F.R.O.G.

Enhanced Gear for Environmental Field Researchers

by
Mark Connolly

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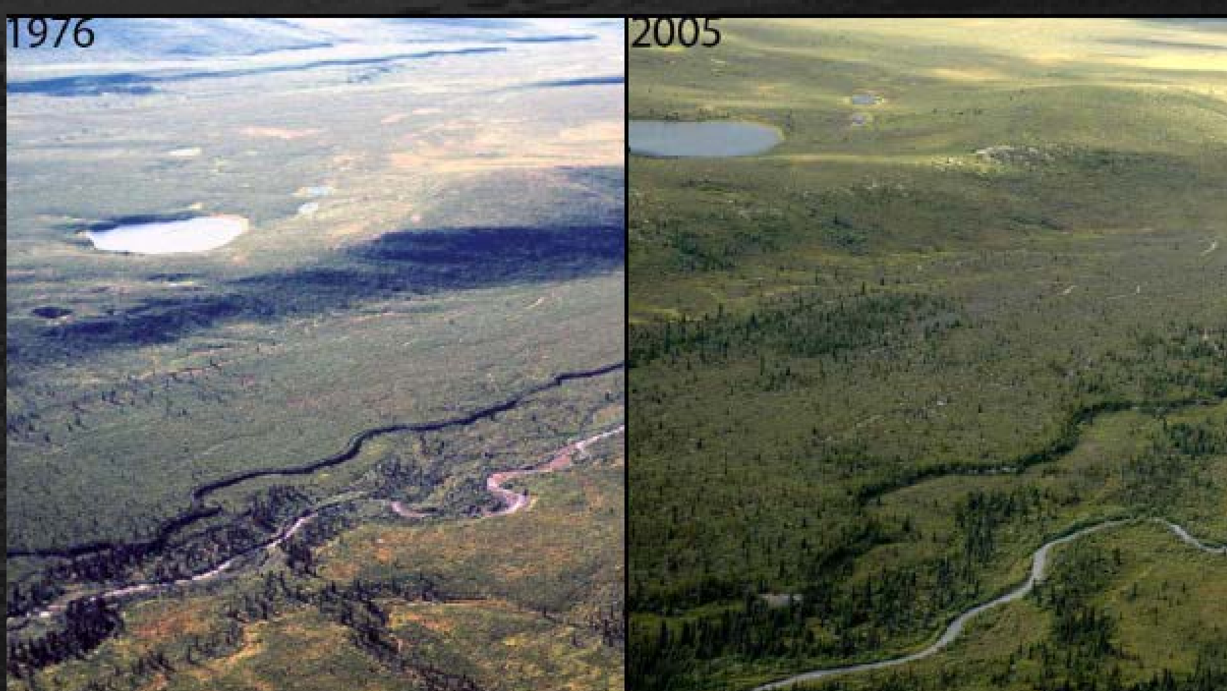
Abstract

The consequences of climate change caused by anthropogenic sources are unknown, making the demand for current data increasingly high. At the front lines of providing society with climate data are environmental scientists, whereby government agencies, post-secondary institutions, or industry personnel are among the primary employers. Regardless of their specialty discipline, traversing into often remote wilderness areas to conduct field research remains a central responsibility for environmental researchers. In the context of this study, those working in subarctic ecoregions are the focus. With the temperatures rising in the north at twice the rate of the global average, the natural systems of the subarctic are under extreme stress as a result of melting permafrost, wildfires, extreme snowmelt, and air pollution, to list a few. As environmental scientists help human society get ready for a future in the age of climate change, it is also pertinent to provide them with adequate resources, especially with respect to outfitting gear. By the end of this project, a design solution that reduces the end-to-end pain points for environmental researchers during their field work period is hoped to be met. To provide the basis for the design solution, information was gathered through qualitative interviews with target end-users and through extrapolating knowledge from relevant and valid academic sources. The analysis will be conducted through a live field research scenario by reviewing and comparing the experiences of one wearing the eventual design solution and an outfit of current solutions with the conventional shell jacket, field pants, and footwear. Helping environmental scientists prepare for the physical demanding work of field research with an extra layer of safety, comfort, and professionalism, means also helping humanity prepare for an uncertain future.

Keywords: environmental, field, climate, scientists, design



(U.S. Department of Interior, n.d.)

Acknowledgments

Thank you to my friends, family, and instructors, for helping maintain my joy and enthusiasm toward design.

A special thanks to my research advisor, Gordon Fraser, for his patience and expertise.

Chapter 1: Introduction

1.1

A prominent issue environmental researchers face is getting caught in poor weather conditions, which could result in loss of data, personal injury, or becoming separated from a group. Additionally, researchers are often conflicted with packing too much or too little for extended field expeditions, given the highly variable nature of subarctic environments. Adverse weather or arduous terrain pose a myriad of challenges for environmental researchers during field work yet, the overall process to adapt to developing emergency situations can be burdensome and laborious. Further, once daily field activities are completed researchers must ensure their gear is both clean and dry before their next use, implying that they often bring multiple sets of gear. This project aims at ensuring environmental researchers have adequate resources before, during, and after their field work, in response to a rapidly changing environment.

1.2

With climate change transforming and adjusting the arctic and subarctic regions on a drastic scale, natural patterns are becoming increasingly less predictable. Environmental field researchers require a unique outfitting solution to better adapt to adverse conditions and to satisfy essential equipment. There is a clear need for gear that can protect electronic instruments from precipitation, withstand unpredictable terrain, help cool off and warm up the user without having to layer up or down, minimize the amount of bulk in packs for items to be more accessible, and ease the taxing physical demands of field work. While environmental workers vary in discipline, such as biology, glaciology, geology, hydrologists, etc., the fact remains that these professionals go out into the environment for a prolonged period and return with findings, for which to write reports. Additionally, the season in which they collect data is similar, from the late spring through early fall. On top of having to bring multiple articles of clothing to adapt to the weather among other basic survival, the other important equipment and gear field workers must bring is just another stressor to an already high-stakes and difficult industry.

1.2.1

Given that this project aims at developing enhanced outfitting gear for field research, considering the firsthand experiences of professionals is the most prominent way to figure out what needs to be included in the eventual design solution. In addition, it would also be best to know the duration of their study periods and how many people are present while on site. As well, the list of responsibilities and duties one has before, during, and after their workday.

1.2.2

- What do you do to prepare for your field work ahead of time?
- What does the average day to an environmental researchers look like?
- What are some general positive and negative aspects of doing field work?
- What hazards might one encounter while performing field work in the subarctic?
- In your experiences, how have you overcome any challenges during field work?
- What time of year does field work normally get done?
- What items do you deem essential for field work?
- How satisfied are you with current outfitting apparel?

1.2.3

Literature Review:

One article from a researcher with the Canadian Ice Service disucssing day-to-day field work duties and another discussing the correlation between poor weather and hiking injuries.

User Interviews and Surveys:

Personal 1-on-1 interviews and qualitative questionnaires with environmental researchers and professionals in the outdoor gear industry.

Product Benchmarking

Only companies that offered all products, such as footwear, jackets, pants, and bags, over a wide price range were reviewed.

Video Analysis & User Observation

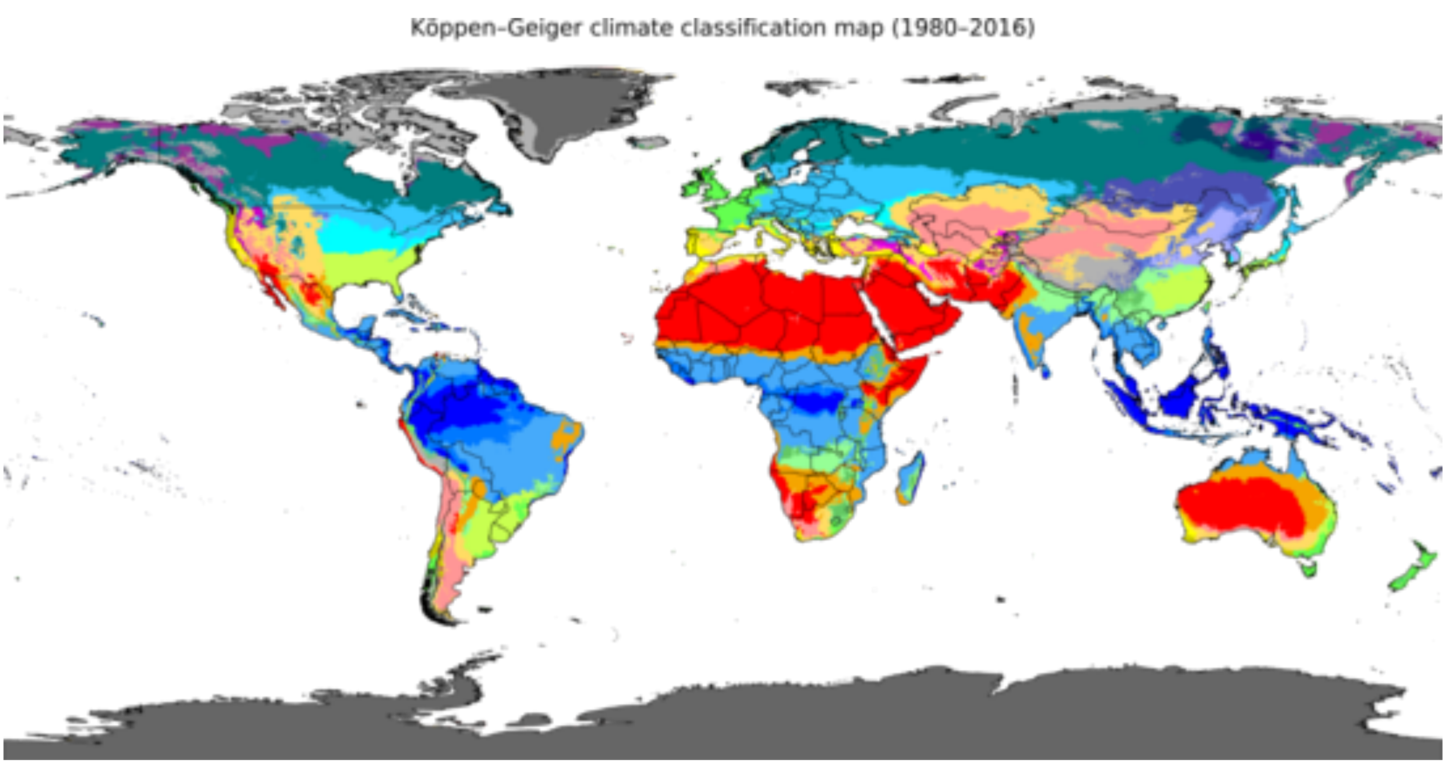
A qualitative analysis of “a day in the life” of the intended secondary user group and a user observation by proxy with images and recounted events of academic researchers.

Ergonomic Study:

Reviewed published material on human factors for clothing sizing across a range of user types, specifically the 5-percentile female and 90-percentile male.

1.3

Field research is an exercise whereby one situates themselves in a given place for the purpose of observing and recording raw data (Amy Blackstone, 2018). Each discipline has specific duties to achieve their respective objectives however the overall concept and processes of fieldwork for qualitative analysis is credited to work of late American sociologist, William Foote Whyte, who "is considered by many to be the pioneer of the use of participant observation methods in sociological studies" (Amy Blackstone, 2018). In more depth, the topic of this project specifically is concerned with those conducting environmental research in subarctic ecoregions. The subartic region is an area of the northern hemisphere that lies in between 50o and 70o N in latitude, just below the arctic circle. Generally, the climate of the subarctic, as described by on the Koppen-Geiger climate classification diagram below, is described as one of brief summers with cooler temperatures and long and unusually cold winter seasons. Subarctic climates occupy large areas of land, away from ocean sources to regulate the temperatures, therefore weather patterns can vary greatly. The level to which the climates vary from place to place in the subarctic is largely based on a matrix conjoining annual precipitation amounts and temperatures on a monthly basis, thereby dividing subarctic areas into specific classes.



(Beck et al., 2018).

Chapter 2: Research

2.1

The primary user group consists of those performing environmental research for academic purposes. Academic researchers are employed by certain post-secondary institutions and tend to lean more toward environmental conservation and providing data that helps make the public more aware of the effects of climate change. The field work they do is specific to sustainability, of which there is a large emphasis in the design industry as well. Furthermore, this age group of those doing in-depth environmental research at accredited post-secondary institutions would be Master's and PhD students and university associate professors.

Primary User:

Info:

Name: Dr. Laura Ross
Job: Biology Professor
Income: $90,000-$135,000
Education: BSc, MSc, PhD
Location: St. John's, Canada

Profile:

Dr. Laura Ross is a 40 year-old professor of both biology and geography at Memorial University of Newfoundland, where she also leads a team of field researchers.

The emphasis of her research involves the direct implications of climate change on boreal forest systems.

Most recently, her research is concerned with the state of Terra Nova National Park, a remote protected area hours away from the city of St. John's.

Motivations:

- Climate Change
- Love for the outdoors
- Working with a team of like-minded individuals

Barriers:

- Inclement weather
- Research funding
- Scheduling constraints
- Faulty equipment
- Bug bites

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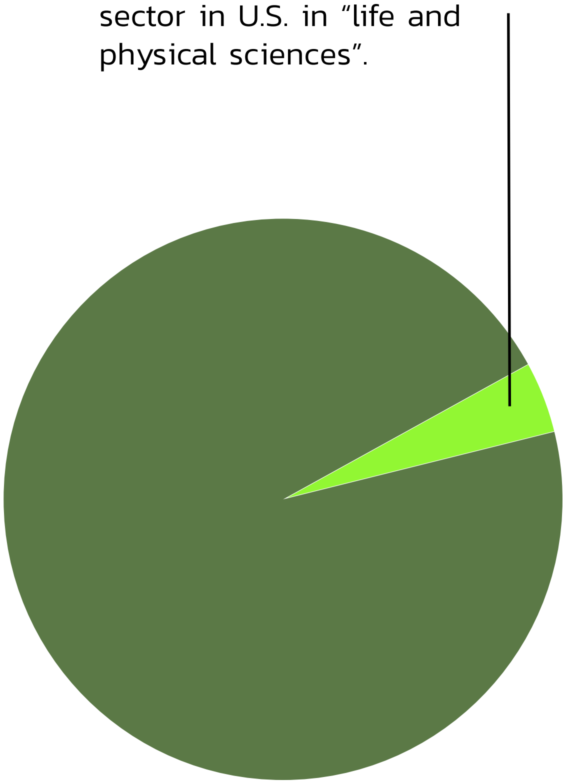
Goals:

- Collect raw data
- Not get injured in the field
- Analyze and process data for lab research

Secondary User:

- Industry Surveyors/Environmental Assessment Workers
- Typically employed by big industry or governments

8% of all jobs in science and engineering sector in U.S. in "life and physical sciences".



(Sargent Jr., J.F., November 2, 2017)

Tertiary User:

- Advanced-level backcountry hikers
- Affluent outdoor recreationists wanting the "professional" experience

$646 billion is spent on outdoor recreation on average each year.

More than **140 million Americans** make outdoor recreation a priority in their daily lives"

(U.S. Bureau of Economic Analysis, 2012).

2.1.2

Routine Tasks

In the user observation by-proxy, routine tasks for field expeditions included:

- Unpacking tools, equipment, and gear at site of lodging or accommodations.
- Driving a distance to the field site, one last check of their equipment.
- Collecting raw data setting up equipment, and walking vast distances, all while taking intermittent breaks.

Non-Routine Tasks

Tasks often veer away from routine when visibility is low due to either torrential precipitation, dim sunlight, or when they are accessing extremely remote areas through bushwhacking. As tasks become increasingly more complicated, the possibility of personal injury may also occur through tripping and falling, as it can often be difficult to determine how deep or uneven a feature in the terrain can be when covered by bush. Another contributor to complications in field work is air transport could be delayed, meaning that users can be faced with having to ration their food and camp in the wilderness or an unknown amount of time. Regardless, spending a prolonged period of time with the same person or people under negative circumstances can take a toll on one's mental wellbeing.

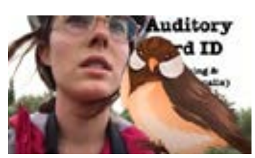
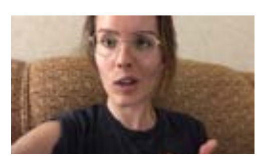
(Dodge, 2020)

2.1.3 & 2.1.4

User Observation By Proxy - Primary User

Measuring:	**Observation/Recording:**	**Gear:**
• Soil Moisture meters, hypsometers, digital light meters, calipers, quadrats, DBH tape, wooden skewers/sticks	• "Rite-in-the-rain" notebook, large metal clipboard, phone, "black ink only" sharpies, pencils, binoculars	• Dry sac, cruiser vest, layers, gloves, hardshell pants and jacket, "highly visible" clothing
		

Video Observation - Secondary User

 **Preparation:** • Packing • Fueling up • Traveling to field site	 **Step 1:** • Arrive at site • Review research duties	 **Step 2:** • Traverse through study area	 **Step 3:** • Stop at various points of interest
 **Step 4:** • Adjust to terrain or weather	 **Step 5:** • Often encountering insects and/ or bears	 **Step 6:** • Often encountering insects and/ or bears	 **Complete:** • Retire for the evening • Clean gear and plan for next day

2.1.5

Working in remote areas often implies being vast distances away from healthcare, let alone nearby communities, which is an afterthought when dealing with an injury in heavily forested areas where transportation out of dire situations proves to be even more complicated. Having a partner or group around one for support in wake of an accidental injury during field work offers one comfort but generally does not necessarily help the issue of getting out of an area and into the hands of healthcare professionals. At best, one may know the weather conditions of the day if it is expected to colder or there has been a previous prolonged period of precipitation and can then plan what to bring in terms of gear accordingly, to prevent hypothermia, for example. As it turns out, field researchers are apathetic toward some forms of harsh weather, with some even expressing they enjoy when their body comes in contact with the environment. But bodily harm, such as sprained ankles or limb breaks, are always imminent dangers of which field researchers must always be mindful.

(Dodge, 2020)

2.2.1

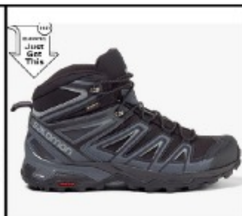
These particular products are in line with what is considered to be common articles of gear, drawn from the user observation study.

The commonalities between the two boots shown is their higher cut along the ankle, construction of durable and water-resistant polymers and fabrics, and soles with traction patterns that offer users extra grip along rugged terrain.

The jackets shown in the table are exemplary of mid-to-low tier products in their respective categories. The primary difference between them is the construction and the materials of which they are made.

The pants is a pair of cargo pants by Columbia, that are in an economical price range and offer the user comfort, breathability, and UV protection. These are standard for field research because many people do not wish to walk around all day in fully waterproof, hard-shell pants in the event of sudden rain, as it was discovered in interviews.

