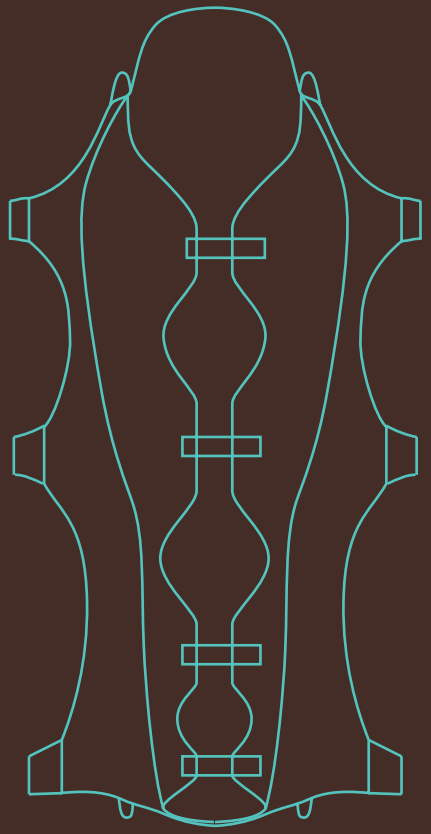
# XSPAND STRETCHER



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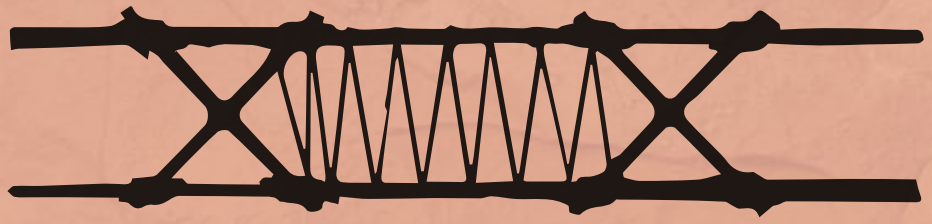
**MEDICAL DESIGN | JEFF KAPEC**
**PRATT INSTITUTE | FALL 2016**

# SCENARIO

Here, in the heart of Utah's Canyonlands, some of the best climbing and trekking in the world is far from emergency response. If a team-member breaks his back, neck, or leg, how do you carry out to medical care?



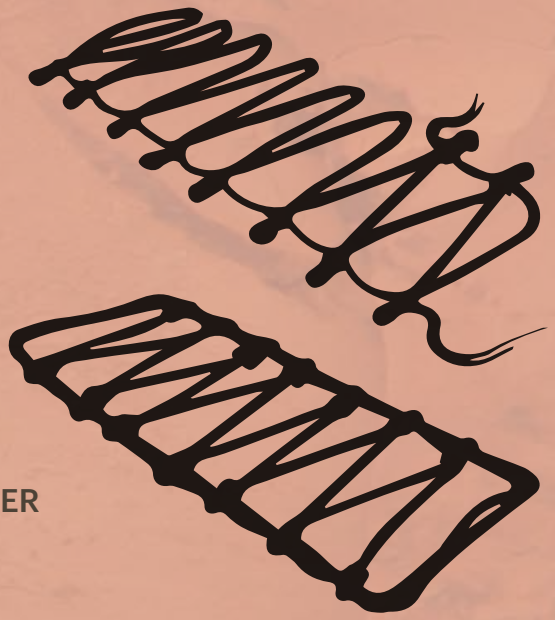
TRADITIONAL BUSH STRETCHER

ROLLED BLANKET STRETCHER

STRETCHER FROM SHIRT

# IMPROVISE

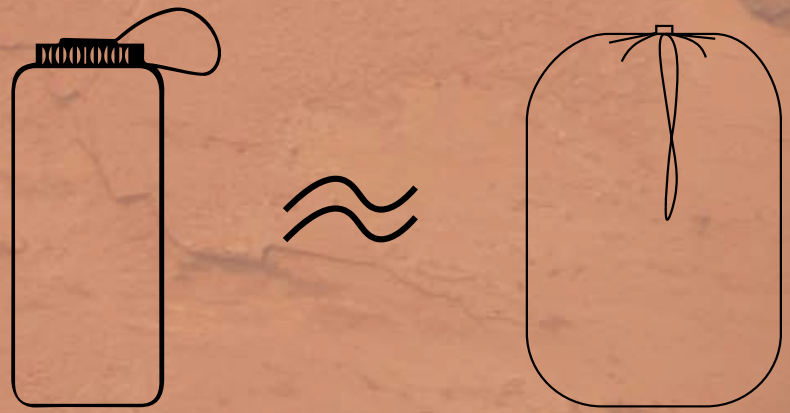
With a spine or neck injury, it is vital to keep the patient immobilized while transporting to medical care. Current wilderness medicine education teaches improvisation with materials at hand. But these do not fully immobilize, and if there are no trees in the area, are structurally unsound.



