

**An Equipment Collection for the Wildland Firefighters of the PNW**

*How can we improve on-body water transportation for Type 2IA wildland firefighters?*

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## History

Forest fires have always been one of nature's management tools for maintaining biodiversity across wild forests (University of Washington News, 2020). Through this burning process the heat of the fire burns away all of the vegetation and organic matter on the surface of the soil, which makes some nutrients more readily available to the soil (Minas, 2019). Although forest fire occurrences are not new, studies show that recent fires are more intense and burn the same areas in quick succession compared to historical patterns (Cascade Forest Conservancy, 2020). Over the past 10 years, there has been an average of 64,100 wildfires annually burning over 6.8 million acres in the United States alone (Congressional Research Service, 2020). There are several factors that contributed to the record-breaking fires that we are experiencing today. Some of these factors include: the urbanization of forest areas, the replacement of old-growth forest trees with overgrown homogeneous, single-species strands of trees, as well as the warm and dry weather condition attributed to climate change (Cascade Forest Conservancy, 2020).

For more than 10,000 years, indigenous people in the Pacific Northwest adapted to the threat of destructive fires by developing methods such as controlled burns which consists of purposefully burning fuel ahead of the fire season in order to reduce the potential of big fire spread during the season (University of Washington News, 2020). From the mid-1800s to the early 1900s, there were several waves of settlements in the American West (The American West: History & Settlement, 2017), and as the number of people living in the forested areas of the Pacific Northwest increased, a large amount of fuel built up over the years. During the years of rapid industrialization in particular, between 1860 and 1910, many forest spaces were clear cut to make more space for infrastructures and living spaces (Forest History society, 2020). As the demand for wood used for construction increased, old-growth forest trees were replaced with

homogeneous, single-species trees intended to grow fast and harvest. Most of the Pacific Northwest's ecosystems were practically replaced by a tinderbox (Cascade Forest Conservancy, 2020).

In 1905 President Theodore Roosevelt expanded the country's national forests and created the bureau of forestry (now known as the U.S Forest Service) to regulate timber use, oversee wildlife minerals and conduct forest preservation research (PBS, 2015). At the head of the service he put Gifford Pinchot, an advocate for the protection of forests (PBS, 2015). In the summer of 1910, on August 10th one of the biggest wildland fires yet sparked in the mountains surrounding Wallace, Idaho when peak dryness and unfavorable weather conditions aligned (PBS, 2015). The big burn destroyed an area the size of Connecticut in 36 hours (PBS, 2015). The massive fire not only transformed the landscapes of the west forever, but it also changed how the United States viewed its forest spaces (PBS, 2015). Furthermore it allowed Gifford Pinchot to make a case for the importance of the country to invest in a unit that helps suppress forest fires and maintain the forest lands (PBS, 2015).

Ed Pulaski who joined the U.S Forest Service in 1907, was one of the leaders remembered for his organizational role in successfully leading men to and back in the fight against the big burn of 1910 (PBS, 2015). He is reputed for creating the pulaski tool, an axe and adze combination tool used by many firefighters all over the world today (PBS, 2015). Today the U.S Forest service employs about 10,000 wildland firefighters and they also receive help from contracted private agencies (US Forest Service, n.d.).

### **Environment**

The average surface fire in a forest fire may have flames reaching up to 3.3 feet in height and at temperatures of 1,472 degrees F or more (Gabbert, 2011). To understand how fires get this

intense it is essential to consider the factors that influence their severity. The three important factors that influence fire behavior are fuel, weather, and topography (National Park Service, 2017).

### **Fuel**

A fuel's composition, including moisture level, chemical makeup, and density, determines its degree of flammability (National Park Service, 2017). Moisture level is the most important consideration (National Park Service, 2017). Live trees usually contain a great deal of moisture whereas dead logs contain very little (National Park Service, 2017). The moisture content and distribution of these fuels dictate how quickly a fire can spread and how intense or hot a fire may become (National Park Service, 2017). High moisture content will slow the burning process, because heat from the fire must first eliminate moisture (National Park Service, 2017).

In addition to moisture, a fuel's chemical makeup determines how readily it will burn (National Park Service, 2017). Some plants, shrubs, and trees contain oils or resins that promote combustion, causing them to burn more easily, quickly, or intensely than those without such oils. Finally, density of a fuel influences its flammability (National Park Service, 2017). If fuel particles are close together, they will ignite each other, causing the fuel to burn readily (National Park Service, 2017). But if fuel particles are so close that air cannot circulate easily, the fuel will not burn freely (National Park Service, 2017).

Soil types also must be considered because fire affects the environment above and below the surface (National Park Service, 2017). Soil moisture content, the amount of organic matter present, and the duration of the fire determine to what extent fire will affect soil (National Park Service, 2017).

## **Weather**

Weather conditions such as wind, temperature, and humidity also contribute to fire behavior (National Park Service, 2017). Wind is one of the most important factors because it can bring a fresh supply of oxygen to the fire and push the fire toward a new fuel source (National Park Service, 2017).

Temperature of fuels is determined by the ambient temperature because fuels attain their heat by absorbing surrounding solar radiation. The temperature of a fuel influences its susceptibility to ignition (National Park Service, 2017). In general, fuels will ignite more readily at high temperatures than at low temperatures (National Park Service, 2017).

Humidity, the amount of water vapor in the air, affects the moisture level of a fuel. At low humidity levels, fuels become dry and, therefore, catch fire more easily and burn more quickly than when humidity levels are high (National Park Service, 2017).

## **Topography**

Topography describes land shape (National Park Service, 2017). It can include descriptions of elevation with the height above sea level; slope, the steepness of the land; aspect, the direction a slope faces (e.g., the south side of a canyon will have a north-facing slope); features, such as canyons, valleys, rivers, etc (National Park Service, 2017).

These topographical features can help or hinder the spread of fire (National Park Service, 2017). For example, a rocky slope can act as a great natural fire break due to a lack of fuel and wide gap of open space (National Park Service, 2017). Drainages can act as fire breaks, as well if fuels are moist or there is little vegetation (National Park Service, 2017). Beyond the shape of the land, it is also important to consider elevation, slope, and aspect (National Park Service, 2017). Elevation and aspect can determine how hot and dry a given area will be (National Park Service, 2017). For example, higher elevations will be drier but colder than low ones, and a north-facing slope will be slower to heat up or dry out) (National Park Service, 2017). Slope can determine

how quickly a fire will move up or down hills (National Park Service, 2017). For example, if a fire ignites at the bottom of a steep slope, it will spread much more quickly upwards because it can preheat the upcoming fuels with rising hot air, and upward drafts are more likely to create spot fires (National Park Service, 2017).

### **Athlete and Pertinent Market Size**

To be a wildland firefighter you must be between the age of 18 and 35 years old (US Forest Service, n.d.). There are several kinds of wildland firefighters including Engine crews, and Helitacks to name a few (US Forest Service, n.d.). This project will focus on the Type 21A Handcrew wildland firefighters of the Pacific NorthWest, these are the men and women on the ground. They are often organized in groups of 18 to 20 people and they use a variety of tools, equipment, and methods to suppress fires (Environment and Natural Resources, 2020). The Forest Service has been managing wildland fires for more than 100 years. Today they employ 10,000 wildland firefighters and they work closely with federal, tribal, state, and local partners (US Forest Service, n.d.).

### **Physiological Needs**

Performing fire suppression activities are physically demanding and require ample aerobic fitness and muscle endurance. The specific demands of a crew member will depend on their level of experience, training and qualifications (Delatorre, 2020). The following tests were adopted to determine a crew member's capacity: the pack test for arduous work, the field test for moderate work, and the walk test for light work (Missoula Technology and Development Center, 2001).

#### **Arduous work**

These duties involve field work that require above average physical performance including running, walking, climbing, jumping, twisting, bending and lifting more than 50

pounds (Whitlock & Sharkey, 2003). The pack test is the test designed to assess this work capacity which consists of completing a 3-mile hike course with a 45-pound pack over a steep terrain under 45 minutes (Whitlock & Sharkey, 2003). Analysis indicated that a score of 45 minutes for the 3-mile pack test predicts a VO<sub>2</sub> max of 45 milliliters/kilogram-minute, the equivalent to the standard on-field physiological demands (Whitlock & Sharkey, 2003).

### **Moderate work**

These duties involve field work work that may include considerable walking over irregular ground, standing for long periods, regularly lifting weight between 25 to 50 pounds, climbing, bending, stooping, squatting, twisting, and reaching (Whitlock & Sharkey, 2003). The assessment test for this work capacity, the field test, consists of a 2 mile hike with a 25-pound pack within 30 minutes or less (Whitlock & Sharkey, 2003).

### **Light work**

These duties mainly involve office related work with occasional field activity. These may include climbing stairs, standing, operating a vehicle, bending, stooping or light lifting (Whitlock & Sharkey, 2003). The assessment test associated with light work capacity is the walk test which is designed to ensure the crew member's ability to meet emergencies and evacuate to safety zones (Whitlock & Sharkey, 2003). It consists of a 1-mile test with no load under 16 minutes (Whitlock & Sharkey, 2003).

## **Positions**

Looking at the different Handcrew positions, there is an IC (incident commander) who is in charge of making strategic decisions for the whole crew including where to initiate the fire attack, and a predetermined escape route in case things get beyond control (Environment and Natural Resources, 2020). Under the IC are 2 -3 assistant crew bosses who are often relied upon

to operate chainsaws and also supervise the crew in the absence of the crewboss (Environment and Natural Resources, 2020). Under the assistant crew bosses are the squaddies, the members of the squads who are relied upon to perform a number of fire suppression activities (Environment and Natural Resources, 2020).

### **Sport rules + success**

#### **Firelines**

The crew's main responsibility is to construct firelines which are 12 to 36 inch trail-like lines scraped down to the dirt, removing any grass, bush, or any combustible that can serve as fuel for the fire creating a boundary line to contain the fire (Environment and Natural Resources, 2020). This activity is done with any scraping tool similar to an adze shape. Crew members typically begin constructing firelines from an anchor point. Anchor points can be a road, a lake, a stream or a river, they are used to minimize the chance of crewmembers being flanked by the fire while the fireline is being constructed (USDA, 2018). Anchor points will also serve as easy entry and exits routes.

