



JESSAMY TAYLOR | PROCESS BOOK

EVEN KEEL

AN INNOVATIVE CRASH PAD FOR BOULDERING



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BACKGROUND

WHAT IS BOULDERING?

Bouldering is the sport of rock climbing relatively short boulders, as opposed to cliff faces, without a rope. Boulderers usually start on the ground and complete a series of moves called a “boulder problem” to reach the top of the boulder. If the boulderer falls before reaching the top of the problem, they (hopefully) land on mats covering the ground below. After successfully climbing to the top, the boulderer climbs, walks or jumps off the boulder to return to the ground.

HISTORY

Bouldering began as a way to train for roped climbing. No one used any padding; the closest thing to a crash pad was a carpet square to wipe the dirt off your climbing shoes before beginning the boulder problem. In the 1980's, boulderers controversially started using mattresses and couch cushions to protect landings (Leibovitch).

The first commercial crash pad, The Sketch Pad, was created in 1994 (Leibovitch). This as well as subsequent additions to the protective options for boulderers helped make bouldering a bit more mainstream and popular.

Today, bouldering is wildly popular with bouldering-only gyms popping up around the country and internationally due to the simplicity, accessibility and efficiency of the discipline. Boulderers need not mess around with ropes or most other gear, allowing beginners to get right into it and allowing experienced boulderers to try intense moves over and over without the need for a belay partner.

SPORT ENVIRONMENT

Bouldering can be done inside a climbing gym or outdoors wherever there are natural boulders.

Indoors, there is usually continuous padding over the entire floor below the artificial boulders. Indoor bouldering wall heights tend to max out at 18 feet, whereas outdoor boulders can range from a low traverse a few feet off the ground to 50-foot highballs that would almost be considered free solos.

This project will focus on outdoor bouldering, where climbers must bring their own padding. They carry rectangular foam mats called crash pads on their backs from their cars to the boulders, sometimes hiking for miles over rocky hillsides. They place these pads underneath each boulder problem in the predicted landing zone before starting up the climb.

Landing zones vary greatly between climbing areas, and even between boulders in the same area. In the high deserts of Bishop, California, and Joe's Valley, Utah, for example, landing areas tend to be level and uncluttered. Contrast this to Index, Washington where oven-sized granite blocks litter the landing areas and tree stumps jut out between them. Not only does this make it difficult to balance the crash pads in a steady way and create a smooth landing area, but even if a

climber lands directly on the pads he or she could bounce off and hit her head on a nearby rock.

When one climber is bouldering, her friends can act as spotters to guide her onto the crash pads and keep her from falling or bouncing onto adjacent hazards. The spotters are not there to catch the climber, but rather to direct her fall and help her land on her feet.

Ideally, the climber lands with slightly bent knees and uses her legs to absorb the impact. Depending on the height of the fall, she can drop all the way down and roll onto her back to lengthen the acceleration time and reduce the forces on her body. Even with a flat landing, especially during falls from highball boulders, these forces can be enough to cause injury.

RISKS

Even indoors with “perfect” landing areas, injuries to the foot, ankle, knee and back dissuade many injury-prone and older climbers from bouldering. They opt instead for roped climbing, which involves greater risk of death but much lower overall risk of injury.

Outdoor bouldering, even at areas with flat landings, there is an increased risk over indoor bouldering. Bouldering programs have been eliminated from many university outdoors programs for this reason. A 2007 study published in *Wilderness and Environmental Medicine* found that 28% of outdoor boulderers had sustained ankle injuries compared to 14% of indoor boulderers (Josephson). No matter how carefully the crash pads are laid out, there will always be junctions between the separate mats, where a foot can become caught, twisted or slip through to the hard ground. At areas with uneven landing areas, the risks are even greater. Crash pads that attempt to even out uneven landings could potentially reduce the risk of injury in these situations.

BIOMECHANICS

The ideal landing position for a falling boulderer is feet first with knees slightly bent. The knees continue to flex and absorb impact as the climber's torso quickly lowers down to the mat. Extending the arms behind the body would put the climber at risk for upper limb injury so instead, the climber rolls onto her back to absorb the remaining kinetic energy. She finally come to a stop, hopefully still on the crash pad.

Even in this ideal fall, the constrictive and downturned nature of climbing shoes means that the foot cannot splay out to absorb impact or increase stability. Nor can the toes bend back to allow the climber to land first on the ball of the foot. Instead, the climber lands on a supinated midfoot and heel, putting tremendous stress on the ankles, knees, hips and back, and increasing the likelihood of rolling the ankle. The better the cushioning below the climber, the less stress the joints will undergo.



Aggressive climbing shoes tightly bind the foot and encourage supination

Boulderers fall repeatedly throughout the session, perhaps upwards of 100 times in a few hours. Some of these falls are expected and controlled, with the climber able to look down, spot the landing and contact the ground feet first in a relatively stable way. Other times, the climber falls while twisted in an awkward position or while jumping wildly for a hold. In these cases, the climber might land with limbs twisted unnaturally, on her side, or even upside-down. All this is to say, crash pads are critical pieces of safety equipment for reducing acute injury as well as injury from repetitive impact.

TRANSPORTING PADS

One of the biggest problems with crash pads today is transport, due to their inherent bulk. They are, after all, the single biggest piece of climbing gear that the average climber will ever use. Let us follow a crash pad from the warehouse to the crag.

As of 2017, FedEx and UPS charge \$72.50 and \$70 respectively to ship “oversize” or “large” packages, which are those that exceed 130 inches in combined girth and length (length plus two times width plus two times height) (Franklin Parcel). Most crash pads do not actually exceed these dimensions, but a survey of outdoor retail websites reveals that oversize fees of around \$75 apply nonetheless, perhaps due to the packaging around the pads.

Airline regulations are even tighter. A standard cutoff for length plus width plus height is 62 inches (Delta). A packed crash pad on the smaller end of standard often measures 68 inches by this metric.

Even if a climber can purchase her crash pad in-store and never needs to fly with it to a remote climbing destination, she will most likely need to fit in into a car. Strapping crash pads to a roof rack significantly decreases fuel economy, is potentially hazardous and is just cumbersome. It's best to fit the pads inside the car. If a solo boulderer has a massive van, this is not a problem (though she'll

have to carry the pads by herself later). But a smaller car full of friends has very little room for crash pads, limiting the amount of protection the climbers can bring.

Once the car full of people and pads arrives at the parking area of the climbing area, the pads still have to get down the trail to the actual boulders. Large crash pads can weigh around 20 pounds, and a nice big pad like the Black Diamond Mondo measures 44" x 33" x 10" when folded up for carrying. The pads are unwieldy, getting caught on trees and underbrush, bumping into rocks, and catching breezes such that the climber can feel off balance. Often, climbers will pack other items like shoes, water bottles, extra layers, snacks and guidebooks into the folds of the pads to tote them to the crag, but this places the weight far from the spine of the hiking climber, contributing to the discomfort and awkwardness of carrying the pad.

STASHING PADS

Due to the difficulties of transporting crash pads from the home to the base of the boulder problem, some boulderers choose to hide caches of pads under rocks near their projects (problems they return to many times to reattempt until they successfully climb the problem). Though the motives for this are clear, a host of problems arise from this strategy. Whether stashing pads takes place on private or public land, so long as the area does not belong to the climber, this can be considered akin to littering. Weather can degrade the pads if they are left long enough, resulting in many small particles of trash spreading across the landscape. Animals may nest inside the pads or ingest plastic particles. The pads may be unsightly to visitors. Landowners can understandably become incensed and ban climbers from bouldering there in the future.

Boulderers sometimes use this “solution” despite its negative aspects, showing that the need to more easily transport pads to and from boulder problems is a real problem and a better solution is needed.

Crash pad manufacturers must balance coverage, thick padding and other features with ease of transport.

EXISTING PRODUCTS

At least 40 companies make crash pads, and most if not all of those companies make two or more different models. There are many options available, though many are somewhat similar. In 2019, Chris Summit and others from Outdoor Gear Lab researched many different pads and tested the 10 best pads side-by-side. Below is their summary of the top five results. No pad checked all the boxes; notice that the best pad for high falls scored the lowest for low falls and vice-versa. Also note that the 5” thick pads performed best for high falls but were rather heavy and of course bulky.

					
	Mad Rock Duo	Mad Rock R3	Organic Simple	Petzl Alto	Black Diamond Mondo Pad
Awards					
Price	\$240 List	\$199 List	\$210.00 at REI	Check Price at Amazon Compare at 2 sellers	\$349.95 at Amazon
Overall Score	0 100 80	0 100 78	0 100 76	0 100 73	0 100 71
Star Rating	★★★★★	★★★★☆	★★★★★	★★★★☆	★★★★☆
Pros	Straps to attach a second pad, plush suspension, sturdy foam for high falls	Versatility, soft but dense foam with multiple hinges conforms to uneven landing surfaces and cushions short to medium length falls very well. It also hauls a lot of gear well and has handy features	Super durable, amazing foam, lightweight	Folds open and closed better than any other taco-style pad, innovative zip-up flap closure system securely stores gear, well made, sleek look	Great foam, large surface area, lots of grab loops
Cons	Foam is hard for low falls, stiff for uneven landings	Specialized, the soft, squishy, shredded foam and slightly lumpy "baffles" are not the best for some long, high falls - they could possibly roll an ankle	Lack of features, doesn't pack much gear well	Does not pack large or bulky loads of gear well, no center lifting handle, Velcro and zipper could wear out prematurely	No sternum strap, outdated hinge closure
Bottom Line	Great crash pad distinguished by its innovative strap system for carrying a second pad and many other features that other pads lack.	A unique pad with plush foam and plenty of space for packing gear.	The best crash pad of its size.	An expensive pad given its size and thickness.	An excellent large pad with a big price tag.
Rating Categories	Mad Rock Duo	Mad Rock R3	Organic Simple	Petzl Alto	Black Diamond Mondo Pad
High Falls (30%)	0 10 9	0 10 6	0 10 8	0 10 7	0 10 9
Low Falls (30%)	0 10 6	0 10 10	0 10 8	0 10 7	0 10 6
Durability (20%)	0 10 8	0 10 7	0 10 8	0 10 8	0 10 7
Packing Gear (10%)	0 10 9	0 10 10	0 10 6	0 10 7	0 10 7
Features (10%)	0 10 10	0 10 6	0 10 6	0 10 8	0 10 5
Specs	Mad Rock Duo	Mad Rock R3	Organic Simple	Petzl Alto	Black Diamond...
Surface Size (inches)	56" x 42"	55" x 35"	48" x 36"	46" x 39"	65" x 44"
Thickness (inches)	5"	4"	4"	4"	5"
Weight (lbs)	17 lbs	18 lbs	11 lbs	12 lbs	22 lbs
Hinge/Taco	Hinge	Hinge(s)/Baffles	Hinge	Taco	Hinge

CRASH PADS TODAY: FORM

Crash pads have not changed significantly in the last 30 years, though some innovations have come along. Most are essentially a large rectangle comprised of layers of foam, covered in durable fabric. The Sketch Pad of the 1980s was much smaller than today's crash pads, but similarly to modern pads it was made up of different densities of foam to cushion and stabilize. Commonly, the top inch

of foam is closed cell to distribute the load and provide stability, and the bottom 2-5 inches are open cell for impact absorption. Configurations such as dense foam on top and bottom with open cell in the middle, or other layups are common as well.

A few exceptions to this exist. The Edelrid Balance has a beanbag on the bottom to level out uneven surfaces. The Mad Rock R3 is filled with shredded recycled foam in a baffled construction instead of solid sheets, so it conforms well to the terrain.



Left: Edelrid Balance. Right: Mad Rock R3 draped over a rock.

There are few different mechanisms for folding the pad. Many pads have one (or occasionally two) hinges where two halves of the pad are joined by fabric. This hinge makes the pad easy to fold in half for carrying, and it lays flat on flat landings, but it introduces the risk of landing right on the unpadded seam in the middle. It is less functional on uneven surfaces where rocks could protrude through the hinge or where the surface causes the pad to fold. The alternative is a taco style pad with no hinge. Folding a taco pad for transport involves bending the pad back on itself so it doesn't pack quite as flat, and it should be stored open to avoid compressing the middle foam over time. These pads have no dead spots and are good on uneven surfaces but don't lay as flat on smooth landings.

Companies like Organic and Asana use a hybrid style fold, with continuous dense foam on top, and the compressible foam split in two for easy folding.

One big pad has an advantage over many small pads in that it results in fewer junctions between pads where a foot could slip through. However, multiple smaller pads offer versatility for filling holes and protecting uneven landings. In either case, thicker pads absorb more impact, and the more pad surface area and thickness, the better.

Most pads have some sort of backpack straps and usually a hip belt as well for carrying the pad. Some pads have ways of attaching a second pad to the first for carrying multiple pads. Some pads also have pockets or flaps for carrying other gear in more easily, though many people opt to bring a separate bag and stuff it in the middle of the fold.

Some pads have long straps that can be connected to make the hinged pad into a couch. This is nice for lounging around between tries on boulder problems, or back at camp.

CRASH PADS TODAY: MATERIALS

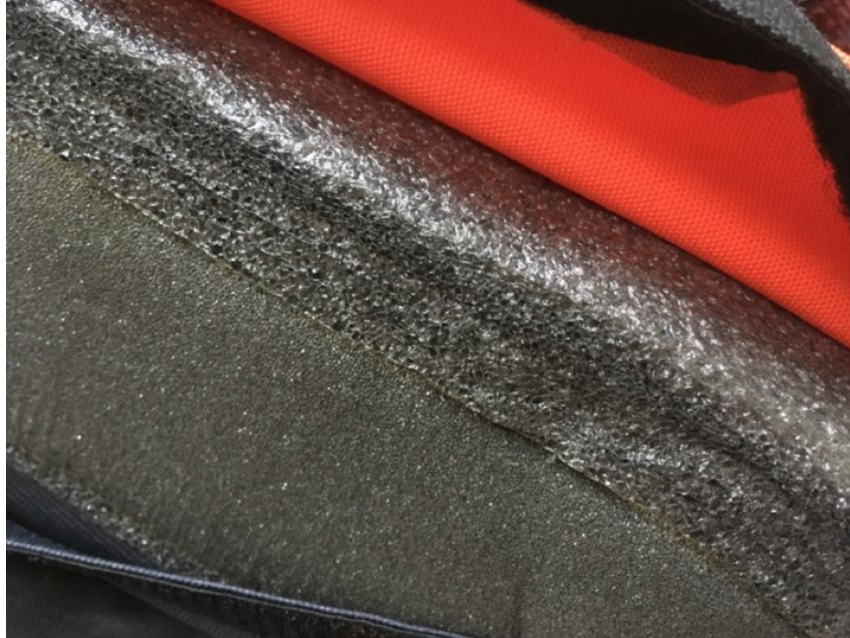
Cushioning:

Most crash pads are filled with sheets of foam. About a third of their thickness comes from one or more sheets of dense, closed-cell polyethylene for stability. The rest of the pad's thickness is usually comprised of one or more sheets of open-cell polyurethane foam for shock absorption. Some pad manufacturers use EVA or other foams instead of PU. Organic has a pad with an inch of memory foam on top, in addition to the typical choices for the rest of the pad.

Sometimes these foam layers are glued together with spray adhesive or similar, and sometimes they are simply stacked atop each other and held in place by the fabric cover.

Mad Rock fills the R3 pad with 15lbs of recycled EVA foam chopped into small pieces.

Edelrid is not clear about what the “beans” inside their Balance pad beanbag are made of. Surely, they are not actual beans as in a traditional beanbag, as that would make the pad far too heavy for easy carrying to the boulders.



The Metolius Session pad unzipped to show closed-cell foam on top and bottom with thick open-cell foam in between

Cover:

The outside covering of the pad is often made mostly of woven nylon due to its strength. Sometimes, polyester will be added for abrasion resistance. Sometimes the entire top of the pad, or patches of the top, are made of automotive carpet to wipe dirty shoes off before beginning a boulder problem.

Organic Climbing uses 1000d Cordura offcuts to make the colorful customized tops of its pads, with 1050d Cordura on the bottom for durability (Organic).

Many companies use waterproof coatings on the bottom of their pads to keep moisture out when the pad is on moist ground for long periods. Some even use vinyl for easy cleaning (Havens, 2017).

High friction coatings or fabrics can be used on the bottoms of pads to keep them from sliding over slanted rocks. Black Diamond uses a rubber coating on their Mondo pad for this purpose. Evolv sews molded rubber caps onto the corners of its pads that serve two purposes: they reinforce the corners for durability, and they also may help keep the pad in place (Evolv Maverick).

Fasteners:

Plastic buckles used to be common on crash pads but due to frequent breakage, nowadays the buckles that hold the pad closed during transport are most often made of a solid piece of aluminum. The waist buckle for carrying is still often a large plastic side release buckle.

Most companies use nylon webbing straps to tighten the pad closed for carrying, and to suspend the pad on the shoulders and hips. Some pads' suspension systems are unpadded, but most have foam such as polyethylene to cushion the user from the straps.

Many pad makers use a heavy-duty zipper to close the cover around the foam. Other companies use a long strip of hook and loop for this purpose.

Some companies put hook and loop fasteners on the sides of the pad to connect multiple pads together. Hook and loop can also be used at the hinge area to help keep the pad flat.

CRASH PADS TODAY: COLOR AND GRAPHICS

The bottoms of most pads are black or dark in color as this portion of the pad often becomes the dirtiest. The bottoms also usually do not have many graphics or logos.

The top landing area is where designers have fun. Many pads are brightly colored, both for decoration and to easily see where to land. Logos are usually printed or applied prominently in the center or at one corner on the top of the pad. Cassin makes a pad with domino dots printed on the pad to help climbers spot their landing. Metolius puts a carpet square logo in the middle of the pad to serve as a landing target.

Some brands like Organic allow customers to choose their own colors and even designs for the tops of the pads.



A Black Diamond Mondo pad with the BD logo in the center, an Asana pad and an Organic pad made from fabric offcuts. Every Organic pad is unique.

On a hot day in the sun, a pad with black cloth on top can become uncomfortable to stand on. However, dark colored pads will show less dirt readily and the best temperatures for bouldering are cool to downright chilly anyway.

MANUFACTURING

Polyurethane foam is produced in large factories in which computer-controlled machines mix chemicals together and deposit them on a moving conveyor belt. It foams up, forming a massive and continuous block which is cut into sections and cured. It can then be cut into sheets or other more complex shapes with more computerized precision cutting equipment (EUROPUR, 2015).

Generally, the cover of a crash pad is sewn inside-out with all the backpack straps, closures and other fixtures sew on. It is then flipped right side out and pulled tightly over the foam sheets. The zipper or hook and loop closure is closed around the foam.

TRADEOFFS

There are three main tradeoffs to consider in crash pad design: coverage versus ease of transport, soft versus firm, and flat versus easy to deform.

When it comes to making landings safer, the more padding the better. The ideal would be to bring lots and lots of super massive pads to the crag. But when it comes to transporting the pads, smaller and lighter is better.

Softer pads are nice for short falls or jarring falls onto your back because they cushion small impacts more effectively. For big falls off highball problems, a firmer pad is much better because it prevents the climber from bottoming out through the pad and it provides a smooth, stable landing surface.

Hinged pads often lay flat nicely but don't fare so well on rocky ground. Taco style pads do better on rocky ground but don't lay as smoothly on big flat landings. The Edelrid Balance pad is flat on top and its beanbag is able to deform over surface irregularities, but it is prone to slipping laterally during the climber's landing.

SWOT ANALYSIS

Strengths of current product landscape:

- *Many different options in a range of sizes*
- *Suspension systems have improved significantly*
- *Pads are easy to use*

Weaknesses:

- *Pads are difficult to transport*
- *Injuries are still common*
- *Some specialty pads like the R3 are great for a certain purpose but there is no all-around pad that excels in all categories*

Opportunities:

- *A pad that truly does it all so that users don't need to buy and transport different pads for different boulders*
- *Better cushioning that decreases injuries on unstable landings*
- *More sustainable pad making:*
 - *Repurposed materials*
 - *Durability*
 - *Fewer different pads needed*
 - *Ability to break down and reuse materials from the pad*
 - *Ability to repair the pad*

Threats:

- *Approximately 40 companies are already making crash pads*
- *Customers may not trust a new pad from an untested manufacturer to keep them safe*
- *Distribution channels: shipping big pads is so expensive that customers might just buy whatever pad is in the nearest brick-and-mortar store*

SOLUTION: EVEN KEEL

The Even Keel crash pad combines ease of transport with an adaptable cushioning system that levels uneven ground. Possible areas to address are:

- *Smoothing out uneven landings*
- *Multi-directional cushioning that gives in shear on slanted landings*
- *Portability*
 - *Size*
 - *Weight*
 - *Collapsible*
- *Convertible*
 - *Adjustable firmness*
 - *Small and thick for tall straight problems to wide and thin for low traverses or covering other pads*

MARKET AND USER

Climbing is a rapidly growing sport, with the commercial climbing industry growing over 10% in 2017 and 2018 (Dwyer, 2019). Over 5 million people climbed indoors in 2017 (Tilton, 2019). Along with the rise of indoor climbing has come an increased popularity of outdoor climbing as climbers seek to enjoy the outdoors while testing themselves on real rock.

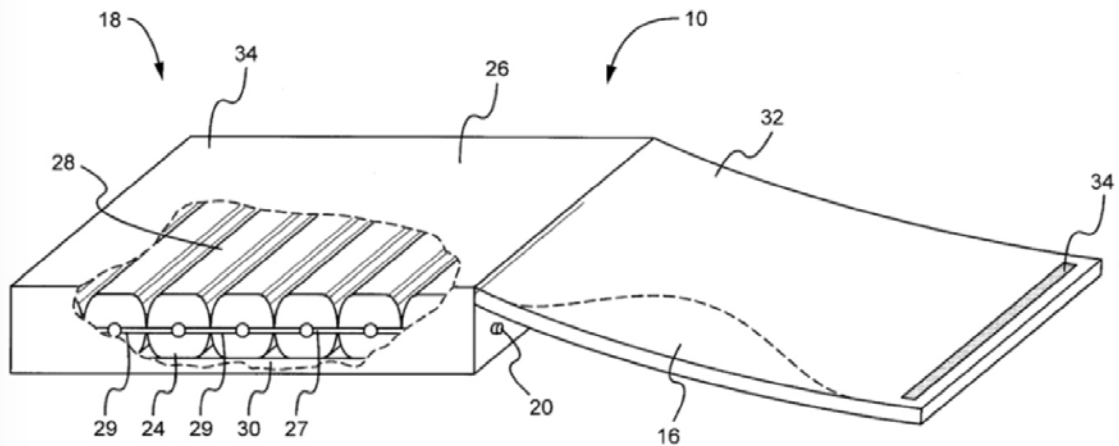
Since the risk of landing badly is one of the biggest deterrents to would-be boulderers, improvements in crash pad technology will only help to increase participation in the sport.

The Crumple Zone crash pad is intended for use by adult outdoor boulderers of any gender, weighing between 110 and 200lbs. Users at the lighter end of this range might wish for a softer pad, especially for short falls, and users at the heavier end of this range should use caution or a second pad to avoid bottoming out the pad on big falls. Most outdoor boulderers are between the ages of 18 and 40, with many older climbers preferring roped climbing as it tends to be easier on the joints.

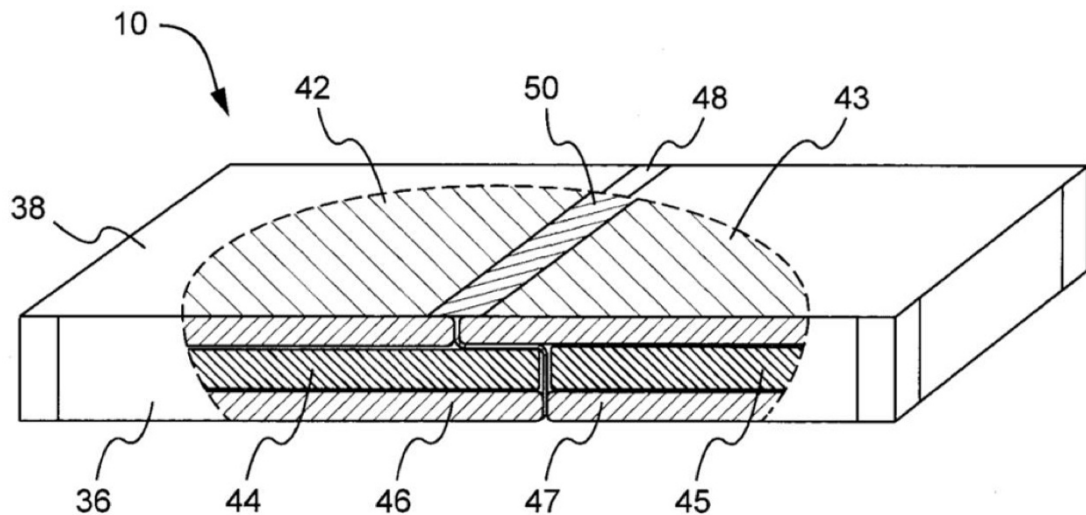
The versatility of this pad will make it suitable as a first crash pad for less experienced boulderers, but all outdoor bouldering presents risk and should be attempted with caution and the mentorship of experienced boulderers to assist with proper pad placement.

PATENT LANDSCAPE

One solution to the transportation issue would be a pad comprised of a foam topper that can be rolled up, with inflatable pontoons underneath. A US patent (number US20130086744A1) filed in 2011 is for just such a pad, though it has not yet hit the market. This pad has a valve to the outside air, and some sort of elastic foam inside to self-inflate the pontoons or single air bag.



Another patent in the space which seeks to resolve the issue of dead spots at the hinge is patent number US20130061393A1 for a pad with a stepped interlocking hinge.



Patent US20130043627A1 covers pads like the R3 with chopped up foam pieces as the filling inside baffles.

THE RIGHT INNOVATOR FOR THE JOB

Jessamy Taylor is uniquely positioned to innovate new crash pad technology. She has a background in mechanical engineering with a focus on biomechanics so she will get the technical aspects of this project right. She has 14 years of climbing experience and access to many more boulderers at all levels, so she understands first-hand what boulders need from a crash pad. She has excellent functional brainstorming skills, coming up with innovative ideas for how to solve physical problems. She can also critically analyze how and whether an idea will actually function as desired. She is proficient at making functional prototypes to test physical concepts, with a breadth of prototyping experience from soft goods to woodworking and carving foam. She has some familiarity with mechanical testing, and this can be applied to dropping accelerometers onto the pads and analyzing video of people jumping onto the pad prototypes.

Jessamy would like to pursue a career in the outdoor—or especially the climbing—industry. This project will showcase her ideation and prototyping skills as well as her ability to solve problems and make adjustments based on rigorous testing.

CREATING EVEN KEEL

FIELD WORK

In setting about this project, it was important to ensure that the crash pad would solve a real problem. To determine which features and benefits would be most important to boulderers, an online survey was conducted. Respondents were asked to rate the importance of the following factors on a scale from 1-5:

- *Price*
- *Durability*
- *Cushioning high falls*
- *Cushioning low falls*
- *Ability to cover a large area with one pad*
- *Ability to pack the pad into a small space*
- *Weight of the pad*
- *Suspension (i.e. comfy backpack straps, hip belt)*
- *System to attach other pads for carrying*
- *Sustainable materials*
- *Versatility*
- *Conforming to or evening out uneven surfaces*

- *Joining pad edges together*

Other questions gauged interest in a collapsible or inflatable crash pad, and a crash pad that better absorbs impacts from a variety of angles, i.e. when landing on a slanted surface. Respondents were asked about what their favorite crash pad on the market is, and why.

23 boulderers from around the country responded to the survey. The most important factors when buying a crash pad were price, durability, cushioning high falls, conforming to/evening out uneven surfaces, and versatility. Ten respondents listed Organic pads as a favorite brand, due to their customizable and aesthetic covers, durability and foam quality. Respondents were far more interested in a pad that better absorbs impacts from a variety of angles than an inflatable or collapsible pad. It is possible that parts of the survey could have been worded differently or that people had biases such as having trouble envisioning an inflatable pad or concern that it could rupture. However, between the ranking of factors and the specific interest question, it seems clear that most boulderers are more interested in improved cushioning rather than improved portability.

To gain more experience bouldering outdoors and using more crash pads, I traveled to Smith Rock State Park near Bend, Oregon. I also made stops in Bend at Metolius Climbing and in Redmond at Edelrid North America. I spent two afternoons bouldering at Smith Rock. One session involved using a Moon crash pad and a Metolius Session crash pad that I already own. The other session involved borrowing a Crux crash pad and a Balance crash pad from Edelrid. It was helpful to carry and fall on these other pads and to get a feel for different cushioning systems, and other features and benefits of the pads such as suspension and attachment systems, zippers, center of gravity while carrying them and ease of fitting them into a car.

A highlight of the trip was meeting with Jim Karn, an accomplished climber and product developer at Metolius Climbing in Bend. He became a mentor for the

project and had many key insights. Decades ago, he was part of creating a crash pad about the size of a twin mattress comprised of a foot-thick bag of scrap foam with a zipper. The pad provided excellent cushioning when the zipper was opened to allow air to escape. He spoke about the cost of crash pad materials, revealing that the main expenses are open cell foam and metal buckles. In designing the Session pad, Metolius found a way to use only one buckle by adding a clever fabric closure and thus minimized the cost. The quality of the closed cell foam apparently does not matter but cheap open cell foam packs out quickly. Regarding testing, Karn confirmed that few companies are currently using the UIAA crash pad testing standards, and that a good place to start is by jumping off a table onto the pad. He believes that that is what most companies do; just try it out and compare it to existing pads. He thinks of crash pads not as safety equipment, but as comfort equipment, saying, “I tend to think of it [crash pads] as it just makes the fall not hurt as much; it makes it less harsh.” The UIAA has no particular performance requirement anyway, and there is no equivalent CE standard, so companies test it by using it. Karn said, “We use it. You know we jump on it and fall on it...I don’t think it’s practical to think of it as a piece of safety equipment.” This validated my intended testing plan. In addition to describing a pad similar to that which I had envisioned, Karn validated the premise by saying “I always thought there was a lot of promise in a foam/air hybrid.” “I think that the foam/air hybrid is a promising...that’s a way you have a chance of coming up with something that nobody else is really doing effectively.”

I conducted an in-person interview with climber and owner of Antigravity Equipment Juan Rodriguez, and a phone interview with climbers Marni Epstein and Dylan Alvarez. They gave me insights from the climber’s point of view in terms of what they saw as missing in the market. Marni (who is just over 5’ tall and quite slim) noted that the hip belts are often too big for her, and that pads tend to hit the backs of her legs because of how low they sit on her back. Dylan wanted a pad with a waterproof bottom, and both spoke about how important it is to have straps for carrying multiple pads and other items. Juan said his favorite pad is the Black Diamond Mondo, and that at 6” thick it’s about as much

cushioning as you ever need for medium-tall boulder problems. He said it is also as big as you'd want a pad, and that greater portability in a pad that size would be desirable.

I spoke over the phone with Tahany Huerta, a Black Diamond product developer who works on soft goods equipment including crash pads. She said that in addition to jumping onto pads and taking them into the field and testing them, another testing method would be fatigue testing with thousands of compressions. This is the type of testing that quality engineers carry out at Black Diamond. One idea that came up in this conversation was a bean bag-style pad without a sheet of foam on top, to be used in conjunction with other pads.

I spoke with Alec Forget, an elite boulderer in Portland. He brought my attention to some innovative pad technology by French company Snap, as well as some of the benefits of Ocun pads.

DESIGN PRIORITIES AND BRIEF

Based on the survey results as well as conversations with climbers and product developers, some key priorities emerged. Although cost is a driving factor in crash pad sales, and durability is important, those are less of a priority for this project in which innovation is the goal. Instead, the priorities here should be the other three of the top five from the survey results: cushioning high falls, cushioning uneven landings, and versatility.

The name of the product is the Crumple Zone because it cushions against impacts like the crumple zone of a car, and it is in the landing zone under boulder problems.

