Multi-Use Affordable Trad Climbing Protection for Low-Income Climbers

Michael J. Orlow
M.S. Sports Product Design, University of Oregon

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Carly Mick, Vanessa Preisler, & Rachel Volker

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Introduction

As early as there have been mountains, ridges, cliffs, and all manner of towering natural features, humans have felt the draw to test themselves physically and mentally by ascending these features with their own strength and perseverance. In the pursuit of self-improvement through climbing, a sub-population of athletes dedicates themselves to non-traditional living such as nomadic van housing or hitch-hiking while working remote or odd jobs. These individuals often do not have a stable income and so are limited in their access to essential life-saving equipment used in the specific discipline of climbing referred to as “trad” or traditional, in favor of food, clothing, and shelter.

Specialized and highly functional equipment for trad exists but is made inaccessible to some through high unit cost and/or limited versatility which requires a large investment into many unique and duplicate pieces of equipment. The intent of this project is to explore design and manufacturing methods that allows greater versatility and efficiency for both development and performance for the user. This singular type of protection should fulfill the role that multiple different types of protection currently fill. By only needing to invest in and learn how to use one type of protection, users will see reduced cost and more easily achieve participation in trad climbing.

Definitions

Connector: Metal shackle that opens at one spring-loaded gate to facilitate connection of a frictional anchor to a rope or sling

Frictional anchor: *Adjustable* wedge-shaped body, which is intended to be wedged in cracks in the rock and can withstand a load in the direction of the longitudinal axis of the means of attachment.

Holding force: Force necessary to cause the frictional anchor to break or slip through the test apparatus, as determined in the cyclic loading test.

Means of attachment: Any system which allows the attachment of a connector to a frictional anchor.

History

Before rock climbing there was mountaineering, born from the necessity for exploration and expansion of civilizations, and is recorded as early as 1492 but is presumed to be a much older pursuit. Mountaineering involves the use of equipment such as ropes and ladders as the method of ascent, and the goal is typically to reach the summit, or highest point of a mountain (“A Brief History,” n.d., para. 3).

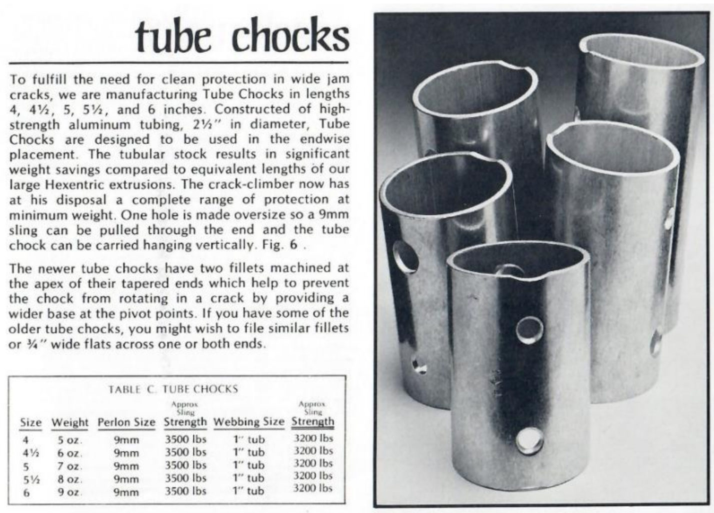
In contrast, rock climbing is “all about the act of climbing itself, climbing for its own sake” (“A Brief History,” n.d., para. 6). The person most often credited as the progenitor of rock climbing is Walter Parry Haskett Smith, a wealthy, educated man from the UK. In 1886, he free solo climbed Napes Needle, helping to distinguish rock climbing from mountaineering. It is believed that after this feat was when rock climbing started to be considered its own sport (“A Brief History,” n.d., para. 7).

In the early days of rock climbing, many climbers used a tool from mountaineering called pitons, soft iron spikes that are hammered into rock permanently and used to help ascend and/ or descend (Allbright, 2020, para. 5). However, many English and American climbers felt dissatisfied with leaving permanent marks or scars in rock features. In the 1950s in Yosemite National Park, climber Royal Robbins began advocating for “clean climbing,” where as little equipment as possible is left behind and rock features are not scarred or altered (“The History,” 2020, the 1900s section).

In 1972, Yvon Chouinard, a manufacturer of pitons and another proponent of clean climbing began manufacturing and selling the aluminum chock (Fig. 1), a temporary piece of protection that is removed on the way down from a climb or by a second climber on the way up. Chocks, hexcentrics, stoppers, and spring-loaded cam devices allowed the ascent of most routes without the need to place any permanent equipment (Allbright, 2020, para. 8).

Figure 1

Chouinard Tube Chocks



tube chocks

To fulfill the need for clean protection in wide jam cracks, we are manufacturing Tube Chocks in lengths 4, 4½, 5, 5½, and 6 inches. Constructed of high-strength aluminum tubing, 2½" in diameter, Tube Chocks are designed to be used in the endwise placement. The tubular stock results in significant weight savings compared to equivalent lengths of our large Hexentric extrusions. The crack-climber now has at his disposal a complete range of protection at minimum weight. One hole is made oversize so a 9mm sling can be pulled through the end and the tube chock can be carried hanging vertically. Fig. 6 .

The newer tube chocks have two fillets machined at the apex of their tapered ends which help to prevent the chock from rotating in a crack by providing a wider base at the pivot points. If you have some of the older tube chocks, you might wish to file similar fillets or ¾" wide flats across one or both ends.

TABLE C. TUBE CHOCKS

Size	Weight	Perlon Size	Approx Sling Strength	Webbing Size	Approx Sling Strength
4	5 oz.	9mm	3500 lbs	1" tub	3200 lbs
4½	6 oz.	9mm	3500 lbs	1" tub	3200 lbs
5	7 oz.	9mm	3500 lbs	1" tub	3200 lbs
5½	8 oz.	9mm	3500 lbs	1" tub	3200 lbs
6	9 oz.	9mm	3500 lbs	1" tub	3200 lbs

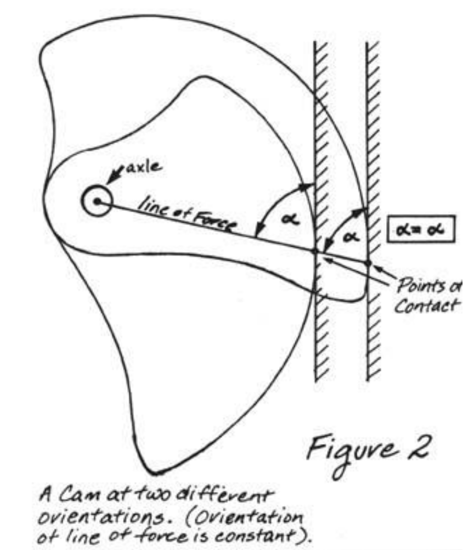
(Chouinard, 1927)

User

The most versatile piece of protection for trad climbing is the spring-loaded cam device (SLCD), which features 3-4 cam lobes that are forced open by a spring. These lobes can be retracted by pulling a trigger in order to fit the device into a crack. Due to the shape of the lobes, any downward force that attempts to pull the device out of the crack it is placed in will cause the lobes to widen, firmly locking the device in place (Fig. 2).

Figure 2

SLCD Diagram



(Middendorf, 1985)

SLCDs are very expensive for athletes new to the sport, and many SLCDs of various sizes are needed in order to attempt trad climbing. The target user for this product is intermediate, non-professional outdoor climbers of any sex or gender, aged 18-35. This population is generally students with a lower income or nomadic lifestyle and unstable income. These users will have experience with and understanding of the act of leading a climb but will not have had the resources to trad climb regularly or by their own means.