#### **Sawlines**

Sawlines consist of cutting tree limbs that are in close proximity to the fire (Environment and Natural Resources, 2020), this task is performed with a chainsaw by members with more experience, sometimes the chainsaw is also used to cut open tree trunks to extinguish the fire from within.

#### **Swamping**

Swamping consists of picking up the limbs and ensuring they are on the safe side of the fireline (Environment and Natural Resources, 2020), this task is done by hand.

#### **Back burning and backfiring**



These methods refer to setting low intensity fires along the fire break to burn all possible fuel on the way (Environment and Natural Resources, 2020). Backfiring differs slightly in that squad members start a fire in the opposite direction along the fire break which helps stuff the main fire (Environment and Natural Resources, 2020). This activity is done with a drip torch.

### **Dry mopping and wet mopping**

These refer to what handcrews do after a fire has gone through an area to prevent reburn (Environment and Natural Resources, 2020). Mopping up can be in two forms, wet or dry (Environment and Natural Resources, 2020). Dry mopping is finding hotspots and digging them up and mixing them with cooler unburnt soil (Environment and Natural Resources, 2020). Wet mopping is the same process but you are mixing water into the soil ensuring the heat has no remaining oxygen, thus no spread potential (Environment and Natural Resources, 2020). Wet mopping is more effective and is performed with a water camel bag-like water bladder with a spray bump (Environment and Natural Resources, 2020). The fire pump backpacks carry 5 gallons of water which equates to 41.71 pounds.

## **Project Scoping**



*Fig. 1. Indian Chief 5-Gallon Heavy-Duty Nylon Fire Pump  
(Forestry-suppliers, n.d)*

This project will focus on the wet mopping activity and the main product this project seeks to be improved upon is the Indian DBL500 Dual Collapsible Fire Pump Bag. It consists of a thermoplastic polyurethane inner bag liner with a protective nylon taffeta fabric outer including storage compartment. The bag is collapsible when it is not in use and is equipped with a brass pump with a combination nozzle that allows the operator to change from a straight stream to a cone spray quickly and easily. Although it is a reliable bag design which has been in use for over 80 years, crewmembers find themselves having to wear these bags on top of their line gear as there is no time nor place to put down their line gear while performing the task. In addition to the inconvenience of stacking two heavy bags now amounting to 60lbs, crewmembers complain that these water bladders have leaks at the gasket level which soak their line and cause efficiency problems. This project seeks to resolve the ergonomics problem around the stacking of the line gear and the water bladders by considering alternative forms other than the vertical form the bag currently has. The project also seeks to improve the overall stability and weight distribution of both weight loads being transported. Finally, this project seeks to address the performance malfunctions of the gasket. The main bag used by handcrew members are the Mystery Ranch bags. This project will be focusing on this bag as a reference to design around.



*Fig. 2. Shift Plus 900 |  
(MYSTERY RANCH Backpacks, n.d.)*



*Fig. 3 The Hydrant Drink Aid - 1 Liter  
(Maddak, n.d.)*

This project will also consider the personal hydration means by which crew members drink water during physically demanding tasks and hot temperatures. Currently, crew members rely on two to four 1-liter bottles (Fig. 3) which they stack on the side pockets of the Mystery Ranch backpack (Fig. 2). Sometimes these bottles have tubes that make it convenient to drink and other times they are regular water containers that require to be reached for, and opened while having gloves on which makes it difficult to manage during activity. The broader project topic will focus on improving on-body water transportation for wildland fighters.

### **Competitor Product Research**

The Indian Fire Pump has established a name of its own throughout the Fire Service with the invention of the fire pump in 1925 (The Fountainhead Group, n.d.). The company is still around today and continues to be the most recognizable name in the wildland fire arena (The Fountainhead Group, n.d.). Today they offer four fire pump backpack designs: the polyurethane lined bladder with a nylon outer, the collapsible vinyl fire pump backpack, the galvanized

stainless steel fire pump backpack and the polyethylene fire pump backpack (The Fountainhead Group, n.d.).



*Fig. 4. Indian Smith Tanks  
(Baseline Equipment Company n.d.)*

Name	Indian 90G Galvanized Fire Pump	Indian DBL500 Dual Collapsible Fire Pump Bag	Smith Poly Fire Pump	Indian FSV500 Collapsible Smokechaser Fire Pump Bag
Price	\$264	\$176	\$150	\$149
Strength	Stable, Durable, Lumbar support.	Collapsible. Puncture and abrasion resistant.	Stable, Durable, Lumbar support.	Collapsible. Puncture and abrasion resistant.
Weaknesses	Not collapsible. Hard to wear with linegear.	Gasket Leakage.	Not collapsible. Hard to wear with linegear.	Gasket Leakage.
Opportunity	Revisit form. How can this be designed to work with FF linegear.	Revisit form for ergonomy and stability.	Revisit form. How can this be designed to work with FF linegear.	Revisit form for ergonomy and stability.
Threat	Compromising Stability.	Compromising Product Simplicity	Compromising Stability.	Compromising Product Simplicity



*Fig. 5. Hydration Water Bladders  
(King, 2020)*

Name	HydraPak HydraSleeve	Badlands Hydration Reservoir	Osprey Hydraulics LT Reservoir	Source Tactical WXP 3L
Price	\$60	\$40	\$34	\$34
Strength	Insulation, High flow rate.	Insulation tube, Lightweight, easy to use and store.	Large handle and long collar for easy filling.	Versatile filling options, insulated tube, puncture resistant.
Weaknesses	Expensive, hose comes out of of the connect and can leak water.	Durability issues, Slower flow rate.	Hard to flip inside out, plastic taste.	Flimsy plastic handle.
Opportunity	Revisit connection points.	Address flow problem.	Address form, Implement modularity, Revisite connection points	Address form, Modularity, connection points.
Threat	Spillage, Hard to use.	Spillage, Hard to use.	Spillage, Hard to use.	Spillage, Hard to use.

### **State-of-the-art Materials and Manufacturing**

#### **Indian DBL500 Dual Collapsible Fire Pump Bag**



*Fig. 5. Indian DBL500 Dual Collapsible Fire Pump Bag*

*(Baseline Equipment Company n.d.)*

### **Materials and Manufacturing**

The lining is made of polyurethane sheets. The reacting compounds required to produce polyurethanes are polyol and diisocyanates. Polyurethanes can be produced in four different forms including elastomers, coatings, flexible foams, and cross-linked foams (How polyurethane is made,.n.d). In this case the bladder is an elastomer. Its production process can be broken into three distinct phases (How polyurethane is made,.n.d). First, the bulk polymer product in steel tanks (How polyurethane is made,.n.d). Next, the polymer is exposed to various heating processes. Finally, the polymer is compressed or extracted on a conveyer belt (How polyurethane is made,.n.d). After the lining patterns are cut to the desired dimensions, a lid is added to the front pattern and airtight-sealing is ensured through heat bonding (Forestry-suppliers, n.d).

The outer bag is made from nylon. Nylon fibers are synthetic strands made by melting nylon chips and drawing them through a spinneret (The science of synthetic textiles, 2019). Fibers of different length and thickness are made by using holes of different size and drawing them out at different speeds (The science of synthetic textiles, 2019). Once the fibers are drawn, big nylon threads are webbed to make the attachment straps for the bag's harness. Smaller fibers are used in a taffeta weave construction to make the outer bag patterns (Forestry-suppliers, n.d). The straps, the front outer pocket patterns, and velcro strips are then sewn to the single

rectangular outer pattern which is then folded into half and sewn on both length sides to make the bag (Forestry-suppliers, n.d).

The brass tubes and connectors are metals composed primarily of copper and zinc. raw materials into a molten metal, which is allowed to solidify in mold or extruded in the form of plates, sheets, strips, foil, and rods (How brass is made, n.d.). Rubber handles are then molded over the brass pump and a rubber hose is secured to the brass pump and the metal connectors that attach to the lining lid (Forestry-suppliers, n.d).

### Graphic, Logo + Color Application



*Fig. 8. Indian DBL 500  
(Baseline Equipment Company n.d.)*



*Fig. 9. Osprey Hydraulics LT Reservoir  
(King, 2020)*

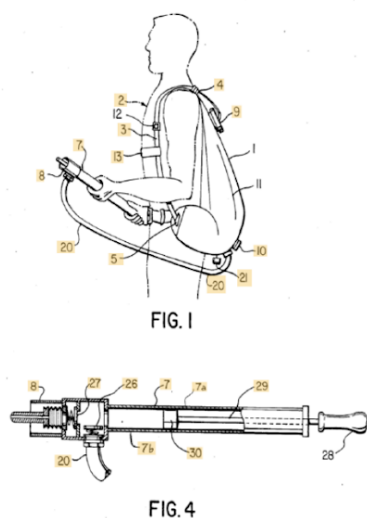
### Fire Pump backpack Colors & graphics

Looking at color, most of the fire pump backpacks on the market are of the color yellow just like the shirt crewmember wears. The color yellow stands out as visibility is really crucial on the fireline. As for the graphics, the company logo and a caution warning for not drinking are screen printed on the patterns of the bag before sewn.

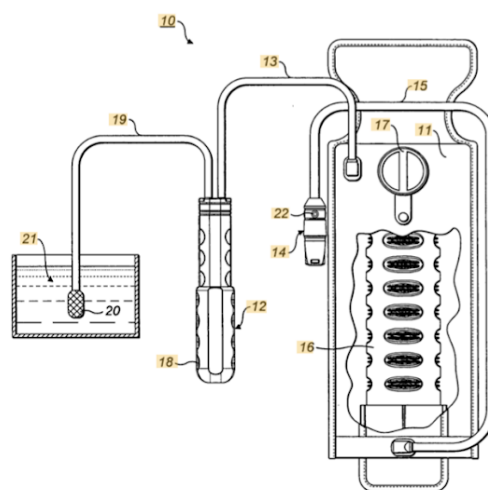
### Hydration Pack Colors & Graphics

Most hydration bladders on the market are made of different plastic film gauges. The body and tubes are transparent to allow the user to visually assess the level of water remaining. Bright colored accents are used on parts of the bottle to draw attention to important features such as the lid, drinking tube and connection points. For the graphics on water bladders, the company's logo, and important information the maximum capacity and increment measurement are applied on the bladder through a type of heat transfer process.