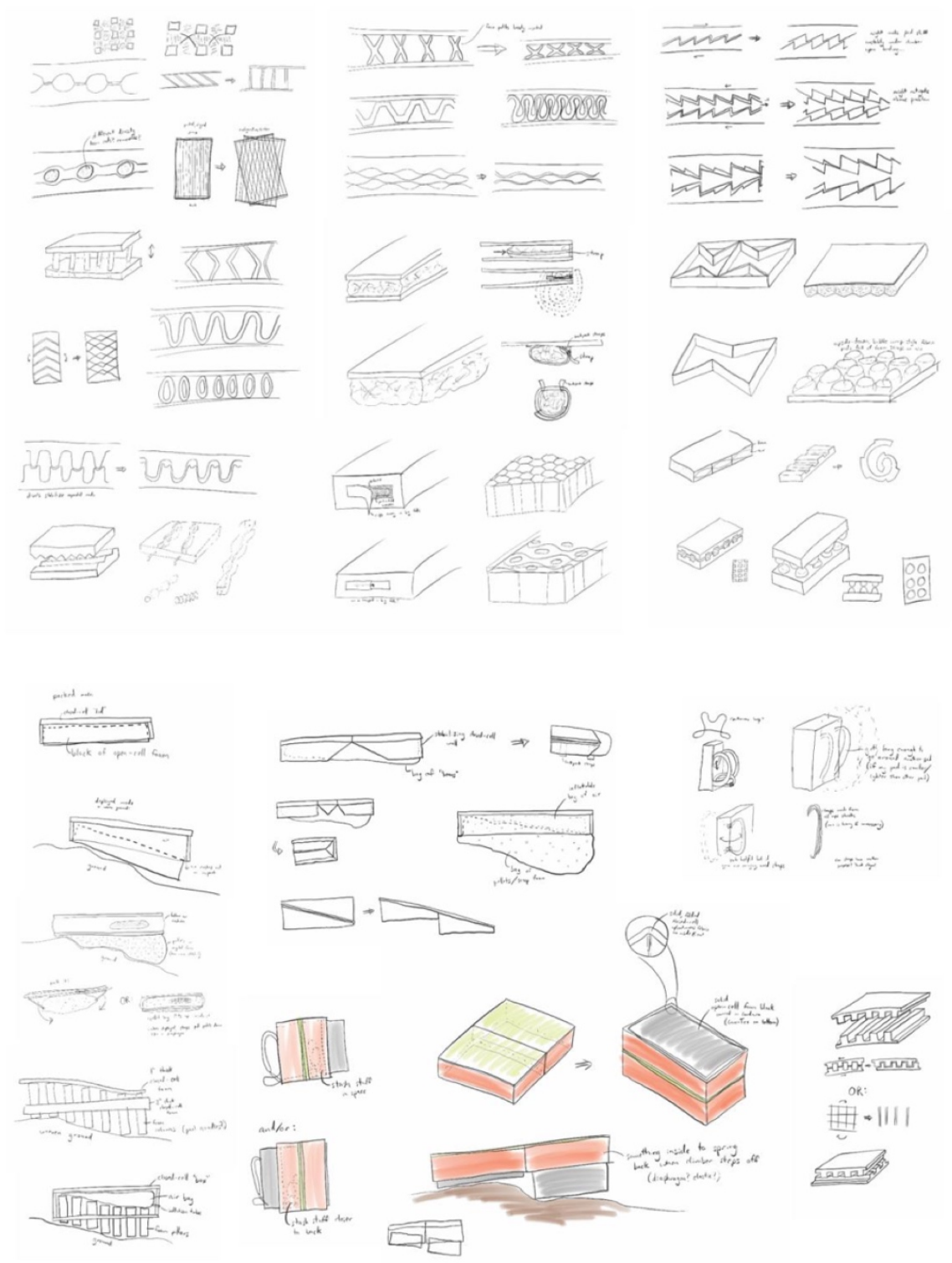
The retail price of the pad should be at the high end of the current product landscape, since this pad will have an innovative cushioning system. Therefore, the retail price is \$360 with an FOB of \$90.

The Crumple Zone is geared toward serious outdoor boulderers who are willing to pay premium prices for a fully featured, high performance pad. It is not designed for one particular gender. The target user is between the ages of 23 to 35. Most boulderers are fairly young but students or recent graduates may be less willing to pay premium prices, so the Crumple Zone is designed for the young professional boulderer.

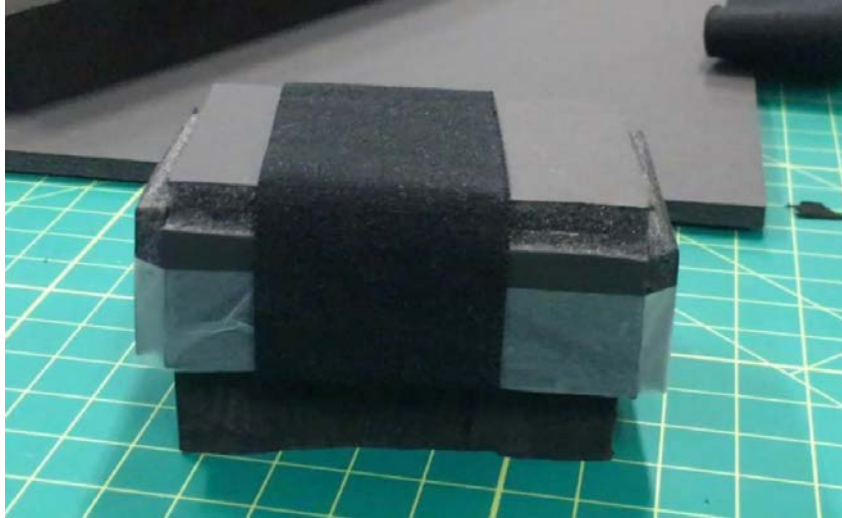
IDEATION PROCESS

The search for inspiration revolved around ways to conform to uneven surfaces, ways to create volume and thickness while limiting weight, and structures that can be modified or deformed in different directions. Inspiration was drawn from footwear cushioning, mattress technology, MIPS helmet structures, stunt bags, foam pits, and pin art toys, among other things.

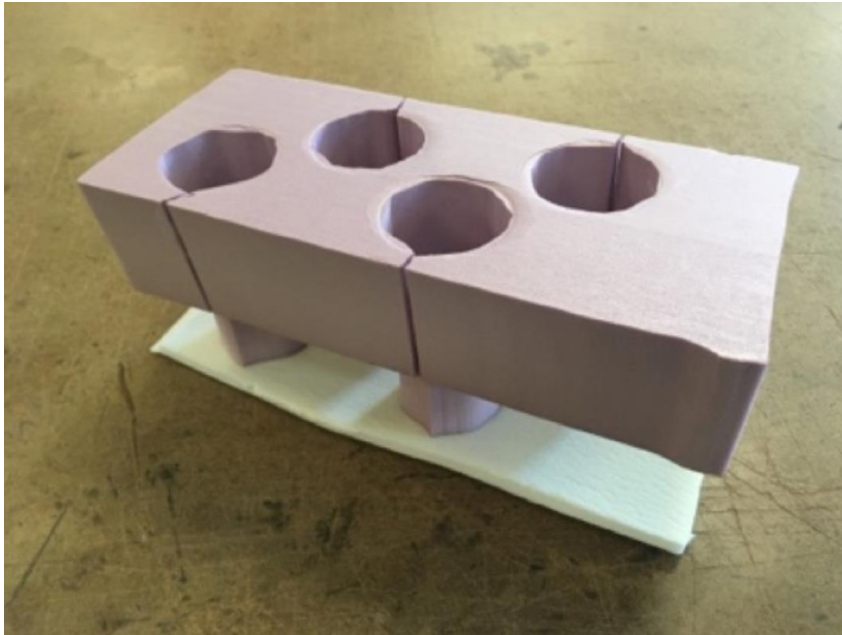
The ideation process involved sketching, folding paper, and creating mini prototypes. The primary method was sketching, with only a handful of paper foldings. The mini prototypes were made from foam core board, elastic, EVA foam, synthetic woven fabric scraps, scrap open cell foam, pink foam, sheets of plastic, and Reese's Puffs cereal. Folding paper was not particularly helpful because it is very thin and two-dimensional whereas crash pads have considerable thickness and the materials that comprise them do not crease easily. It was difficult to visualize the transition from paper to a foam crash pad. Thus, sketching was more helpful and less limiting. Creating the mini prototypes from materials more similar to those that would actually be used was helpful once ideas were somewhat refined via sketching. It was useful to work through the process of actually constructing different cushioning mechanisms as a way to think through manufacturability and the making process at various scales.



A selection of ideation sketches.



The foam core prototype with elastic successfully rebounded after loading.



The column idea, pre-Reese's Puffs.



Reese's Puffs were an easy way to validate the concept.

Through the process of prototyping a design with columns, it became clear that not only cutting round columns but also getting them to slide up and down in their holes would be challenging. Additionally, the complications of gluing, sewing or otherwise attaching the columns and layers of foam to the right parts of the fabric cover were revealed. Although innovation is the priority in this project over cost, the manufacturing hurdles seemed too great. Meanwhile, the idea of a closed cell foam "lid" over a reversible block of foam with a beanbag on one side proved to be much more easily and effectively prototyped. An 8" by 12" prototype even withstood repeated jumping with full body weight.



Final winter term prototype of the lid and beanbag block idea.

VALIDATION PLAN

The Crumple Zone must do three main jobs:

- *Cushion 2' to 12' falls as well as a commercially available 6" thick pad*
- *Conform to slanted and uneven surfaces*
- *Fit in a sedan and be carried as easily as a standard pad*

The following tests will be used to determine whether the Crumple Zone accomplishes these things.

Cushioning Test 1, in studio:

1. *Stomp on the pad with one foot*
2. *Jump onto the pad from the ground next to the pad*
3. *Jump onto the pad from a chair*
4. *Jump onto the pad from a tall stool*
5. *Conduct similar tests with the Metolius Session pad*
6. *For all of the above, record qualitative data on comfort, feeling of stability (of ankles and of overall balance), perceived impact etc. Record video of landing on the pad.*

Cushioning Test 2, in studio:

1. *Using Accelerometer app on iPhone, drop phone from heights between 3' and 7' above the floor onto the prototype, and onto the Metolius Session pad.*
2. *Look at accelerometer data to better understand the peak force, damping effect/bounce reduction, etc.*

Conforming to Slanted and Uneven Surfaces Test 1, in studio:

1. *Place various irregular objects such as shoes, boxes, ski boots, and textbooks on the floor.*
2. *Place the pad over each of these objects, and combinations of these objects*
3. *Photograph how the pad sits*
4. *Observe and record whether the pad feels stable or is wobbly, where it contacts the objects and the ground, and any dead spots*

Packability Test 1, in the field:

1. *Convince one or more friends with cars to go bouldering with me.*

2. *Try placing pad prototype in the trunk of their sedan and/or hatchback*
3. *Photograph how the pad fits*

Main Field Test:

1. *First, conduct Packability Test 1, above.*
2. *Upon arriving to the crag, attempt to pack the pad as I normally would, putting small items in it for convenient carrying. Notice convenience or lack thereof, and what features I might want to alter.*
3. *Carry the pad down the trail, noting comfort or lack thereof. Also note center of gravity, and ability to fit under trees, between boulders etc.*
4. *Unpack the pad and lay it under various boulders. Climb and fall on it. Note performance.*
5. *Get feedback from friends on the pad's performance.*
6. *Photograph the pad in place under boulderers. Possibly take video of people landing on the pad.*
7. *Repeat this at various different crags including Carver, Empire Boulders, and Smith Rock.*

Optional Field Test:

1. *Lend pad to a friend, to Juan, or to another avid boulderer who has a good frame of reference for crash pads.*
2. *Get their feedback.*

Note: This test did not take place due to COVID-19.

Expert Feedback:

1. *Speak with industry professionals (i.e. Jim Karn at Metolius) and show them the pad. Ask for impressions, thoughts and feedback.*

EDIT: The previously detailed tests were carried out, with some modifications and additions due to COVID-19 and other factors as follows:

Perception Test/Expert Feedback:

Record Google Hangouts call with Jim Karn (Metolius Product Developer, my capstone mentor).

Questions to ask:

What are your thoughts/impressions of what I have so far (prototypes and sketches)? Do you think the product will work as intended? Do you think the lid will provide stability?

What do you think of the....

- *Lid*
- *Suspension*
- *Straps/flap design*
- *Carpet design for top*
- *Color*
- *Hexagon shapes*
- *Performance potential*

Cushioning Test 2, updated:

1. *Strap iPhone to lower leg just above ankle using duct tape. Begin recording acceleration, particularly in the Y-axis (vertical).*
2. *Whilst recording video of each jump, jump from 25" tall stool onto pad at least 5 times.*
3. *Look at accelerometer data to better understand the peak force, damping effect/bounce reduction, etc.*
4. *Repeat with both pad configurations, and Metolius Session pad as a control.*

PRESENTATION PLAN FOR SPRING TERM

On June 5th, the Crumple Zone crash pad will be displayed in the White Stag atrium. Two display boards will show the design brief, research, ideation, and validation results. Prototypes will be displayed on a table as well as on the floor. A rubber traction mat will prevent prototypes from slipping on the smooth floor so those looking at the work can try jumping onto the pads. The Metolius Session pad may be displayed alongside the pad for comparison and for viewers to understand what a typical crash pad is like. Props such as climbing shoes and a chalk bucket may be displayed for context, and because items such as these must be carried inside the pad. A Keynote presentation will include imagery of the pads in context, videos of in-studio validation and folks landing on the pad outside, and results.

EDIT: Due to COVID-19, a virtual showcase comprising slides and a presentation was the primary method of sharing the work with the public.

MAKING PLAN

Materials for 48"x36" pad:

- *Grey GoreTEX SPL600XK/TR 3L Pro from Jonathon for the bottom*
- *1000 denier Cordura for the top (could be as low as 600d); I have 2.5 yards of 1000d from Mill End in a golden color*
- *Open-cell foam scraps from Rose City Upholstery (I have a large bag already)*
- *48"x36"x2" open-cell foam sheet*
- *2x3/4" thick closed-cell PE or EVA foam for top and "lid" sides*
 - *Pieces to cut: 1 48"x36", 2 48"x4", 2 36"x4"*

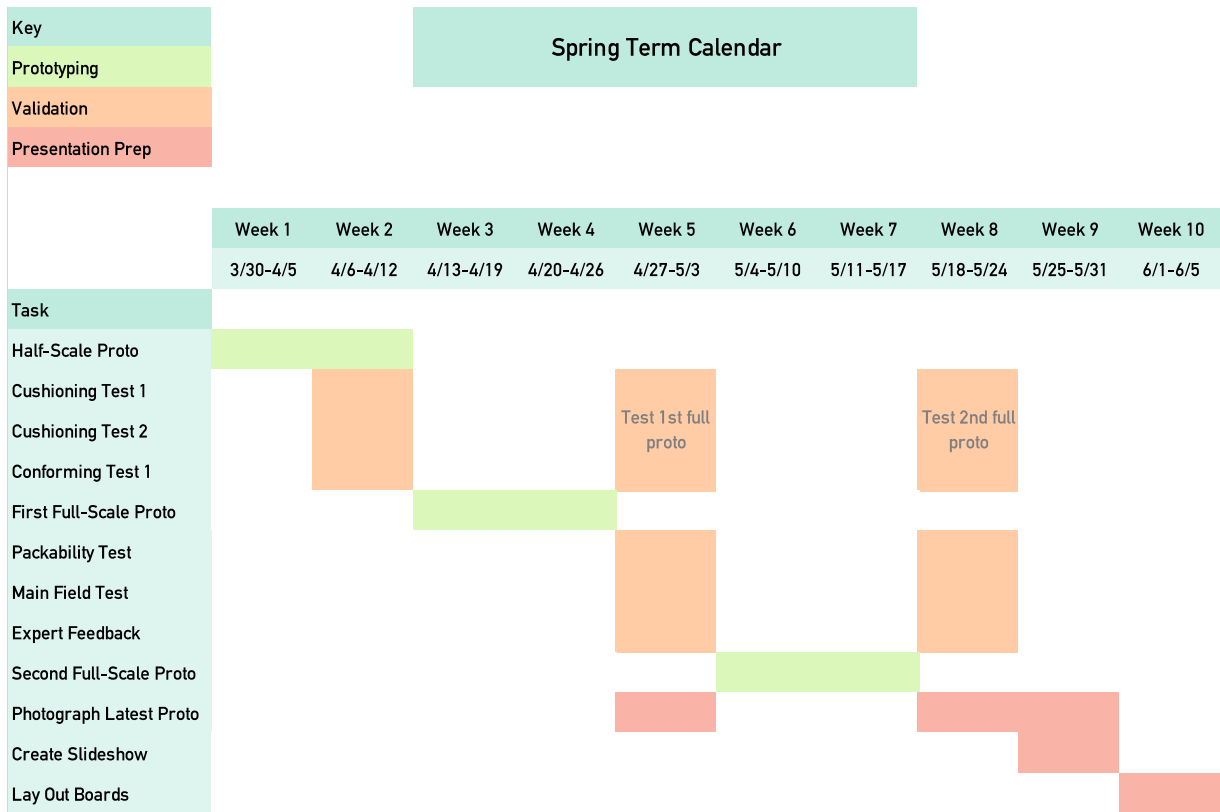
- *Velcro closure for foam into cover, and for closing 2" sheet of open cell into its cover*
- *Aluminum g-hook buckles*
- *Synthetic knit for next-to-skin side of backpack strap padding (other side will be same Cordura as above)*
- *Retired rope sheaths from scrap monkey tails bin at Planet Granite*
- *Zippers (Brendon was organizing this?)*

Method:

- *Cut foam using snap off craft knife and/or bandsaw*
- *Sew Cordura using walking foot machine*
- *Glue necessary components using spray adhesive and in some cases Barge*

Making Plan:

- *Make a 24"x18" mini prototype to further test the cushioning mechanism.*
- *Prototype carrying strap system separate from pad (shoulder straps, hip belt, attachment flaps/straps)*
- *Make a full-scale prototype and, after validating cushioning, complete it by attaching all straps and flaps.*
- *After testing this full-scale proto in the field, make a second, improved full-scale proto based on validation results. Note: Due to COVID-19 and disinclination to waste materials, only one full-scale prototype was made.*



The two-week window (week 6 and 7) is ample time to make modifications to the design of the first full-scale prototype. This period will most likely involve not just making one second full-scale prototype, but will also involve prototyping components of the pad as in earlier prototyping stages if, for instance, the suspension straps need modifications.

UPDATED CALENDAR

The following is a weekly calendar updated based on what is possible due to COVID-19.

Week 1

- Create this weekly calendar
- Create explanatory view of crash pad in Illustrator
- Create mood board

- *Order replacement needle, acquire materials for prototyping from studio and begin ordering*
- *Reply to Jim Karn's latest feedback*

Week 2

- *Define materials pallet for approval*
- *Order remaining materials: open and closed cell foam, wide webbing, hip buckle, shoulder strap adjustment ladder locks, closure buckles, closure webbing, needles, spray mount adhesive ASAP. See manual for size needle. Get Singer Domestic size 14 or 16. Get a bunch of packs because I'll break a lot. Email Susan links of what I want and Jen can buy it for me. Bias tape or piping. Grey thread.*
- *Prototype suspension strap system if I have materials, and begin half scale proto*

Week 3

- *Complete half scale prototype*
- *Get feedback from Jim on latest proto*
- *Refine Illustrator explanatory view*
- *Begin full scale proto*

Week 4

- *Determine brand elements: Logo, wordmark, call it something intuitive, design language.*
- *Initial packaging ideation—website, tags, demos etc. Branding moment on straps/flap. Unique stitching, or something.*
- *Make full scale prototype*
- *Prepare for Formal Group Critique*

Week 5

- *Create deck for Formal Group Critique*

- *Begin refining proto based on crit*

Week 6

- *Finalize prototype*
- *Test in apartment, or in field if possible*
- *Get feedback from athletes*

Week 7

- *Complete final prototype*
- *Begin tech flats*

Week 8

- *Work toward finalizing packaging*
- *Buffer for final prototyping*
- *Finish flats*
- *Create tech pack*

Week 9

- *Photograph pad under a rock in wilderness*
- *Photograph pad on athlete's back hiking on trail i.e. in Forest Park*
- *Prepare for final presentation*

Week 10

- *Present!*

MARKETING EVEN KEEL

The sheer size of crash pads makes distribution difficult, but it is helpful for marketing purposes. They are often displayed prominently in gear shops and their large expanses of brightly colored Cordura are eye-catching. They are highly visible in many photographs and videos of bouldering, as a colorful

backdrop to the shot. Even carrying them to the crag is a spectacle, as passersby see the massive rectangles on climbers' backs. They are like mini billboards.

Packaging for this product will be minimal; whilst being shipped the crash pad will be bagged and boxed but once it is in a retail location it should be displayed with no packaging other than a hang tag. Since the Crumple Zone employs novel cushioning technology, the hang tag does need to convey the features and benefits of the pad. Namely, these are the superior cushioning, ability to conform to uneven surfaces, and versatility to switch between these two modes.

Although crash pads are not usually a lifesaving piece of equipment, they can reduce injury risk so climbers may be wary of new technology. The best ways to overcome this barrier to entering the crowded crash pad market are to have climbers experience the technology firsthand, and to have well-known athletes use them in a visible way. Gear demos at climbing festivals would be a great strategy. Climbers could borrow the pad for part or all of a day and see how great the cushioning is. Crumple Zone could be given to athletes who are active on social media. Outdoor Gear Lab and other review websites often try out new gear, so that could be an opportunity for exposure and honest feedback. Events like Outdoor Retailer are also good places to show off new innovations.

If the Crumple Zone was actually going to market, a website would provide an opportunity for direct-to-consumer sales and to explain the benefits of the innovative cushioning solution. The website would contain animations and video of the system in action, and testimonials from athlete testers.

PRODUCT NAME

Even Keel is named for the fact that it evens out irregular surfaces, thus allowing climbers to keep a cool head in otherwise nerve-wracking situations.

EVEN KEEL CONCEPT STATEMENT

Even Keel is the crash pad that provides superior cushioning under almost any boulder problem. In highball mode, Even Keel combines airbag-like cushioning with structured stability. For uneven landings, a bag of recycled foam smooths out the scree. The convertible design eliminates the need for specialized pads.

ATHLETE OUTCOMES

Reducing risk of injury and inspiring confidence, Even Keel is the versatile crash pad that allows boulderers to forget about the landing and focus on the climbing.

BRAND TENNETS

Be bold. Even Keel inspires courage and try-hard with statement colors and strong design language.

Trust. Even Keel is all about safety and durability.

Adapt. Even Keel adapts to rough landings so climbers can focus on adapting to the challenges of the climb itself.



JESSAMY TAYLOR | PROCESS BOOK

WINTER PRESENTATION

MARCH 2020

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<https://www.5280.com/2019/10/as-the-popularity-of-indoor-climbing-grows-as-does-the-need-for-gym-to-crag-programs>.

A man is climbing a steep, reddish-brown rock face. He is shirtless, wearing dark pants and red climbing shoes. A woman in a yellow shirt and red pants stands at the base of the cliff, reaching up with her arms outstretched. The background shows more of the rocky terrain and some sparse vegetation.

JESSAMY TAYLOR

CRUMPLE ZONE

WINTER FINAL REVIEW

WINTER PRESENTATION

MARCH 2020

WINTER PRESENTATION

MARCH 2020

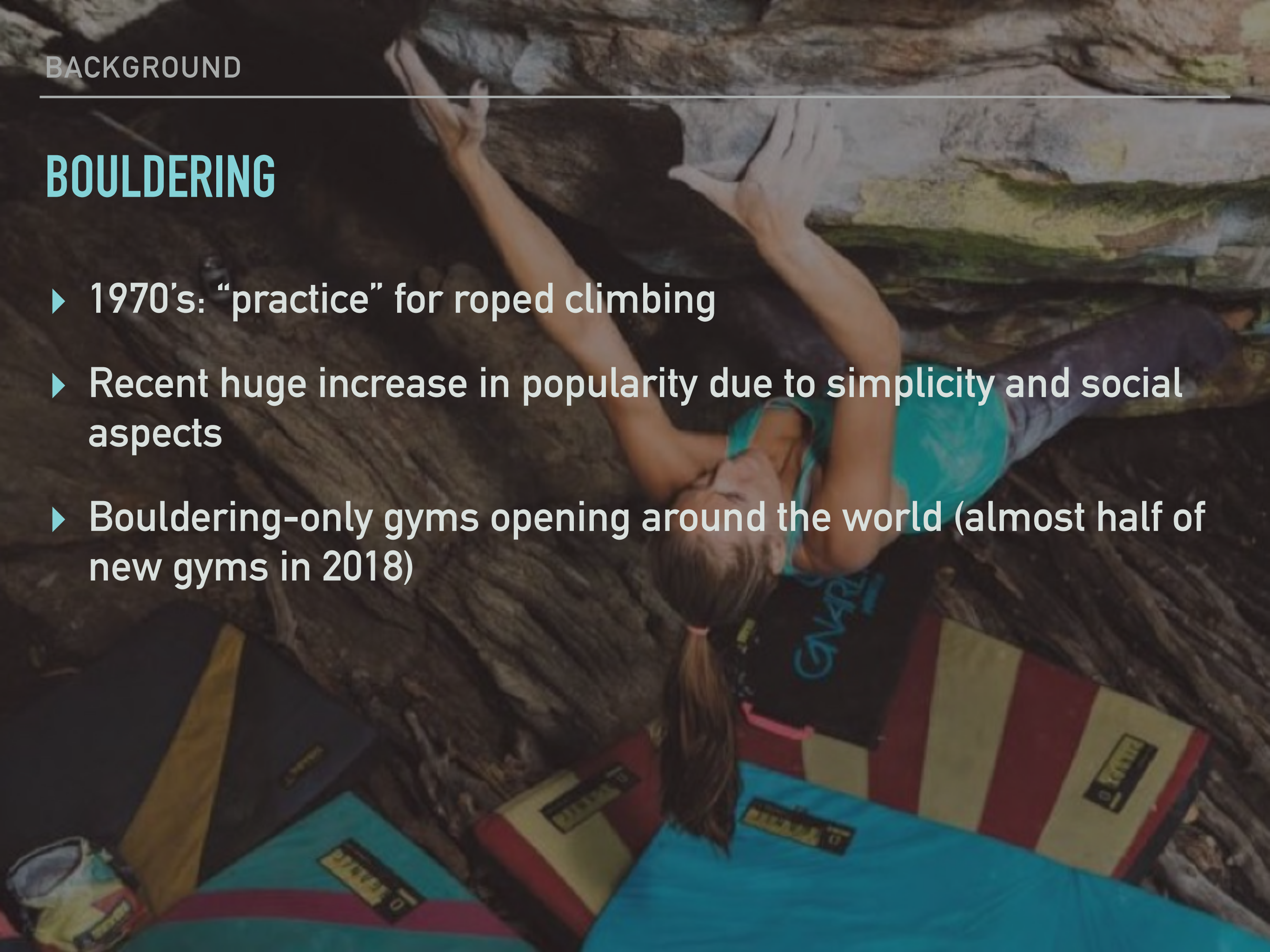
OVERVIEW

14 YEARS OF CLIMBING



BOULDERING

- ▶ 1970's: “practice” for roped climbing
- ▶ Recent huge increase in popularity due to simplicity and social aspects
- ▶ Bouldering-only gyms opening around the world (almost half of new gyms in 2018)



PROBLEMS TO SOLVE

THE RISK: EVERY FALL IS A GROUND FALL





PROBLEMS TO SOLVE

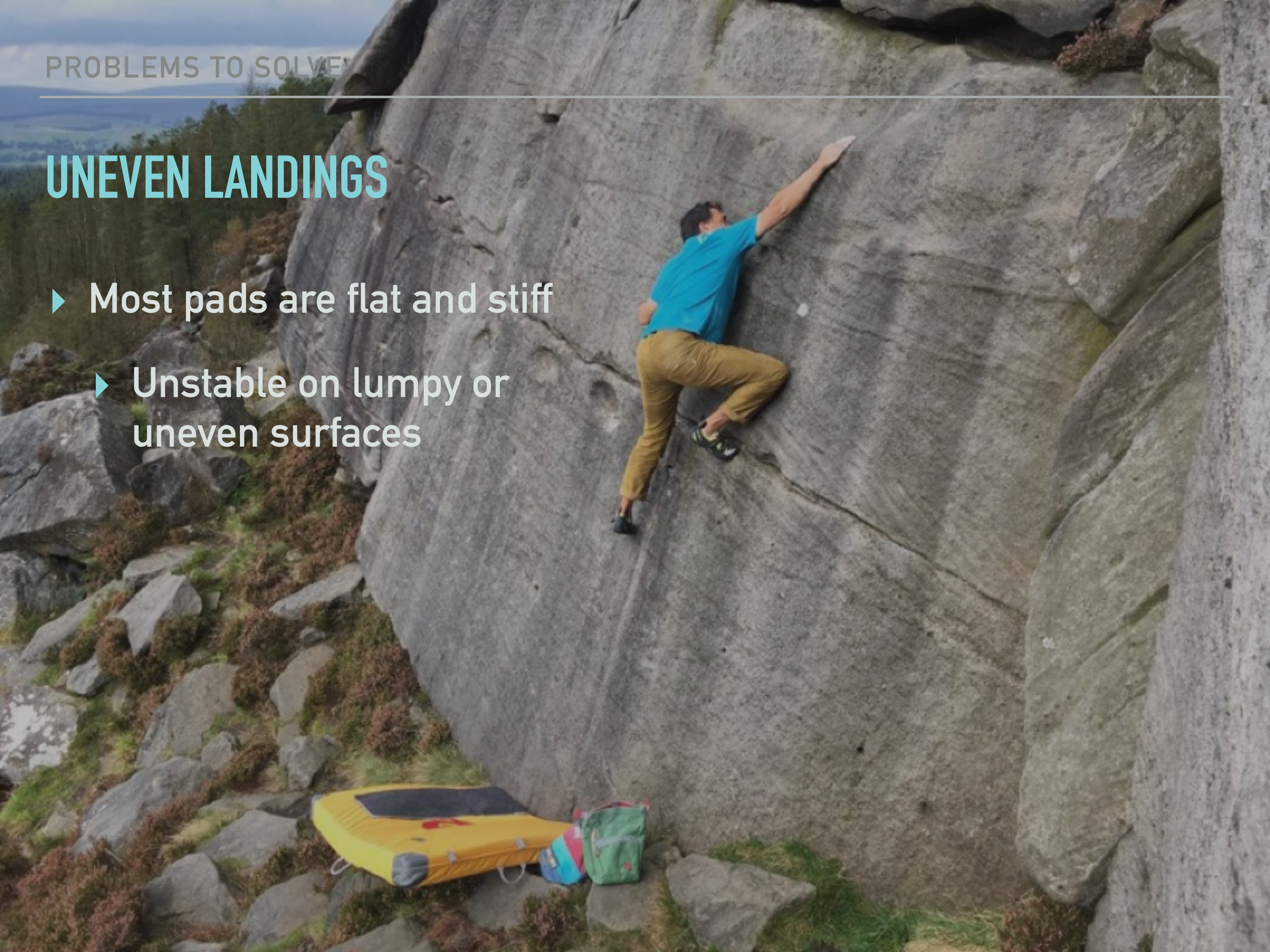
INJURIES ARE COMMON

60%

of outdoor boulderers in one study had sustained lower extremity injuries (Wilderness and Environmental Medicine, 2007)

UNEVEN LANDINGS

- ▶ Most pads are flat and stiff
- ▶ Unstable on lumpy or uneven surfaces



TRANSPORT: PADS ARE BULKY

- ▶ Bigger crash pads provide better fall protection, but are hard to fit...
 - ▶ ...in a plane
 - ▶ ...in a car
 - ▶ ...on your back



PROBLEMS TO SOLVE

THE GOAL

- ▶ Cushion uneven surfaces as well as flat landings
- ▶ Maintain portability



CRASH PAD FACTORS

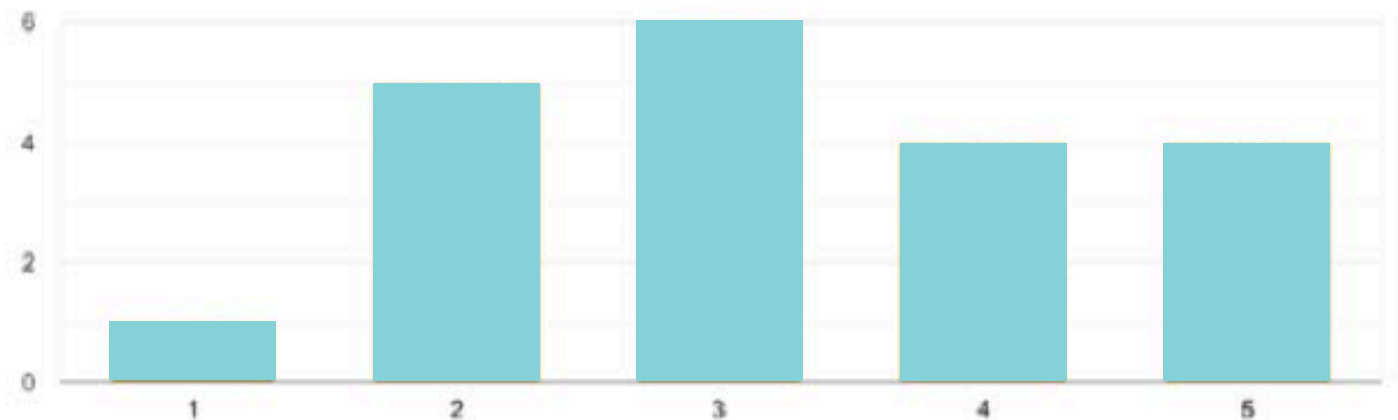
- ▶ Price
- ▶ Durability
- ▶ Aesthetics
- ▶ Cushioning falls of varying heights
- ▶ Cushioning uneven surfaces
- ▶ Coverage
- ▶ Weight
- ▶ Versatility
- ▶ Sustainable materials
- ▶ Suspension straps
- ▶ Ways to carry small items inside the pad
- ▶ Attaching other pads for carrying
- ▶ Attaching pad edges to each other
- ▶ Waterproof bottom/ease of cleaning

ATHLETE SURVEY

- ▶ 22 responses from boulderers across the country
- ▶ Most important features:
 - ▶ Durability
 - ▶ Price
 - ▶ Cushioning high falls
 - ▶ Conforming to/evening out uneven surfaces
 - ▶ Versatility
- ▶ Favorite pad: Organic full pad

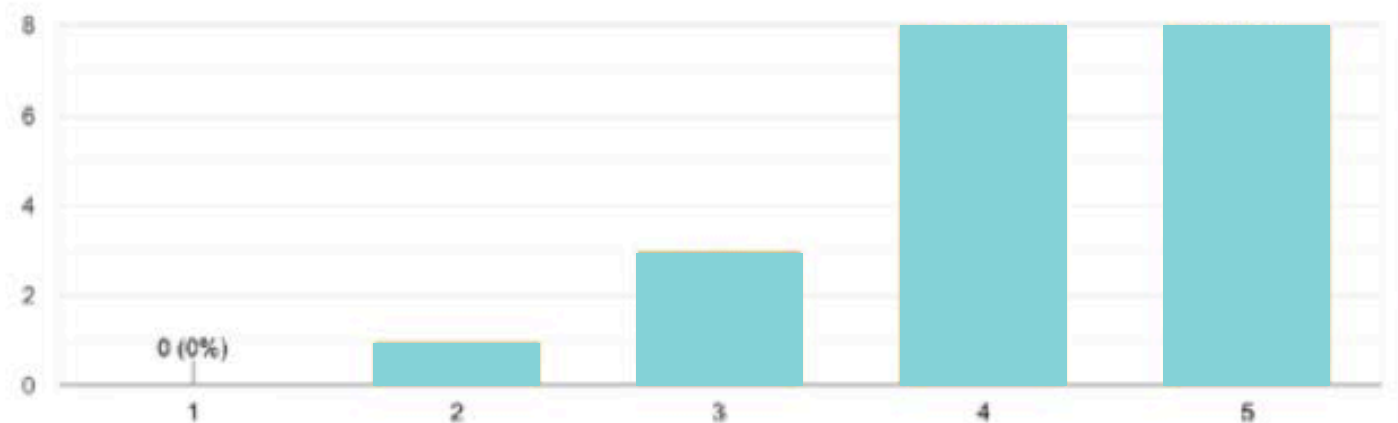
How interested would you be in a collapsible or inflatable crash pad that packs down small(ish)?

