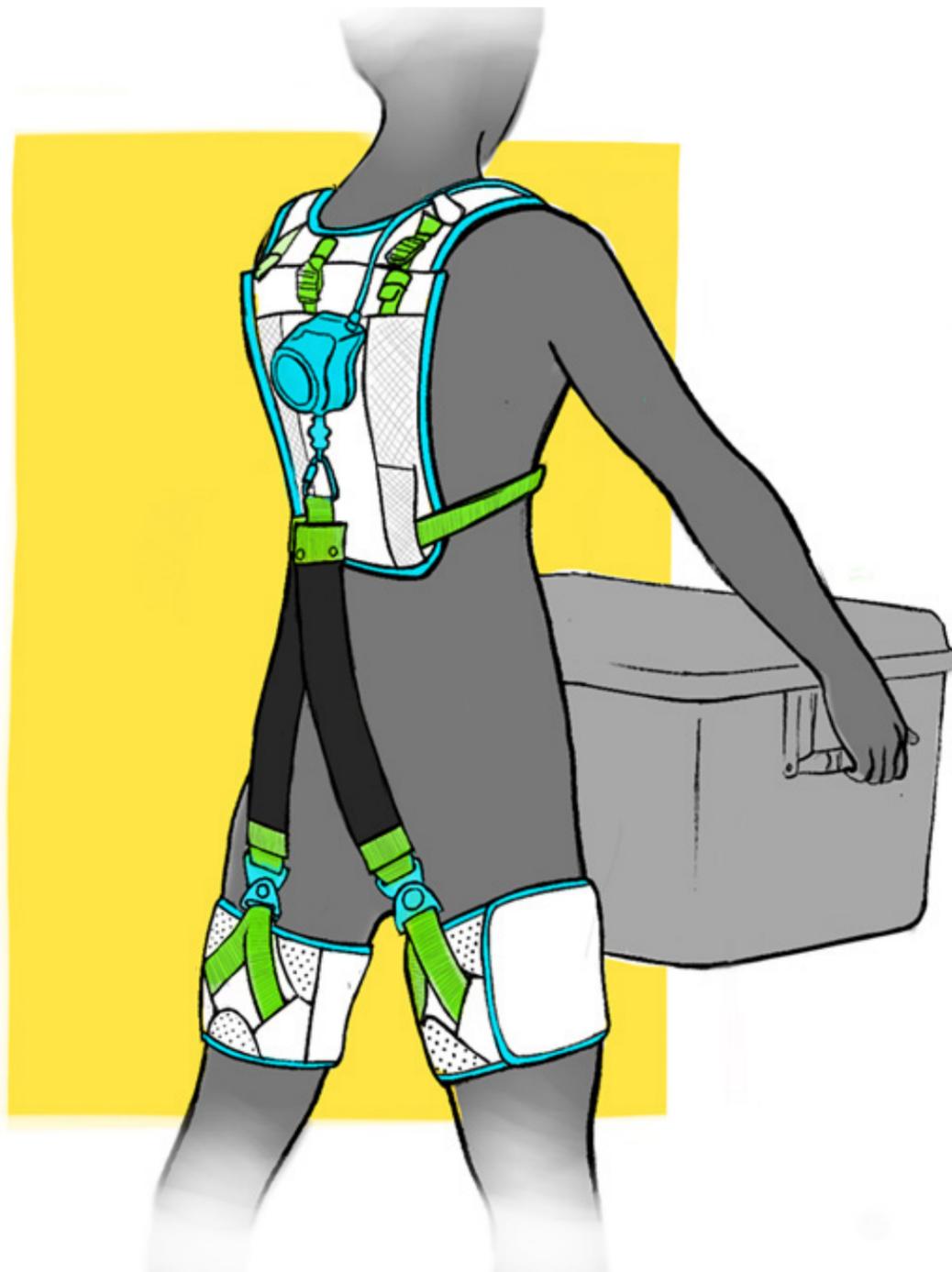




APEX Back Assistive Exosuit designed by Interwoven Design Group, LLC



The Apex is a lightweight exoskeleton worn workers in the logistics industry. The device aids to fight fatigue in the workplace. All without motors or batteries, the science-backed Apex weighs just 3.4 lbs. and can reduce over 50 lbs. of strain on the back.