Market

According to the Outdoor Industry Association (OIA), there were 2.374 million trad/ice/mountain climbers in the U.S. in 2021. This is 0.007x the U.S. Population ("2022 Outdoor," p. 42). If this fraction of the U.S. population is applied to the global population, then there are potentially 54.271 million trad/ice/mountain climbers globally. The Outdoor Foundation, the non-profit branch of the OIA, recorded in 2015 that 45.7% of trad climbers are between the ages of 18-34 and that the male and female split is 61.7% and 38.3% ("Traditional Climbing," p. 4).

Jobs to be Done

Traditional climbing is most different from other forms of rock climbing in that the climber needs to regularly place protection into the rock to safeguard themselves in the event of a fall. In order to place protection properly so that it can support a fall or falls, the climber needs to identify suitable features where they can place protection, select the appropriately sized piece of protection to fit in the feature, place the protection snugly into the feature, and then be able to remove the protection when cleaning the route ("Lead climbing," n.d.). Climbers must often do this while in awkward, strained positions or even blindly.

Figure 3

Placing protection from below

("Lead climbing," n.d.).

User Physiology

Anthropometry

Across several studies, body mass between elite and average climbers was not found to be significantly different. Some state that in any activity "where body mass is repeatedly lifted against gravity, extra mass […] is disadvantageous," but "differences within the literature would suggest that a low body mass and percentage body fat are not a prerequisite for elite level climbing." (Giles et al., 2006, p.533). As such, reduction of weight in any form, including equipment, is perceived as positive for climbers.

Climbers tend to be an average of 5.91' tall with an ape index of +1". As this does not differ from the average population, "it could be suggested that both height and ape index are not a prerequisite for climbing success, but as reach is perceived as advantageous in climbing, a positive ape index may be beneficial" (Giles et al., 2006, p.534).

Muscular Strength & Endurance

Climbers generally have a greater maximum grip strength than non-climbers.

Table 1

Comparison of elite & non-climbers finger strength

	Elite climbers			Non-climbers		
	Grant et al.[1]	Grant et al.[5]	Quaine et al.[12]a	Grant et al.[1]	Grant et al.[5]	Quaine et al.[12]a
Grip 1 right hand ± SD (N)	321 ± 18	446 ± 30	420 ± 46	256 ± 15	309 ± 30	342 ± 56
Grip 1 left hand ± SD (N)	307 ± 14	441 ± 34		243 ± 11	309 ± 34	
Grip 2 right hand ± SD (N)	193 ± 17	221 ± 16		136 ± 12	184 ± 16	
Grip 2 left hand ± SD (N)	186 ± 20	228 ± 17		136 ± 15	182 ± 16	

a The hold whereby fingertip force was generated consisted of a steel plate covered with a non-skid surface fastened to the force sensor, participants were right-hand dominant.

Note. Grip strength values were not notably different between elite climbers and recreational climbers. However, when measured as grip strength *relative to bodyweight*, elite climbers scored much higher than recreational climbers (Giles et al., 2006, p.535).

As climbers need to repeatedly perform isometric contractions of the forearm with various types of hand grips, endurance is just as important if not more so than absolute strength. According to studies in grip endurance, increase in blood lactate correlates with a decrease in hand grip endurance. Climbers were able to recover more quickly from this lactic acid accumulation due to greater vasodilation capacity (Giles et al., 2006, p.537). While climbers have high endurance and quick recovery, any amount of time that can be reduced from placing protective equipment will decrease the level of endurance necessary for recreational climbers to continue climbing.

User Biomechanics

Vertical Balance

In a vertical environment, the user's center of mass is outside of the "base of support," rather one's legs are not directly underneath one's torso. To be in equilibrium, a climber is pulling into the wall with their hands as the holds try to push their upper body off the wall and they push up against the wall with their feet while gravity tries to pull them down. "Resultant forces equal and opposite to the weight of the climber can be produced by the hands pulling downwards and outwards and the feet pushing downwards and inwards" (Low, 2005, p.13). The arms control distance from the wall and the legs support weight.

Climbers exhibit a tendency to move their center of mass closer to the wall to increase stability and decrease the moment of their body weight against their support structure. In practice, this means that the farther the climber's center of mass at their hips is from the wall, the greater force is felt on the arms and legs. (Low, 2005, p.15). Any method of placing protective equipment which forces a body position whose center of mass is moved away from the wall will drain the climber's endurance more quickly.

Prehension

Prehension in rock climbing differs from typical prehensile tasks in that the subject manipulates their body around the grasped object/hold as opposed to manipulating a grasped object around their body. As a result, the stability of the climber's body has as great an impact on the success of the prehension task as the act of reaching and grasping itself. (Low, 2005, p. 26)

For prehension tasks in climbing, climbers "[use] a strategy of optimizing the duration of the tripodal position during the reach" (Low, 2005, p. 27). When in a tripodal position, only three limbs are connected to the wall, placing extra strain on either the singular hand or foot left while the opposing limb completes prehension. This tripodal position is less stable and more difficult to maintain. The more precise the target, the longer the transport phase of prehension typically lasts (Low, 2005, p. 27). Minimizing the duration of a tripodal position is essential for stability but moving too fast may compromise posture. Additionally, the more difficult a protective device is to place through precision needs, the more time the climber will spend in an unstable posture.

User Psychology

Self-Efficacy

The older a climber is, the more likely they are to have been climbing longer and have developed more experience with climbing than someone who is younger. Age is strongly correlated with experience, and experience is strongly correlated with self-efficacy. Self-efficacy is, in turn, the strongest indicator of any other climbing behavior (Llewellyn et al., 2008, p. 78).

For climbers who have had little to no opportunity to start trad climbing and acquire experience, self-efficacy is expected to be very low and decreased frequency of participation will follow.

Flow & Motivation

Climbers with motivation for high achievement are far more likely to experience flow. Flow is the state where an individual is "[operating] at full capacity," and occurs within a delicate balance of skill and difficulty of a task. This state is often used to explain athlete's motivations. If skill is greater than difficulty an athlete will experience boredom, but if difficulty is greater than skill an athlete will experience anxiety (Lopez et al., 2009, p. 196). On routes which are far above a climber's skill, they are likely to experience fear of failure without hope of success, a combination which does not promote flow (Schattke et al., 2014, p. 14). Desire to improve performance is a strong incentive for achievement. Flow will often increase on routes which are just above a climber's skill level but which the climber believes they have hope of completing (Schattke et al., 2014, p. 15).

Likewise, if the skill and experience necessary for using a trad protection device are inordinately difficult relative to the user's skill and experience, they are unlikely to exhibit feelings of motivation or experience incentives for achievement.

Golden Circle

The goal of this research is to promote accessibility and inclusion in outdoor sports and encourage environmental stewardship through user-focused, responsible design and manufacturing of accessible trad climbing protection.

Strengths Finder

Top 5 strengths:

- Deliberative
- Responsibility
- Relator
- Learner
- Discipline

These strengths are beneficial for this project because they all goal-oriented and encourage continuous improvement. This project will require a lot of testing, user feedback, and integration of small improvements over many iterations. In addition, these strengths facilitate strong and reliable relationships with mentors and industry professionals, which will be of great importance for further learning and professional development.

This body of work will help to support a career in the sports product design industry because of its technical requirements including cognizance of national safety and manufacturing standards for specialized equipment, management of time, resources, and funds for accomplishing a task, and meaningful iteration on ideas. These components will showcase an outdoor recreation product design acumen which should prove valuable in a variety of necessary positions within outdoor brands.

Problem Statement

How could we design easy and affordable to manufacture trad climbing protection that fits any shape or orientation crack for intermediate, non-professional climbers who want to trad climb?