Lastly is a pair of gaiters from Outdoor Research. Gaiters are intended to provide added insulation and protection from debris for user footwear but ultimately do not create a waterproof seal in the event of possibly stepping in a puddle.

					
Salomon Quest 4 GORE-TEX	Salomon X Ultra 3 Mid GTX	Marmot ROM 2.0	Outdoor Research Helium Jacket	Columbia Silver Ridge Cargo Pants	Outdoor Research Crocodile Gaiters

Benefits

• Offers user extreme comfort, support, and stability • Boot is waterproof and strong against harsh terrain	• Provides grip and stability amid rough surfaces and conditions • Protects user against lower body injury • Waterproof • Could be worn casually • Lightweight	• Comfortable • Weather-resistant • Lightweight • Breathable	• Very lightweight • Repels rain • Compact and packable • Highly mobile • Inexpensive • Breathable	• Lightweight yet durable during intense use • UV-ray protection • Breathable • Comfortable	• Lightweight • Protect lower-leg from debris and precipitation • Breathable • Durable • Comfortable • Aid in visibility

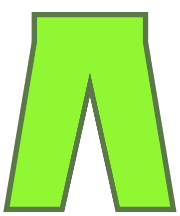
Features

• Higher ankle-cut helps prevent/mitigate lower-body injuries • Gore-Tex material membrane for waterproofing • Designed to withstand heavy use and carrying loads • Innovative support structure • High-traction sole	• Contragrip rubber sole with "aggressive" lug pattern • Gore-Tex lined upper • Mid-cut	• Several pockets • Gore-Tex Infinium Windstopper • Adjustable wristcuffs and hood	• 6.3 ounces in weight • Nylon, cordura, and spandex blend	•100% "ripstop" nylon • 0.62 lbs • Inseam gusset to prevent rips when crouching and bending • Side-elastic panels on waist • 6 pockets total, good for storage	• Gore-Tex lining • Abrasion guard at bottom • Neoprene-coated instep strap • Reflective panels

2.2.2

Features and Functions

Products	 Salomon Quest 4 GORE-TEX	 Salomon X Ultra 3 Mid GTX	 Marmot ROM 2.0	 Outdoor Research Helium Jacket	 Columbia Silver Ridge Cargo Pants	 Black Diamond Apex GTX
Weight	• 2.9 pounds per pair	• 1 lb, 15.6 ounces per pair	• 17.1 oz	• 6.4 oz	• 0.62 lbs	• 230 g (8 oz) per pair
Waterproof	✓	✓		✓		✓
Materials	• GORE-Tex-lined upper • Rubber sole •	• GORE-Tex-lined upper • EVA midsole • Contragrip rubber	• GORE-Tex infinium	• Pertex® Shield Diamond Fuse 2.5L, 100% nylon, 30D ripstop	• 100% nylon Silver Ridge ripstop Omni-Wick mesh panels: 57% recycled polyester/43% polyester mesh	• GORE-Tex upper • Neoprene instep • Nylon strap •Nickle-plated instep buckle
Use	• long, demanding treks with heavy loads • varying terrain conditions	• long treks and hiking • suitable for varying terrain	• Suitable for climing and skiing (alpine environments) • Breathability for varying weather conditions • Wind-block	• Compactability to be worn during onset sudden rain	• UPF 50 • prevent wear when crouching and bending	• fit around footwear for cold, wet-weather pursuits
Price	• $290.00	$165.00	$215.00	$159.00	• $79.99	• $79.95
Fastening	• Lace-up • High-cut ankle	• Lace-up • Mid-cut ankle	• 4 pockets • Main zipper • Adjustable hood and cuffs	• Chest pocket • Main zipper • Adjustable hood • Elastic cuffs	• Elastic waist • Hook-and-loop pockets • Zippered pockets	• Hook-and-loop front • slide-release buckle

		
• Full range of motion • Lightweight • Breathable and flexible in crevices • Waterproof along calves when walking through damp bush • Bathroom access • Rip-resistant	• Full range of motion • Breathable but waterproof, only when necessary • Lightweight • Better storage • Layer up or down in response to changing weather conditions	• Water-resistance • Sturdy to prevent bodily injury • Thermal insulation • Lightweight • High traction • Durable and no breakable elements

2.2.3

Performance outdoor products are more commonly being worn during everyday activities, far removed from wilderness areas. This is most often the case with outdoor jackets and backpacks. The overall design aesthetic of Arc'Teryx products can be deemed quite minimal, which is intentional so that the user experiences the benefit of its specialty Gore-Tex materials. They offer minimal pockets and are constantly driven to create products are more waterproof, breathable, and lighter (Arc'Teryx, 2018).

2.2.4

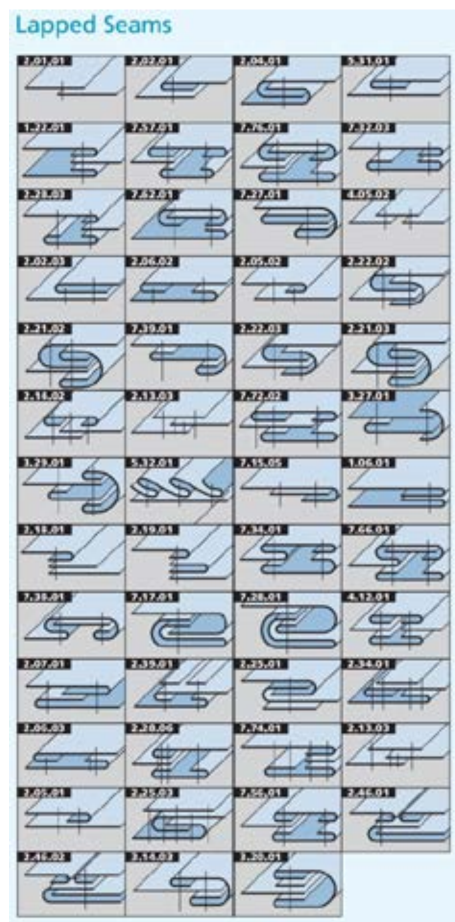
Gore-Tex was mentioned several times in interviews with environmental researchers discussing their preferred gear. Gore-Tex fabrics are used in everything from pants, to footwear, to jackets because of the benefits it brings to the user by being incredibly lightweight and waterproof at a mere 0.001 millimeters, or 1 micrometer, in thickness (Nathan, 2017).

The minimum size for the pores generally need to be able to resist 1500 mm of water over a square-inch of surface area (FortNine, 2019). Because of the fact the waterproofing technology occurs at the center layer, apparel manufactures have the flexibility of applying their own face garments as the outer layer through a laminating process.

Fabrics composed of polyamides are commonly utilized throughout the outfitting industry for their moisture wicking and heat-retention capabilities but are typically not environmentally sustainable materials. Novel scientific research proving that there is opportunity for "green polymers", which would be based on the following criteria from Jiang and Loos, 2016:

1. Green raw materials, catalysts and solvents;
2. Eco-friendly synthesis processes;
3. And sustainable polymers with a low carbon footprint, for example, (bio) degradable polymers or polymers which can be recycled or disposed with a gentle environmental impact.

The most common seam type found throughout the protective outdoor garment industry, is a Class 2 seam, or a lapped seam. Lapped seams, as per Coats, require two or more materials have their edged overlaid, which are then brought together by one, or several, rows of stitching (Coats Group, 2014), usually with a 401 chainstitch, a type of cast-off stitch formation. Lapped seams have a reputation of being strong and are therefore used in products that sustain heavy use such as jeans and rain gear (Coats Group, 2014).



(Coats Group, 2014)

2.2.5

Textile waste has increased 811% since 1960," with the majority of products being discarded in landfills.

(O'Driscoll. 2021)

Textiles only have a recycling rate of 14.7% in 2018, with 2.5 million tons recycled.

65% of a garment's environmental impact happens during manufacturing and sourcing

A study by Andreas R. Köhler outlines three best practices that "Design for Recycling" can be achieved in the e-textiles industry:

1. **harness the inherent advantages of smart materials for sustainable design;**
2. **establish open compatibility standards; and**
3. **label the e-textiles to facilitate their recycling.**

Manufacturers of garments and footwear can earn sustainability and responsibility certifications.

2.3

Chapter Summary

Chapter 2 largely discusses the effectiveness of current products and solutions when applied to normal user scenarios by providing an objective presentation of the relationship between the specifications of benchmarked products and day-to-day activities of environmental field researchers. In the context of this industrial design thesis, it is argued that environmental researchers require improved means of outfitting during field work in remote sites to improve safety and comfort in wake of unfavourable physical conditions. For field work in remote areas, the duration one must spend away from their residences is often extended from a few days to up to a few weeks, therefore users are conflicted with tradeoffs in the gear they purchase as a result of overpacking. This is largely due to the fact that user needs with current products are not being met, which then demands field workers to be resourceful with the gear they have on them at a given time.

Chapter 3: Analysis

3.1.1

Technology and materials of outdoor gear in today's market differ greatly that those in decades past yet the overall configuration of products such as jackets and footwear remain relatively unchanged. With respect to jackets, it can be argued that the lack of storage features and layering of certain materials in specific areas is not an innovative approach to designing outdoor gear. A resounding sentiment among environmental researchers is that they would rather put up with some light rain in favour of remaining cool underneath their layers, however, that can only last so long before they rely on their gear to function as intended.

Field researchers are often expected to be resourceful in times hardship as a result on inadequate gear because it would be difficult and burdensome to bring everything along in a backpack. As it stands, current products do not work in conjunction with one another to protect the user from the overwhelmingly large list of unfortunate circumstances that can occur while in remote areas. Compensating for occupational health and safety is the sole inspiration for the eventual design for wearable ergonomic outdoor gear.

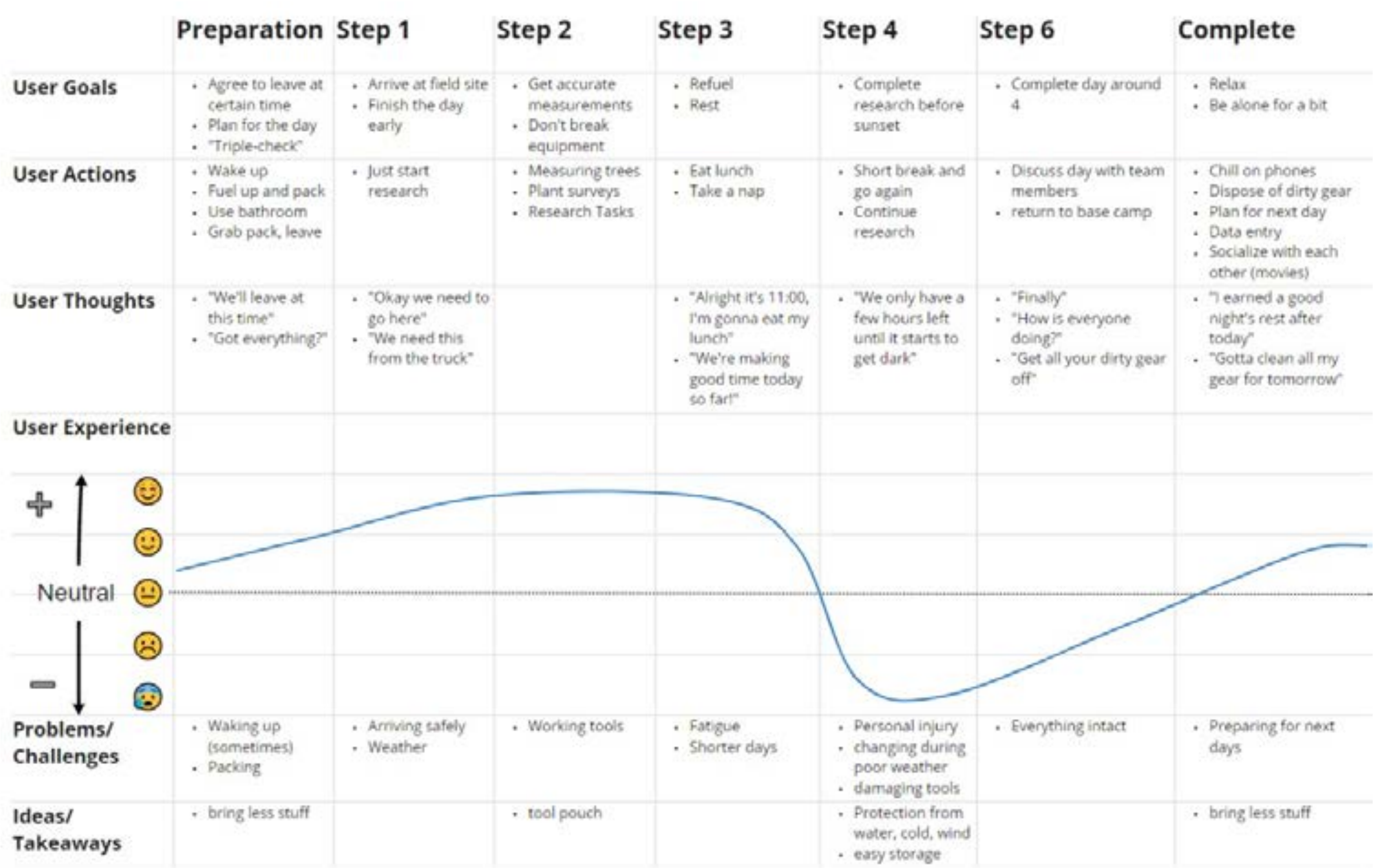
3.1.2 & 3.1.3

Given that latent needs revolve around the consumer and the products they acquire, marketing and psychology are two specific areas of interest. With respect to marketing, environmental field researchers could greatly benefit from products that come equipped with emergency weather modules integrated within, as well as any weather specific products that can be adjusted to one's liking. From a psychological perspective, the social interaction aspect is highly overlooked with respect to outdoor gear, and users are constantly comparing gear and swapping articles of clothing as necessary. Therefore, it is observed that providing environmental researchers with more uniform outfitting solutions could reduce a classist mindset while also appearing more professional, further distinguishing them from outdoor recreation users.

Immediate Needs	Latent Needs	Wants/Wishes
Marketing: Existing Needs • Maintain warmth in hands/arms • Normal range of motion • Store larger items	Marketing: Latent Need • Emergency weather products require easier access and modify	Marketing: Incipient Need • Easy access to important items and layers • Reduce packing load • Prevent water from entering through cuffs
Psychology: Human Needs • Uninhibited performance/ control in physical tasks • Durability – bang for one's buck • User remains comfortable, cool, and dry	Psychology: Latent Need • Social interaction: researcher to researcher • Professionalism, looking the part to coworkers	Psychology: Wants/Wishes • Less time dumping and picking up backpack • Stylish but also functionally sound gear • Remain "tough" against elements and adapt

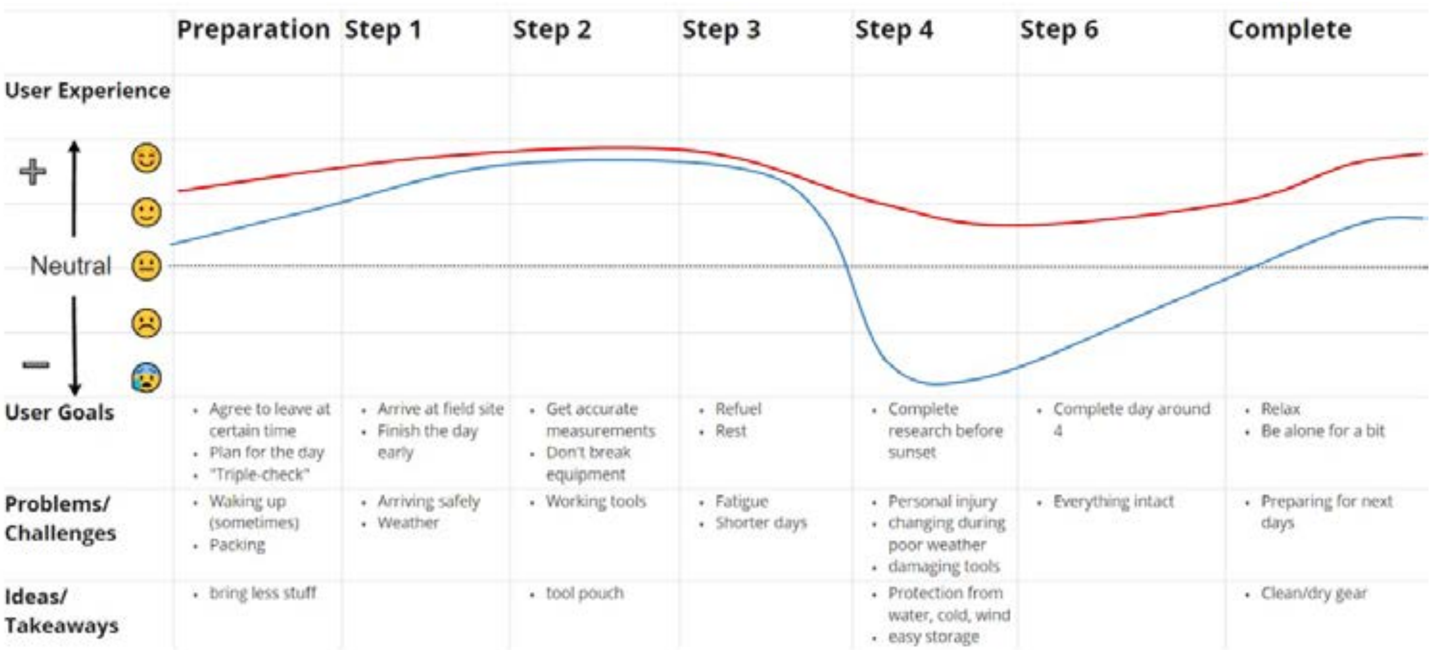
3.2.1

The needs of the primary users were based on the journey map, which consists of the typical routine for environmental researchers doing field work. After discussing the approach to understanding one's activities during field research with interviews and user observations, their activities were mapped along chart and sentiments were valued on the left from upset, unhappy indifferent, satisfied, and very happy. If users are productive and achieve their daily research goals and objectives for the day, which they often do, it is mostly attributed to a positive mindset, stemming from their passion for and appreciation of their profession that allows them to spend time in nature. Poor weather is to be expected almost always, especially in the subarctic, given that the climate is "highly variable" according to an interviewee. There are things field workers tend to tolerate, such as rain, wind, and cold temperatures, because they have prepared for it when they packed certain gear. However, if poor meteorological conditions persist, routine tasks for field work can become painstaking.



