes fit is too narrow which doesn't work well for wider feet; other times fit is too wide which doesn't provide proper lockdown - Toe box volume is often too big or too small	- **Reduce the layering of the upper to create better ventilation & breathability** - Potentially apply a DWR finish as spring is often a wet season (but this may not be needed as this is for summer as well)	- Reducing the layering of the upper will most likely reduce the comfort & stability of the upper - DWR finish is probably not needed and would just add cost
SOCKLINER	- Inexpensive - Fits the shoe interior well - **Deep heel cup eliminates slippage**	- Not anti-microbial or odor resistant	- Addition of anti-odor or sweat wicking technology - Insoles contoured to the unique foot morphology due to sex	- Increasing technology in the insole will increase price - Insoles are often overlooked & technology in this area is often viewed as unnecessary
MIDSOLE	- Forefoot air unit increases comfort - **Embedded S-shaped, full-length nylon plate provides comfort, impact attenuation, & solid energy return** - Rocker technology helps the foot move through the proper biomechanical gait	- Too much cushioning can slow the runner down - Requires a break-in period to be comfortable - Single density foam - **No rocker technology** - No rock or energy return plate	- Variable density cushioning to specifically cater to the individual cushioning needs for different areas of the foot - **Addition of sensor technology** - Full-length energy plate for a faster midsole	- Increasing technology in the midsole will increase price - Including a sensor may impact comfort and will increase weight
OUTSOLE	- Made of hard-wearing, durable rubber that resists abrasion - **Visually-pleasing outsole design** - **Decent traction performance** - Lightweight design	- **Traction is below average on wet surfaces due to the hard rubber outsole material** - Outsole doesn't fully protect the foam midsole which can cause damage to the foam when running on a road that has debris	- Redesign the outsole & traction pattern to provide better grip on wet surfaces - **Develop a full-length traction pattern that is designed specifically for heel-strikers**	- Creating an outsole designed specifically for wet surfaces may impact the performance of the outsole on dry surfaces as well as the durability of the outsole - A full-length traction pattern may add unnecessary weight

PERFORMANCE ATTRIBUTES

"FUNCTIONAL COMFORT"

THE FOOTWEAR NEEDS TO INTEGRATE A SHEAR SENSOR
WITHOUT COMPROMISING UNDERFOOT COMFORT

OVERALL WEIGHT OF THE SHOE

- Increasing the weight of a shoe will affect running efficiency & decrease performance [100g+ slows down athlete by 1%]

DUROMETER & FLEXIBILITY OF THE SOLE UNIT

- If the sensor does not allow the sole unit to flex with a similar amount of force, then this will negatively affect performance

PLANTAR PRESSURE DISTRIBUTION

- Plantar pressure hot spots originating adjacent to or at sensor placement will affect comfort

OUTSOLE TRACTION

- Outsole traction is key to helping the athlete feel confident & comfortable in the footwear

WEIGHT

DATA COLLECTION

1 INSPECT THE SHOE

- Shoe is clean; insole & laces are present

2 WEIGH THE SHOE

- Zero the scale; place the shoe on the scale

WEIGHT RESULTS

244
GRAMS

259
GRAMS

245
GRAMS

DUROMETER

DATA COLLECTION

1 PREP THE DUROMETER

- Press indentor on surface 20 times

2 TAKE THE MEASUREMENT

- Select a flat surface
- Press the indentor down perpendicularly until the presser foot touches the surfaces

3 REPEAT

- Take multiple measurements for each midsole
- Take multiple measurements for each outsole

MIDSOLE RESULTS

31.8
SHORE A

29.1
SHORE A

31.8
SHORE A

OUTSOLE RESULTS

61.0
SHORE A

67.3
SHORE A

62.0
SHORE A

SOLE UNIT FLEXIBILITY

DATA COLLECTION

1 CLAMP THE SHOE DOWN

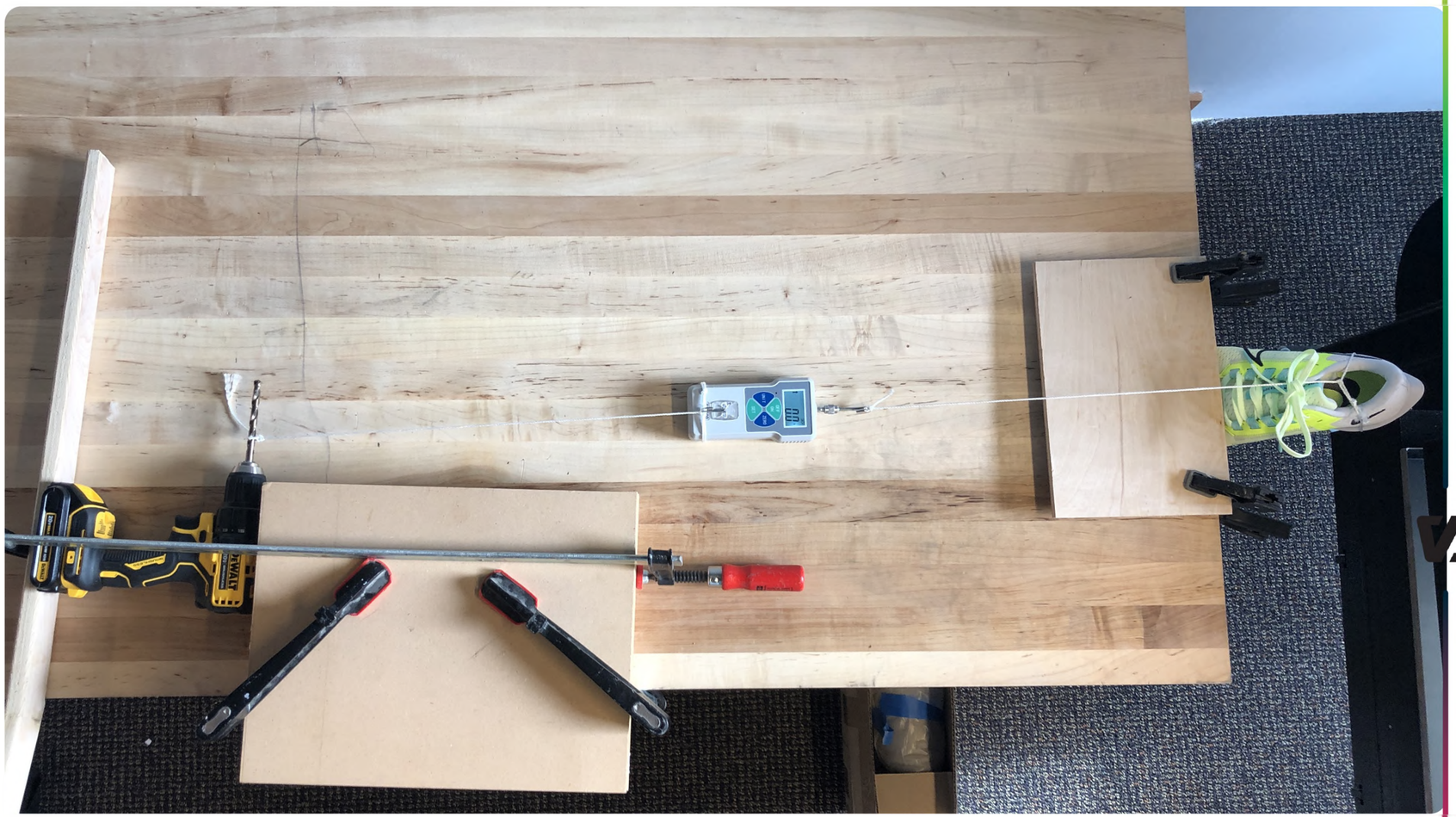
- Clamp at forefoort breaking point of shoe
- Set force gauge to measure peak force

2 APPLY FORCE TO FLEX

- Use drill to pull heel to 90 degrees flexion
- Use drill at a controlled speed
- Ensure that force gauge stays in place

3 REPEAT & RECORD

- Record the peak force in Newtons
- Repeat 5 times for each shoe (R & L)



TORIN IQ RESULTS

35.6
NEWTONS

PEGASUS TRAIL 3 RESULTS

30.0
NEWTONS

PEGASUS 38 RESULTS

29.0
NEWTONS

PLANTAR PRESSURE

DATA COLLECTION

1 PLACE ARION INSOLES

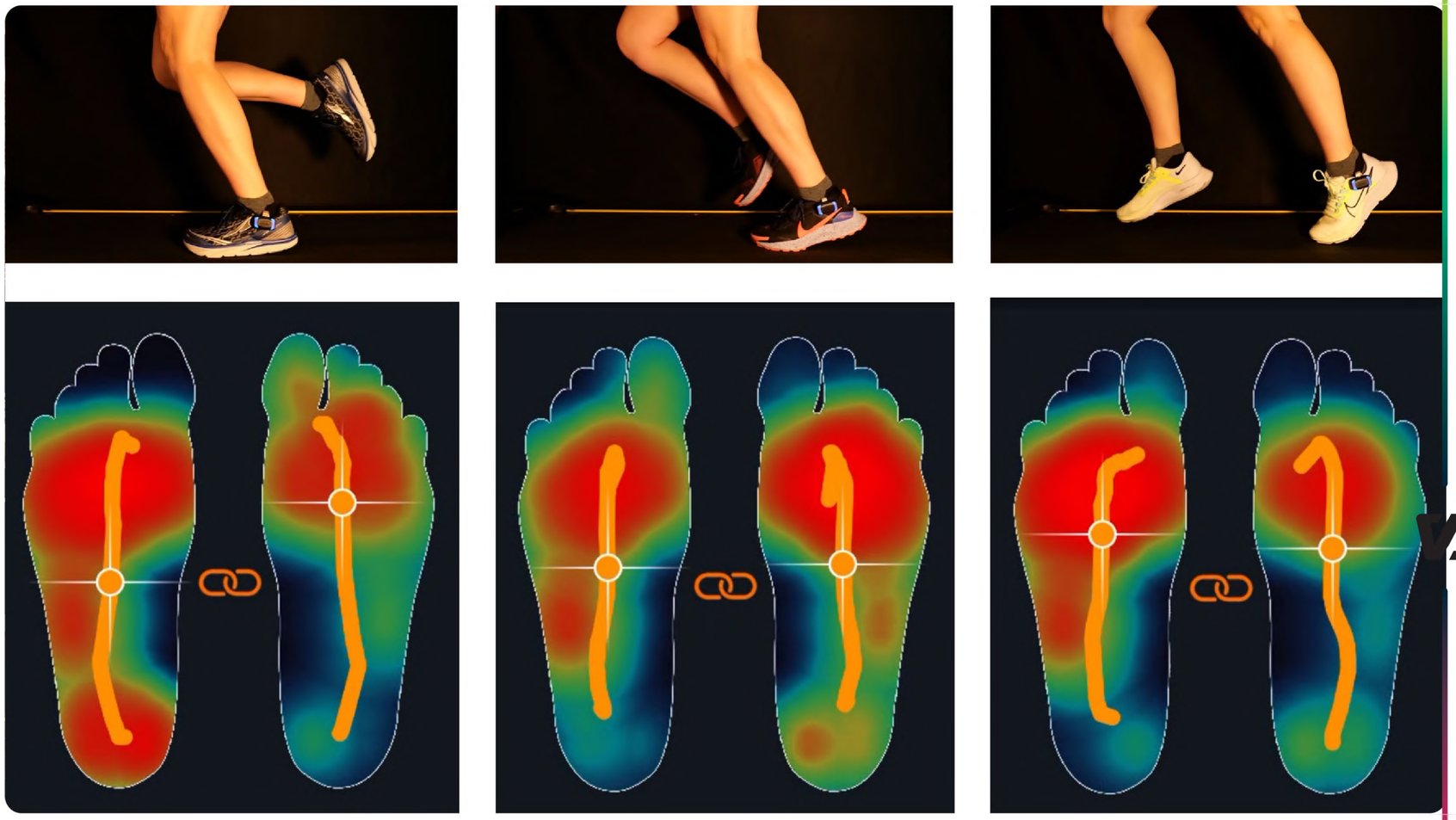
- Put insoles in shoe & shoes on athletes
- Make sure app & insoles are functioning

2 TREADMILL RUN

- Use app to record a 5 minute treadmill run
- Ask athletes questions regarding comfort at the 2.5 minute & 5 minute marks

3 REPEAT & RECORD

- Plantar pressure distribution videos & graphs
- Repeat for all test footwear



TORIN IQ IMPULSE

219
N*S

PEGASUS TRAIL 3 IMPULSE

210
N*S

PEGASUS 38 IMPULSE

223
N*S

WEAR TEST PERCEPTIONS

	COMFORT	CUSHIONING	VENTILIATION	ENERGY RET.	AESTHETICS	OVERALL*
	5.6 /10	4.4 /10	6.0 /10	2.9 /10	2.5 /10	4.8 /10
	7.7 /10	6.2 /10	5.8 /10	6.4 /10	7.4 /10	7.0 /10
	7.3 /10	7.8 /10	5.4 /10	7.5 /10	6.6 /10	6.9 /10

OF PARTICIPANTS 05

*OVERALL RANKING IS DETERMINED BY AVERAGING THE WEAR TESTERS' RANKS OF PERCEIVED COMFORT AT BOTH 2.5 MINUTES & 5 MINUTES, TRACTION, CUSHIONING, STABILITY, BREATHABILITY, ENERGY RETURN, FIT, & AESTHETICS.

TRACTION

DATA COLLECTION

1 PLACE WEIGHTS

- Put 4 flat weight plates inside the shoe
- 2 weights at forefoot, 2 in the heel area

2 SET FORCE GAUGE

- Use drill to pull shoe across the surface
- Use drill at a controlled speed
- Ensure that force gauge stays in place

3 REPEAT & RECORD

- Record the peak force
- Repeat for all test footwear

CONCRETE

ASPHALT

WET DIRT

CONCRETE RESULTS

12.1 NEWTONS

12.7 NEWTONS

12.5 NEWTONS

ASPHALT RESULTS

12.0 NEWTONS

12.9 NEWTONS

12.5 NEWTONS

WET DIRT RESULTS

13.4 NEWTONS

15.8 NEWTONS

13.5 NEWTONS

IMPROVING PERFORMANCE

"FUNCTIONAL COMFORT"

THE FOOTWEAR NEEDS TO INTEGRATE A SHEAR SENSOR **WITHOUT COMPROMISING UNDERFOOT COMFORT**

AVG. RANKING

COMFORT	*AESTHETICS*	*OVERALL**
6.8 /10	**5.5** /10	**6.2** /10
<5% ACCEPTABLE PERCENT DIFFERENCE -	>5% ACCEPTABLE PERCENT DIFFERENCE +	<5% ACCEPTABLE PERCENT DIFFERENCE -

AVG. BASELINE RESULTS

SHOE WEIGHT	*SOLE DUROMETER*	*SOLE UNIT FLEXIBILITY*	*IMPULSE*	*TRACTION*
249.3 GRAMS	**34 / 65** MID / OUTSOLE SHORE A	**31.5** NEWTONS	**217.0** N*S	**13.0** NEWTONS
<5% ACCEPTABLE % DIFFERENCE +/-	<3% ACCEPTABLE % DIFFERENCE +/-	<5% ACCEPTABLE % DIFFERENCE +/-	<3% ACCEPTABLE % DIFFERENCE +/-	<5% ACCEPTABLE % DIFFERENCE +/-

USER INSIGHTS

 # OF PARTICIPANTS **129**

"RUNNERS WILL ALWAYS PRIORITIZE A SHOE'S PERFORMANCE OVER ANY SMART FEATURES"

83% *OF PARTICIPANTS* ***TRACK THEIR PERFORMANCE METRICS***

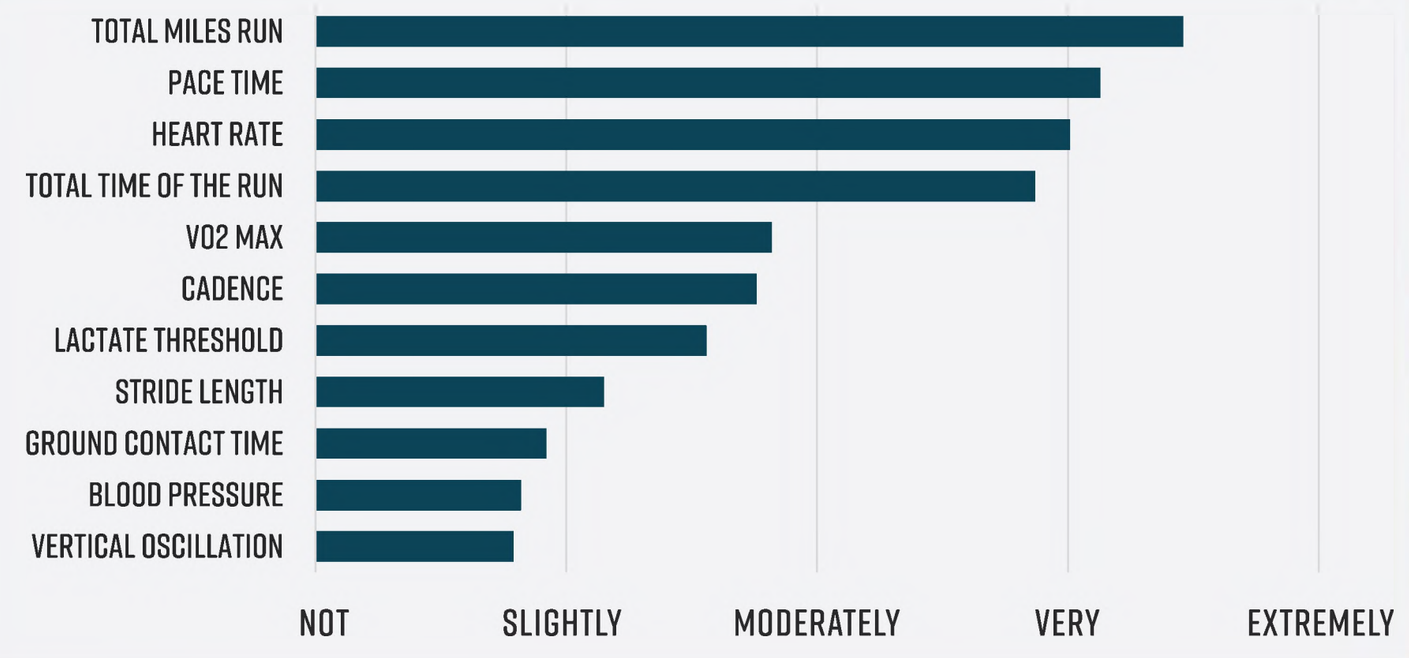
POTENTIAL CONCERNS WITH SMART RUNNING FOOTWEAR ACCORDING TO THE PARTICIPANTS

1. ***DECREASE IN PERFORMANCE***
2. ***COMFORT***
3. ***RELIABILITY***
4. ***WEIGHT***
5. ***PRICE***
6. ***DURABILITY***

55% *OF PARTICIPANTS ARE* ***INTERESTED IN A SMART TRAINING SHOE***

35 MILES *BY PARTICIPANTS FOR TRAINING PURPOSES* ***AVERAGE MILEAGE RUN PER WEEK***

WHICH PERFORMANCE METRICS ARE MOST IMPORTANT TO RUNNERS?



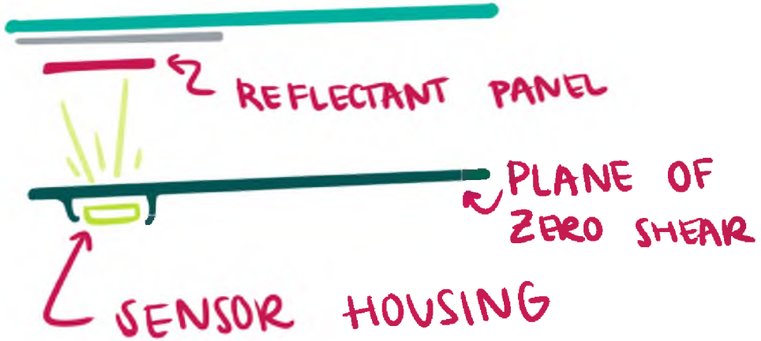
IDEATION

SKETCHING, PROTOTYPING, ETC.

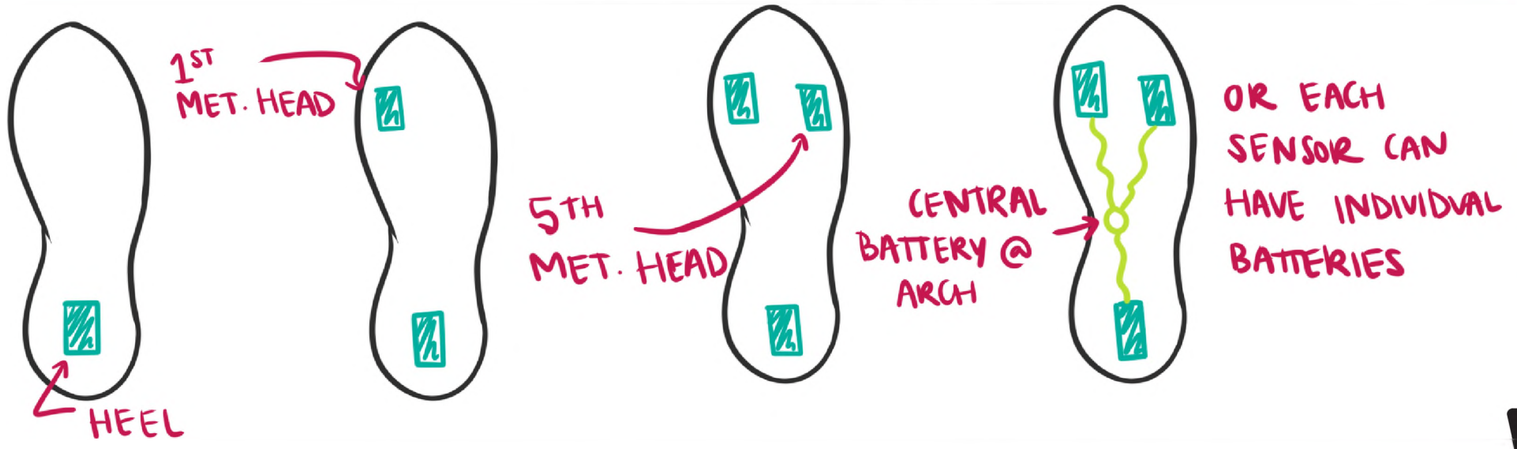
SENSOR INTEGRATION DEVELOPMENT

MULTI-AXIAL, OPTO-ELECTRONICS BASED SHEAR SENSOR

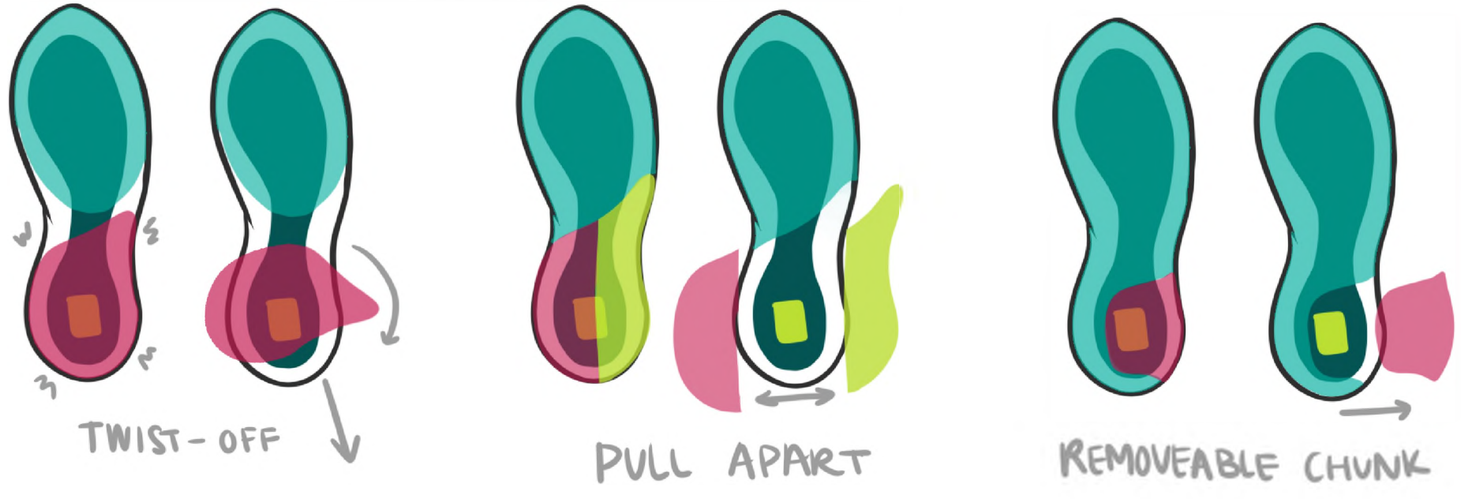
↳ VISIBLE SURFACES MUST BE BLACK BESIDES REFLECTANT PANEL



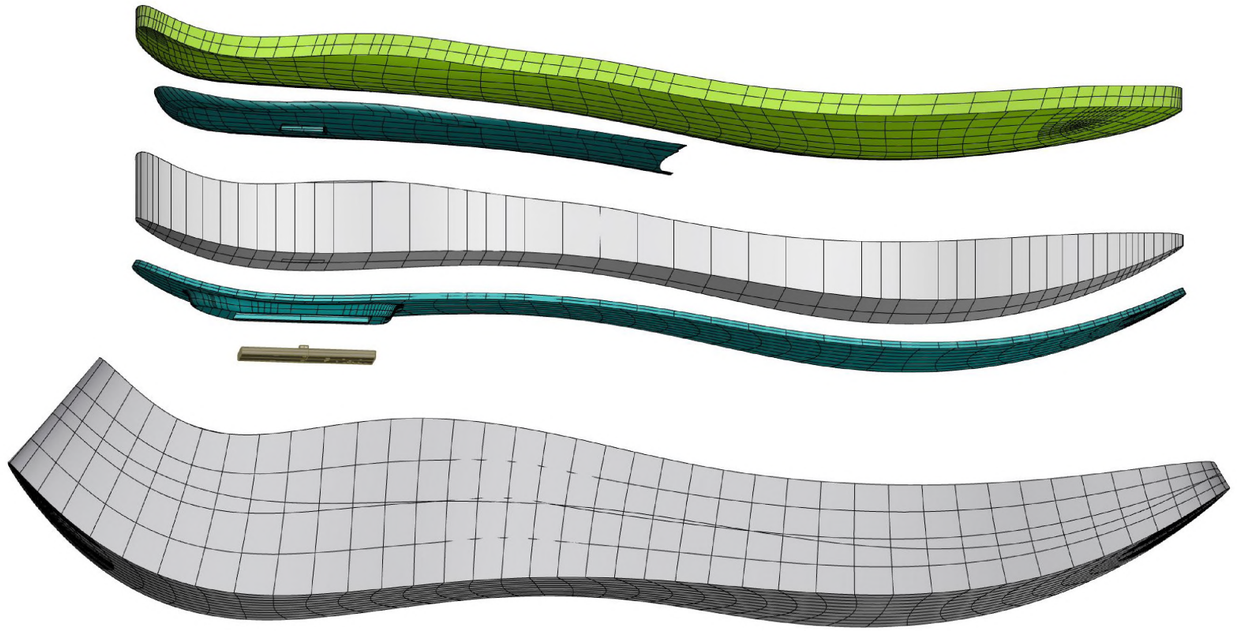
* INVESTIGATE SENSOR + BATTERY PLACEMENT