### Utility Patent Landscape



*Fig. 6. US4688643A  
(Firefighting back tank and pump, n.d.)*



*Fig. 7. US20110192785A1  
(Hydration pack, n.d.)*

The first patent that I am looking at (Fig. 6.), is a novel portable flexible water tank and pump which can be carried on a firefighter's back and used for fighting forest fires. The water carrying backpack and water pump combination comprises: a flexible hollow waterproof water container; harness means attached to the water container suitable for securing the water container to the back (Firefighting back tank and pump, n.d.).



The other patent that I am looking at is A hydration pack includes a bladder attached to a pump via a feed tube and to a bite valve mouthpiece via a drinking tube. The bladder incorporates a filter cartridge which is capable of ultra-filtration and thereby effective to remove viruses as well as bacteria from water. The filter cartridge is coupled to the drinking tube such that any water that passes from the bladder to the mouthpiece must pass through the filter cartridge. The pump is able to act both to transfer water into the bladder and also to pressurize the bladder with air (*Hydration pack. n.d.*).

### Detailed S.W.O.T

Going into Winter term, I started a detailed S.W.O.T analysis of my benchmark product. At this stage the project's priorities were improving the **ergonomic problems** with the hose packs (such as mis-alignment on the line gear), addressing **stability issues** (water movement) and solving for **performance malfunctions** (such as gasket leaks). I started the S.W.O.T analysis by observing the different parts and subparts of the product in cross reference to the priorities. The parts I identified were: the outer bag, the straps, the liner, and the brass pump.



Fig. 8. Indian DBL Parts

Outer bag and ergonomics per part - Handle, velcro opening, nylon body, liner/hose hole, outer pocket.



Fig. 9. Outer bag and subparts

### Handle and Ergonomy

- i. What are the strengths of the outer bag **handle** and **ergonomy**?

*Rigid and durable.*

The construction and the material of the handle (flat nylon webbing) makes for a long lasting and rigid handle.

- ii. What are the weaknesses of the outer bag **handle** and **ergonomy**?

*Too rigid for minimal gloves and bare hands.*

The webbed nylon handle is rigid but it may be uncomfortable to handle with minimal gloves and bare hands.

- iii. What are the opportunities of the outer bag **handle** and **ergonomy**?

*Adding a rubber cylinder over the webbed handle.*

Adding minimal padding to the webbed handle or passing it through a short rubber cylinder would make the handle easy to hold even with bare hands.

- iv. What are the threats of the outer bag **handle** and **ergonomy**?

*Taking away from the natural feel.*

This may take away from the natural feel of holding the weighted water bladder through the handle.

### **Velcro opening and Ergonomy**

- i. What are the strengths of the outer bag **velcro opening** and **ergonomy**?

*Strong and sturdy velcro strip. You have to intentionally unpatch the strip from one end to the other.*

The opening of the outer bag consists of a half inch wide velcro strip that goes across the top of the bag and secures the liner bladder containing water. The velcro strip is quite sturdy, and you would have to intentionally rip it bit by bit across the top to open the bag. The location of the opening is very convenient and makes it easy for the liner to be taken out.

- ii. What are the weaknesses of the outer bag **opening** and **ergonomy**?

*Hard to grab, especially with gloves.*

The half inch velcro strip is hard to get a grip of especially when wearing gloves.

- iii. What are the opportunities of the outer bag **opening** and **ergonomy**?

*Easier grip access.*

Sewing a few tabs across the top could make it easy for a person with gloves to unpatch the velcro opening without having difficulties gripping the narrow velcro patch.

- iv. What are the threats of the outer bag **opening** and **ergonomy**?

*Hooking onto things.*

If these tabs are too large they may get in the way or hook onto things during activity.

### **Nylon body and Ergonomy**

- i. What are the strengths of the outer bag **nylon body** and **ergonomy**?

*Rough, form fitting, natural lumbar support, collapsible.*

The nylon body makes for an abrasion resistant and durable outer bag. The woven taffeta nylon body is rough and heavy but makes for a form fitting bag that molds to the back of the wearer. With the weight of the water staying at the bottom of the bag, this provides a natural lumbar

support when the bag is worn without a line gear. Finally, the nylon body material allows for the bag to be rolled when it is not in use.

- ii. What are the weaknesses of the outer bag **nylon body** and **ergonomy**?

*No way to hold the bag in a rolled position when not in use and no way to store the rolled bag.*

Although the bag is collapsible and able to be rolled when it is not in use, there are no features included to hold the bag in that rolled position. Furthermore there is no designated storage space for the rolled bag.

- iii. What are the opportunities of the outer bag **nylon body** and **ergonomy**?

*Closure/ locking feature for rolled up position.*

Adding a velcro hub to allow the bag to be held in a rolled position. Designating a place for the rolled bag to be stored, preferably on top of the line gear.

- iv. What are the threats of the outer bag **nylon body** and **ergonomy**?

*Hard to reach.*

If the designated storage of the rolled bag is set to be on top of the line gear, it might be hard for the wearer of the line gear to put the rolled bag on the top of the linegear (behind them) without having to take the line gear off completely.

### **Nylon body and Stability**

- i. What are the strengths of the outer bag **nylon body** and **stability**?

*Not identified.*

I have not identified the strengths of the outer bag nylon body and stability.

- ii. What are the weaknesses of the outer bag **nylon body** and **stability**?

*Form fitting.*

When considering ergonomy the form fitting aspect of the product is a plus but when taking into account the over stability of the fire pump bag, the free form becomes a problem. All of the water slouches to the bottom of the bag rather than an even distribution from top to bottom.

- iii. What are the opportunities of the outer bag **nylon body** and **stability**?

*Semi-rigid front and segmentation of the stored water.*

A semi-rigid front would give the outer part of the bag a little structure which may help address this problem. In addition, a segmented bladder system might divide the force of the water and make the movement of the smaller segment more stable.

- iv. What are the threats of the outer bag **nylon body** and **stability**?

*Intervenience of collapsibility and complexity of water flow.*

A semi-rigid front might now make the bag harder to put away and a segmented bladder system might make the flow of the water in the bladder more complex.

### **Liner/hose connection hole and Ergonomy**

- i. What are the strengths of the outer bag **liner/hose connection hole** and **ergonomy**?

*Ease of liner removal, and secure sitting of liner connection hub.*

The liner/hose connection hole on the outer bag makes it easy for the liner to be removed once the hose is disconnected from the connection hub. In addition, a thick circular plastic film is sewn on the outer of the cut out hole to allow the connection hub of the linner to sit properly when the liner is filled and connected to the hose.

- ii. What are the weaknesses of the outer bag **liner/hose connection hole** and **ergonomy**?

*Not identified.*

I have not identified a weakness.

- iii. What are the oppourtunities of the outer bag **liner/hose connection hole** and **ergonomy**?

*Absorption?*

The circular plastic film could be replaced with a material that has some absorption properties to it to soak the ocaasional gasket leaks.

- iv. What are the threats of the outer bag **liner/hose connection hole** and **ergonomy**?

*Might not be necessary.*

This may not be necessary.

### **Outer pocket and Ergonomy**

- i. What are the strengths of the outer bag **outer pocket** and **ergonomy**?

*Does not interfere with water storage and the rounded sewn corners secure stored items very well.*

The outer pocket storage leaves all of the room inside the bag for water storage explicitly. The rounded sewn corners of the pocket make it hard for the pocket to open - you would have to intentionally unpatch the velcro opening.

- ii. What are the weaknesses of the outer bag **outer pocket** and **ergonomy**?

*Rounded sewn corners make access to stored objects hard.*

The rounded sewn corners of the outer pocket make it hard to access the pocket.

- iii. What are the opportunities of the outer bag **outer pocket** and **ergonomy**?

*Opening at the top of the pocket would give more access room for storage and retrieval.*

If the pocket opening was at the top of the pocket in the same manner in which the opening of the outer bag is at the top of the bag, it would make the access of the objects stored in the pocket easier.

- iv. What are the threats of the outer bag **outer pocket** and **ergonomy**?

*Not identified.*

I have not identified a threat to this opportunity in regards to ergonomoy.

#### **Straps - Padded sleeve, nylon strap, buckles and adjusters.**



*Fig. 10. Straps and subparts*

#### **Padded sleeve and Ergonomy**

- i. What are the strengths of the **padded sleeve** and **ergonomy**?

*Breathable mesh, semi-rigid padding, nylon covering.*

The padded sleeve includes a breathable padded mesh that interfaces with the wearer's clothing. In the middle, we have a padding that is sturdy but flexible. On the outer, we have a softer gage nylon covering that makes the sleeves easy to grab when wearing and removing the fire pump bag.

- ii. What are the weaknesses of the **padded sleeve** and **ergonomy**?

*Padding is too sturdy.*

The padding in the middle is too sturdy and thin to absorb the weight of the bag especially at the shoulder level.

- iii. What are the opportunities of the **padded sleeve** and **ergonomy**?

*More padding.*

More padding is needed to make it more comfortable to carry 45 pounds on the shoulders.

- iv. What are the threats of the **padded sleeve** and **ergonomy**?

*Thick padding, harder to grab and wear.*

More padding might make the sleeve too thick and harder to grab during the wear process.

### **Webbed nylon strap and Ergonomy**

- i. What are the strengths of the **webbed nylon straps** and **ergonomy**?

*Sewn on the outer part of the padded sleeve.*

The webbed nylon is sewn on the outer side of the padded sleeve, this allows for most of the tension of the strap to be absorbed through the padded sleeve.

- ii. What are the weaknesses of the **webbed nylon straps** and **ergonomy**?

*Visibility.*

Both the webbed nylon straps and the padded sleeve are of black threads which can make it hard to see the webbed nylon in the dark.

- iii. What are the opportunities of the **webbed nylon straps** and **ergonomy**?

*Visibility.*

Using colored webbing for the nylon strap would make it easy for the strap to be distinguished from the padded sleeve in case of adjustments.

- iv. What are the threats of the **webbed nylon straps** and **ergonomy**?

*Might not be necessary.*

Although this might be a convenience it might not be a necessary change as wildland firefighters have headlamps.

### **Buckles and adjusters and Ergonomy**

- i. What are the strengths of the **buckles and adjusters** and **ergonomy**?

*Easy to remove, creates a fast way to wear the bag.*

The PPE/PE buckles allow for the easy detachment of the straps from the outer bag at the shoulder and hip level. This also creates an easy way to wear the bag without sliding the strap on both arms the typical way a bag would be worn.