DESIGN GUIDELINES:

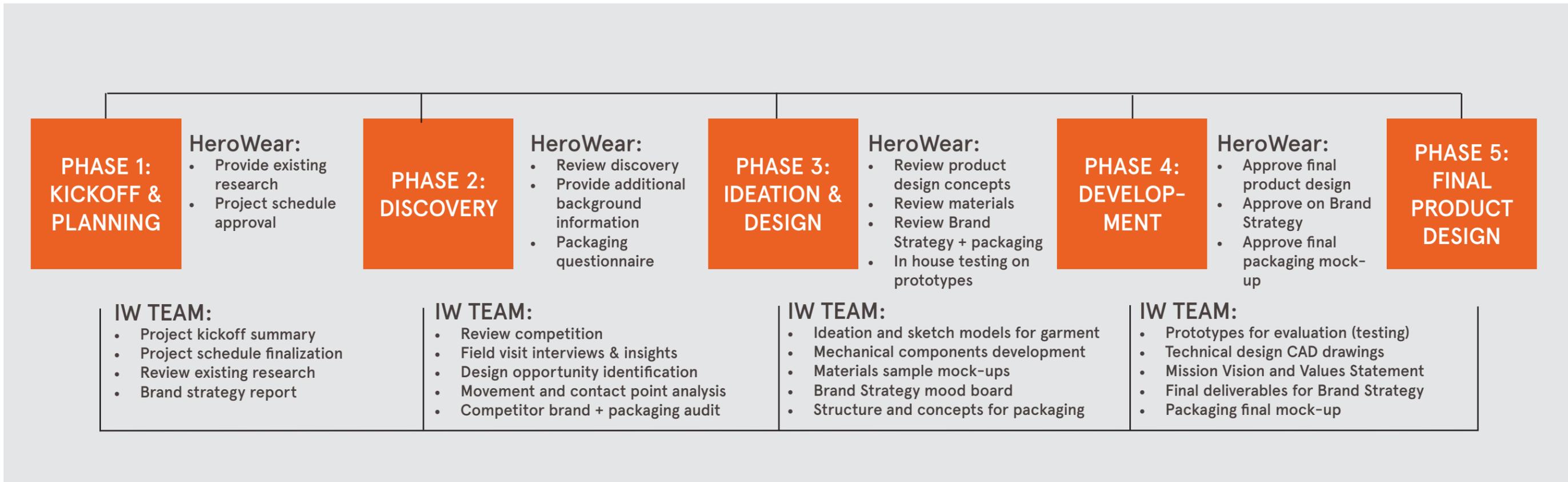
In 2019, a group from Vanderbilt's Center for Rehabilitation Engineering & Assistive Technology developed a proof-of-concept prototype for a mechanical exoskeleton that could alleviate strain on the lower back for workers. They approached Interwoven Design Group to design and develop their technology into a fully commercialized product. The resulting Apex suit took 18 months from the start of development to product launch in March of 2020.

Interwoven was tasked to designed for a diverse workforce in the logistics industry, while creating a highly breathable, comfortable, and durable device without obstructing the workers' movements and agility. The ultimate goal was to empower the users - have workers to establish a sense of ownership in the Apex.

ACHIEVEMENTS:

Upon final delivery, Interwoven delivered a modular suit, inclusive to men and women of all sizes which is easy to don and doff. The Apex is designed as as textile-based breathable device for comfort, but to also reduce costs and expand the pool of manufacturers availble. The intuitive backpack-like device allows for a personalized fit with an assistant that workers can feel and modify based on their level of strength.

Project Timeline



PART 1: APEX EXOSUIT

After many months of design development and trials, IW introduced the Apex exosuit, the first full iteration of the back assistive device developed for market distribution.

Apex has been developed with both functionality and manufacturing in mind, prioritizing the interest of both the user and the business.

It features durable woven fabrics with the placement of breathable textiles in strategic areas to reduce body heat build up. The use of multiple types of foam in the internal structure give both support and comfort for the user.

The mechanical components have been tested for both durability and functionality and are designed for both ease of use and to withstand the rigor of daily use over months - if not years.

This document summarizes the design development of the product and describes the features and benefits of Apex.

- **Back Component**
- **Thigh Sleeves**
- **Straps**
- **Latex Bands**
- **Clutch and Switch Mechanism**