20 responses



How interested would you be in a crash pad that better absorbs impacts from a variety of angles, i.e. when landing on a slanted surface?

20 responses



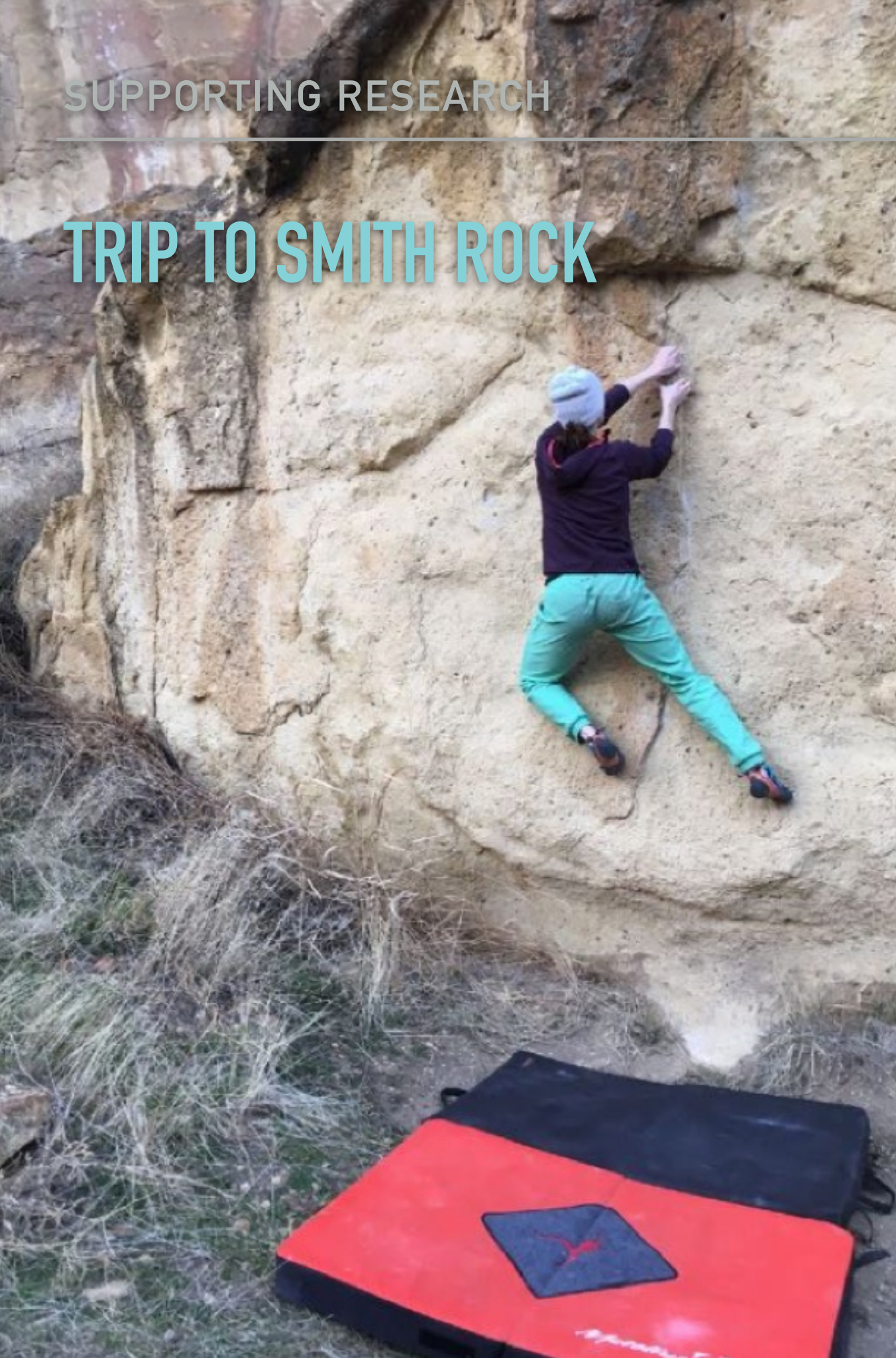
CRUMPLE ZONE

- ▶ A crash pad for serious outdoor boulderers
- ▶ Versatile cushioning for big falls on flat landings, and for smoothing uneven ground
- ▶ FOB: \$90 // Retail price: \$360
- ▶ Features and benefits:
 - ▶ Versatile cushioning system provides stability and shock absorption for big falls, AND conforms to uneven surfaces
 - ▶ Compression system allows the pad to fit in the trunk of a sedan
 - ▶ Cushioning system is either more durable than traditional foam or can be replaced or refreshed to extend the lifespan of the pad
 - ▶ Partially constructed of recycled foam for sustainability



SUPPORTING RESEARCH

TRIP TO SMITH ROCK



JIM KARN, METOLIUS PRODUCT DESIGNER

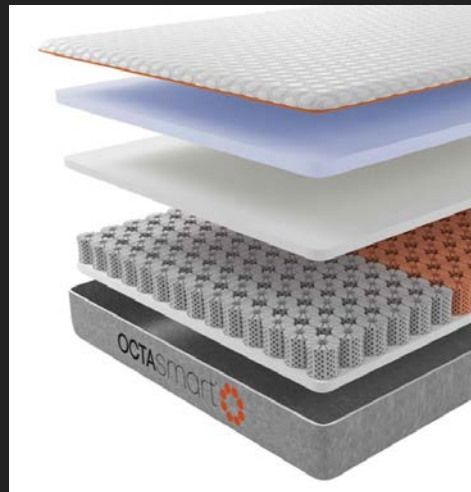
- ▶ Professional climber turned product designer in the 1990s
- ▶ Once prototyped an exceptionally effective pad with controlled air exhaust cushioning



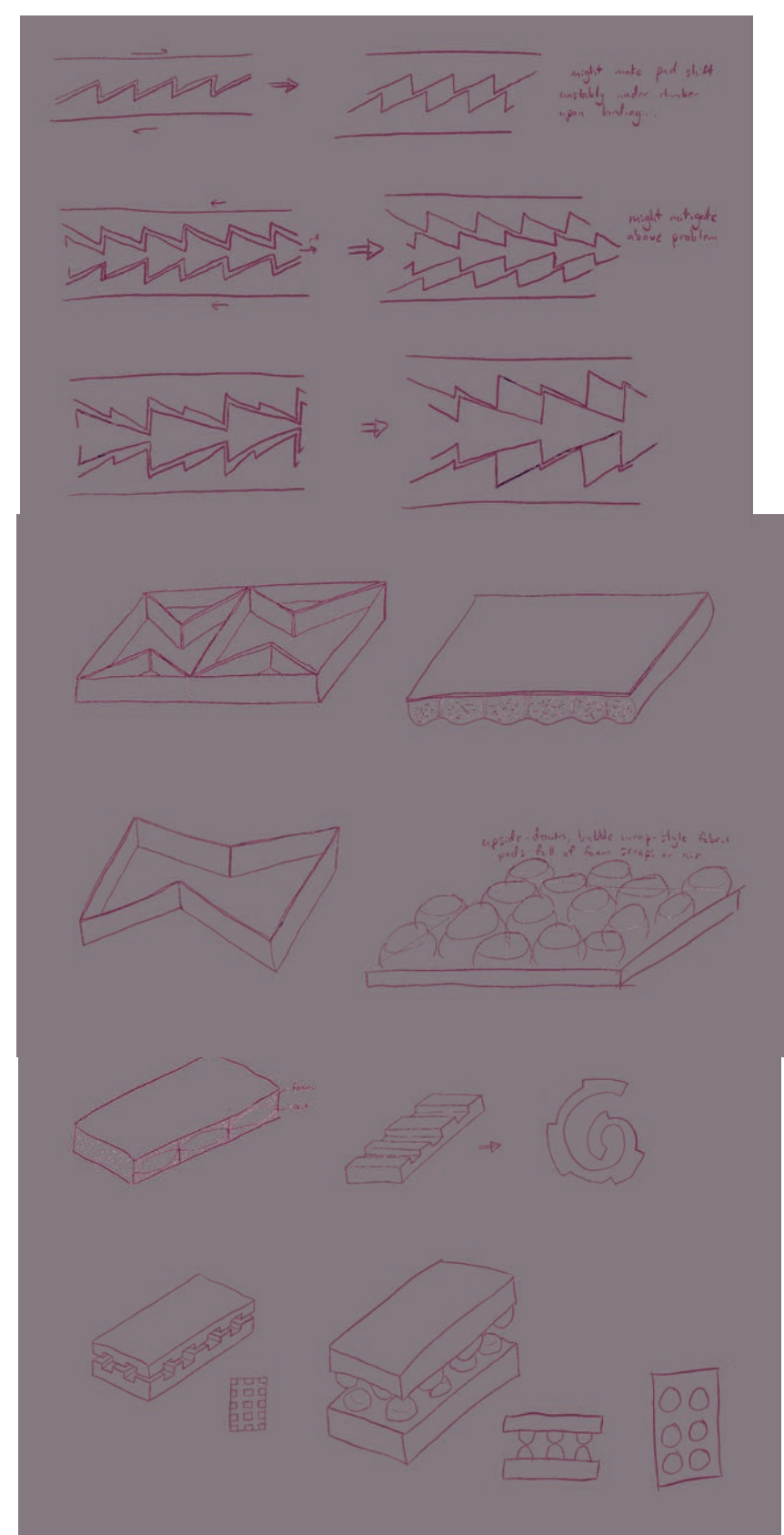
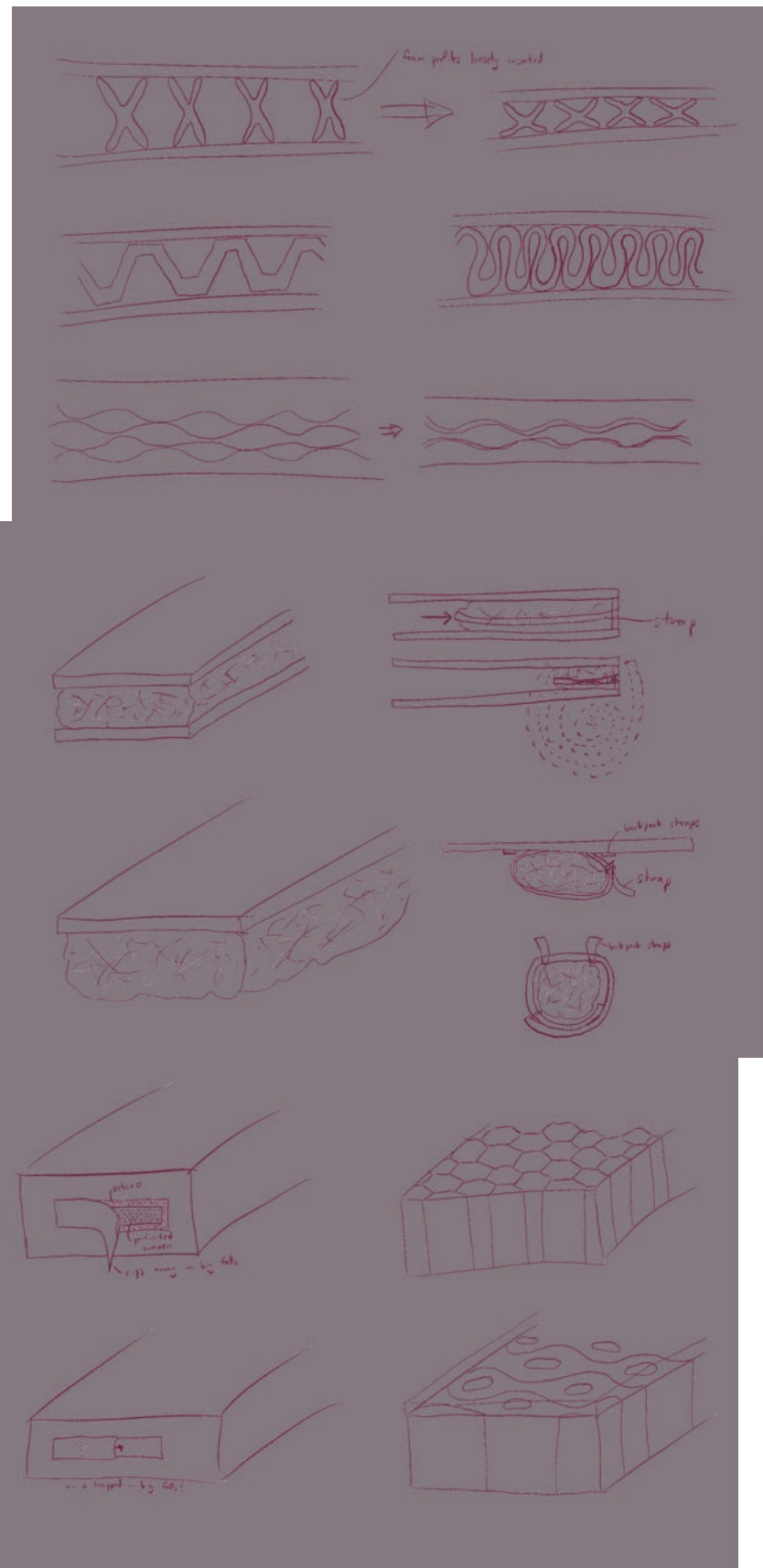
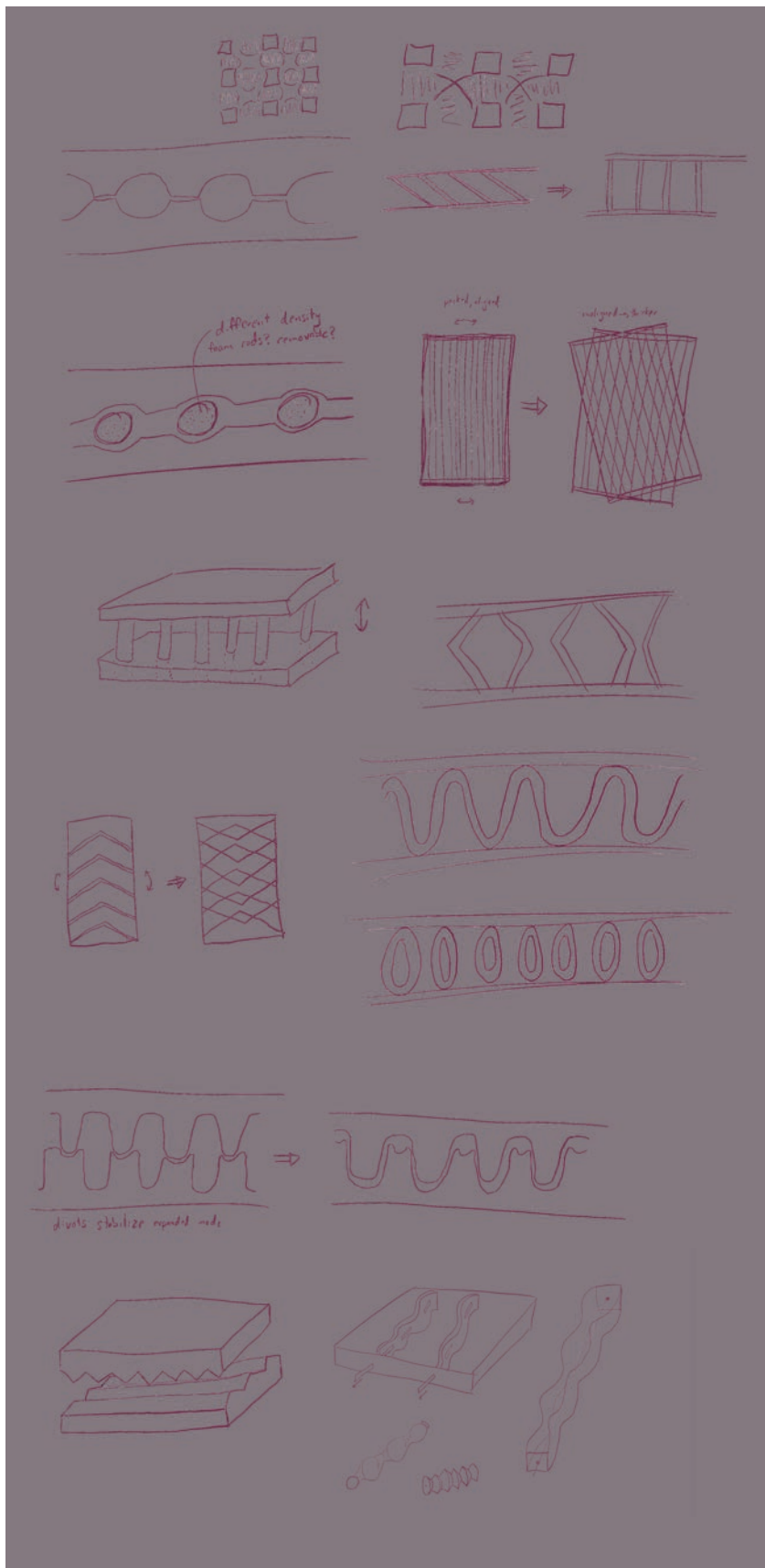
INSPIRATION



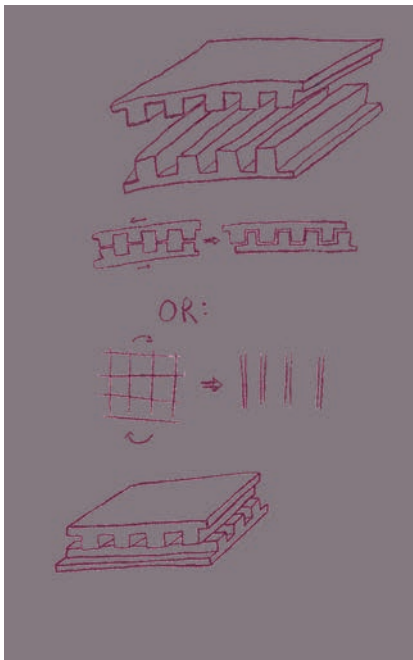
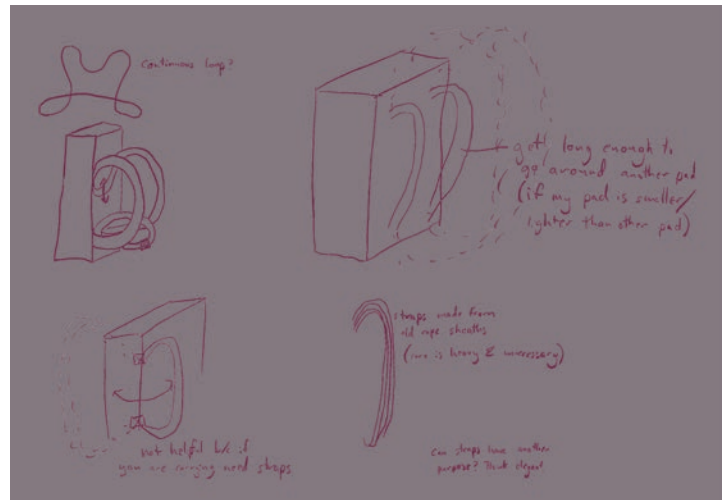
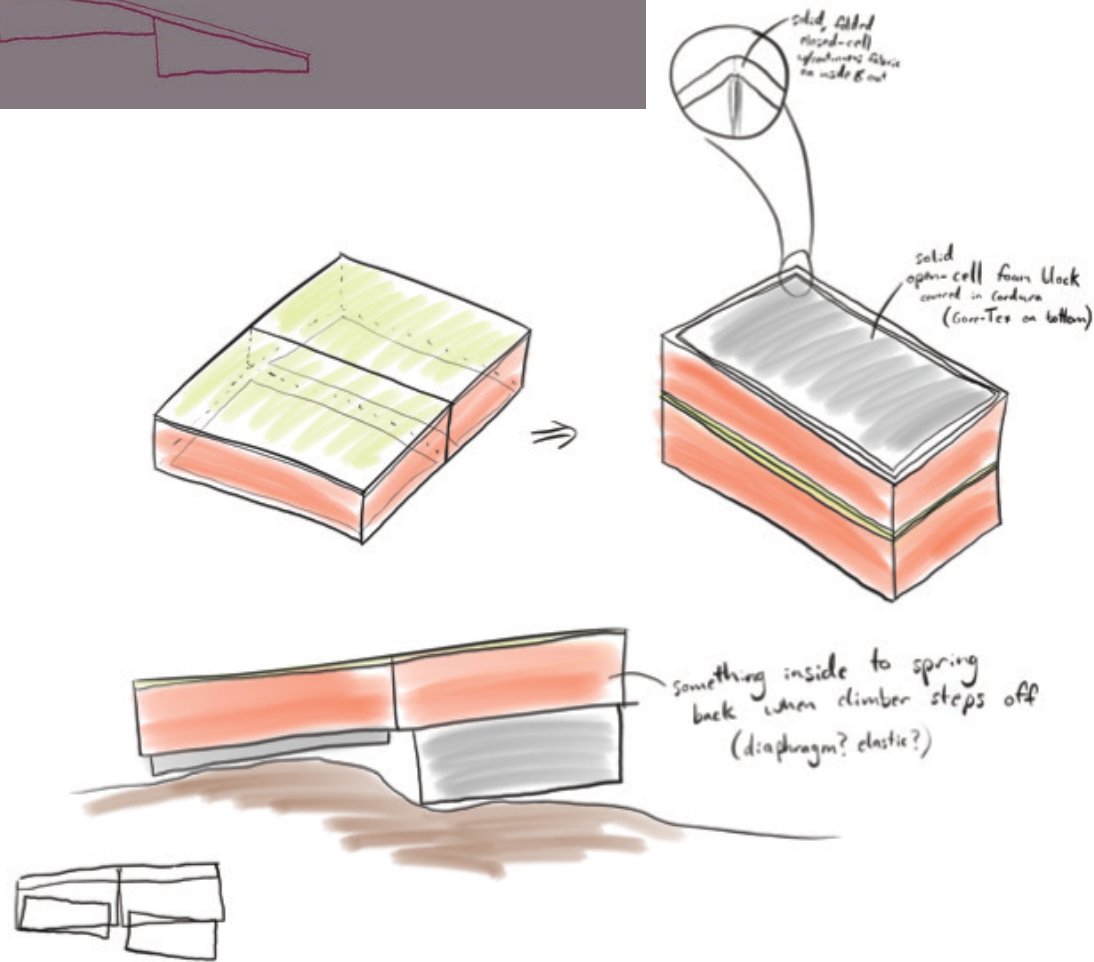
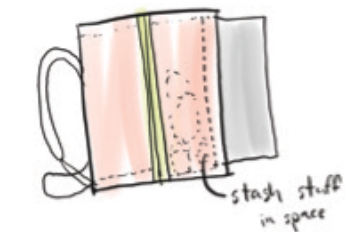
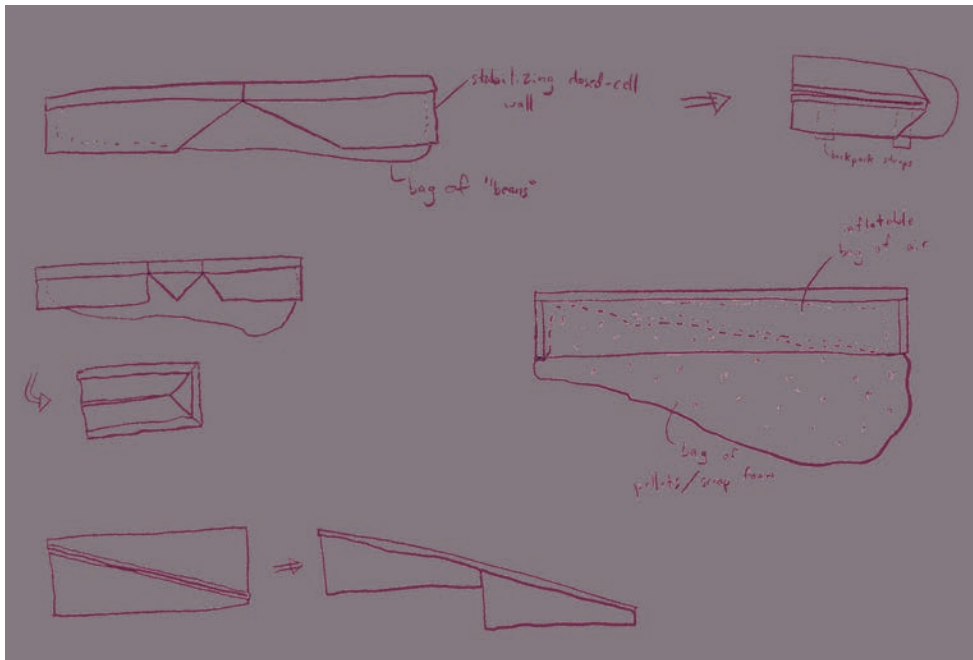
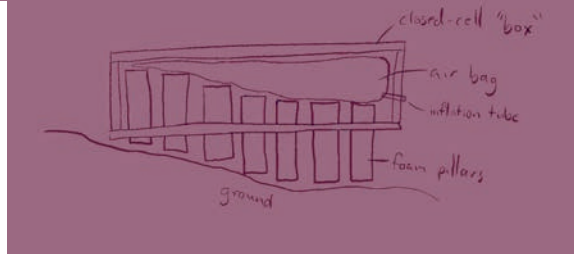
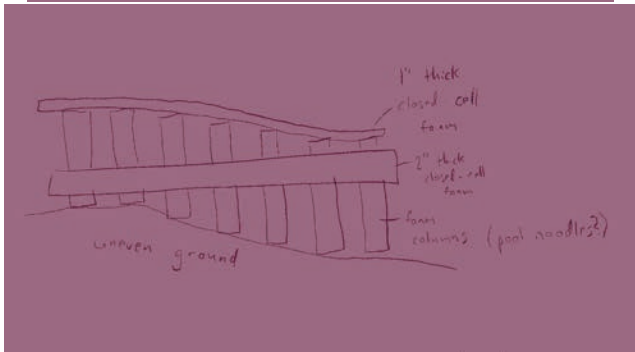
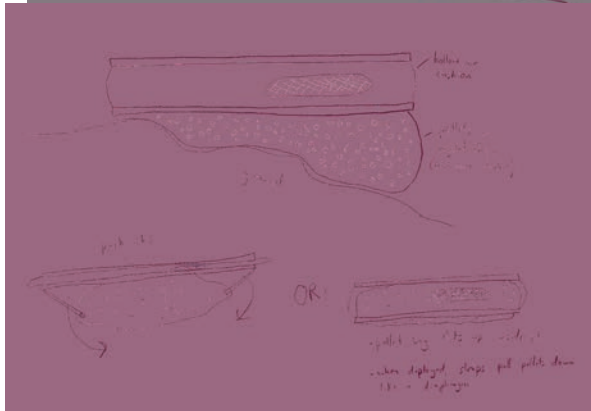
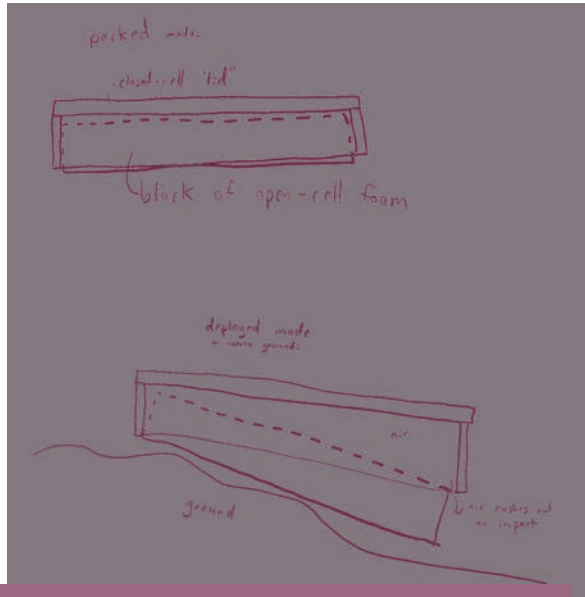
INSPIRATION