3.2.2

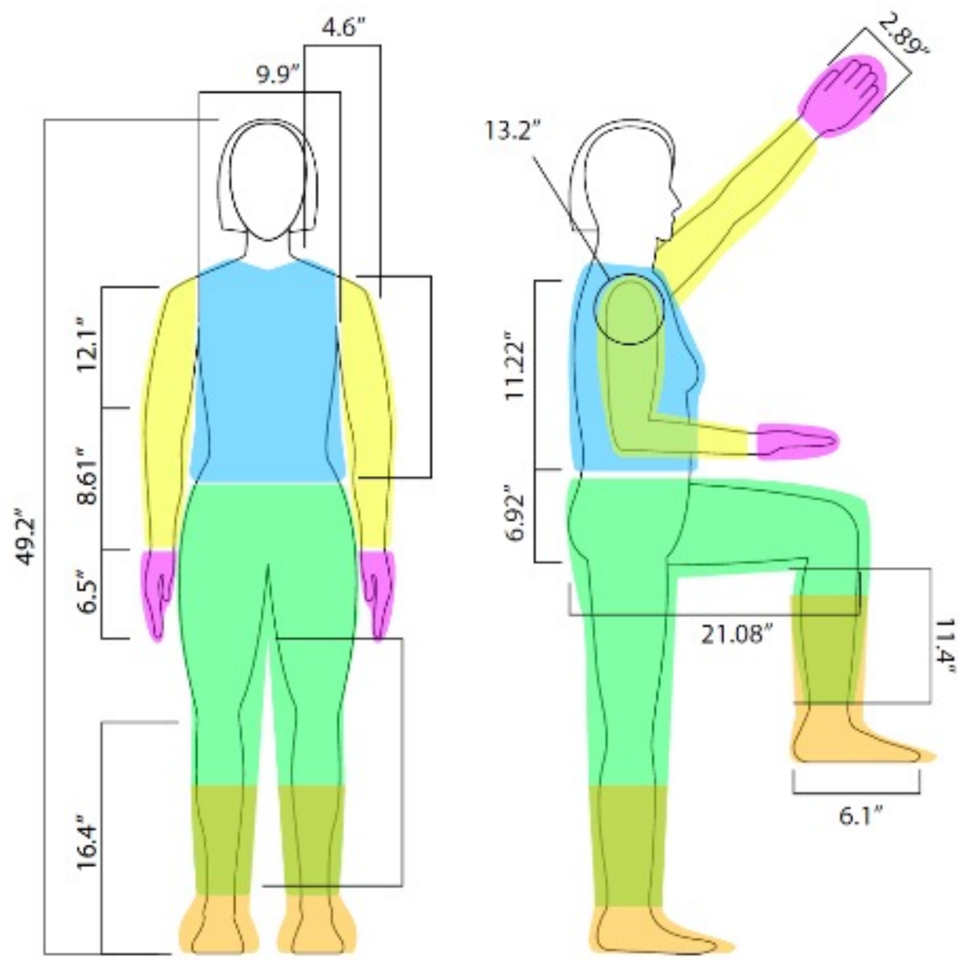
The user experience map is a depiction of the user's emotions during the task at hand. Below is an analysis of the eight-step process of the daily tasks for field research, shown by a blue curved line and the expected and desired experience, shown in red. The largest and most important area for improvement is around step 4, whereby the user may encounter inclement weather as the day progresses and works in a hurry to complete research tasks before sundown. Even though users take occasional breaks during the day, it was observed that the benefits are only for the short-term and constantly dumping one's backpack on the ground often results in drudgery when the break is complete. Additionally, users may often take unplanned breaks as they wait for adverse weather conditions to subside, which may be for an unforeseen amount of time. The outfitting gear solution, then, would hopefully provide comfort during adverse conditions, so that researchers and continue to work without hindrance.



3.3.1

The list of challenges one faces reach beyond the boundaries of designated research sites. reducing complicated logistical issues also remains a strong focus to the eventual design solution. Products for feet, legs, torso, arms, hands, and head, will be separate modules within an entire integrated smart-clothing system. When creating the 1:1-scale mock-up model, measurements for the 90th-percentile male were used, with standing heights provided by the research of Cassola et al. 2011, as well as Gordon et al. 1988 and the human avatar sizes in the software CLO3D for additional topic-specific measurements. The general measurements of chest, waist, hips, and sleeve length however, are relatively consistent throughout the fashion industry (Outdoor Research). The coloured areas in the ergonomic diagram indicate where interactive smart technology could be utilized, along the hands, arms, legs, torso, and feet.

	5th-Percentile Female	90th-Percentile Male
Standing Height	60.0"	72.53"
Chest	30.8"	40.4"
Waist	23.4"	40.6"
Arm Length	21.93"	27.94"
Hips	33.7"	42.0"



5th-Percentile Female

WOMEN'S TOPS

Measurement shown in: IN CM

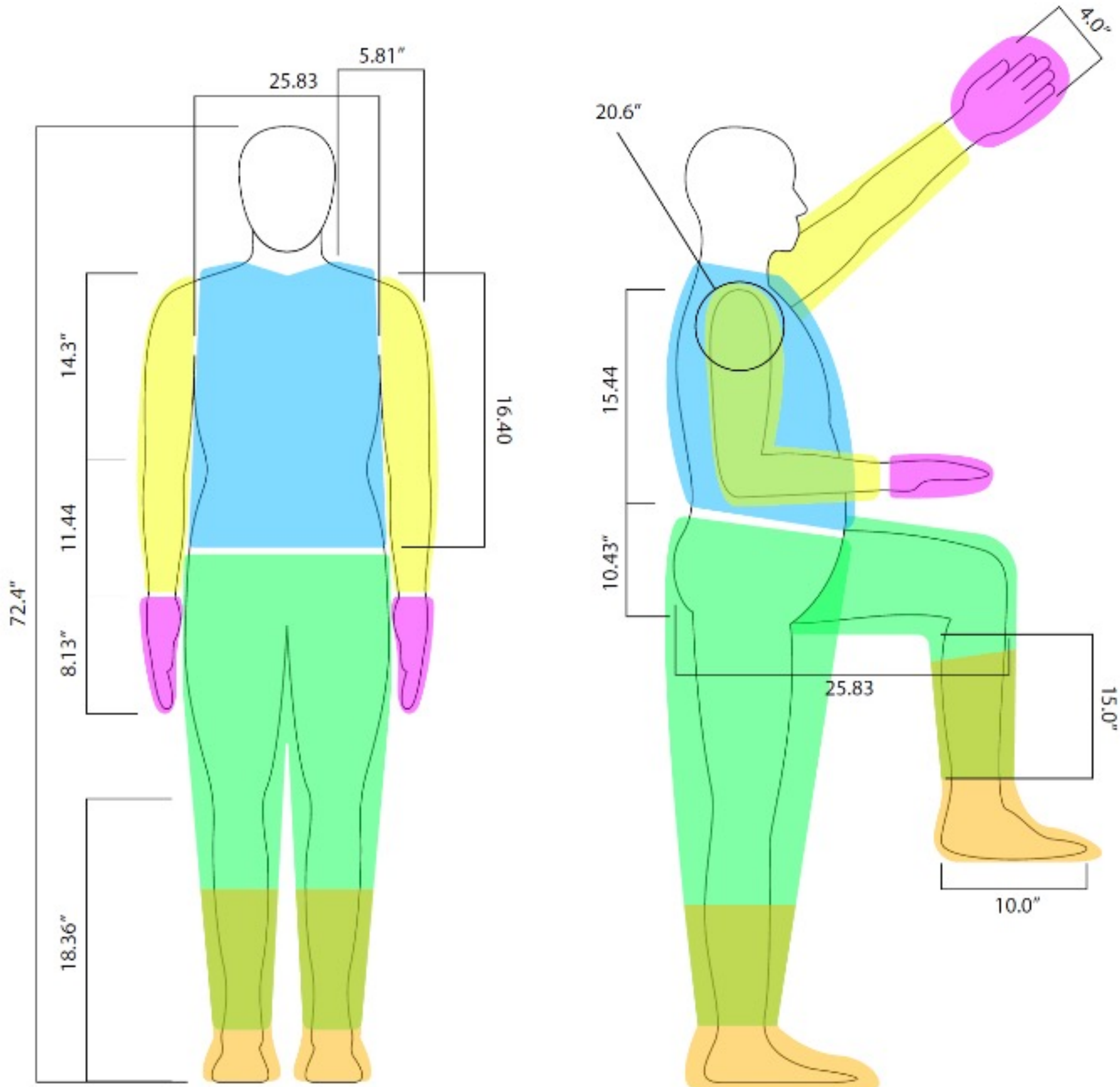
	XS	S	M	L	XL	XXL	XXXL
BUST	30.5"-33"	33"-35.5"	35.5"-38.5"	38.5"-41.5""	41.5"-45"	45"-48.5"	48.5-52.5"
WAIST	24"-26.5"	26.5"-29"	29"-32"	32"-35"	35"-38.5"	38.5"-42.5"	42.5"-46.5"
HIPS	33.5"-36"	36"-38.5"	38.5"-41.5"	41.5"-44.5"	44.5"-47.5"	47.5"-51"	51"-55"
SLEEVE LENGTH	31"	31.5"	32"	33"	34"	35"	36"

MEN'S TOPS

Measurement shown in: IN CM

	XS	S	M	L	XL	XXL	XXXL
CHEST	33.5"-36"	36"-38.5"	38.5"-41.5"	41.5"-44.5"	44.5"-48"	48"-52"	52"-56"
WAIST	26.5"-29"	29"-31.5"	31.5"-34.5"	34.5"-37.5"	37.5"-41.5"	41.5"-45.5"	45.5"-50"
HIPS	32.5"-35"	35"-37.5"	37.5-40.5"	40.5"-43.5"	43.5"-46"	46"-49.5"	49.5"-53"
SLEEVE LENGTH	30"	31"	32"	33"	34	35"	36"

(Outdoor Research)



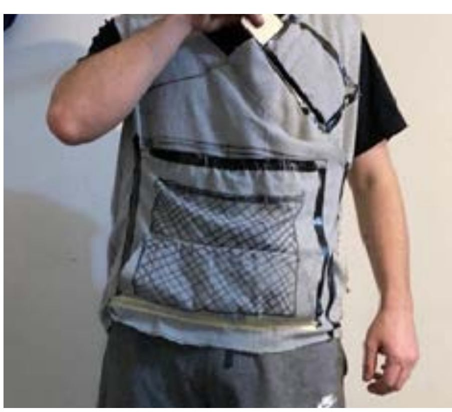
90th-Percentile Male

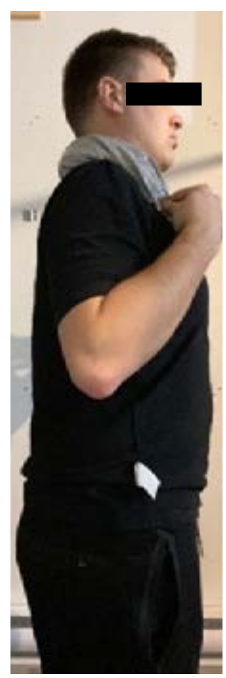
3.3.2

The protective shell garment covering the torso is inventive in contrast to current products on the market. Two garment pieces are overlapped and zipped along the wearer's sides from the inside and outside. The shell is configured in such a way to maintain extra warmth and protection against elements for the vital organs and to provide more storage space along front for easy access to items.

The footwear product is best described as the combination of a gaiter and overboot that creates a watertight seal without sacrificing traction or fit. The user puts their foot in, zips the upper together, and tightens and fastens the strap for extra security. Sizing for this product could be done in small, medium, or large. to accommodate a range of users.

The emergency rain guard stores along the neck and collarbone area of the torso shell. Once out, the user unravels the garment over their torso and can wear the hood.





3.4

To capture the essence of this proposed design solution of outdoor gear weaved with technological features, one must draw on a variety of influences in areas of trends in materials and technology, cultural inspirations, and naturally occurring features. The images below make up the aesthetic and semantic mood board by drawing inspiration from science-fiction references in popular culture, the adaptability of unique naturally occurring things, and a blend of future and existing technologies in textiles.

Materials & Tech

Cultural

Nature

The rationale for selecting such images drew on scientific applications that aided in performance and function for a conceptual outdoor wearable set of products. In general, this column represents how the product will be used, taking benchmarked and emerging technologies into account.

Given that this product is very much advanced and revolutionary to the outdoor clothing industry, science-fiction and historial references coalesce to create the aesthetic approach.

The proposed design solution is intended to work seamlessly in its respective environment, responding to conditions as they arise not unlike many florae and fauna have in order to survive.

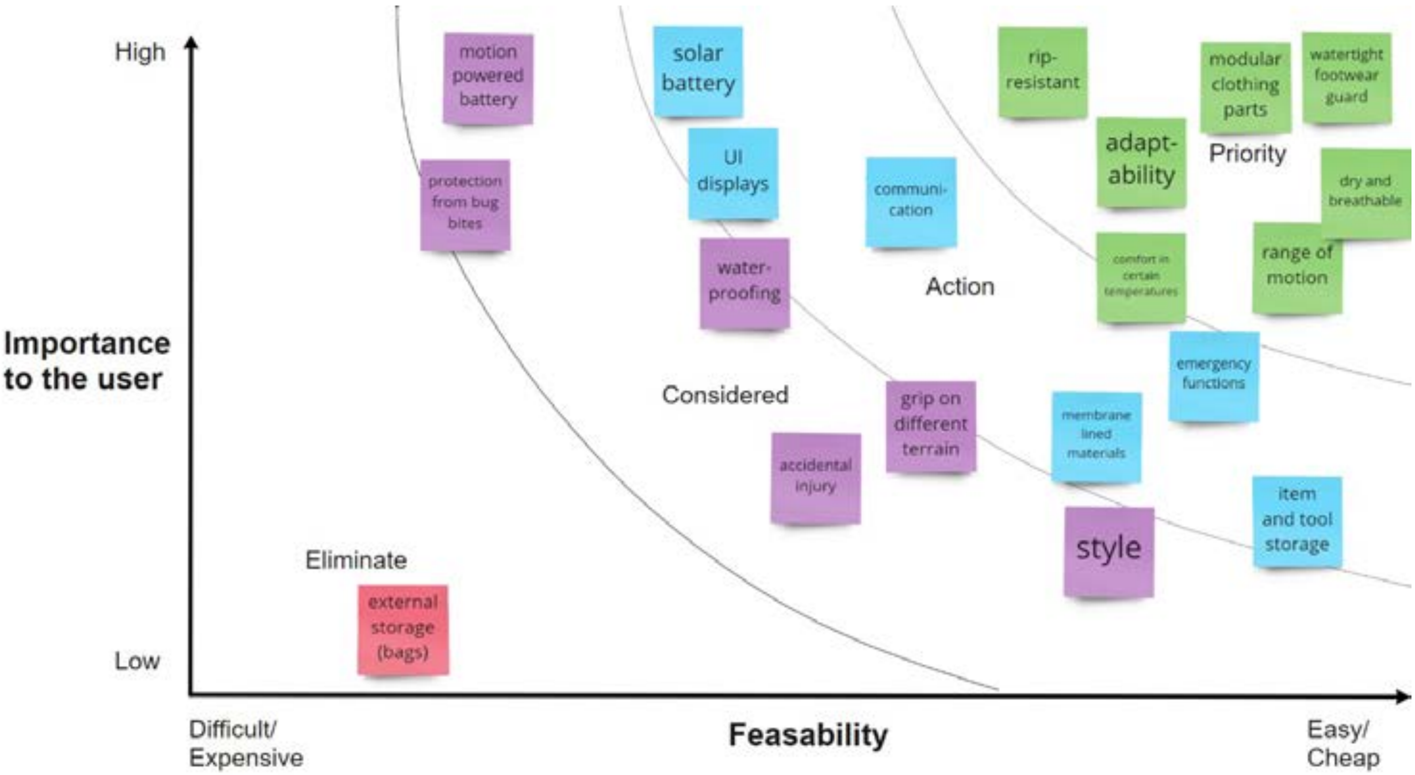
This matrix compares the aesthetics among benchmarked products. This project aims for somewhere along the middle-left side of the coordinate plane, to create a product that is both highly functional with an intriguing aesthetic to entice consumer decisions. Gear that is more utilitarian and geometric in design, such as the cruiser-vest in the upper right portion of the coordinate plane, is sometimes treated with neglect, and therefore more sought as more dispensable to users, as it was observed in the research period. Therefore, a more modern aesthetic might contribute to longer product longevity.

3.5

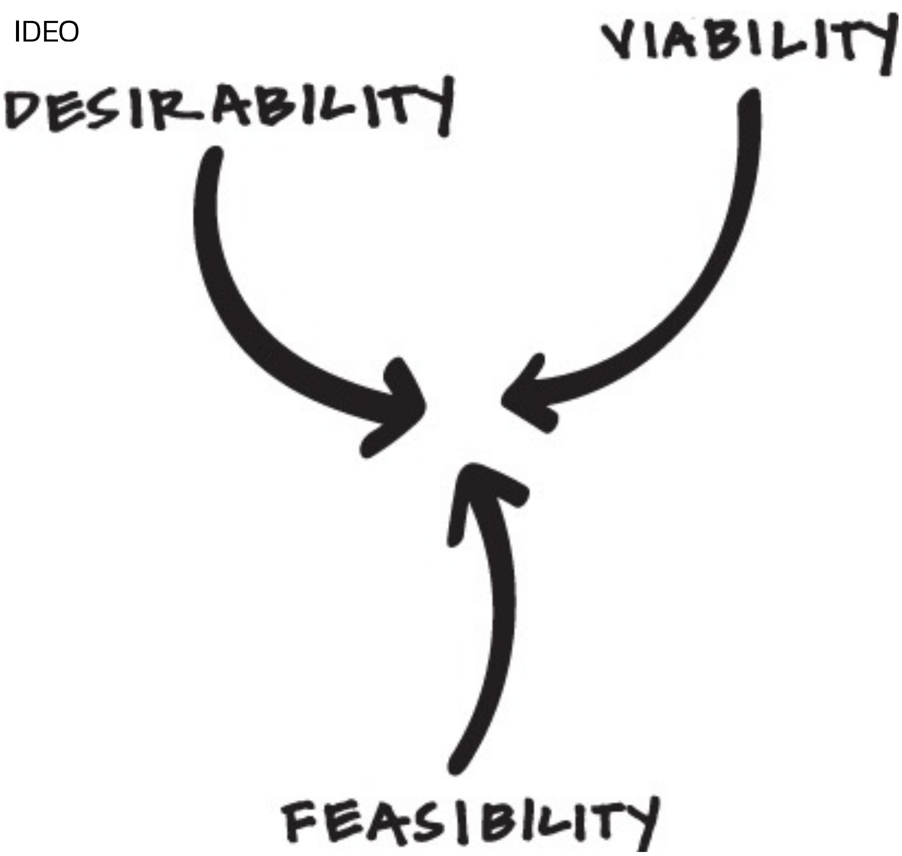
No matter how many sustainability initiatives and certifications there are, the fact remains that environmental researchers are often required to bring ample articles of clothing during field expeditions that they do not value highly, in the event they get torn, stained, or ruined by other environmental factors. What this project aims to achieve, then, is creating a garment product integrated with technology that combines the function of multiple products in one cohesive system. The integration of technology in the design solution will allow for more capabilities while using less physical material. For example, lining the garment system with heaters or auto-inflatable insulators will prove to be a more sustainable method of regulating the core temperature of the user without the need for multiple bulky layers of fabric. Designing for sustainability and safety would be complimentary. Parts that could perhaps be modularized are the sleeves and protective overboots, as complimentary pieces to the central system of a torso shell and ergonomic pants. Designing for modular parts would present the opportunity for easier repairing of gear. Repairing gear, as stated previously in section 2.2.5 is something many leading manufacturers do to boost sustainability efforts.