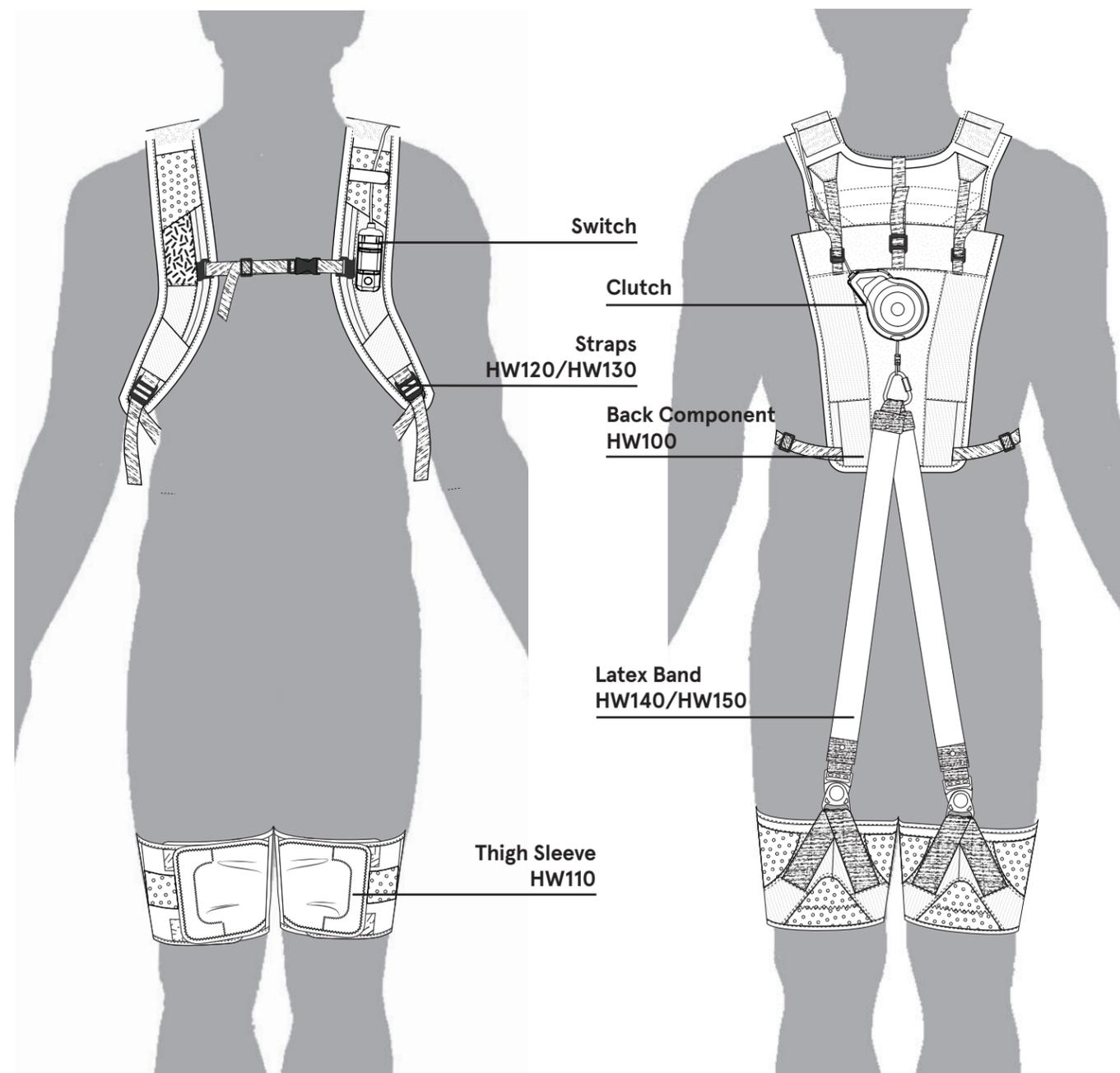


Apex

The technical drawing, on the right, shows a front and back overview of Apex on the body. It consists of 6 parts: the back, straps, thigh sleeves, latex bands, the clutch, and the switch. This section will breakdown the garment components of Apex and capture the design development we've made throughout this design process.

- Back Component
- Thigh Sleeves
- Straps
- Latex Bands

Prepared by	Interwoven Design Group, LLC.
Client	HEROWEAR, LLC.
Style Name	Supersuit
Style Numbers	HW100 - Back Component HW110 - Thigh Sleeves HW120/HW130 - Straps HW140/HW150 - Latex Bands



Apex - Color Placement

Apex features primarily black fabrics and reinforced plastic hardware with yellow binding trim to match the company logo and branding. The back features a plastic top housing for the clutch and the logo highlights the most functional component of the suit. The breathable fabrics; spacer mesh and mini-mesh are both a mid gray which blends with the black fabric yet highlights the breathable features.