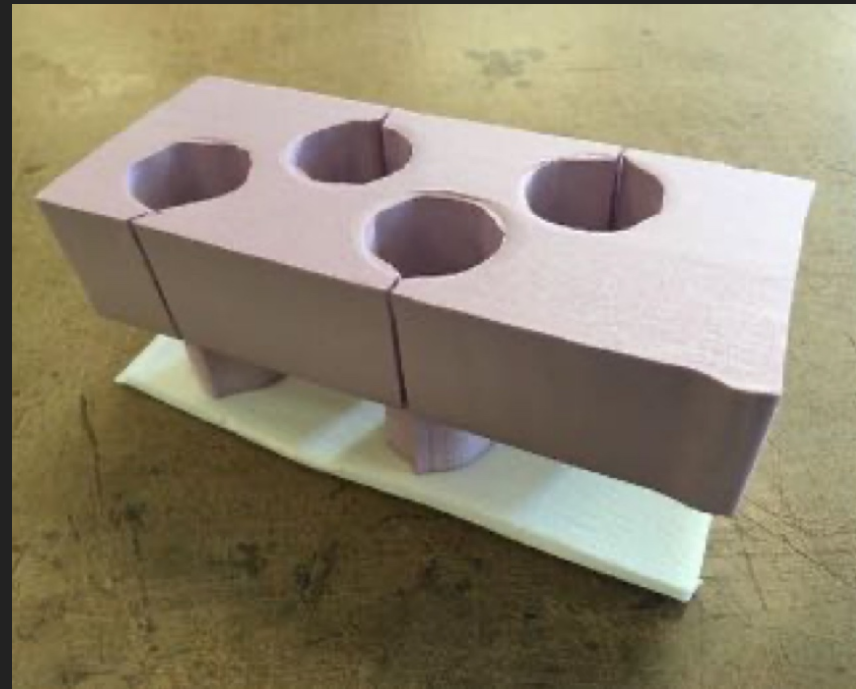
IDEATION



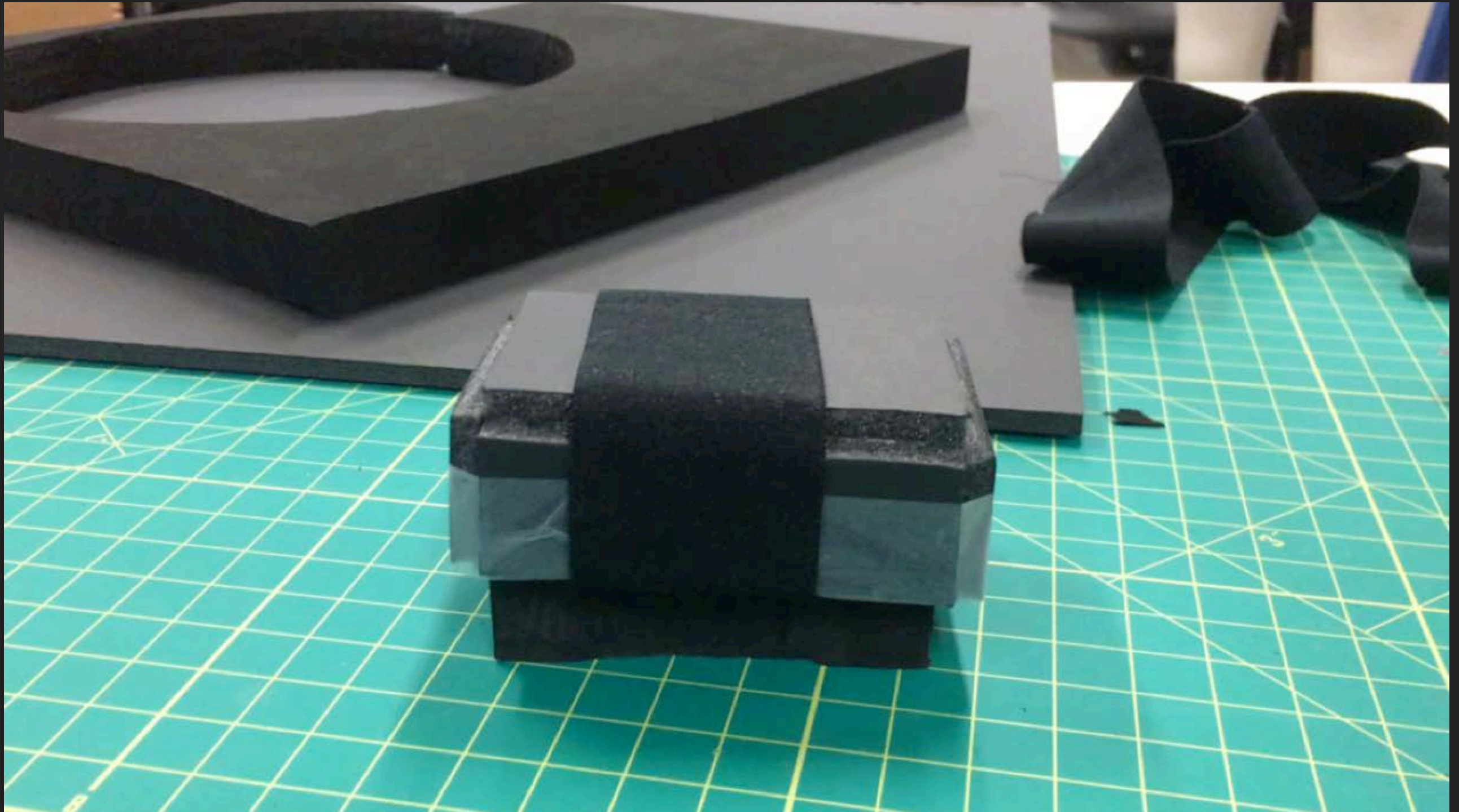
IDEATION



COLUMNS



AIR CUSHION

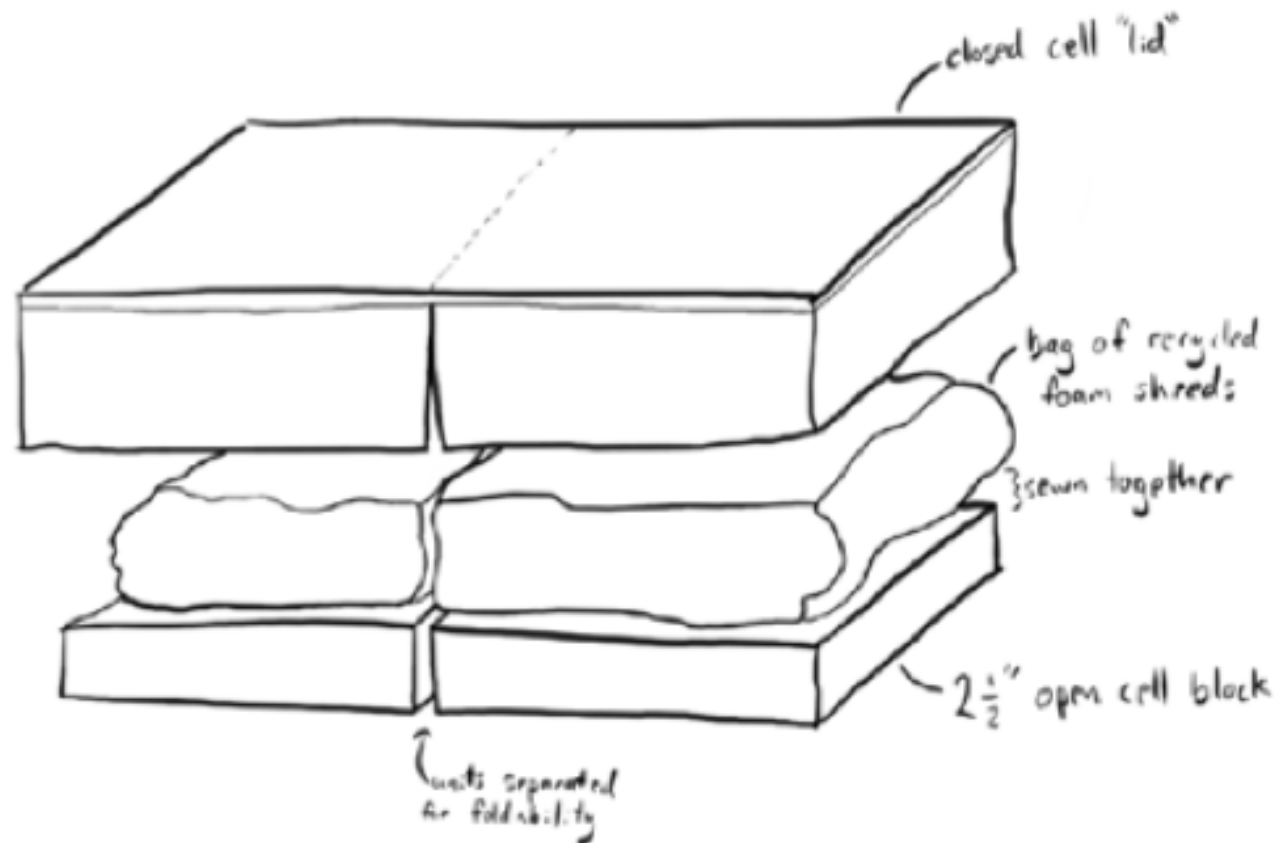


AIR DAMPING

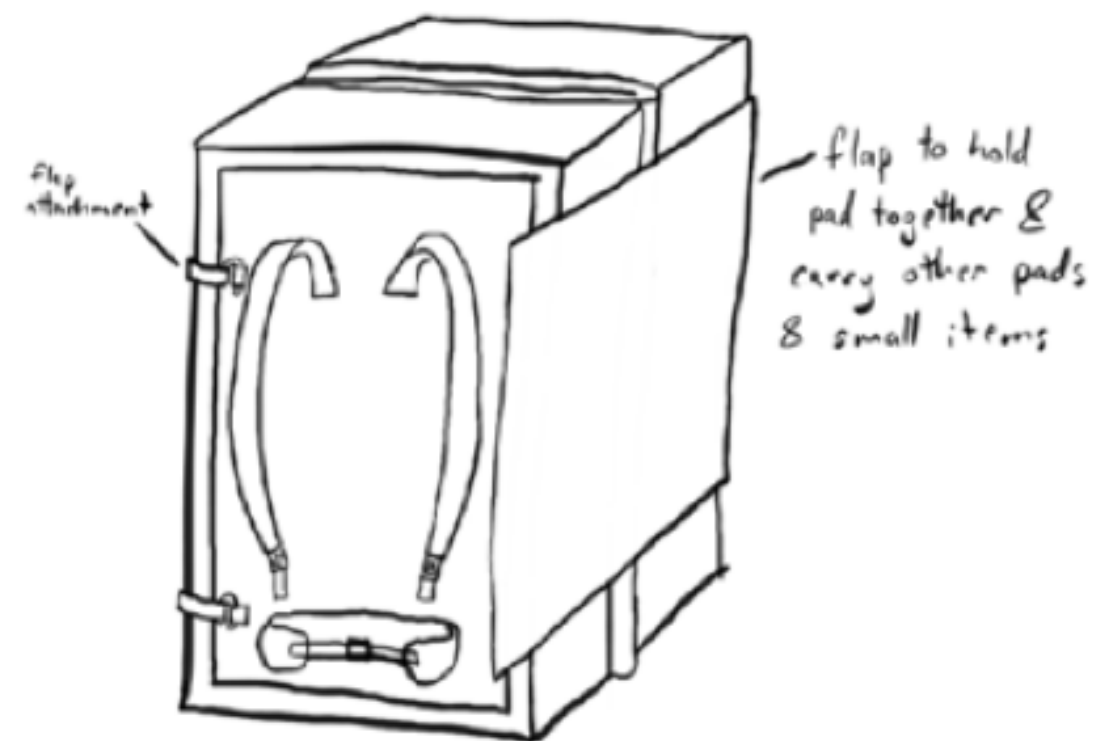


COMPONENTS AND FORM

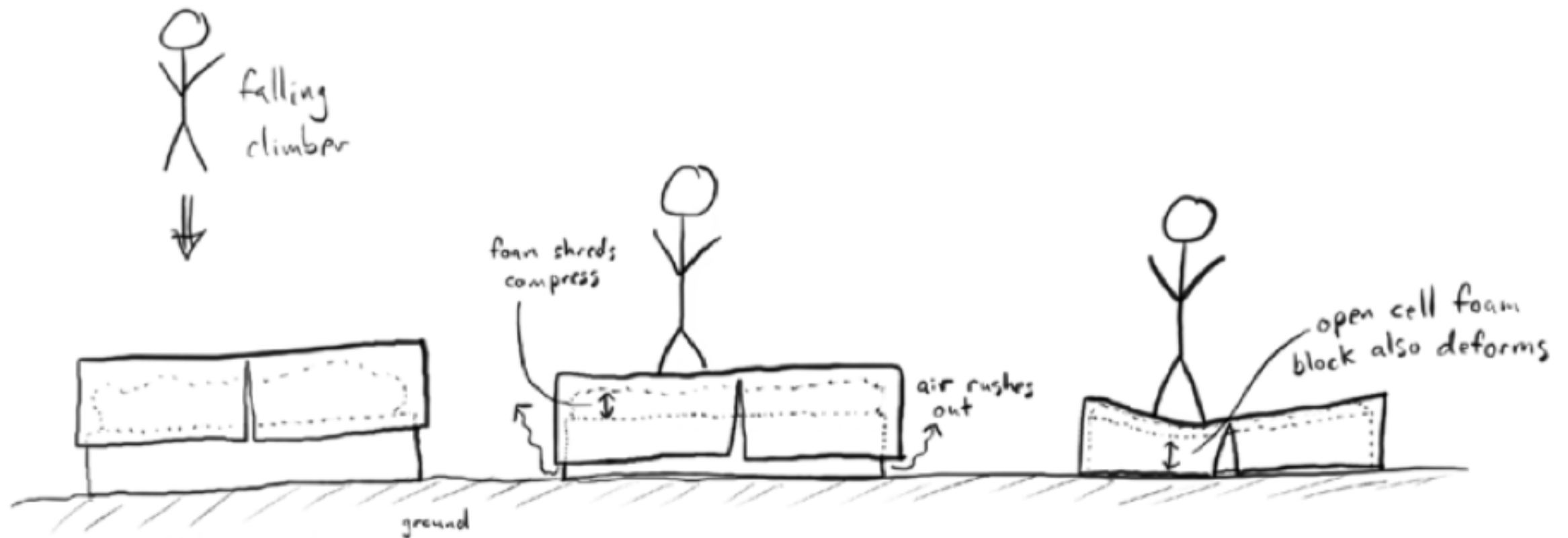
components:



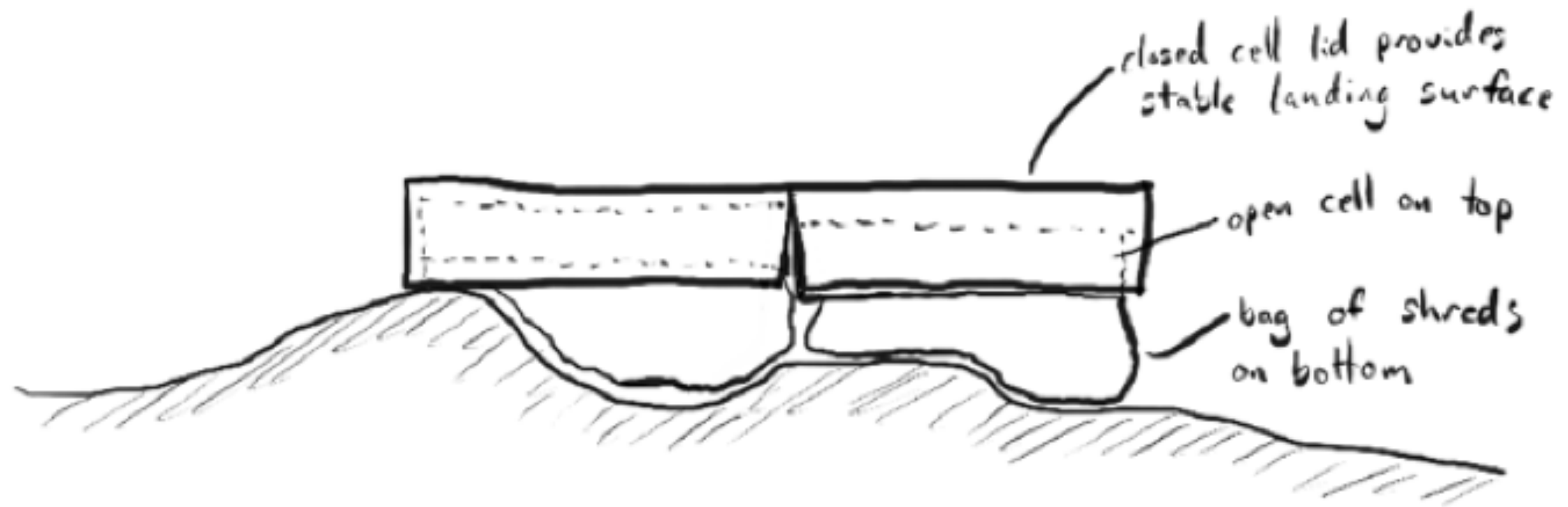
Carrying mode:



FLAT GROUND MODE



UNEVEN GROUND MODE



CONSTRUCTION



PROTOTYPING

MOMENT OF TRUTH



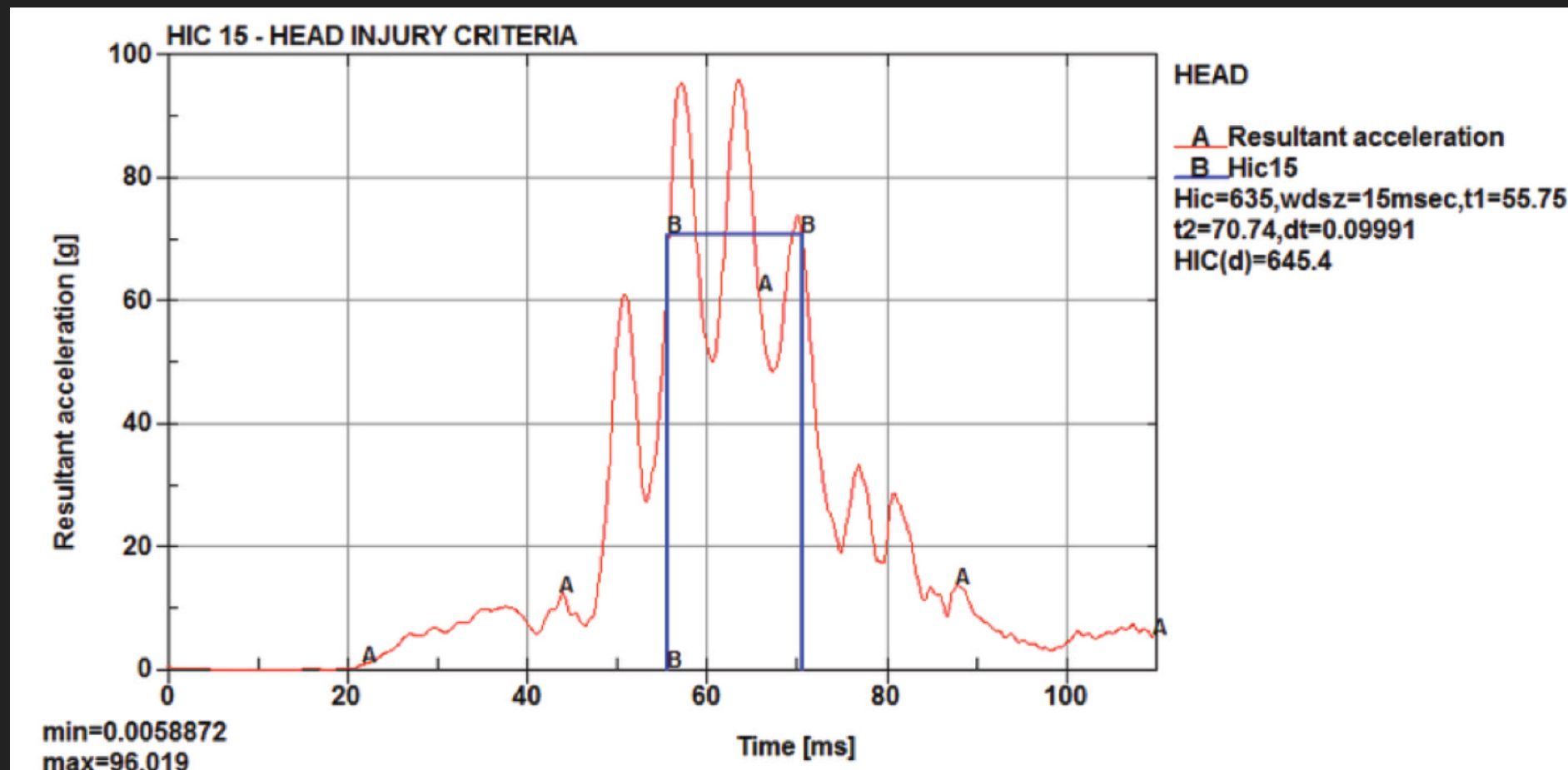
NEXT STEPS

- ▶ Larger scale prototypes
- ▶ Hinged construction
- ▶ Glued construction
- ▶ Denser closed cell foam
- ▶ Backpack straps
- ▶ Testing, iteration, validation



VALIDATION PLAN

- ▶ Accelerometer attached to ankle
- ▶ Goal: 2 meter drop with $HIC < 400$





THANK YOU

EVEN KEEL FINAL PRESENTATION

JUNE 2020

A photograph of a person bouldering on a rock face. The person is wearing a light blue puffy jacket and dark pants. A large, tan-colored crash pad is attached to their back, extending upwards and outwards. The background is a blurred view of a mountain range. The title 'EVERYWHERE' is overlaid in a large, bold, black-outlined font.

EVERYWHERE

A VERSATILE BOULDERING CRASH PAD

JESSAMY TAYLOR / UNIVERSITY OF OREGON / SPORTS PRODUCT DESIGN CAPSTONE

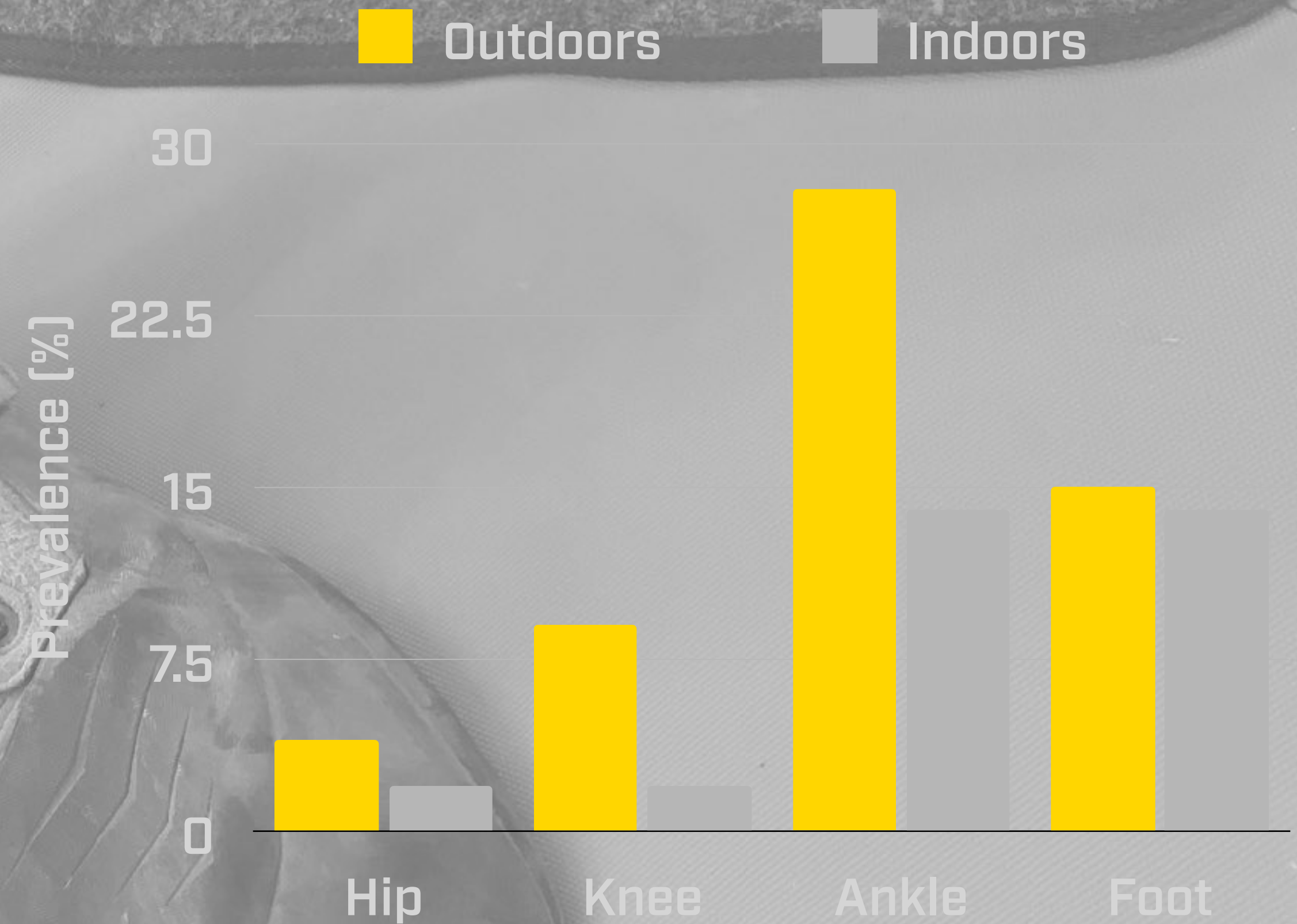




44%

of outdoor boulderers in one study had sustained at least one lower extremity injury from bouldering falls

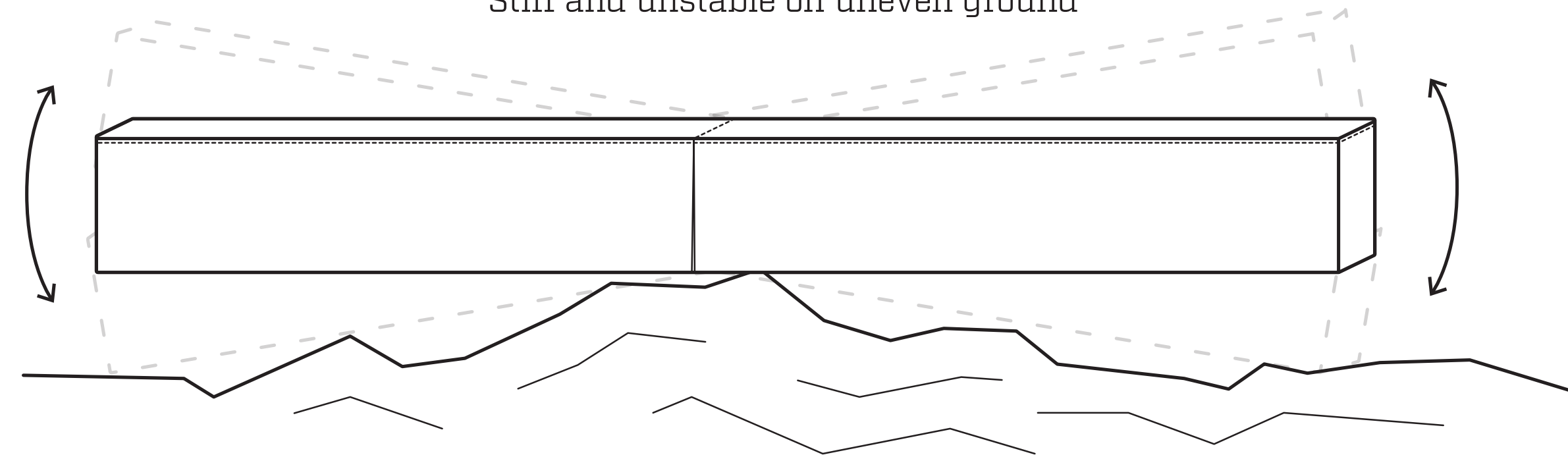
[Wilderness and Environmental Medicine, 2007]



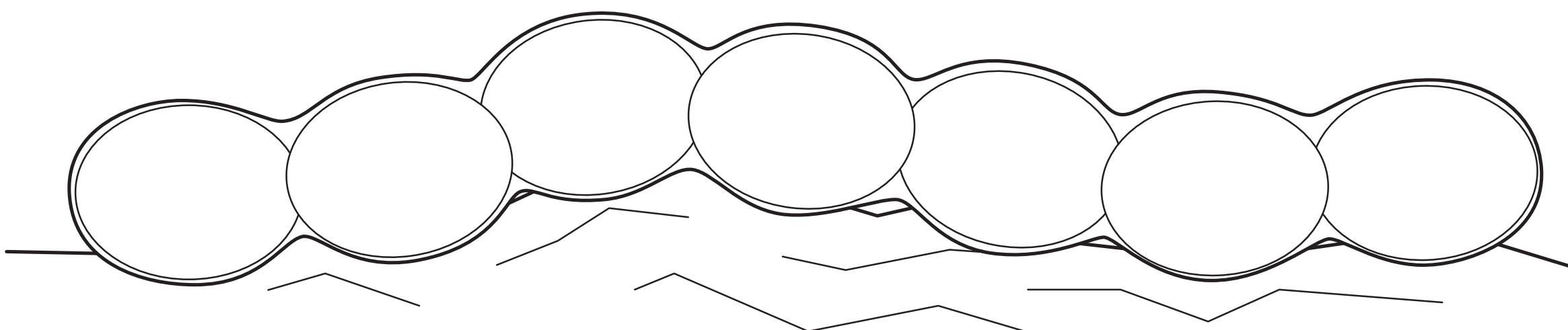
EXISTING “SOLUTIONS”

EACH IS A COMPROMISE

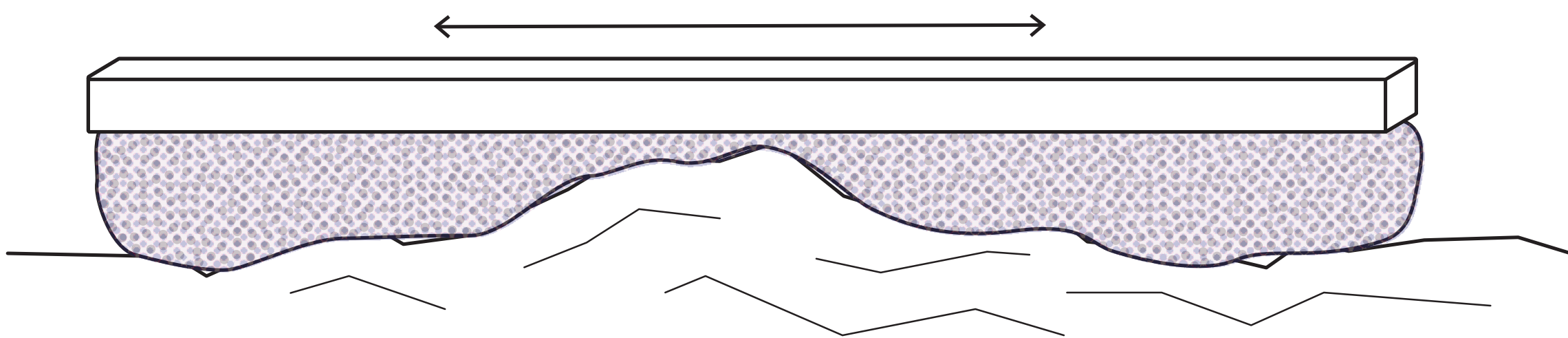
Standard Hinged Crash Pad
Stiff and unstable on uneven ground