- ii. What are the weaknesses of the **buckles and adjusters** and **ergonomy**?

*No traction, hard to grip with gloves.*

The PPE/PE buckles and adjusters have shiny and smooth finish which may make it hard for the user to grab and unclip the buckles especially when wearing gloves.

- iii. What are the opportunities of the **buckles and adjusters** and **ergonomy**?

*Add ridges for traction.*

Adding ridges on the buckles would improve grip when wearing gloves.

- iv. What are the threats of the **buckles and adjusters** and **ergonomy**?

*Thick buckles.*

The buckles might now be really thick.

**Liner - Body/ material, quick hose connection hub/ gasket.**





Fig. 11. Bladder Liner

**Body/ material and Ergonomy**

- i. What are the strengths of the liner **body/ material** and **ergonomy**?

*Collapsible.*

The liner body/material allows the liner to collapse and store easily.

- ii. What are the weaknesses of the liner **body/ material** and **ergonomy**?

*Not identified.*

I have not identified a weakness to the liner body/material in regards to ergonomoy.

- iii. What are the opportunities of the liner **body/ material** and **ergonomy**?

*Not identified.*

I have not identified an opportunity for linear body/material in regards to ergonomoy.

- iv. What are the threats of the liner **body/ material** and **ergonomy**?

*Not identified.*

I have not identified a threat to the liner body/material in regards to ergonomics.

### Quick hose connection hub/ gasket and Ergonomics

- i. What are the strengths of the liner **quick hose connection hub/ gasket** and **ergonomics**?

*Easy to maneuver.*

The quick hose connect mechanism has a criss-crossed-hatched texture that makes it really easy to hold and push downwards to release the hose.

- ii. What are the weaknesses of the liner **quick hose connection hub/ gasket** and **ergonomics**?

*Not easy to access.*

The quick hose connection hub/ gasket is right at the middle of the outer side of the bag.

- iii. What are the opportunities of the liner **quick hose connection hub/ gasket** and **ergonomics**?

*Moving the quick hose connection mechanism to the side.*

Moving the location of the quick hose connection hub/ gasket to the side of the fire pump bag would allow the user to disconnect the hose from the liner without having to remove the bag all together.

- iv. What are the threats of the liner **quick hose connection hub/ gasket** and **ergonomics**?

*Minor interference with collapsibility.*

This might interfere with the way the bag is intended to be rolled up.

### Pump - Cylinder Assembly and Hose.

#### Cylinder Assembly - cap nut + foot valve + inner cylinder + nozzle adapter + hand grip



*Fig. 12. Pump and subparts*

### Cylinder Assembly and Ergonomy

- i. What are the strengths of the pump **cylinder assembly** and **ergonomy**?

*Wide extension and compression range, overmolded padding.*

The cylinder assembly is long and allows for a full extension and compression for optimal performance. The overmolded padding at the base gives the user the necessary traction to compress the pump with ease.

- ii. What are the weaknesses of the pump **cylinder assembly** and **ergonomy**?

*Nowhere to put the pump.*

One of the biggest complaints wildland firefighters have is that there is no wear to put this big pump cylinder assembly when the bag is not in use. The user has to hold the pump in their hands at all times and would have to drop it to the ground if they need to grab something or use their hands for something else such as adjustments.

- iii. What are the opportunities of the pump **cylinder assembly** and **ergonomy**?

*Storage hub for bras pump.*

There is an opportunity here to sew a small hub for the pump cylinder assembly on the left or the right strap of the bag.

- iv. What are the threats of the pump **cylinder assembly** and **ergonomy**?

*Not properly secured.*

The threat to this would be if the pump is not secured properly or just at one point of the bras, this would lead to unnecessary movements of the pump.

### Hose - tube + connector + clamp





Fig. 13. Pump hose connections

### Hose tube and Ergonomy

- i. What are the strengths of the **hose tube** and **ergonomy**?

*Rolls up to a certain extent.*

The tube is rigid and intended to last. As rigid as it is, it can at least be rolled when the pump is not in use.

- ii. What are the weaknesses of the **hose tube** and **ergonomy**?

*Too sturdy to roll up all the way.*

Although the hose rolls up about two times, it may still be in the way and hard to deal with when not in use.

- iii. What are the opportunities of the **hose tube** and **ergonomy**?

*Retractable hose, circular hub.*

The hose may perhaps use a retractable mechanism which would get it out of the way when the product is not being used.

- iv. What are the threats of the **hose tube** and **ergonomy**?

*Taking up water storage room.*

A retractable mechanism may be too complicated for the simple nature of this product and may take away some of the room intended for water storage.

### Hose connector and Ergonomy

- i. What are the strengths of the **hose connector** and **ergonomy**?

*Easy to grab with gloves.*

The square shape of the hose connector makes it easy to grab even with gloves when looking to detach the hose from the liner connection hub/ gasket.

- ii. What are the weaknesses of the **hose connector** and **ergonomy**?

*Possibility to injure a close by partner*

This square shape connector becomes the outermost point of the fire pump bag when it is in use. A brusque swing with someone behind could potentially lead to an injury.

- iii. What are the opportunities of the **hose connector** and **ergonomics**?

*Overmolded covering*

Including a sort of over the square piece could prevent these odds.

- iv. What are the threats of the **hose connector** and **ergonomics**?

*Harder to grab*

While this could eliminate the odds of injury, this overmold may also make this piece harder to grab, especially with gloves.

### **Hose connector and Performance malfunctions**

- i. What are the strengths of the **hose connector** and **performance malfunctions**?

*Easy to plug and remove.*

The hose connection system is an easy one to work with - users can disconnect the hose in a split second.

- ii. What are the weaknesses of the **hose connector** and **performance malfunctions**?

*Occasional leaks.*

Leakage unfortunately occurs as there is no rubber padding or overmold in the system - only metal on metal - and water finds a way to move through.

- iii. What are the opportunities of the **hose connector** and **performance malfunctions**?

*Overmolding and rubber use.*

Including rubber in the system may ensure complete sealage of the connection system.

- iv. What are the threats of the **hose connector** and **performance malfunctions**?

*Manufacturing difficulties and wear over time.*

The overmolded rubber parts may wear over time and may be difficult to include on the tip of the metal connectors.

## Hose clamp and Ergonomy

- i. What are the strengths of the **hose clamp** and **ergonomy**?

*Not a lot of short term tightening.*

The newer models are permanently clamped as opposed to the older models that had screws. Users do not have to worry about tightening the clamp.

- ii. What are the weaknesses of the **hose clamp** and **ergonomy**?

*Manual pressure tightening over time.*

If the clamp gets loose over time, users would have to apply pressure with a sort of compression tool.

- iii. What are the opportunities of the **hose clamp** and **ergonomy**?

*Marmon clamp.*

Using a Marmon clamp would give the user the ability to tighten the hose with a screw and allow for easy release without having to unscrew the clamp.

- iv. What are the threats of the **hose clamp** and **ergonomy**?

*Involuntary release.*

This might leave room for involuntary release if the hose hits something.

## Benchmark Research

Moving into benchmark research, my priorities were to understand the experience that firefighters had when wearing both the hose pack and linegear, and also what effects such an accumulated load had on the firefighters. I also wondered if the distribution of the loads changed anything about their spinal flexion and walking gait. Before testing on anyone, I decided to wear the bag myself in a similar environment to that in which wildland firefighters would perform.

## Pretest



*Fig. 14. Pretest hose pack strapped to line gear*

Only having the hose pack at the time, I used a substitute hiking back that had a similar backrest as the shift 900. With it I packed a weight of 35 pounds and formed it to be similar to the silhouette of the shift 900 line gear. During my assessment drills I experienced what it was like to fill the bag, I experienced how it is like to try and load the bag on yourself (which is very hard to do unless you have a ledge you could squat near or get assistance), I experienced the effects the straps of the two bags had on the shoulder and I also tried hooking the hose pack to the line gear to simulate a combined load like shown in (Fig. 14). From this pretest I noted that I

needed a more controlled environment to collect data and I was able to structure an official truck flexion observation metrics test.

### **Ergonomic Metrics**

This research will assess ergonomic and stability metrics the range of “trunk flexion” under varying load arrangements in three environmental conditions with the hope of understanding the strain put on the lumbar spine.

### **Leakage Metrics**

This research will assess if leakage frequency on bladders to better understand if it is a serious problem and where it occurs.

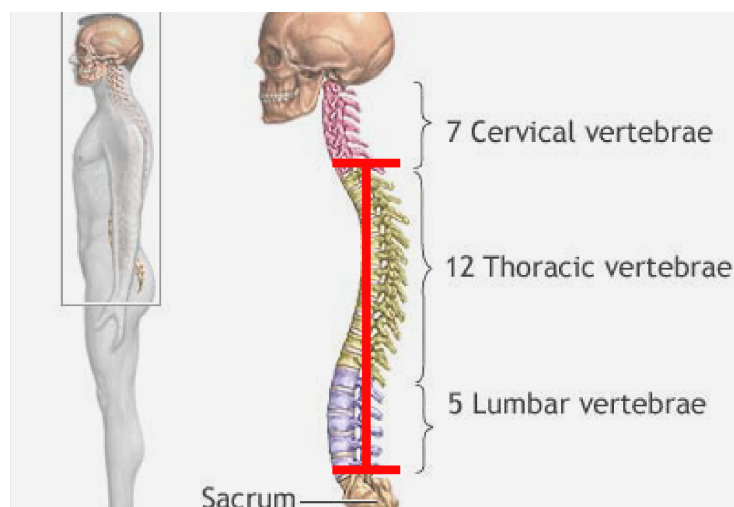
### **Methods and Materials**

**Location of Study:** I will be conducting the majority of my study at the nexus lab on campus.

**Materials of Study:** I will be using a treadmill, a tripod, a camera and body markers.

**Method:** Recording the participant’s walk cycle without any load, with the standard load alignment, and with the hose pack strapped to the line gear (resulting in the use of 1 strap) over a flat slope and a 12% inclined slope on a treadmill. All together we are looking at 6 drills, 2 being walks without loads. The participant will walk for 2 minutes in each drill. With the captured video, I intend to examine 3 frames of the 2 minutes - one towards the beginning of the walk, one towards the middle and the last frame towards the end - to properly assess the effects of the load on the athlete over time. To adequately assess this information I decided to use body markers to generally mark the bottom of the Cervical Vertebrae to the bottom of the Lumbar vertebrae as shown in Fig (15). With my recording I will mark the flexion between these two point and later compare them to the same test with my product.