EXTERIOR VIEW

INTERIOR VIEW



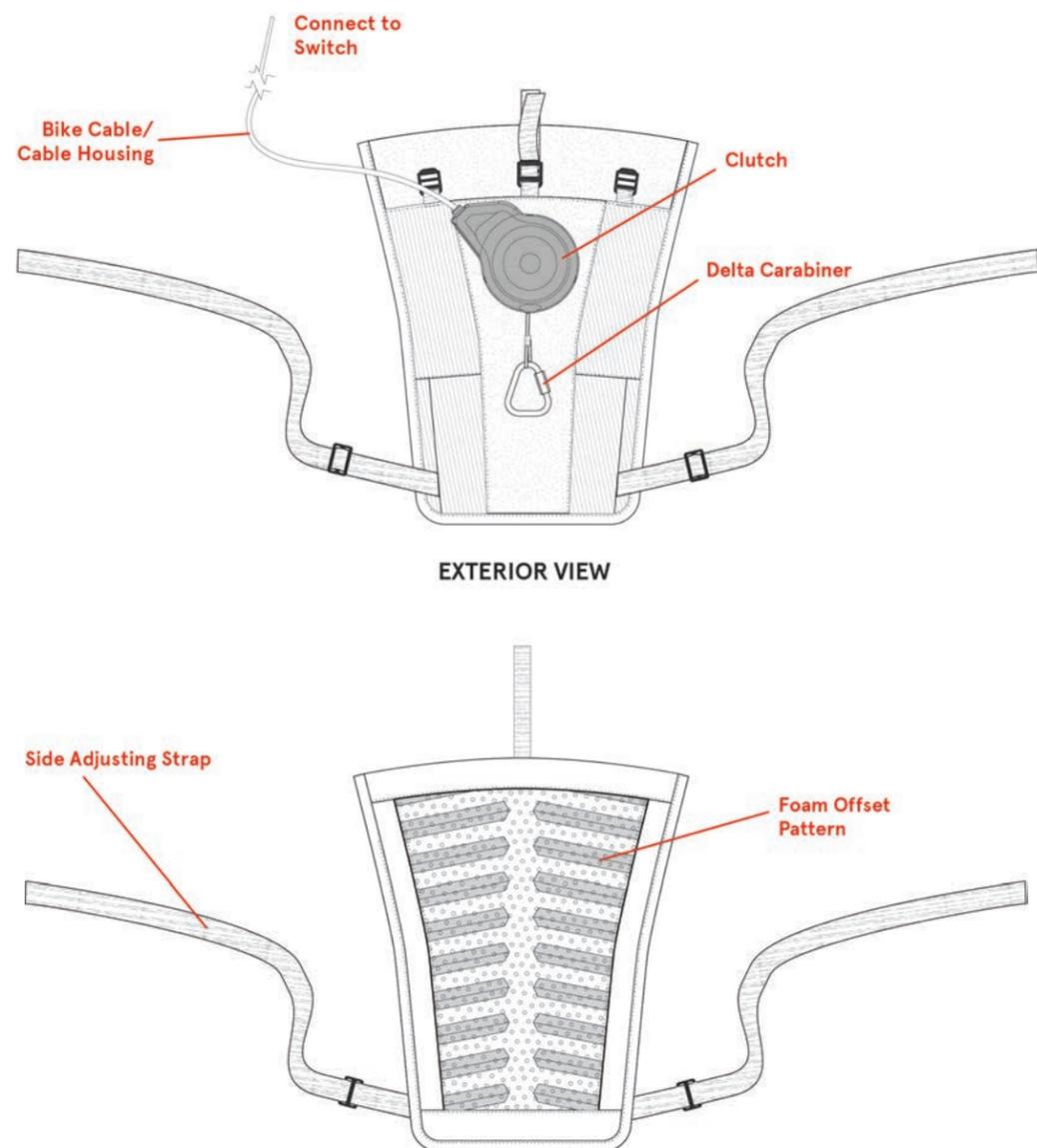
Back Component

The back component is the central system of Apex. The back went through multiple iterations during the design process to achieve maximum comfort, adjustability, heat control, functionality and interaction with both the clutch and switch.

The IW and HeroWear teams worked in tandem to fine-tune the back to include cord control, visual aesthetics, and enhanced the user comfort and experience.