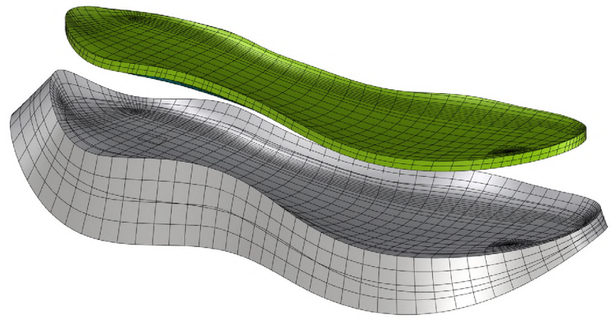


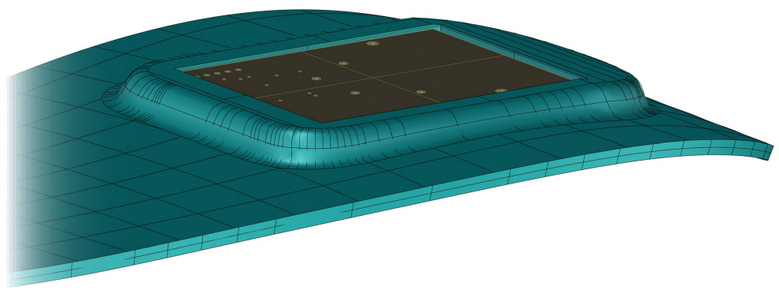
* SENSOR + BATTERY SHOULD BE ACCESSIBLE

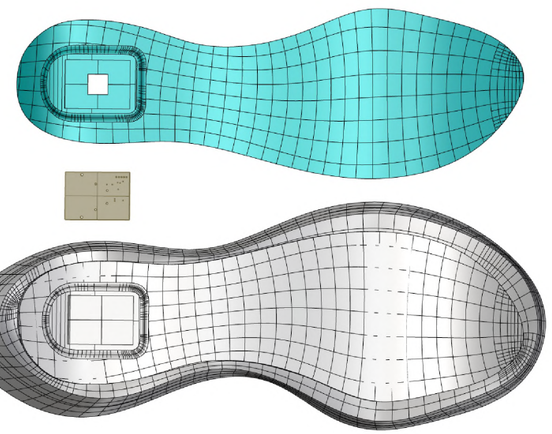


SENSOR INTEGRATION DEVELOPMENT

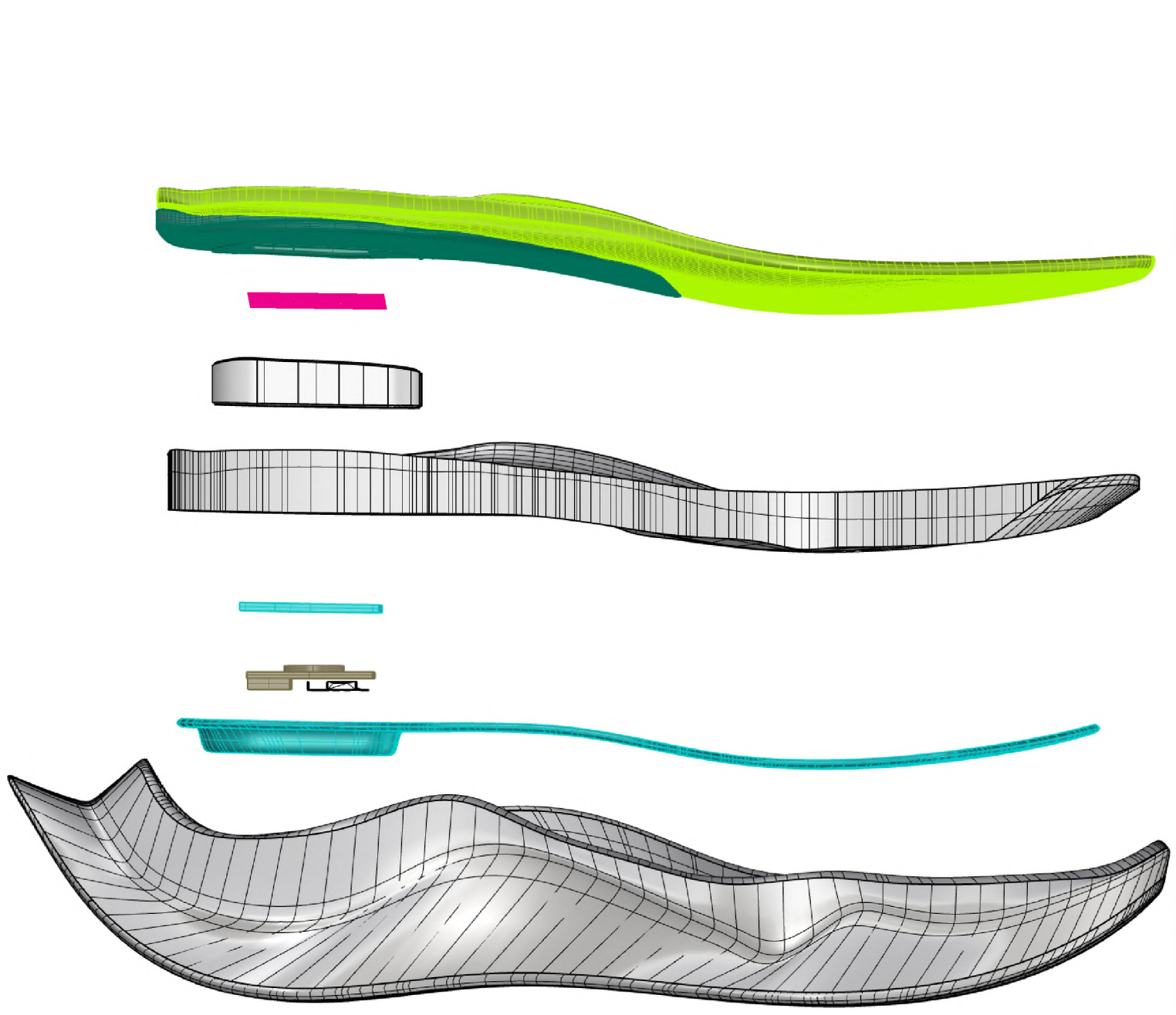


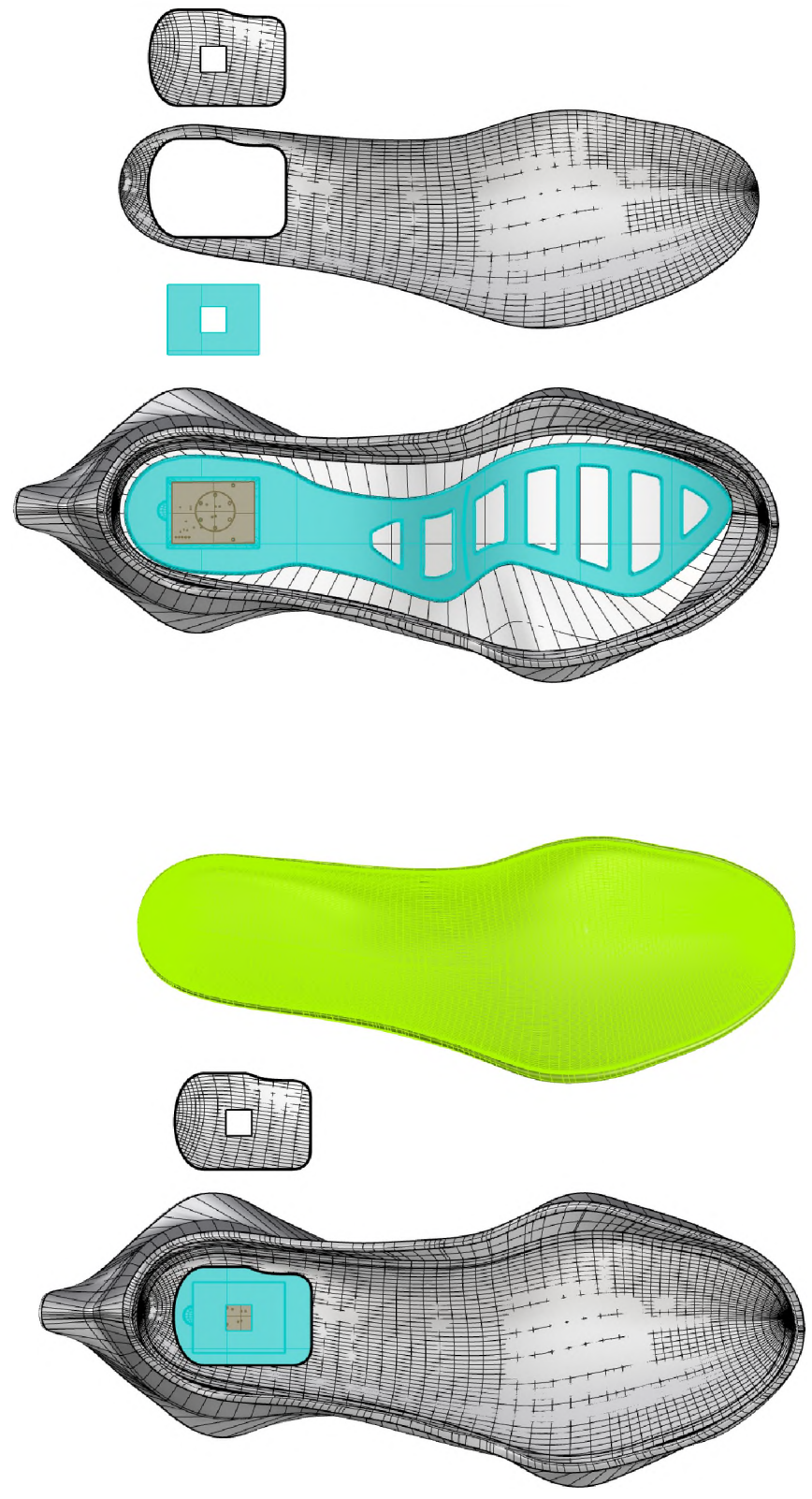




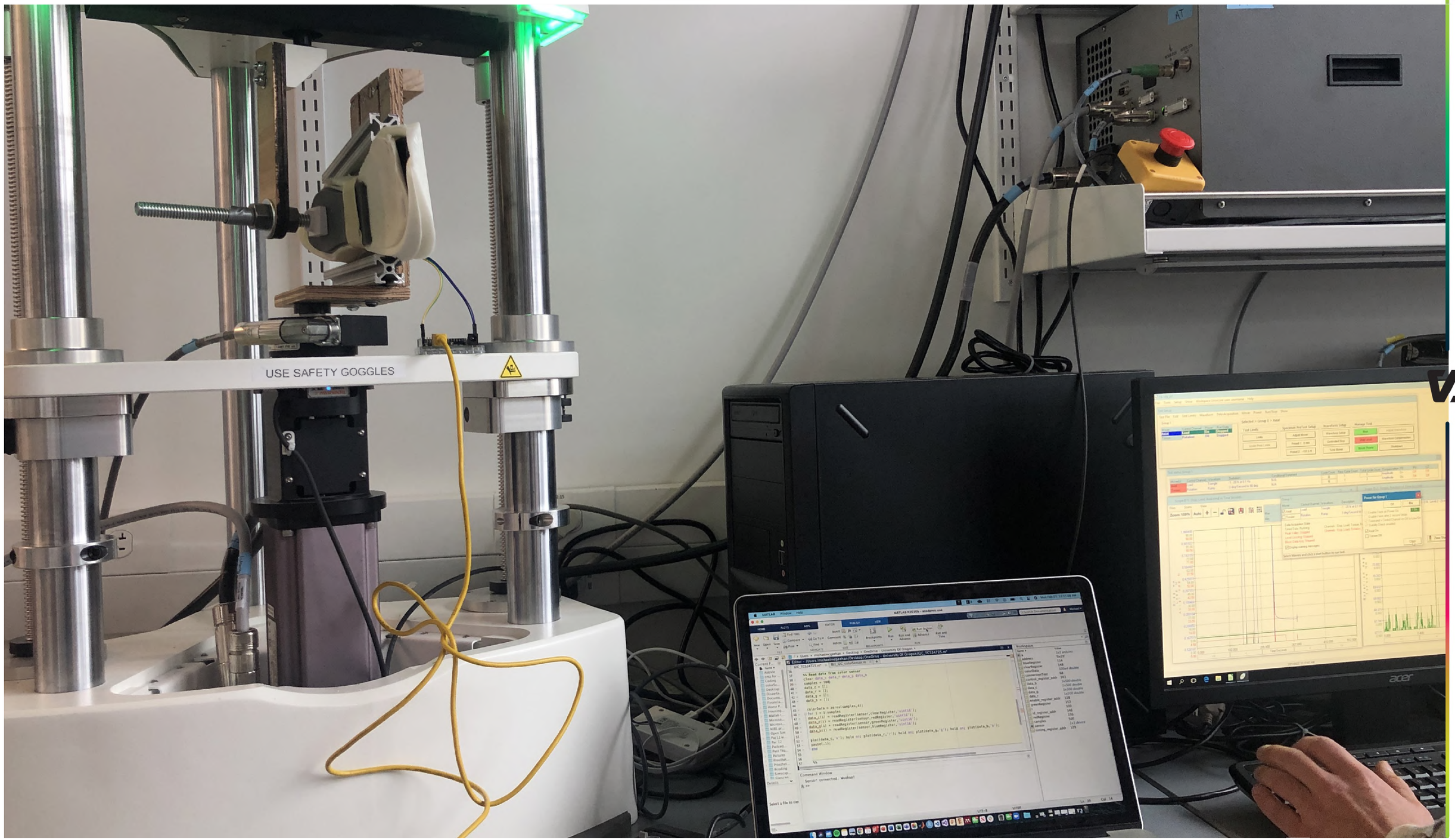


SENSOR INTEGRATION DEVELOPMENT

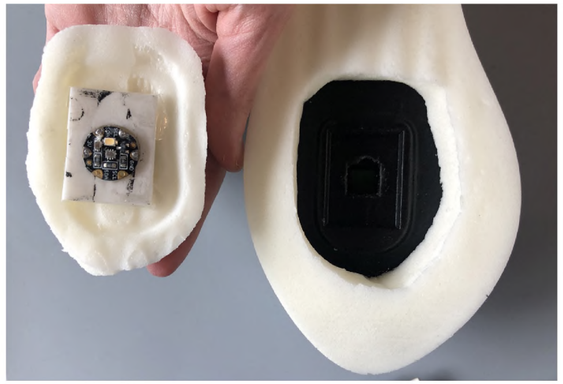




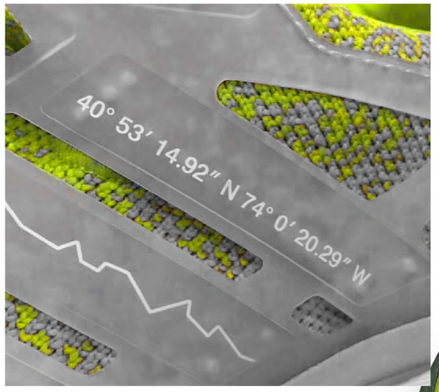
SENSOR INTEGRATION DEVELOPMENT

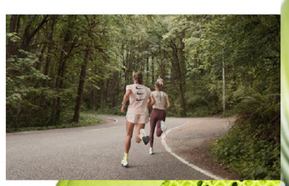


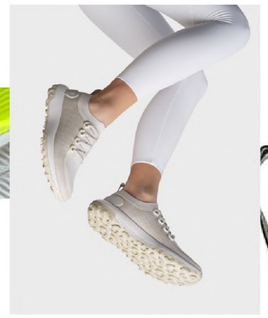
SENSOR INTEGRATION DEVELOPMENT

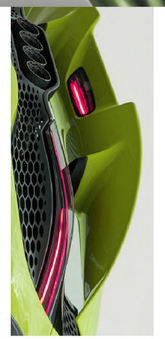


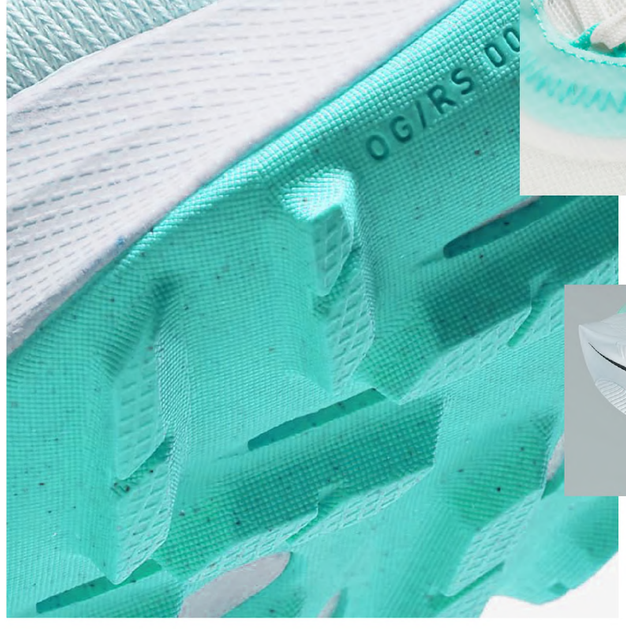
INSPIRATION & COLOR

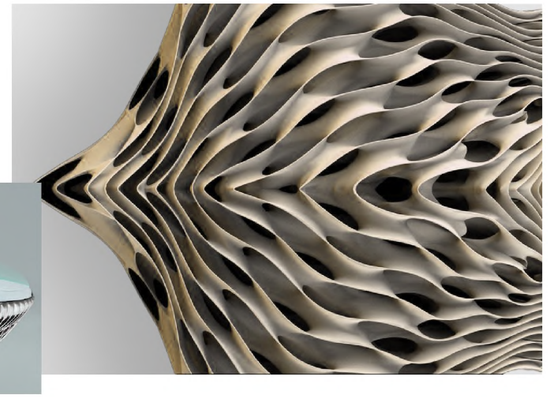










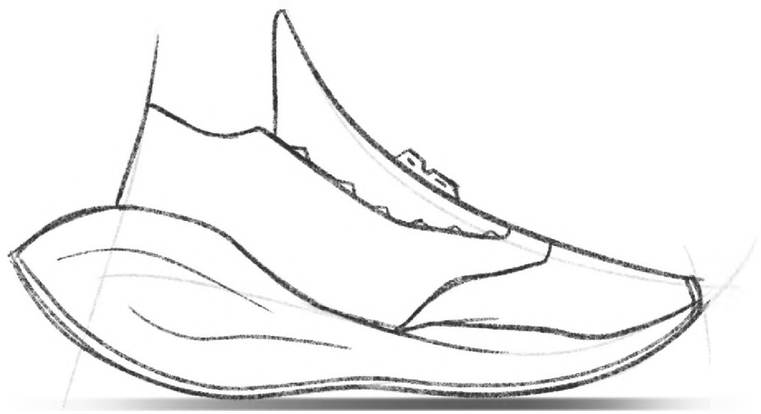


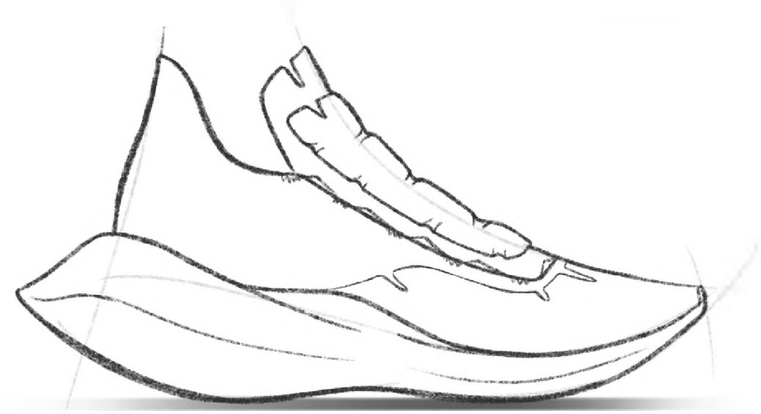
ROAD COLORWAY

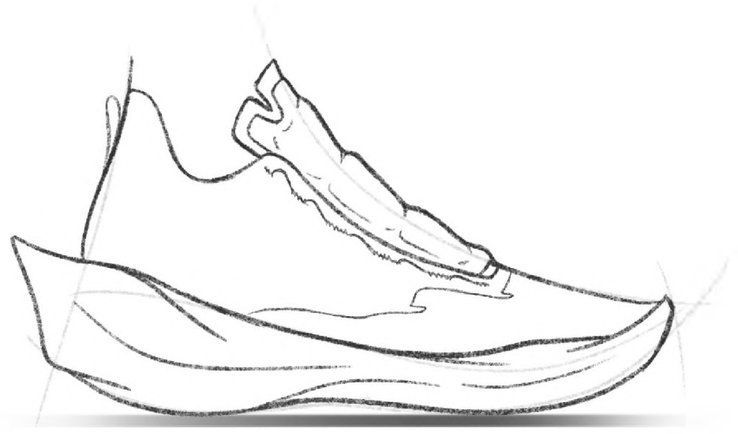
	15-4305 TCX	QUARRY
	12-0703 TCX	SEEDPEARL
	14-0340 TCX	ACID LIME
	12-0741 TCX	SUNNY LIME
	18-1856 TCX	VIRTUA_ PINK

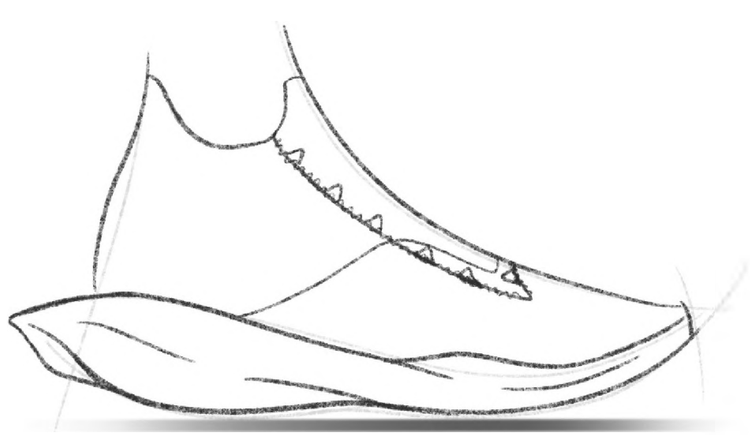
TRAIL COLORWAY

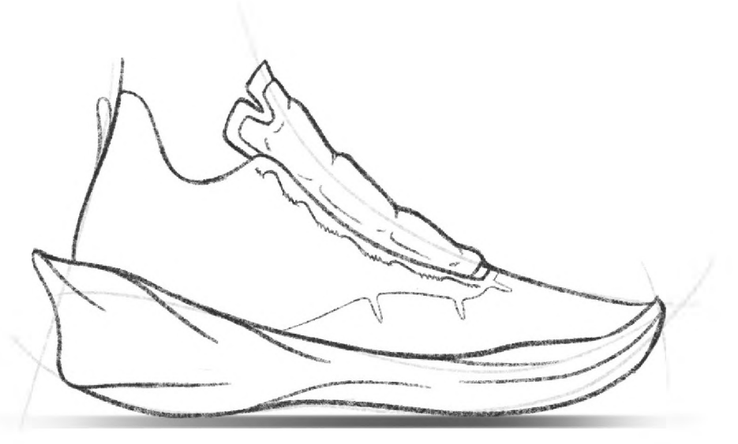
	19-4405 TCX	FOREST RIVER
	15-4305 TCX	QUARRY
	19-5217 TCX	STORM
	16-5425 TCX	POOL GREEN
	18-1856 TCX	VIRTUAL PINK