Line Plan

This collection will include a series of four variably sized multi-width adjustable pieces of protection which fit cracks from the ranges of 0.25"-1", 0.75"-2", 1.75"-3.5", and 3.25"-5", as well as a carabiner to pair with them for attachment to ropes and slings. The greater the functional range of each individual piece of protection, the fewer distinct pieces will be needed by the user to fit different width cracks along a route. Carrying multiples of a maximum of four different sizes allows the user to spend less time deciding which piece of protection to grab when assessing a crack for placement.

Environment

Smith Rock State Park is a park near Bend, Oregon. Smith Rock is home to sport, trad, aid, and bouldering routes that range from 20-600 ft. Autumn Averages are 31-75°F, 50-70% humidity, 5-7 mph winds, 11 days of rain, 8 days of snow. This encompasses the months of September through November (“Smith Rock,” n.d.).

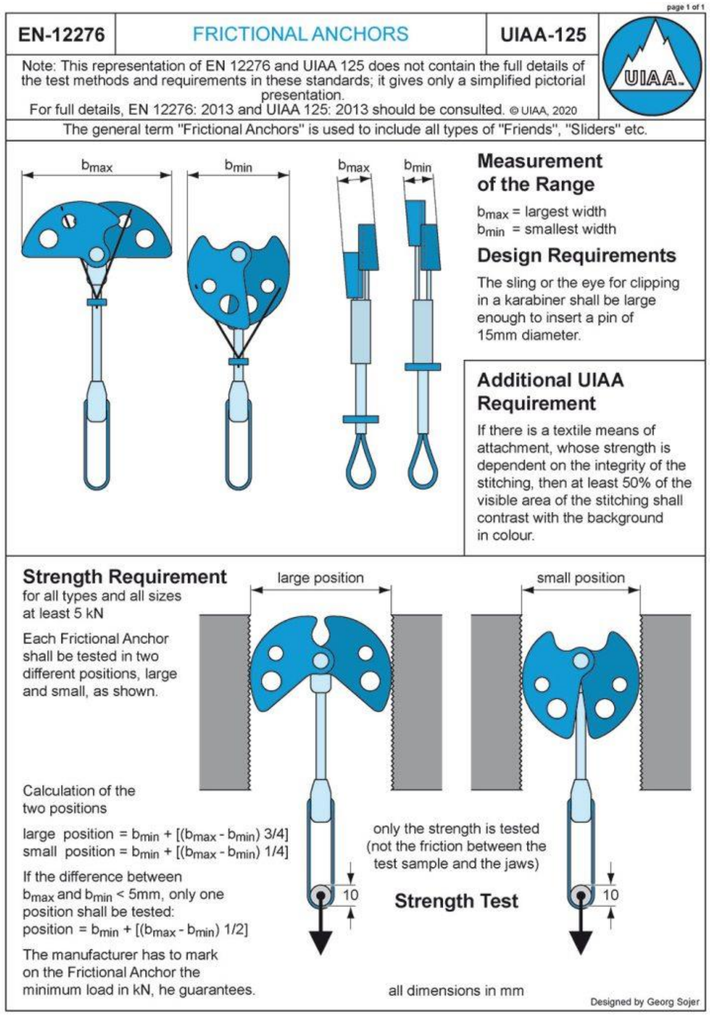
The features in Smith Rock are formed of columnar basalt. Basalt develops when volcanic magma cools very quickly. Gas bubbles present in the magma result in tiny pockets on the surface of the rock, ranging from a sandpaper texture to large enough to fit a finger into and providing good friction for climbers (Key, 2022, paras. 5-7). It is considered safe to climb on wet basalt as long as it is in good condition and comparably climbable when dry Basalt tends to dry quickly because of its fine grain structure (Key, 2022, para. 17). Basalt is rich in iron, and basalt that has oxidized and turned brownish red will be more fragile than fresh greyish black basalt (Key, 2022, paras. 18-19).

Rules

There are no specific rules for trad climbing in Smith Rock state park. Trad climbing equipment, however, must abide by the standards set by the Union Internationale des Associations d'Alpinisme (UIAA). The current UIAA standard for protection classified as “frictional anchors” is UIAA-125 or EN-12276. UIAA-125 covers means of attachment, holding force, design, strength, safety requirements, testing methods, testing samples, information to be provided, and marking.

Figure 4

UIAA-125



("UIAA-125," 2018)

Competitor Products

For trad climbers there are a handful of brands who manufacture protection, most of which are SLCDs, hexes, nuts, and stoppers. There are also a few specialty protection options which do not see as much use. The most used alternative protection is the CAMP Tricam, a device which can function as either active or passive protection. Climbing protection is most often made from 6061-T6 aluminum alloy and braided steel cable, ultra high molecular weight polyethylene (UHMWPE), polyamide, or some combination of those (Oro 2020, para. 13). Climbing carabiners are made of 7075-T6 aluminum alloy with either stainless steel wire or a solid gate made from the same aluminum alloy with a stainless steel pin. T6 aluminum is a two-step heat treatment at 986°F and an aging temperature of 302 to 356°F. The heat treatment increases the alloy strength by up to 30%. (Oro 2020, para. 11). SLCD parts are CNC milled or lathed and then hand-finished and assembled. Such tasks involved in finishing are de-burring and polishing milled pieces, brazing steel cable, epoxying fittings together, and electrically anodizing the aluminum components for color (Metolius Climbing, 2013).

Frictional Anchors

Figure 5

Black Diamond Camalot C4

Note. The Black Diamond Camalot is manufactured from CNC milled 6061-T6 aluminum alloy and features a polyamide connector, vinyl covered braided stainless steel attachment, and high density polyethylene (HDPE) flexible stem and trigger. The Camalot retails for $79.95-$139.95 depending on the size (“Camalot,” n.d.).

Figure 6

Metolius Ultralight Master Cam

Note. The Metolius Master cam is manufactured from CNC milled 6061-T6 aluminum alloy and features a sewn Dyneema loop connector and a braided stainless steel stem with milled aluminum attachment and trigger hardware. The Master cam retails for $69.95-$74.95 depending on the size (“Ultralight master cam,” n.d.).

Figure 7

Wild Country Rockcentric

Note. The Wild Country Rockcentric is manufactured from forged 6061-T6 aluminum alloy and features a UHMWPE connector with polyamide color accents. The Rockcentric retails for around $13.99 per piece (“Rockcentric,” n.d.).

Figure 8

CAMP Dyneema Tricam

Note. The CAMP Dyneema Tricam is manufactured from forged 6061-T6 aluminum alloy and features a UHMWPE connector with polyamide color accents and a stainless steel pin. The Tricam retails for around $24.99 per piece (“Dyneema Tricam,” n.d.).

Carabiners

Figure 9

Petzl Ange L

Note. The Ange L is manufactured from forged 7075-T6 aluminum alloy and features a stainless steel single wire keyhole gate with an HDPE keeper. The Ange L retails for $13.95 per piece (“Ange L,” n.d.).

Figure 10

DMM Wales Alpha Trad

Note. The Alpha Trad is manufactured from forged 7075-T6 aluminum alloy and features a stainless steel bent wiregate. The frame of the carabiner is hooded for anti-snag. The Alpha Trad retails for $16.95 per piece (“Alpha trad,” n.d.).

Figure 11

Wild Country Helium 3.0

Note. The Helium 3.0 is manufactured from forged 7075-T6 aluminum alloy and features a stainless steel bent wiregate. The frame of the carabiner is hooded for anti-snag. The Helium 3.0 retails for $13.95 per piece (“Helium 3.0,” n.d.)

Graphics, Logos, and Color

Climbing protection uses color to visually differentiate variably sized pieces from each other immediately.

Figure 12

Camalot C4 Series

Note. Vibrant solid colors for easy identification (“Camalot C4”).