Back Component: Technical Drawing



Thigh Sleeves

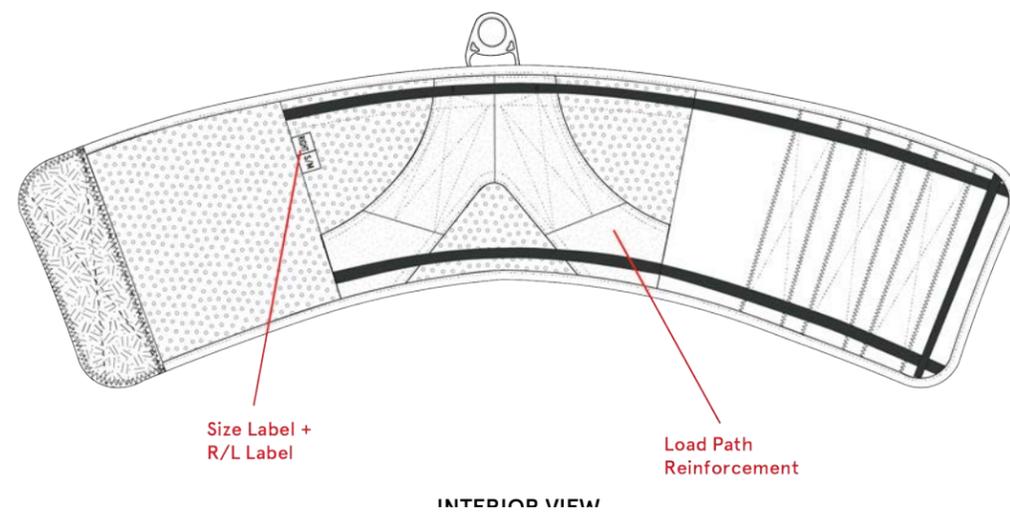
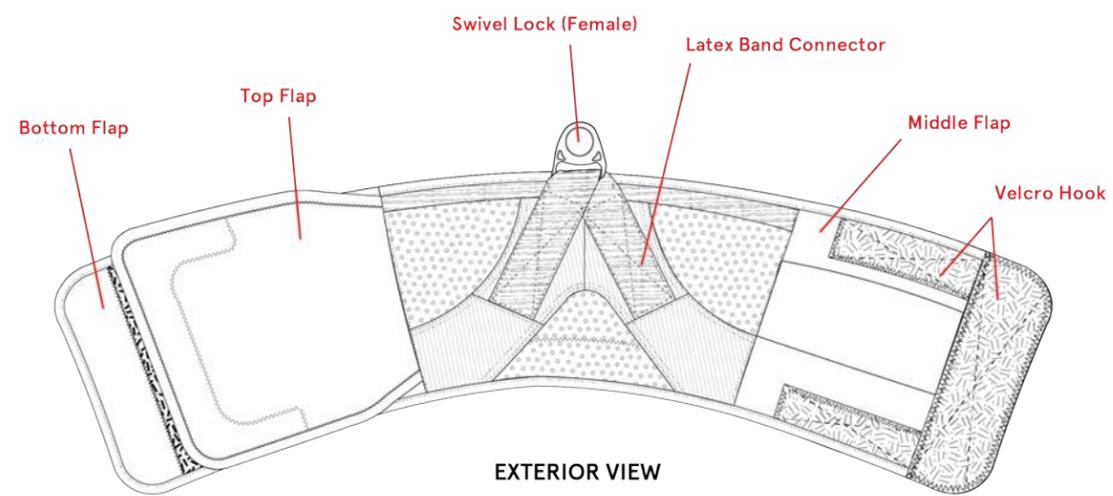
To meet the design requirements of this highly technical component, IW worked hard through many iterations of the thigh sleeve throughout the design process.

The resulting design, combines the qualities from the original thigh sleeve developed by Matt Yandell of the HeroWear Product Innovation Team with the IW design developed in Phase IV. This resulted in a successful design which combined the structure and stretch qualities with enhanced breathability and comfort with improved "stickiness" to reduce the thigh sleeve from migrating on the leg.

- **Final Development**
- **Technical Drawings**
- **Material Placement**
- **Construction Details**