ROPE STRETCHER

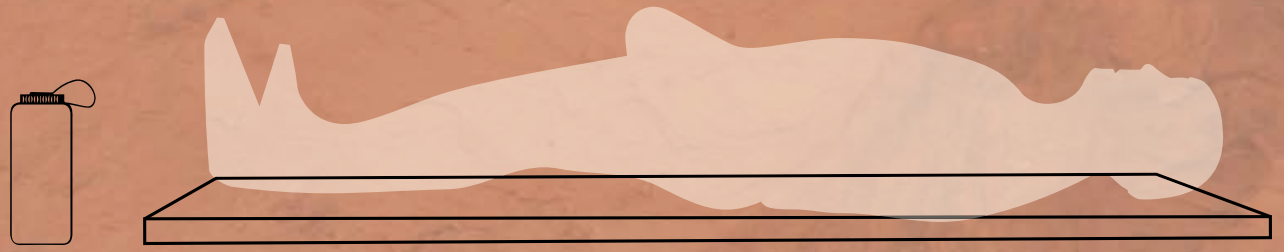
# SOLUTION

A piece of equipment that can be carried on every expedition, which:



**STARTS SMALL AND COMPACT...**

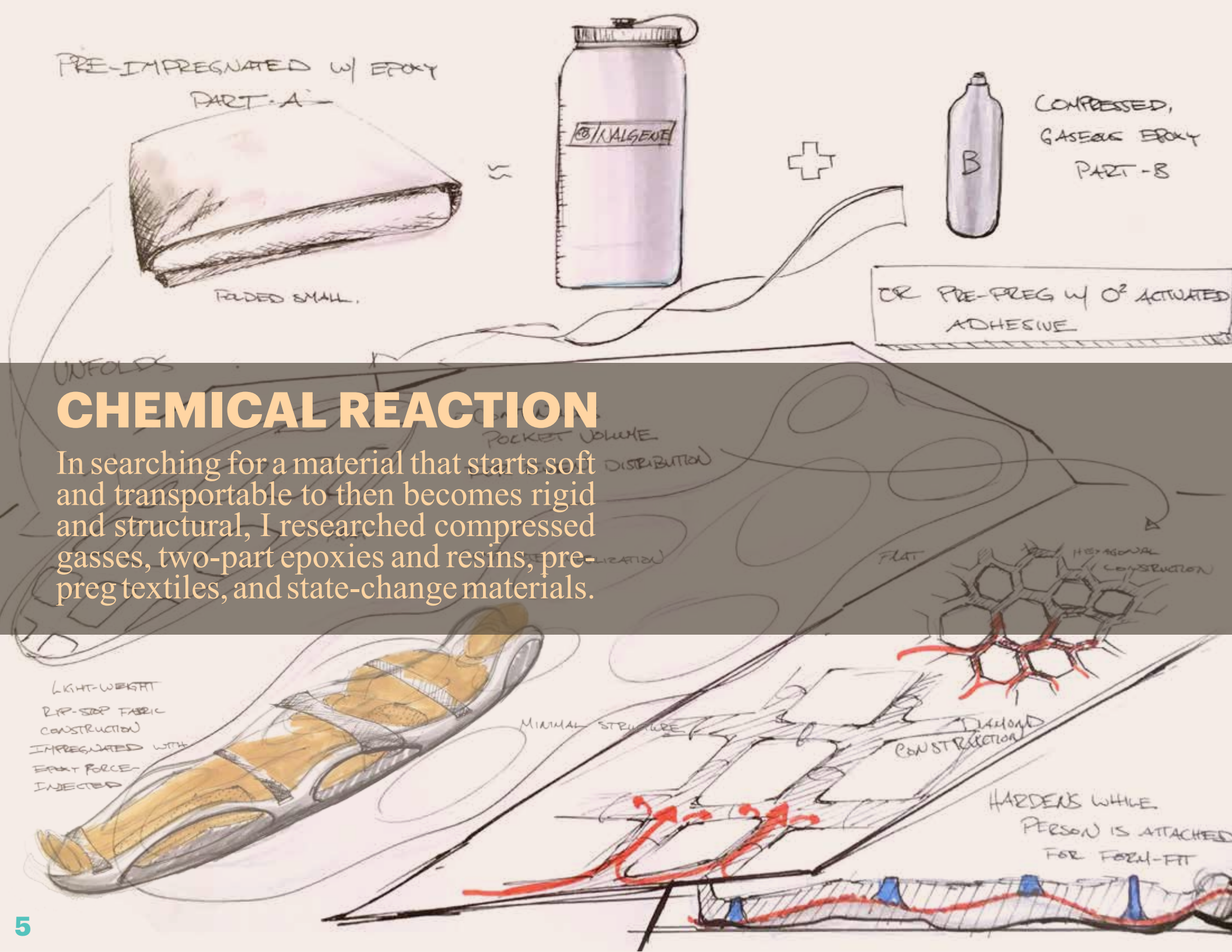
**... TO BECOME LONG, PLANAR, AND RIGID.**