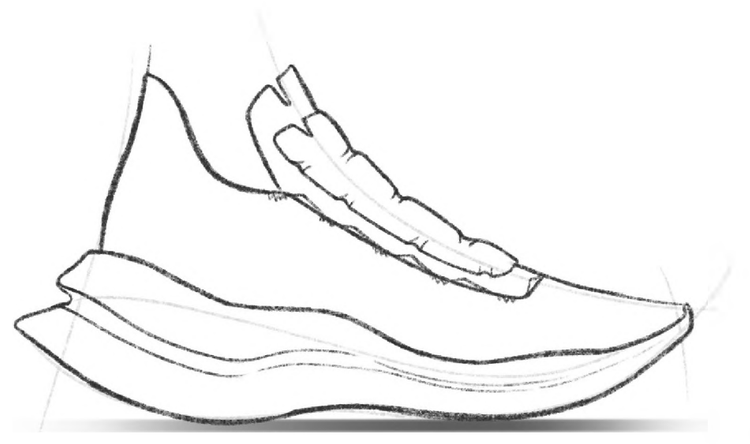


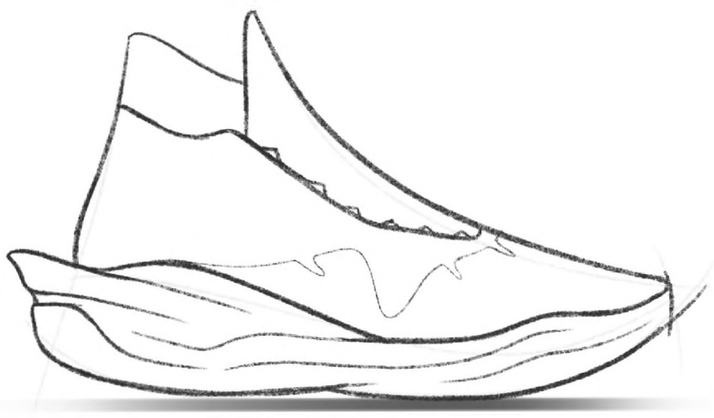


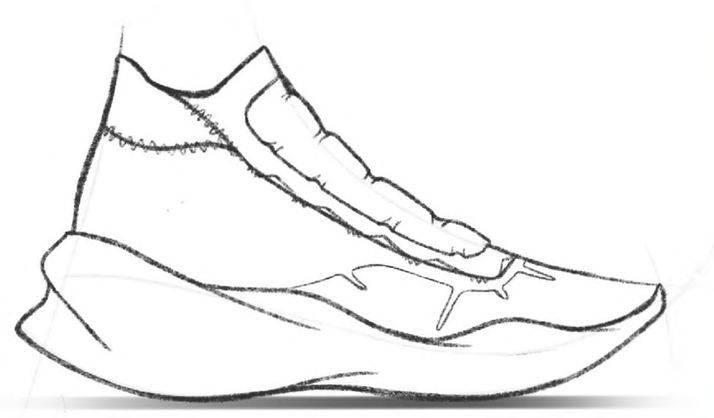


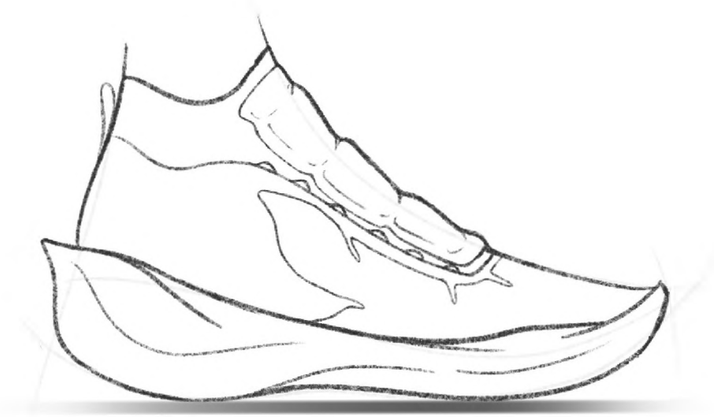


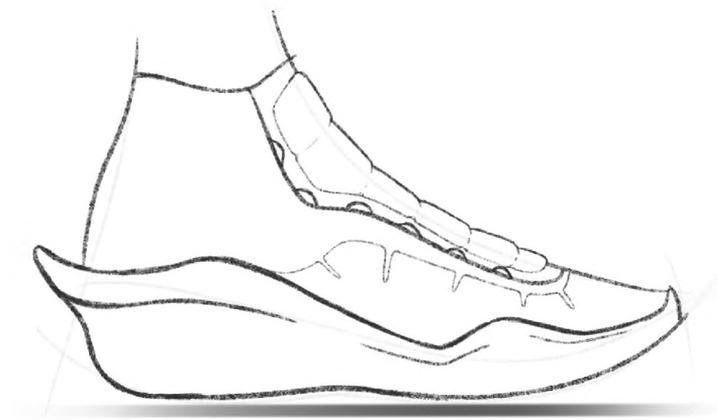


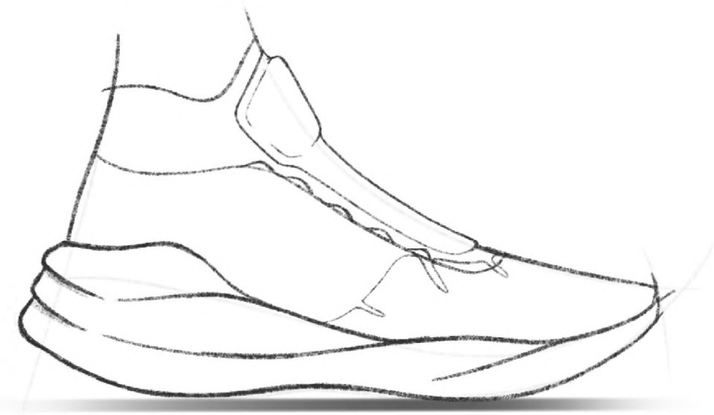


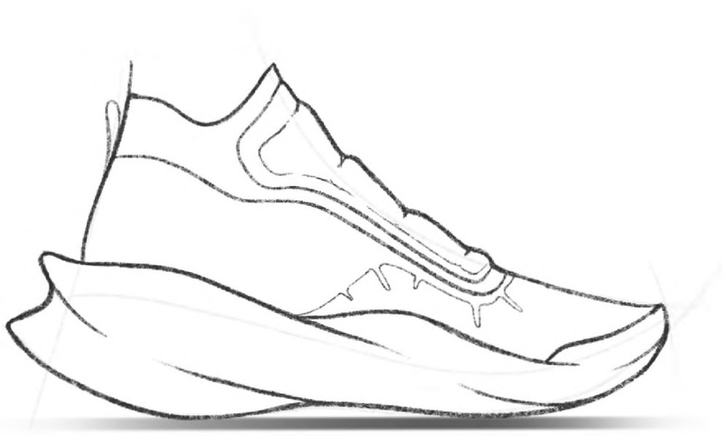


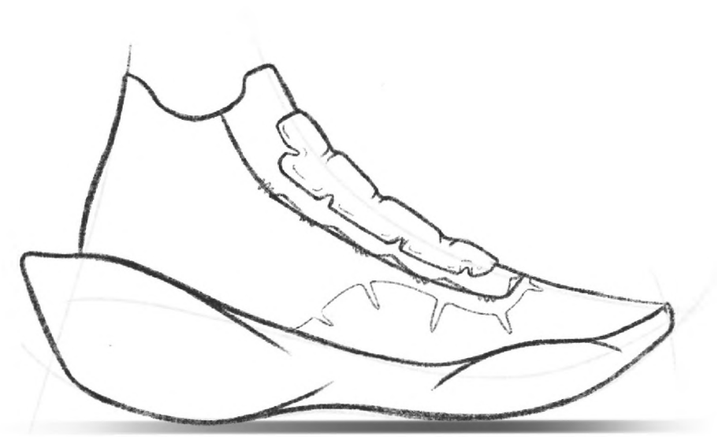


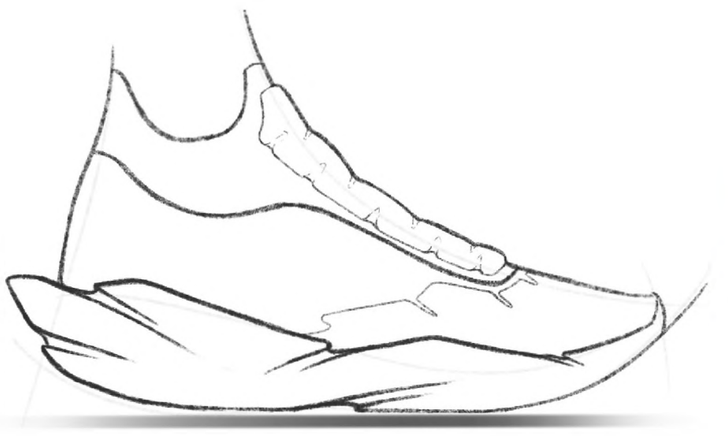


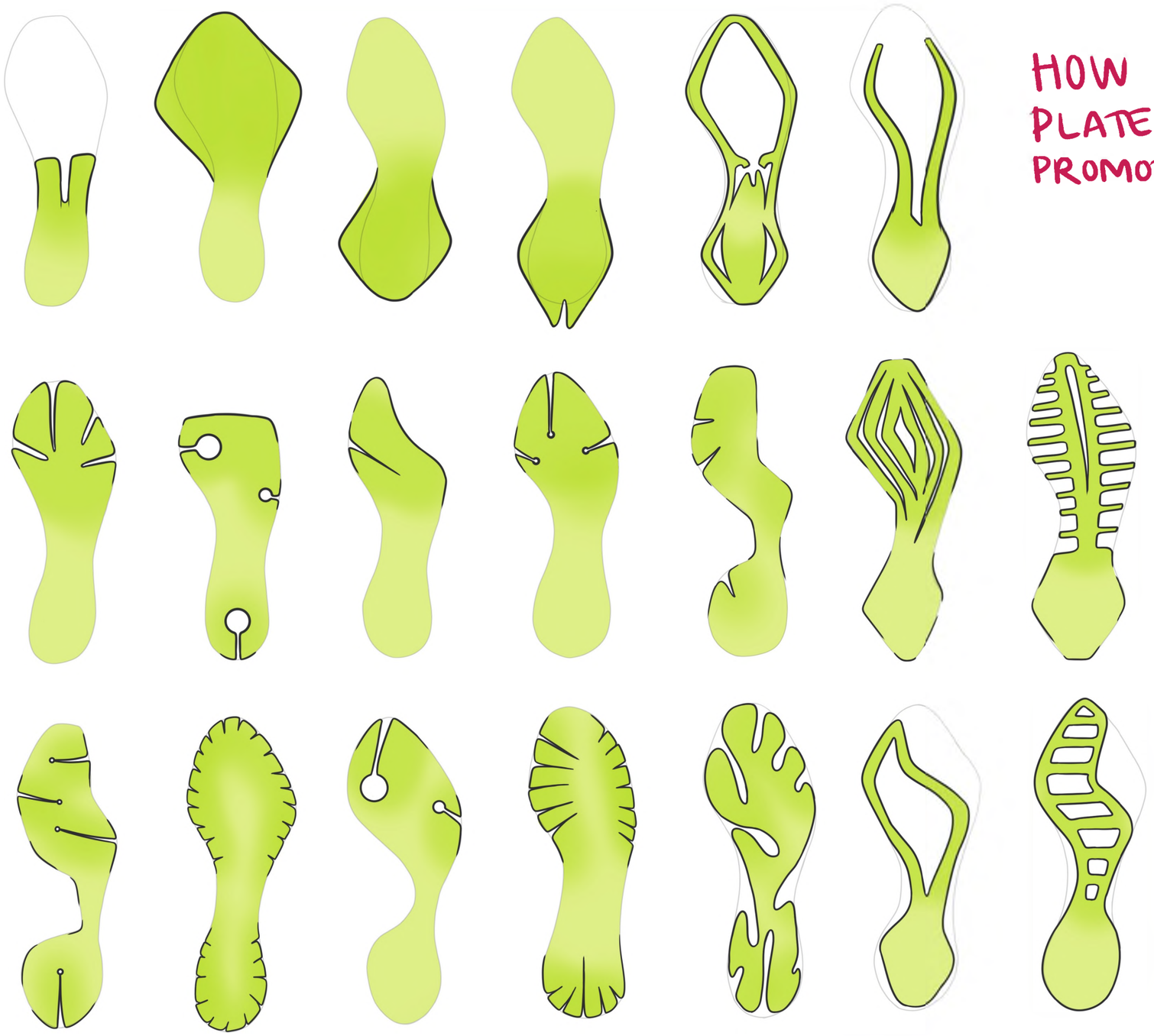




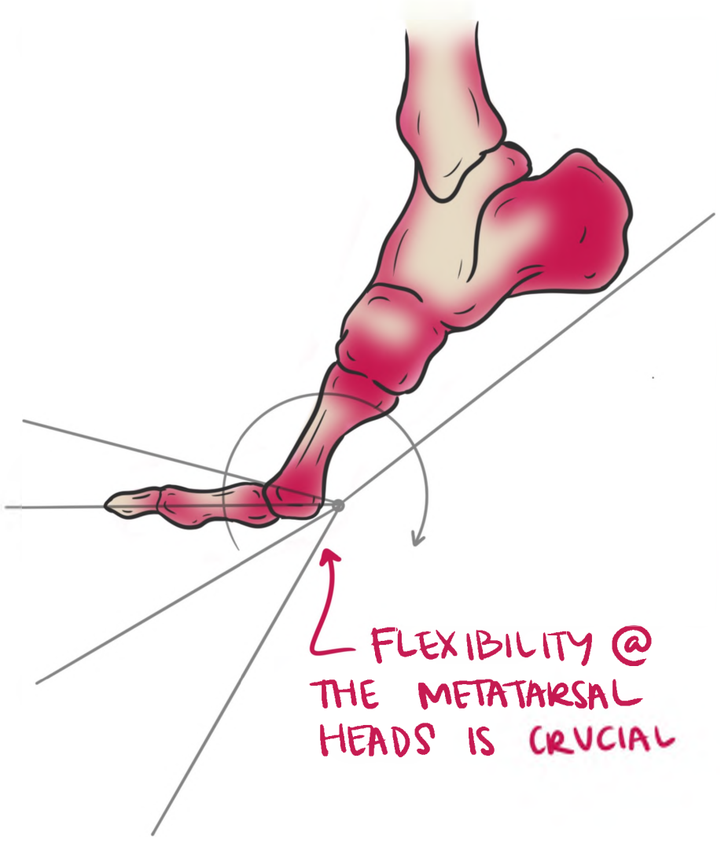




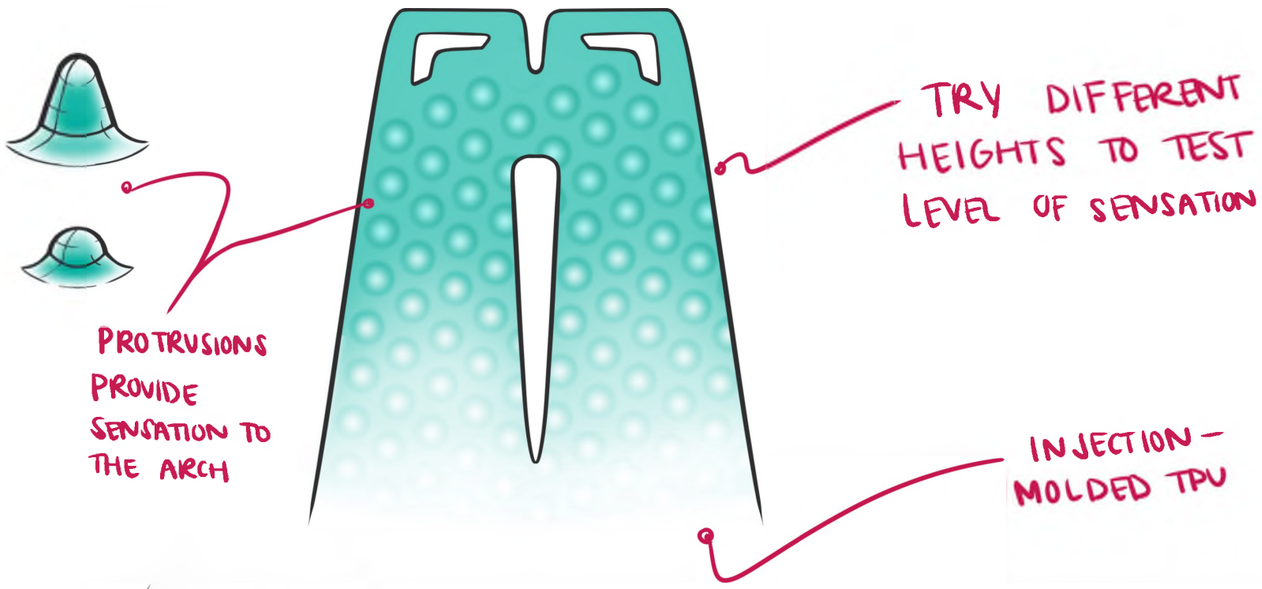


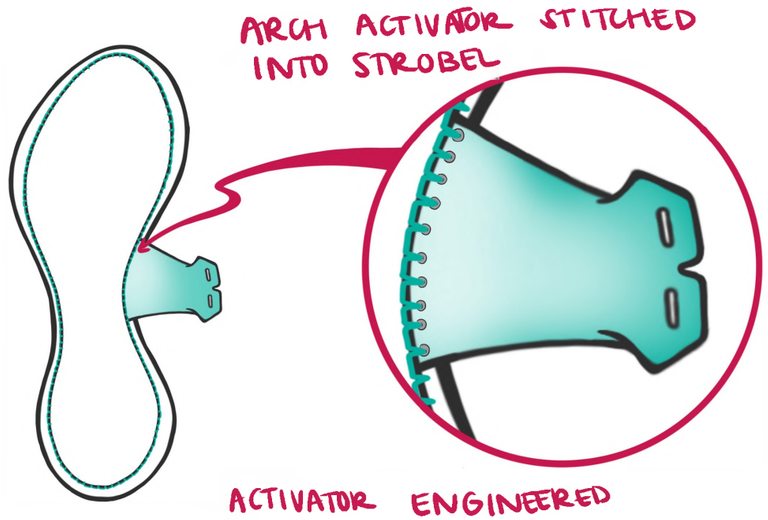


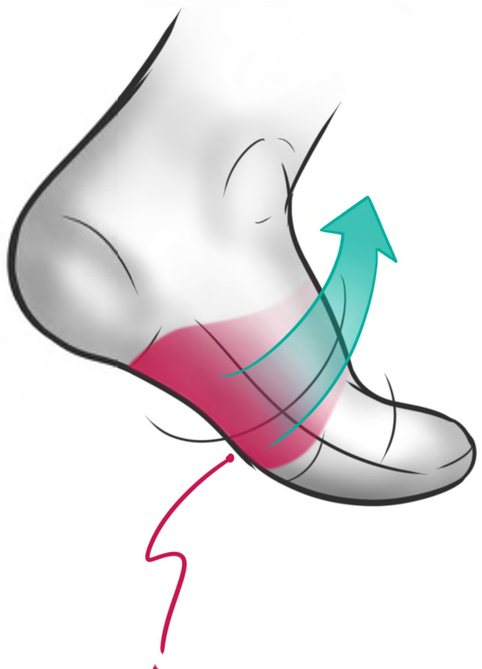
HOW CAN THE ENERGY PLATE / SENSOR HOUSING PROMOTE FLEXIBILITY?

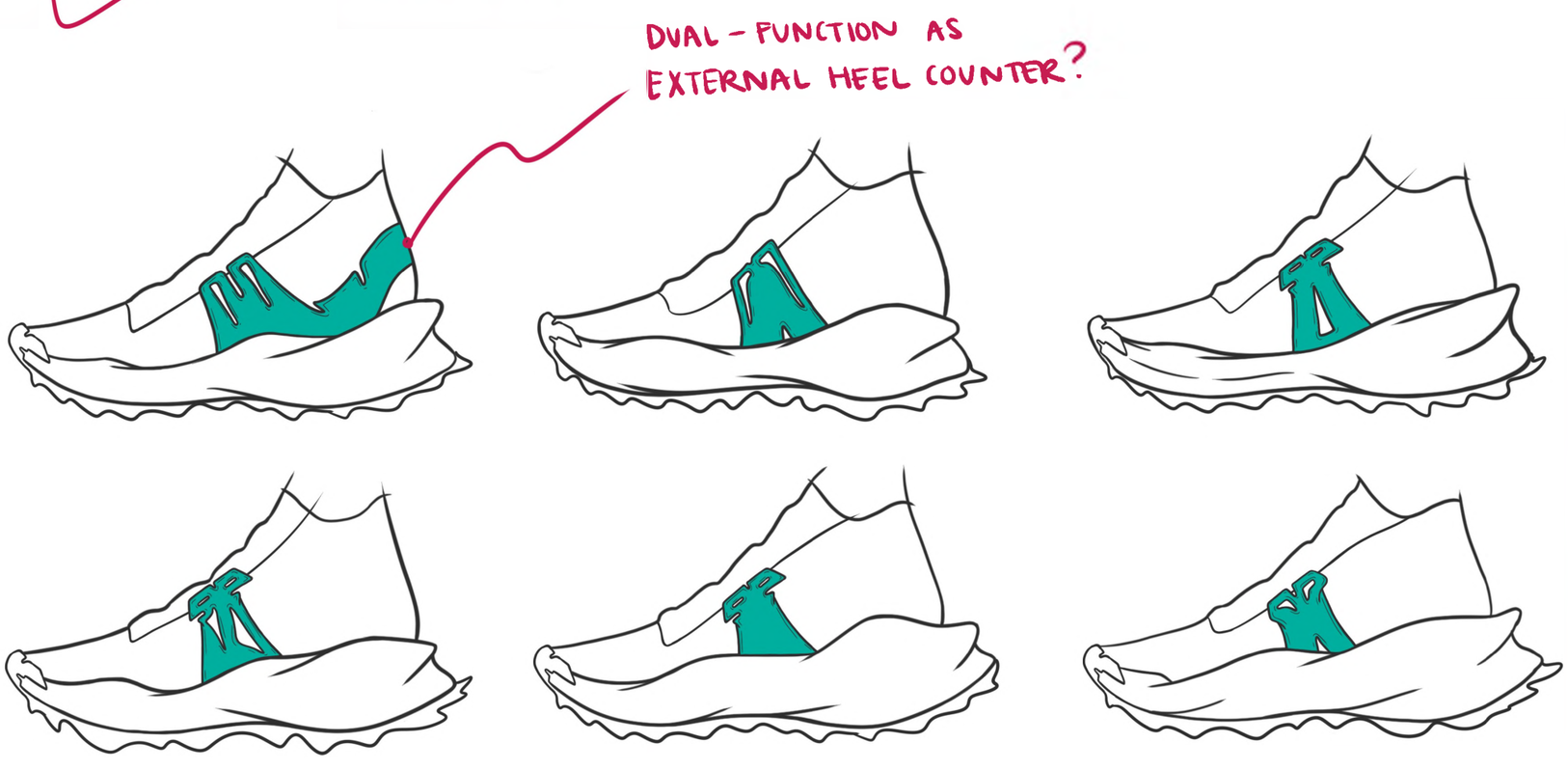


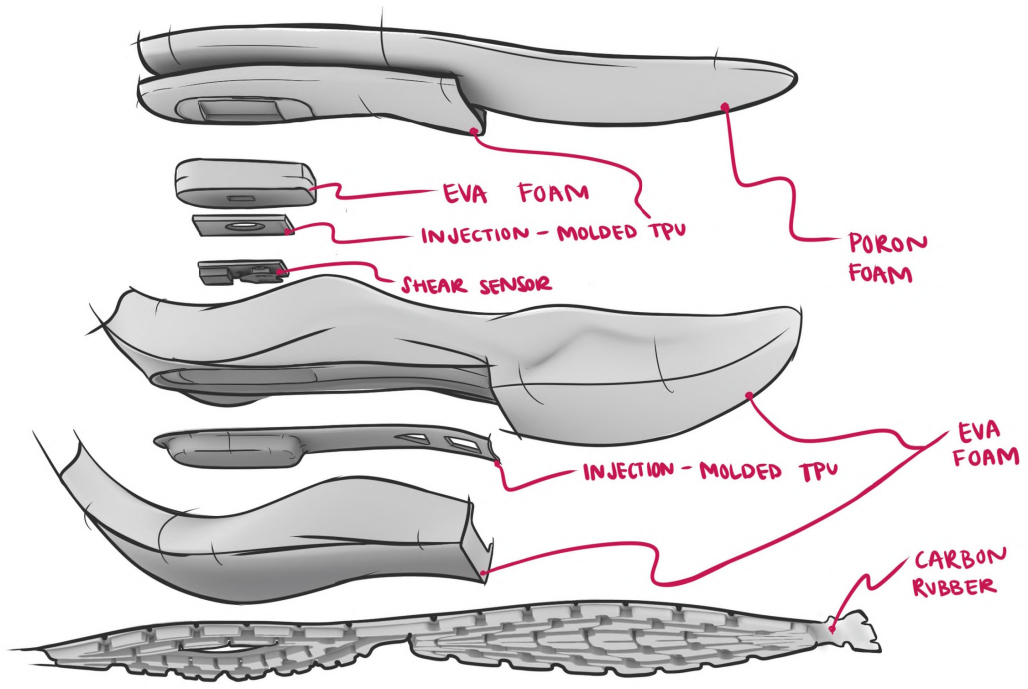
COULD BE IMPORTANT / HELPFUL TO DECOUPLE THE MEDIAL & LATERAL SIDES OF THE FOOT FOR THE TRAIL SHOE SINCE IT'S BUILT FOR VARIABLE TERRAIN