Existing Alternative: Baffled Construction
Uneven landing surface



Existing Alternative: Bean Bag of Foam Pellets
Laterally unstable during impact

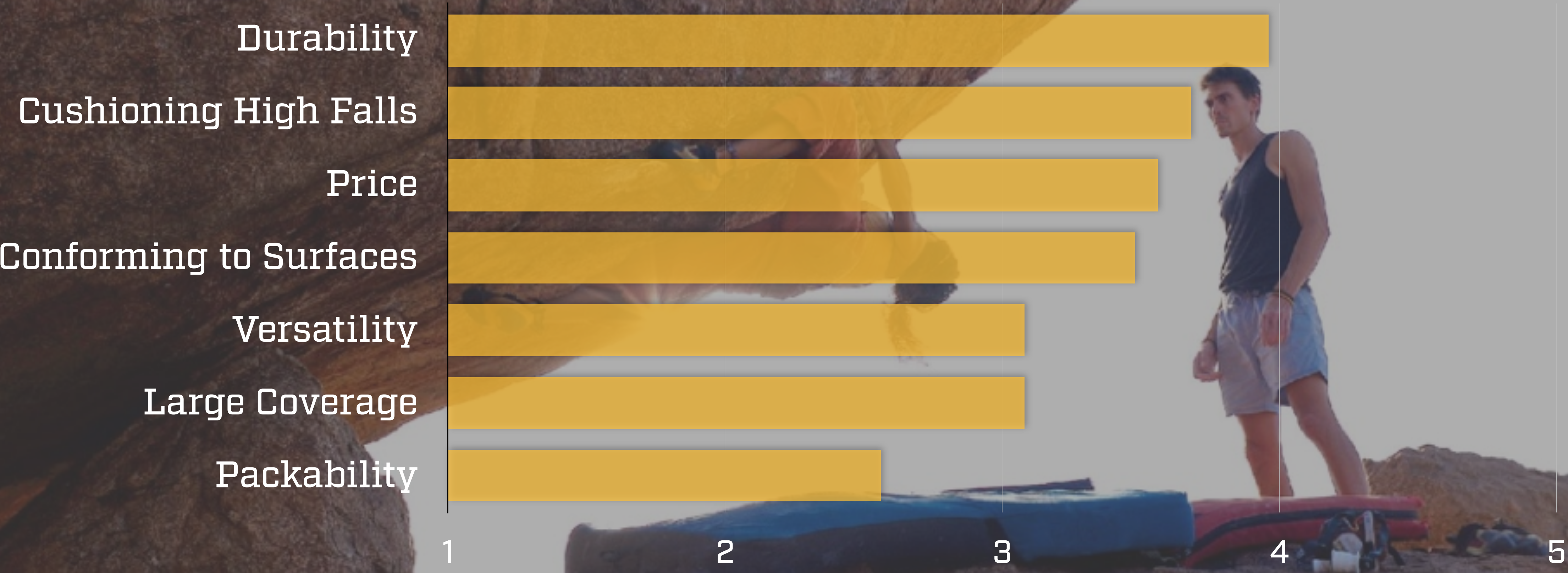


**NO CRASH PAD EVENS OUT ROUGH
LANDINGS EFFECTIVELY. NO CRASH
PAD WORKS FOR BOTH FLAT AND
UNEVEN LANDINGS.**



ATHLETE SURVEY

23 BOULDERERS RANKED IMPORTANCE OF 14 ATTRIBUTES FROM 1 TO 5



ATHLETE SURVEY

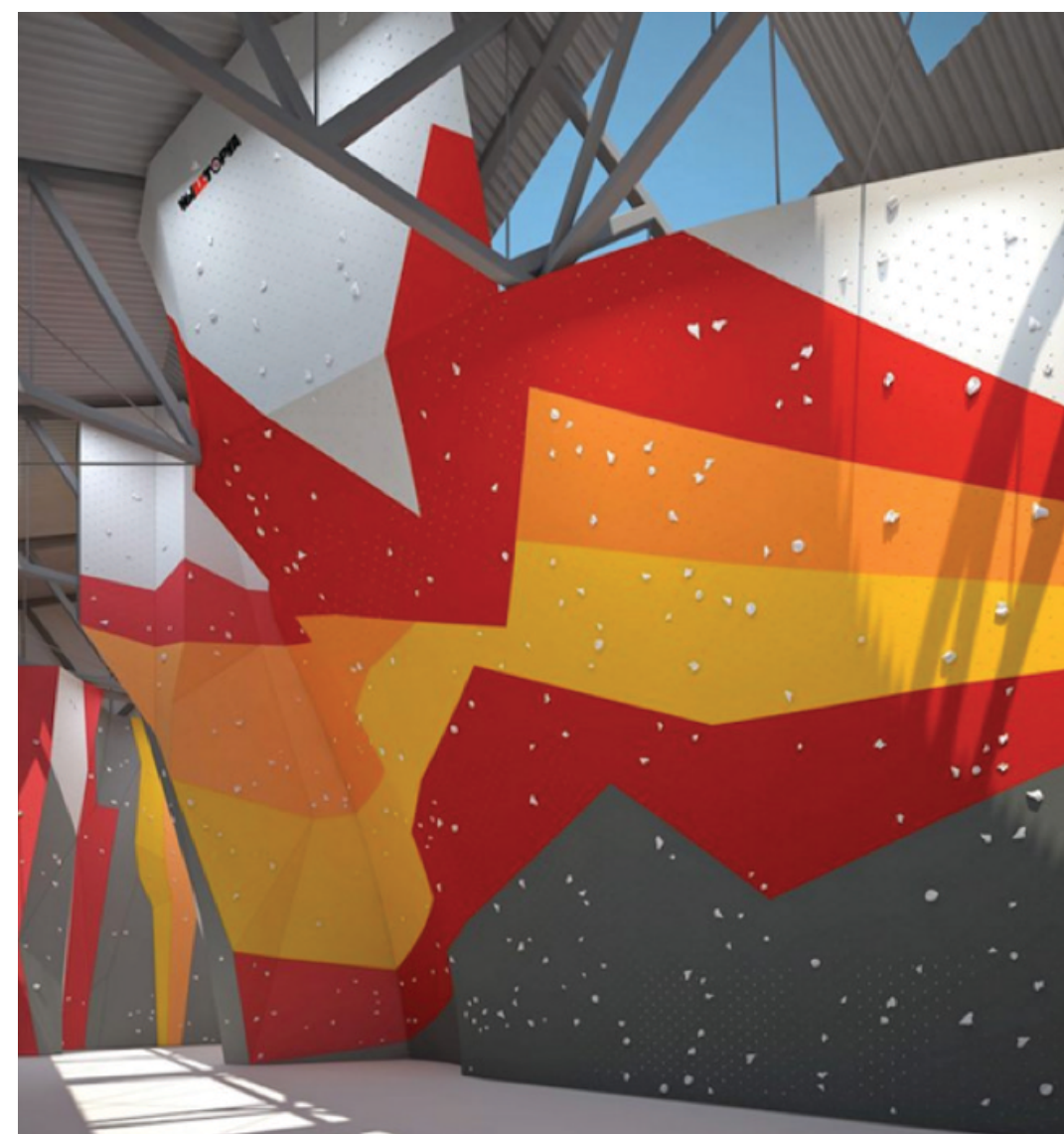
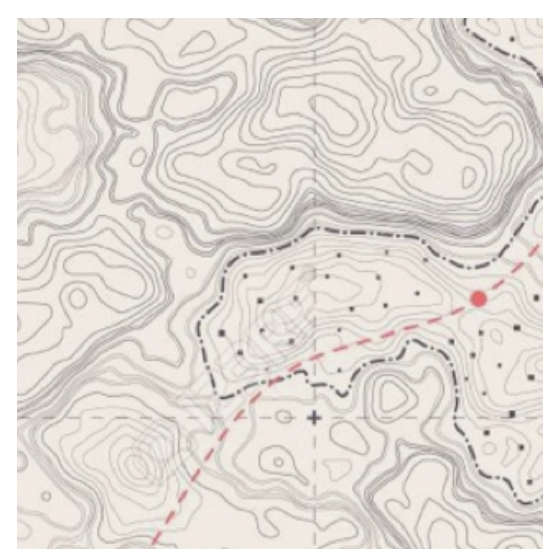
HOW INTERESTED WOULD YOU BE IN A CRASH PAD THAT BETTER ABSORBS IMPACT FROM A VARIETY OF ANGLES, I.E. WHEN LANDING ON A SLANTED SURFACE?





COLOR AND GRAPHICS:

- Sunny gold inspires confidence for the send and provides a landing target
- Light but grounded grey evokes rock and sky
- Bold red accents
- Organic geometry within adaptable structure



BE BOLD // TRUST // ADAPT

Have confidence in yourself, in your spotter, in your pad. Forget about the landing and focus on the climb. Find a solution. Be versatile.



MATERIALS DIRECTION:

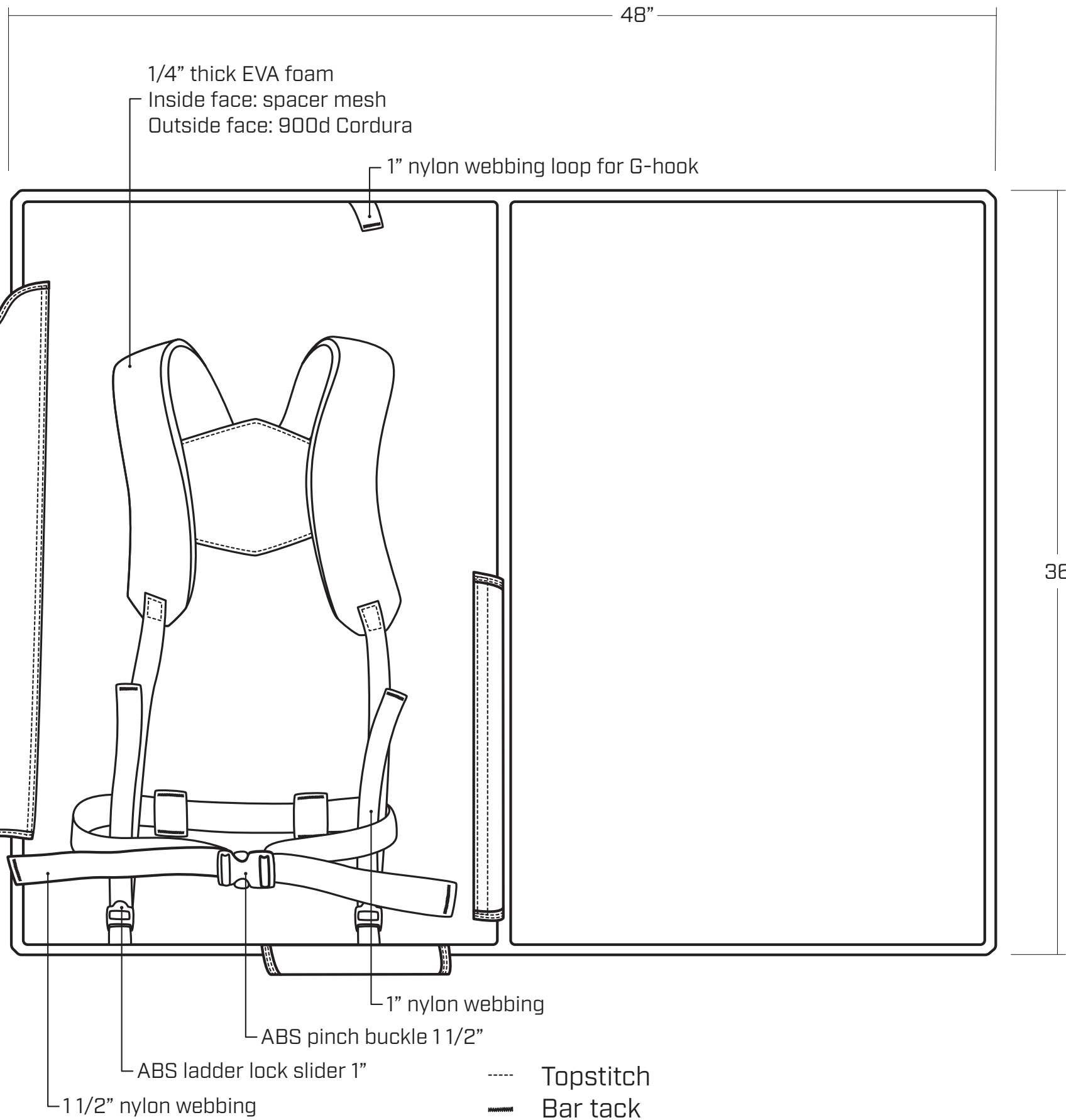
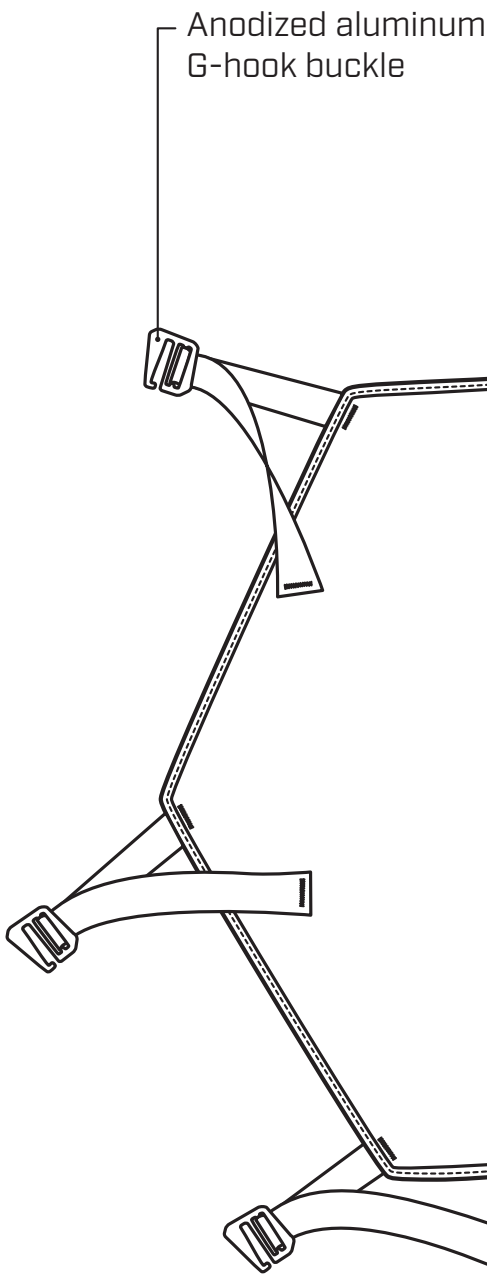
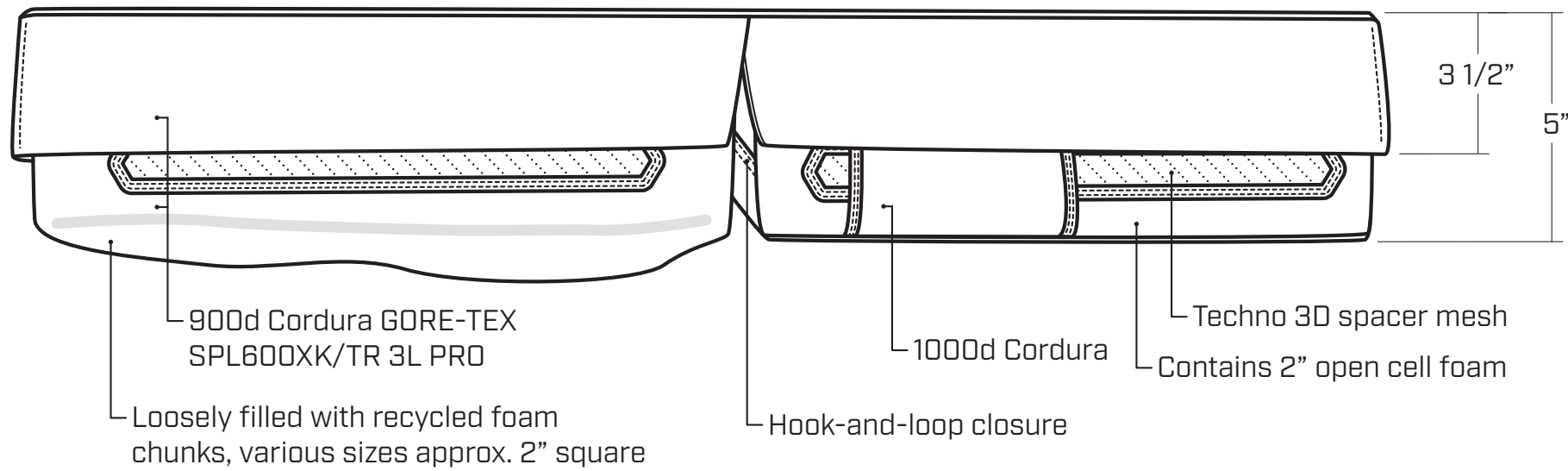
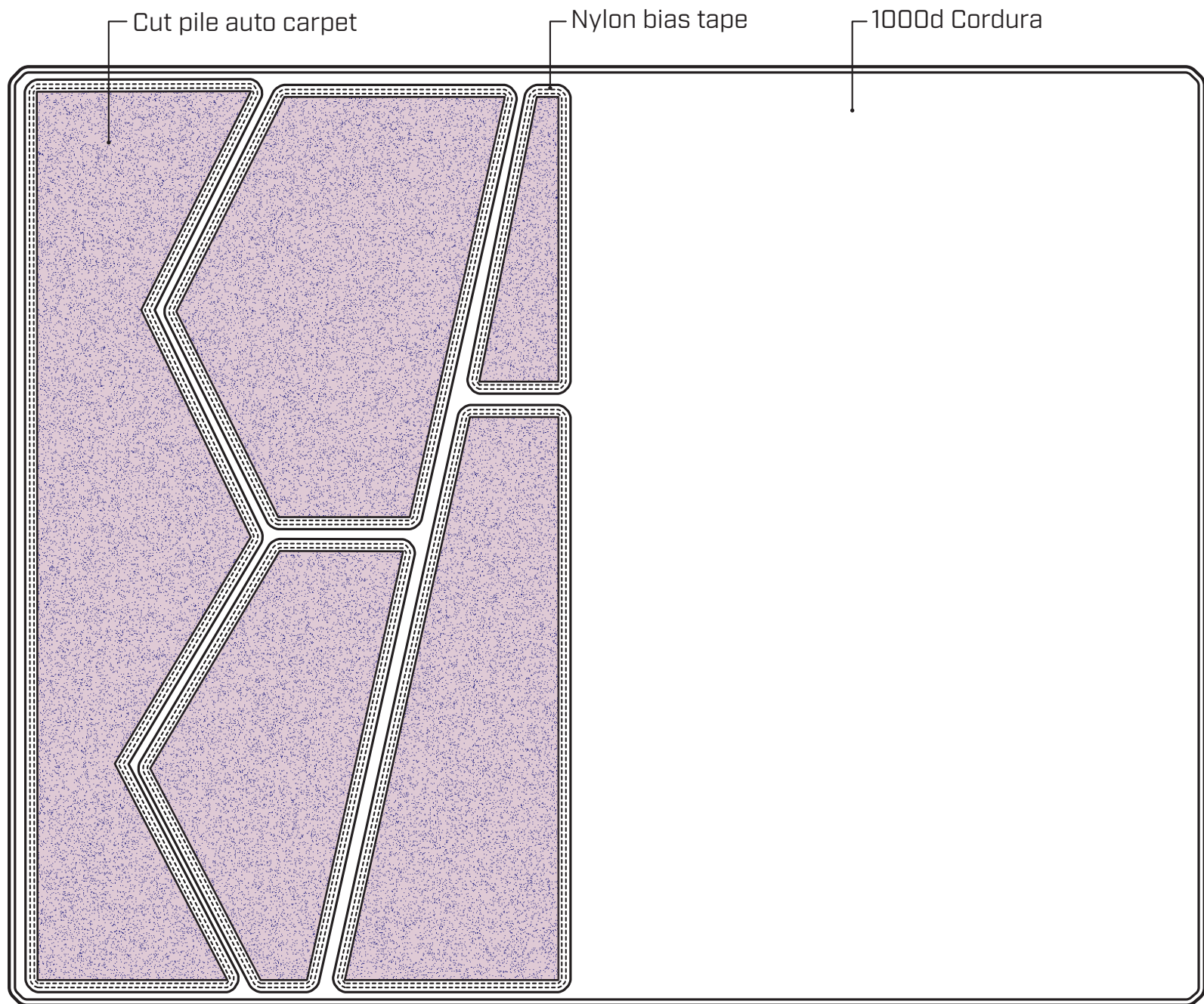
- Durable simplicity with sustainability in mind
- Recycled foam and rope sheaths
- Cordura base with carpet patch appliques
- Nylon webbing and bias tape
- Anodized aluminum and tough plastic closures



SKETCHING



EVEN KEEL: TECH FLATS



----- Topstitch
===== Bar tack
Thread: Nylon 66 (N66). Size: Tex 70 (T70 #69)
210D/3, color matched to material



JESSAMY TAYLOR
SPORTS PRODUCT DESIGN

Project: Even Keel Crash Pad

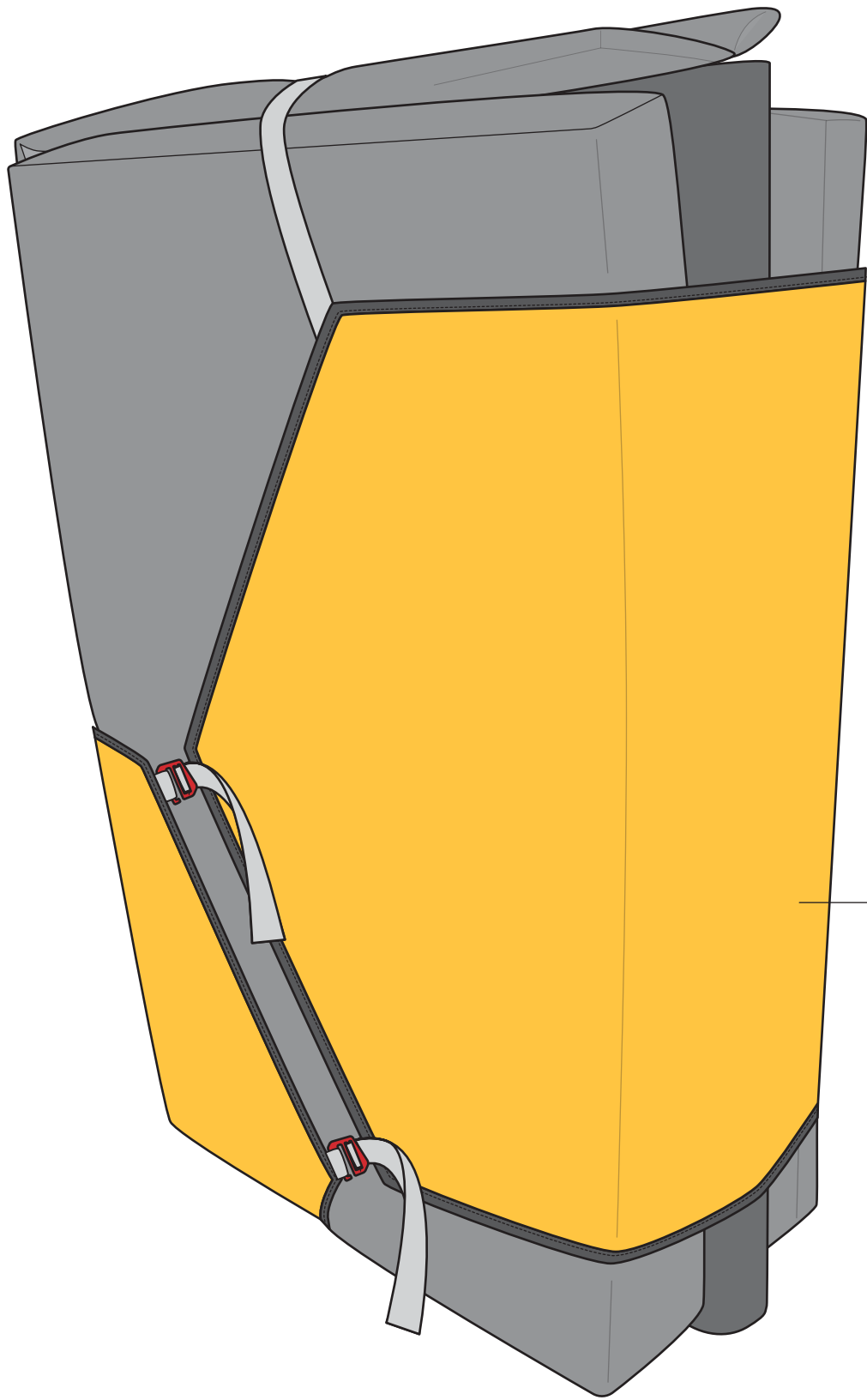
Drawings: Top, side, bottom

Date: 05/30/20

Scale: 1:1
Units: Inches

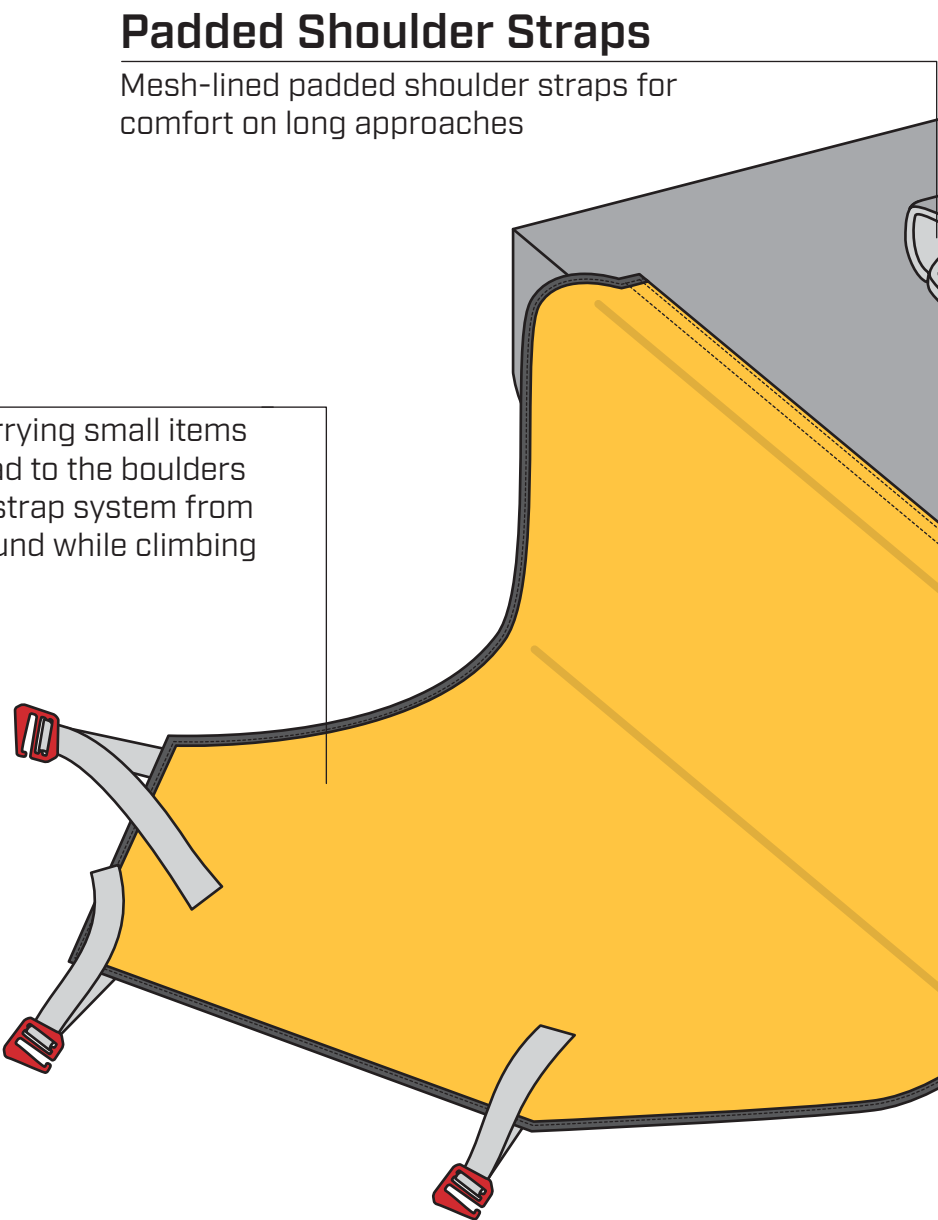
Page
1/1

PARTS & PURPOSE



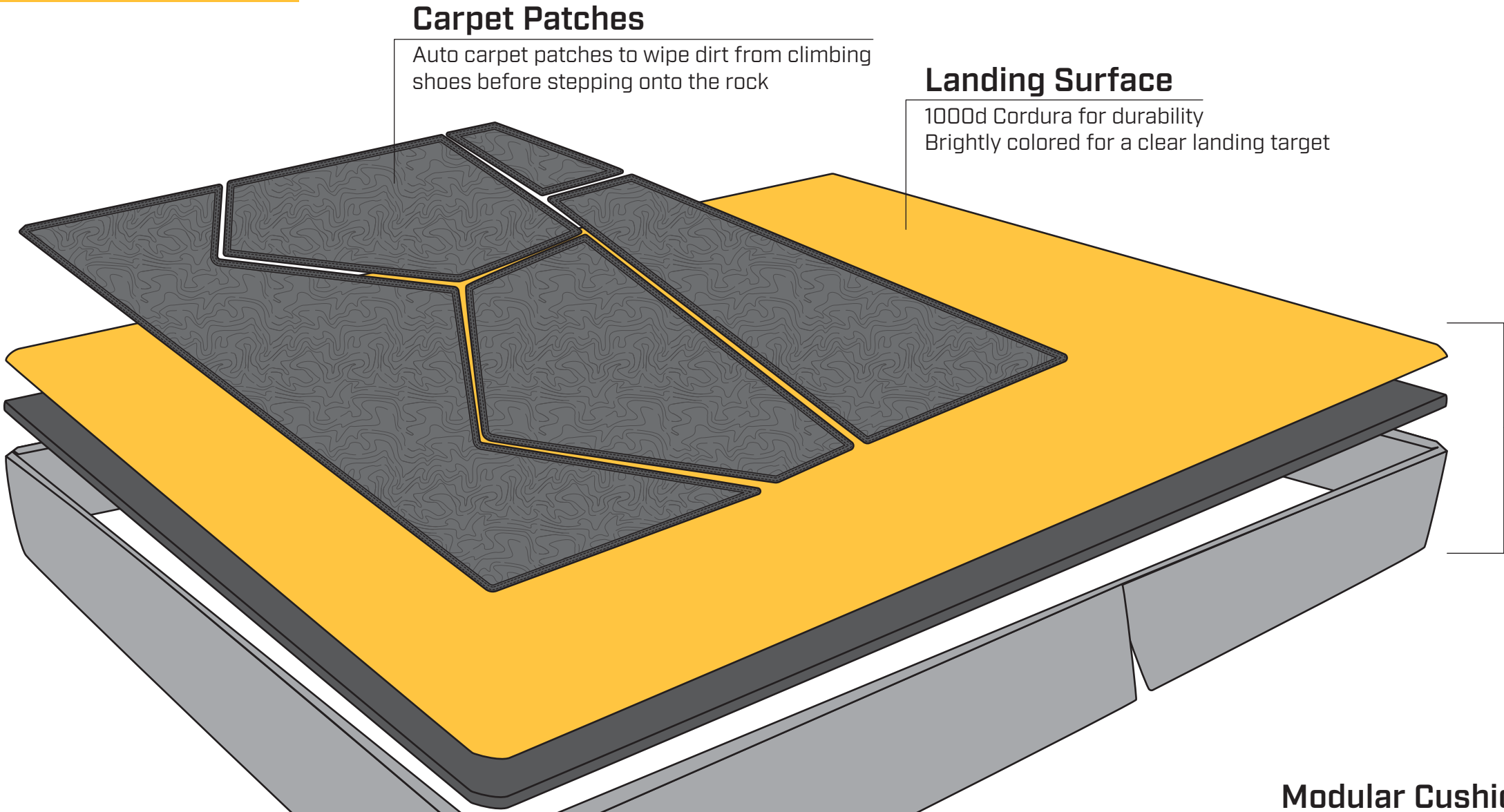
Flap System

Flap system for carrying small items and/or a second pad to the boulders
Flaps also protect strap system from muddy or dirty ground while climbing



Padded Shoulder Straps

Mesh-lined padded shoulder straps for comfort on long approaches



Carpet Patches

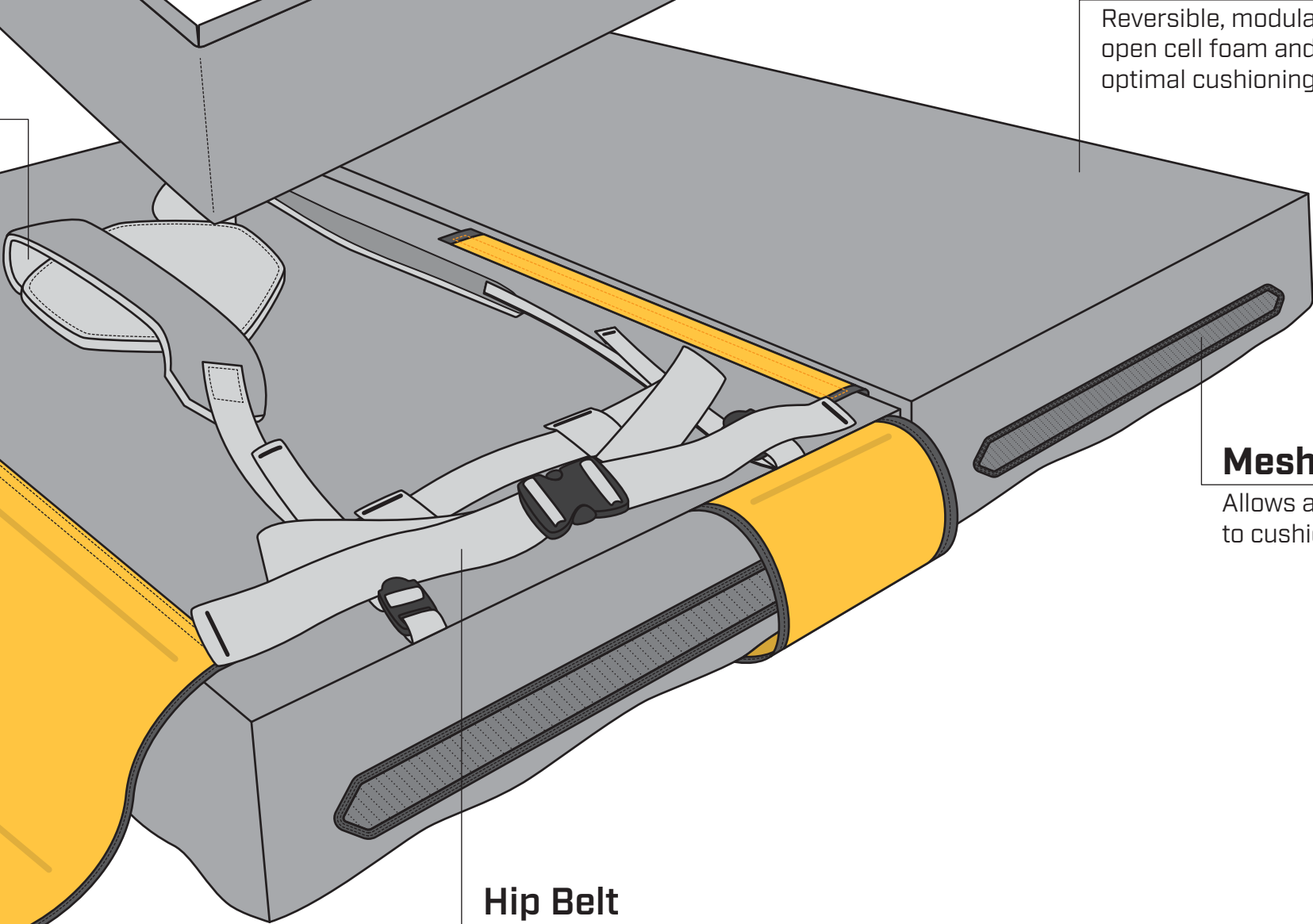
Auto carpet patches to wipe dirt from climbing shoes before stepping onto the rock