# ROLLING OUT TO SPAN

A stretcher is essentially a bridge. It needs to span between points on the edge to support a load: ~ 180lbs over 6ft. First sketches were rods and stretched fabric, then

pneumatics and expanding folding structures. But then I began researching chemical reactions and state-change materials.




# CHEMICAL REACTION

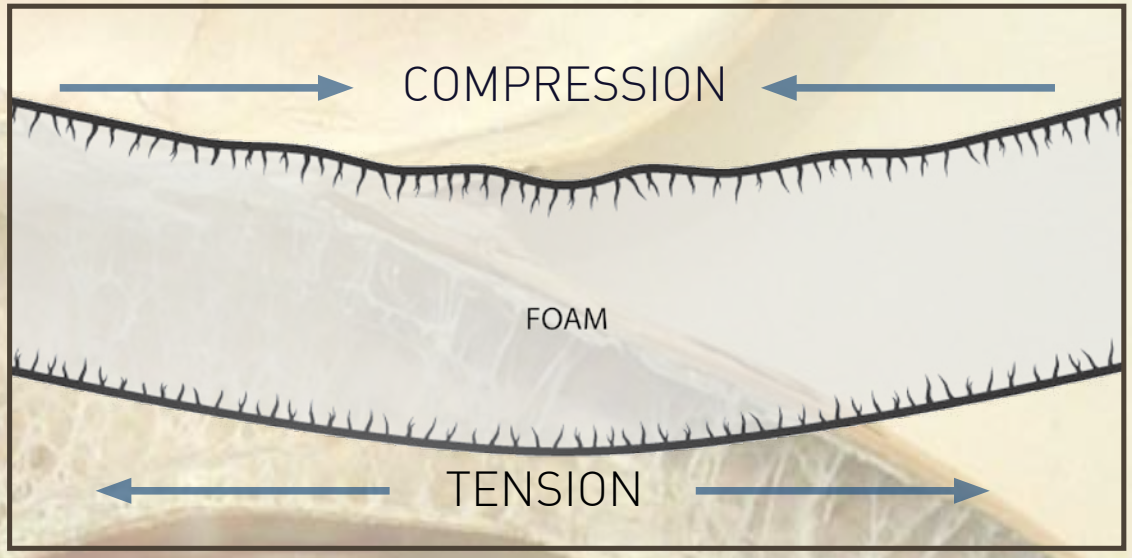
In searching for a material that starts soft and transportable to then becomes rigid and structural, I researched compressed gasses, two-part epoxies and resins, pre-preg textiles, and state-change materials.

# FOAM

Expanding insulation foam comes in a stable, two-part liquid state, which when mixed expands up to 60% to become rigid. During it's expansion, it molds around any form, including the human body, creating a perfect fit and keeping the patient comfortable and warm.

# EXPANDING FOAM

Foam by itself is very brittle. It has good compressive strength, but poor tensile strength. When bent, it snaps easily.




# TENSION + COMPRESSION

Looking around at what other objects use foam construction, I was inspired first by the surfboard (and later by the Toucan's beak). Both have an inelastic membrane bound to the interior foam that adds tensile strenght to the compressive strength of the foam to create a structural body.