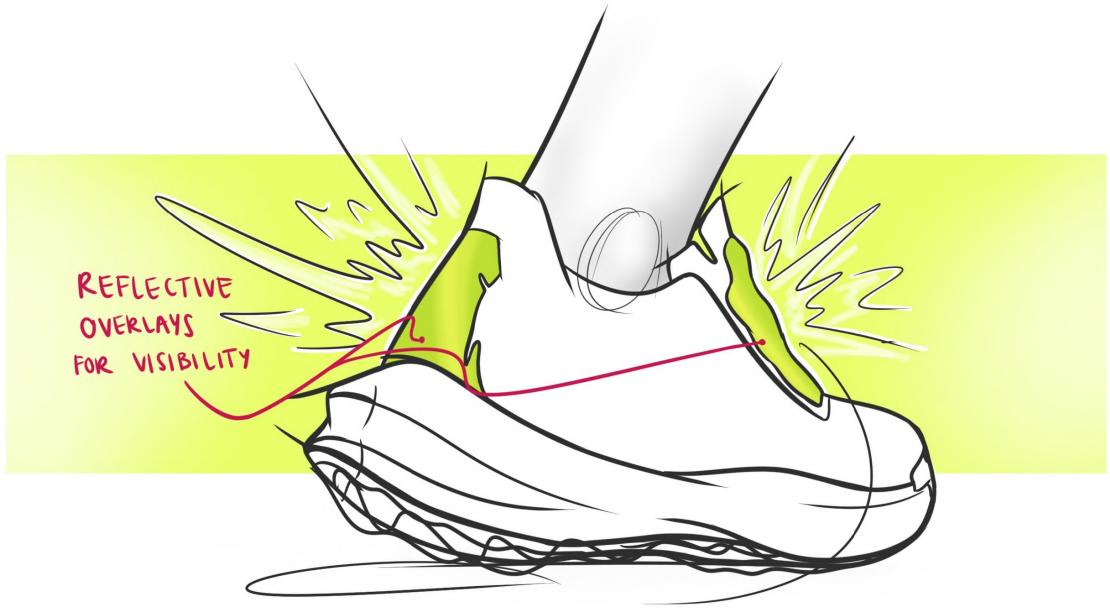

PROTRUSIONS PROVIDE SENSATION TO THE ARCH
TRY DIFFERENT HEIGHTS TO TEST LEVEL OF SENSATION
INJECTION-MOLDED TPU

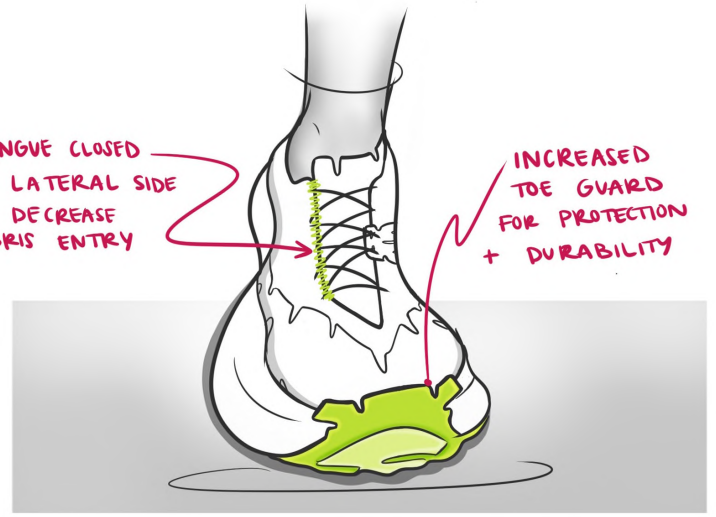

ARCH ACTIVATOR STITCHED INTO STROBEL
ACTIVATOR ENGINEERED WITH STITCH HOLES

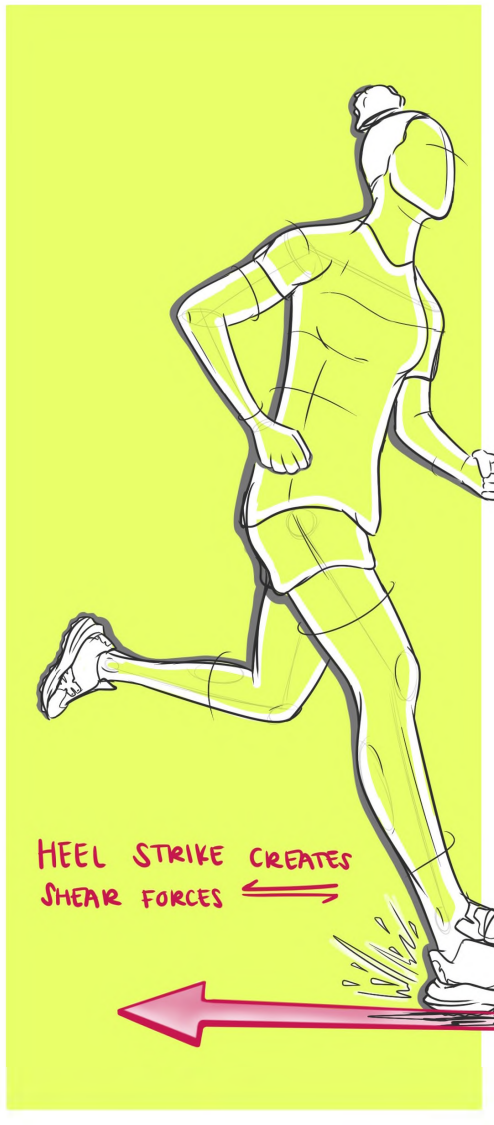

ARCH WILL ACTIVATE + RETRACT

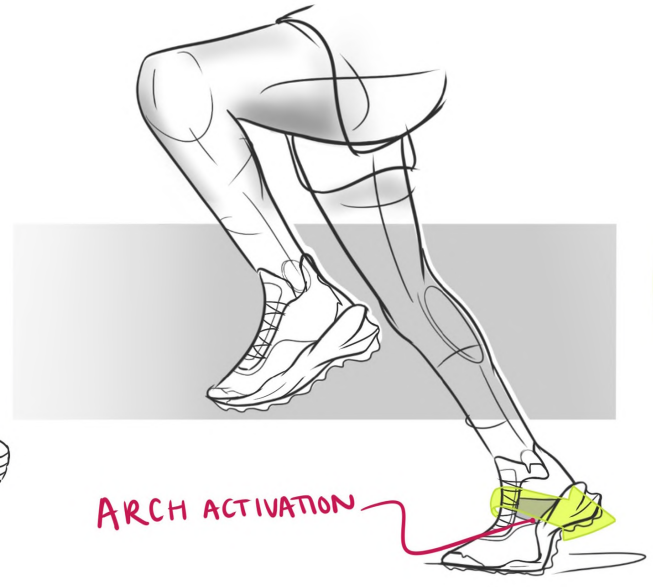

DUAL-FUNCTION AS EXTERNAL HEEL COUNTER?

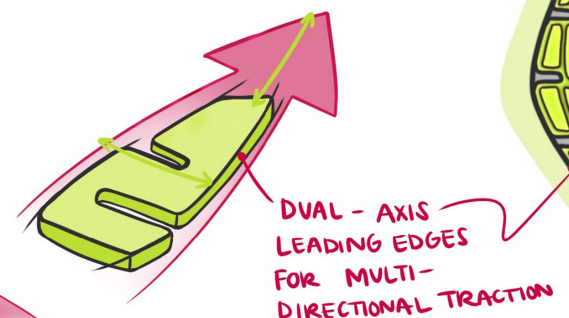

EVA FOAM
INJECTION - MOLDED TPU
SHEAR SENSOR
PORON FOAM
INJECTION - MOLDED TPU
EVA FOAM
CARBON RUBBER

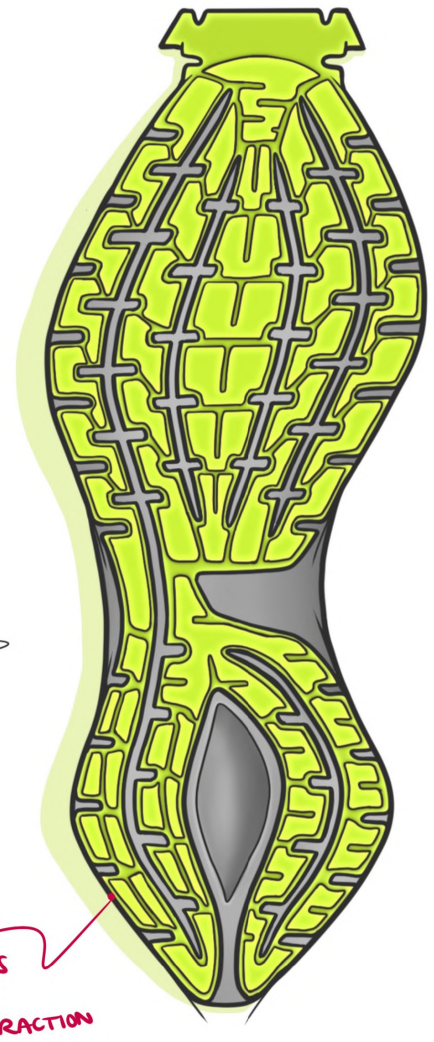

REFLECTIVE OVERLAYS FOR VISIBILITY


TONGUE CLOSED ON LATERAL SIDE TO DECREASE DEBRIS ENTRY
INCREASED TOE GUARD FOR PROTECTION + DURABILITY

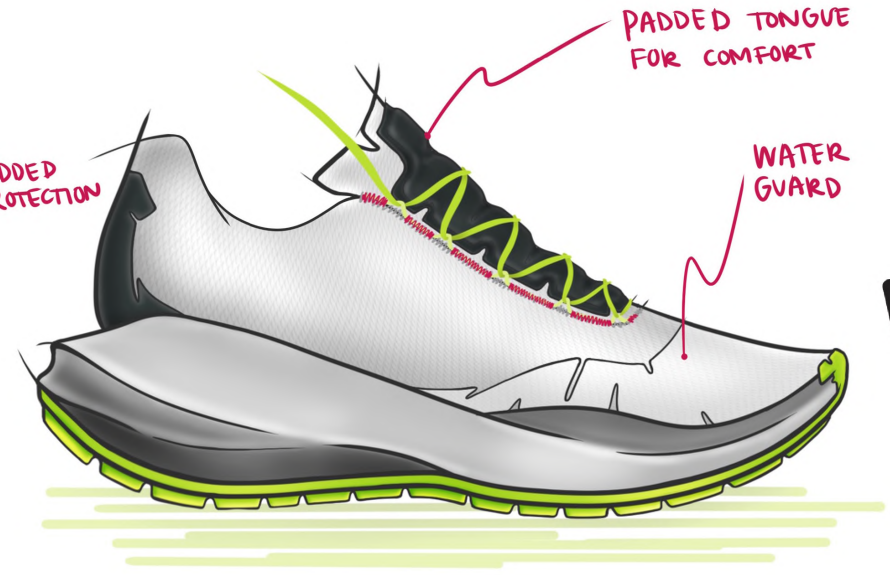

HEEL STRIKE CREATES SHEAR FORCES

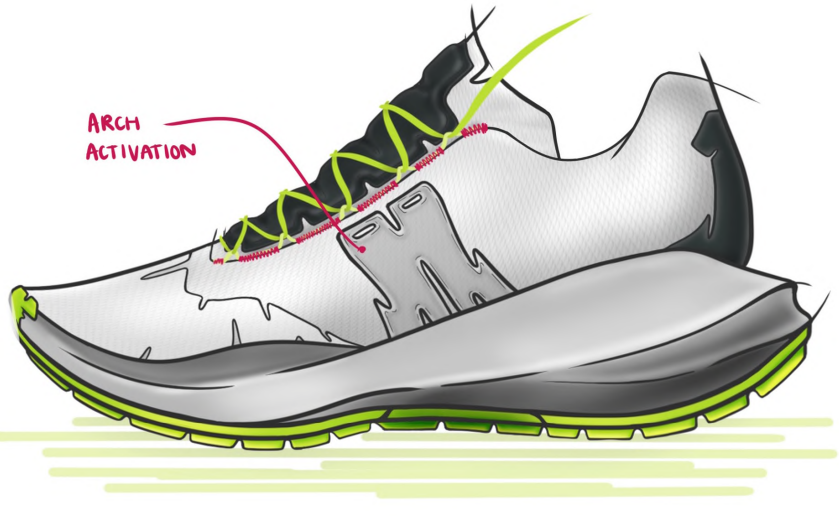

ARCH ACTIVATION


DUAL - AXIS LEADING EDGES FOR MULTI-DIRECTIONAL TRACTION




ADDED TOE PROTECTION

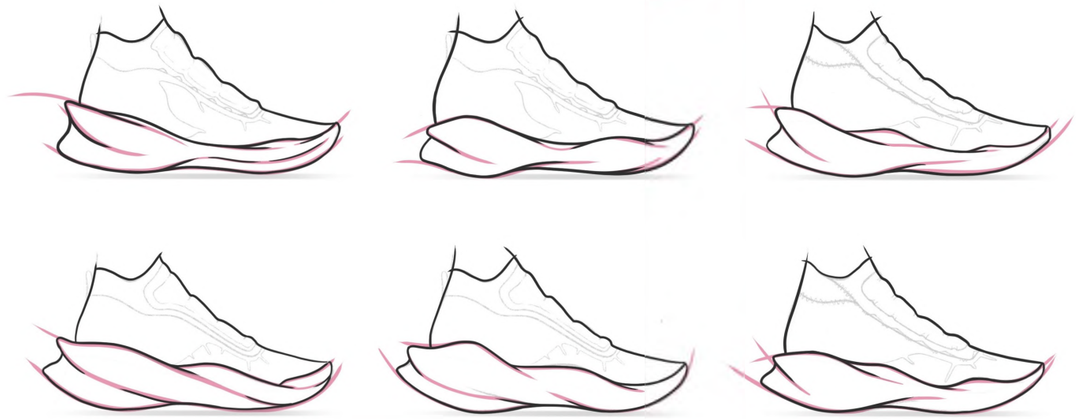

PADDED TONGUE FOR COMFORT
WATER GUARD

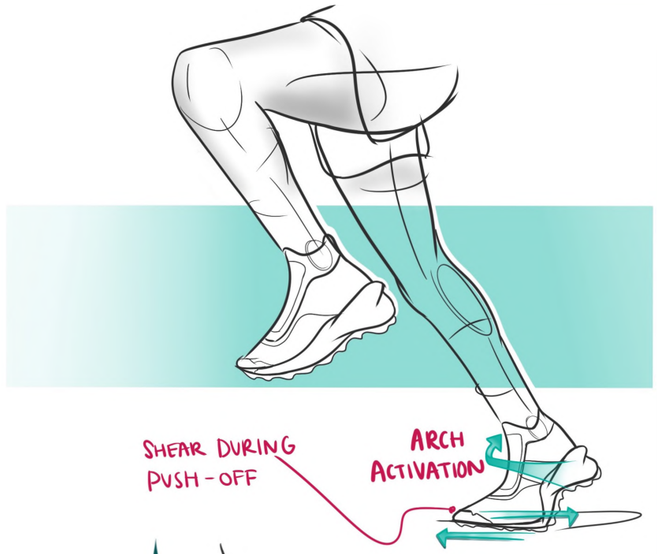

ARCH ACTIVATION

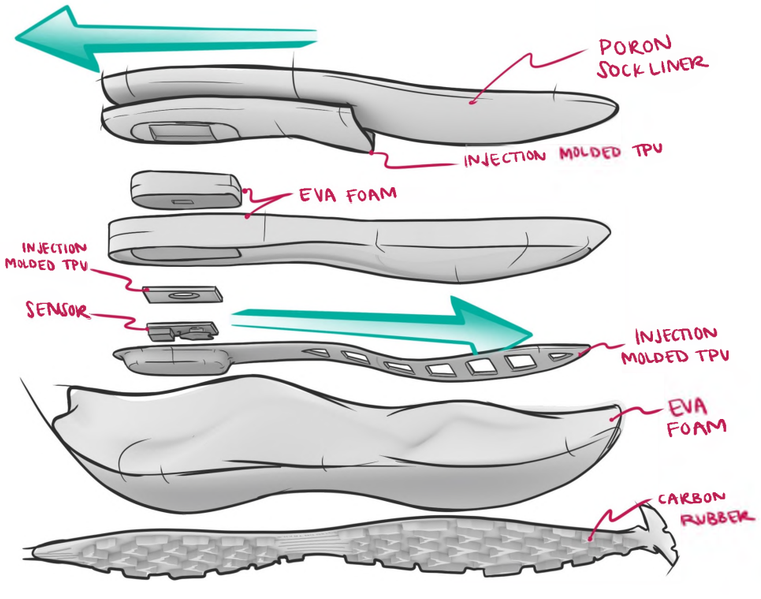

PULL TAB
WORDMARK
SEAM @ HEEL
COVERED BY BEMIS
SOCKLINER ASSEMBLY
IS REMOVEABLE

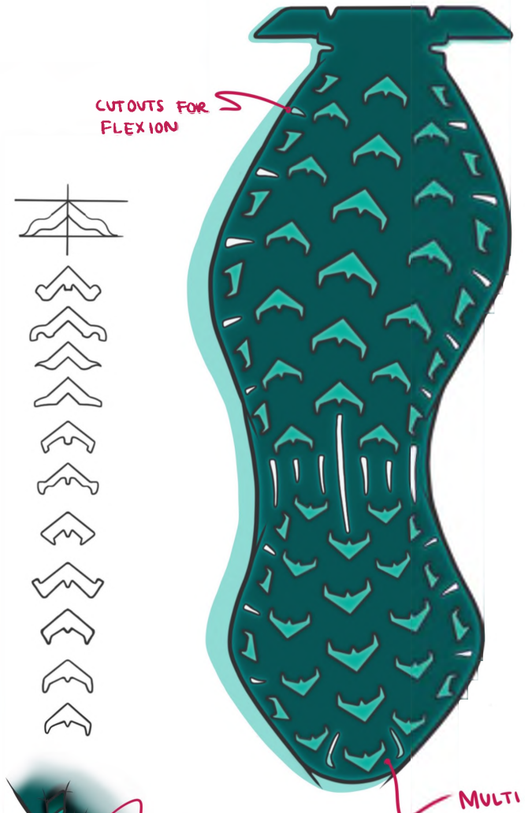

OPEN-CELL
FOAM COLLAR
PODS
INTERNAL
HEEL COUNTER
OPEN-CELL
FOAM PADDING
SUEDE TRIM
REFLECTIVE BEMIS
TONGUE OVERLAY
BEMIS
HEEL
OVERLAY
LINING
ARCH ACTIVATOR/
MEDIAL LOCKDOWN
STRAP
FOAM HEEL
PADDING
SPACER MESH
TONGUE
SPACER MESH
MAIN UPPER
TRANSLUCENT BEMIS
WATER/MUD GUARD
PORON SOCKLINER
INJECTION-MOLDED TPU
SOCKLINER STABILIZER
SENSOR ACCESS
PORTAL
STROBEL BOARD

HIGH STACK MIDSOLE — IMPACT ATTENUATION; HIGH SIDE WALL FOR STABILITY

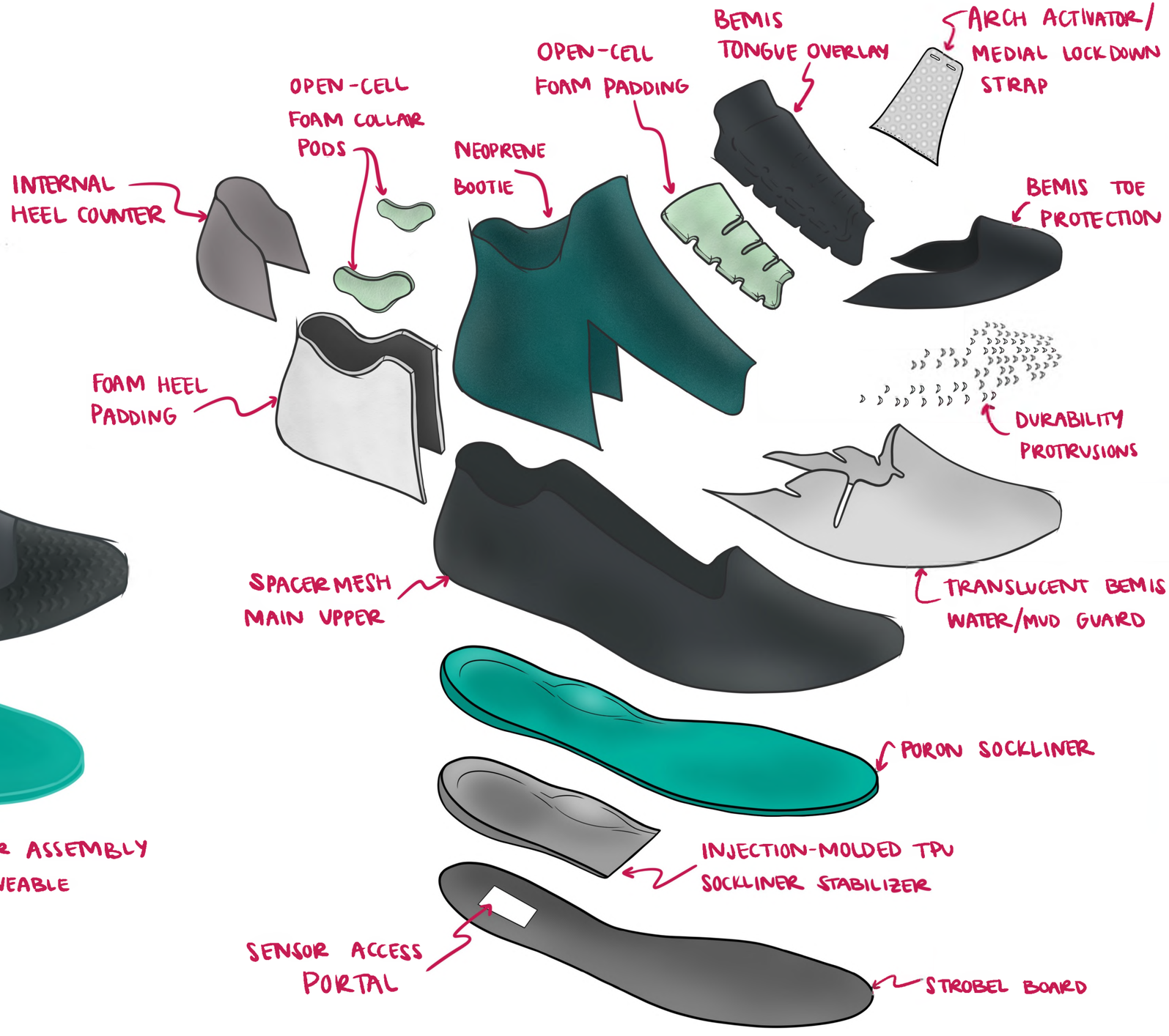






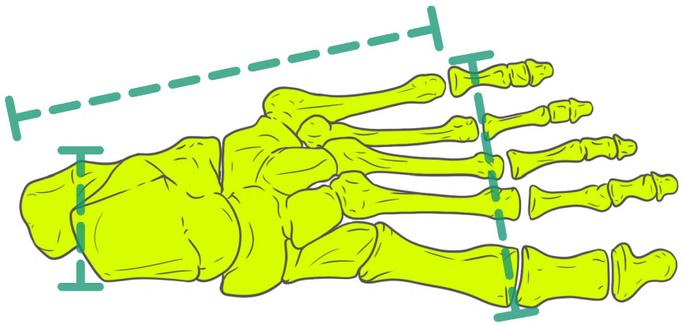


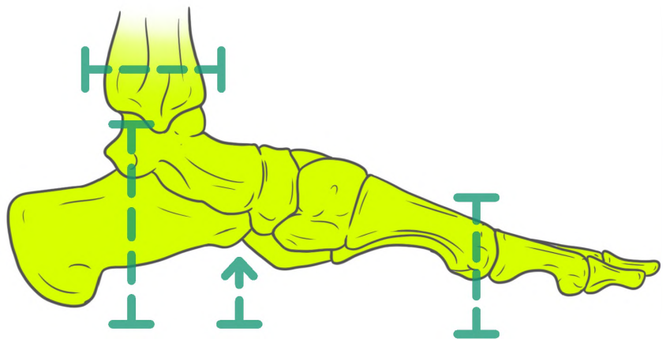

LOGO
LOGO
WORDMARK
SEAM @ HEEL
SOCKLINER ASSEMBLY
IS REMOVEABLE

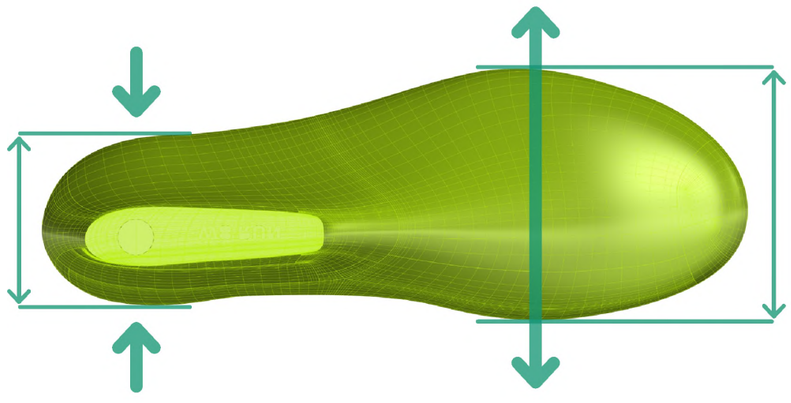

INTERNAL
HEEL COUNTER
OPEN-CELL
FOAM COLLAR
PODS
NEOPRENE
BOOTIE
OPEN-CELL
FOAM PADDING
BEMIS
TONGUE OVERLAY
ARCH ACTIVATOR/
MEDIAL LOCKDOWN
STRAP
BEMIS TOE
PROTECTION
FOAM HEEL
PADDING
DURABILITY
PROTRUSIONS
SPACER MESH
MAIN UPPER
TRANSLUCENT BEMIS
WATER/MUD GUARD
PORON SOCKLINER
INJECTION-MOLDED TPU
SOCKLINER STABILIZER
SENSOR ACCESS
PORTAL
STROBEL BOARD