*Fig. 15. Cervical vertebrae to lumbar vertebrae*

**Timing:** I am planning on conducting the research on 2 different days. Ergonomic and Stability Metrics on 1 day and Leakage on another. I am estimating the Ergonomic and Stability Metrics to take about 1 hour per participant.

### Ergonomic Metrics

Phase of Study	Procedure	Data Collected	Timing
<b>Reach out to participants.</b>	via social media, and amongst SPD classmates. (Making sure the subject is apt to carry a load of 60+ pounds).	No data collected.	Throughout 1 day (2 hours).
<b>Participant confirms participation.</b>	Confirmation.	No data collected.	N/A
<b>Basic Data Collection.</b>	Document participants Name, Weight and Height.	Name, Weight, Height.	2 mins <.
<b>Explanation of Drills.</b>	Explaining the different drills.	No data collected.	5 mins.
<b>Ergonomic Metric test begins on campus.</b>	Participant meets me on campus in	No data collected.	N/A Time it may take for

	the green room		participants to meet me on campus will depend on the participant.
<b>Camera Setup.</b>	Set up-camera.	No data collected.	5 mins.
<b>Orthographic stills 1.</b>	Orthographic video taken. 5 second for each direction.	4 sides no load 5 seconds each	1 mins.
<b>Orthographic stills 2. Standard Load (hose pack+ line gear)</b>	Orthographic video taken. 5 second for each direction.	4 sides no load 5 seconds each	1 mins.
<b>Orthographic stills 3. Load 2 (hose pack strapped to line gear)</b>	Orthographic video taken. 5 second for each direction.	4 sides no load 5 seconds each	1 mins.
<b>Slope Form 1 + Weight Load 1 (no load).</b>	Participants walk on slope form 1: flat slope with no weight.  Camera set up on parallel and back	Normal gait will be recorded from side and back.	2 mins.
<b>2 min Break w/ questions.</b>	Participants rest and answer questions.	Trunk flexion compensation on a scale of 1 - 10.	2 min.
<b>Slope Form 1 + Weight Load 2 (vertical arrangement).</b>	Participants walk on slope form 1: flat slope with vertical weight arrangement.  Camera set up on parallel and back	Gait recorded from side and back.	2 mins.
<b>2 min break w/questions.</b>	Participants rest and answer questions.	Trunk flexion compensation on a scale of 1 - 10.	2 min.
<b>Slope Form 1 +Weight</b>	Participants walk	Gait recorded from	2 mins.

<b>Load 3 (Horizontal arrangement).</b>	on slope form 1: flat slope with horizontal weight arrangement.	side and back.	
<b>2 min break w/questions.</b>	Participants rest and answer questions.	Trunk flexion compensation on a scale of 1 - 10.	2 min.
<b>Orthographic stills 1.</b>	Orthographic stills of posture taken.	1 Side view.	2 mins.
<b>Slope Form 2 + Weight Load 1 (no load).</b>	Participants walk on slope form 2: flat slope with no weight.	Gait recorded from side and back.	2 mins.
<b>2 min Break w/ questions.</b>	Participants rest and answer questions.	Trunk flexion compensation on a scale of 1 - 10.	2 min.
<b>Orthographic stills 2.</b>	Orthographic stills of posture taken.	1 Side view.	2 mins.
<b>Slope Form 2 + Weight Load 2 (vertical arrangement).</b>	Participants walk on slope form 2: flat slope with vertical arrangement.	Gait recorded from side and back.	2 mins.
<b>5 - 10 min Break w/ questions.</b>	Participants rest and answer questions.	Trunk flexion compensation on a scale of 1 - 10.	2 min.
<b>Orthographic stills 3.</b>	Orthographic stills of posture taken.	1 Side view.	2 mins.

<b>Slope Form 2 + Weight Load 3 (Horizontal arrangement).</b>	Participants walk on slope form 2: flat slope with horizontal arrangement.  I will be walking parallelly with a Stabilizer and camera.	Gait recorded from side and back.	5 mins.
<b>5 - 10 min Break w/ questions.</b>	Participants rest and answer questions.	Trunk flexion compensation on a scale of 1 - 10.	5 - 10 min.

### Ergonomic Metrics and Results

These are orthographic stills I was able to export from a video of the participant wearing the two packs, from this I was able to observe the current or standard posture.



*Fig. 16. Orthographics Stills*

### Treadmill Drills

Taking 3 frames from each of the drills and marking the bottom of the Cervical Vertebrae to the bottom of the Lumbar vertebrae as shown in Fig (15), this is the data I established:



*Fig. 17. Slope 1*

*Fig. 18. Slope 2*

I will re-conduct this test with my product and compare the results.

### Leakage Metrics and Results

<b>bladder filled with water.</b>	Filling the bladder to full capacity.	No data	5 - 10 min.
<b>New bladder weighted.</b>	Weight.	45 lbs	1 hour.
<b>Bladder weight after 1 hour.</b>	Weight.	44.80 lbs	1 hour.
<b>Bladder weight after 2 hour.</b>	Weight.	44.33 lbs	1 hour.
<b>Bladder weight after 3 hour.</b>	Weight.	44.25 lbs	1 hour.
<b>Bladder weight after 4 hour.</b>	Weight.	44.03 lbs	1 hour.
<b>Bladder weight after 5 hour.</b>	Weight.	43.87 lbs	1 hour.
<b>Bladder weight after 6 hour.</b>	Weight.	43.64 lbs	1 hour.
<b>Bladder weight after 7 hour.</b>	Weight.	43.42 lbs	1 hour.
<b>Bladder weight after 8 hour.</b>	Weight.	43.18 lbs	1 hour.

I noticed that the bladder lost an average of 2lbs over the 8 hours it was suspended and deemed this problem secondary to the alignment issue.

### **Consumer Research Method, Questions, and Results**

To better understand firefighter experiences and preferences around the current hose pack and particularly how it works with the line gear, I put together a survey with google forms to which I received 12 responses.

**Consumer research (experience and preferences)**

I am a Sports Product Design student at UO looking for Wildland Firefighters' experience and preferences around the Indian Chief Dual Bag Fire Pump. I am looking to understand this product, how it is carried and particularly how it interfaces with your line gears with the hopes of improving it.

- Intro Questions.
- Dual Bag Fire Pump
- Line Gear + Features
- Ergonomic experience (Line gear + Fire Pump bag)
- Straps and Buckles Maneuvering/ with gloves.

The survey covered introduction questions such as their height and how long they have been firefighters, questions about the line gear features, questions about the ergonomic experience of wearing the hose pack with the line gears and strap/ buckle preferences.

**Dual Bag Fire Pump**

- How do you fill the bag with water? (ex: plunge it in water, remove the liner from the nylon bag and put it back, etc...).
- Do you fill the bag prior to getting on site?
- Do you fill the bag at full capacity?
- On a scale of 1 - 10 how hard is it to wear the water bladder once it is full?
- How long on average does it take to use the 5 gallons? ( ex: 1 hour, 3 hours, etc...).
- How often do you experience gasket/ hose connection leaks?
- If yes, what are some make shift solutions you have used in the past to prevent this problem?

**Line Gear + Features**

- What line gear do you wear on the job?
- What 2 features do you like/ dislike about it?

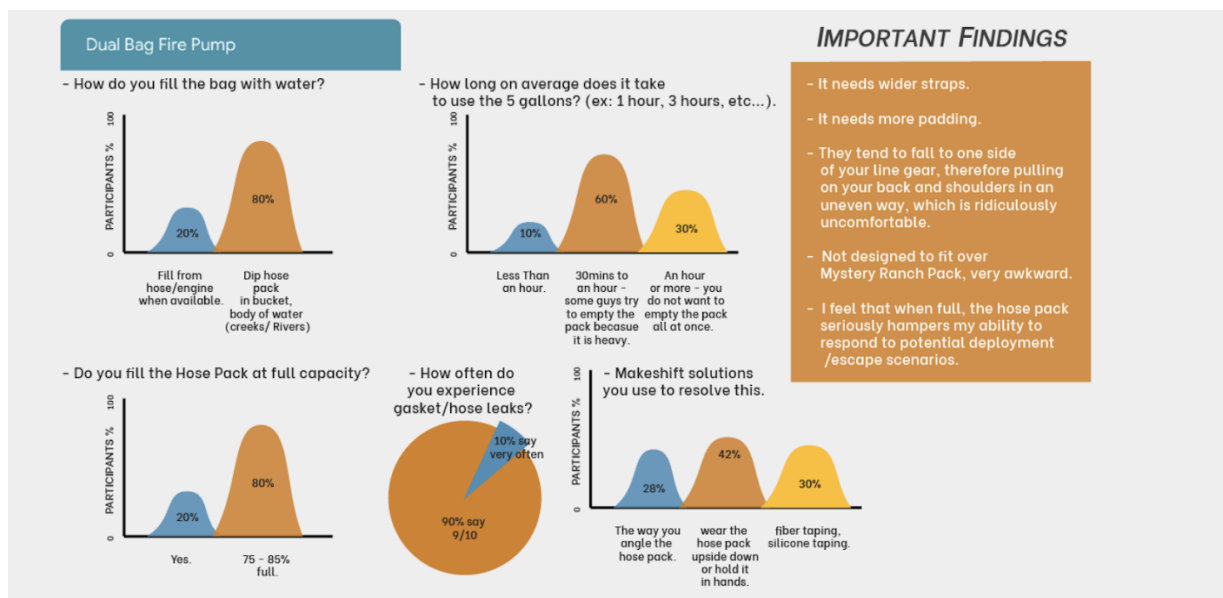
**Ergonomic experience (Line gear + Fire Pump bag)**

- When wearing a fire pump bag, how low do you have your line gear?
- Have you experienced any lower back strains when stacking a fire pump bag over your line gear?
- How do you relieve the stress put on your lower back?

**Straps and Buckles Maneuvering/ with gloves.**

- Do you prefer wider or thinner straps?

## Important Consumer Research Findings



Some important findings were that: 80% of users do not fill their hose packs to full capacity because it may inhibit their ability to escape in dangerous situations, some firefighters wear their hose pack upside down to have the hose connection facing up just do avoid leaks, they

wear the hose pack from anywhere between 1 hour to 2 on average consideration the hike to location time, the interfacing of the two products is really awkward and they do not enjoys the double straps.