(Graduate Store. n.d.)

3.6.1



3.6.2



IDEO, describes their approach to human-centered solutions as one that "integrate(s) the needs of the people, the possibilities of technology, and the requirements for business success" (IDEO, n.d.). The arrows of relatively equal length represent the equality across various human-centered situations, to which the designer must pay attention. Ideally, according to IDEO, true innovation takes place when designers are mindful of all three areas of desirability by consumers, viability in manufacturing, and feasibility with respect to cost. As the final iterations of the design develop, the extent to which these design-thinking factors are applied will be expressed.

3.7

Chapter Summary

Chapter 3 is an analytical extrapoloation of the information provided by environmental researchers observed for the purpose of this project and putting forth solutions that could accommodate user needs and desires. The needs and desires of environmental researchers were asked in the interview process but latent needs, needs that the user is not aware they might have, was deciphered through more research and critical thinking. When applying this information to a smart-integrated wearable products, ergonomic analyses of body types was conducted across numerous sources and the 1:1 scale-model was fabricated on the dimensions of the 90th-percentile man. Following the ergonomic analysis of an early rendition of a possible design solution, the needs of the primary user were dicussed in conjunction with the concepts of market feasability, manufacturing viability, and consumer desirability.

Chapter 4: Design Development

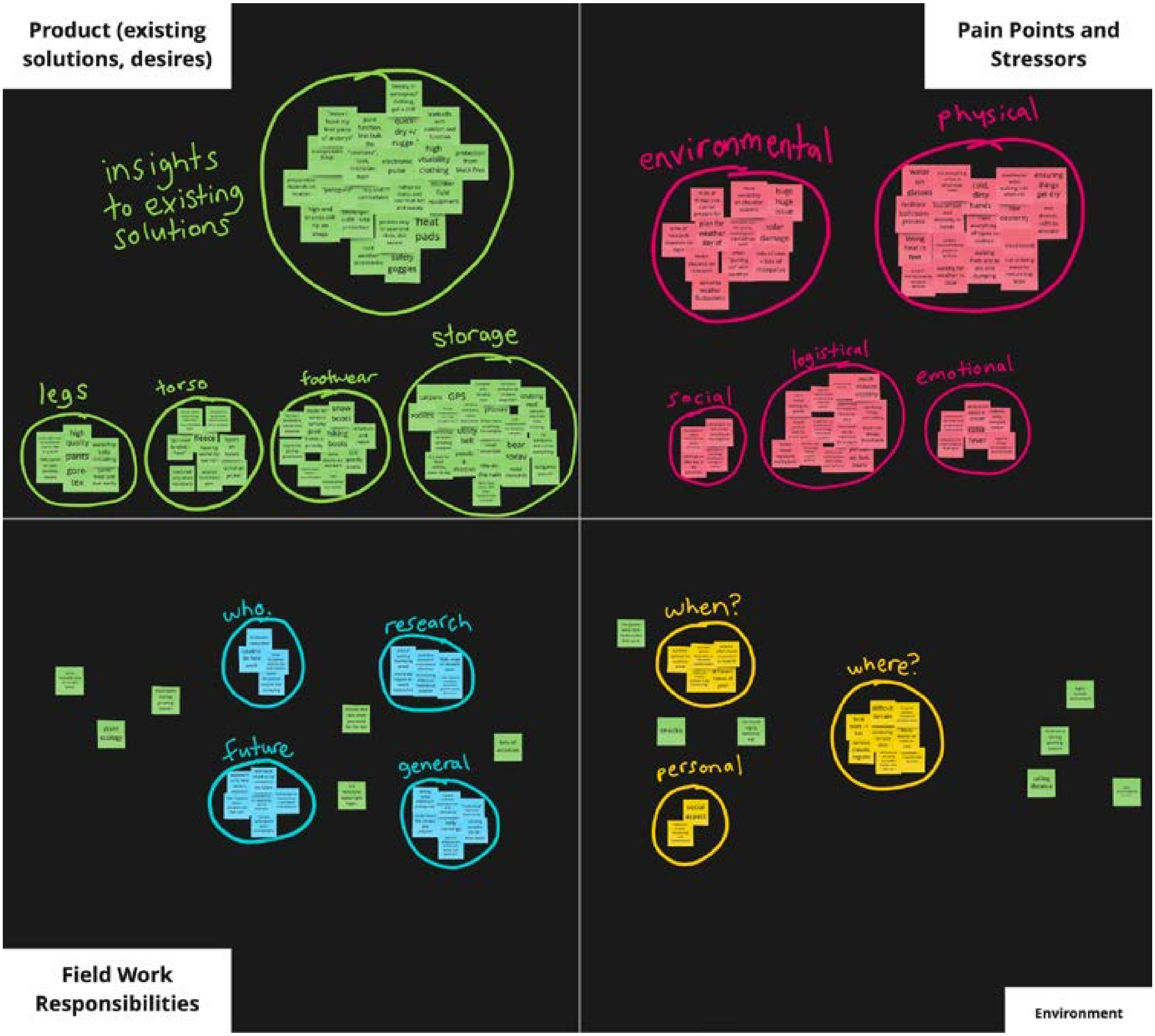
4.1.1

Bloodhound is a playable character in the popular online game, Apex Legends.

They are a "technological tracker" and use magic and technology to track/sense opposing players.

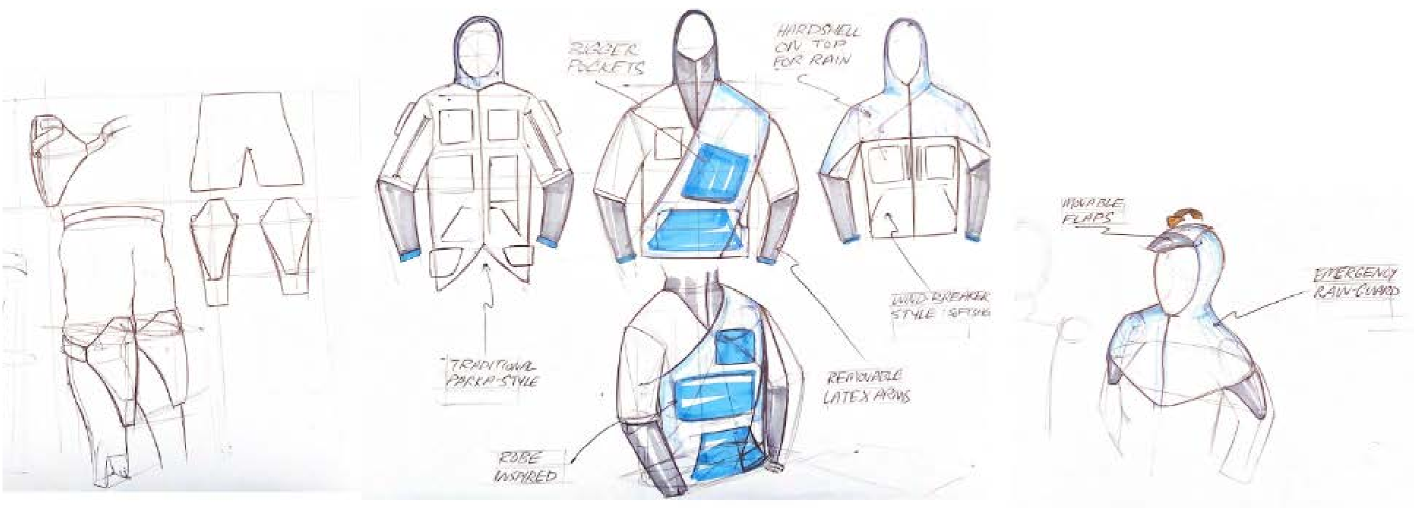
The lore of Bloodhounds backstory is rooted in Norse mythology and nature.

4.1.1 & 4.1.2



the most useful information was coded into two sections relating to product-specific information and areas of struggle and pain points for the end-user. With respect to the product-related information, users talked about interaction and functional issues with their gear involving everything from footwear, pants, upper layers, and potential areas for improvement and solutions. Common problems discussed by interviewees were breathability versus waterproofness and storage. Interestingly, many environmental researchers discussed their desires of waterproofing for emergencies only, because they would rather remain dry, cool, and comfortable during field work as opposed to too warm and moisture-laden in hydrophobic rain gear. On the right side are the pain points, which were coded further into specific scenarios of social, logistical, emotional, and environmental. It was hypothesized that logistical and environmental concerns would be the most looming, therefore most emphasis was given there as the design phases continued.

4.1.2



At the crux of these initial idea generation sketches, is merely coming up with products that either functioned or performed a certain way to provide benefit to the user. At the time of generating these ideas, form, style, aesthetics, and other aspects relating to the art of the design concept was barely even secondary, and more of an afterthought. At the initial idea generation phase, gauging the opportunity for improvement in outdoor gear for environmental researchers was examined from, literally head to toe, and the products were divided up into standard products used for field work and outdoor recreation such as traditional boots and gaiters, shell jackets and field pants.

The products were initially designed to make adjusting to certain adverse environmental circumstances physically easy and less time consuming.

With regards to footwear, the central problem to be solved was creating a watertight seal around the boot and ankle to prevent excess moisture from entering in bog areas or bodies of water.For shell jackets, given how much movement and interaction takes place along one's upper body, ensuring one is comfortable in both warm and cool temperatures was a must while allowing them to easily adjust to sudden precipitation. Finally, for the lower body

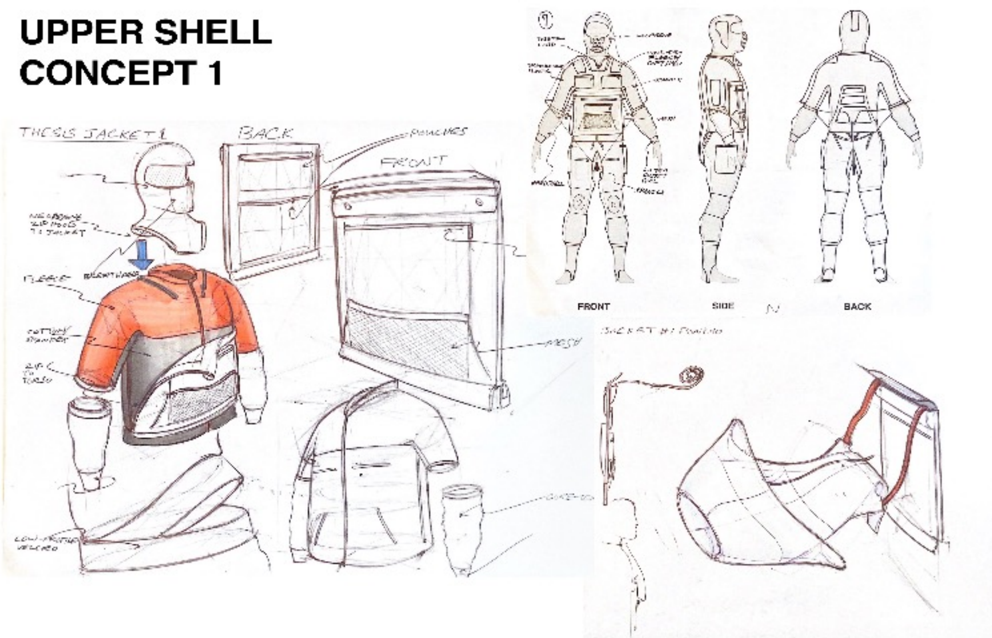
and pants, it was received that maintaining physical ability in the knees was crucial, given how intensive field work is due to the amount walking over often arduous terrain. Though as a basepoint, all of the following overboot concepts have the same intended function from one of the ideation sketches, which consists of a moldable gel insole that forms to the tread on the wearers boot and modular crampon attachments, and a combination of structural and shell materials.

4.2

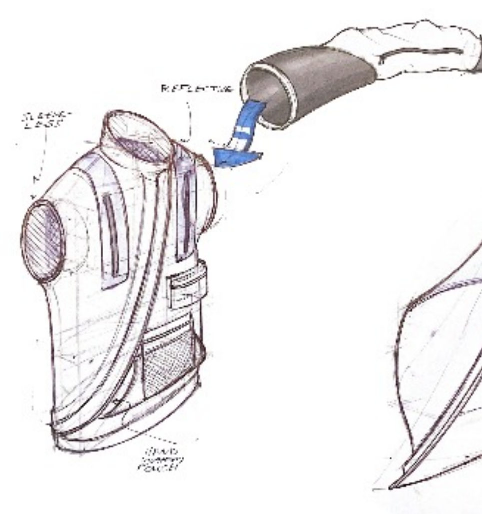
OVERBOOT CONCEPT 1

OVERBOOT CONCEPT 2

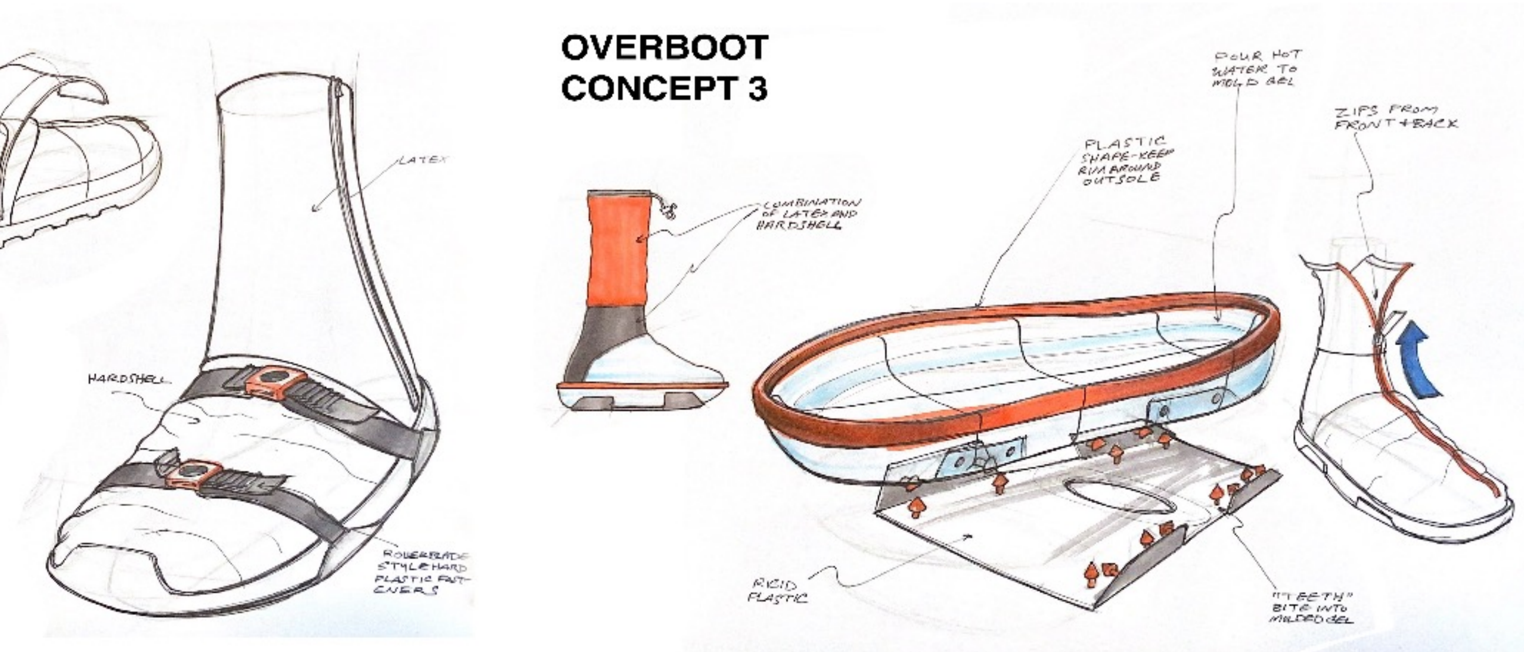
UPPER SHELL CONCEPT 1

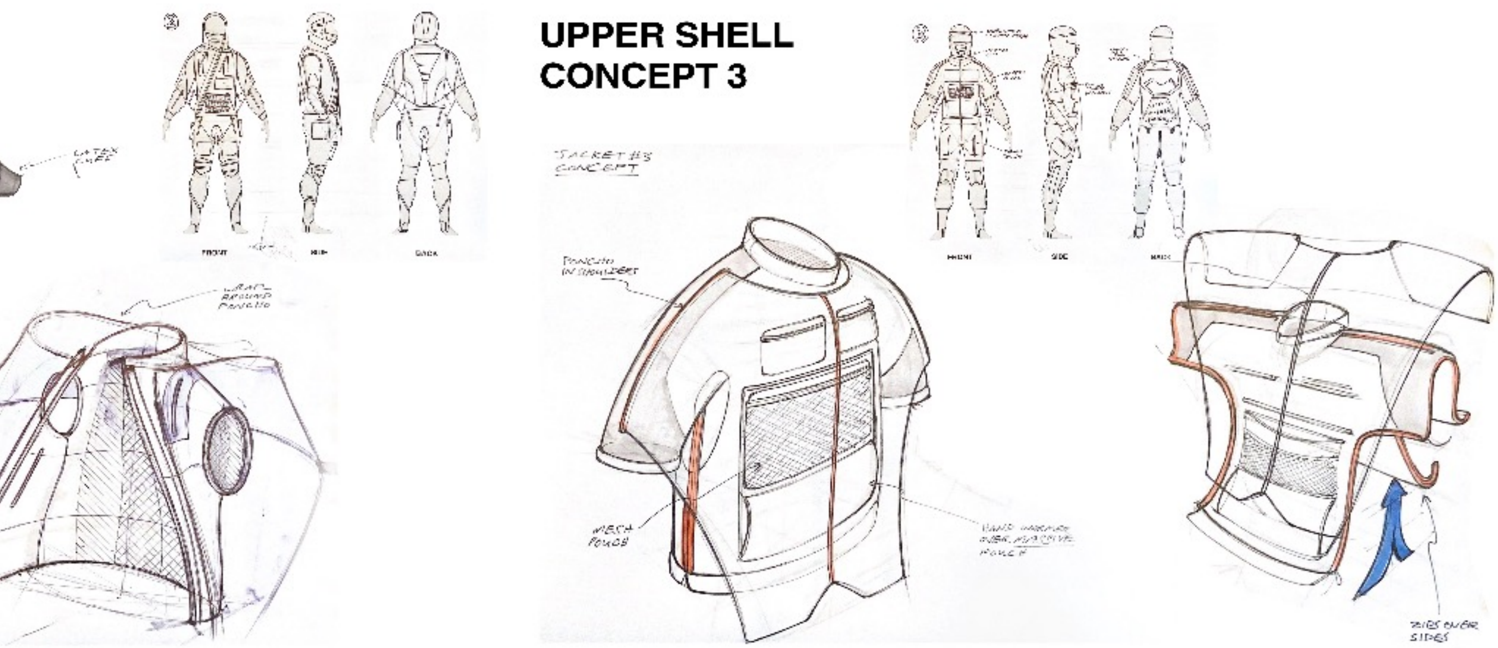


UPPER SHELL CONCEPT 2



Following the phase of generating a plethora of ideas for the design solution, it was determined that most interaction and ergonomic opportunities in gear for environmental researchers were among the products specific to footwear and the upper body. The opportunity for innovation with respect to pants was not broad enough in scope therefore more attention was diverted to creating products that offered safer and smarter products that could enhance one's experience in field work. The most common issues address in the information gathering stages were storage, warmth, waterproofing, and lower leg discomfort. It was crucial for the success of this project, at this particular time, to figure out the functions of the upper body and overboot products, so that researchers conducting field work in remote areas could easily adapt to adverse events with minimal effort. At this stage, it was a prime focus to determine how to create a watertight seal around the entirety of the user's foot while maintaining a high degree of comfort, function, traction, and mobility in arduous terrain conditions. Additionally, the level of