This collection of protection will take inspiration from the Worth Global Style Network’s (WGSN) projected August/Winter 2023/2024 forecast of “NatureVerse” and the Spring/Summer 2024 Active Colour Forecast for summer pastels. NatureVerse refers to “[exploring] the surprising synergies between the organic and technological, where the metaverse and multispecies thinking inspire otherworldly and eco-friendly prints and graphics” (Chow, 2022, para. 1).

Figure 13

NatureVerse Styling

Note. (Chow, 2022)

The colors used in this collection will be pantone 16-0928 TCX, pantone 17-1537 TCX, pantone 14-1309 TCX, pantone 17-4139 TCX, pantone 17-3014 TCX, pantone 15-1247 TCX, pantone 14-3209 TCX, and pantone 16-4030 TCX. These are color stylings that pair well as high contrast colors with pantone neutral black C to draw attention to important elements for safety and usability.

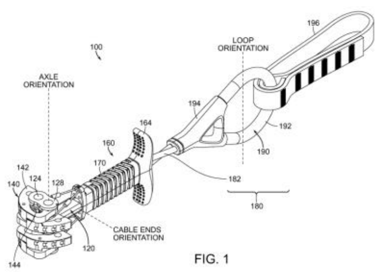
Logos are among the only graphic elements placed on climbing protection besides minimum breaking strength (MBS) and other relevant safety information or user instructions. These are either laser-etched into aluminum, forged as a relief in aluminum, molded into HDPE components, or printed on tags attached to soft connectors. Equipment is usually a single matte color, and any variation is used to indicate separation of parts or safety features such as bright striped patterns on ropes or locking carabiners. These stripes allow a climber to easily identify the speed at which a rope is moving or indicate an unlocked carabiner (Figure 14). Similarly, the marketing language used for climbing protection is often only informative, stating performance metrics and showing the equipment in use. As a result, there is opportunity for more creative design language but it must also not be distracting to users.

Figure 14

Industry graphic styling - safety stripes

Note. Climbing equipment has a very simple color and styling language. This Mammut carabiner displays three colors. The gate is a different color from the frame to allow users to easily identify which side of the carabiner opens. The orange stripe highly contrasts the frame to draw attention to the fact that the gate is unlocked when the stripe is visible (Workhorse, n.d.)

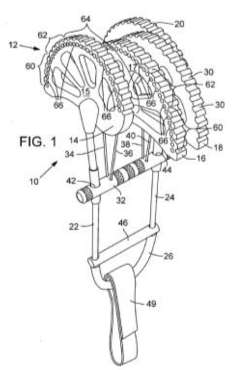
Intellectual Property



Camming Stem System (U.S. Patent No. 11,383,136 B2, 2022)

- Semi-rigid coupled loop covering a twisted steel core
- Greater opposing force to maintain rigidity when retracting the device

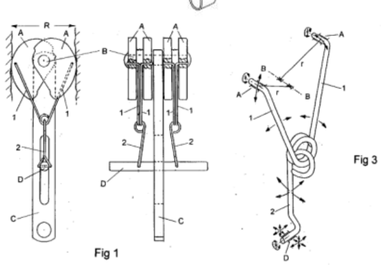
(Steck et al., 2022)



Climbing Cam Placement Indicator (U.S. Patent No. 2005/0218282 A1, 2005)

- Colored dots representing cam placement quality
- Visual indicator of proper placement

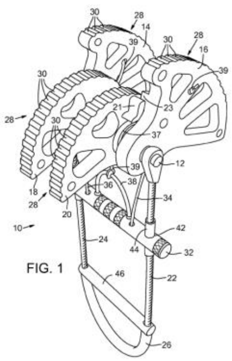
(Douglas, 2005)



Trigger Linkage for Controlling Rock Climbing Cam Device (UK Patent No. GB 2419632 A, 2006)

- Precise manipulation of paired cams
- Expired

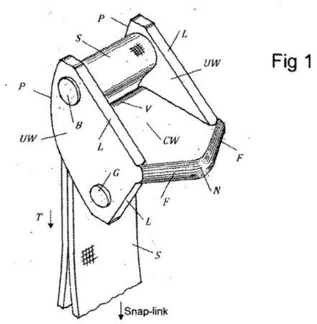
(Walters, 2006)



Mechanical Climbing Aid of the Cam Type (U.S. Patent No. US 7,802,770 B2, 2010)

- A device with five cams whose:
    - First and second cams engage one side of the rock
    - Third and fourth cams engage the other side of the rock and:
    - Whose fifth cam prevents the device from travelling further into the crack it is placed

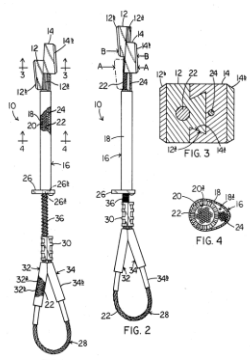
(Field, 2010)



A climbing chock with a cross member running between two upright members to provide a tripodal cam device (UK Patent No. GB 2472398 A, 2011)

- Tricam configuration which functions in active or passive protection modes via a connector wrapping around a cam
- Expired

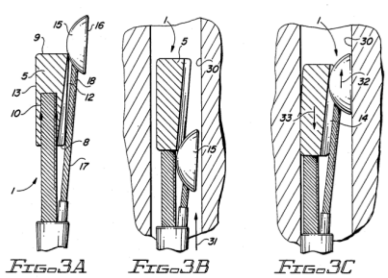
(Walters, 2011)



Change Configuration Climbing Chock (U.S. Patent No. 4,572,464, 1986)

- Wedge elements which may slide past each other for changeable configuration of a chock
- Expired

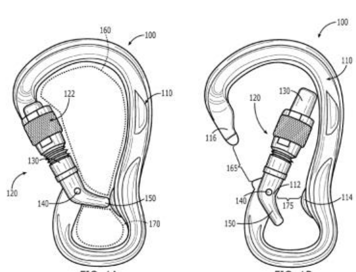
(Philips, 1986)



Self-Adjusting Climbing Chock (U.S. Patent No. 4,834,327, 1989)

- A fixed wedge element with a tapering depression
- A retractable bearing which is forced outwards by the tapering wedge
- Expired

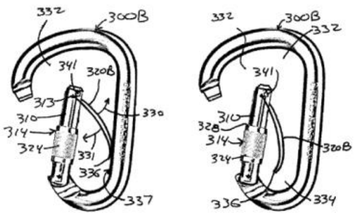
(Byrne, 1989)



Multi-Chamber Carabiner (U.S. Patent No. US 9,003,617 B2, 2015)

- Secondary portion to the gate creates two closed chambers for maintaining orientation of the frame

(Walker et. Al, 2015)



Carabiner with Anti-Cross Loading Feature (U.S. Patent No. US 8.443,495 B2, 2013)

- Spring-like secondary gate which creates two closed chambers for maintaining orientation of the frame
- Expired

(Schwappach & Boutaghou, 2013)

SWOT Analysis

		Strengths	**Weaknesses**	**Opportunities**	**Threats**
	**Stem**	• Precise adjustment with trigger	• Mechanical complexity creates many potential breaking points	• Cam-style mechanism can be used without active springs	• Flexible stems which would not break under stress
	Lobes	• Multiple crack-width compatible • Constantly widens in cracks	• Heavier than other protection • May “walk” in restriction-type cracks	• Exploration of number of lobes may impact performance	• Due to cost, more chocks, nuts, and hexes are purchased
Black Diamond Camalot C4 95$79. - 139.95	**Attachment**	• Very durable	• May close and make attachment difficult	• Rigid extension to stem may improve reach	• Cheaper materials, i.e., stainless steel cable