### **Important Findings from Benchmark and Consumer test**

Based on the athletes feedback from the drills, I established that 3 problems to not were: the pressure on the athlete's shoulder due to the two forces pulling downward and the athlete's lack of ability to use their hips to support the load, the lack of proper interfacing of the two bags, and the need for reducing and reallocating the weight on the athlete to allow the forces to equally revolve around the center of the user's mass.

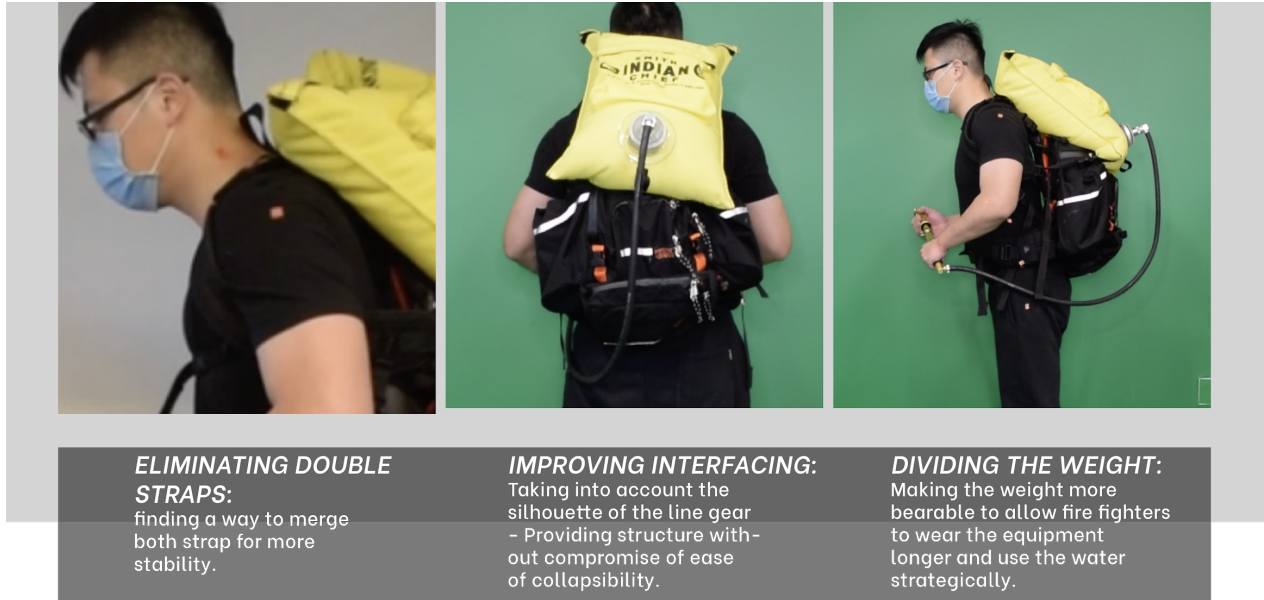
<p><b>SHOULDERS GET ALL THE PRESSURE:</b> Wildland firefighters are wearing to straps that pull downwards.</p>	<p><b>BETTER INTERFACING NEEDED:</b> The hose pack is not designed with the line gear in mind.</p>	<p><b>BETTER ERGONOMICS:</b> The weight sum adds up to over 80 lbs, a weight offset would allow better posture over time.</p>
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*Fig. 18. Important Benchmark and Consumer Findings*

### **Ideation Planning and Manufacturing**

Going into ideation I decided to focus on the 3 points shown in Fig 19: improving the straps, taking into account the silhouette of the line gear and dividing the weight.





*Fig. 19. Important Benchmark and Consumer Findings*



*Fig. 20. Line gear bump*

I began to ideate around this bump which is consistent across all line gears (Fig 20). I started to think about the idea of having a rigid base which mimicked this shape.



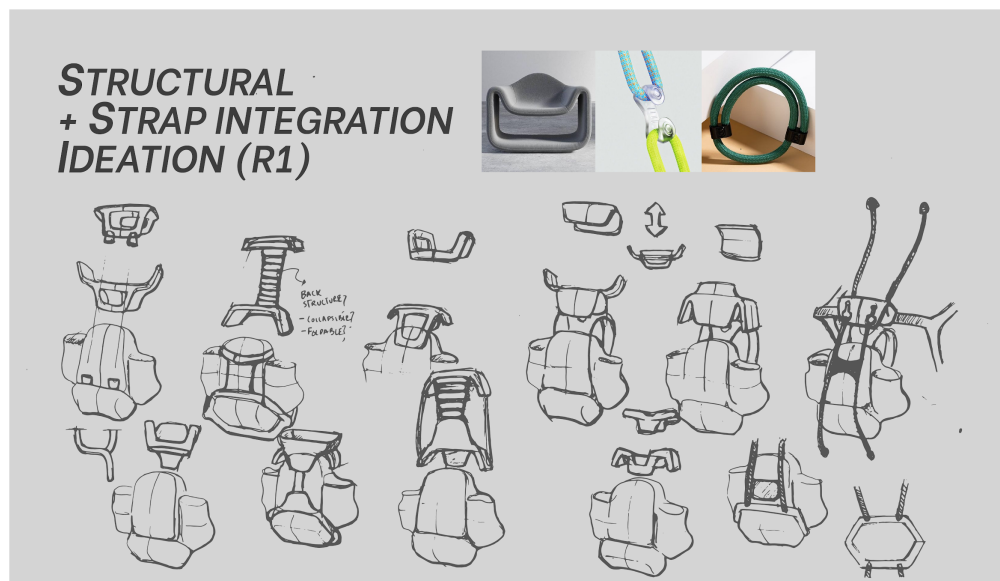
*Fig. 21. Ideation Round 1 Structural Base*

I also looked at how to provide structure without adding weight and without compromising the ability for the upper to collapse. Observing the manner in which the backrest of the line gear itself was made gave me the idea of how to do it by using lightweight/flexible materials and reinforcing them with metal pieces where rigidity was needed the most. With this I was able to develop these base/ structural models (Fig 22.)



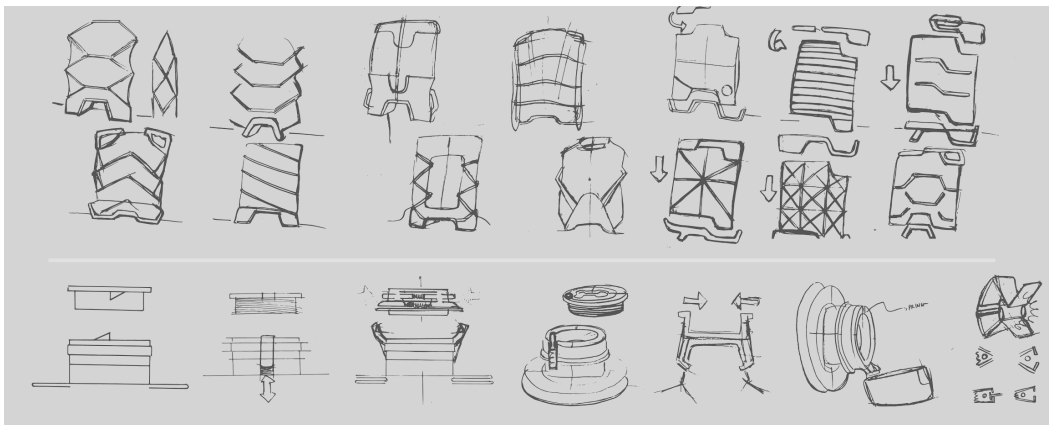
*Fig. 22. Structural Base Manufacturing*

I continued ideating around ways to keep the base strapped or integrated to the line gear with rope, cords and straps as shown above.

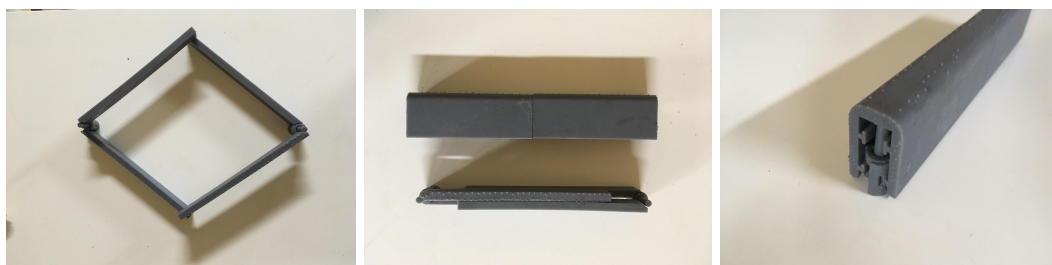


*Fig. 23. Strap and integration*

I continued ideating around the idea of collapsibility and also looking at different ways to address the leakage problem as shown in Fig 23.



*Fig. 23. Collapsible upper and different secure bladder openings.*



*Fig. 23. Bladder opening proposal.*

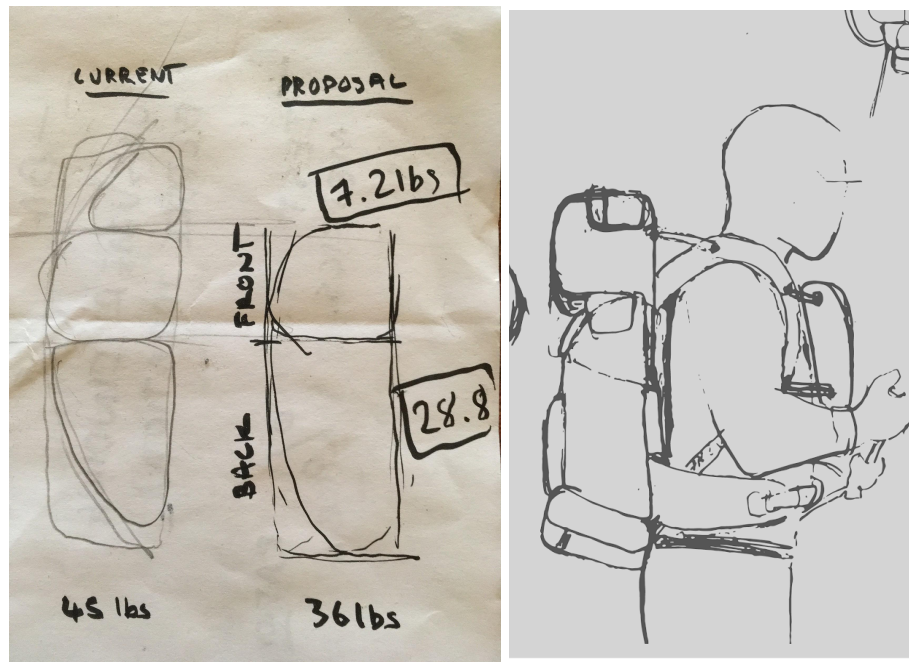
### **Leakage Problem**

To address the issue of leakage I 3D modeled and diamond shape opening that would be located at the top of the bladder. When opened it adopts a diamond shape. The athlete then closes it in a straight line and slides over a double tracked rubber piece over the closure. The location and the mechanism should prove to address leakage problems.