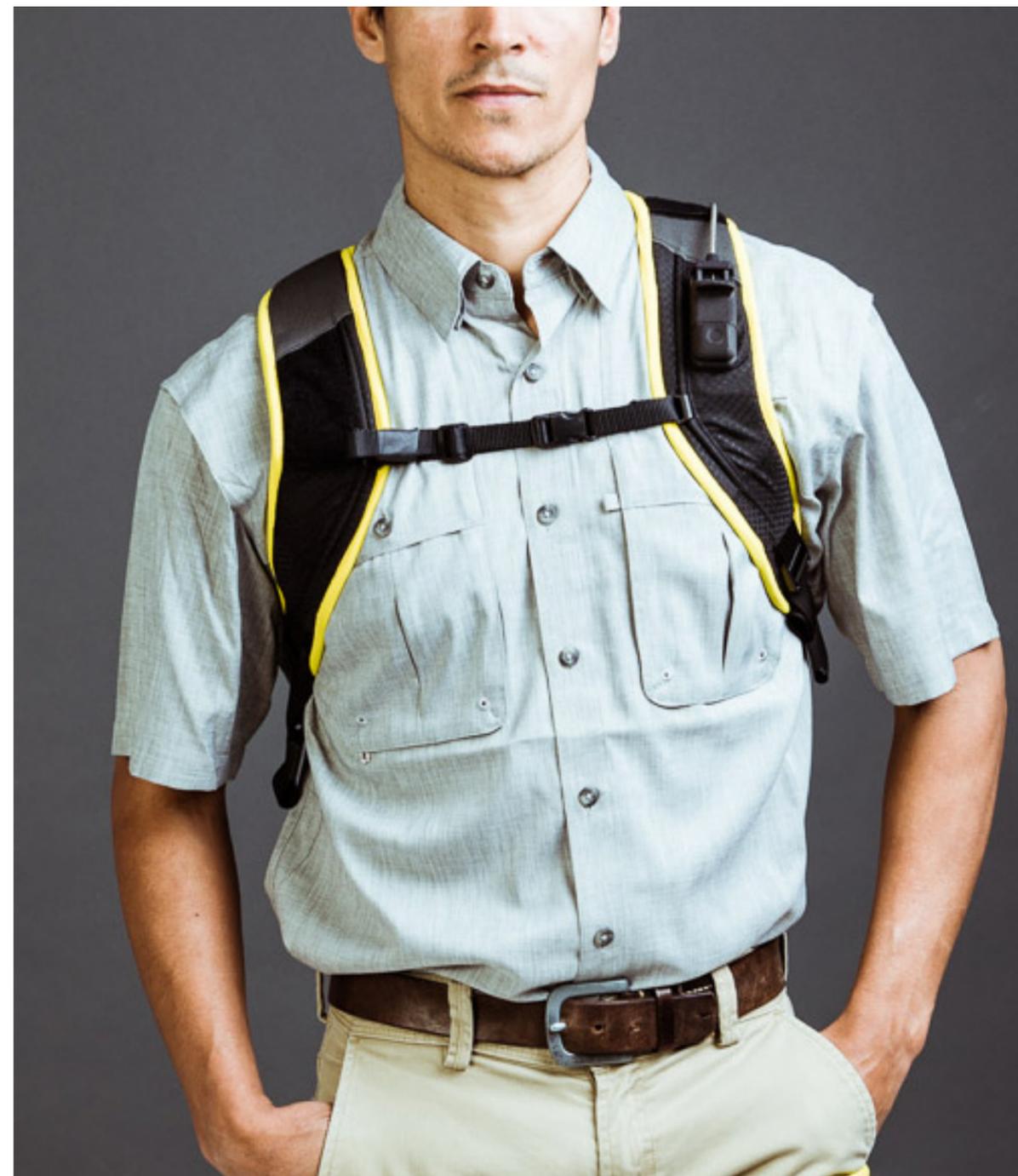
Thigh Sleeves: Technical Drawing



Straps

IW fine-tuned the straps to function seamlessly with the back component. In addition, during this phase we worked with a pattern grading consultant to create size ranges and adjust the strap patterns to fit both men and women. The design of the straps with their multiple adjustment areas maximizes comfort for a large range of body types.

- **Final Development**
- **Technical Drawings**
- **Material Placement**
- **Construction Details**