# MATERIAL COLLABORATION

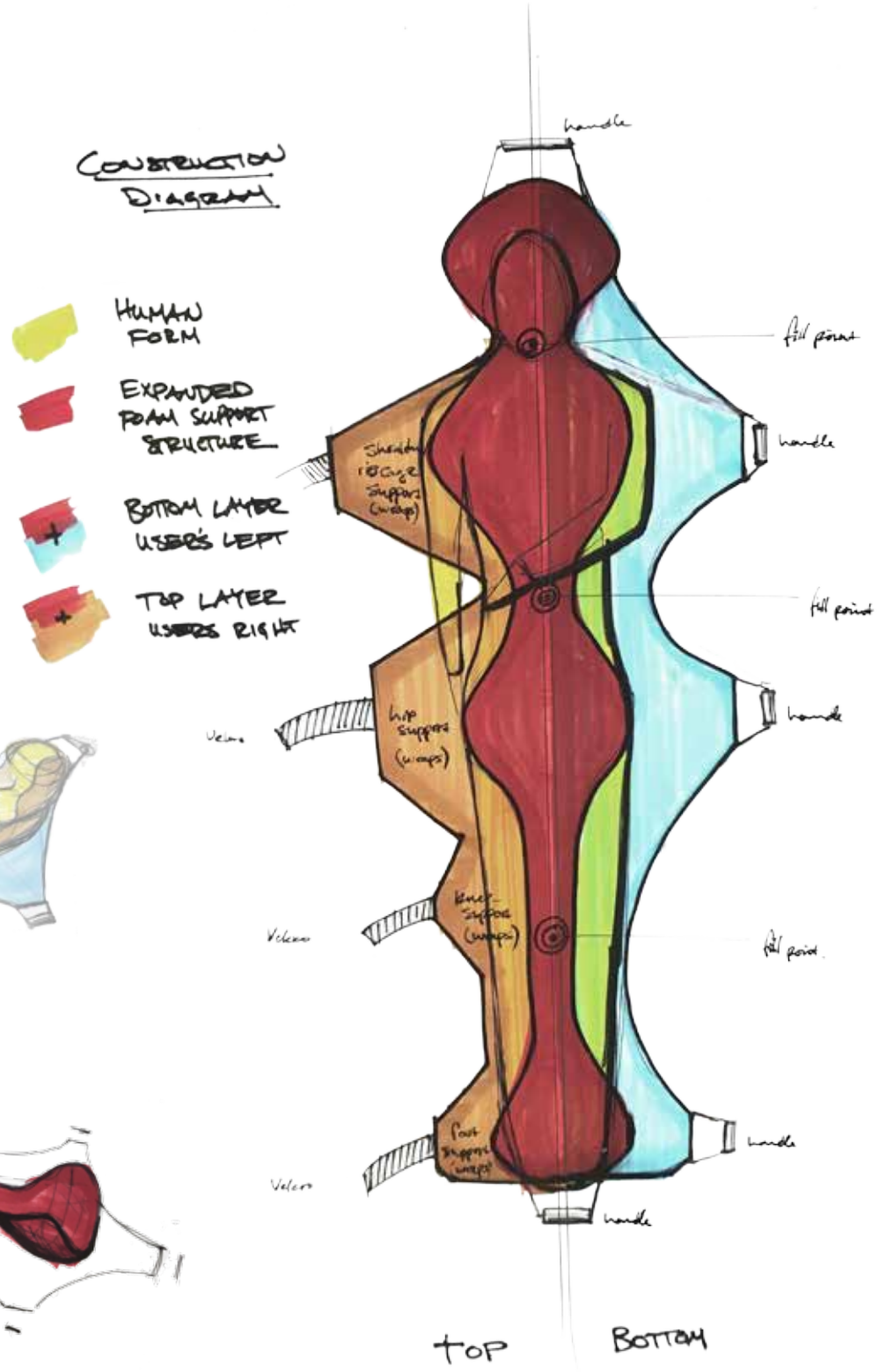
When a ripstop nylon, selected for inelasticity, was employed, the foam to textile bond supplied sufficient tension to create spanning structural stability.

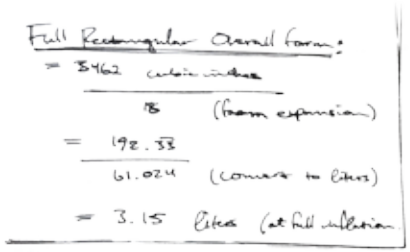
# BENEFICIAL SIDE EFFECTS

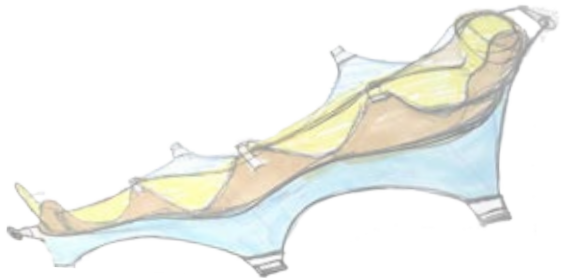
Testing at larger sizes showed that the foam could expand with a human body already in place. This means that the foam will mold up around the human body, creating a perfect fit with no pressure points, a common complaint with existing stretcher solutions.