### **Weight Division and Redistribution**

To address the issue of load I looked at the overall load and assessed division by geometric proportions. I looked at reducing the overall weight by 20% as most firefighters only fill their bladders up to 80% capacity. From there I further divided the now 36 pound into two,

moving 20% of that to the front of the athlete resulting in 28.8lbs now on top of their regular 35+ lbs pack and 7.2lbs in a slim tall bladder intended to be worn on their front side.



*Fig. 23. Weight division logic.*

### **Liner and Outer Manufacturing**

I continued my ideation by looking at different ways the outer bag and structural base could work together and ended with 36 sketches (Fig 24), from there I narrowed down to 10 patterns and began to explore those shapes for the liner and the outer parts of the product (Fig 25)(Fig 26).

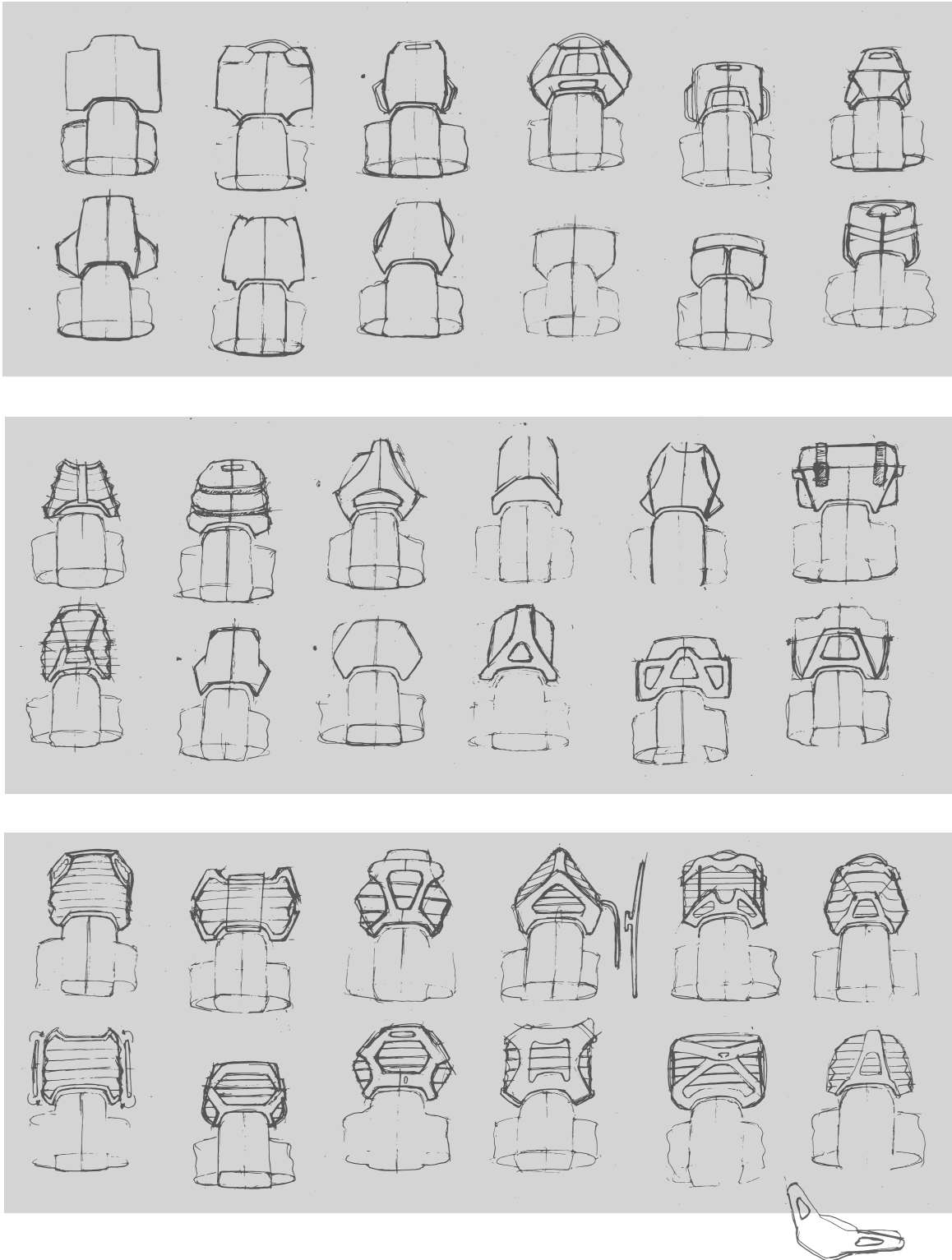


Fig. 24. Weight division logic





*Fig. 25. Liner making.*



*Fig. 26. Outer bag making.*



*Fig. 27. Ensemble Aqua Chaser.*

## Conclusion

As the threat of fire is likely to persist year after year, it is important to provide wildland firefighters with better fighting tools that have the potential to increase work efficiency. While the current fire pumps on the market are reliable as stand alone products, crewmembers find themselves having to wear the heavy water bladders over their line gears which results in them wanting to disperse the water as fast as possible. The ideal situation would be to have them carry the water comfortably so they could strategically use their water reserve over a longer period of time. The Aqua Go Chaser sought to provide a product that interfaces perfectly with firefighter's line gear's and allows them to adopt a better spinal form while performing.

## Project and Strengths alignment



The project topic of improving on-body water transportation for wildland firefighters will certainly be one consisting of a lot of trial and error through the concept development and prototyping phase. **Context** describes people that understand today best once they have had a chance or opportunity to make sense of the past it is a strategic theme (Gallup, 2019) - I think this project aligns to this particular strength in that to be successful at creating a really good solution, I would have the intuition to establish a strong base and understanding of the solutions have been developed in this area and why they might have failed. **Harmony** describes people who are talented at helping a group find areas that they agree on (Gallup, 2019), I hope this strength would allow me to develop good relationships with the stakeholders that I will be working with on this project.

### **How Do You See This Body of Work Supporting Your Career**

I am hoping to develop a portfolio that showcases my ability to work with both hard and soft parts. This project is just perfect for that - throughout my ideation and model making I have had to experiment with different materials to develop the proposal of a soft good product that interacts with a lightweight structure. Furthermore I am also interested in demonstrating my ability to translate these designs digitally both at an explorative level around the potential of future technologies and also at a state-of-the-art level demonstrating the stories around any product that solves a problem. Looking at the state-of-the-art level, the three stories that I think are important to tell for any product that solves a problem including: the demonstration of the problem's circumstance, what the features of the proposed solution are, and how those features effectively address the problems to be solved. With this project I also want to do that. I would like to show my future employer that I am a designer with knowledge of how products are made and that I am also able to tell the stories around it in a visually engaging manner through

animation. Some of the job titles that I am looking at include Immersive experience designer, Visual experience designer and 3d Motion graphics artist.

### **Mentor Mapping**

#### **Nikki Dunsire**

#### **Faculty & Immersive Technology Lab Manager (Oregon Reality (OR) Lab) at the University of Oregon**

Nikki has been my teacher for motion graphics and immersive design and maya modeling, she is very well connected in the industry and will have a good comprehension of the animation standards I am hoping to achieve.



From [Nikki Dunsire](#) on 2021/03/03 14:57

[Details](#) [Plain text](#)

Hi Charbel,

Totally understand. Of course I'm open to mentoring. Just let me know when you want to connect. Happy to help where I can. 😊

Best,  
-N

Nikki Dunsire  
Faculty | Oregon Reality Lab Manager  
ndunsir5@uoregon.edu

#### **Barton Damer**

#### **Owner & Founding Artist of Already Been Chewed**

Already Been Chewed is a design, motion graphics and 3d animation studio I founded in 2010. Barton Damer serves as the Owner and Creative Director. In the last 8 years the firm has handled the demands of creative projects for Nike, Vans, DC Shoes, Marvel, DC Comics, Patagonia, Ubisoft, MTV, Nixon x Star Wars, and The Dallas Mavericks among others. They are a small firm of 9 including himself.

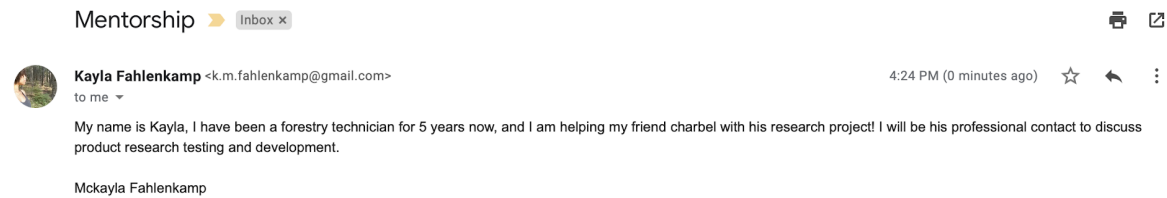
#### **Celeste Leizer**

**Lead compositor - Introduction intended to be done through Daniel Calabrese**

## Kayla Fahlenkamp

### Wildland Firefighter - Darrington ranger station

Kayla is a dedicated Wildland Firefighter who loves the firefighting profession. She has been my go-to for through this initial research phase and is willing to contribute as a member of my network and as a mentor.



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*A FORMATION OF 18 - 20 MEN & WOMEN WHO  
FIGHT FOREST FIRES USING A VARIOUS NUMBER  
OF FIRE SUPPRESSION METHODS.*

## INITIAL ATTACK



GET THE ALERT ABOUT A FIRE.