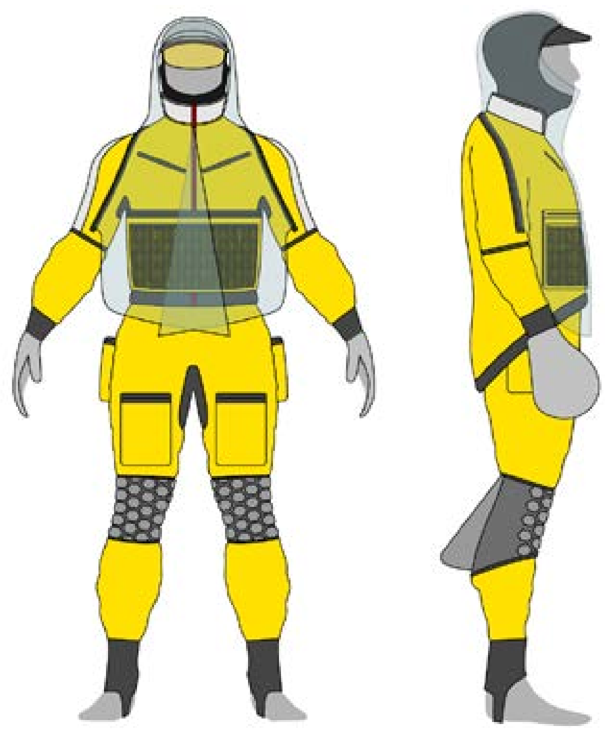


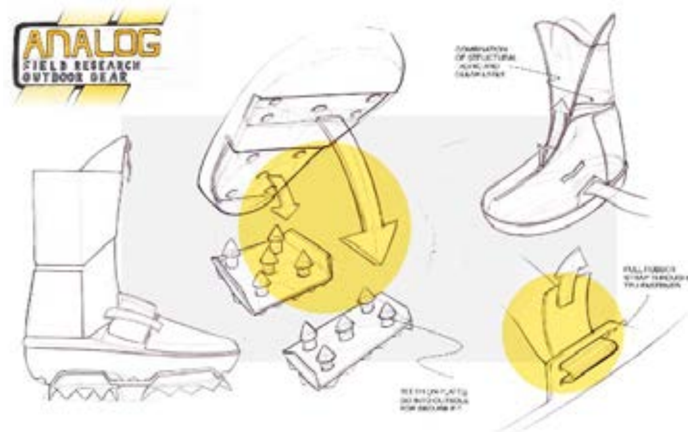


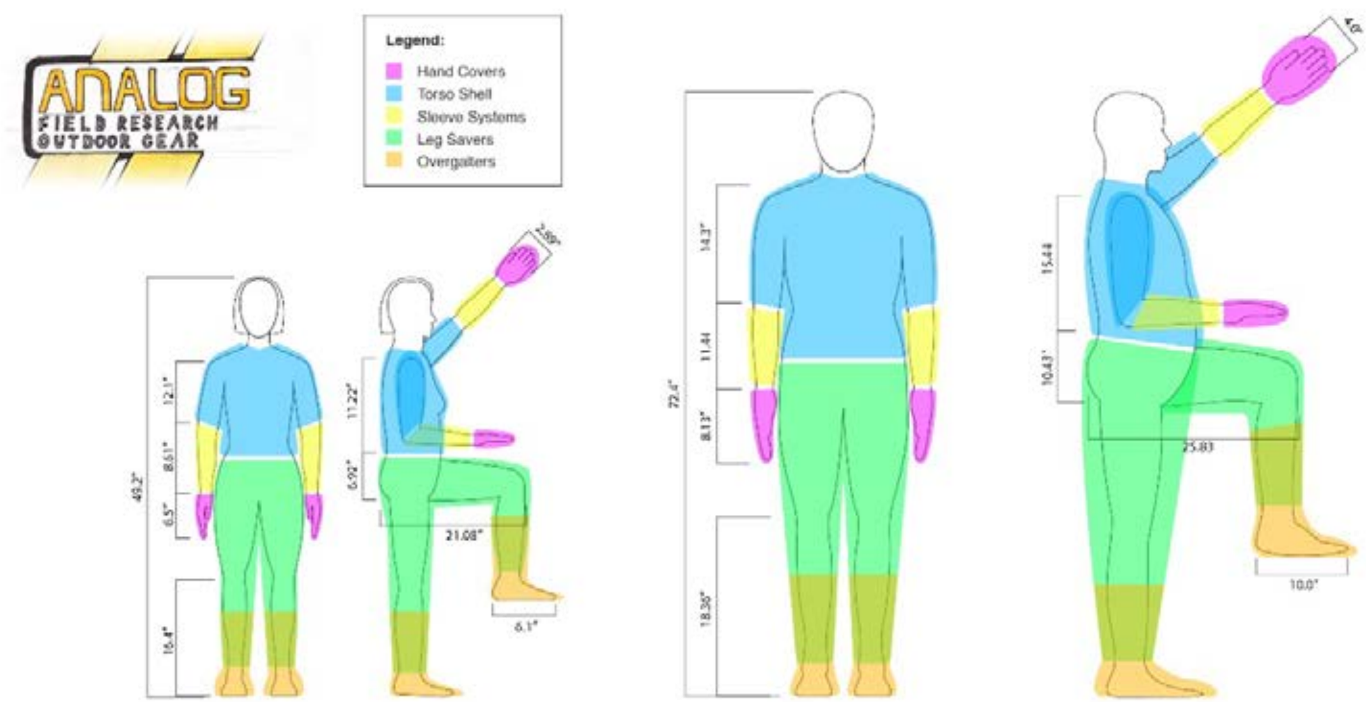
function for the torso shell was intended to be quite high. Storage, mobility, emergency features, waterproofing, breathability, and fit were all concerns that had to be met, let alone the aesthetical features, according to the research participants. Once the function of the torso and footwear products were strategized, other parts to the design would follow.

4.3

The first concept strategy is a series of module designs in the clothing system that is to be considered analog, such that there is a reliance on the physical properties of materials and how they are arranged to achieve specific functions.



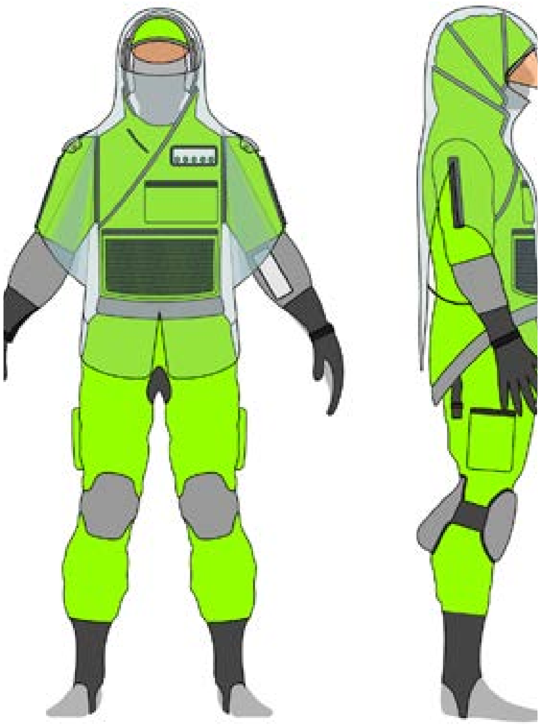


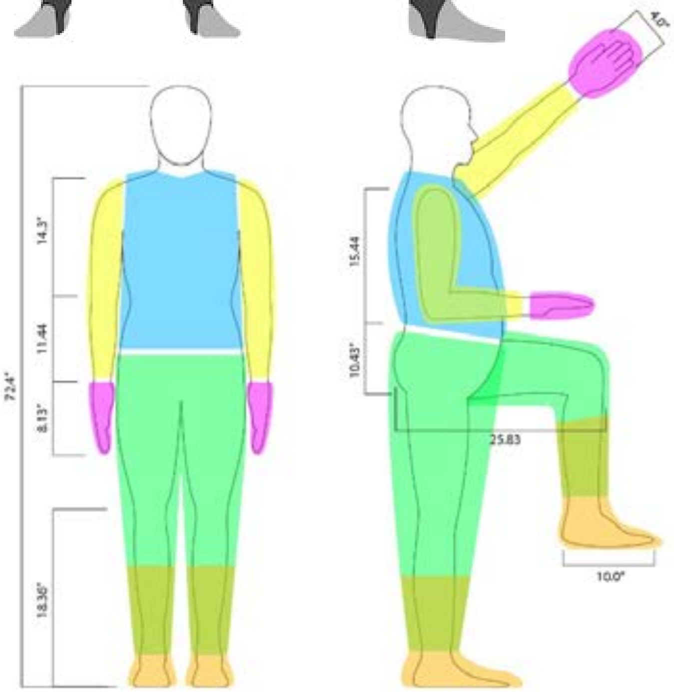


5th-Percentile Female

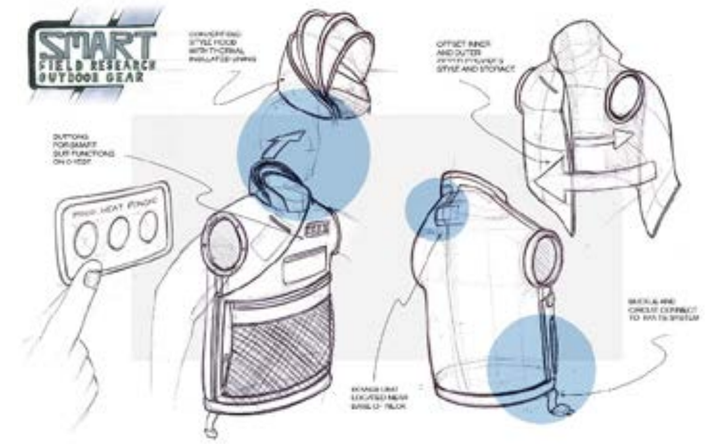
90th-Percentile Male

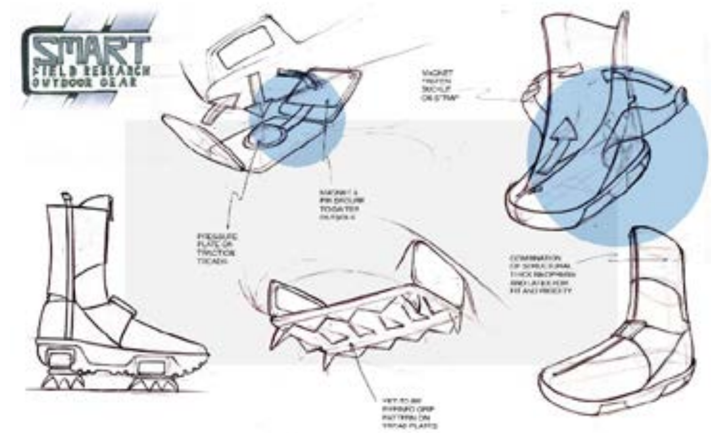
The second strategy for configuring the set of modules in this design project would be with the assistance of responsive technology. It was hypothesized that technology could improve the overall functionality of a garment system, by reducing weight for thermal capabilities, automating the response to inclement weather, and enhancing comfortability during physical activities.

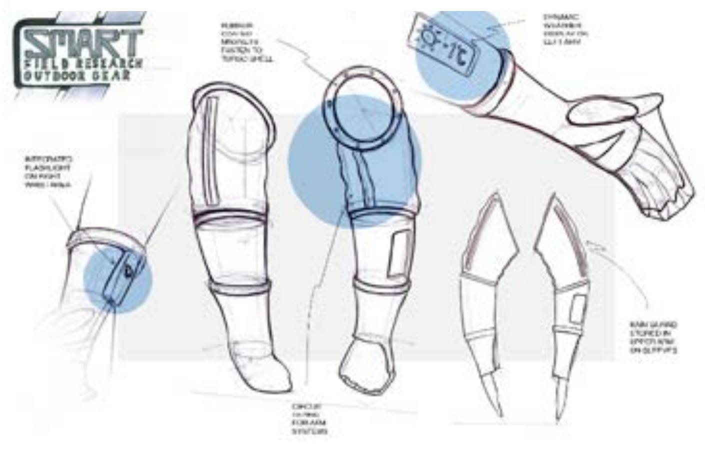


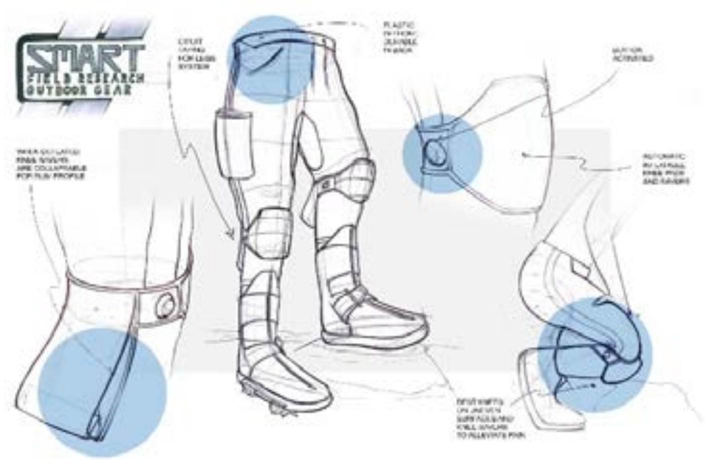


90th-Percentile Male





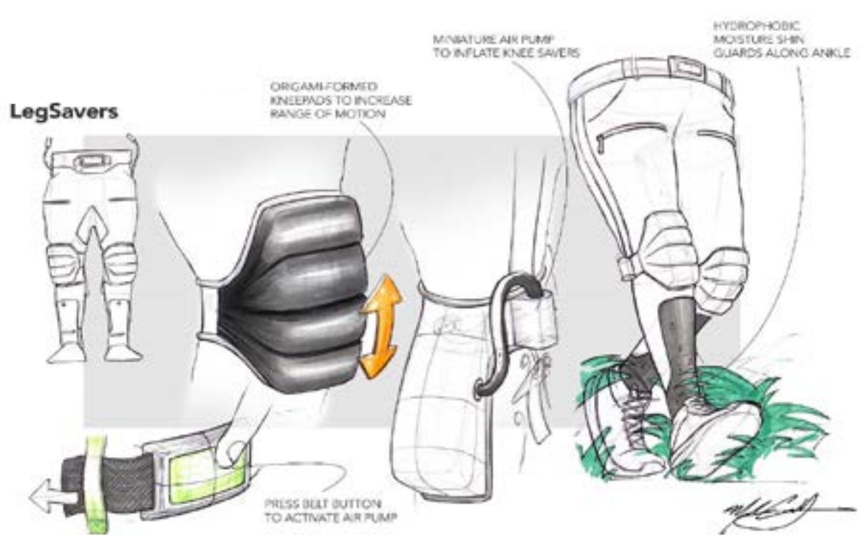




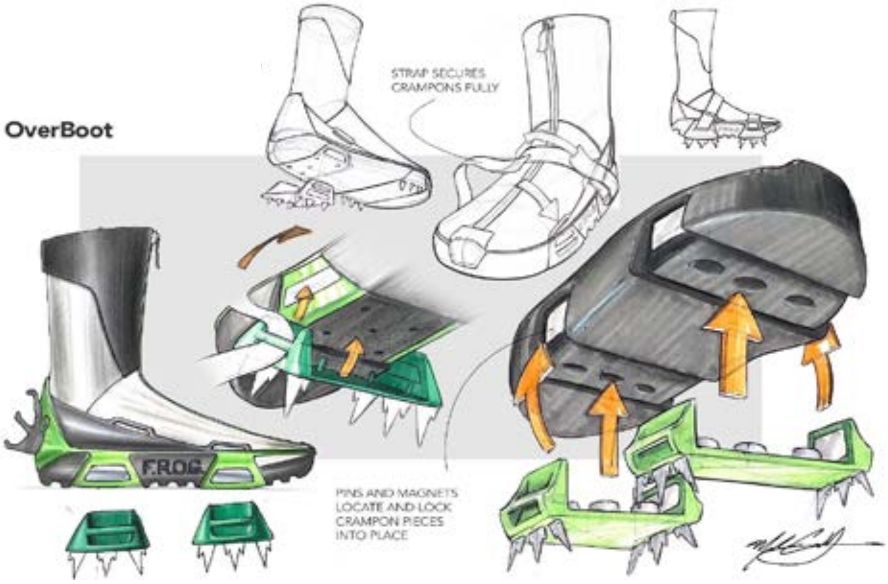
4.4.1 & 4.4.2

The final design solution as a garment system integrated with modular smart attachments was strictly based off this sketch, showcasing the general layout. The smart tech modules that provide the user with added adaptability and safety features must be designed in such a way to not restrict movement or be glaringly interruptive to the design aesthetic.