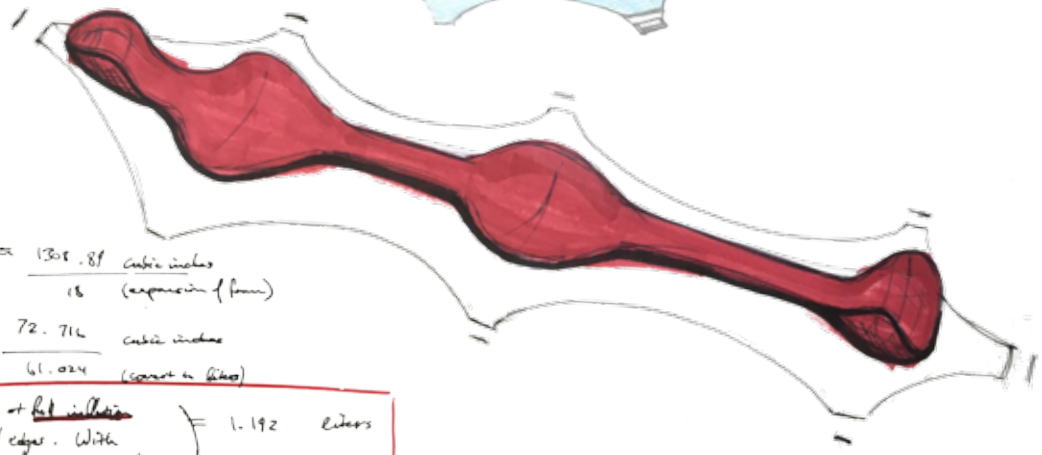
# SCALING UP

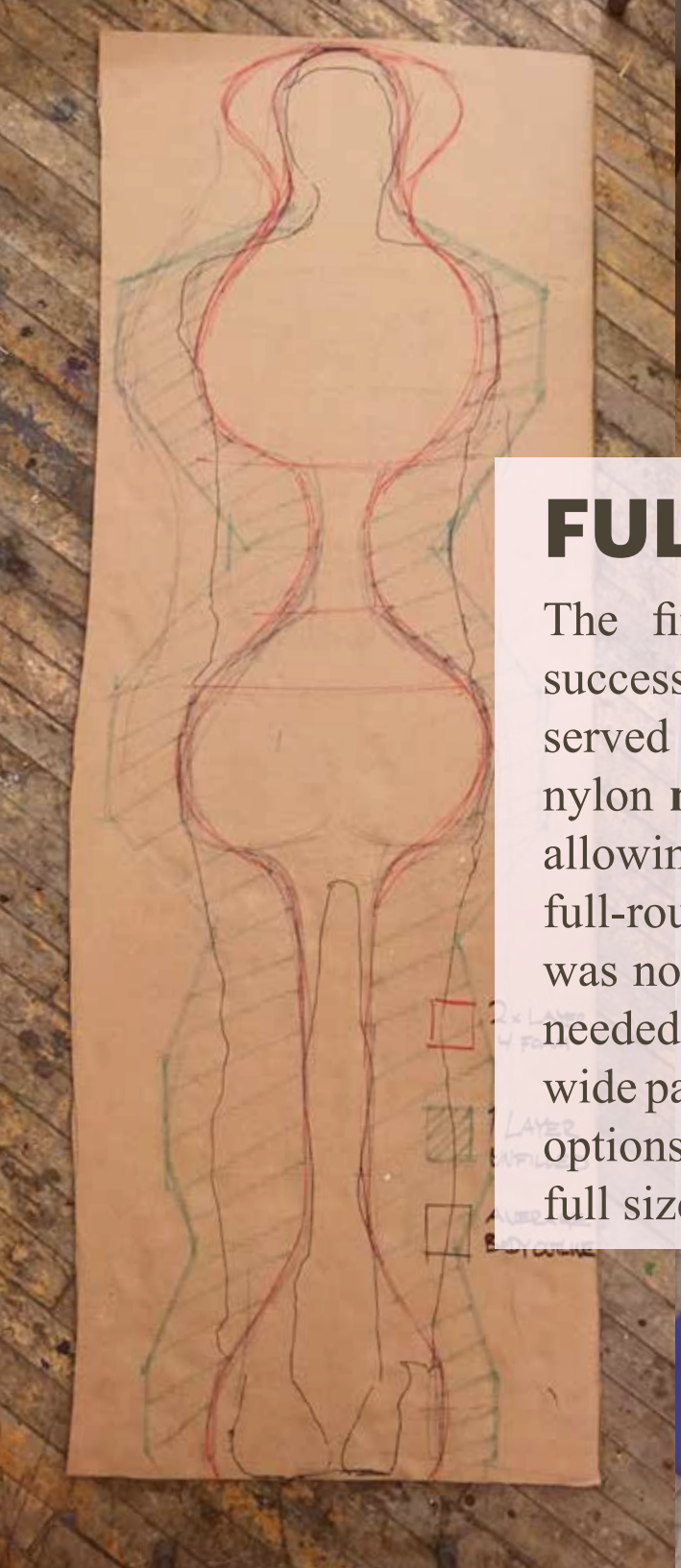
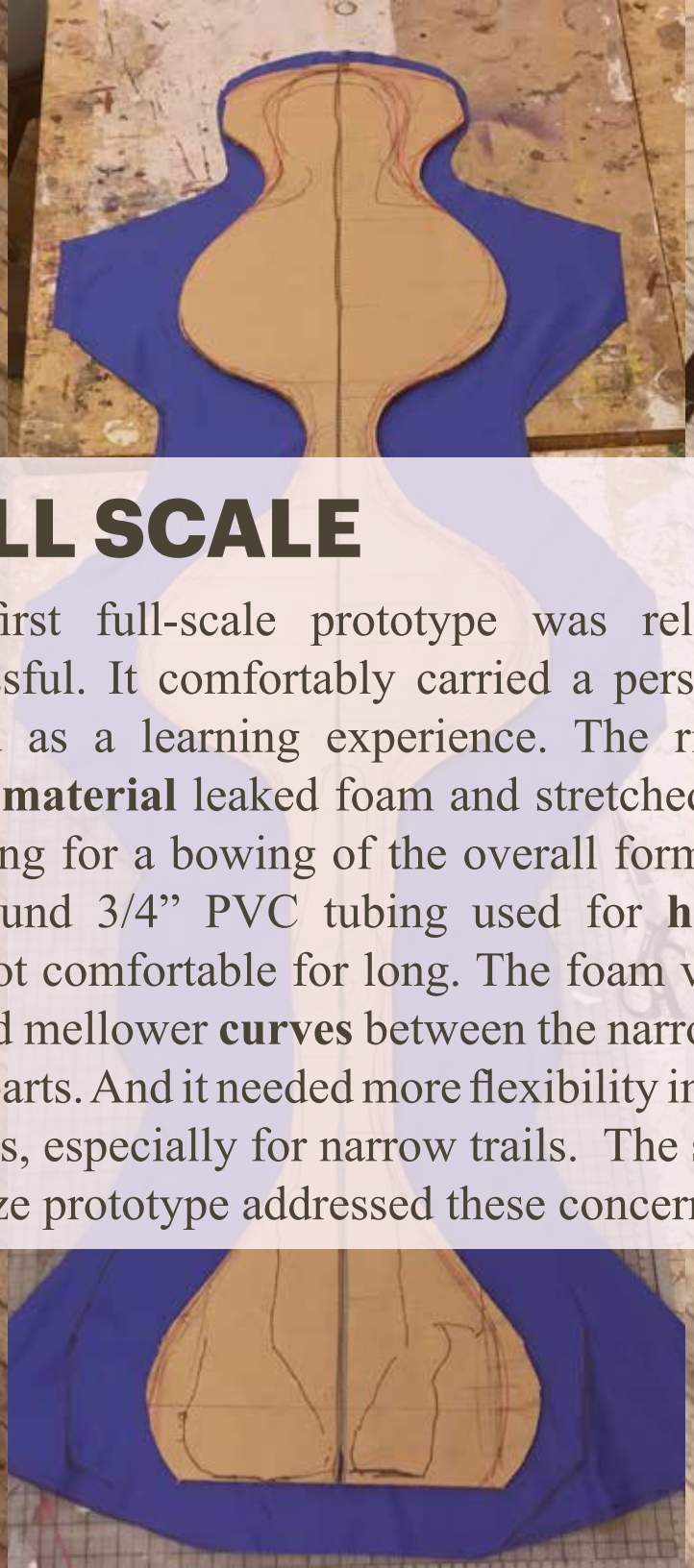
After modeling the overall volume, I found that it would be necessary to formally restrict the foam volume ( ■ ) so as to limit the amount of unmixed (liquid) carried on an expedition. By sewing inside the form to create a volume, I was able to approximate the body's ( ■ ) outline, applying the supportive foam only where necessary.