		Strengths	**Weaknesses**	**Opportunities**	**Threats**
	Stem	• Visible components allow for easy safety inspection	• Exposed components may be at risk of abrasion	• Cam-style mechanism can be used without active springs	• More comfortable injection molded grips

	**Lobes**	• Multiple crack-width compatible • Constantly widens in cracks	• Heavier than other protection • May “walk” in restriction-type cracks	• Exploration of number of lobes may impact performance	• Due to cost, more chocks, nuts, and hexes are purchased
Metolius Ultralight Master Cam $69.95-74.95	**Attachment**	• Very durable	• May close and make attachment difficult	• Rigid extension to stem may improve reach	• Cheaper materials, i.e., stainless steel cable, nylon

		**Strengths**	**Weaknesses**	**Opportunities**	**Threats**
	Head	• Very lightweight • Affordable • Mechanically simple • Will not walk out of restrictions	• Proper placement is more difficult • Only useable in restrictions • Very loud against other metal	• Many other shapes may have greater performance benefits	• Active protection is easier to use
Wild Country Hexcentric $13.99	**Attachment**	• Very durable • Bends around corners easily	• Flexible attachment reduces reach • May close and make attachment difficult	• Semi-rigid “stem” applied to passive protection may drastically improve reach	• Cheaper materials, i.e., stainless steel cable, nylon

		Strengths	Weaknesses	Opportunities	Threats
 CAMP Dyneema Tricam $9924.	**Head**	• Active or passive modes allow versatility • Excellent for horizontal cracks	• Some crucial components (pin & spike) are prone to breaking faster than other components	• Many other shapes may have greater performance benefits	• Standard cams are more versatile • Chocks are more durable
	Attachment	• Very durable • Bends around corners easily	• Flexible attachment reduces reach • May close and make attachment difficult	• Semi-rigid "stem" applied to passive protection may drastically improve reach	• Cheaper materials, i.e., stainless steel cable, nylon

		Strengths	Weaknesses	Opportunities	Threats
 Petzl Ange L $13.95	**Frame**	• Holds attachment in proper axial alignment • Anti-snag release	• Not as comfortable in hand • Wide nose cannot be used in lead ATCs • May be difficult to slip through attachment	• Ergonomic/ anthropometric considerations	• Any other carabiner • Keylocks
	Gate	• Lightweight • Simple manufacturing	• Short opening may make clipping difficult	• Ergonomic/ anthropometric considerations	• Any other carabiner • Keylocks

		Strengths	Weaknesses	Opportunities	Threats
 Wild Country Helium 3.0 $13.95	**Frame**	• Holds attachment in proper axial alignment • Anti-snag release • Comfortable in hand	• Wide nose cannot be used in lead ATCs • May be difficult to slip through attachment	• Ergonomic/ anthropometric considerations	• Any other carabiner • Keylocks
	Gate	• Lightweight • Great clearance for attachments	• Wire opening may snag secondary connectors	• Ergonomic/ anthropometric considerations	• Any other carabiner • Keylocks

		Strengths	Weaknesses	Opportunities	Threats
 DMM Alpha Trad $16.95	**Frame**	• Holds attachment in proper axial alignment • Anti-snag release • Comfortable in hand	• Wide nose cannot be used in lead ATCs • May be difficult to slip through attachment	• Ergonomic/ anthropometric considerations	• Any other carabiner • Keylocks
	Gate	• Lightweight • Great clearance for attachments	• Wire opening may snag secondary connectors	• Ergonomic/ anthropometric considerations	• Any other carabiner • Keylocks

Research Plan

Athlete insights and additional primary research will be gathered through surveys and interviews with climbers and industry professionals. The surveys will be posted on bulletin boards at climbing gyms in Portland, OR and on online communities for climbers. Additionally, climbers who have responded are asked to snowball the survey to others that they know who fulfill the demographic criteria. Travel will also be used for gathering industry insights.

Research Questions

- What are the manufacturing costs associated with trad protection?
- What are the most expensive components/processes

- What are the demographics of those most commonly purchasing cams vs. chocks/nuts?
- What is the design & development process used by industry leaders for climbing hard goods?
- What is the testing & validation process used by industry leaders for climbing hard goods?
- What kinds of innovations are industry leaders pursuing with climbing hard goods? (These devices have been largely unchanged since the 1930s-70s)

Industry Interviews

In seeking answers to the research questions in this section, industry professionals in the climbing product space were interviewed on their experience. Alex Szela, climbing product manager and Colin Hansel, lead climbing industrial designer at Black Diamond were interviewed. Most noteworthy are the industry standards for improvement. The level of innovation that leads to a distinct product being developed is influenced by market competition, specific user needs, or industry manufacturing or materials advancement. It is when there is a significant improvement in performance, such as weight, efficiency, or strength, as a result of one of these influences that an innovation is marketable.

Some innovations are beneficial to the business side of product development, and these are not typically marketed to consumers. Innovations that improve performance are the ones that become new or updated products. While there are a handful of highly specialized use-cases for niche athletes, it is generally preferable to design and develop products with "general use," that are needed by a larger market.

(C, Hansel, personal communication, November 8, 2022 & A, Szela, personal communication, November 22, 2022)

Athlete Insights

Survey

- How often do you climb indoors?
- How often do you climb outdoors?
- Why do you climb?
    - Personal Achievement
    - Fitness
    - Social Interaction
    - Sense of Adventure
    - Competition
    - Other
- How long have you been climbing?

If respondent has interacted with trad protective equipment in a climbing setting:

- How many times have you participated in trad climbing as a belayer?
- How many times have you participated in trad climbing as a leader?
- Where did the trad-specific equipment you have used come from?

  - Personal property
  - Borrowed from a friend
  - Rented
  - Included with a class
  - Included with a guide service
- What types of trad protection have you used?
- If you have used multiple types of trad protection, which is your favorite?
- Why is the answer to the previous question your favorite?
- Is there anything you dislike about that type of protection?
- What was the hardest part about trad climbing for the first time?
  - Cost of equipment
  - Finding a location to trad climb
  - Finding a partner to trad climb with
  - Learning the required skills
  - Mental block/discomfort
  - Other
- Rate how comfortable you feel leading a trad climb (1-5)

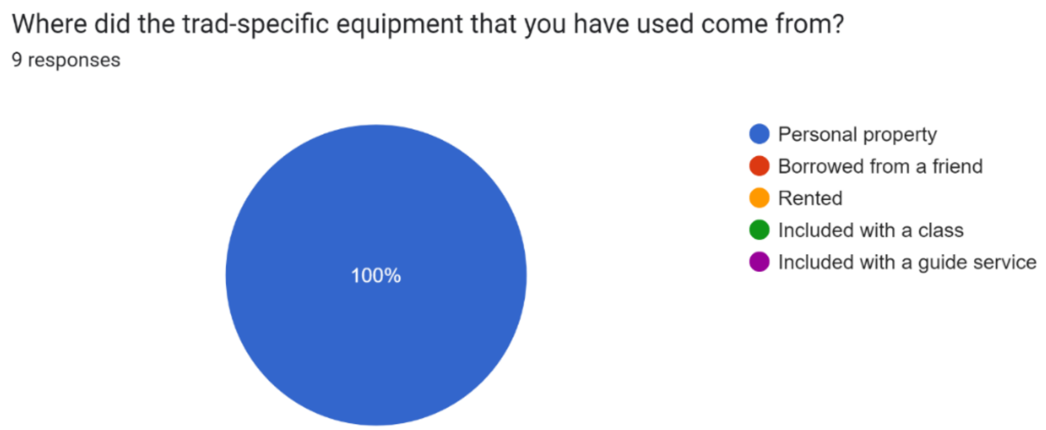
If respondent has ***not*** *interacted with trad protective equipment in a climbing setting*