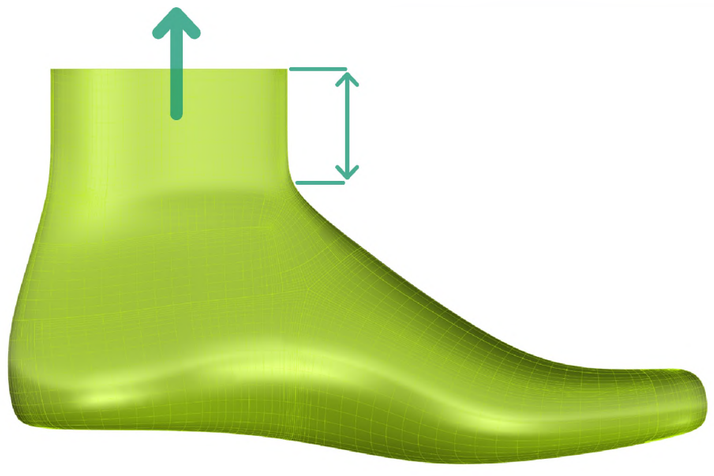
FINAL DESIGN INTENT

DEVELOPING A FEMALE-SPECIFIC LAST









FEMALE-SPECIFIC UPDATES

FEMALE FEET

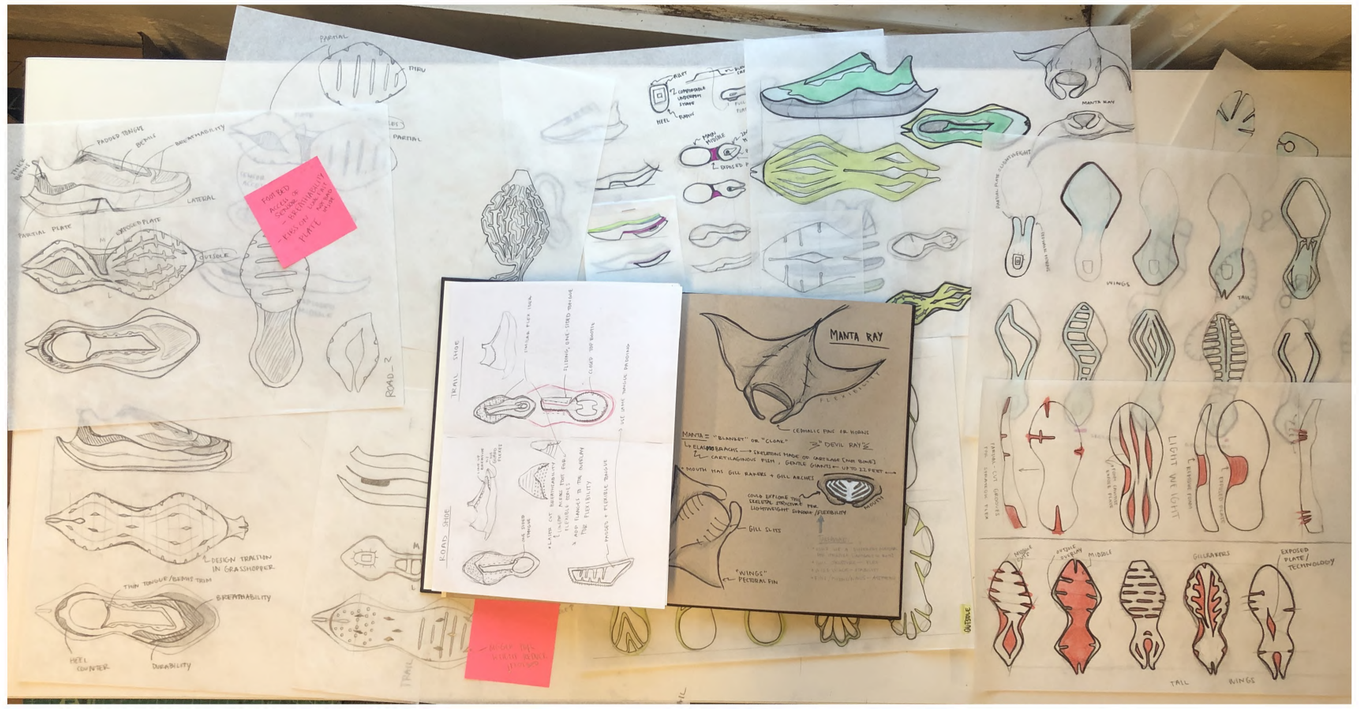
- NARROWER HEEL
- SHORTER @ HL TO 5TH MPJ
- NARROWER BALL OF FOOT WIDTH
- SHORTER ANKLE LENGTH
- SHORTER MEDIAL MALLEOUS HEIGHT
- HIGHER & MORE VARIABLE ARCH
- SMALLER INSTEP CIRCUMFERENCE

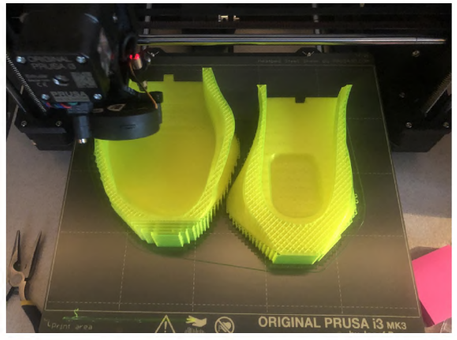
TYPICAL W8

65	MM	HEEL BREADTH
90	MM	FOREFOOT BREADTH
0	MM	LAST HEIGHT

TAU TRAINER

60	MM	HEEL BREADTH
94	MM	FOREFOOT BREADTH
42	MM	LAST HEIGHT

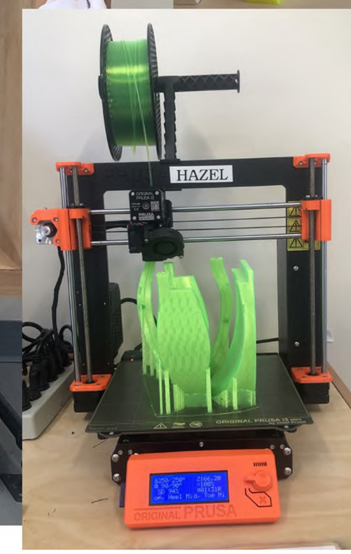

MANTA RAY
DESIGN TRACTION IN GRAINSPACE
SPRINKABILITY
DURABILITY
LIGHT WAY LIGHT
TAIL
WINGS

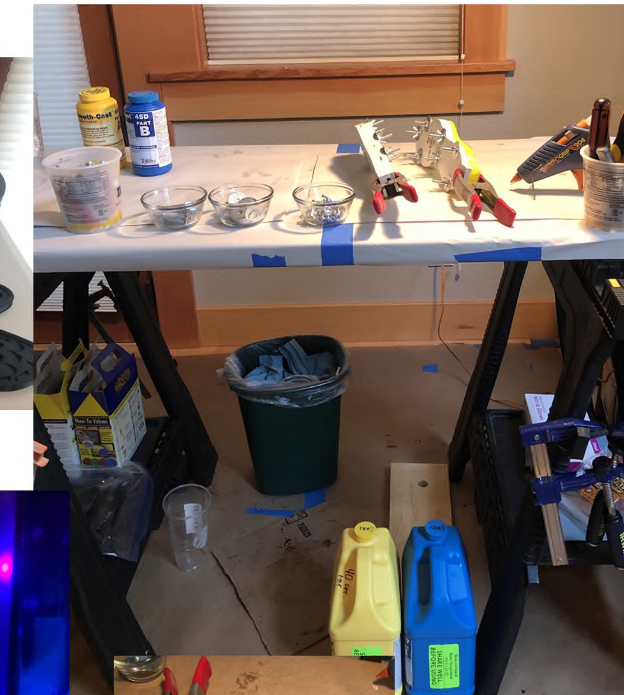

ORIGINAL PRUSA i3 MK3

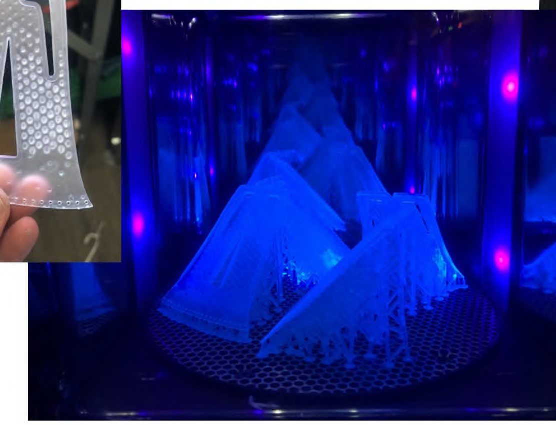

EXPOSED PLATE
REMOVABLE HEEL (INVERT)
CREATES SENSOR ACCESS
MEDIAL
MIDSOLE REMOVES TO SIDE FOR SENSOR ACCESS

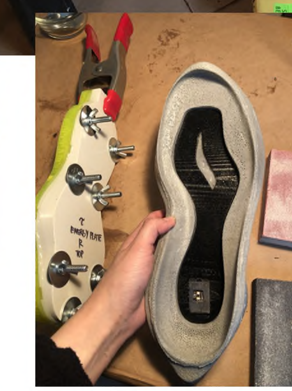
UPPER IDEATION

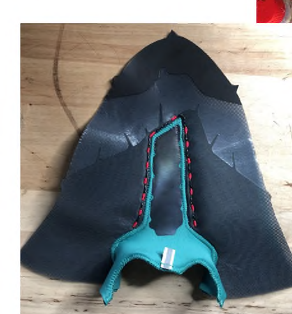
PROTOTYPING







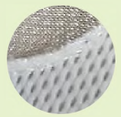




MATERIALS & MANUFACTURING

UPPER

ROAD MATERIALS

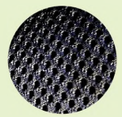


WHITE SPACER MESH
100% POLYESTER, KNIT, 3MM THICK, 350 GSM

PROTECTIVE FILM
BEMIS TL644 - FORMFIT, ELASTOMERIC POLYURETHANE

BLACK KNIT LINING
100% POLYESTER + OPEN CELL PU FOAM FOR PADDING (4MM THICK)

TRAIL MATERIALS



BLACK SPACER MESH
100% POLYESTER, KNIT, 3MM THICK, 350 GSM, DWR FINISH

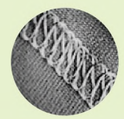
PROTECTIVE FILM
BEMIS RS3500 - RAINBOW, ELASTOMERIC POLYURETHANE

BLACK KNIT LINING
100% POLYESTER + OPEN CELL PU FOAM FOR PADDING (4MM THICK)

STITCHING

STROBEL

ZIG-ZAG



COVERSTITCH

SOLE UNIT

MIDSOLE

EVA FOAM
INJECTION MOLDED & ADHERED WITH BARGE CLEAR TF

FLEX-IT! FOAM I7
SMOOTH ON EXPANDING POLYURETHANE FOAM

ENERGY PLATE

THERMOPLASTIC POLYURETHANE
INJECTION MOLDED

ONYX SLOW LIQUID PLASTIC
SMOOTH CAST MERCURY-FREE URETHANE RESIN, ULTRA-BLACK

OUTSOLE

CARBON RUBBER
HYDRAULICALLY HEAT PRESSED & ADHERED WITH BARGE CLEAR TF

REOFLEX 60
SMOOTH ON URETHANE RUBBER, DYED WITH IGNITE FLUORESCENTS

FINAL DESIGN

CAD RENDERS, TECH PACK, COLORWAYS

TAU TRAINERS ROAD

REFLECTIVE BEMIS

INCREASES VISIBILITY & WEATHER PROTECTION

OPEN CELL PU FOAM, 3/8”

CUSHIONING FOR ADDED COMFORT
GLUED & STITCHED IN

OPEN CELL PU FOAM, 1/4”

CUSHIONING FOR ADDED COMFORT
GLUED & STITCHED IN

SPACER MESH, 100% POLYESTER KNIT

ENGINEERED FOR ZONED BREATHABILITY

EVA FOAM SOCKLINER

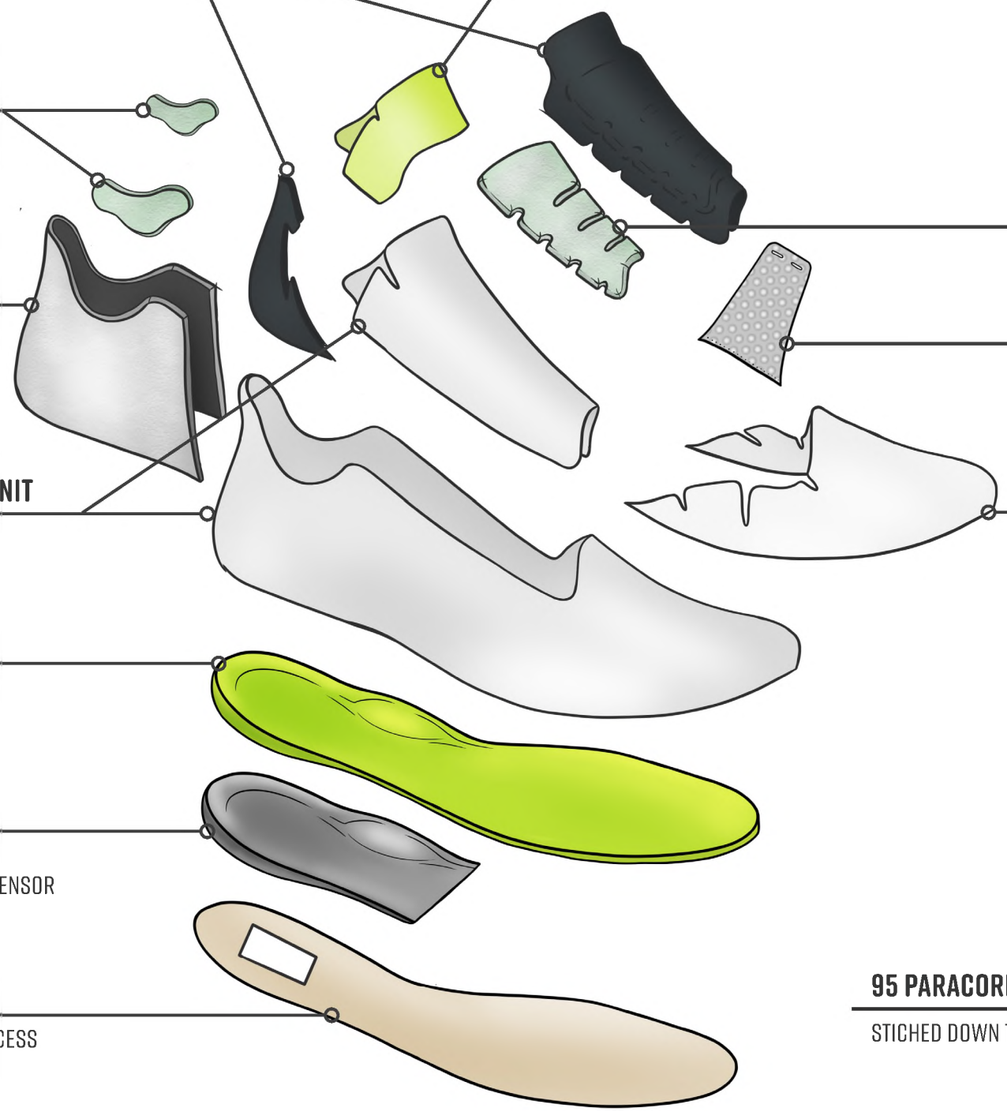
DESIGNED WITH A DEEP HEEL CUP TO
CUSHION SPECIFIC FEMALE-PHYSIOLOGY

INJECTION MOLDED TPU

ADHERED TO THE SOCKLINER
HOUSES THE REFLECTANT PANEL FOR THE SENSOR

NON-WOVEN STROBEL

DESIGNED WITH A CUTOUT FOR SENSOR ACCESS



100% POLYESTER KNIT LINING

ANIT-MICROBIAL FABRIC THAT WICKS SWEAT TO KEEP
THE FOOT COMFORTABLE ON LONG RUNS

OPEN CELL PU FOAM, 1/4”

DESIGNED WITH NOTCHES TO FACILITATE FLEX

INJECTION MOLDED TPU

STITCHED INTO STROBEL
DESIGNED WITH PROTRUSIONS TO ACTIVATE THE ARCH

TRANSLUCENT BEMIS

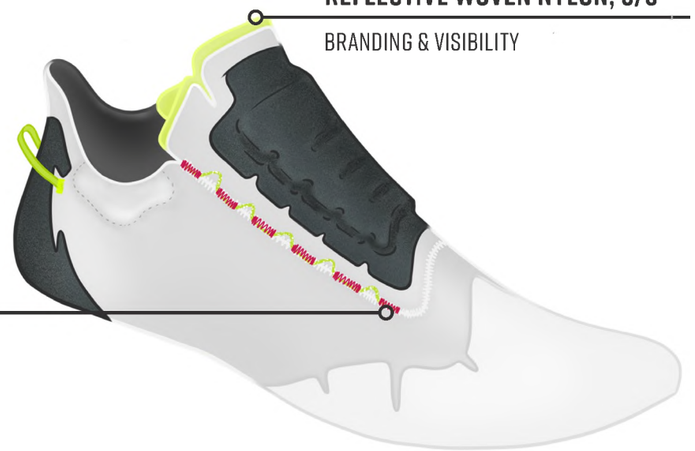
INCREASES WEATHER & DEBRIS PROTECTION

REFLECTIVE WOVEN NYLON, 3/8”

BRANDING & VISIBILITY

95 PARACORD, REFLECTIVE

STICHED DOWN TO CREATE EYE STAY LOOPS



ROAD FINAL DESIGN

PADDED TONGUE WITH CINCH LACES

NOTCHED FOAM FOR EXTRA COMFORT WITHOUT COMPROMISING FLEXIBILITY

CINCH LACES ALLOW QUICK LACING

POLYESTER, KNIT, SPACER MESH

DWR FINISH, EXTENDED WATER GUARD WITH FLEX-NOTCHES

SINGLE-SIDED TONGUE FOR DECREASED DEBRIS ENTRY

ACTIVO-ARCH, INJECTION MOLDED TPU

RAISED PROTRUSIONS

INCREASES LOCKDOWN & ARCH ACTIVATION

IMPULSE INTEGRATION SYSTEM

MULTI-LAYER CONSTRUCTION ENABLES THE QUANTIFICATION OF SHEAR DISPLACEMENT AT THE FOOT-SHOE INTERFACE

RLEAYS INFORMATION TO AN APP VIA BLUETOOTH

EVA FOAM MIDSOLE

HIGH SIDEWALLS FOR INCREASED STABILITY

MAXIMALIST STACK HEIGHT FOR INCREASED IMPACT ATTENUATION

TOTALIS TRACTION, CARBON BLOWN RUBBER OUTSOLE

ENGINEERED FLEX GROOVES & LEADING EDGES FOR MAXIMUM TRACTION ON WET SURFACES

EXTENDED TOE WRAP FOR INCREASED PROTECTION & DURABILITY

POLYESTER, KNIT, SOCKLINER

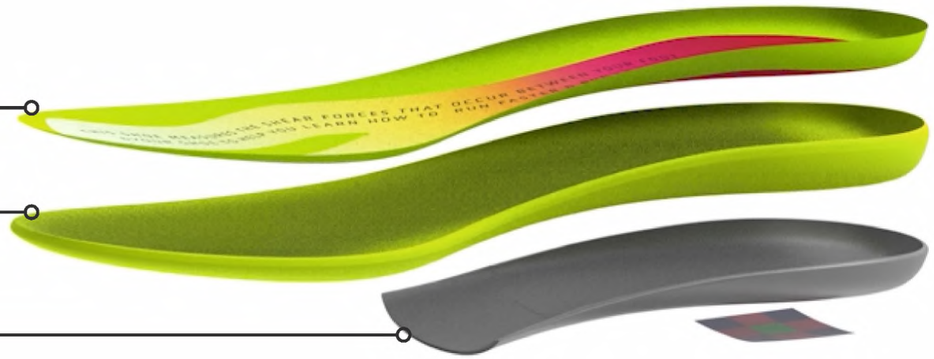
EVA FOAM FEMALE-SPECIFIC INSOLE

DEEP HEEL CUP TO FACILITATE IMPACT ATTENUATION

INSOLE SHELL

TPU INJECTION MOLDED, INCREASES STABILITY

HOUSES THE REFLECTANT PANEL THAT THE SENSOR READS



EVA FOAM MODERATOR SCOPE

ALLOWS SHEAR STRESS TO BE QUANTIFIABLY MEASURED

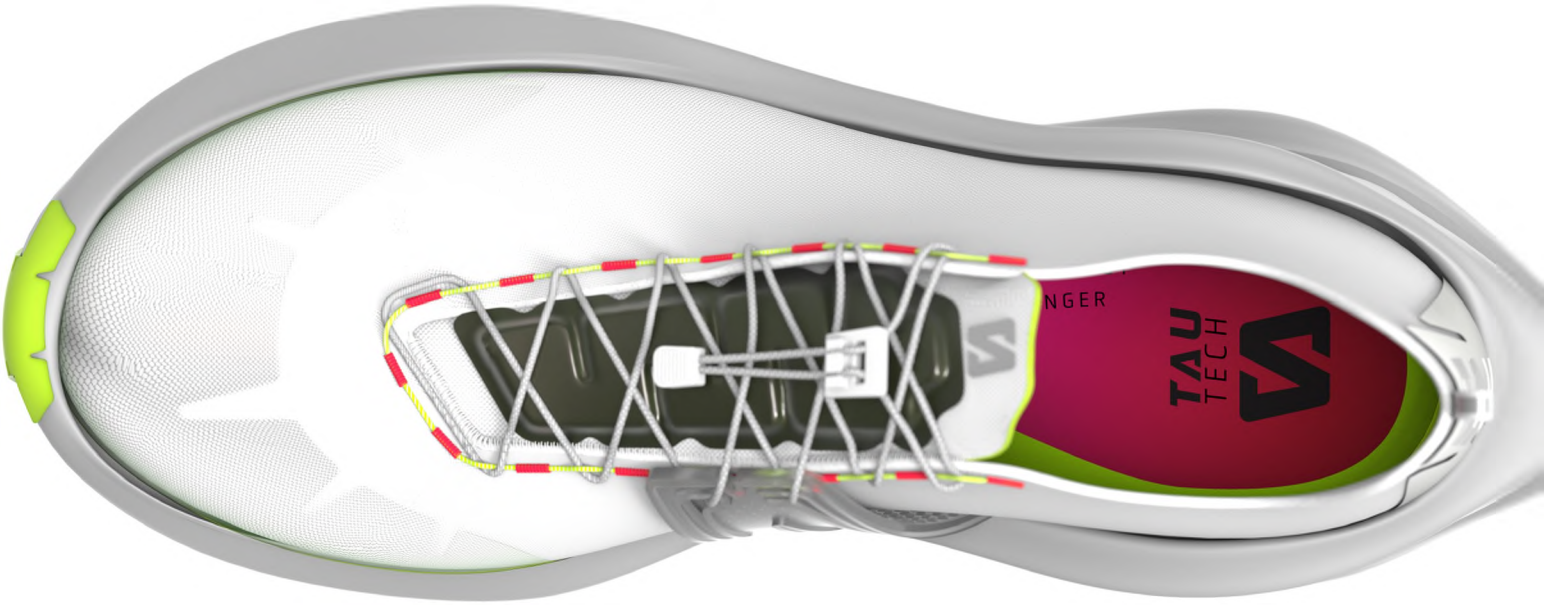
TAU-TECH & ACCESS PANEL

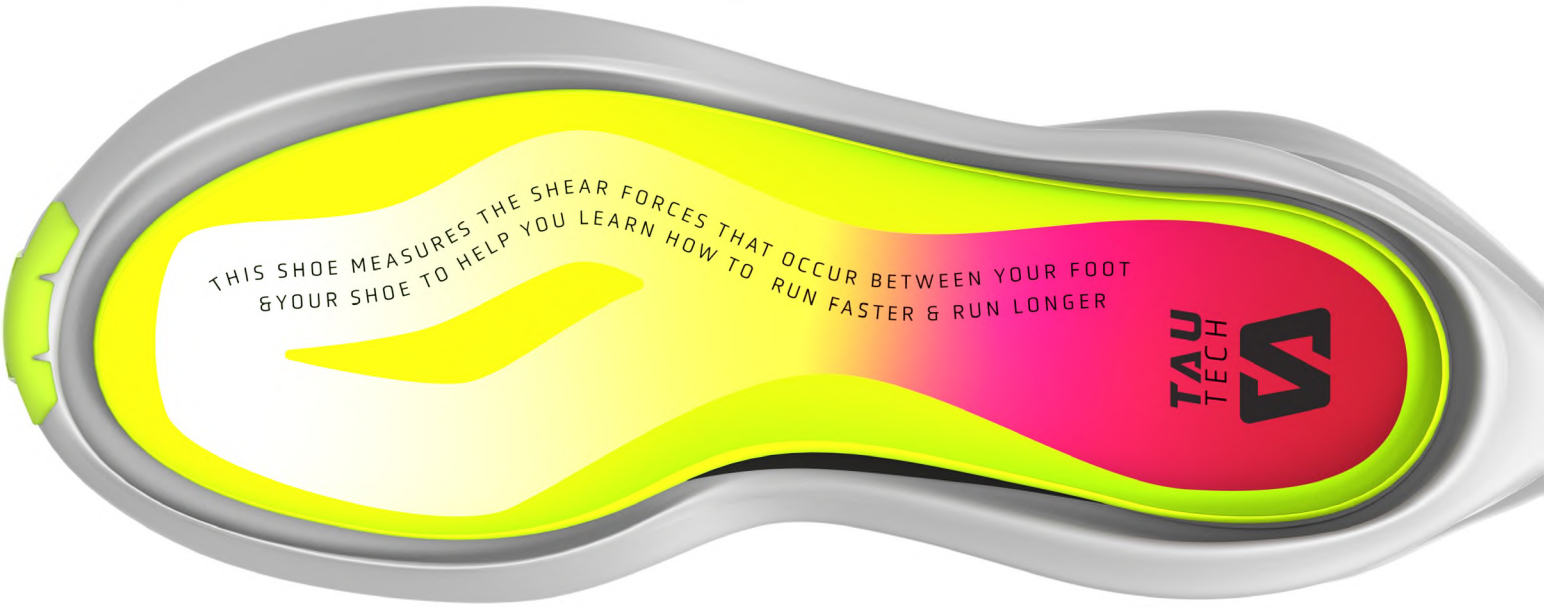
EVA FOAM INNER MIDSOLE

TPU INJECTION MOLDED PLATE

SECURELY HOUSES THE SENSOR & INCREASES ENERGY RETURN

EVA FOAM OUTER MIDSOLE


NGER
TAU
TECH


THIS SHOE MEASURES THE SHEAR FORCES THAT OCCUR BETWEEN YOUR FOOT
&YOUR SHOE TO HELP YOU LEARN HOW TO RUN FASTER & RUN LONGER
TAU
TECH

TAU TRAINERS TRAIL

OPEN CELL PU FOAM, 3/8”