Full Rectangular Overall form:
= 3462 cubic inches
18 (foam expansion)
= 192.33
61.024 (convert to liters)
= 3.15 liters (at full inflation)




Volume = 1308.89 cubic inches
18 (expansion of foam)
= 72.716 cubic inches
61.024 (convert to liters)
(This at full inflation of inflated edges. With body weight, volume decreases) = 1.192 liters


# FULL SCALE

The first full-scale prototype was relatively successful. It comfortably carried a person but served as a learning experience. The rip-stop nylon **material** leaked foam and stretched a bit, allowing for a bowing of the overall form. The full-round 3/4" PVC tubing used for **handles** was not comfortable for long. The foam volume needed mellower **curves** between the narrow and wide parts. And it needed more flexibility in **carry** options, especially for narrow trails. The second full size prototype addressed these concerns.

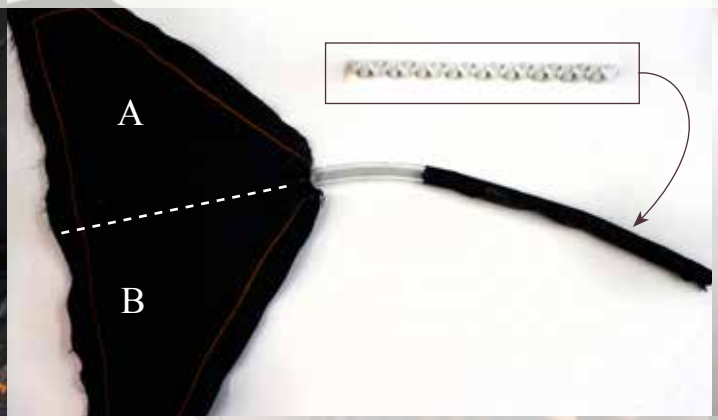
## UNPACK

## UNROLL

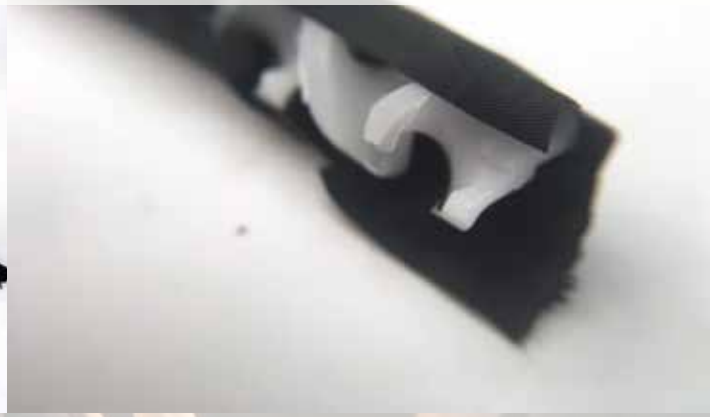
## SECURE PATIENT

## COMPRESS 3x INJECTION POUCHES

## PUSH UNMIXED FOAM OUT THE FEED TUBE...




## ...THROUGH STATIC MIXER AND INTO THE STRETCHER



## WAIT 15mins FOR FOAM TO CURE

## CARRY AWAY

# MATERIALS

The xSPANd stretcher is made of relatively few materials: nylon webbing, velcro, the expanding foam, thread, and a body textile. A variety of foams were identified and tested. Certain architectural insulation foams boast expansion rates near 100x. But foams are tricky and many operate in a narrow temperature range. A custom formulation is currently being developed for cold weather applications. An Ultra High Molecular Weight Polyethelene (UHMWP) textile called Cuben Fiber was tested and found to have extremely high tensile strength while being very light and compressible.

# HANDLES

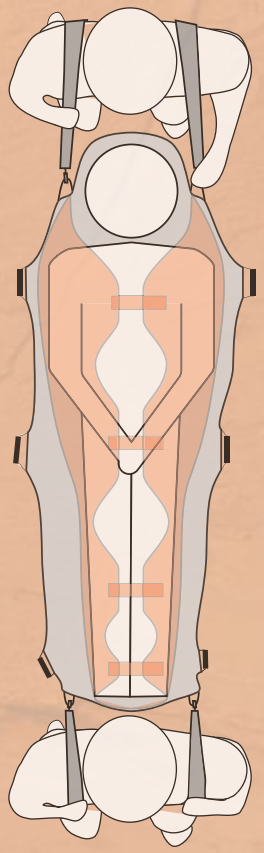
Starting with a lump of clay grasped in the hand, I moved through a number of iterations and found an ideal ergonomic shape for long distance carry: a simple form that can be held by a variety of hand sizes, and with or without a glove. The strap is fixed at the bottom to orient the handle and relay control to the textile stretcher base.