- How many times have you participated in sport climbing as a belayer?
- How many times have you participated in sport climbing as a leader?
- Would you like to try trad climbing?
  - If yes, what is the largest barrier you face right now?
    - Cost of equipment
    - Finding a location to trad climb
    - Finding a partner to trad climb with
    - Learning the required skills
    - Mental block/discomfort
    - Other
  - If no, why?
- Rate how comfortable you think you would feel leading a trad climbing (1-5)

Notable Responses

Figure 15

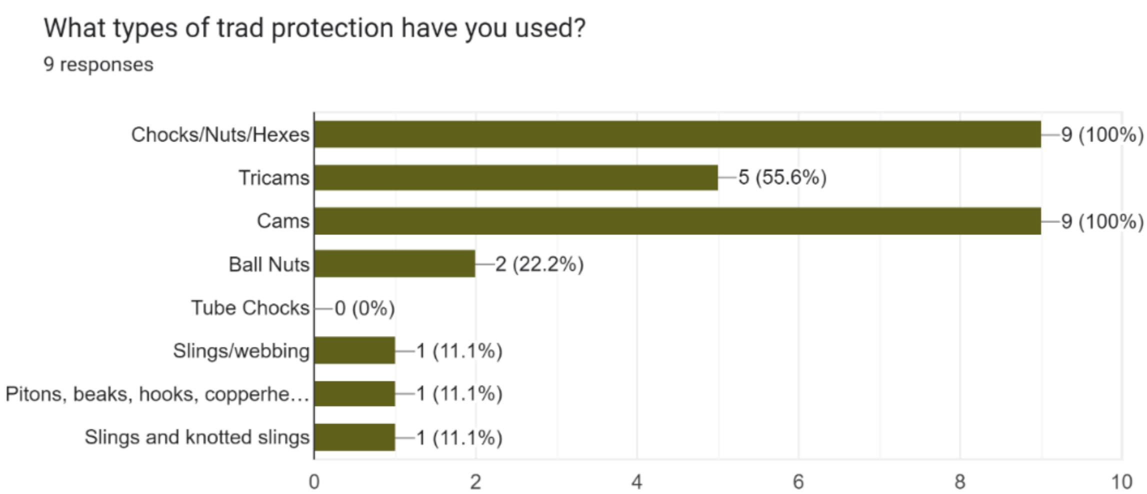
Equipment sourcing



Note. All surveyed users acquired their own equipment with their own money in order to participate in trad climbing.

Figure 16

Protection use



Note. Users have equal exposure to chocks, nuts, and hexes as cams despite most users preferring cams. Users receive more than half as much exposure to tricams, despite only one company manufacturing tricams.

Figure 17

Favorite protection

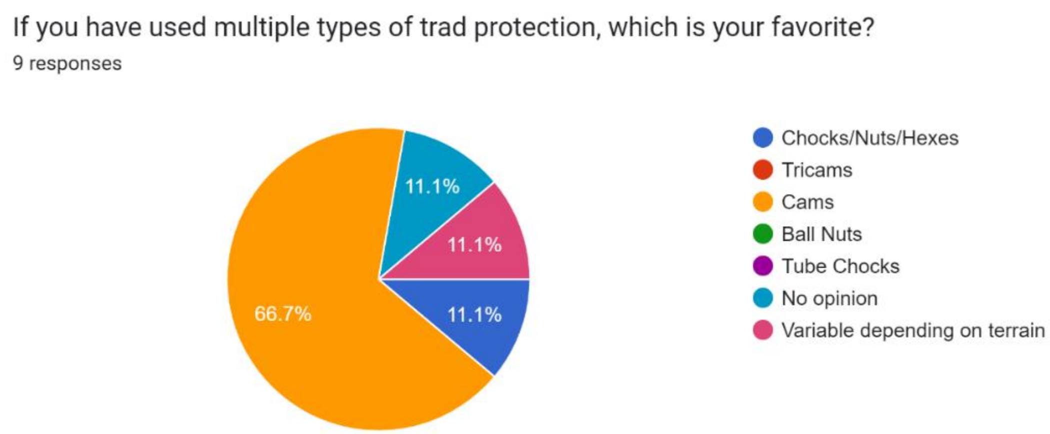


Table 2

Favorite protection likes and dislikes

Protection	Likes	Dislikes
Cams (8/12)	• Versatility • **Ease of placement (4x)** • Ease of removal (2x) • Adjusts to movement • Placement evaluation • Size range • Feeling of security (2x)	• **Weight (4x)** • Limited range • **Cost (3x)** • Walking (2x) • Many parts to break (2x) • Security at small sizes • Harness space real estate • Difficult placement • Size evaluation
Chocks/Nuts/Hexes (2/12)	• Lightweight • No moving parts • Feeling of security	• Difficult placement • Difficult removal • Lack of versatility
No Preference (2/12)		

Note. The primary concerns and needs of users were found to be about weight, cost, and ease of use.

Interview Questions

The following follow-up questions will be asked to survey respondents who are willing to continue providing insight into their climbing experience.

- What is the biggest problem you face when using trad protection?
- If you could imagine a perfect piece of protection, what does it do?
- What lead you to purchase the trad protection that you did?
- What would your reaction be to a new type of protection that entered the market that wasn’t a cam, tricam, or chock?

Initial Travel Plan

Activity	Location	Date(s)	Estimated Costs
Outdoor Retailer Snow Show, Black Diamond See innovations & get samples	Salt Palace Convention Center, 100 S W Temple St, Salt Lake City, Utah 84101	Jan 10-12, 2023	[Public Transit: $45x2/ Carpool Gas: ~$176x2] Hotel: ~$80/Night (~$160) Food: ~$25/day (~$50)
Black Diamond HQ, Alex Szela (Product manager- Climb Unit) Talk with industry leaders & tour facilities	2092 East 3900 South Salt Lake City, Utah 84124	Jan 13, 2023	Hotel: ~$80/Night (~$80) Food: ~$25/day (~$25) Uber: ~$45x2
Testing Photography	Smith Rock State Park, Terrebonne, OR 97760	Jan 21, 2023	[Uber: $300x2/ Carpool Gas: ~$31x2]
			Total: Up to $1,382 Minimum: $582

Testing Plan

The focus areas for testing are **versatility**, **user experience**, **comfort**, and **dexterity**. Subjects for testing will be individuals aged 18-35 with experience or understanding of lead climbing and trad protection. Metrics to beat will be versatility of placement options, subjective satisfaction for the user experience, comfort in hand and in use, and time and effort required to properly place the protection.

Step	Desired Information	Method	Time
Product Appearance	Subjects will be asked their initial impressions on aesthetic, tactile sensation, complexity, and reliability	• Questionnaire (Scale 1-10) • Interview	5 minutes
Product Comfort	Subjects will hold and manipulate samples and be asked if there any noticeable uncomfortable elements	• Questionnaire (Scale 1-10) • Photos • Interview	5 minutes
Product Dexterity	Subjects will be asked to properly place equipment in a simulated rock feature from a variety of positions relative to the feature • Subjects will be asked their thoughts on the interaction	• Questionnaire (Scale 1-10) • Photos • Interview	15 minutes
Product Versatility	Samples will be placed in different shaped cracks in a simulated rock	• Videos/photos	20 minutes

	feature and subject to cyclic loading with standardized weight		

Testing Methods

Video Analysis
User interaction with the products and adaptation to using the products will be recorded and analyzed for problem areas.

Questionnaires/Interviews
Subjects will be asked their thoughts on specific factors related to the appearance and use of the samples that is not easily understandable through observation alone.

Cyclic Loading
Cyclic loading is the application of repeated stresses. A standardized weight (100lb) will be dropped a standardized height (5 ft) while attached to the protection samples placed in different shaped simulated cracks made of molded concrete. This simulates taking repeated falls on a piece of protection while climbing.