Landing Surface

1000d Cordura for durability
Brightly colored for a clear landing target

“Lid”

3/4” EVA foam for a smooth, firm landing surface and lateral stability
Covered in 900d Cordura for durability



Modular Cushioning Unit

Reversible, modular cushions containing 2” open cell foam and chunks of recycled foam for optimal cushioning on a variety of surfaces

Mesh Vent

Allows air to escape upon impact, helping to cushion the fall

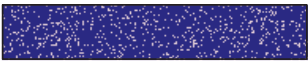
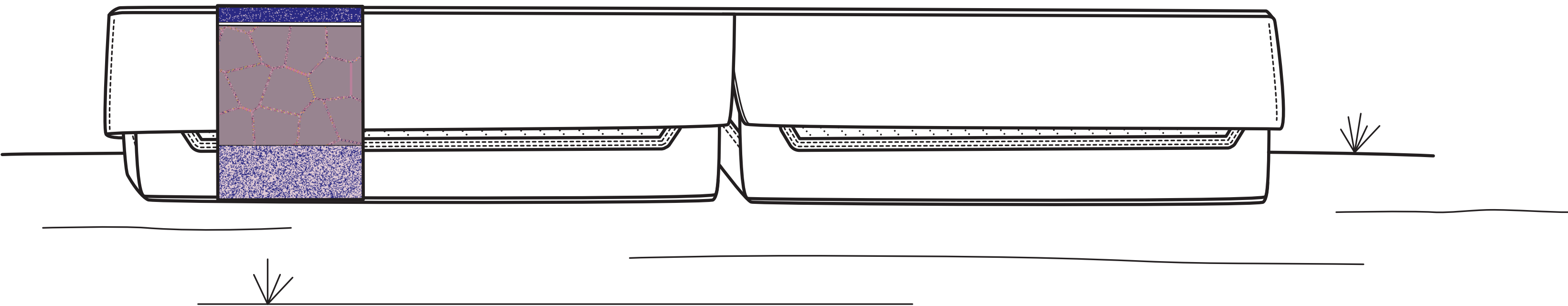
Hip Belt

Lightweight nylon webbing hip belt assists in carrying the pad without creating bulk when the pad is in use

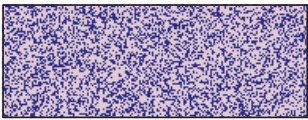
CONCEPT

TECHNOLOGY

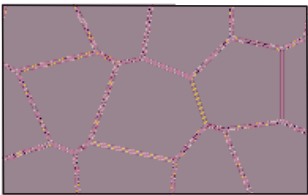
Flat Ground Mode
Maximizes air cushioning



3/4" EVA foam for stability



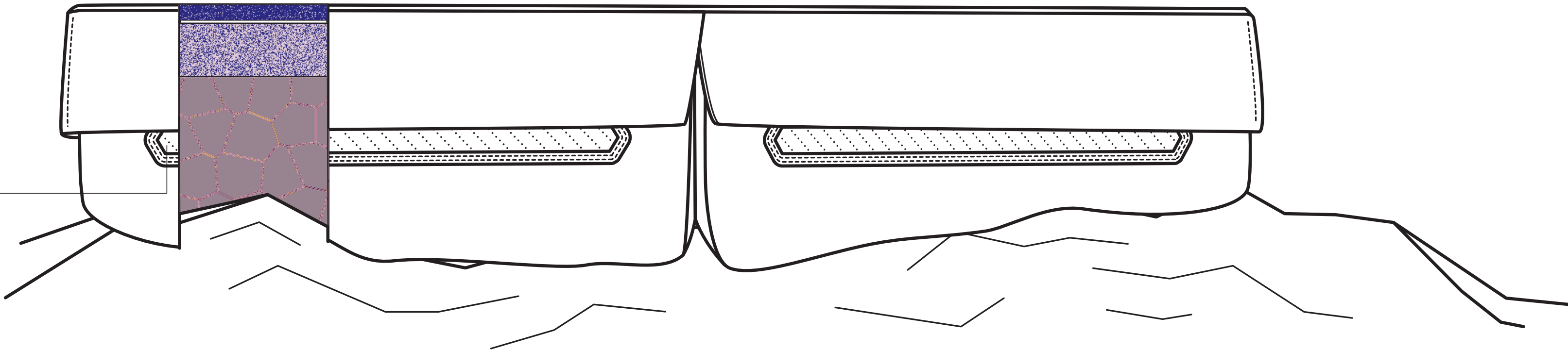
2" open cell foam for cushioning



Recycled foam chunks to even rough landings

Uneven Ground Mode
Smooths rough ground for a flatter landing

Vent to allow controlled air release



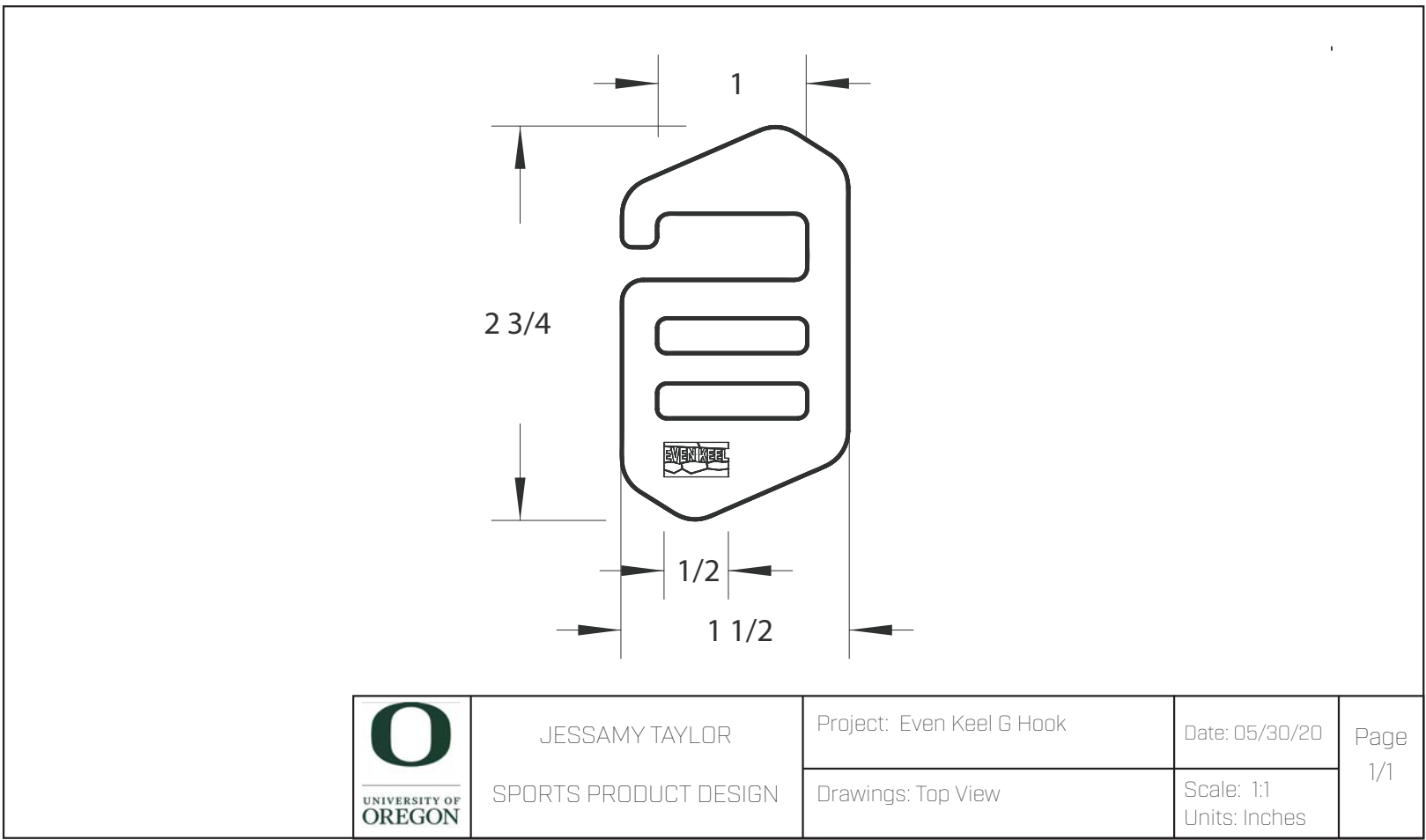
BRANDING: BUCKLES

3 G-HOOK BUCKLES TO SECURE FLAP SYSTEM

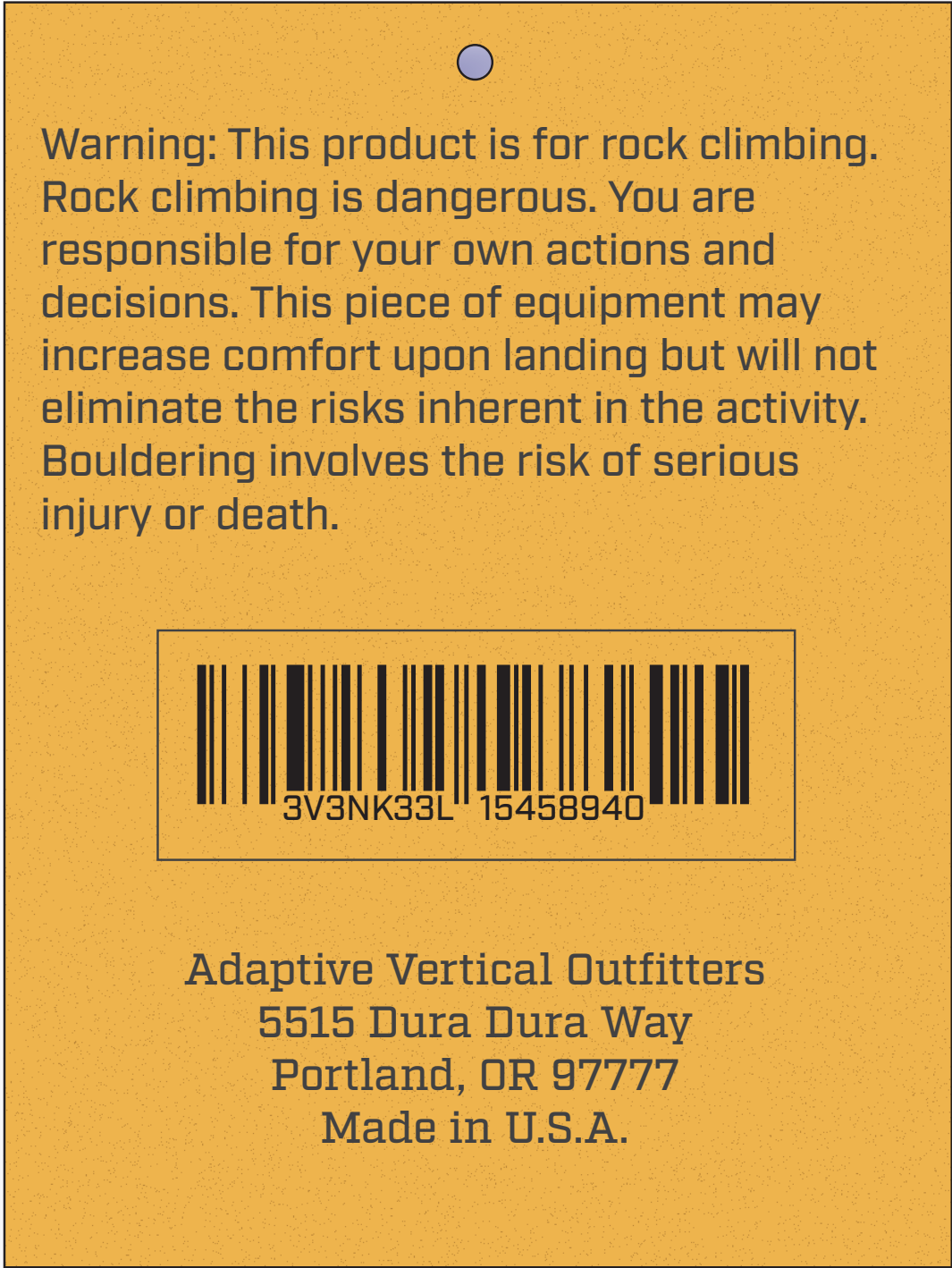
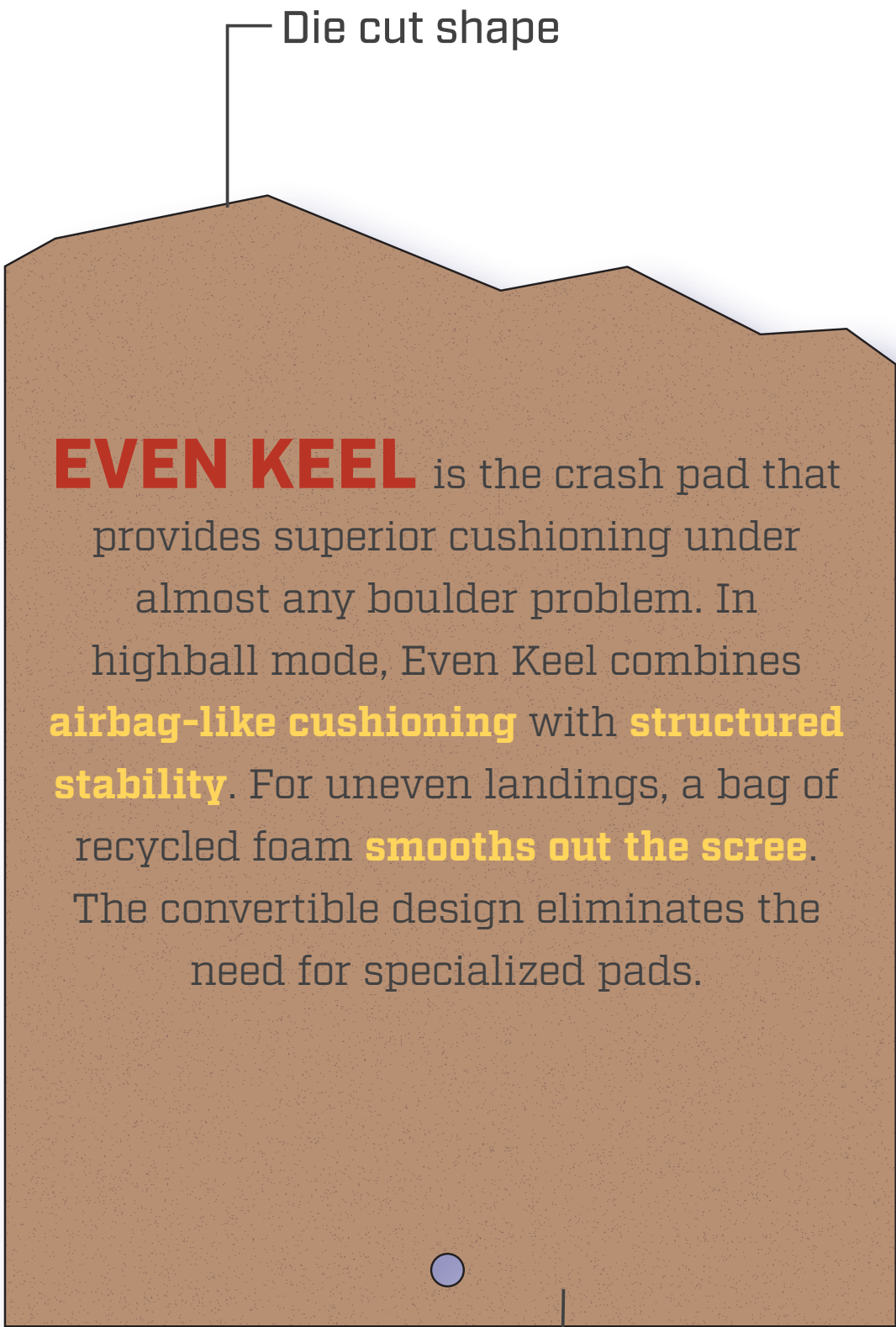
Anodized aluminum, 1/8” thick

Stamped logo

Fits 1” webbing



BRANDING: HANG TAG

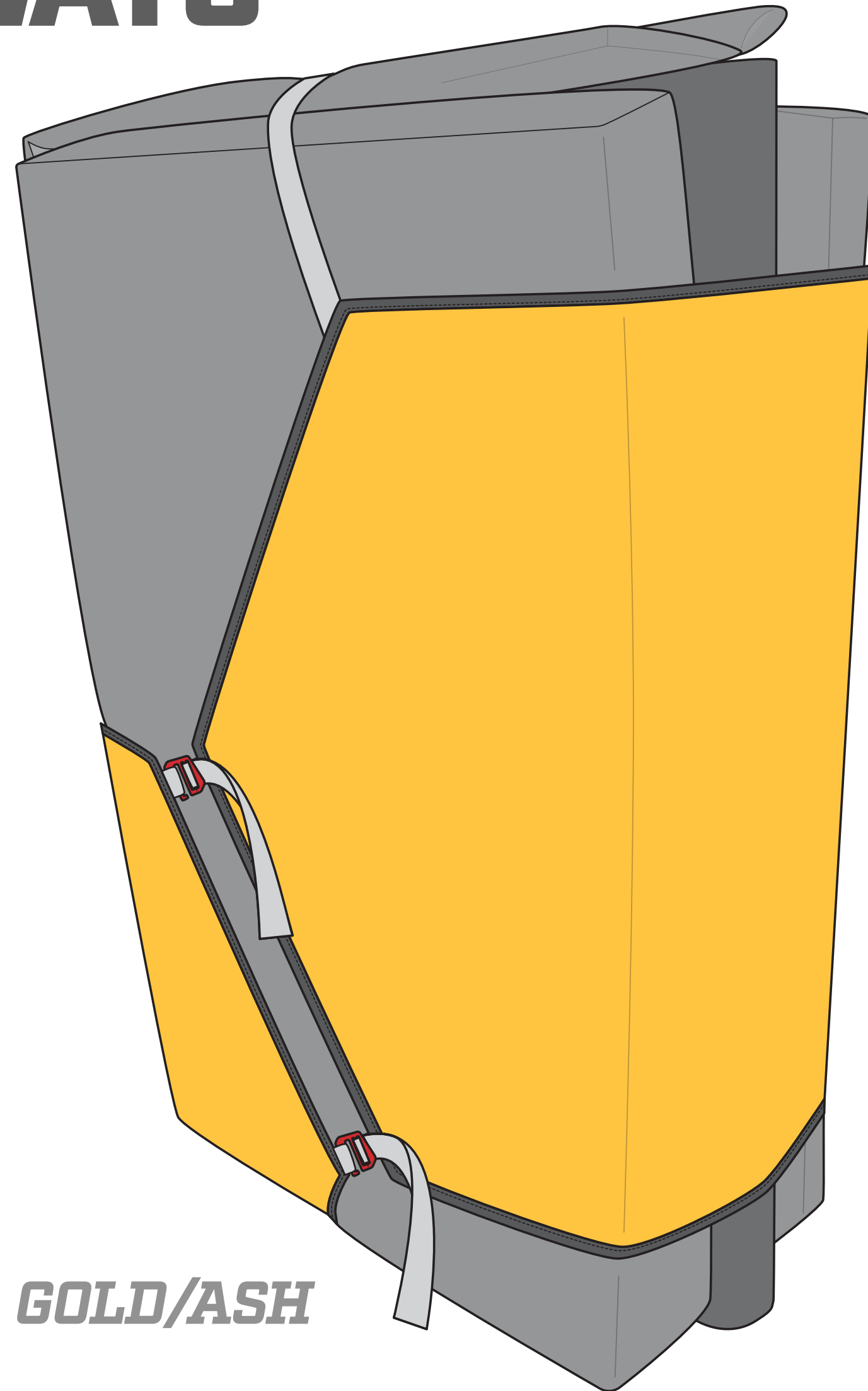


Recycled cardstock

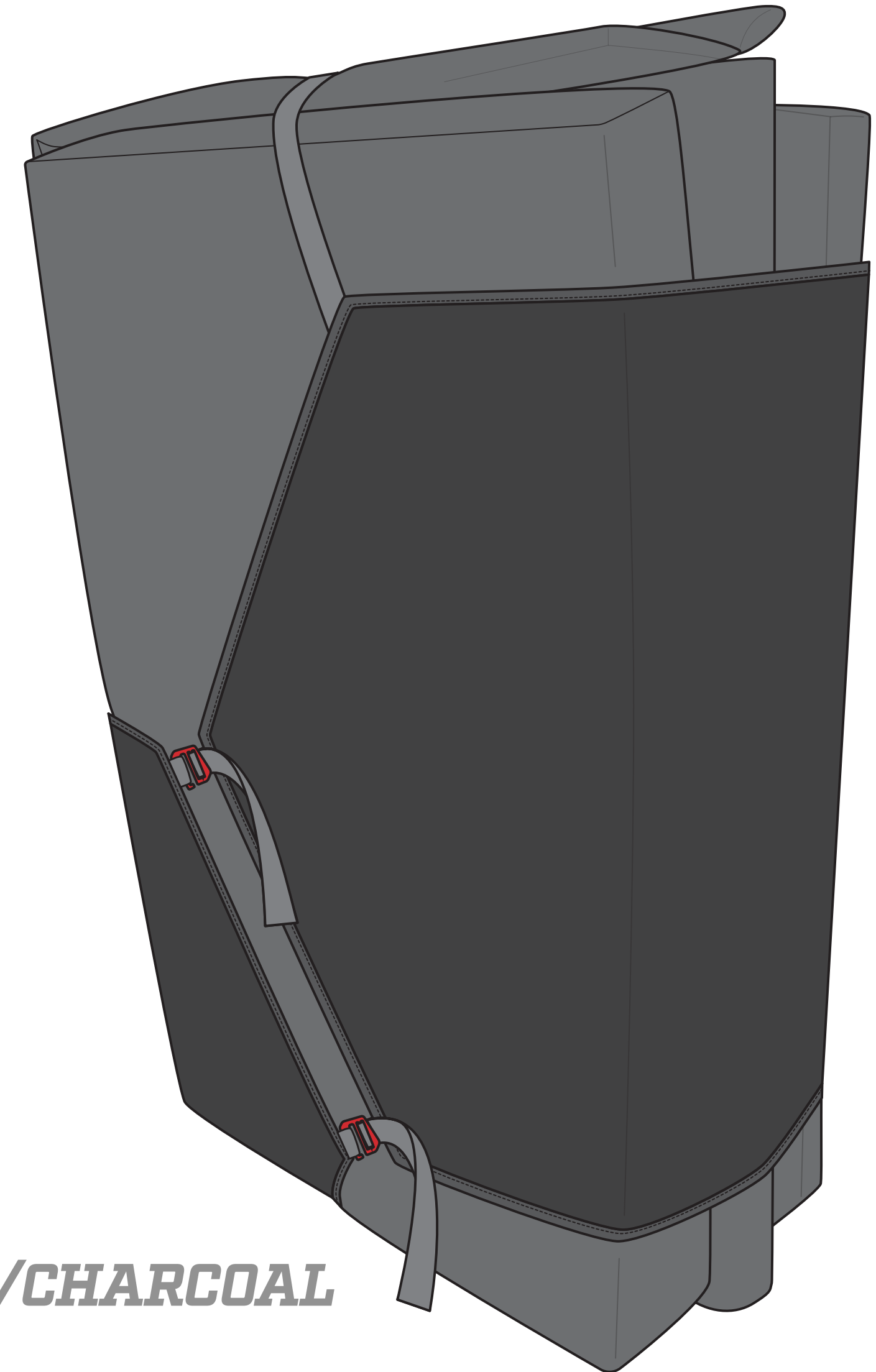
Soy-based ink

Die cut shape

COLORWAYS



GOLD/ASH

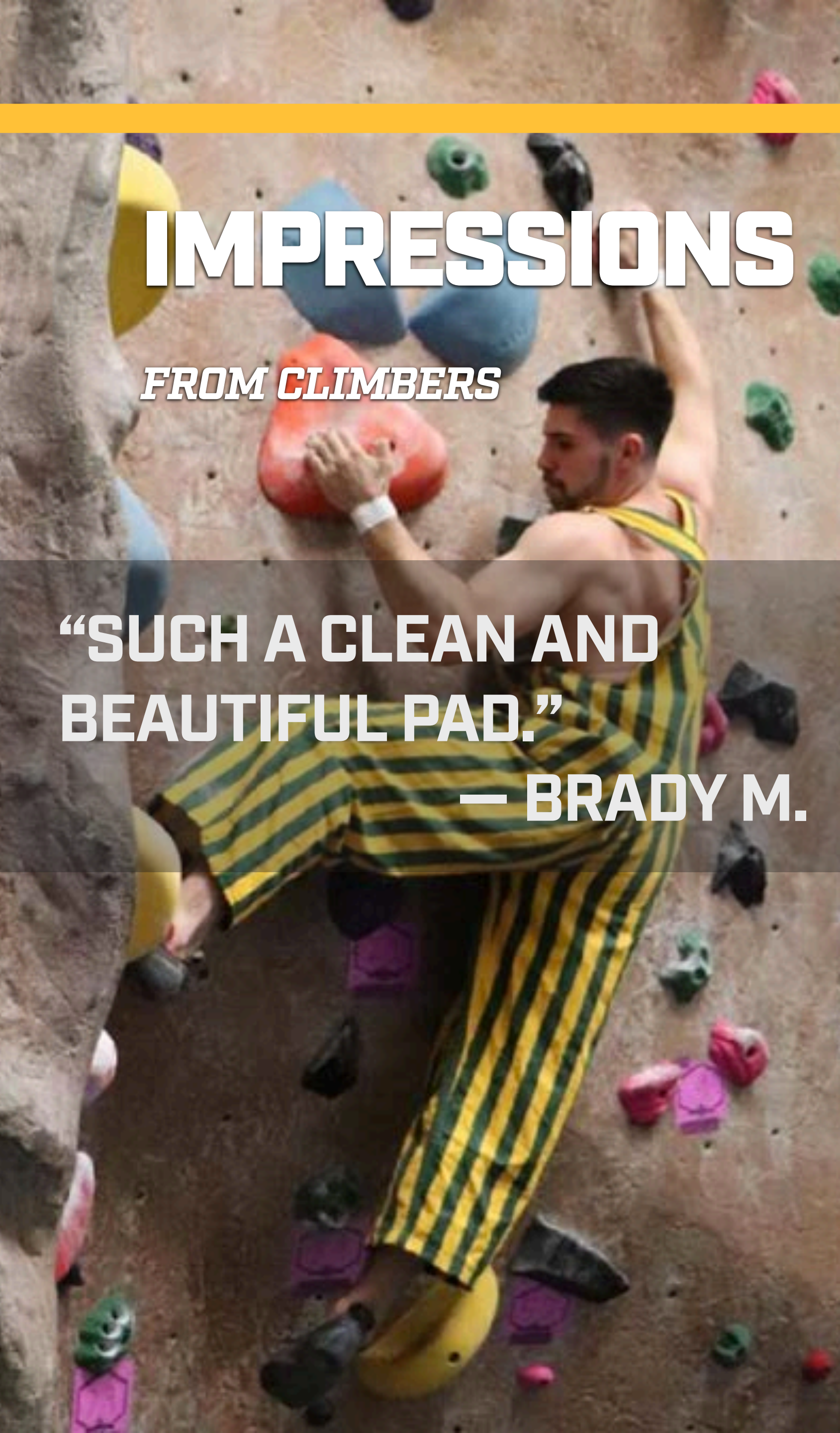


BLACK/CHARCOAL

PROTOTYPING

CORDURA, CARPET, WEBBING AND FOAM



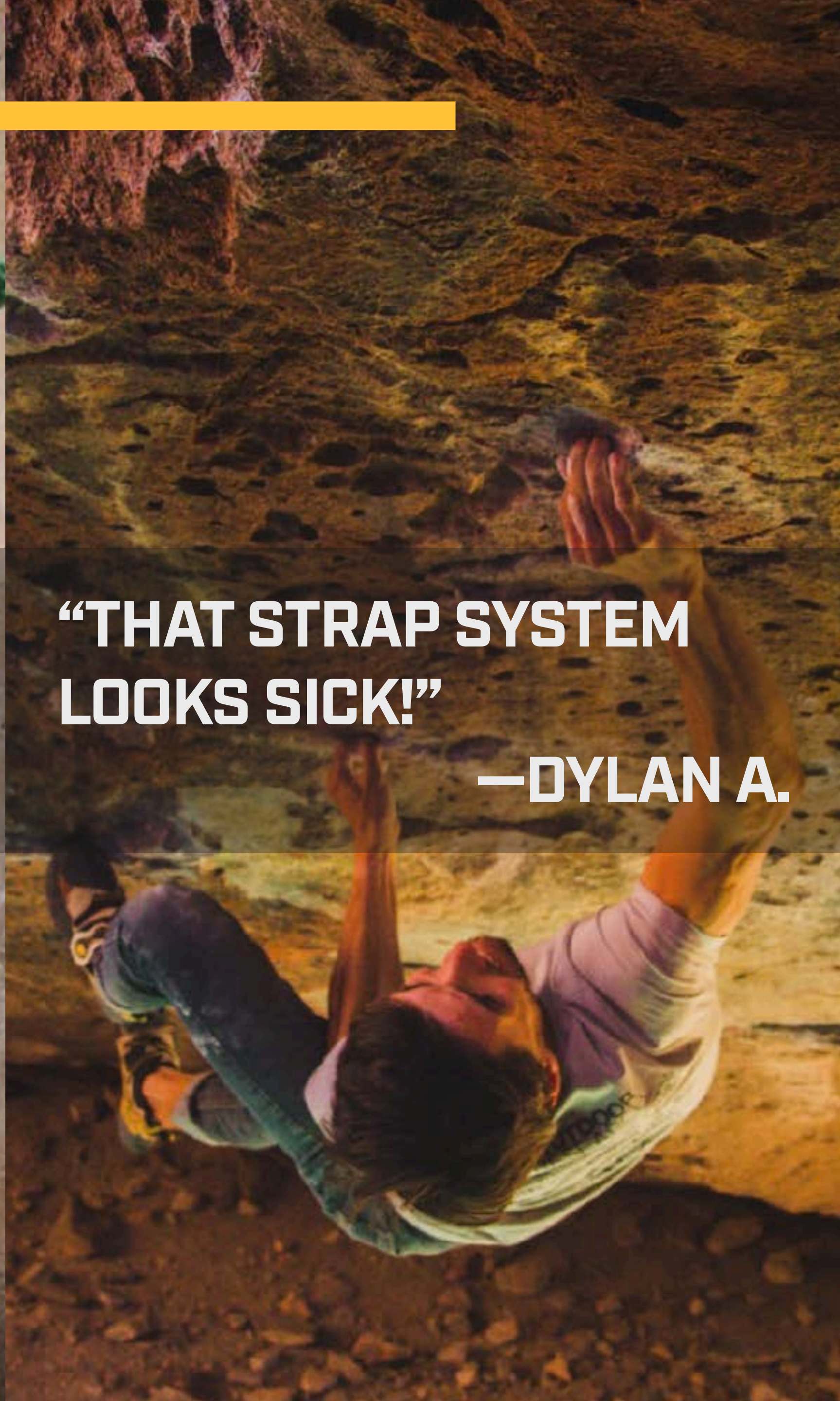


IMPRESSIONS

FROM CLIMBERS

“SUCH A CLEAN AND
BEAUTIFUL PAD.”