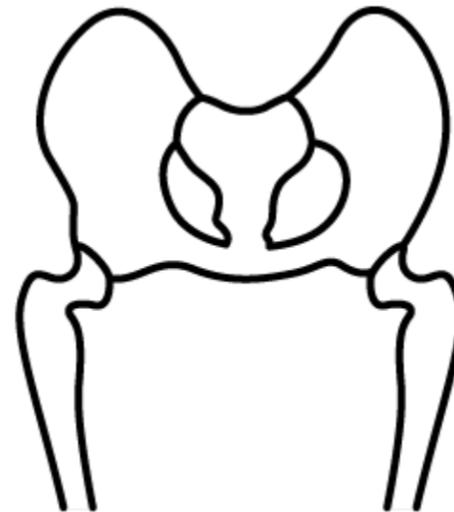


Straps: Womens Sizing and Grading - Final Development

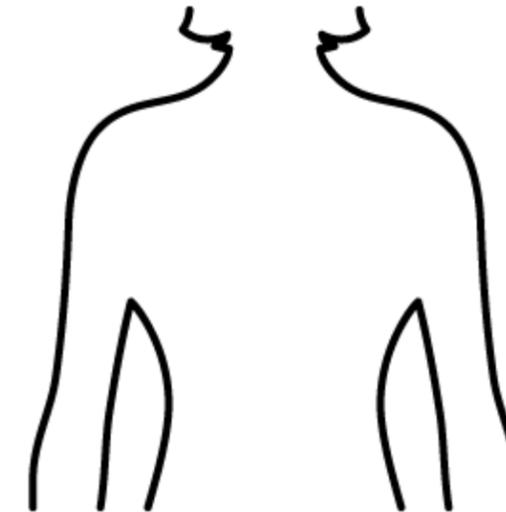
One of the biggest achievement in creating the Apex was in developing an exosuit designed specifically for women. The backpack-like straps are sized by gender and body-type, but the women's sizing introduces curvilinear outline with an open chest design. The inherent nature of the Apex's design also allows for a greater range of movements to accommodate women who physiologically have a greater Q-angle as compared to men.



Curvilinear Outline



Greater Q-angle



Open Chest Design

Straps: Womens Sizing and Grading - Final Development

To make sure that the strap is equally as comfortable for both male and female users, IW created a female pattern strap, available in both S/M and L/XL sizing. The female strap contours the shoulders and snakes under the armhole at a higher point to ensure maximum comfort. The straps are also slightly narrower across the upper chest/shoulders compared to the male straps. As for grading, there is a 5/8" increase in length the space between the hot shoe and the shoulder, and additional 1 1/8" from below the sternum piping to the end of the strap tip. This sizing range allows a wide group of users to fit within the sizing scale with a limited SKU quantity.



Phase Four Strap Pattern on Female Body



Mens Straps

Womens Straps



Phase Five Straps

Straps: Additional Features - Final Development

Through this phase, IW made a number of minor tweaks to update the straps. We experimented with different foams and landed on one which is comfortable and flexible. An additional padding layer was added to the shoulder area for support. Second, the hole in the webbing attachment on the shoulder was eliminated to enhance the experience when testing the Fit Kit. As a replacement, a Velcro tab was placed on the left shoulder to secure the angle of the Bowden cable. Additionally, the Velcro patch is added to the right strap to add customer branding.



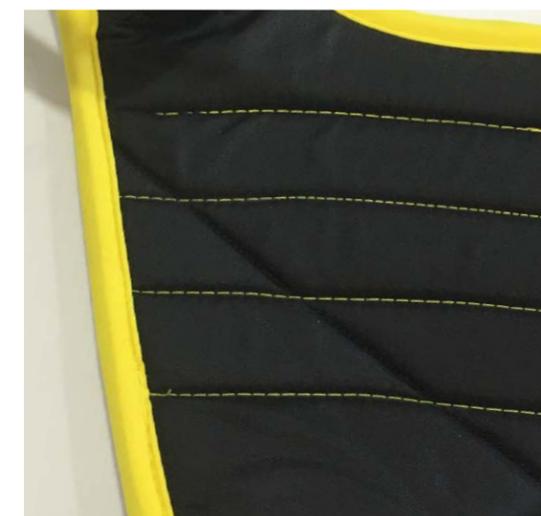
Phase 5 Strap



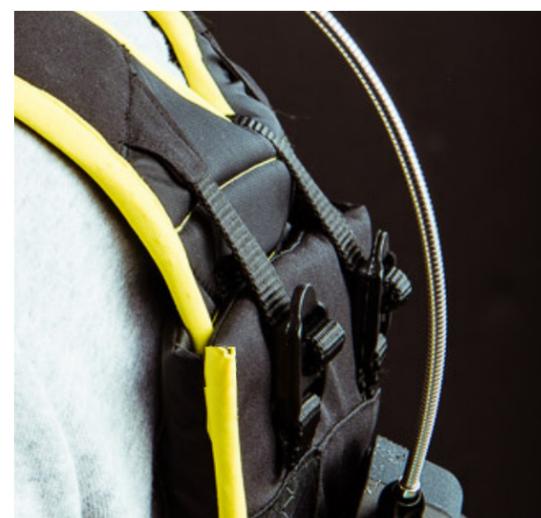
Velcro tab



Velcro Patch



Contrast Stitching



Webbing Attachment



Foam

PART 2:

Mechanical Components - Clutch and Switch

Part 2 summarizes the final development of the switch and clutch mechanisms including and our process of testing different materials.

- Switch
- Clutch



Switch

IW worked through 10 different versions of the linear switch considering functionality and aesthetics. Different materials were used for milling and 3D printing prototypes for approval. The final decision for the initial Fit Kits was to fabricate switch and parts of the clutch in 3D printed plastic. Other parts of the clutch - where durability was critical - we had milled from a metal block. The switch is placed on the left strap using a hot shoe to enable the fast change of different strap sizes.