Figure 18.
Crack test apparatus

Note. This custom apparatus features a 1.5" width vertical parallel crack, a 1.5" to 0.5" vertical restriction, a 0.5" to 1.5" vertical reverse restriction, and a 1.5" width horizontal crack. All simulated features are of 3" depth. This device will feature in product dexterity and product versatility testing of benchmark and prototype samples.

Testing Analysis

Video Analysis: For initial impressions, instinctual tendencies towards how to hold each sample will be recorded and broken down into most and least touched components and most common hand positions. For dexterity tasks, the total time and time spent on each aspect of prehension (reaching & placement) will be compared across samples. Follow up interviews will help discern what components were easy, difficult, enjoyable, or unsatisfactory to use. This will help inform changes to make to the designs.

Questionnaires: Subjective thoughts on comfort, tactile satisfaction, and aesthetics will be compiled and organized into categories, then ranked from most common to least common. The most positive elements will be included and explored further, and the most negative elements will be revised.

Cyclic Loading: During and after each drop, the placement of the protection will be recorded for observation of any shifting. Excessive movement from the protection’s original placement (>1 inch) will indicate unstable placement. Ejection of the device from a crack will indicate catastrophic failure. Number of drops will be recorded to failure. Recordings of the moment of failure will be observed for factors that may have influenced instability for re-design.

Mentorship

Florian Traulle is an R&D innovation lead at Salomon's design lab in Annecy, France. He has connections to UK based companies which operate directly in the climbing space and has worked with mountaineering athletes for projects with Salomon.

Michael Orlow <mjorlow@gmail.com> 3:06 AM (17 hours ago)
to florian.traulle@salomon.com

Hi Florian,

I just wanted to follow up and ask if you would be willing to follow along with my thesis project yourself as a mentor? I know that you don't work with climbing hardgoods, but I believe that your experience regarding R&D and innovation would be really valuable considering that the objective of our thesis project is R&D, and we could learn about the climbing product space together if that would be of interest to you.

This would involve meeting once a month to update you on what I'm working on and talk through things, thesis or otherwise, as I would like to keep in contact with you.

If you have any questions about mentoring or my project, please let me know. I would really appreciate your help with this, and I hope that I can be helpful to you too.

Thank you again,
Michael Orlow

Traulle, Florian 3:36 AM (17 hours ago)
to me

Hi Michael,

I'm touched by your confidence. It's a YES, let's learn together !
I can be available one's a month to follow you, can you tell me if we need to be under contract with the Company and the University ?

My understanding of climbing hardgoods starts with clean climbing statement from YVON CHOUINARD.

- I'm friend from the CEO of Chamonix brand BLUE ICE, you can watch what they are doing on line.
- Working with Kilian Jornet on his insulative one piece to summit Everest put me in a search of lightness and simplicity.
- Today working in group with ARCTERYX gives me a vision on finishes and how much strong and durable the products have to be.
- I participated to a study 3 years ago about sportstyle in Europeans cities, it shows that wall climbing became trendy in many places.

I hope you enjoyed the trip and time together.
Let's start the journey !

SALOMON

Florian Traullé

Special mentions to:

- Alex Szela (Climbing product manager at Black Diamond)
- Colin Hansel (Lead industrial designer for climbing hardgoods at Black Diamond)
- Scott Peterson (Repair tech and U.S. representative with Totem Cams)
- Tim Toliver (CNC machinist at Metolius)

who were unavailable to commit to a mentorship role but were willing to be interviewed on their respective companies and their experience in the climbing product space.

Testing Data Presentation

The following presentation was given on March 17. 2023 to a panel of sports industry professionals.

Figure 19.

Title Slide

Note. An updated concept for branding. A roman Doric style column has been paired with the name “Monolith Climbing” to represent singular strength of each individual piece of equipment. The term “monolith” in climbing refers to a natural feature which is so sturdy that it can safely be the only thing that a climber is attached to. The column logo has been constructed out of evenly spaced squares and paired with vertical text to evoke solidity and consistency.

Figure 20.

Personal Introduction

Note. A simplified version of my golden circle as it broadly applies to my career goals.

Figure 21.

Climbing Rack

Note. A visual representation of the equipment that a climber would be carrying on a trad route, with estimated cost of entry. Depending on the environment, type of rock, and specific route, a climber may choose to carry more or fewer of a particular type of protection and/or duplicates of a particular size of protection. Variation in estimated cost can be a result of this difference in number, or cost may vary between brands due to manufacturing methods, extra features, or materials. This list does not account for specialized versions of stoppers or cams like offset variants.

Figure 22.

Why?

Note. A simplified rationalization for the need for this project, as explained earlier in this paper.

Figure 23.

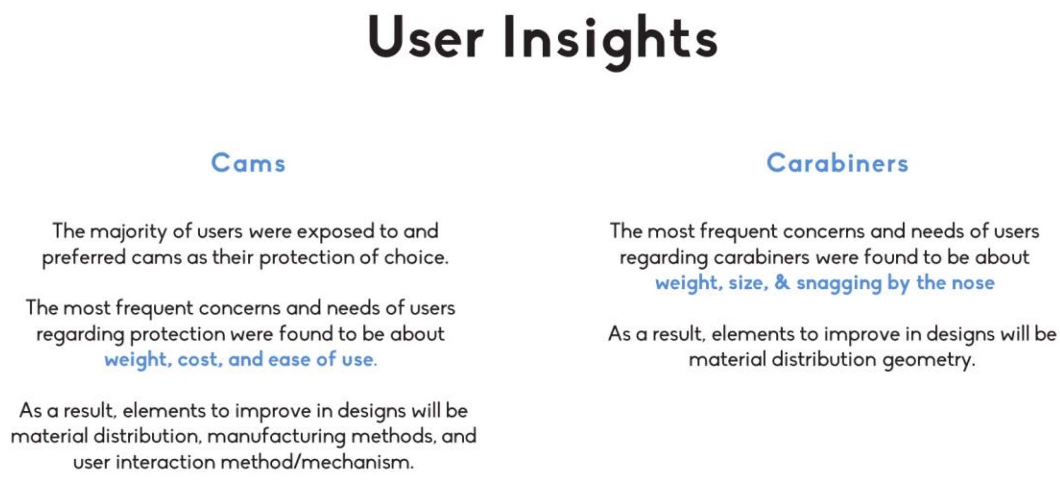
Problem Statement

How could we design **more affordable to manufacture** trad climbing equipment that **performs as well as and is safer** than current options for intermediate, recreational climbers who want to trad climb?

Note. The problem statement for this project repeated with emphasized elements.

Figure 24.

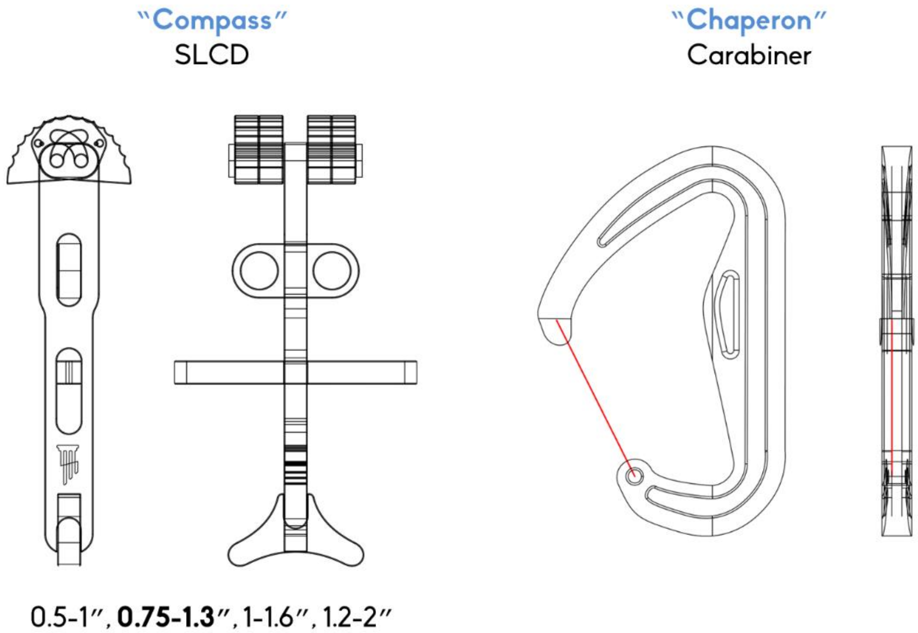
User Insights Summary



Note. A summary of important takeaways from the results of surveying local athletes. This informs some functional components of each product area to focus on in order to solve problems that athletes are consciously facing.