— BRADY M.



“THAT STRAP SYSTEM
LOOKS SICK!”

— DYLAN A.



“IT’S BEAUTIFUL!”

— CLARA H.

EXPERT FEEDBACK

FROM JIM KARN, PRODUCT DEVELOPER AT METOLIUS CLIMBING



- “It doesn’t have that much weight so I don’t think you need a padded waist belt.”
- In reference to my shoulder strap construction method: “I think that’s the nicest way to do it.”
- “Whatever you can do to make it simple and fast and reduce the number of buckles”
- In reference to the carpet square pattern: “I like that. That’s cool.”
- **“I’m not convinced [the cushioning] will be noticeably different [flipped] one way or the other. That’ll be [something] to test.”**

QUANTITATIVE TESTING

ACCELEROMETER LOGGING

Height from ground: 25 inches

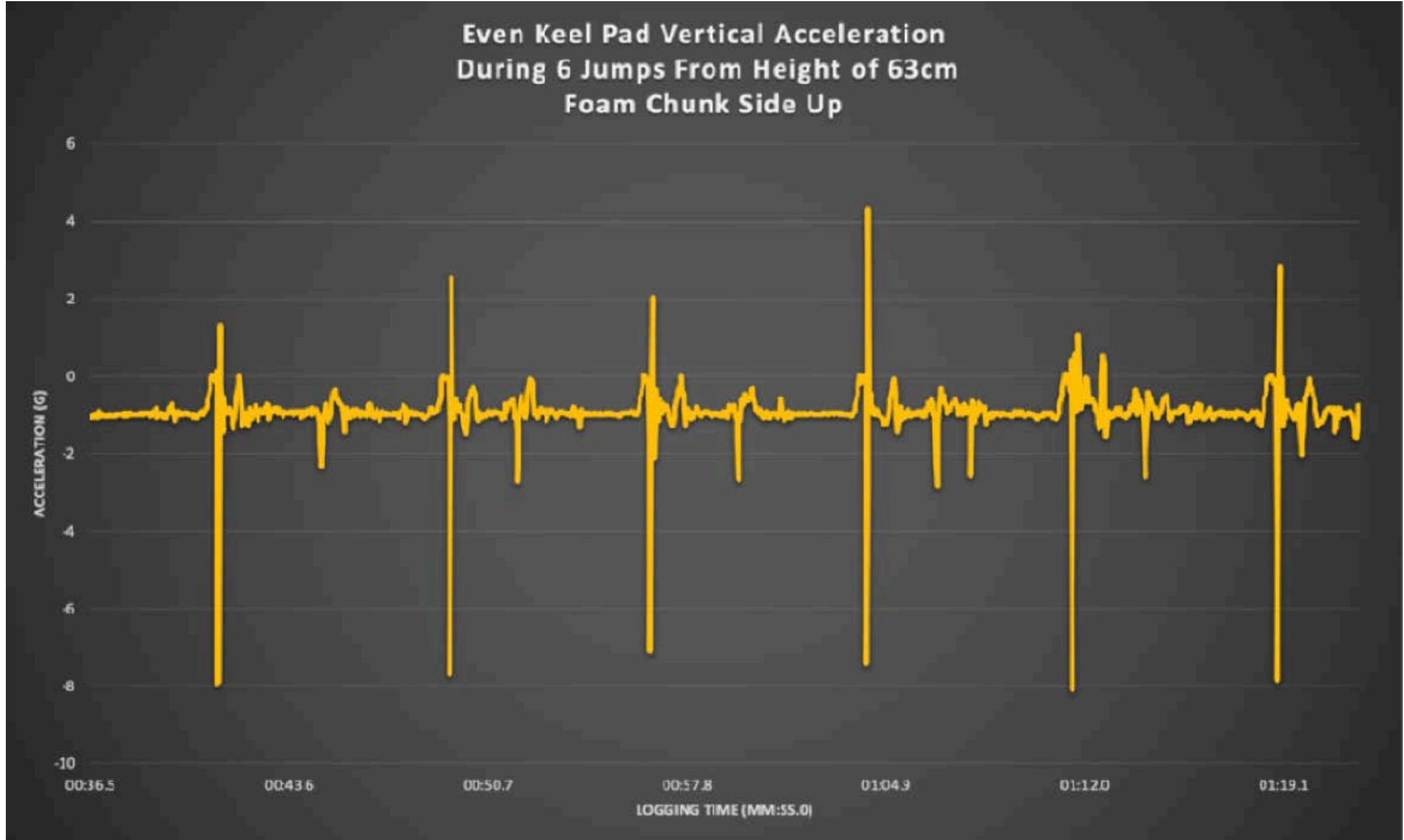
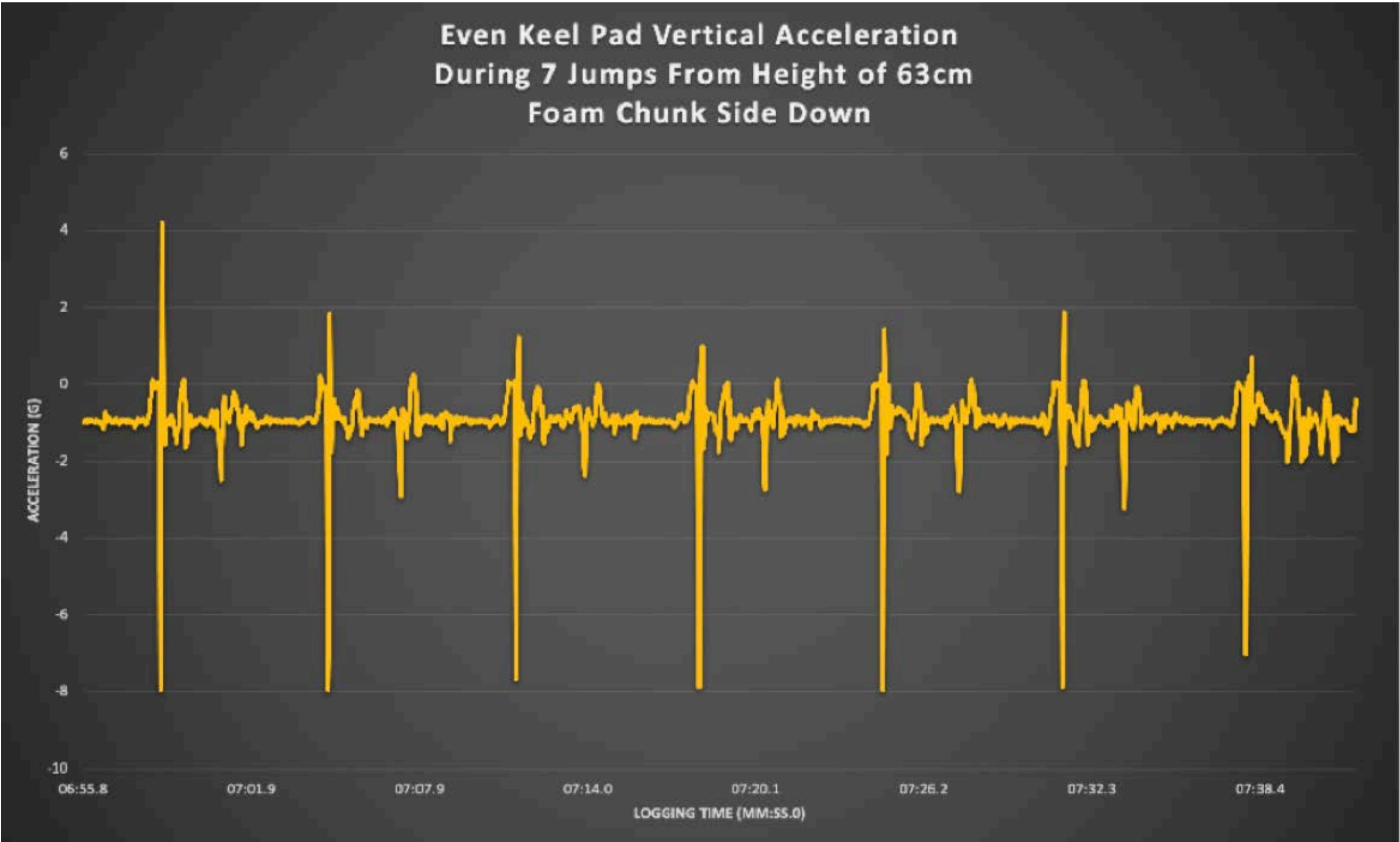
Variety of landing positions

5-7 jumps per pad configuration



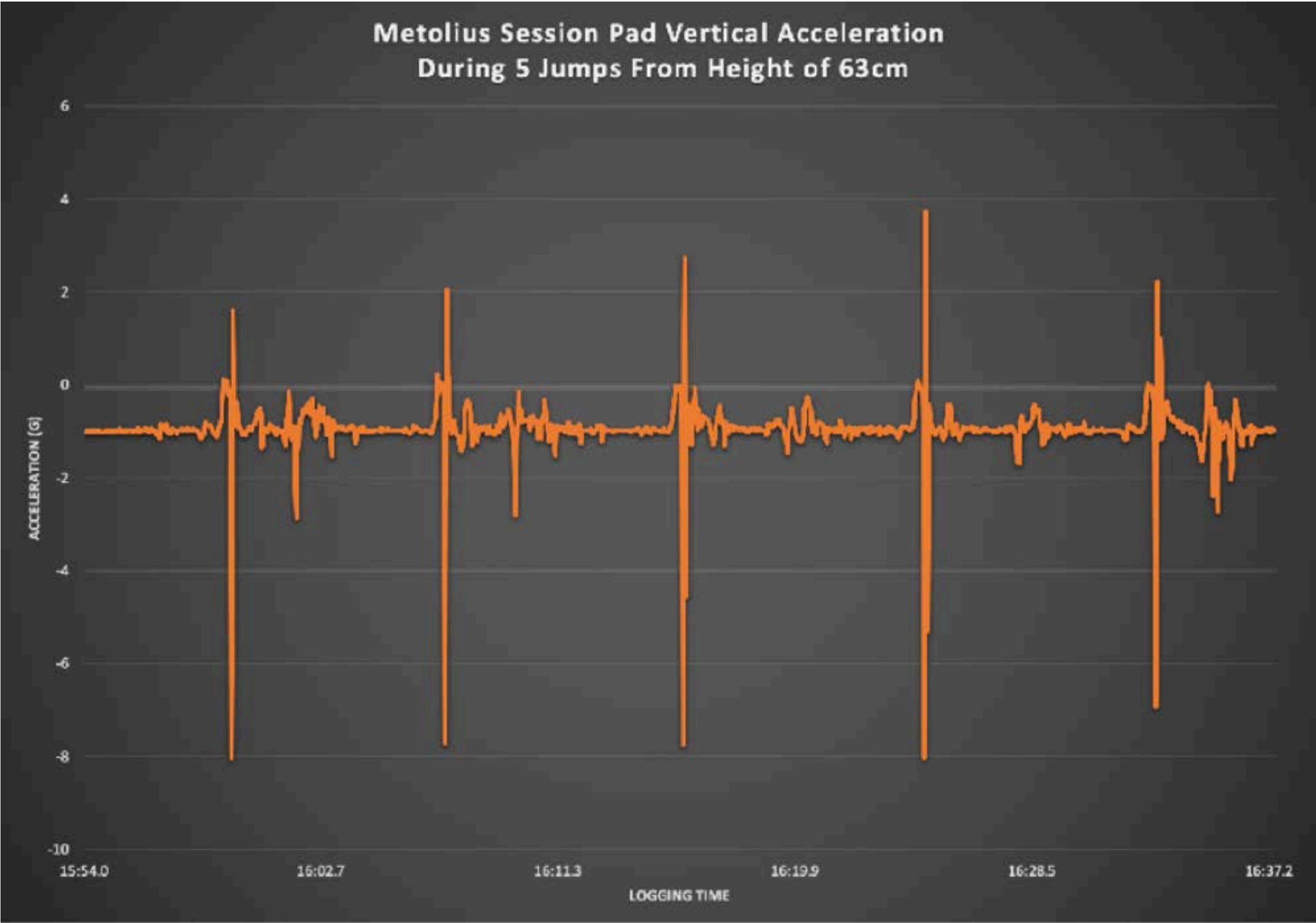
QUANTITATIVE DATA

FROM BOTH EVEN KEEL CONFIGURATIONS



DATA COMPARISON

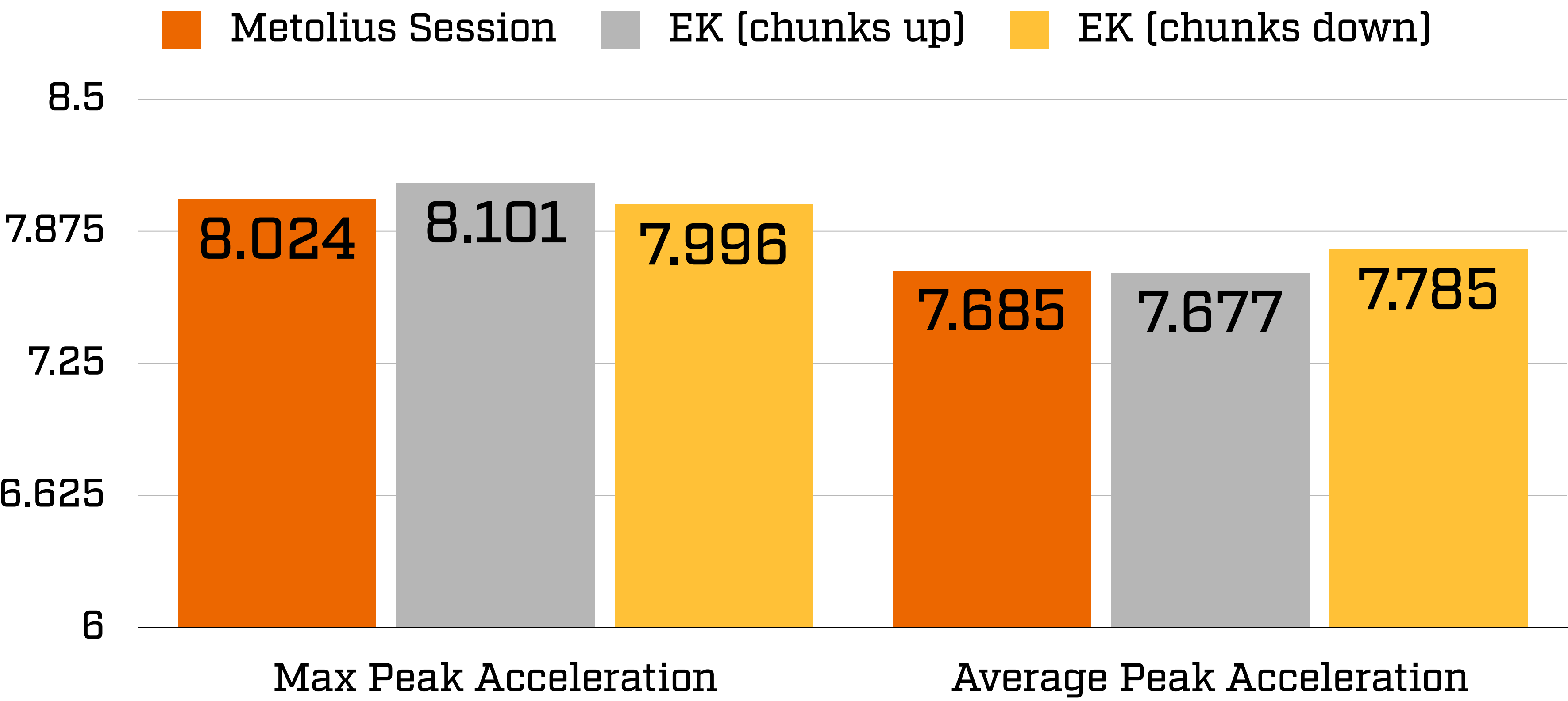
AGAINST METOLIUS SESSION CRASH PAD



[Accelerations in G including gravity]	Metolius pad	EK [chunks up]	EK [chunks down]
	8.018	7.952	7.996
	7.708	7.682	7.989
	7.737	7.076	7.697
	8.024	7.417	7.911
	6.938	8.101	7.961
		7.836	7.892
			7.046
Max peak acceleration	8.024	8.101	7.996
Average peak acceleration	7.685	7.677	7.785

DATA COMPARISON

COMPARABLE TO METOLIUS SESSION PAD



FIELD TESTING

AT CARVER BOULDERS





STABILITY TEST

CONFORMING TO A ROCK

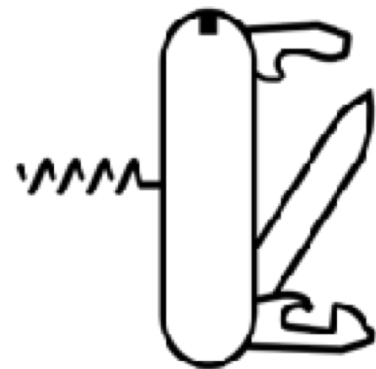




IMPACT

ATHLETE OUTCOMES

Reducing risk of injury and inspiring confidence, Even Keel is the versatile crash pad that allows boulderers to forget about the landing and focus on the climbing.



FUTURE

BUILDING OFF THIS PROJECT

- > Simplify for ease of use, cost and durability
- > Test different vent sizes
- > Continue the use of recycled foam



Special thanks to:

Jim Karn at Metolius Climbing

Juan Rodriguez at AntiGravity Equipment

Chris Pence, athlete tester

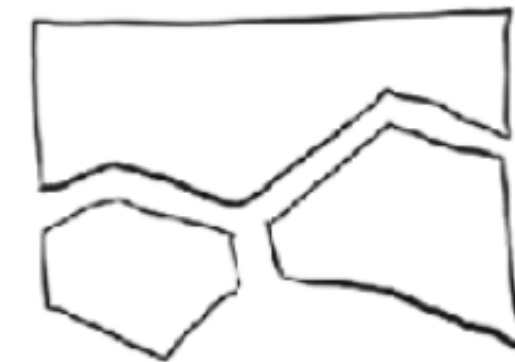
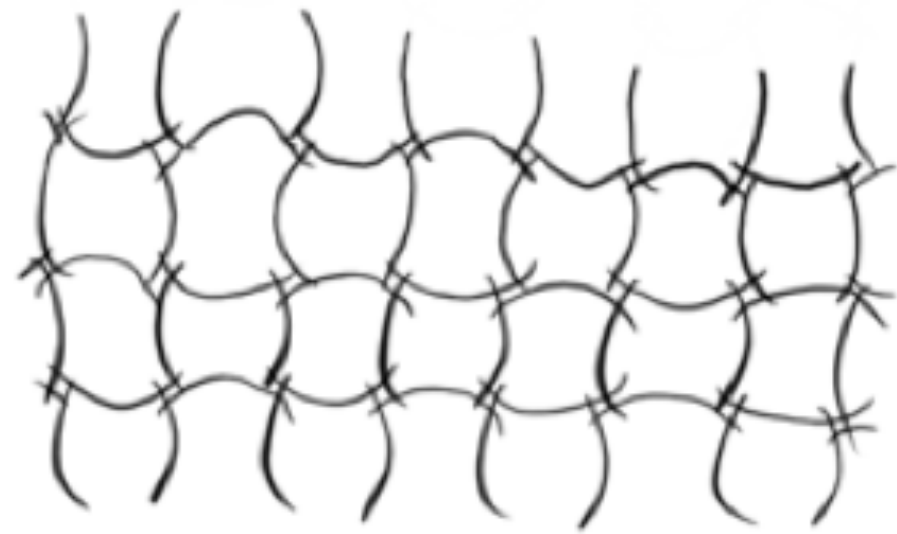
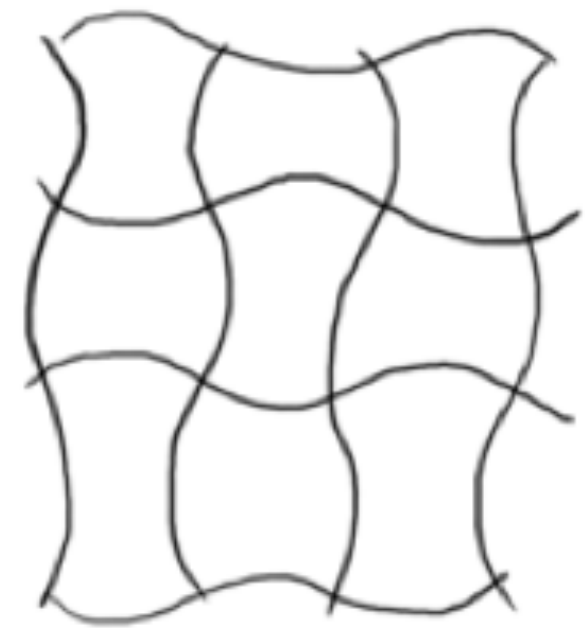
THANK YOU

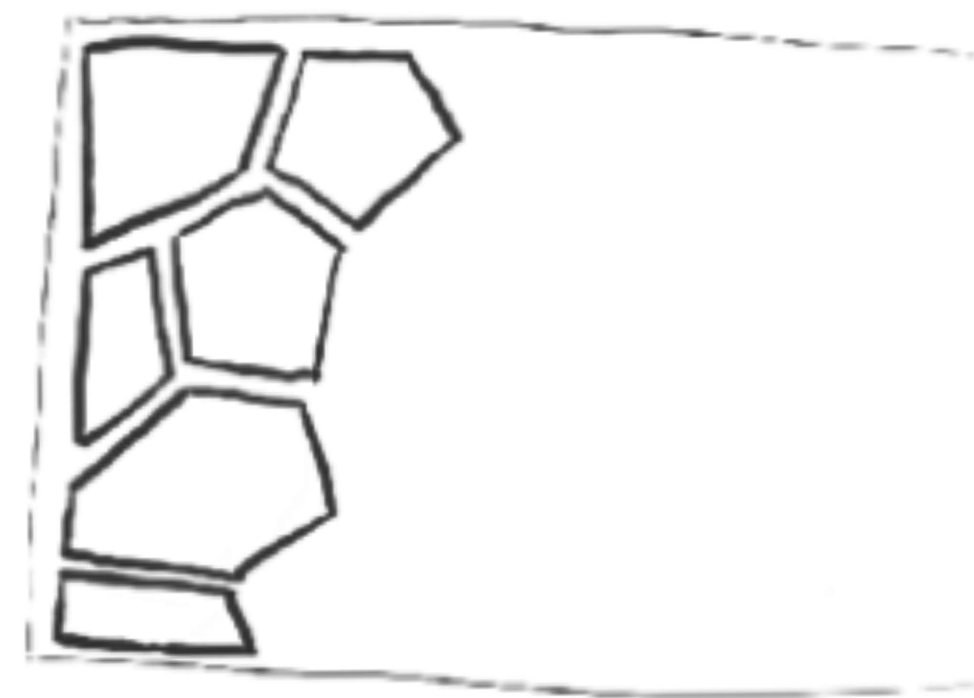
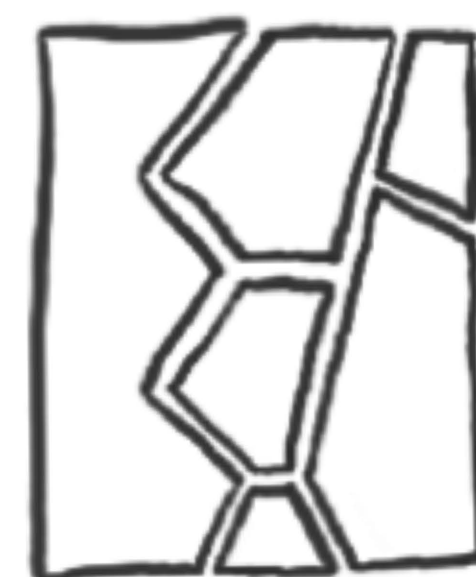
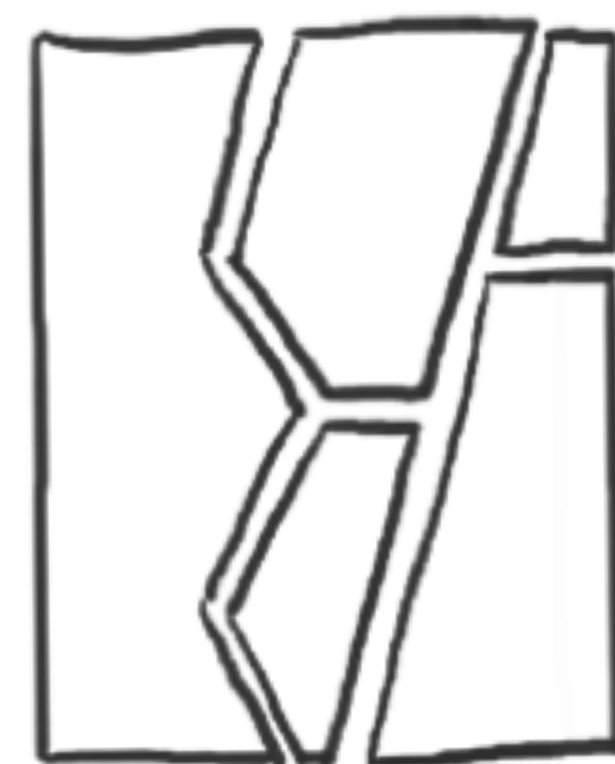
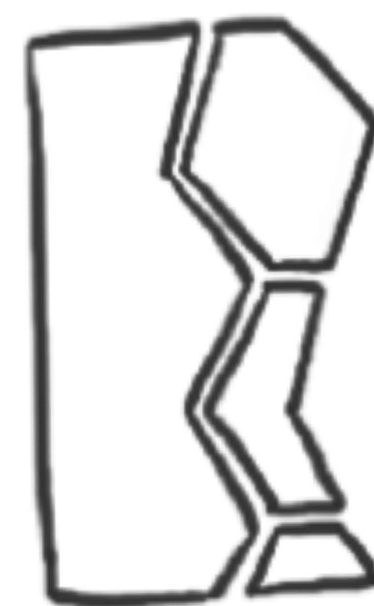
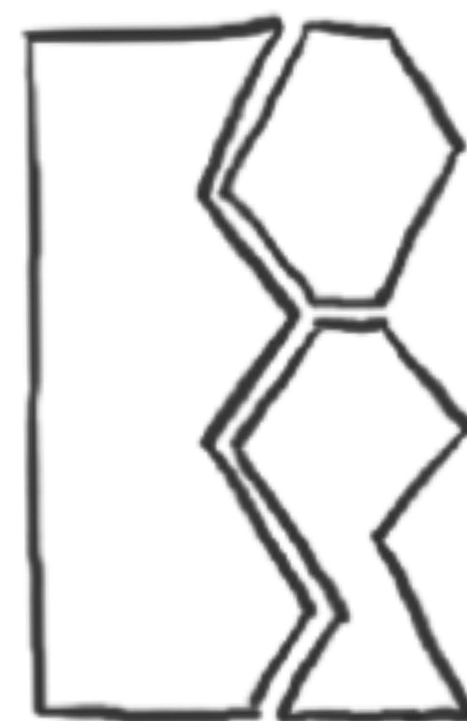
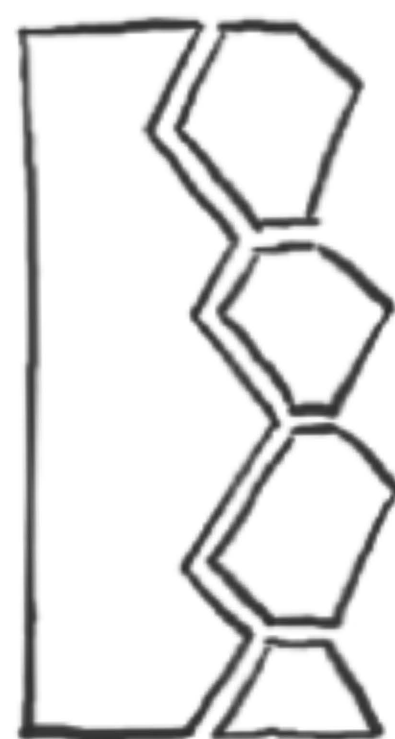
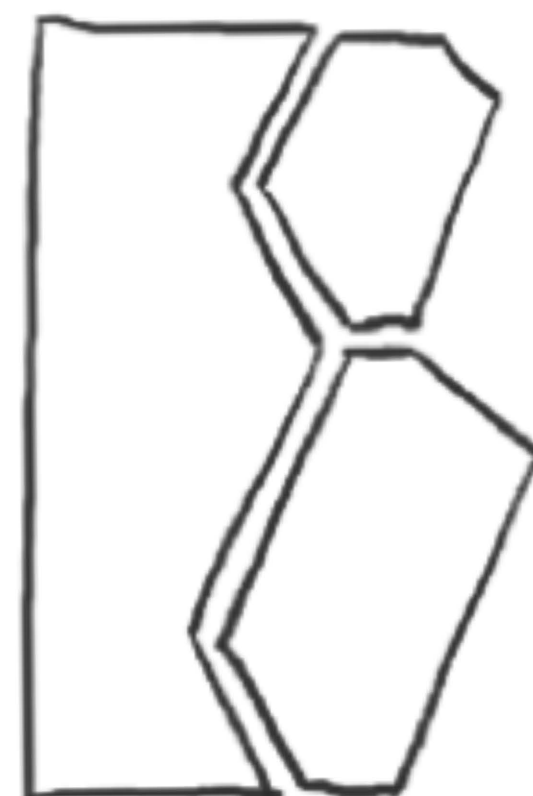