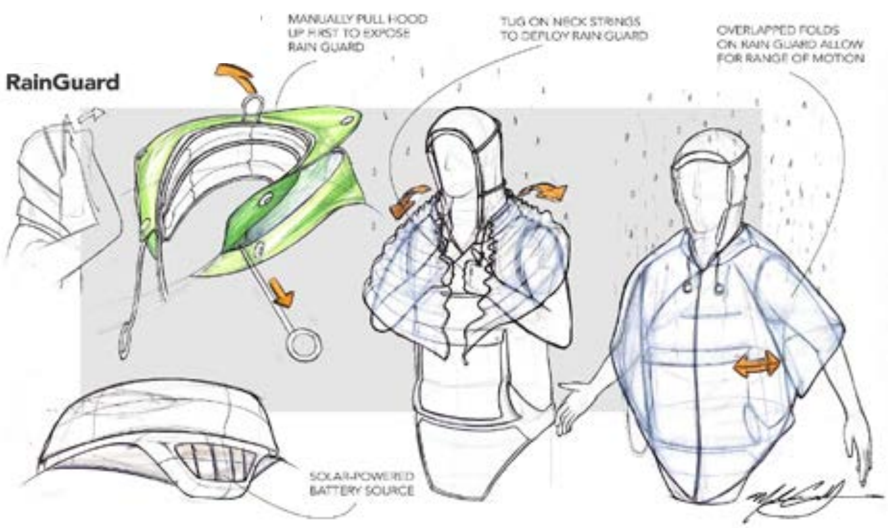
The Torso Shell acts as the primary power unit with a built-in base layer to further add warmth and comfort while reducing the amount of clothes for researchers to pack on field expeditions. The shoulder cuffs are where the electricity for the suit's power is stored and are the female-end of the circuit for the smart sleeve attachments, which connect onto the torso shell via magnets at the end of small grip teeth



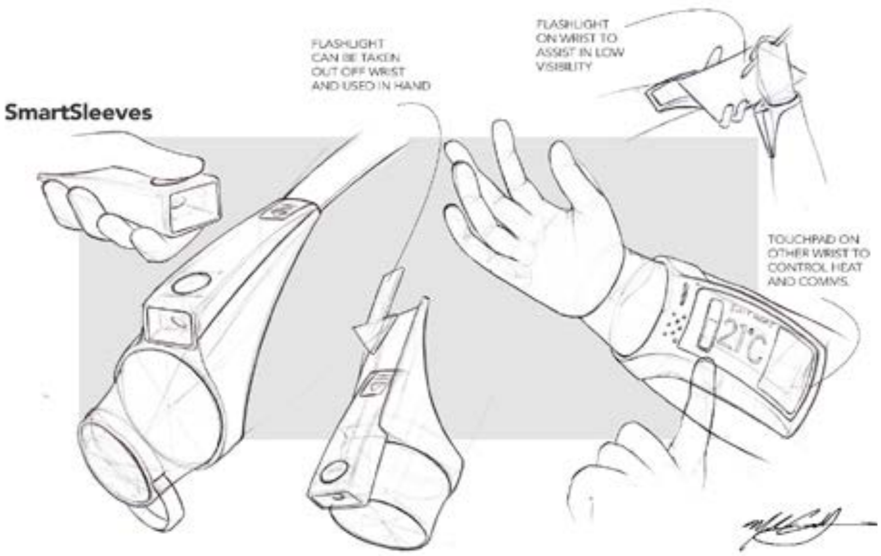
The legs feature a fully-integrated ergonomic apparatus along the wearers knee area. This ergonomic piece is adhered onto the pants garment and consists of inflatable knee-savers, to reduce strain on the knees when bending and crouching. The other main feature in this design was origami-formed knee pads that flex freely as the user walks but still protect a wide surface area of the kneecap when in contact with a rigid surface.



The sole purpose of the overboot is was to create a watertight seal around the user's foot without sacrificing mobility, traction, and comfort. The solution here was a product that has a heat moldable insole and crampon attachments that are locked into the sole along all X, Y, and Z planes for ultimate security along harsh terrain types. The upper zips securely from the toebox, through the vamp.



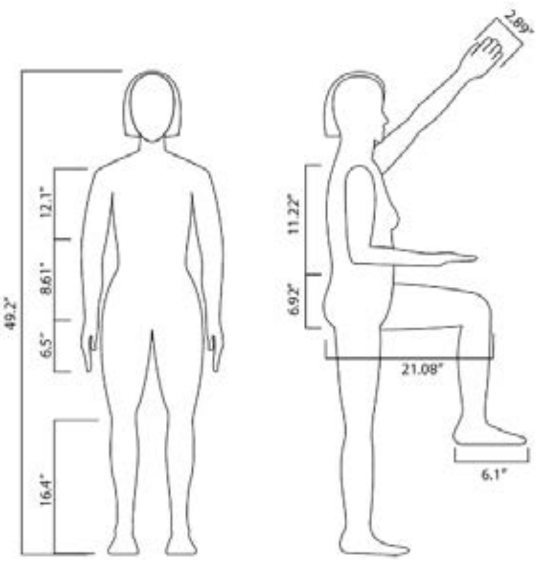
Users were concerned with mobility of their arms with the poncho-like garment draped over top their torso. At this stage, the poncho was designed with origami-like flaps to free-up arm motions as well as valley and mountain fold-ridges throughout so that it could be deployed and stored away in an accordion-like motion, nestled within the hood.

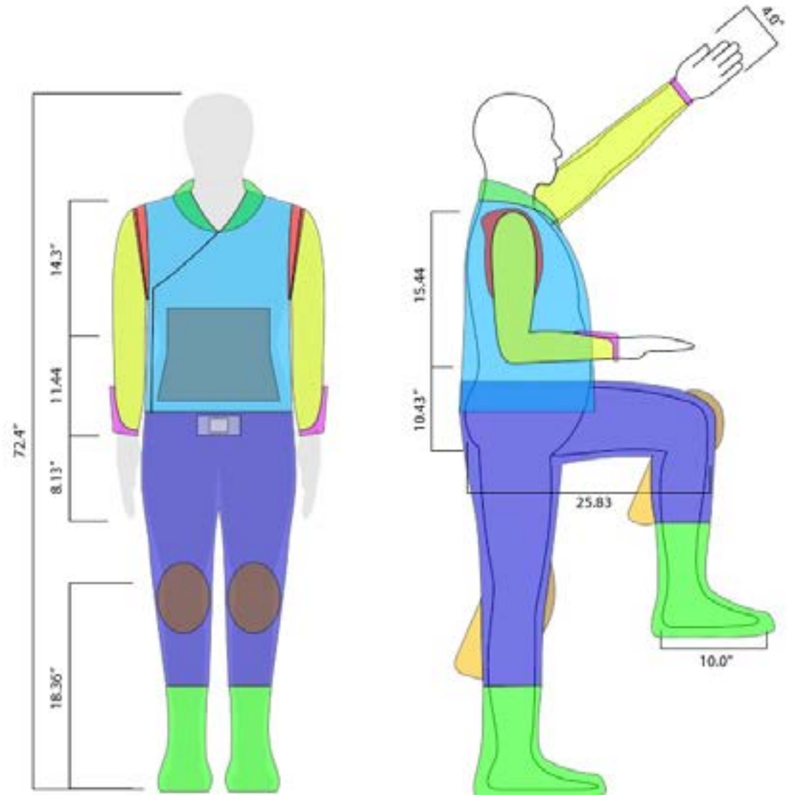


The smart sleeve attachment modules feature a mini technological device with built-in applications. These applications, included a command center for the full-body electric heating panels, a tracker for the wearer and their research team members, and bright mini torch lights for use in low visibility.

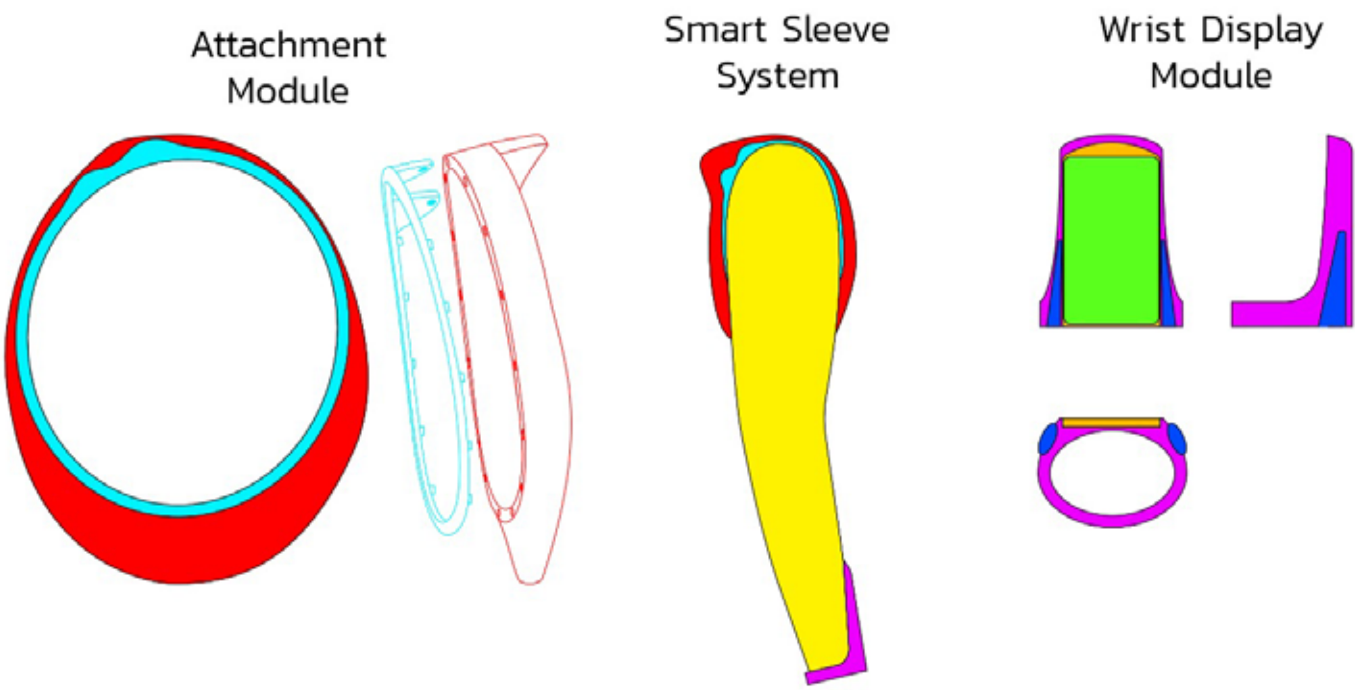
4.4.3

The updated product schematic highlights the dimensions for the 90-percentile male, of which the final model will be designed for, and the updated smart sleeve design. The updated smart sleeve design is showcased for its highly interactive and intricately designed features throughout the module. Given that this will be a full suit, the limit for accounting for various dimensions in designing the garment flat patterns is quite high of course, however the ones shown are the essentials that must be adhered, in order to deliver a garment that fits well in these highly mobile areas.





Smart Sleeves



4.5.1

After researching and sketching, the overall direction for the smart garment system for the final design was well into development on CAD at this stage of the project timeline. The overall scope of the design problem being addressed was large but in general, fairly straight forward enough to transition from planning to refining. Instead of the garment being fully comprised of highly visible fabric, the neon-green-style colour would instead only as accents and areas of covering vital parts of the body such as the torso and outermost extremities of the limbs.

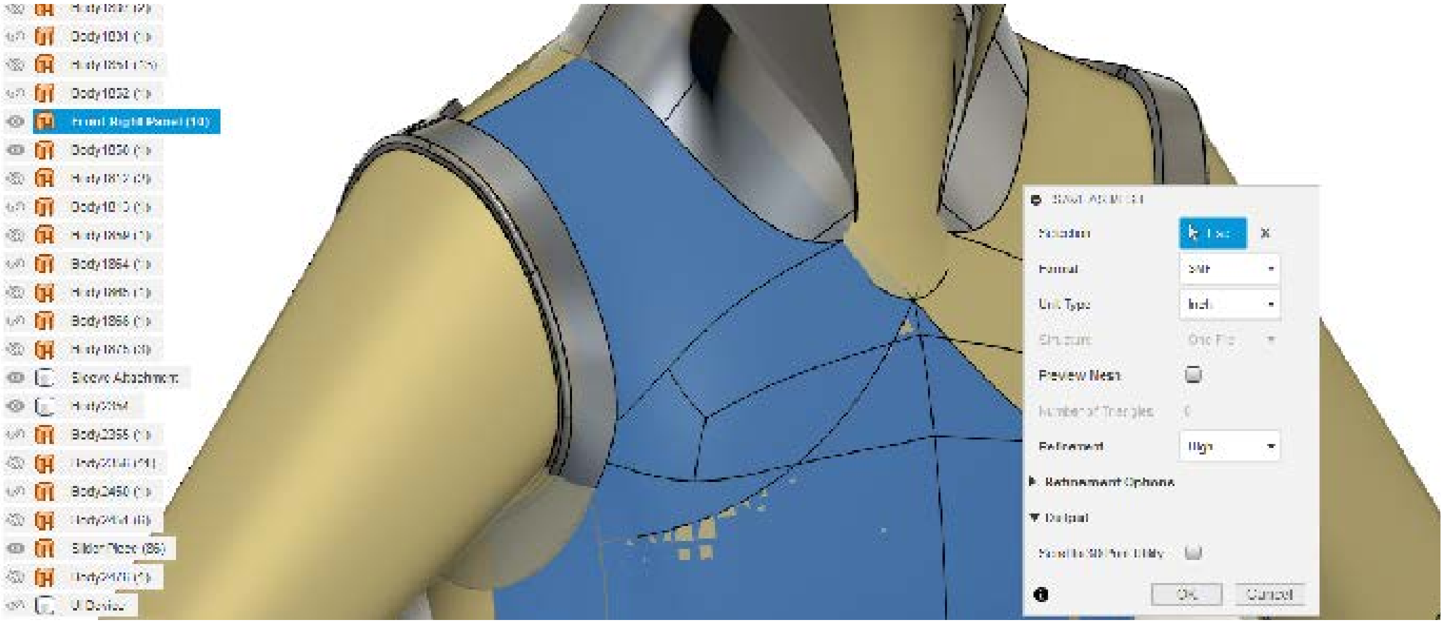
4.5.2

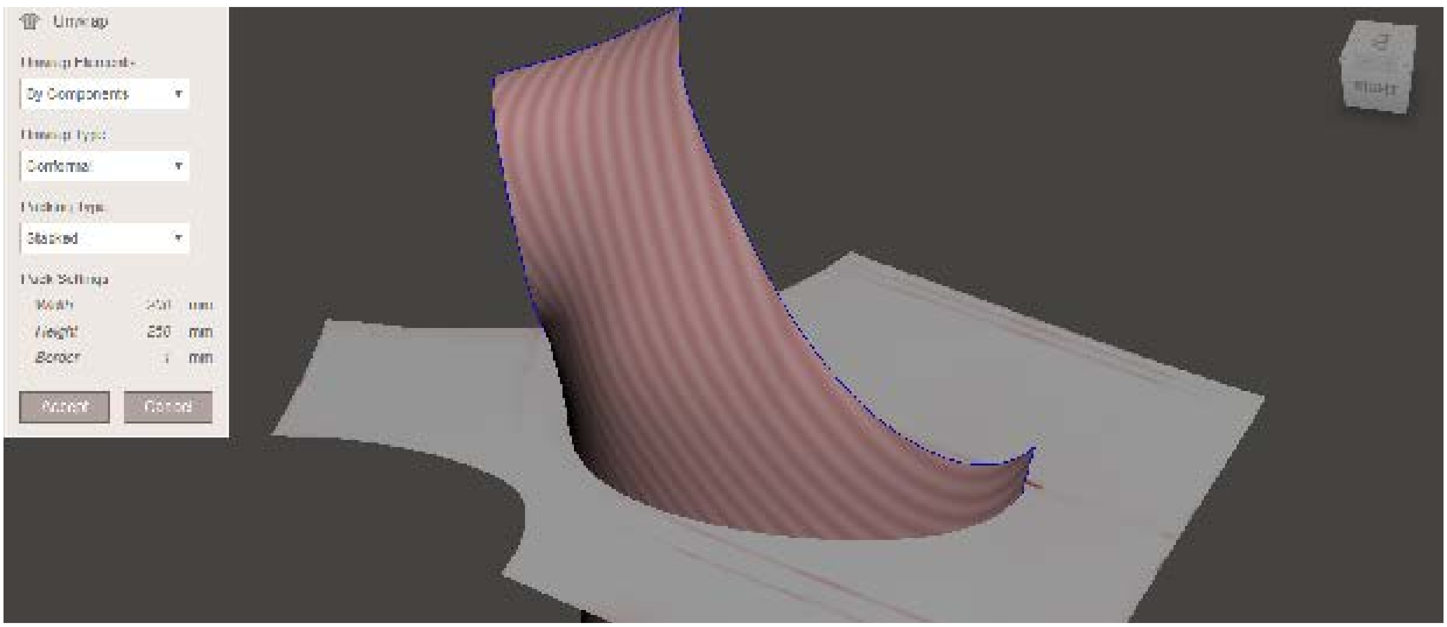
4.6 & 4.7

In order to fully prepare the bodies for 3D printing in line with the project timeline, it was deemed more efficient to finalize the design of some parts in 3D CAD as opposed to sketching. The final design concept as a suit with integrated hardware and technical pieces, the final design specs were configured in Fusion 360 by Autodesk. In Fusion 360, users can do T-spline modelling to create high-end smooth surfaces. Given that each rigid part must fit comfortably on the user, the underside of each part must be specifically contoured to accommodate the humanistic curves of various body parts. To achieve this, clothing was modelled over a 3D file of a person, scaled to the 90-percentile male. Once the clothing surface bodies were made, sketches split the surface bodies and the parts were designed with a bottom-up approach to ensure the curves of the underside remain intact for when it is worn. All parts were modeled in Fusion 360 and were saved as meshes to create the fabric flat patterns. Each surface body was exported as an .STL file and brought into Meshmixer, another Autodesk software, where it was flattened, scaled up, exported as an .SVG file, and refined in Adobe Illustrator.

Computer-Aided Design was utilized as tool for contouring surfaces over a human figure in highly specific ways. Designing both the garment flat patterns and rigid part bodies in cohesion with one another proved to be advantageous on multiple fronts. The drawback of creating everything in a modelling software like Fusion 360 however is that it only allowed for the solid part bodies to be exported for renders. This was acceptable given the scope of the project because it still allowed for close-up exploded view renders to convey specs and materials. As for the soft goods portion of the design, exporting the clothing surfaces from Fusion 360 into Meshmixer and Illustrator to create flat patterns for sewing and assembly was the only way to arrive at the final appearance of the design.

The sketch models were a physical manifestation of the dimensions derived from the model in Fusion 360. Given that they were .STL files edited on multiple software, getting the measurements of each flat pattern was a repetitive and iterative process that ultimately led to the final sketch model.