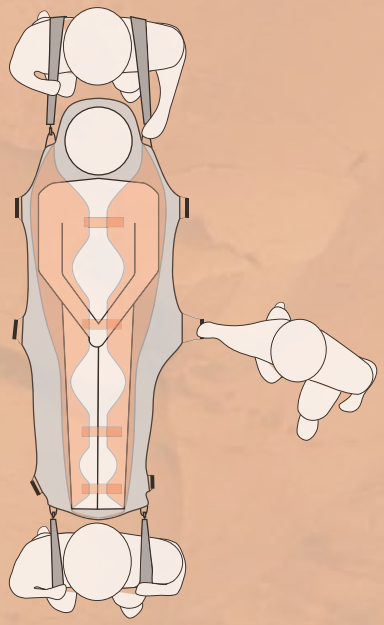
# FLEXIBILITY

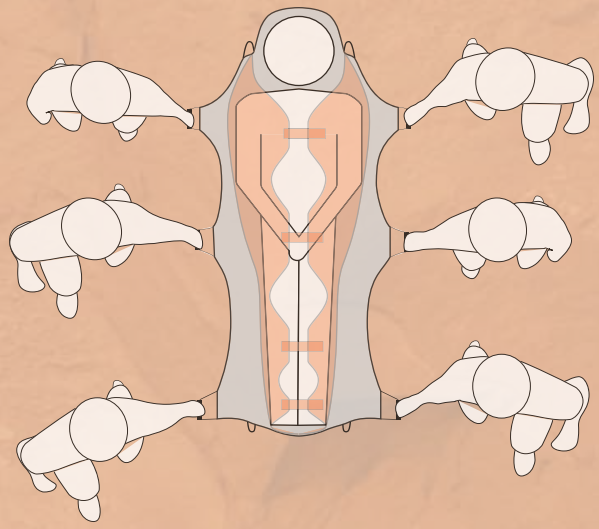
True outdoors people know that the best outdoor gear is flexible and adaptable, assuming that users are savvy with riggings and improvisational thinking. A variety of hardpoints enable multiple carry styles using rope and straps that are commonplace on these expeditions. Loops on the bottom allow end-to-end reinforcement with a piece of line.

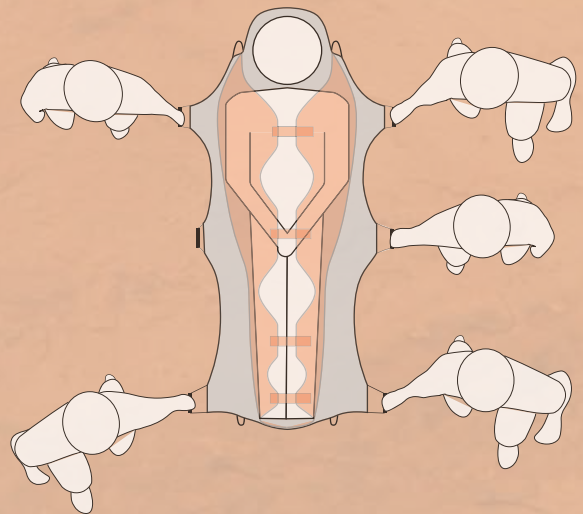
# CARRY

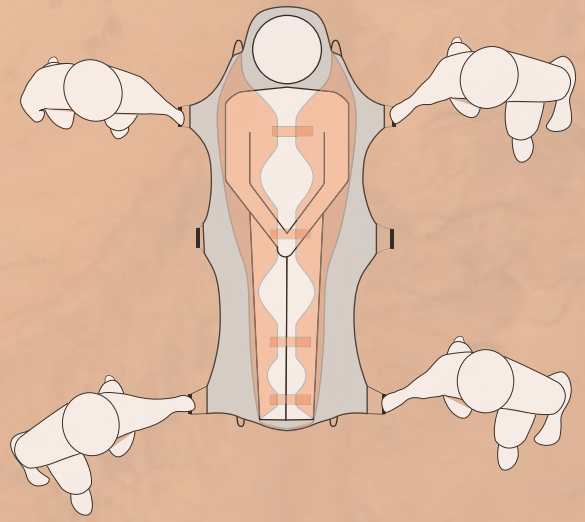
A variety of rigging techniques allow for a variety of carry techniques, adapting to the environment. On a narrow single-track trail, a two-person end-to-end technique may be employed, while with sufficient team members and space, six people can carry for long distances without tiring.











# CONTACT

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