IDEATION

SKETCHES

CUSHIONING AND CARPET SQUARES

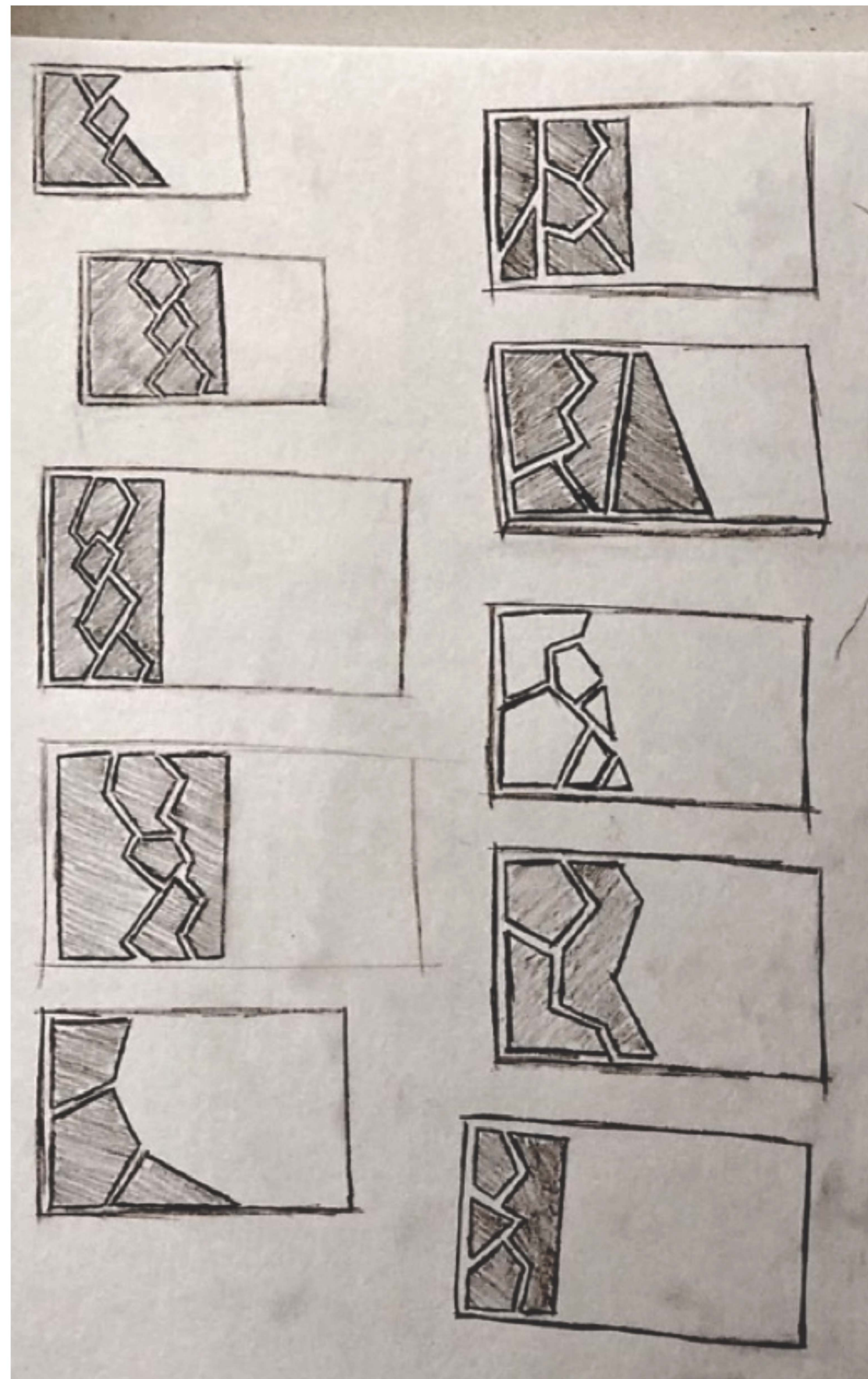
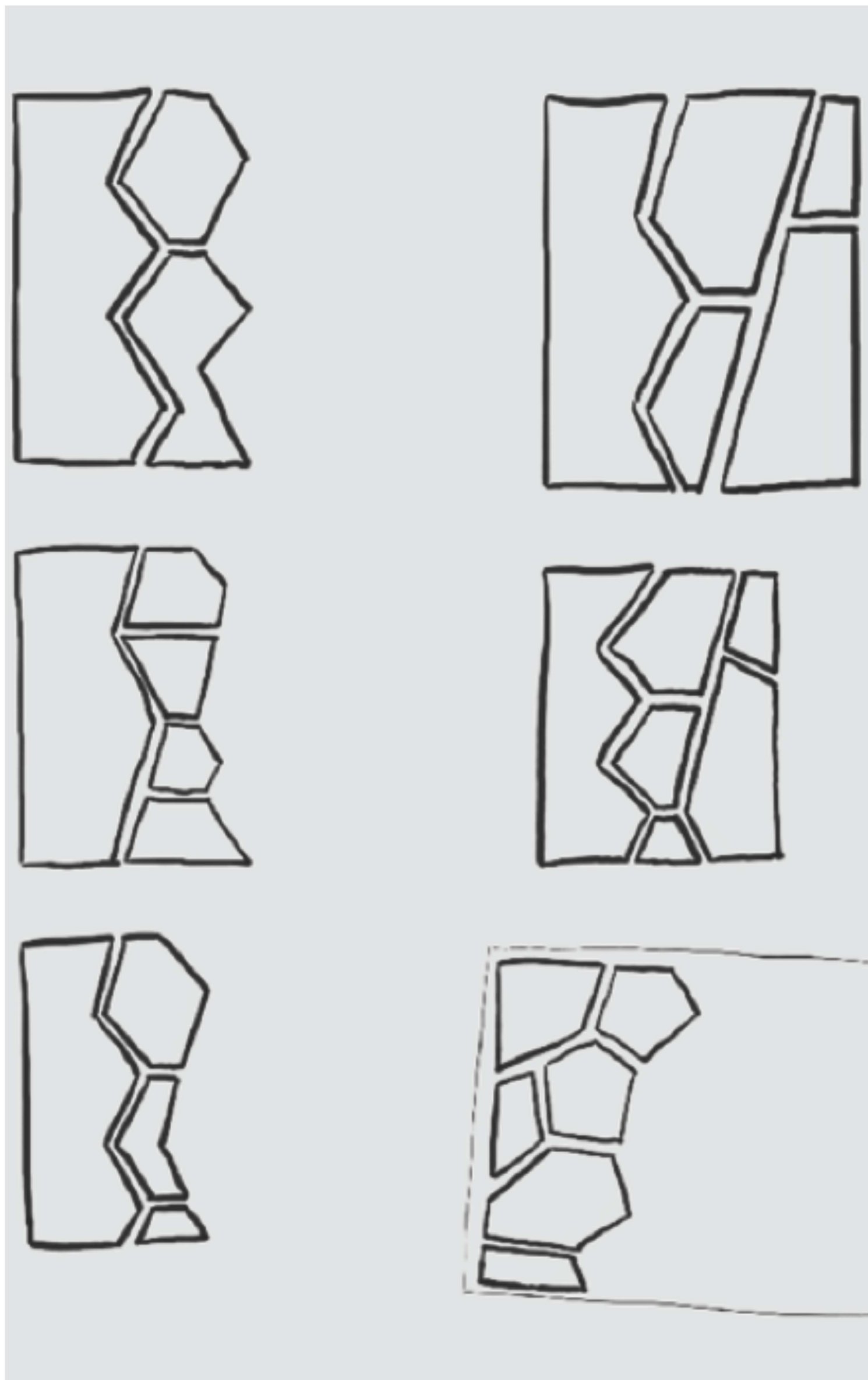
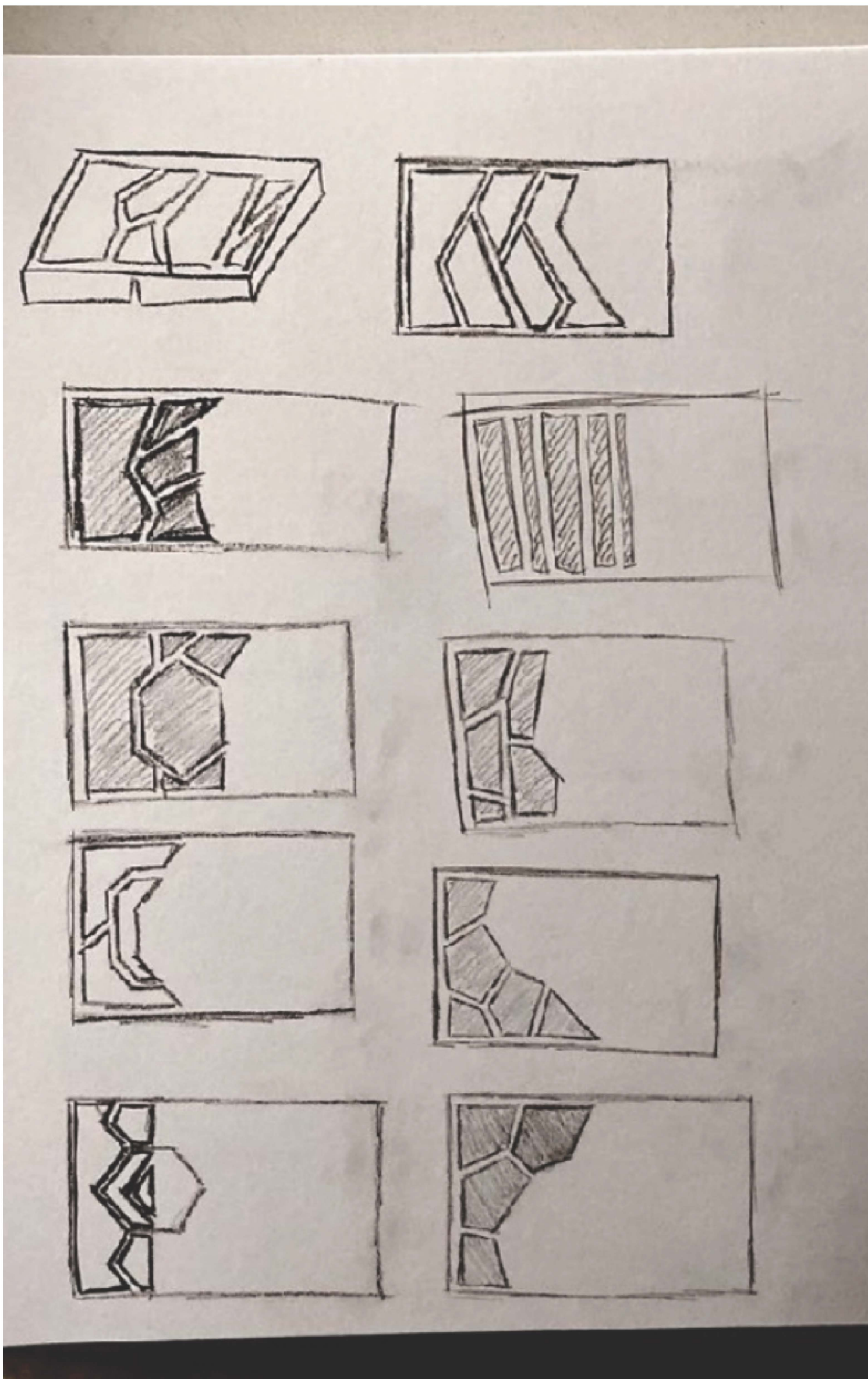


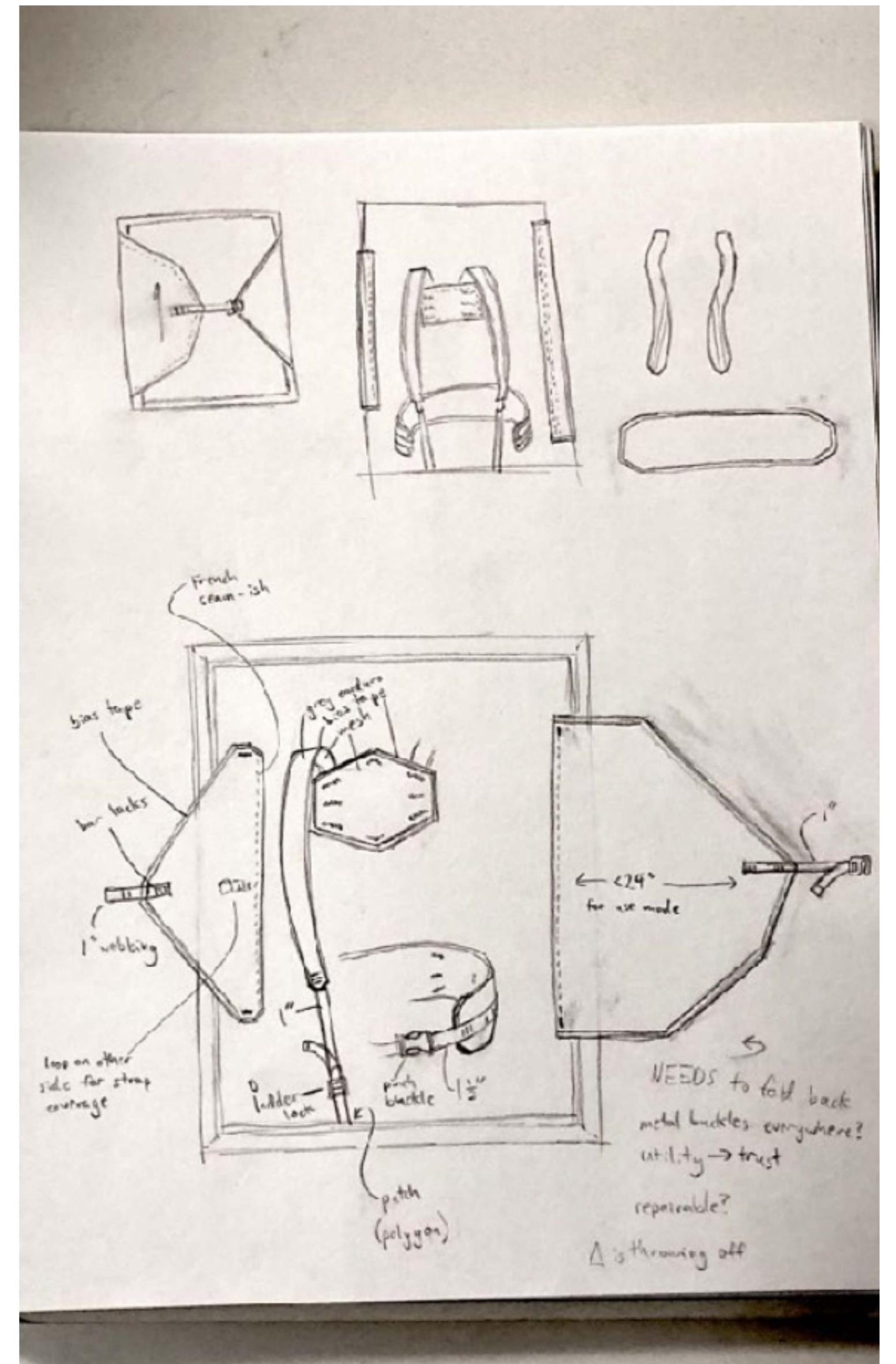
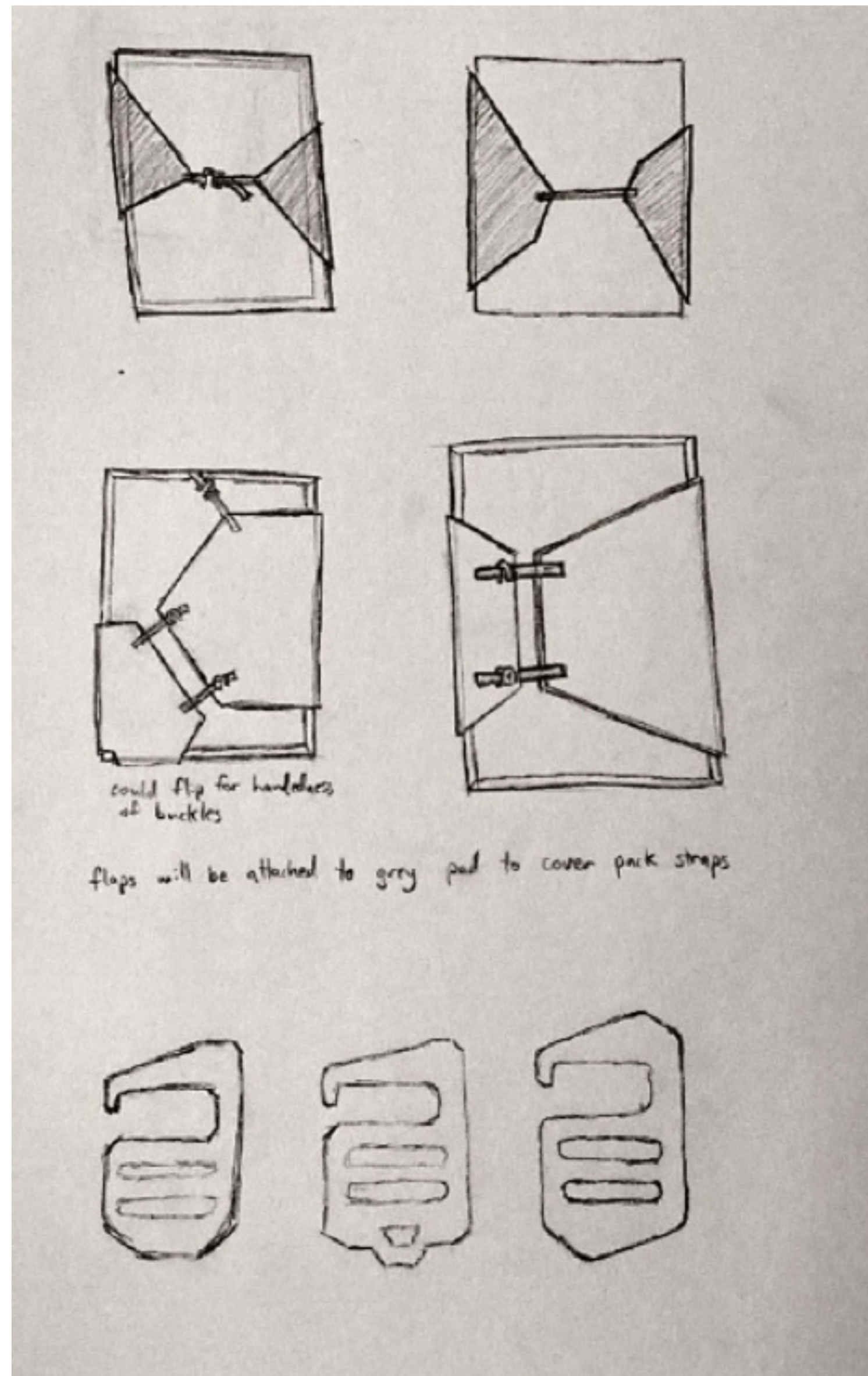
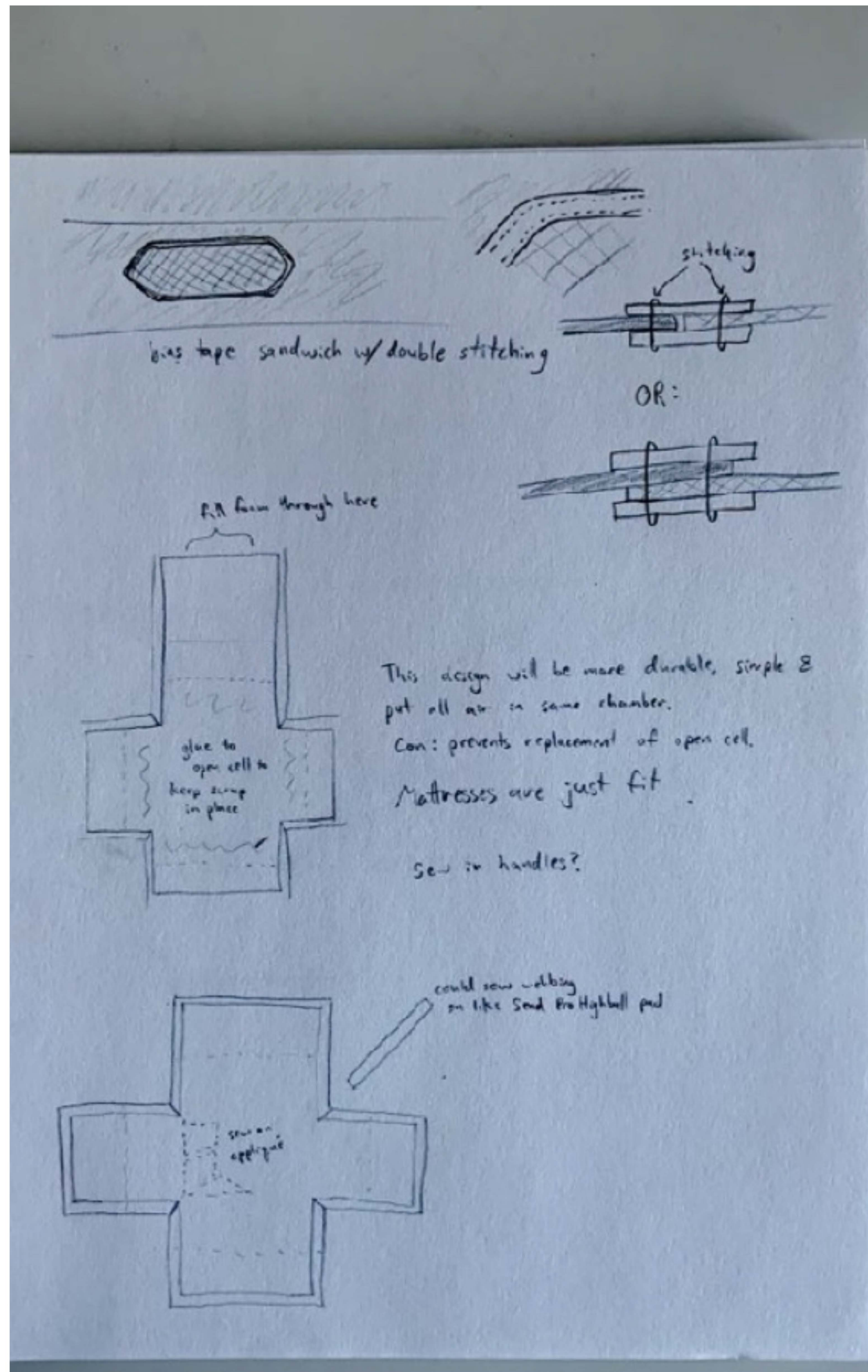


most iconic,
recognizable

quite a bit of
space taken

Up to date but it
may be less like
a standard sketch
you can find in

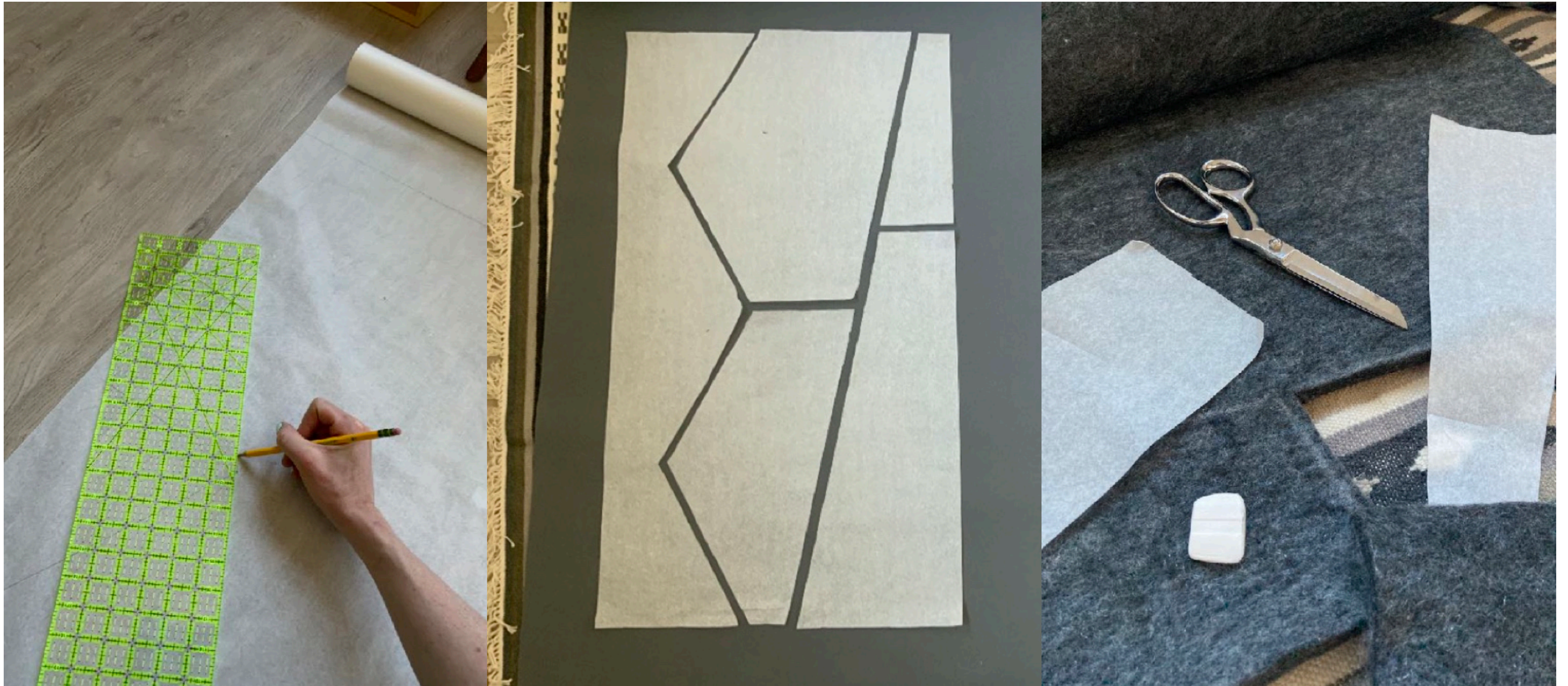




MAKING

PROTOTYPES

PATTERNING AND CUTTING CARPET PATCHES



MAKING THE “LID”



MAKING THE VENTED CUSHIONING UNITS



MAKING THE VENTED CUSHIONING UNITS



BACKPACK STRAPS



NOT EASY ON A DOMESTIC MACHINE...

FLAPS AND STRAPS



BRANDING

STYLE GUIDE AND PACKAGING

STYLE GUIDE

Fonts and Logo

TITLE FONT

INDUSTRY ULTRA

ALL CAPS

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

1 2 3 4 5 6 7 8 9 0



SUBTITLE FONT

FACTORIA BOLD ITALIC

ALL CAPS

*A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z*

1 2 3 4 5 6 7 8 9 0



Factoria Medium

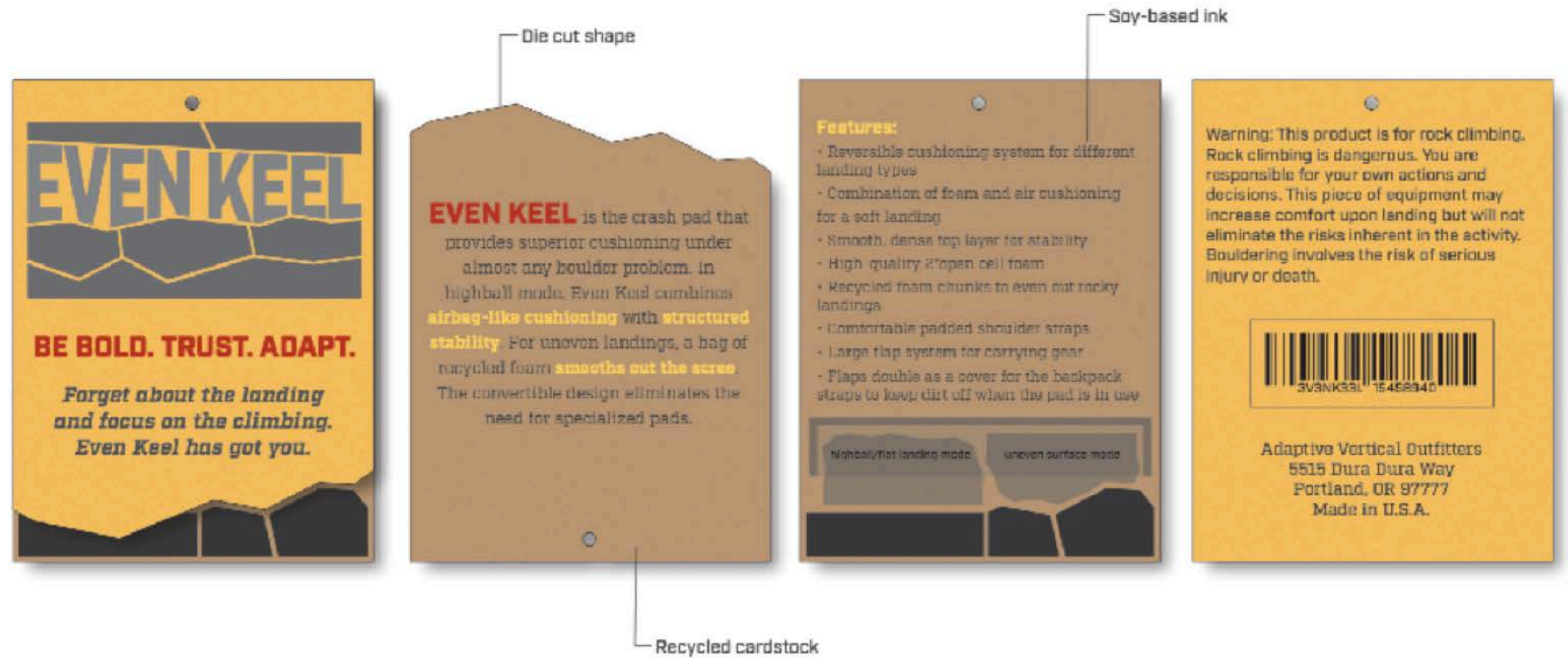
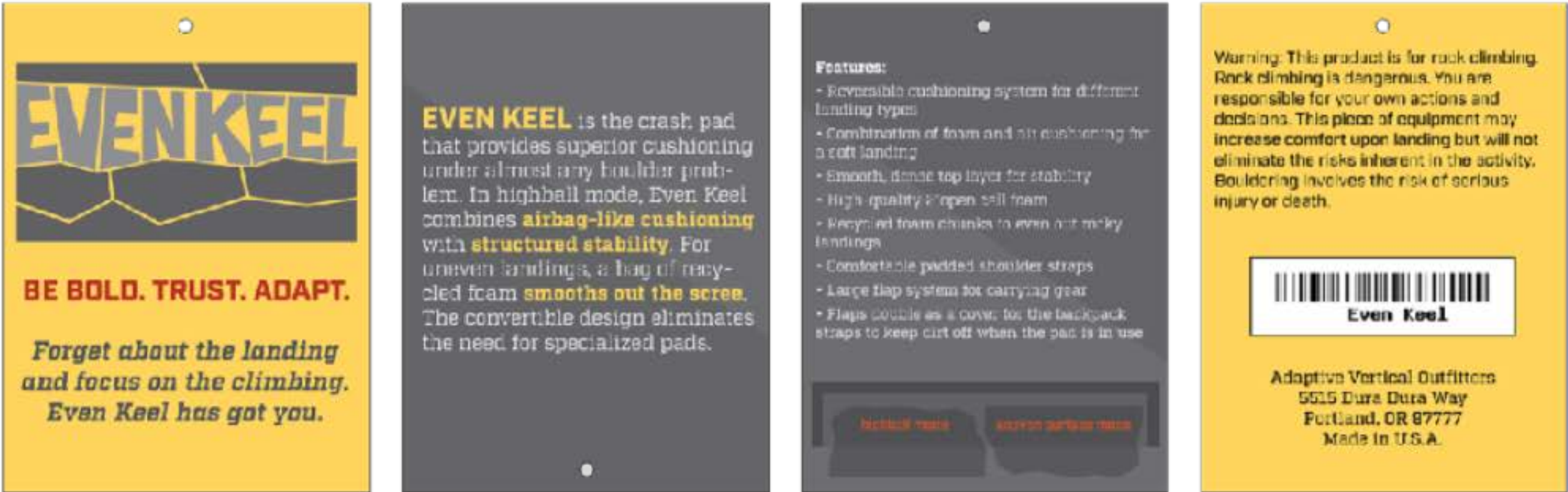
Sentence case

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p
q r s t u v w x y z

1 2 3 4 5 6 7 8 9 0

HANG TAG ITERATION



QUANTITATIVE VALIDATION

WRITE-UP

TESTING RESULTS

Quantitative:

I plotted graphs of the data, which showed similar peak accelerations for my pad (each side) and the Metolius Session pad.

<i>Accelerations in G including gravity</i>	Metolius pad	EK (chunks up)	EK (chunks down)
	8.018	7.952	7.996
	7.708	7.682	7.989
	7.737	7.076	7.697
	8.024	7.417	7.911

	6.938	8.101	7.961
		7.836	7.892
			7.046
Max peak acceleration	8.024	8.101	7.996
Average peak acceleration	7.685	7.677	7.785

Qualitative:

The Even Keel pad makes a louder sound while landing, which I didn't expect.

While jumping over 10 times, I felt pain in my knees more than in my ankles or anywhere else. I was certainly absorbing some impact in my knees, as one would normally while falling, to lessen the jarring of my spine etc.

I recorded videos of all jumps, and looking back through them, there IS NOT a direct correlation between landing with straighter or more bent knees and peak acceleration. This is good because it supports the idea that placing the accelerometer (phone) on my ankle better isolated the test results from my own biomechanics. However, I do recognize that I was not able to isolate the accelerometer from any shock absorption in my foot and ankle. My achilles tendon and various tissues and joints in my foot probably reduced the peak acceleration to some extent, though I attempted to land fairly flatfooted.

Conclusion:

The Even Keel pad felt softer to land on, though the quantitative results didn't necessarily demonstrate that. The chunky side up mode wasn't as stable to land on as chunks down, so I believe that there is no need to have reversible pads. Instead, the next prototype of this pad would eliminate the "lid" system and just have the chunks on the bottom, permanently. The backpack strap system would have to be relocated or covered accordingly.

A more replicable test could be performed using a large weight or sledge instead of a human jumper. Though me jumping onto the pad more closely replicated a falling climber, more variables may have been introduced, making it harder to accurately compare the pads. Additionally, falling repeatedly from a greater height would come with inherent risk, but most boulderers fall fairly frequently from heights greater than 25 inches. It would be informative to test the pad's performance with an inanimate weight falling from, say, 10 feet above the ground as a model for larger falls. This could be done in a laboratory setting if a weight of over 100lbs was available and if it could be lifted and dropped without the risk of it bouncing and/or hitting anyone around it (i.e. this is unrealistic in my apartment with the materials that are available).



THANK YOU!