Front Right Panel (10)
Sleeve Attachment
Preview Mesh
Refinement
Refinement Options
OK
Cancel


Unwrap
By Components
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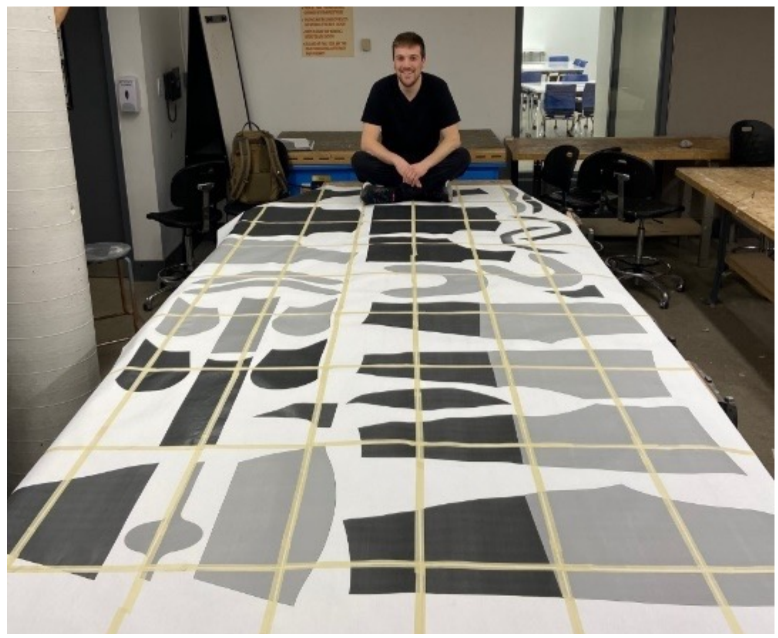
Pack Settings
Height
250
mm
Border
Accept
Cancel

4.8

After designing everything in CAD, from solid part bodies to fabric flat patterns, the next step to finalizing the design was to assemble the suit and put all the parts together, The first stages were to print out and prepare both 3D and 2D files. The 3D printing, was completed by Objex Unlimited, where they were able to pinpoint the exact level of flexibility for the shoulder cuffs and tech housing for the torso shell and smart sleeves respectively. Meanwhile, the flat patterns were laid out and cut by hand on paper, where they were a template to lay over top of the fabric. Once the 3D parts were sanded and painted and all fabric flat patterns were sewn together, the assembly of the final model closely resembled the CAD development process, whereby the rigid parts had to be laid over top the garment once the garment was assembled first. The method for joining the two types of products together was adhesion with a combination of superglue and rubber contact cement.



Chapter 5: Final Design

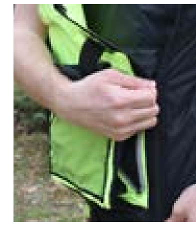
5.1, 5.2.1, & 5.3

The final design is dubbed F.R.O.G., which is an acronym for "Field Research Outdoor Gear". Naming the product seemed obvious because it communicates what the design solution is for and the adaptive nature of the smart garment system, drawing inspiration from the Alaskan Wood Frog early in the development stages. Field researchers can benefit from a tech-integrated suit in the future as it will assist them in adapting to the highly-variable climate in subarctic areas, which are only becoming more volatile and harsh due to the impacts of climate change. Benchmarked products in outdoor gear are mostly designed for outdoor trekkers, which leaves researchers ill-equipped to perform their work tasks efficiently. F.R.O.G. is tailored to accommodate many pain points specific to field research.

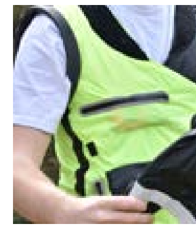
With the F,R.O.G. garment system and its tech modules, users can overcome discomfort and distress when caught in a sudden downfall of heavy precipitation, drops in temperature and alleviate physical pain associated with bending or crouching. The user can also track their team members, activate the suit's heating system, or utilize the LED torch lights in low-visibility through the wrist module on the smart sleeve. With the Gator Boot, users can traverse over almost any type of subarctic terrain, ranging from bog and wetlands to loose gravel and ice.

The F.R.O.G. suit aims to be as amphibious and adaptive as the name suggests. With the F.R.O.G. suit system and its tech modules, environmental researchers will also no longer worry about the logistics of packing weather-specific gear.

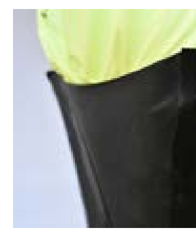
TORS



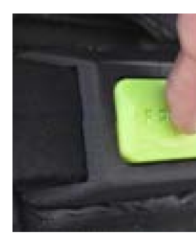
SMAR



GATO

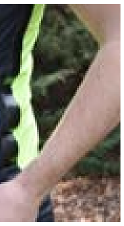


LEG R



CLIMA

O SHELL



Offers integrated electric heating panels, an area to store a large field clipboard, and overall fewer, but larger, pockets to increase carrying capacity and improve organization.

The slim-profile shoulder cuffs are the suit's power source.

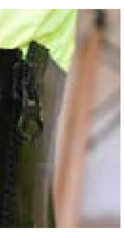
RT SLEEVES



For when conditions are unusually unfavourable for the wearer.

The wrist tech housing has several built-in applications such as a team tracker, a command centre for the suit's heating system, and extra-bright LED torchlights.

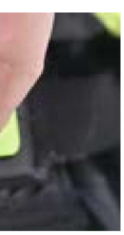
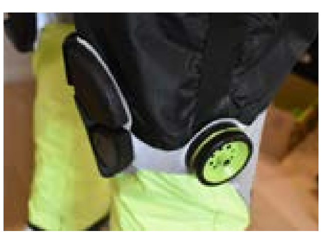
R BOOT



Gives the wearer a watertight seal around the lower leg and comes with detachable crampons for increased grip over loose gravel or ice.

Fastens along X. Y. and Z planes for fit and traction along difficult terrain.

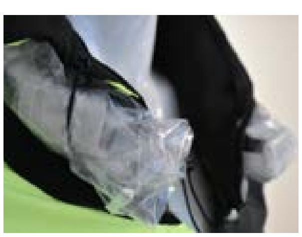
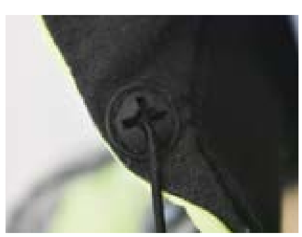
RELIEVERS


Roomy and comfortable in areas of high mobility and tapered near the extremities to mitigate the risk of tripping and tangling.

Integrated unit of kneepads and savers creates a cohesive ergonomic lower-body experience.

ATE COLLAR

Packs and unpacks neatly out of the neck area, held securely by ties, the hood, and a Velcro base.

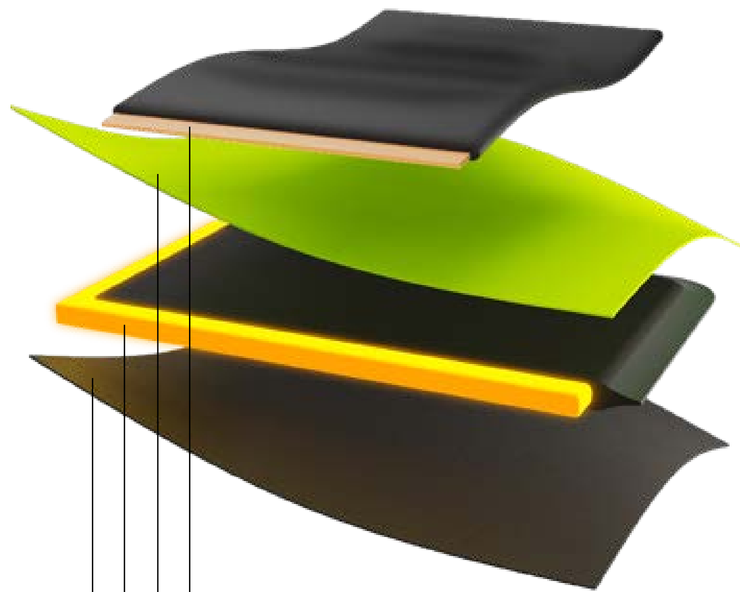
Users are still able to have fully mobility of their arms and shoulders.

5.2.2 & 5.4

FABRIC COMPONENT STRUCTURE

Sustainability lies at the core of the F.R.O.G. smart garment system as it helps environmental researchers perform at their best when gathering data of vulnerable northern environments affected by climate change. To make the fabric and electric components more sustainable, it was decided to veer away from e-textiles and instead take advantage various fabric's physical properties. Reducing the amount of responsive embedded technology in the garment could reduce cost to the system overall and utilizing hard circuits in between the fabric layers would assist in the stripping of materials for repair and recycling. With the business model of renting and encouraging customers to return gear, repurposing fabrics and parts is a strategy that is certainly attainable.

The fabric components of the smart sleeves, torso shell, leg relievers, and climate collar all follow this particular structure. The cotton lining is Cradle-to-Cradle certified and the HeiQ Smart Temp fabric boasts Bluesign and Oeko-Tex certifications.



ELECTRIC STRIPPING

Circuitry placed over top of outermost fabric layers for easy removal and repair

HEIQ SMART TEMP

Fabric pores open for breathability when warm. Fabric colour hue is most visible to human eye.

bluesign

OEKO-TEX® STANDARD 100

ACTIVE HEAT PANELS

In emergencies, users can receive immediate warmth on almost any part of the body.

COTTON BASE LAYER

For a softer feel against the skin and absorbing sweat until it evaporates through outer layer.

TECH HOUSING COMPONENTS

Tech hardware products that are mounted on top of the garment would be made of cast urethane. Electrical circuitry would be integrated within. The method of attaching the rigid polymers to fabric would be through adhesives, which could be dissolved with the right solution making repairs easier and more cost-efficient.

Almost all of the polymers in the design would be semi-rigid, so to maintain a high level of mobility along the user's limbs. Semi-rigid products could be fabricated by cast urethane-based solutions, which may not necessarily be environmentally friendly in the way of chemicals, but they can be recycled

Chapter 6: Conclusion

The most prominent takeaway from this project would have to be learning when to rely on one's own prior knowledge and expertise and when to try and learn a new skill. In an effort to develop more design and fabrication skills before the end of the project deadline, the scope of F.R.O.G. was perhaps a little large. comprised of modular attachments to fit onto a garment system. From sewing and cutting to sanding and painting, looking back on the project from an individual perspective means appreciating one's own work however the road to the end was not a smooth one. Might we have solved the design problem with the end result? Perhaps. However with more time and resources, and maybe even a team, there is no question that the F.R.O.G. design could be improved. It is satisfying knowing that this design project aims to improve the lives of a specific user group, regardless of the outcome, it is the effort and empathy that truly matter.

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Appendices

A

Key Article 1

Multiple search attempts led to the discovery and selection of this article based on its title and the authour's relevance in the environmental sciences as a Glaciologist. The entire article is shown given its format as a blog entry on the Government of Canada website.

- Search Engine: Google
- Key Words: "environmental field research challenges"
- Key Content:
    - Title: The Joys and Challenges of Scientific Field Research
    - Authour: Jill Rajewicz
    - Background: Jill Rajewicz currently works as a Physical Scientist for the Canadian Ice Service in Ottawa. Passionate about polar research, she sits on the board Association of Polar Early Career Scientists (APECS) Canada chapter. In her free time, she loves to cross-country ski, mountain bike, and read.

Key Article 2

Multiple search attempts led to the discovery and selection of this article based on its title and recent year of publication. Relevant information in required content of the abstract, introduction, and conclusion are highlighted.

- Search Engine: Humber Libraries Database
- Key Words: "weather hiking"
- Key Content:
    - Title: The Relationship between Weather Conditions and Hiking Safety
    - Authour: Young-Jae, K., & Jeong-Hyung Cho. (2021)
- Summary Statements:

1. Loss of footing contributes to the most accidents, the majority (65%) of these accidents happened to users during what is said to be ideal conditions.

2. It is crucial for users to be better prepared in wake of adverse events in order to prevent accidents from occurring.

B

Guiding Interview Questions:

1. Describe your background in the environmental sciences and your experience of conducting field research.
2. What do you do to prepare for your field work ahead of time? Are there any supplies you are responsible to get yourself?
3. From the moment you wake up, to the moment you retire for the evening, what does an average day look like to an environmental researcher in the field? How strenuous might your work be from day to day?
4. Overall, would conducting field research be a positive or negative aspect of your career as an environmental scientist? Please elaborate on your experiences.
5. What kind of physical and emotional challenges or hazards might one/teams face? In your experience, how have you overcame any difficulties pertaining to field research?
6. At what time of year does most field research get done? Are there any specific reasons for why you might go out at certain times of the year?
7. What might you bring on a field trip, with respect to outfitting gear, and how often might you replace certain gear such as pants, jackets, boots, etc.?
8. In general, what kinds of objects, equipment, or tools do you think every environmental researcher has on them while in the field and how might they store them when not being used?
9. How satisfied are you with current outfitting apparel and what do you think helps/hinders your ability to perform research tasks in the field?
10. What does the future of environmental field research look like to you? What kinds of advancements would you like to see made as an industry professional?
11. Do you have any additional comments?

Interviews:

1. Luana Sciullo, PhD

- University of Guelph Humber
- Typed Questionnaire
- September 23, 2021

2. Norm Catto, PhD

- Memorial University of Newfoundland
- In-person interview
- September 27, 2021 at 1:54 p.m.
- ~50 minutes
- Keywords: people, field, boots, samples, work, fieldwork, buy, carry, prepared, flying, day, beach, area, happened, tents, camp, clothing, person, big, wear

3. Gordon Fraser (Advisor)

- Owner of Anatom Footwear & TEKO Socks
- Edinburgh, UK
- Typed Questionnaire & Zoom Interview
- October 14, 2021 & February 3, 2022

4. Carissa Brown, PhD (Advisor)

- Memorial University of Newfoundland
- In-person interview
- October 28, 2021 at 12:06 p.m.
- ~55 minutes
- field, gear, summer, people, rain, fieldwork, soil moisture, pockets, measuring, dry, yukon, research, wear, tent, terra nova, arctic, hike, bamboo skewers, newfoundland, tree

C

	Benefits & Features	Features & Functions
What worked?	- Most fasteners must be innovative but not complicated - In general, consumers can access good products on a budget	- GORE-Tex is almost industry-standard - Footwear often higher-cut ankle
What can be improved?	- Products must try and balance adjustability, breathability, comfort, and weight - Waterproofing not always guaranteed but offer other weather resistance	- Having pockets to store objects is major selling point - Design and manufacturing methods of fabric provides better integrity and strength
Converge/Diverge?	**Converge:** It was interesting to contemplate on outdoor gear working together as a system, working in cohesion with each other. I gained insight into why certain products were favoured against others and how each can be improved.	

D

Design Brief

1. Reduce time and effort it takes field researchers to adjust to physical conditions (Needs)
2. Reduce the overall amount clothing researchers take on field expeditions (Needs)
3. Improve the configuration of materials to suit researcher needs with respect to storage and comfortability (Innovation Opportunity)
4. Make field researchers feel more professional (Aesthetics & Semantic Profile)
5. Make field researches look more distinguishable from outdoor recreationists (Aesthetics & Semantic Profile)
6. Provide the academic research industry with more modern resources as they work at the frontier of climate change in the north (Needs)
7. Reduce feelings of anxiety and emotional distress in the field (Needs)
8. Improve efficiency of field researchers so they can remain on schedule (Needs)
9. Reimagine the overall design approach to outdoor clothing (Innovation Opportunity)
10. Find new ways to integrate technology with clothing and gear to further innovate in the industry (Innovation Opportunity)

E

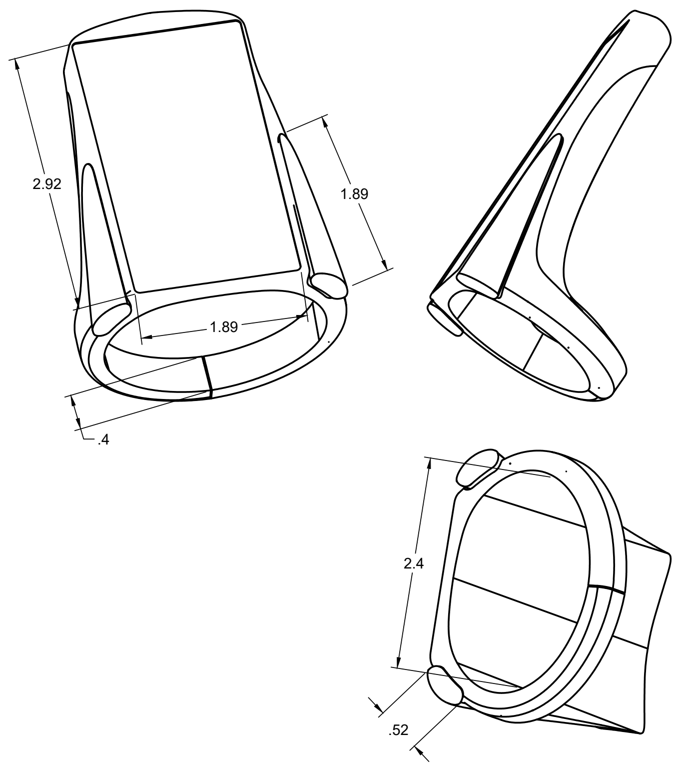
F

Right

Front

In-Situ

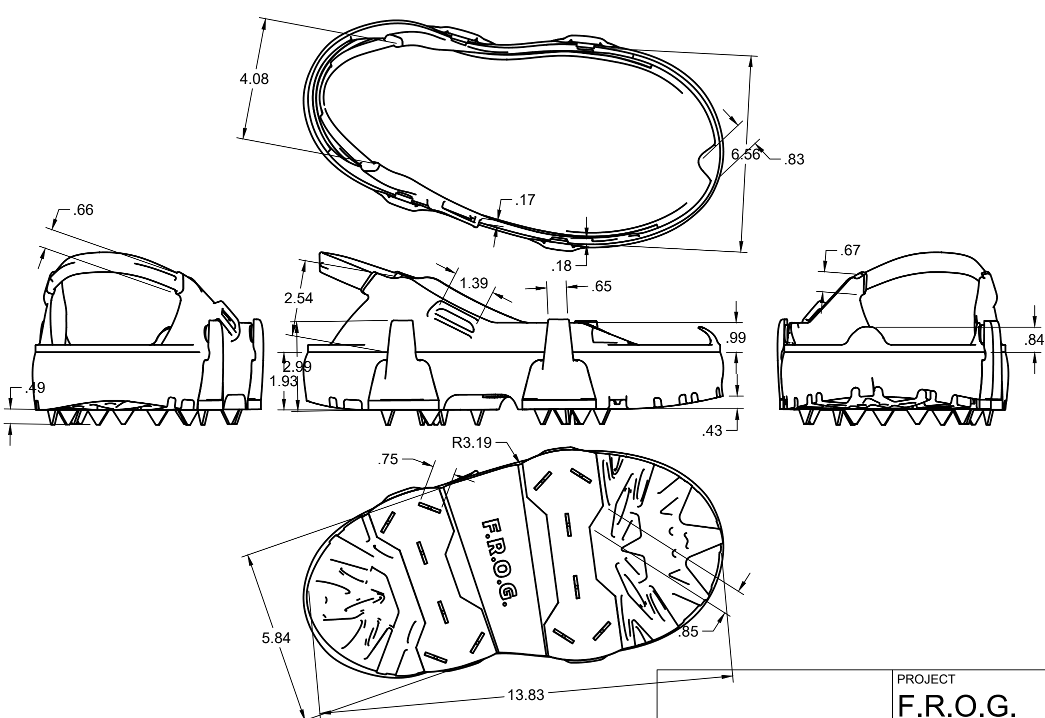
G



PROJECT
F.R.O.G.