- **Final Development**
- **Exploded View**
- **Assembly Instructions**



Clutch

In Phase V the IW design team focused on refining the clutch mechanism. We experimented with different materials - plastics and aluminums both with CNC milling and 3D Printing. We also refined little tweaks within the inner mechanisms. For example, to increase the spring back we needed to add an additional rotor spring. We also worked on many iterations of the inner configuration to both simplify and strengthen the "engage" and "dis-engage" motions.

- **Final Development**
- **Material Placement**
- **Assembly Instructions**



PART 3:

Apex Fit Kit

We finalized the development of the "FIT KIT". The Fit Kit is a customized hard sided suitcase with wheels that houses all the parts of the suit needed to create a custom fitting suit. The idea is to use it when visiting a facility to fit the users and order the parts needed to make their individual suits. We used the Nanuk 935 as the Fit Kit case in a custom yellow color and retro fit it with webbing and elastic straps to hold all the parts inside the case. The finalized design allows the team to use the Fit Kit to display the Apex and leave potential customers with a lasting strong first impression.

- Final Development
- Technical Drawings
- Material Placement
- Assembly Instructions



Fit Kit: Final Development

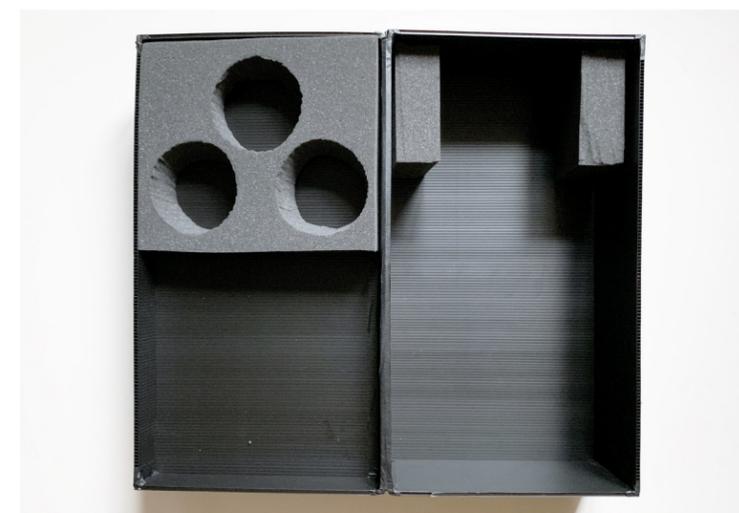
To maximize the limited spatial volume of the Nanuk 935, IW prioritized how and which styles were to be displayed on the each "un-boxing" experience. Each garment housing component was developed as a block and were shuffled around on CAD to figure out what would fit where. The process required IW to develop packaging components including foam inserts, plastic cards and Velcro bands. The result is a layered display system which features one set of the Apex components on display in the top lid and the other sizes neatly stored in the bottom half of the suitcase.



Fit Kit



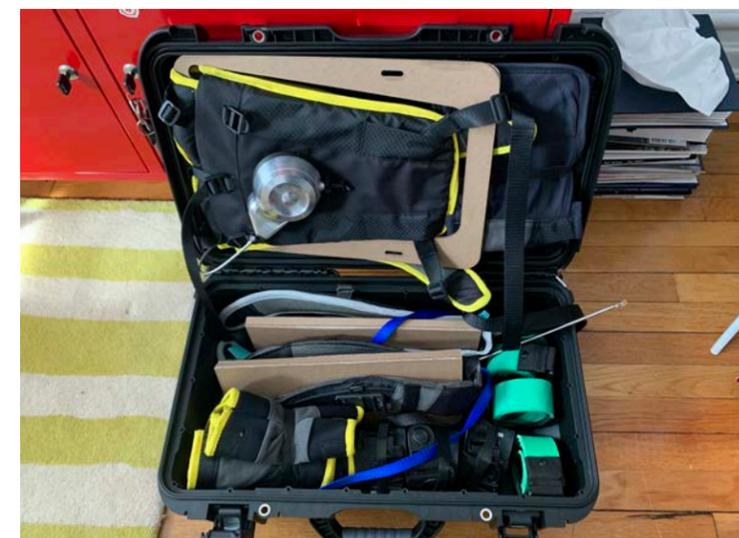
Interior Setup Mock-up



Interior Setup Mock-up



Folding Mock-up



Chipboard Interior Mock-up

-INTERWOVEN-

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