CUSHIONING FOR ADDED COMFORT
GLUED & STITCHED IN

OPEN CELL PU FOAM, 1/4”

CUSHIONING FOR ADDED COMFORT
GLUED & STITCHED IN

SPACER MESH, 100% POLYESTER KNIT

ENGINEERED FOR ZONED BREATHABILITY

EVA FOAM SOCKLINER

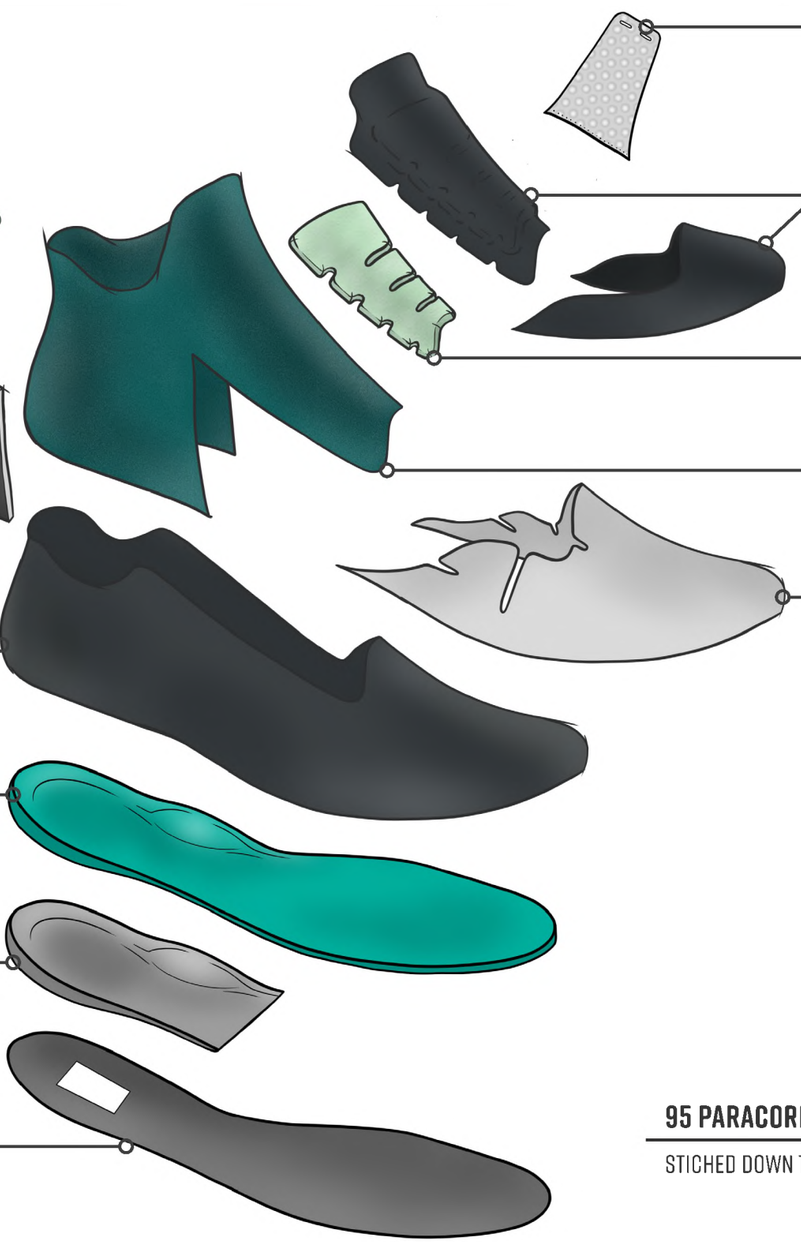
DESIGNED WITH A DEEP HEEL CUP TO
CUSHION SPECIFIC FEMALE-PHYSIOLOGY

INJECTION MOLDED TPU

ADHERED TO THE SOCKLINER
HOUSES THE REFLECTANT PANEL FOR THE SENSOR

NON-WOVEN STROBEL

DESIGNED WITH A CUTOUT FOR SENSOR ACCESS



INJECTION MOLDED TPU

STITCHED INTO STROBEL
DESIGNED WITH PROTRUSIONS TO ACTIVATE THE ARCH

REFLECTIVE BEMIS

INCREASES VISIBILITY & WEATHER PROTECTION

OPEN CELL PU FOAM, 1/4”

DESIGNED WITH NOTCHES TO FACILITATE FLEX

NEOPRENE, 90% POLYESTER, 10% SPANDEX

2MM THICK, 275 GSM, SPACER KNIT

TRANSLUCENT BEMIS

INCREASES WEATHER & DEBRIS PROTECTION

REFLECTIVE WOVEN NYLON, 3/8”

BRANDING & VISIBILITY

95 PARACORD, REFLECTIVE

STICHED DOWN TO CREATE EYE STAY LOOPS

TRAIL FINAL DESIGN

PADDED TONGUE WITH CINCH LACES

NOTCHED FOAM FOR EXTRA COMFORT WITHOUT COMPROMISING FLEXIBILITY

CINCH LACES ALLOW QUICK LACING

POLYESTER, KNIT, SPACER MESH

DWR FINISH, EXTENDED WATER GUARD WITH FLEX-NOTCHES

EXTRA TOE-PROTECTION FOR INCREASED DURABILITY

MID-HEIGHT BOOTIE FOR DECREASED DEBRIS ENTRY

ACTIVO-ARCH, INJECTION MOLDED TPU

RAISED PROTRUSIONS

INCREASES LOCKDOWN & ARCH ACTIVATION

IMPULSE INTEGRATION SYSTEM

MULTI-LAYER CONSTRUCTION ENABLES THE QUANTIFICATION OF SHEAR DISPLACEMENT AT THE FOOT-SHOE INTERFACE

RLEAYS INFORMATION TO AN APP VIA BLUETOOTH

EVA FOAM MIDSOLE

HIGH SIDEWALLS FOR INCREASED STABILITY

MAXIMALIST STACK HEIGHT FOR INCREASED IMPACT ATTENUATION

NARROW FOOTPRINT FOR ENHANCED CONTROL

TOTALIS TRACTION, CARBON BLOWN RUBBER OUTSOLE

MULTI-DIRECTIONAL, 4MM LUGS ENGINEERED TO GRIP THE TRAIL, WET OR DRY

EXTENDED TOE WRAP FOR INCREASED PROTECTION & DURABILITY

POLYESTER, KNIT, SOCKLINER

EVA FOAM FEMALE-SPECIFIC INSOLE

DEEP HEEL CUP TO FACILITATE IMPACT ATTENUATION

INSOLE SHELL

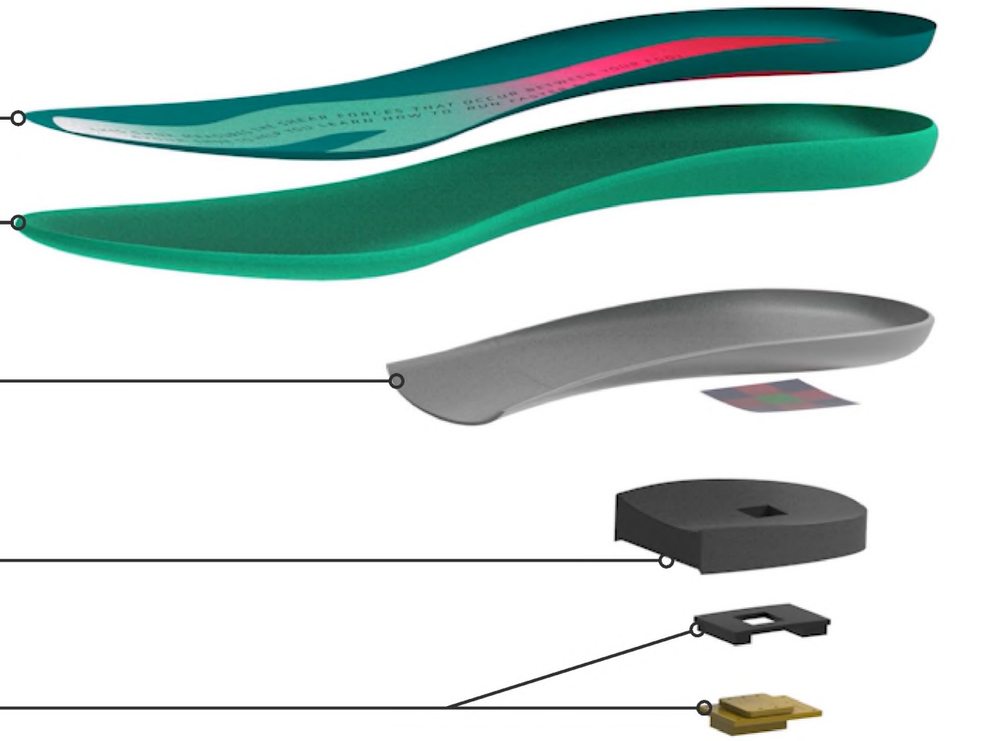
TPU INJECTION MOLDED, INCREASES STABILITY

HOUSES THE REFLECTANT PANEL THAT THE SENSOR READS

EVA FOAM MODERATOR SCOPE

ALLOWS SHEAR STRESS TO BE QUANTIFIABLY MEASURED

TAU-TECH & ACCESS PANEL

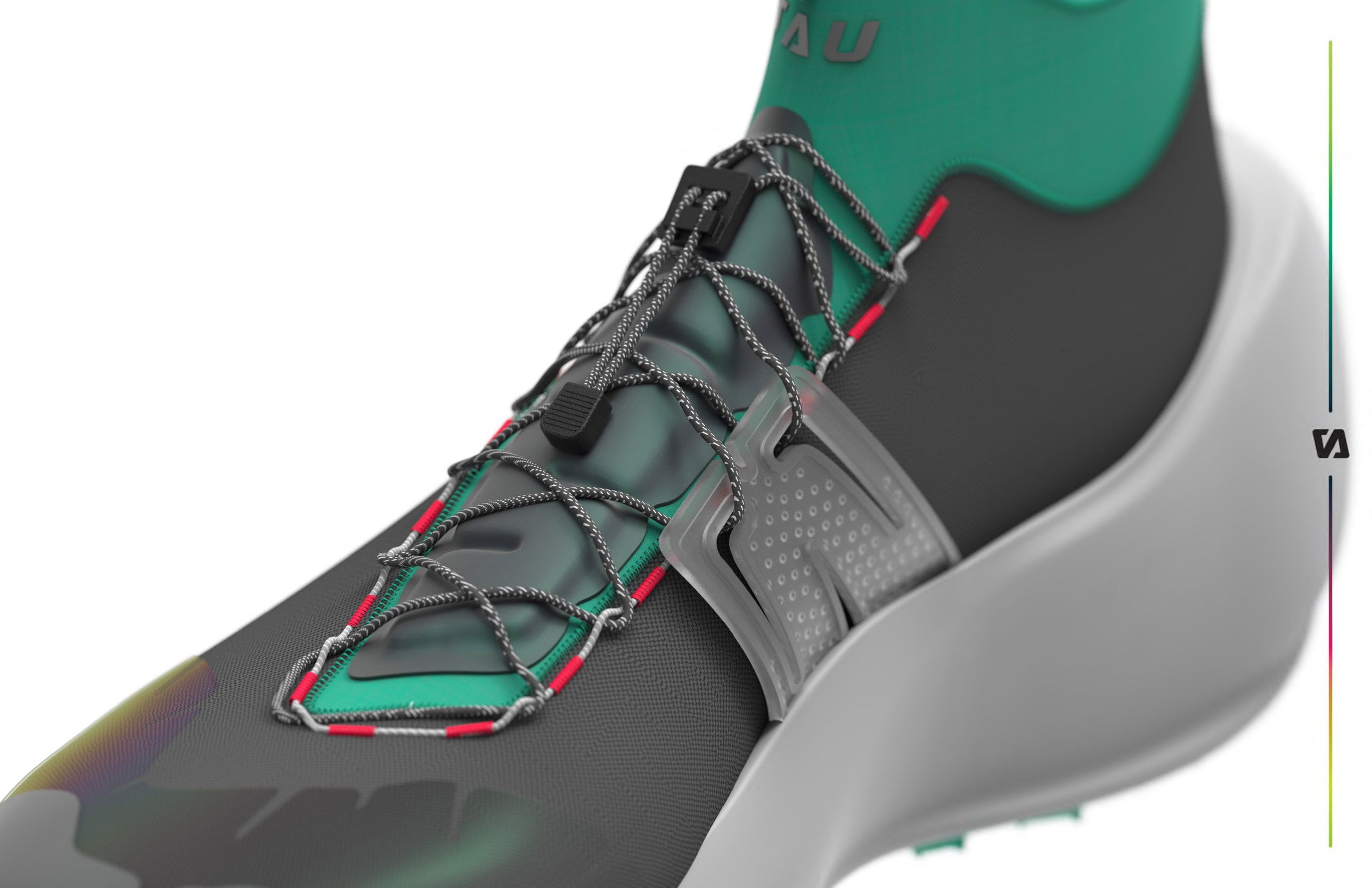


EVA FOAM INNER MIDSOLE

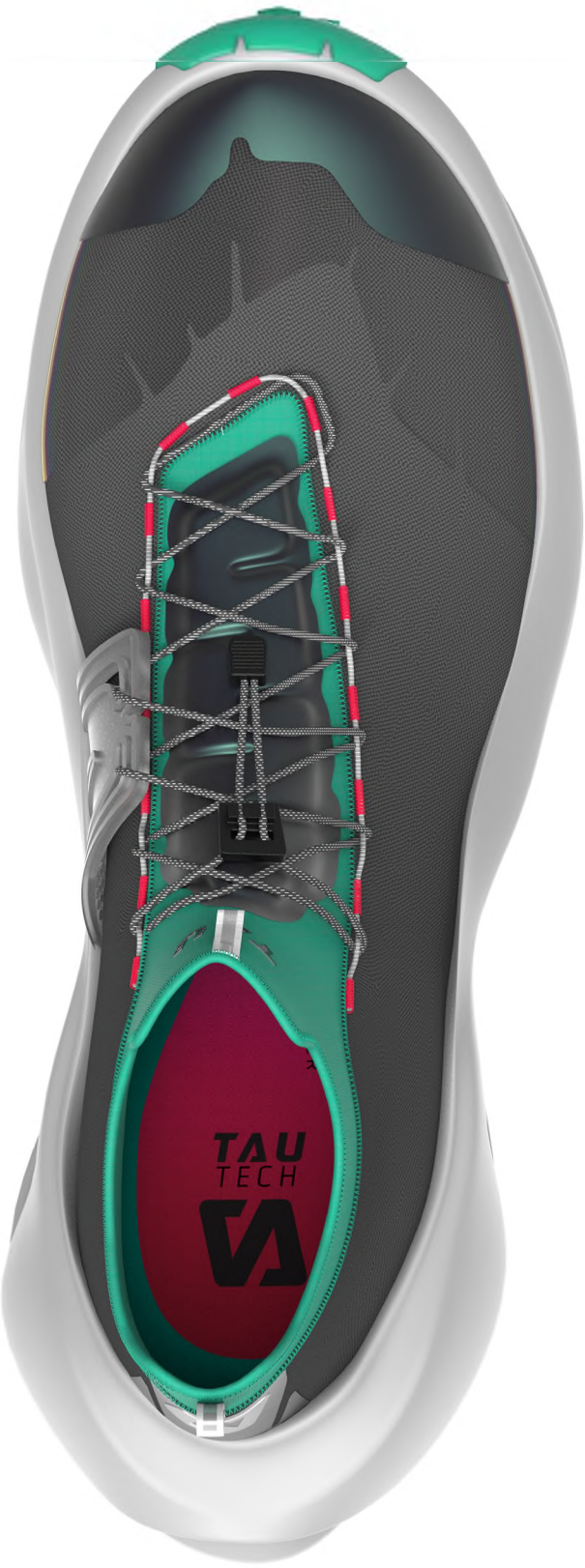
TPU INJECTION MOLDED PLATE

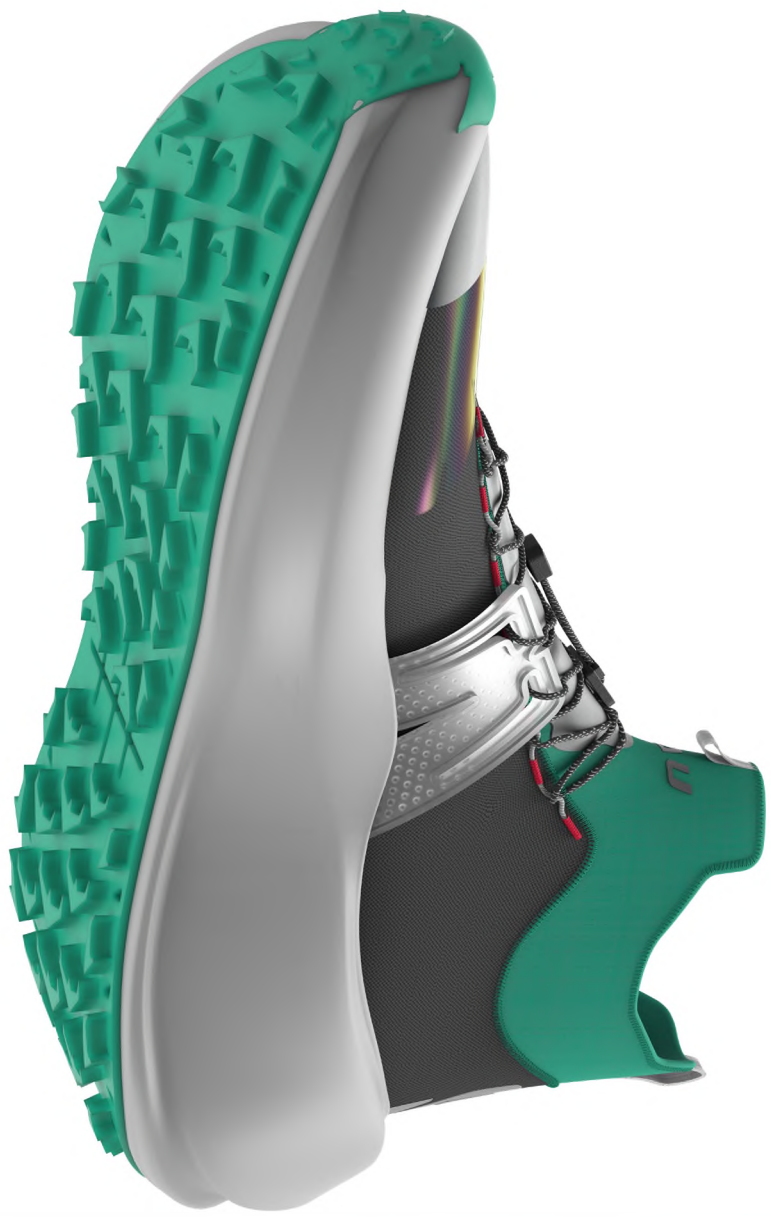
SECURELY HOUSES THE SENSOR & INCREASES ENERGY RETURN

EVA FOAM OUTER MIDSOLE




THIS SHOE MEASURES THE SHEAR FORCES THAT OCCUR BETWEEN YOUR FOOT
&YOUR SHOE TO HELP YOU LEARN HOW TO RUN FASTER & RUN LONGER
TAU
TECH


TAU
TECH



ROAD COLORWAYS

SUNLIT LIME

	XX-XXXX TCX	WHITE
	12-0703 TCX	SEEDPEARL
	14-0340 TCX	ACID LIME
	12-0741 TCX	SUNNY LIME
	18-1856 TCX	VIRTUAL PINK

HOT RIVER

	XX-XXXX TCX	HOT ASH
	12-0703 TCX	SEEDPEARL
	19-5217 TCX	ACID LIME
	16-5425 TCX	POOL GREEN
	18-1856 TCX	VIRTUAL PINK

CLASSIC TEAL

	XX-XXXX TCX	HOT ASH
	XX-XXXX TCX	MOLTEN GREY
	15-4305 TCX	QUARRY
	12-0703 TCX	SEEDPEARL
	16-5425 TCX	POOL GREEN

TRAIL COLORWAYS

RIVER BED

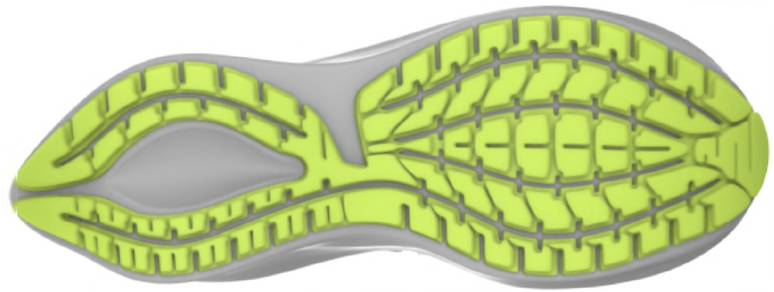
	19-4405 TCX	FOREST RIVER
	15-4305 TCX	QUARRY
	19-5217 TCX	STORM
	16-5425 TCX	POOL GREEN
	18-1856 TCX	VIRTUAL PINK

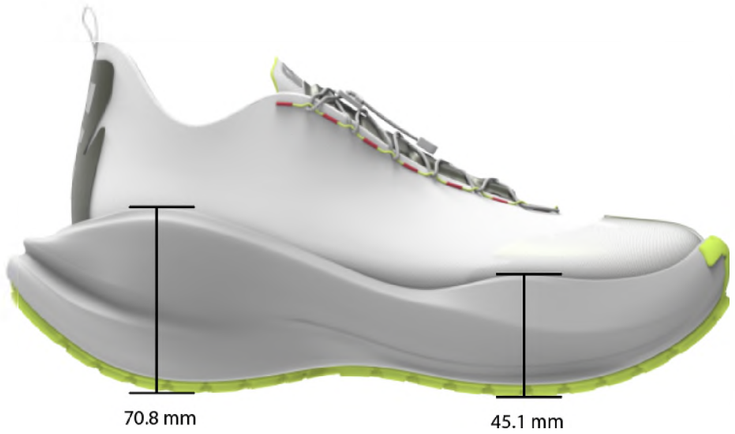
GOODNIGHT LIME

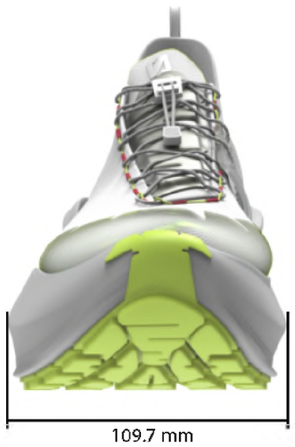
	XX-XXXX TCX	HOT ASH
	XX-XXXX TCX	MOLTEN GREY
	14-0340 TCX	ACID LIME
	12-0741 TCX	SUNNY LIME
	16-5425 TCX	POOL GREEN

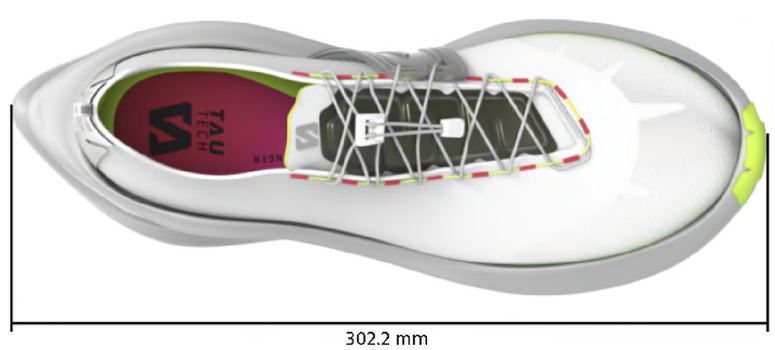
MIDNIGHT TANGERINE

	XX-XXXX TCX	SLEEPY PLUM
	12-0703 TCX	SEEDPEARL
	XX-XXXX TCX	HOT ASH
	XX-XXXX TCX	TANGERINE
	XX-XXXX TCX	DUSK DUST

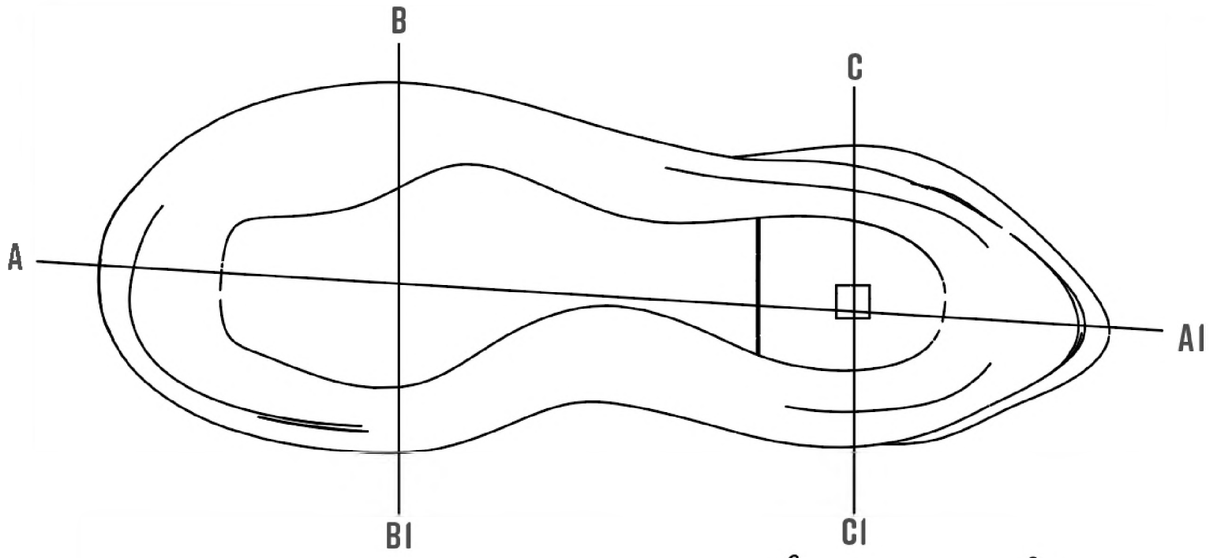


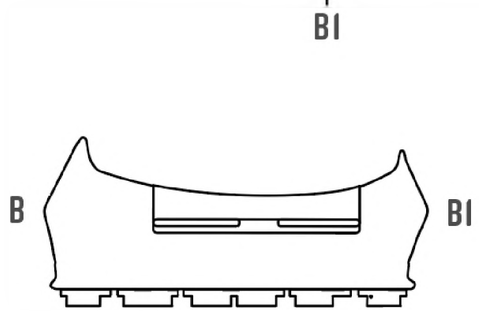


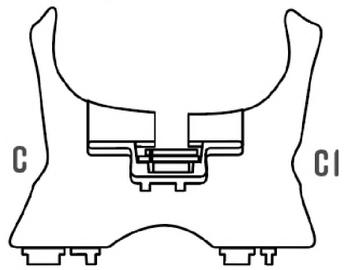


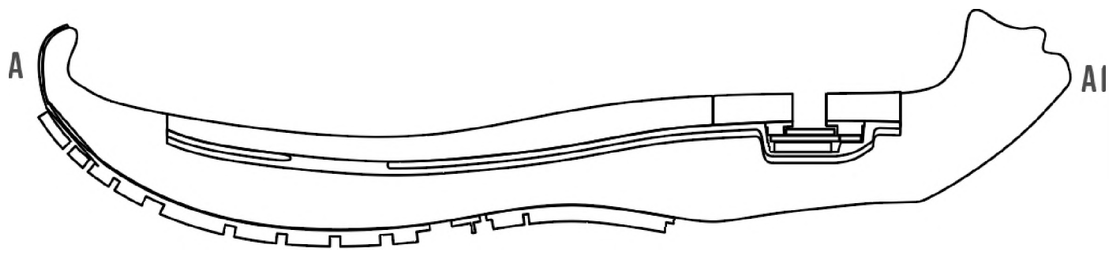


TAU TRAINERS - ROAD Colorway: Sunlit Lime Size Reference: Women's 8	REFERENCE CAD FILES FOR DETAILED DIMENSIONS. REFERENCE PREVIOUS PAGES FOR COLOR TCX. REFERENCE PREVIOUS PAGES FOR MATERIALS.	Designer: Gabi Lorenzo Last Updated: 6/8/2022 Page 1/4