TITLE
WRIST TECH HOUSING

APPROVED	SIZE	CODE	DWG NO		REV
CHECKED	B				
DRAWN Mark Connolly 2022-04-27	SCALE 1:2		WEIGHT	SHEET 1/1	

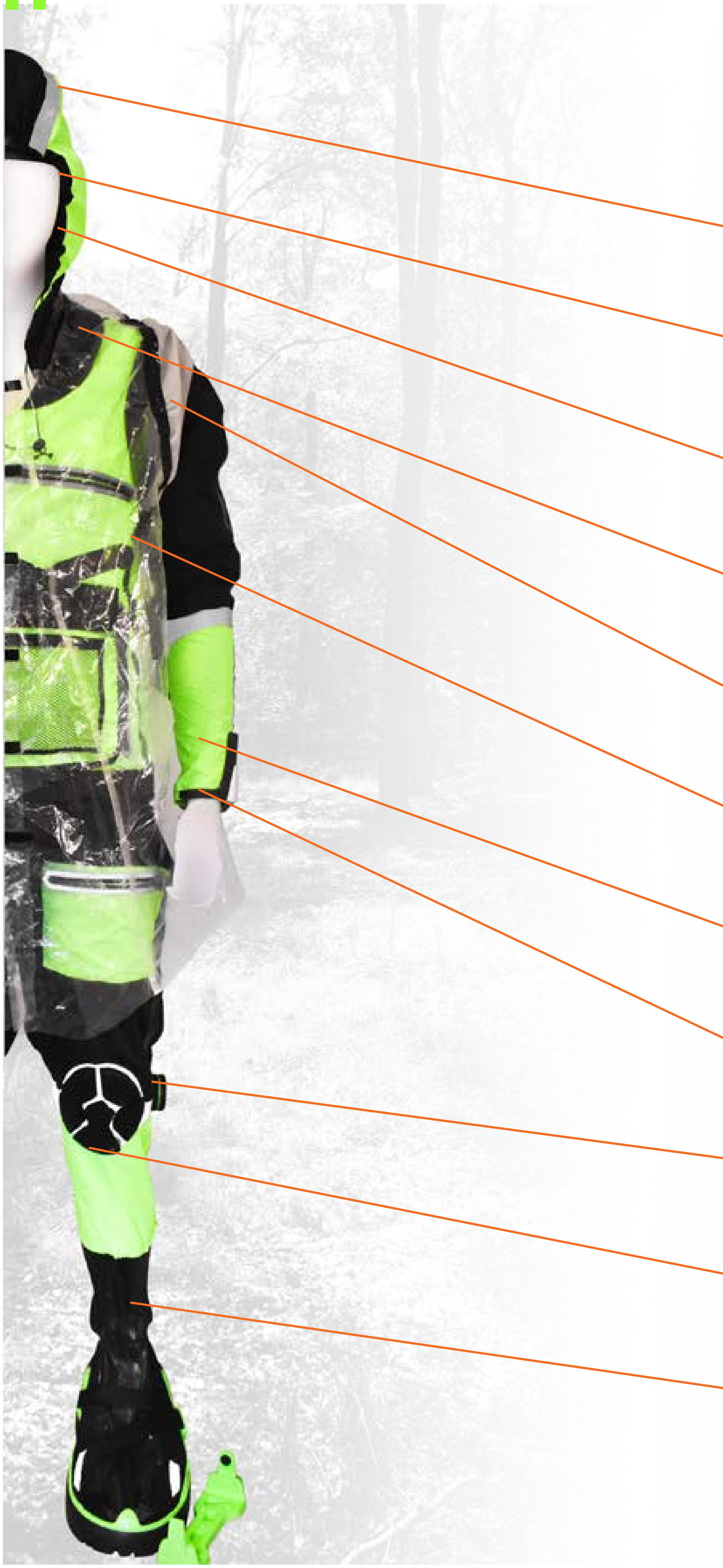


PROJECT
F.R.O.G.

TITLE
Gator Boot

APPROVED	SIZE	CODE	DWG NO		REV
CHECKED	B				
DRAWN Mark Connolly 2022-04-27	SCALE 1:10		WEIGHT	SHEET 1/1	

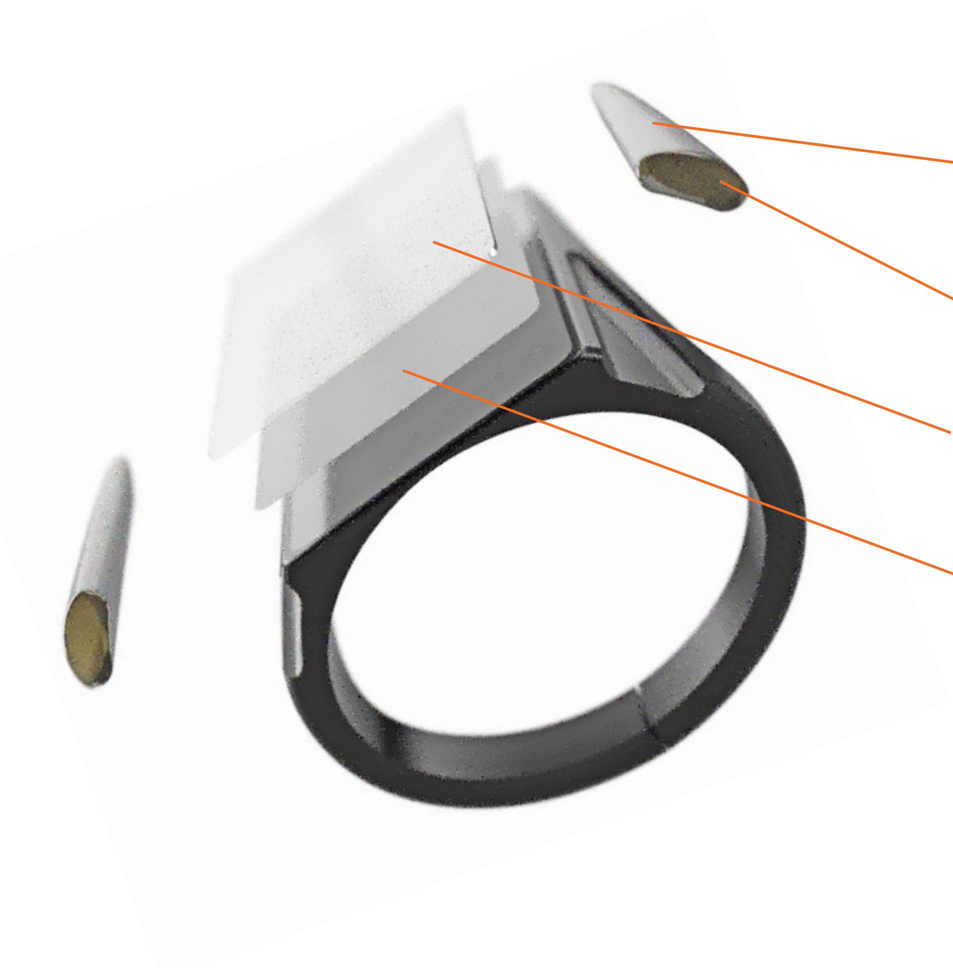
H



No.	Part Name
1	Reflective Accent
2	Inner Lining
3	Heat Panels
4	Climate Collar Base
5	Climate Collar Arm Opening
6	Climate Collar Poncho
7	Outer Layer
8	Wrist Tech Housing
9	Mini Inflator Pump Housing
10	Origami Kneepads
11	Gator Boot Upper

Material	Assembly Method	Average Price
Nylon Spandex	Sewing	1 yard = $40.00
Cotton	Sewing	1 yard = $20.00
Copper & TPU	Laminating	7.5 sq. ft. = $100.00
Hook & Loop Fabric	Adhesive & Stitching	2’x4” = $5.00
Latex	Adhesive	7.5 sq. ft. = $100.00
Vinyl	Laminating	7.5 sq. ft. = $100.00
HeiQ SMART TEMP	Lap Stitch	Distributor-Specifc
Urethane	Over Molding	$1.75 per unit
High-Density Polyethylene	Injection Molding	$0.22 per unit
EVA Foam	Injection Molding & Adhesive	$0.08 per unit
1/4” Closed-Cell Neoprene & Latex	Adhesive	15”x60” = $20.00

12	Achilles Strap
13	Fastener Piece
14	Moldable Insole
15	Outsole
16	Crampon
17	Crampon Teeth



18	Torchlight Housing
19	Torchlight Lens Cover
20	Screen
21	Touch Tech & Screen Light

TPU	Injection Molding	$0.07
TPU	Injection Molding	$0.91
EVA Resin	Injection Molding	$0.041
Rubber	Injection Molding	$1.27
ABS	Injection Molding	$0.16
Titanium	Overmolding	$2.17

Anodized Aluminum	Diecast	$0.04
Borosilicate Glass	Injection Molding	$0.10
Gorilla Glass	Adhesive	Distributor-Specific
Multiple	Injection Molding	$6.00

THESIS TOPIC APPROVAL:

Student Name:	Mark Connolly
Topic / Problem Definition:	How may we improve the experience for environmental field researchers in adverse physical conditions?

TOPIC DESCRIPTIVE SUMMARY (Preliminary Abstract)

Climate change affects cultures all over the world and poses massive implications for the future of society, yet it is a relatively new phenomenon. There is no limit to what we must uncover about the past and present to adapt for the future. With global temperature rise metamorphosizing entire climate zones, Earth's natural patterns are becoming less predictable and more extreme, making those at the frontier particularly vulnerable. At the forefront of climate change, scientists are working in the field and surveying the world around them however, physical conditions such as inclement weather and harsh terrain add unnecessary stressors to an already high-stakes environment. Unfortunately, environmental scientists and outdoor recreationists often share a similar appearance although, the experiences of the two user groups vary greatly. Helping environmental scientists prepare for the physical demanding work of field research with an extra layer of safety, comfort, and professionalism, means also helping humanity prepare for an uncertain future. Surveying those who conduct research in Subarctic ecoregions, through a qualitative approach, will aid in the understanding of various pain points and challenges of field work, so that there may be a solution more specifically tailored to suit their roles.

Student Signature(s):	
Date:	26/09/2021

Instructor Signature(s):	
Date:	07 October 2021

CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION

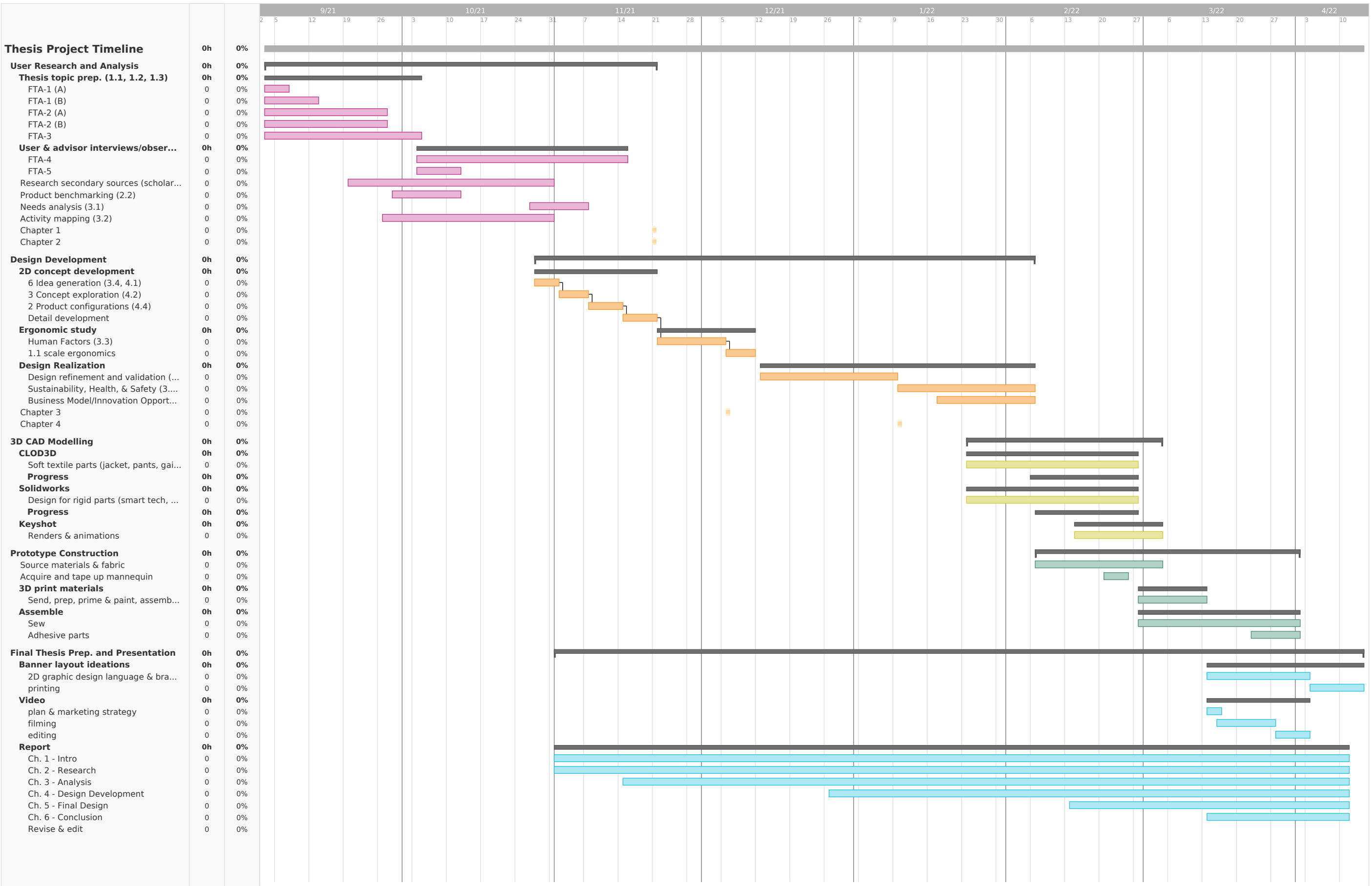
Student Name:	Mark / Connolly (N01299459)
Topic / Thesis Title:	**ENHANCED GEAR FOR ENVIRONMENTAL RESEARCHERS**

THESIS PROJECT – DESIGN APPROVAL FORM

Design is reviewed and approved to proceed for the following:	X	**CAD Design and Development Phase**
Comment:		- Initial CAD started well as of week #6/February 15th, continue with detailing and refinement. - Refinement CAD progress well as of week #8/March 8th.

Design is reviewed and approved to proceed for the following:	X	**Model Fabrication Including Rapid Prototyping / 3D Printing and Model Building Phase**
Comment:		- Once CAD is completed, can move forward to model fabrication from week #9 onward.

Instructor Signature(s):	
Date:	8th March, 2022



PANEL ON RESEARCH ETHICS

Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

Mark Connolly

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

N01299459

Date of Issue: **23 September, 2021**

J

IDSN 4002 /4502

SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER

Faculty of Applied Sciences & Technology

Bachelor of Industrial Design / FALL 2021 & WINTER

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: Improving the experience of field researchers during adverse physical conditions

Investigator: Mark Connolly

Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, « insert advisor Name » GORDON FRASER. *(First Name/Last Name)*, have carefully read the Information Letter for the project Improving the experience of field researchers during adverse physical conditions, led by Mark Connolly. A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Mark Connolly at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording, photography and/or videotaping; with the proviso that my identity will be blurred in reports and publications.

Consent for Publication: Add a (X) mark in one of the columns for each activity

ACTIVITY		YES	NO
Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public	☑	☐
Review	I give consent for review by the Professor	☑	☐

Privacy

All data gathered is stored anonymously and kept confidential. Only the principle investigator /researcher, Mark Connolly and Prof. Catherine Chong or Prof. Sandro Zaccolo may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

I also understand that I may decline or withdraw from participation at any time, without negative consequences.

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or « insert student Name /Phone Number /Email Address ».

Verification of having read the Informed Consent Form:

☑ I have read the Informed Consent Form.

My signature below verifies that I have read this document and give consent to the use of the data from questionnaires and interviews in research report, publications (if any) and presentations with the proviso that my identity will not be disclosed. I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Click or tap here to enter text. Click to enter a date.

Participant's Name: GORDON FRASER

Participant's Signature: G. Fraser.

Date: 15/10/21

Week of:	Deliverable:	Discussion:	Communication method:
Nov. 1	Idea Generation	- Where should this product fit in the industry? - How should it be compared to its competitors? - How will it be perceived by the target audience? - What ideas work? - Select your top 3.	Online: - PDF of sketches can be sent via email for review at advisor's convenience - Marking up pages and writing is encouraged
Nov. 8	Concept Development	- What do you make of the inspiration and creative process? - Provide feedback on the overall aesthetic direction of the proposed designs. - Select your top 2.	Online: - PDF of sketches can be sent via email for review at advisor's convenience - Marking up pages and detailed written feedback is encouraged
Dec 6.	Concept Refinement - Checkpoint 1	General discussion and feedback session: - Ergonomics & Aesthetics - Materials, manufacturing, and technology - Business model and sustainability	Virtual Meeting: - Show work done since previous meeting on Miro - Discussion on design refinement going forward
Jan. 3	Concept Refinement - Checkpoint 2	General discussion and feedback session	Online: - Deliver designs in PDF format for review and critique
Jan. 24	Sustainability & Business Model	- Where are the best areas to improve sustainability in the industry, from manufacturing to end-of-life? - What are some best business practices to keep in mind during the prototyping phase? - How could this product be produced on a mass scale? - Advice for constructing the model if applicable	Virtual Meeting: - Open discussion about business and sustainability in the outfitting apparel industry - Could also be typed questions
Tentative	Prototype Construction Checkpoint 1	General discussion and feedback session	Online
Tentative	Prototype Construction Checkpoint 2	General discussion and feedback session	Online

F.R.O.G.