DRIVE AS CLOSE AS POSSIBLE TO THE LOCATION.



THE IC MAKES A PLAN OF ATTACK.

## ITEMS THEY CARRY



5 QT Water

Baby wipes

Radio

Fire Shelter

Electrolyte Powder

Fuses

Lithium Battery

Head Lamp

Lunch/Snacks

Bandanas

Compass

2 Cigs  
(1QT Oil & 1 QT gas mix for saw)

*They travel with a line gear and a "Red bag". Most of the items they need on the job are kept in their line gear. Items line their tent and sleeping bag are kept in the "Red bag".*





*Wet mopping is a task that requires firefighters to wear a 45lb water bladder over their line gear. This task is performed to turn off hot spots & remove all heat after a fire.*

## INITIAL CONSUMER RESEARCH

Dual Bag Fire Pump

To your knowledge and experience, what are a few tasks the fire pump bag is used for?  
12 responses

- Used in mop up work, also when we don't have a hose near us, we use these bags to carry into the fire
- Killing your back and giving the rookies on crews the job of carrying them... but being serious they are used for Mop up operations to extinguish hot areas of ash or burned up trees. They work great but definitely suck when out on top of your 45lbs pack your carrying.
- Mop up, small hard to get to initial attacks
- Cooling hot spots during mop up
- Mopping up (making sure there is no heat left after a wildfire), generally used for stump holes that hold heat or hot ash

*The task of carrying the overall load is such a hassle that it is thought of as a "punishment" and is often pushed on to the rookies.*

*Due to improper interfacing of both bags the water bladder sometimes slides on one side of the line gear more than the other pulling on the shoulders in an improper manner.*



# INITIAL BENCHMARK RESEARCH



Recorded walk cycles with 2 loads over 2 slope forms from a lateral and posterior view for 2 mins.

- SHOULDERS GET ALL THE PRESSURE
- BETTER INTERFACING NEEDED
- BETTER ERGONOMICS

# PROJECT GOAL



1. LONGER FIGHT TIME & IMPROVING ENERGY EXPENDITURE.



2. ERGONOMIC & SUPPORT.



3. INCREASED ACCESS & IMPROVED USABILITY.

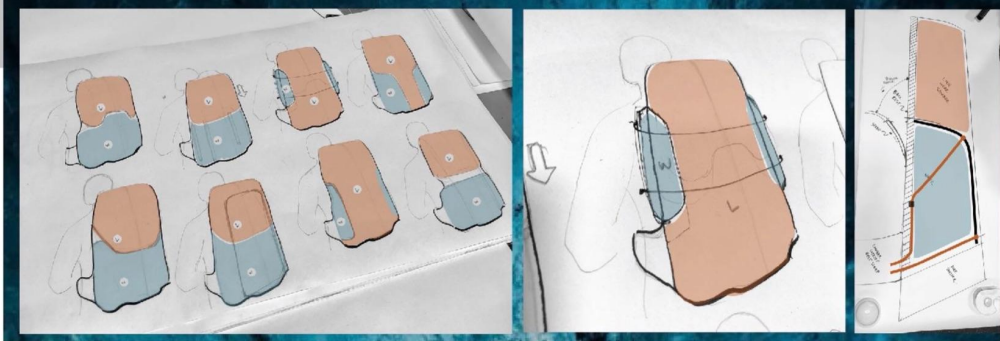
## IDEATION/ DIRECTION



*I initially explored how it would be possible to improve the interfacing of the bladder and line gear.*

*I explored this direction by prototyping solid bases for the bladder keeping the silhouette of the line gear in mind.*

## FINAL CONCEPT DIRECTION



*After receiving advise from bio-mechanic experts, i then begun to think of how i could keep the heaviest load (the water) close to the body.*

*My final direction looked at how I could design a bag with the proper integration of both the bladder and line gear.*

## INSPIRATION



The 2400 series ice climbing backpack



THULE WOMEN'S LANDMARK 70L BACKPACK



OSPREY MEN'S VOLT 75 PACK



Deuter Men's aircontact lite 40 + 10 Pack Black/graphite

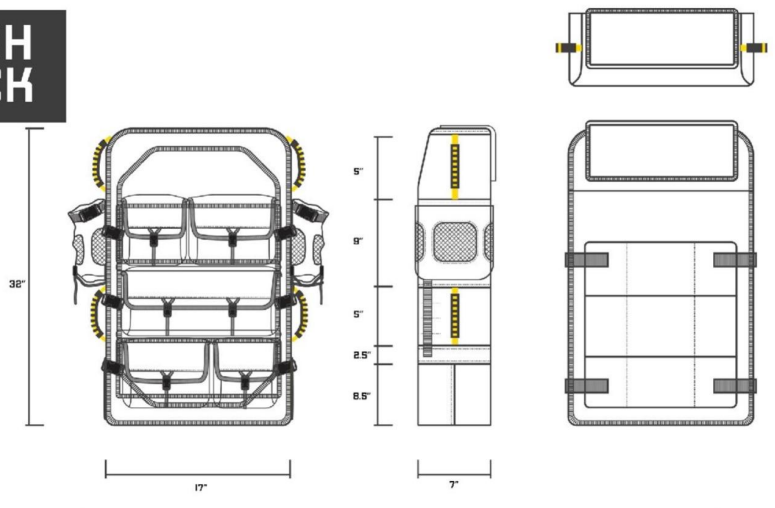
For the ensemble inspiration i looked at hiking bag on the market.

## TESTING CONCEPT





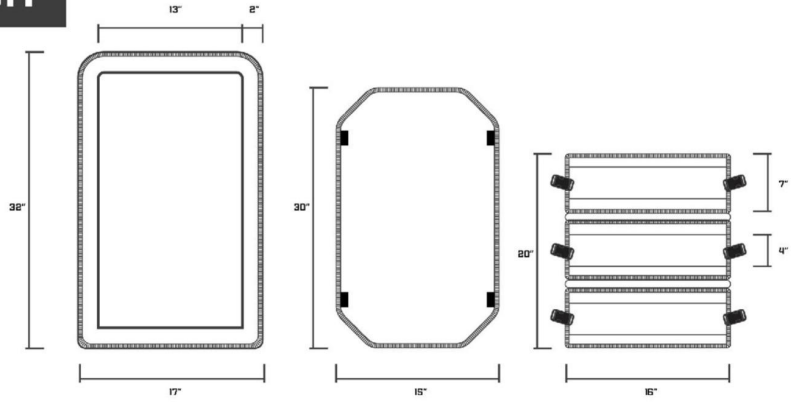
**TECH  
PACK**



<b>AQ   G</b> <b>UA   O</b>	AQUA SHELL		SAMPLE SIZE M
	SEASON: SPRING 2026	CHARBEL HOUIATO	

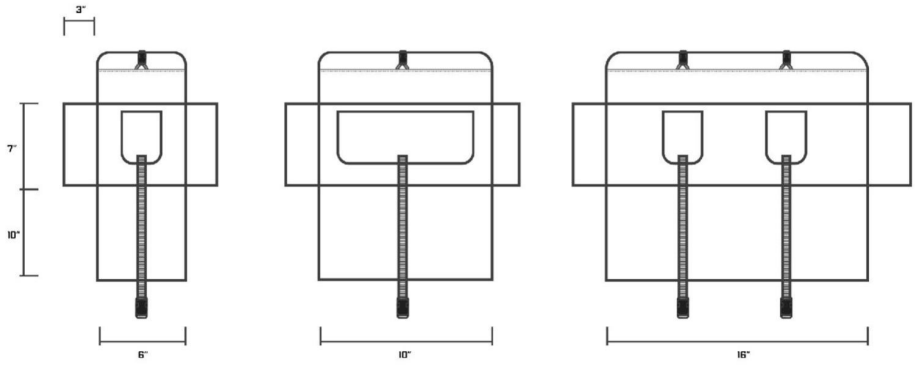


**TECH  
PACK**



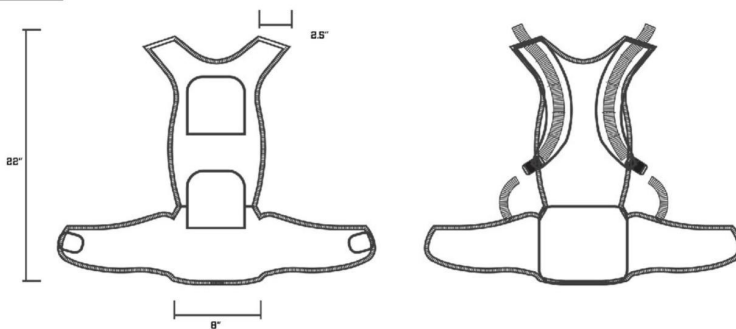
<b>AQ   G</b> <b>UA   O</b>	FRONT OPENING COMPONENTS		SAMPLE SIZE M
	SEASON: SPRING 2026	CHARBEL HOIJNATO	

**TECH  
PACK**



<b>AQ   G</b> <b>UA   O</b>	FRONT POUCHES		SAMPLE SIZE M
	SEASON: SPRING 2026	CHARBEL HOIJNATO	

**TECH  
PACK**



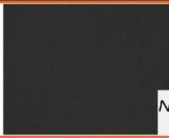





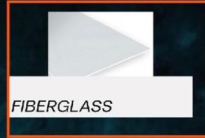
<b>AQ   G</b> <b>UA   O</b>	BACKREST		SAMPLE SIZE M
	SEASON: SPRING 2026	CHARBEL HOINATO	

**MOODBOARD**



*MODULAR // SECURE // EFFICIENT*

# MATERIALS & SPECIFICATIONS

BODY MATERIALS + COLORS				NOMAX
	<i>Flame resistant nomax will be used to ensure the materials in the bag will be protected against extreme temperatures.</i>			
MESHES + FOAMS				
	<i>56" TECHNO 3D SPACER MESH    MEDIUM MESH Polyester    Intek® PFI-1120 high-temperature foam</i>			
SEW-ABLE HARDWARE				
	<i>SEW-ABLE TRACKS    SEW-ABLE D-RINGS</i>			
REINFORCEMENTS				FIBERGLASS



## ATHLETE FEEDBACK



[Click here to play audio](#)

Kayla Fahlenkamp

## BIO-MECHANICS FEEDBACK



[Click here to play audio](#)

Emily Karolidis