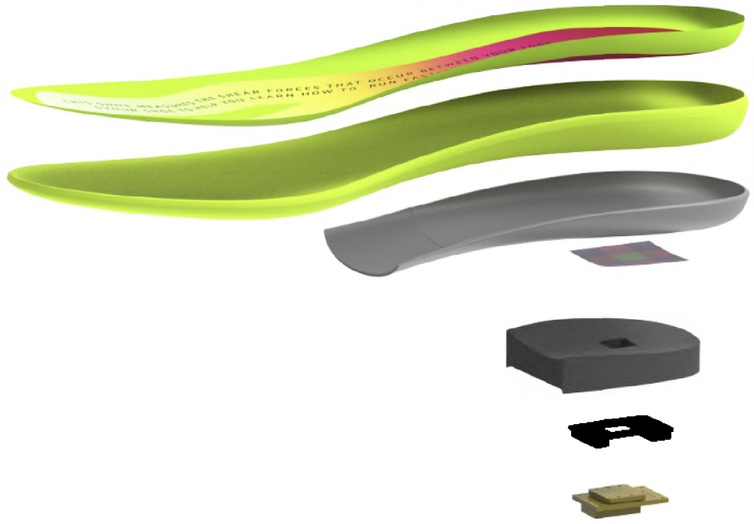








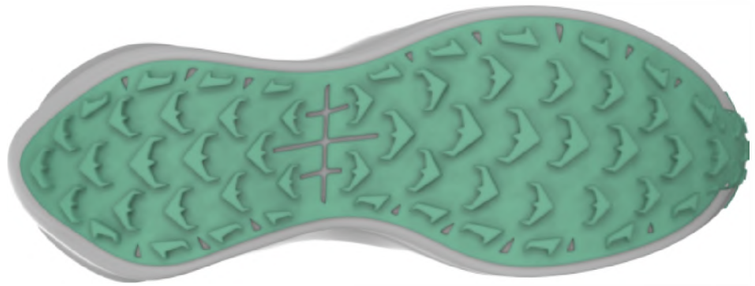
35 mm stack height.

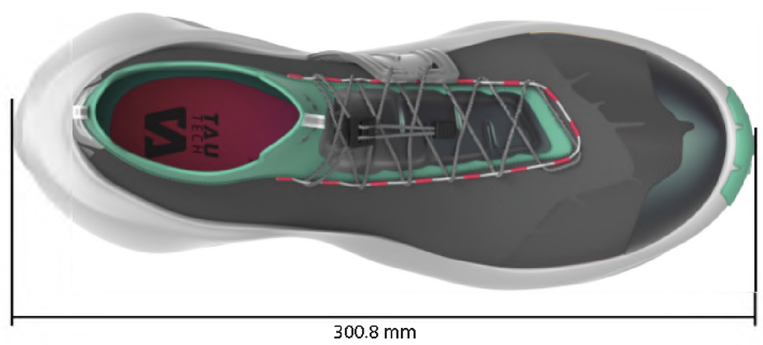


Contact Sensor Team for sensor design specifications.

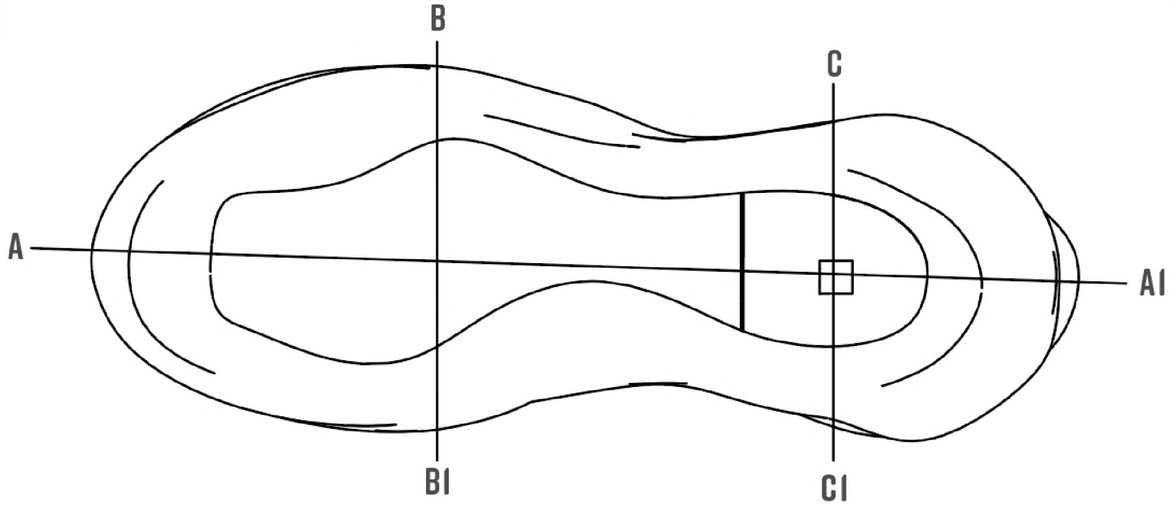
TAU TRAINERS - ROAD	REFERENCE CAD FILES FOR DETAILED DIMENSIONS.	Designer: Gabi Lorenzo
Colorway: Sunlit Lime	REFERENCE PREVIOUS PAGES FOR COLOR TCX.	Last Updated: 6/8/2022
Size Reference: Women's 8	REFERENCE PREVIOUS PAGES FOR MATERIALS.	Page 2/4

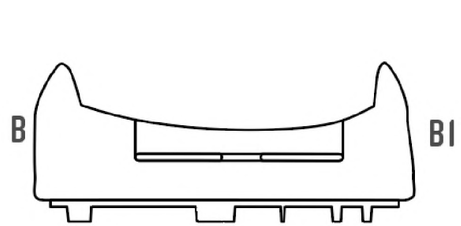
4mm lugs.

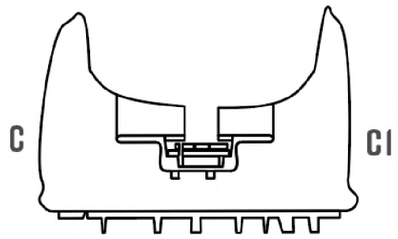


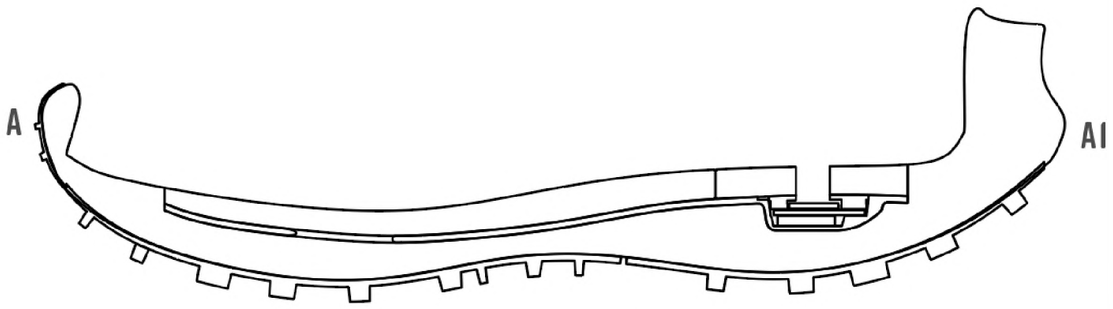


TAU TRAINERS - TRAIL Colorway: River Bed Size Reference: Women's 8	REFERENCE CAD FILES FOR DETAILED DIMENSIONS. REFERENCE PREVIOUS PAGES FOR COLOR TCX. REFERENCE PREVIOUS PAGES FOR MATERIALS.	Designer: Gabi Lorenzo Last Updated: 6/8/2022 Page 3/4

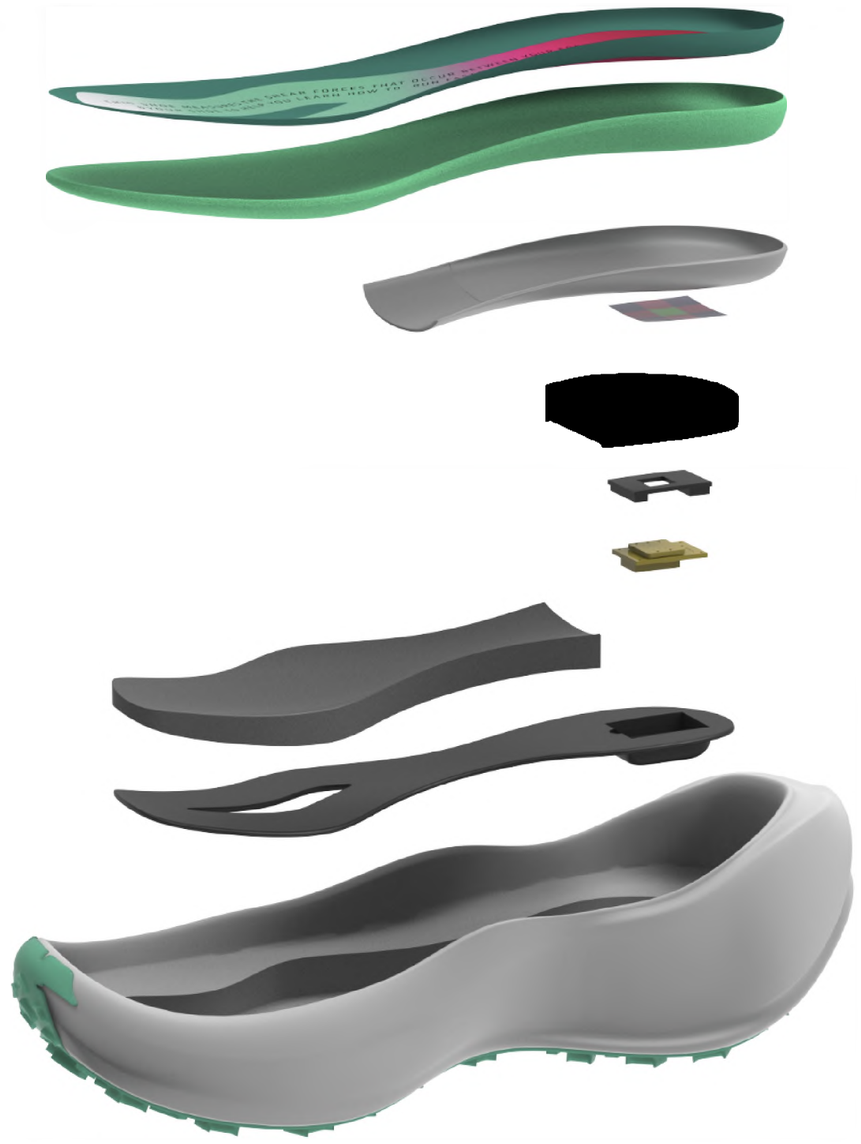








29 mm stack height.



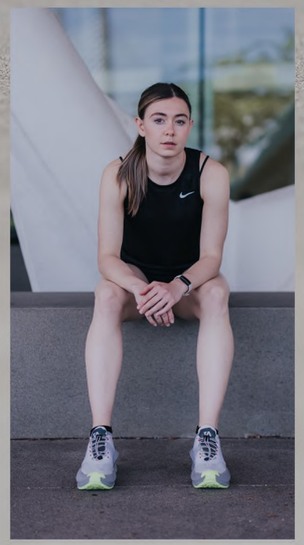
Contact Sensor Team for sensor design specifications.

TAU TRAINERS - TRAIL Colorway: River Bed Size Reference: Women's 8	REFERENCE CAD FILES FOR DETAILED DIMENSIONS. REFERENCE PREVIOUS PAGES FOR COLOR TCX. REFERENCE PREVIOUS PAGES FOR MATERIALS.	Designer: Gabi Lorenzo Last Updated: 6/8/2022 Page 4/4

FINAL PROTOTYPES

ROAD & TRAIL


FINAL ROAD PROTOTYPE



FINAL TRAIL PROTOTYPE

VALIDATION

FINAL TESTING & EXPERT FEEDBACK

EXPERT VALIDATION

WHAT WAS DISCUSSED?

1 MIKE MCGEEHAN

- Validation of sensor integration
- He will help analyze sensor data

2 EMILY KAROLIDIS

- Female fit validation
- Last shape, arch activation, etc.

3 EVAN DAY

- Footwear design for optimal performance & underfoot comfort

TEAM OF EXPERTS

BIOMECH. & ENGR.
BSSC & KNIGHT CAMPUS

MIKE MCGEEHAN

FEMALE BIOMECHANICS
BOWERMAN SPORTS SCIENCE CENTER

EMILY KAROLIDIS

DESIGN & DEVELOPMENT
BROOKS RUNNING

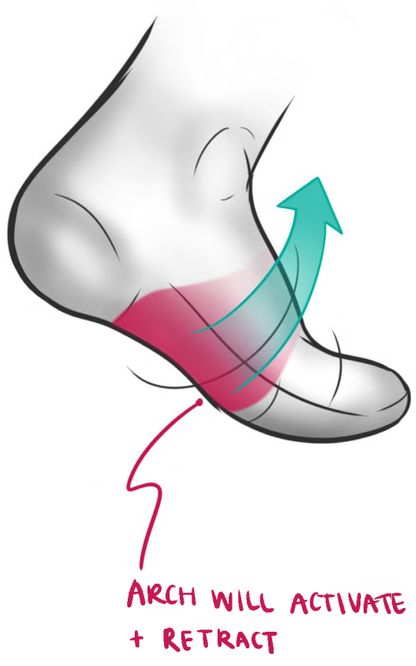
EVAN DAY

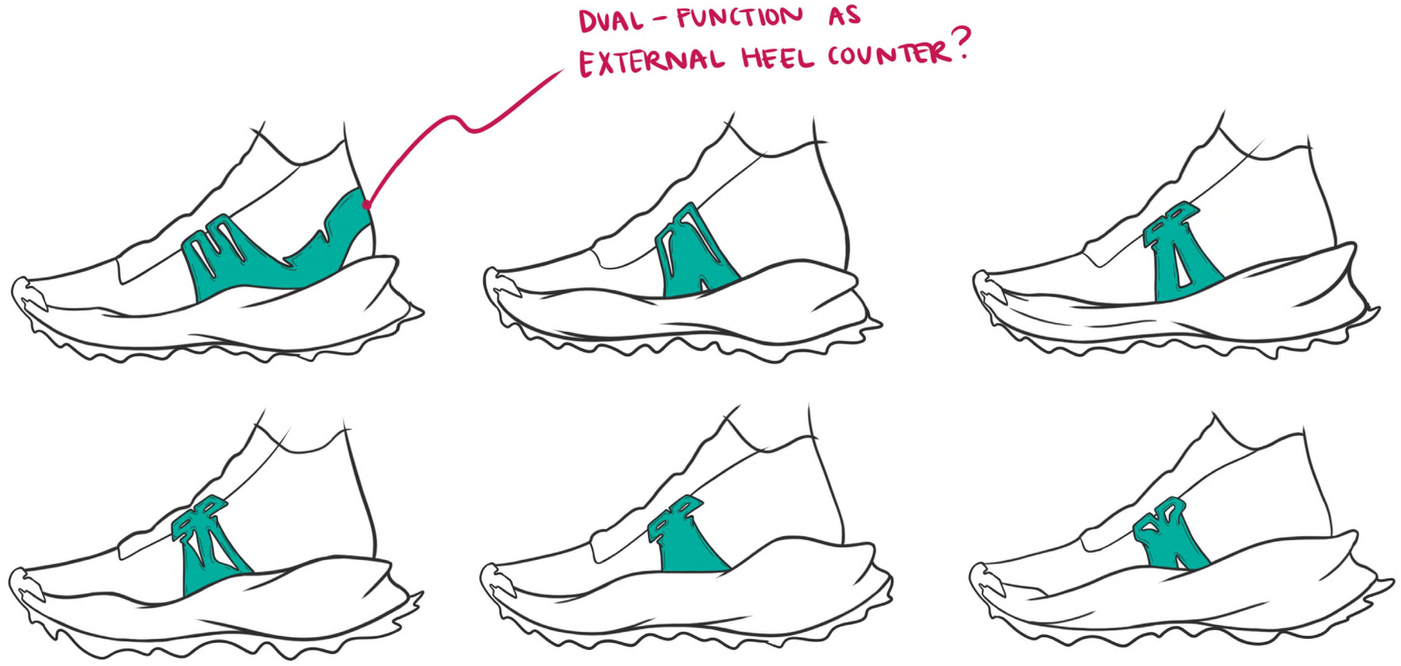
- Mike & I met/did some testing last week. He is happy with the sensor integration & believes it is very accurate/has been proven to be successful.
- Emily & I met. She helped me with some planning for the wear tests/validation techniques. She believes the process I went through to design the last was successful & is interested in how the arch activation strap can increase arch support (she did not know much about arch activation but her comments are on the next slide).
- I met with my design mentor, Evan Day, & got a ton of helpful feedback. I implemented this feedback into my final renders (mainly feedback on midsole, with a few outsole tweaks; he thought the uppers were looking good, & said the arch activator strap would be more powerful if told as a method of increasing athlete perception of the shoe & for the trail to focus on how it can increase lockdown especially on declines/downhill trails) & future prototypes. You can see his comments consildated in sketch/notation form on the second to next slide.

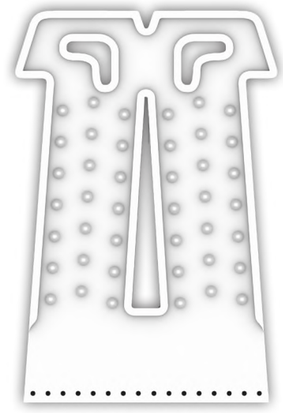
EXPERT VALIDATION

EMILY KAROLIDIS

"You will get some proprioceptive feedback and the arch will be aware [of the arch activation strap]. I'm not sure if there will be a helpful mechanical movement that will occur. However, proprioception does have observable benefits & can trigger the arch. The strap will definitely help athletes feel more secure, locked in, and can increase confidence. It is just important to make sure that it does not aggrevate the foot; you could attempt to validated the strap by looking at the pressure loading at the arch."





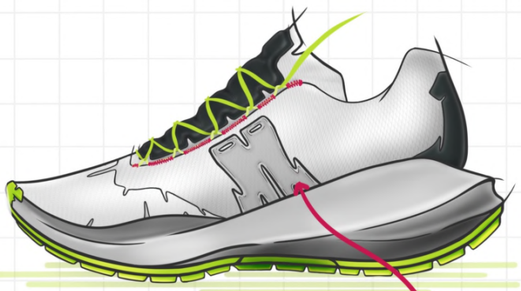


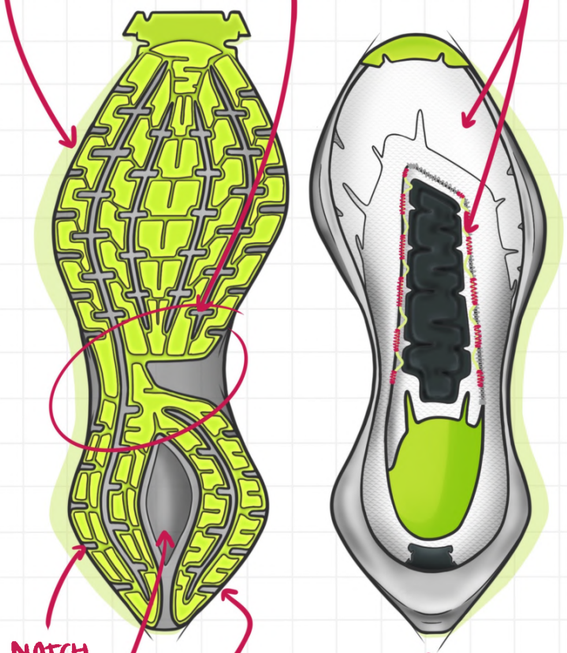
BETTER TO HAVE MORE RUBBER ACROSS MEDIAL SIDE OF MIDFOOT THAN LAT. – HELPS KEEP KNEE IN LINE. "PRESSURE VS. REINFORCEMENT.

BASE NETS LOOK GOOD – WIDE = STABLE.

WATER GUARD / SECURING LATERAL SIDE OF TONGUE ARE GREAT FOR WEATHER PROTECTION.

WANT A "LATERAL RELEASE" CARVE DEEPER THAN MEDIAL SIDE. DON'T EXTEND CARVING UNDER WHERE LAST SITS – SHOE WILL BOTTOM OUT.





NOTCH EVA!

DON'T NOTCH EVA ON MEDIAL SIDE. "PSEUDO-POSTING."

"TRAMPOLINE" IS GREAT. DIVOT WILL BUILD IN CUSHION @ SENSOR.

EXTENDED CRASH PAD LENGTH IS A BIG ROAD TREND.

WILL INCREASE LOCKDOWN ON DECLINES / INCREASE PERCEPTION OF SUPPORT. MAY "ACTIVATE" THE ARCH – MAYBE.

CREATES CLOSE-TO-FOOT FIT.

MAKE SURE GUARD DOESN'T GET TOO THICK ↯ IMPACT FLEXIBILITY

CONSIDER CARVING OUT MORE RUBBER IN FOREFOOT FOR FLEX.

SWITCH TO

FOR MIDFOOT FLEX.

MULTI-DIRECTIONAL LUGS LOOK GREAT!

WIDE NET CAN CAUSE ANKLE SPRAINS.

CONSIDER DE-COUPLING LAT./MEDIAL SIDES.

MID-HEIGHT UPPER WILL CREATE PERCEPTION OF ANKLE SUPPORT / PROVIDE WEATHER-PROTECT.

CARVE LESS ON MEDIAL THAN LATERAL SIDE. PSUEDO-MEDIAL POST/LATERAL RELEASE.

2-3 MM RUBBER BASE WITH 4-5 MM LUGS.

IMPROVED MIDFOOT LOCKDOWN FOR DECLINES / INCREASED PERCEPTION OF ARCH SUPPORT.

CONSILDATED FEEDBACK FROM EVAN DAY (BROOKS RUNNING), DESIGN MENTOR

FEMALE FIT VALIDATION

ATHLETE FEEDBACK

1 DISCOMFORTS

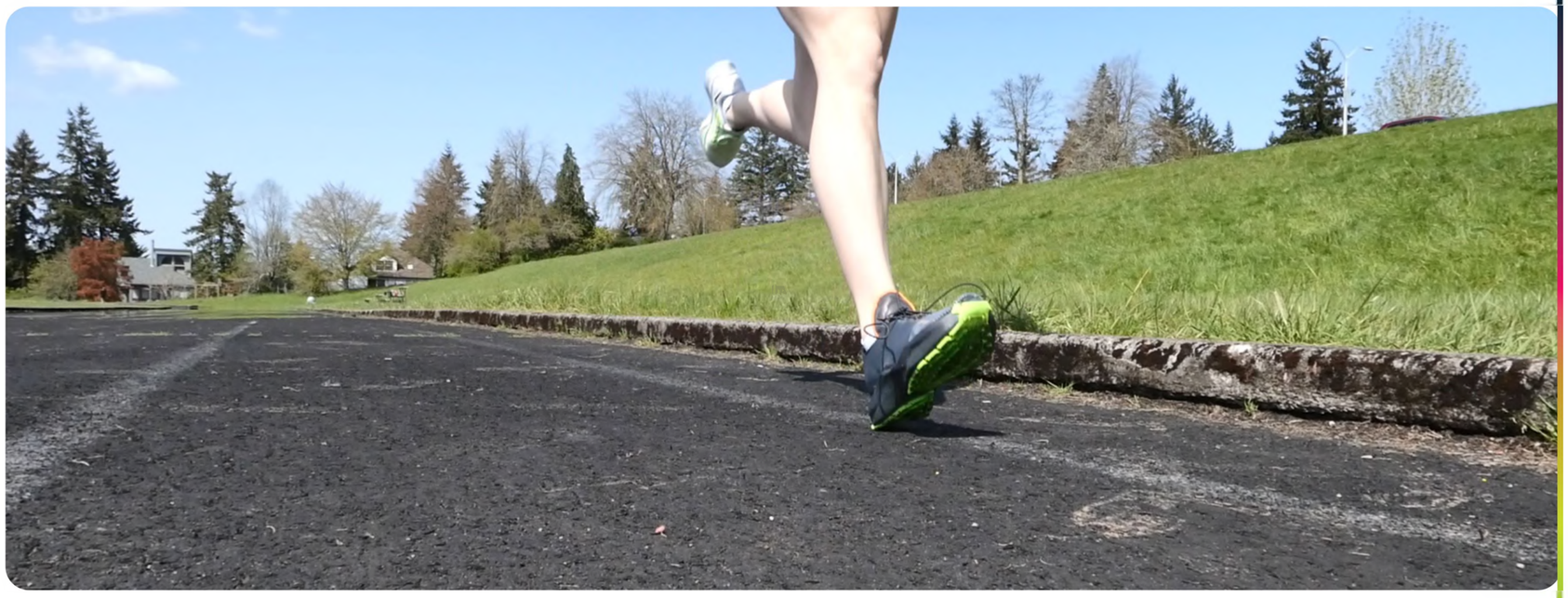
- Athletes did not believe there was enough cushioning in the midsole in both the sensor-equipped & regular midsole versions
- Stability should be improved within the heel
- Transition/ride of the sensor-equipped version can be better

2 POSITIVES

- Athletes loved the aesthetics
- Overall fit of the upper/footbed
- Traction performed well on various surfaces

3 NEXT STEPS

- Not much can be done about cushioning as discomfort is probably due to lack of industry standard materials
- Add an internal heel counter to both uppers
- Transition/ride of shoe will be improved since sensor size will be 50% of original



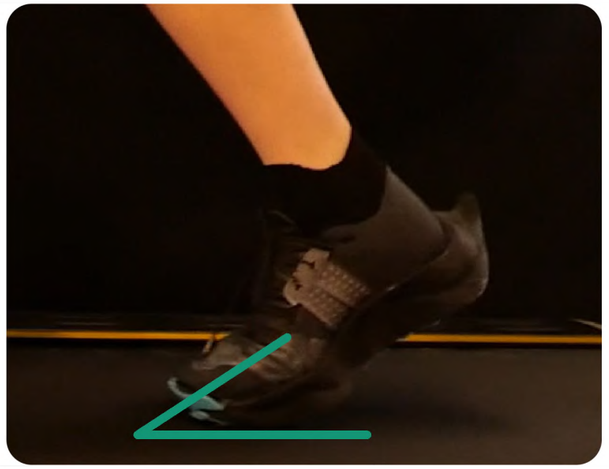
WEAR TEST PERCEPTIONS

	COMFORT	CUSHIONING	VENTILIATION	ENERGY RET.	AESTHETICS	OVERALL*
	7.7 /10	6.2 /10	5.8 /10	6.4 /10	7.4 /10	7.0 /10
	7.3 /10	7.8 /10	5.4 /10	7.5 /10	6.6 /10	6.9 /10
	7.0 /10	6.5 /10	4.0 /10	5.0 /10	9.7 /10	6.7 /10
	6.0 /10	5.0 /10	5.5 /10	5.0 /10	9.7 /10	6.9 /10

OF PARTICIPANTS **03**

*OVERALL RANKING IS DETERMINED BY AVERAGING THE WEAR TESTERS' RANKS OF PERCEIVED COMFORT AT 5 MINUTES, TRACTION, CUSHIONING, STABILITY, BREATHABILITY, ENERGY RETURN, FIT, & AESTHETICS.

FLEXIBILITY VALIDATION



DATA ANALYSIS

- It's very difficult to accurately quantify this information, but I believe my prototypes pass because they clearly flex successfully.
- The flex values are also in a similar range to the baseline competitor products.
- Additionally, there were no complaints about flexibility from the various wear testers who wore the products on the treadmill, track, & trail.

PEGASUS TRAIL 3	PEGASUS 38	TAU TRAINERS TRAIL	TAU TRAINERS ROAD
29 DEGREES	27 DEGREES	36 DEGREES	32 DEGREES

TOTALIS TRACTION TESTING

PROPULSION

LATERAL

BRAKING


MEDIAL


AVG. TESTING RESULTS

TOTALIS ROAD TRACTION

13.7
NEWTONS

10% GREATER THAN COMPETITORS [12.4 N]

14.8
NEWTONS

4% GREATER THAN COMPETITORS [14.2 N]

TOTALIS TRAIL TRACTION

12.7
NEWTONS

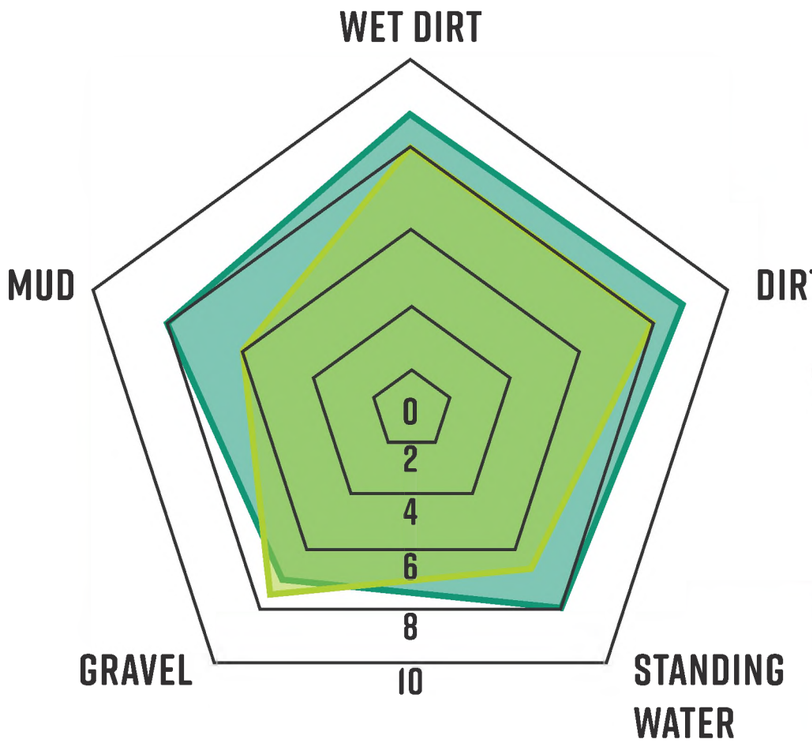
2% GREATER THAN COMPETITORS [12.4 N]

15.0
NEWTONS

6% GREATER THAN COMPETITORS [14.2 N]

EXTRA TRAIL TRACTION TESTING

AVG. WEAR TESTER PERCEPTIONS



TOTALIS TRAIL TRACTION

PEGASUS TRAIL 3 TRACTION

ATHLETE & EXPERT VALIDATION

"INTEGRATING SHEAR SENSORS INTO TRAINING FOOTWEAR CAN PROVIDE A DATA-DRIVEN APPROACH TO IMPROVE ATHLETIC PERFORMANCE."

- MICHAEL MCGEEHAN, U.O., BIOMECHANICS & ENGINEERING

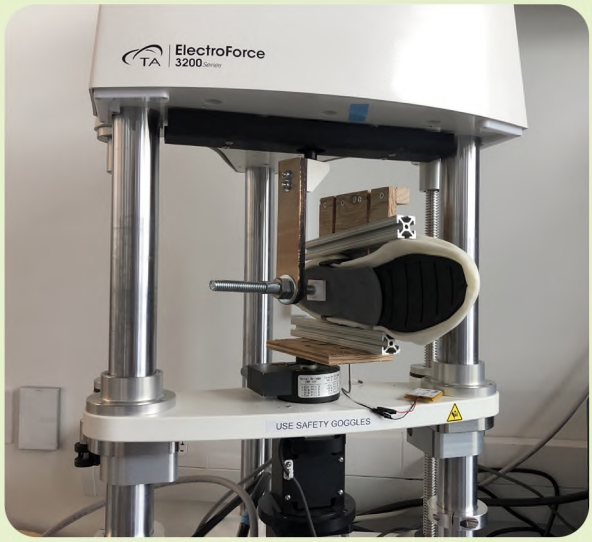
TRACTION	OVERALL*
8.0 /10	7.0 /10
7.0 /10	6.9 /10
9.0 /10	7.3 /10
8.5 /10	7.5 /10

100% OF WEAR TESTERS SAID THE ACTIVO-ARCH TECHNOLOGY PROVIDES **EXTRA SUPPORT & LOCKDOWN**

"THE SPLIT DESIGN WILL HELP FIT VARIOUS FOOT SHAPES. I THINK THIS WILL IMPROVE LOCKDOWN & HELP ATHLETES FEEL MORE SUPPORTED."

- EVAN DAY, BROOKS RUNNING, RESEARCH SCIENTIST

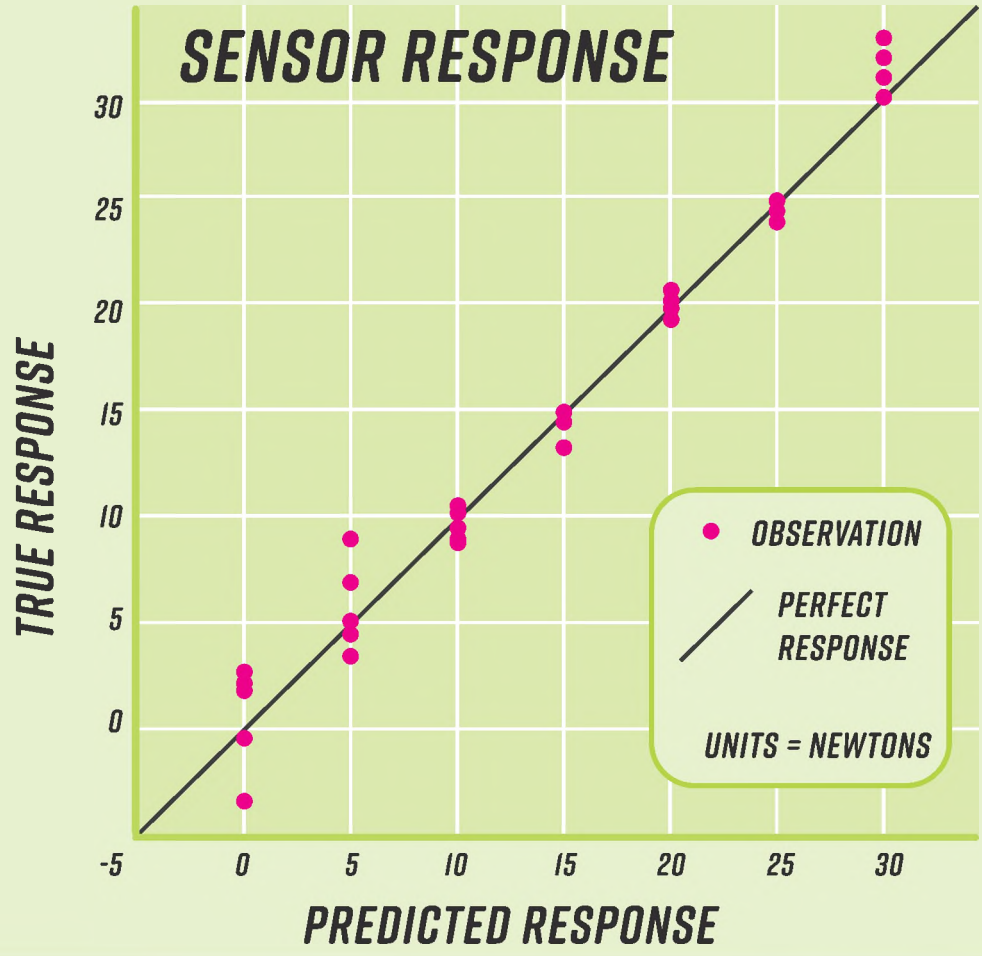
MECHANICAL TESTING



R-SQUARED VALUE

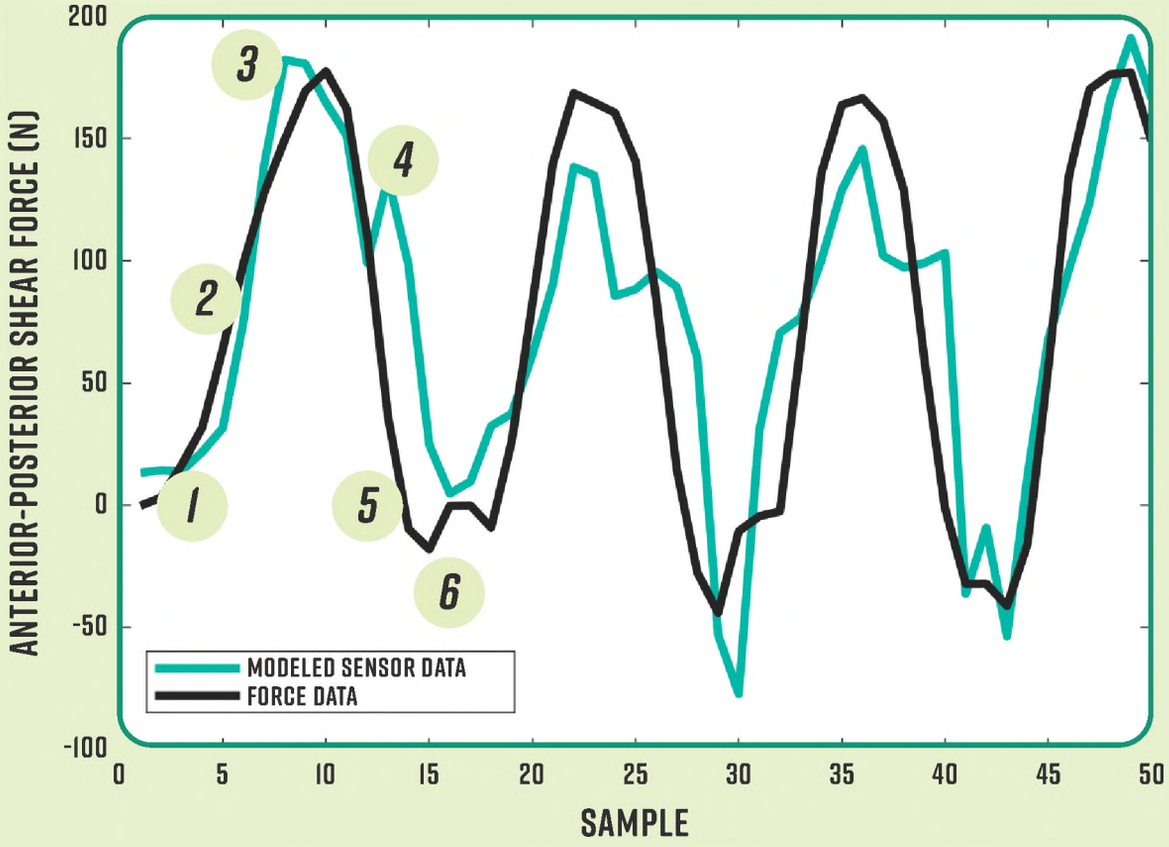
0.98
RMS

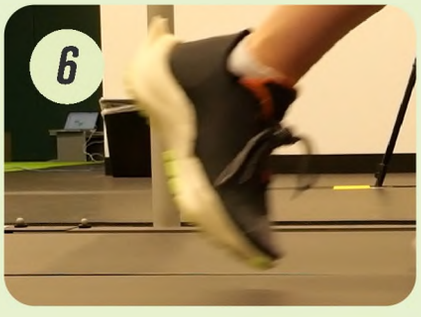
>5% ACCEPTABLE % ERROR FROM TARGET [1.0 RMS]



ALIDATION

FORCE PLATE WEAR TESTING



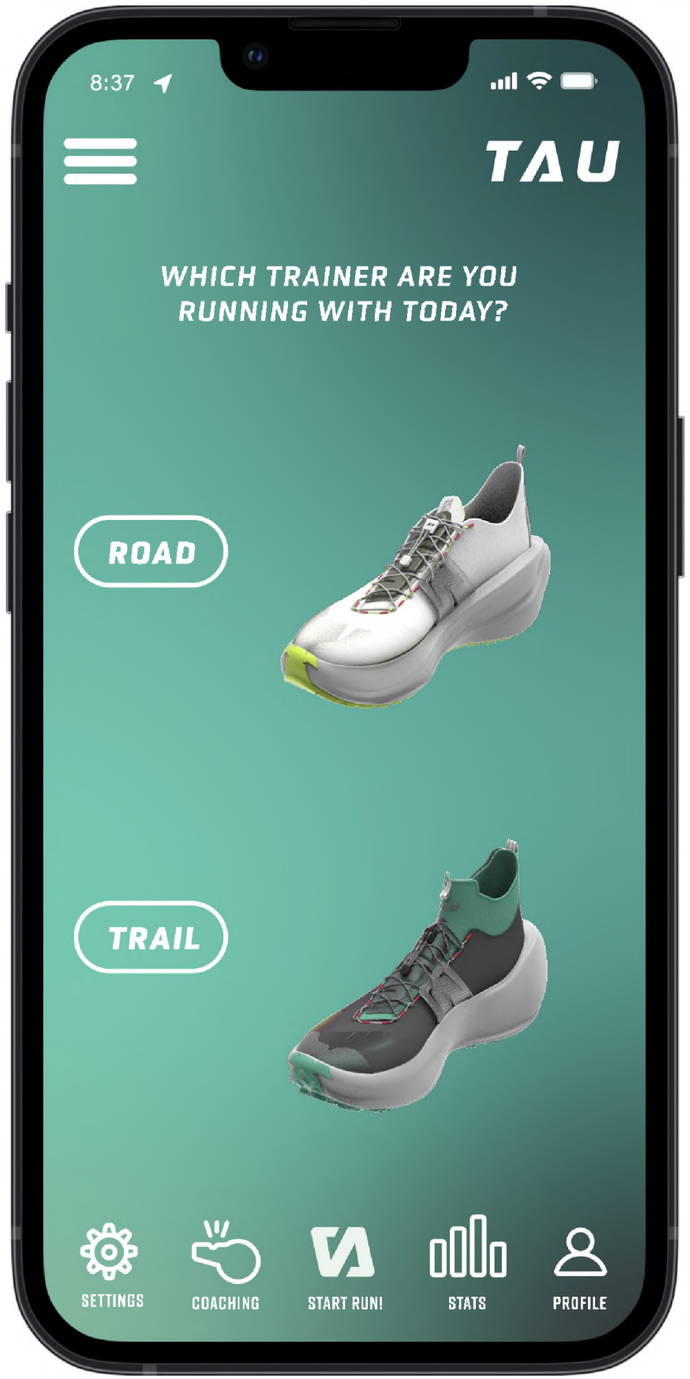


CONCLUSION

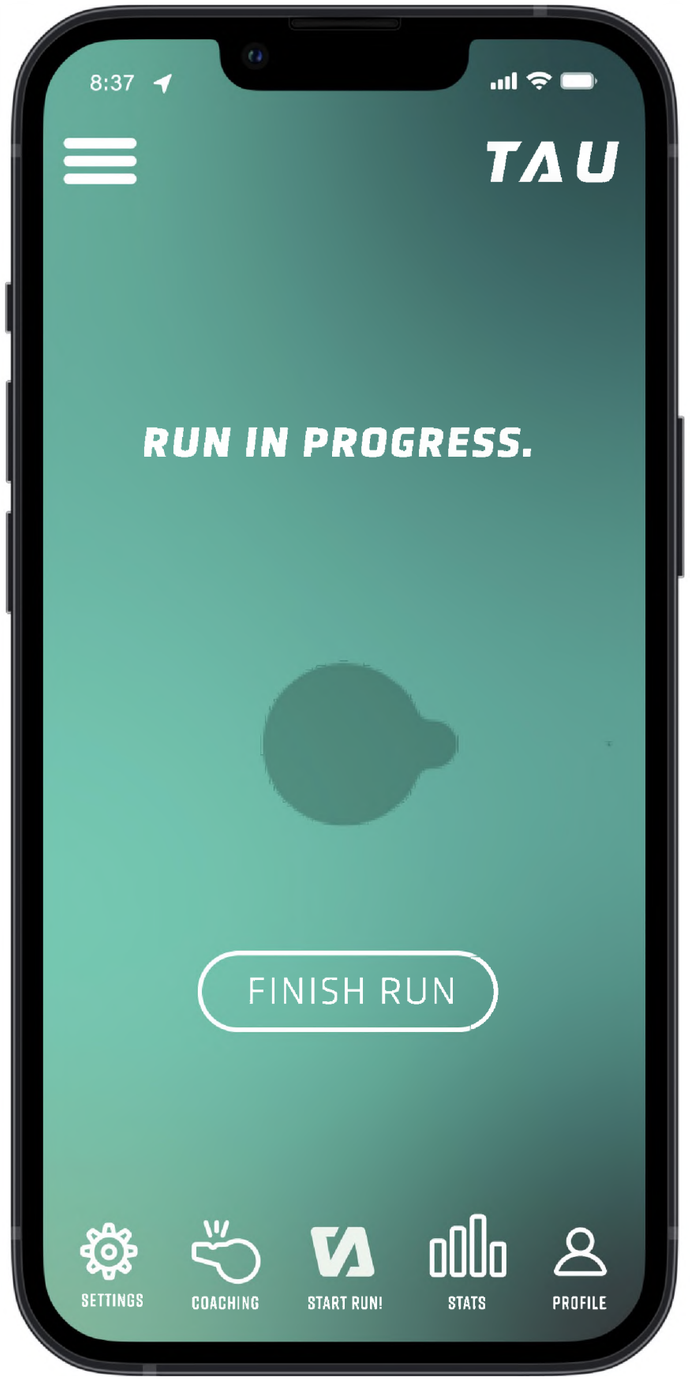
OVERALL BENEFIT, APP, MENTORS, ETC.

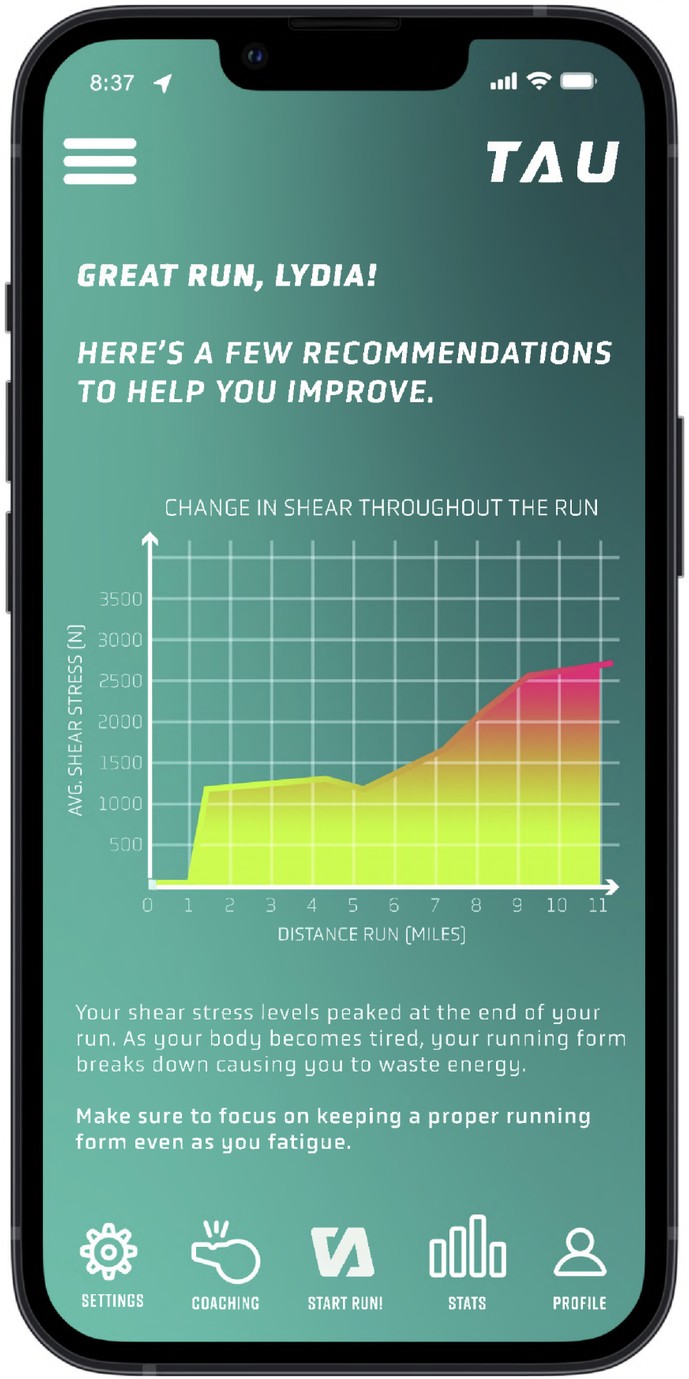
REAL-TIME FEEDBACK OF SHEAR FORCES AT THE FOOT-SHOE INTERFACE PROVIDES ATHLETES WITH A DATA-DRIVEN APPROACH TO IMPROVE PERFORMANCE

INTERACTING WITH THE APP



INTERACTING WITH THE APP





SENSOR DEVELOPMENT TEAM

BIOMECHANICS
BOWERMAN SPORTS SCIENCE CENTER

MIKE HAHN

BIOMECH. & ENGR.
BSSC & KNIGHT CAMPUS

MICHAEL MCGEEHAN

ELECTRICAL ENGINEERING
KNIGHT CAMPUS

GHEE KEAT ONG

ADVISORS & MENTORS

SPORTS PRODUCT DESIGN
WHITE STAG

SUSAN SOKOLOWSKI

BIOMECH. RESEARCH SCIENTIST
BROOKS RUNNING

EVAN DAY

PRODUCT DESIGN
UO EUGENE

KIERSTEN MUENCHINGER

MEDIA & MODELS

PHOTO & VIDEO

DAVID GREEN

TRAIL MODEL

LYDIA POVOLNY

ROAD MODEL

LILIE MATIA


THANK YOU