Figure 25.

Tech Flats



Note. Skeletonized views of the designs of each product as of March 17, 2023. These communicate the construction of the hard components in orthographic views, as designed in Rhino 3D. The working name for the SLCD is "compass," in reference to the function of a compass being that it helps the user tell where to go. In the case of an SLCD, it is orientated facing upwards, as one would climb. The working name for the carabiner is "chaperon," in reference to the role of a chaperon being to supervise and keep people out of trouble. In the case of this carabiner design, the added features help to keep a climber out of trouble.

Figure 26.

Testing Goals

Testing Goals

Protection

1. Match or improve time to place, evaluate, & remove as compared with baseline products
2. Weight reduction of at least 10% (0.23 oz) as compared to lightest baseline product
3. Eliminate need for extra carabiners & slings from cost
4. Reduce estimated manufacturing and sales costs by at least 30% compared to baseline products

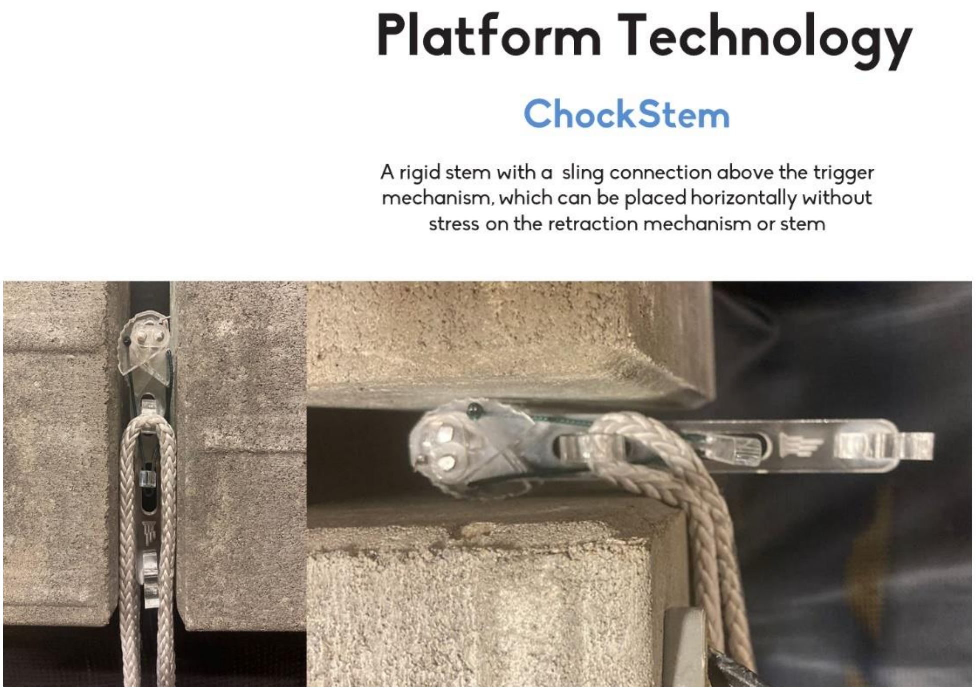
Carabiner

1. Discourage cross-loading without the need for extra gates/hardware on the frame

Note. An outline of the specific metrics to match or beat when testing works-like prototypes against baseline products. Goals without an associated measurable number value operate on a pass/fail binary.

Figure 27.

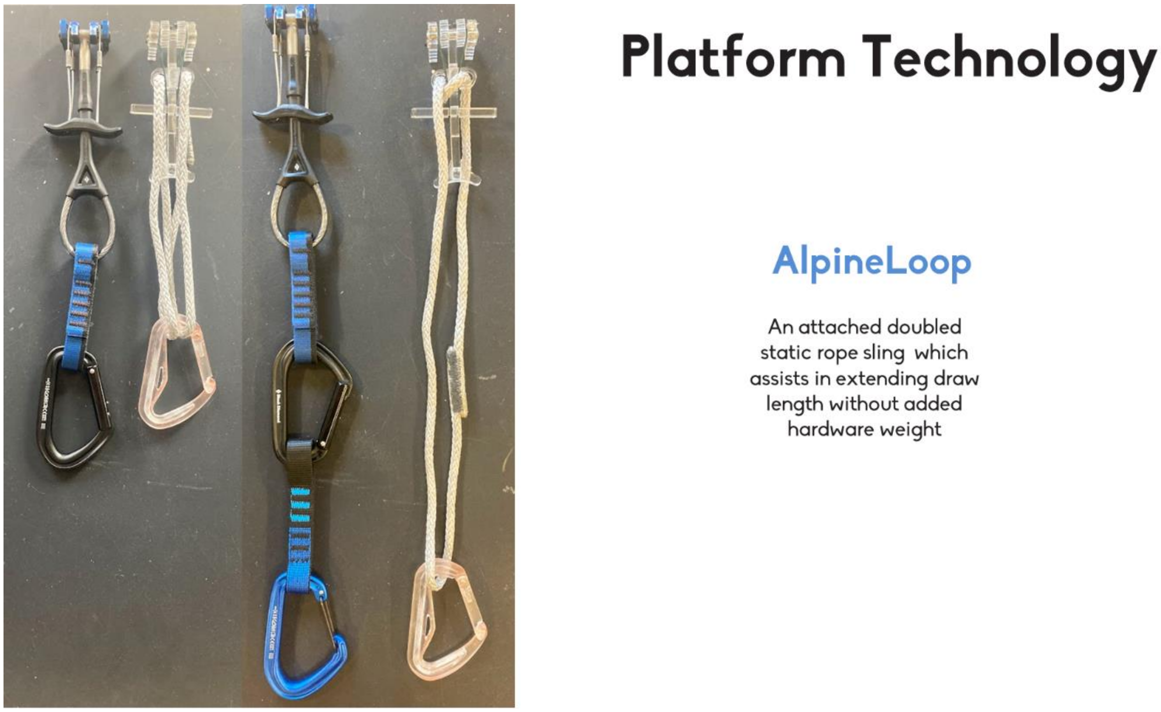
ChockStem



Note. A platform technology developed to help accomplish the testing goals. ChockStem refers to the placement of a static UHMWPE rope sling above the trigger mechanism and directly below the cam lobes on an SLCD. The name "ChockStem" is derived from the fact that chocks (stoppers, hexes, etc.) have their connector (either a twisted steel rope or a UHMWPE webbing sling) attached directly to the wedge component that is placed into a crack. SLCDs typically have their connector attached to the very bottom of the device, below the trigger mechanism. The conventional construction often causes the sling to interfere with the part of the SLCD stem that the user needs to hold to operate the device. The ChockStem sling attachment point keeps the sling out of the way of where the user needs to hold the device, as well as allows the sling movement to be independent from the stem movement.

Figure 28.

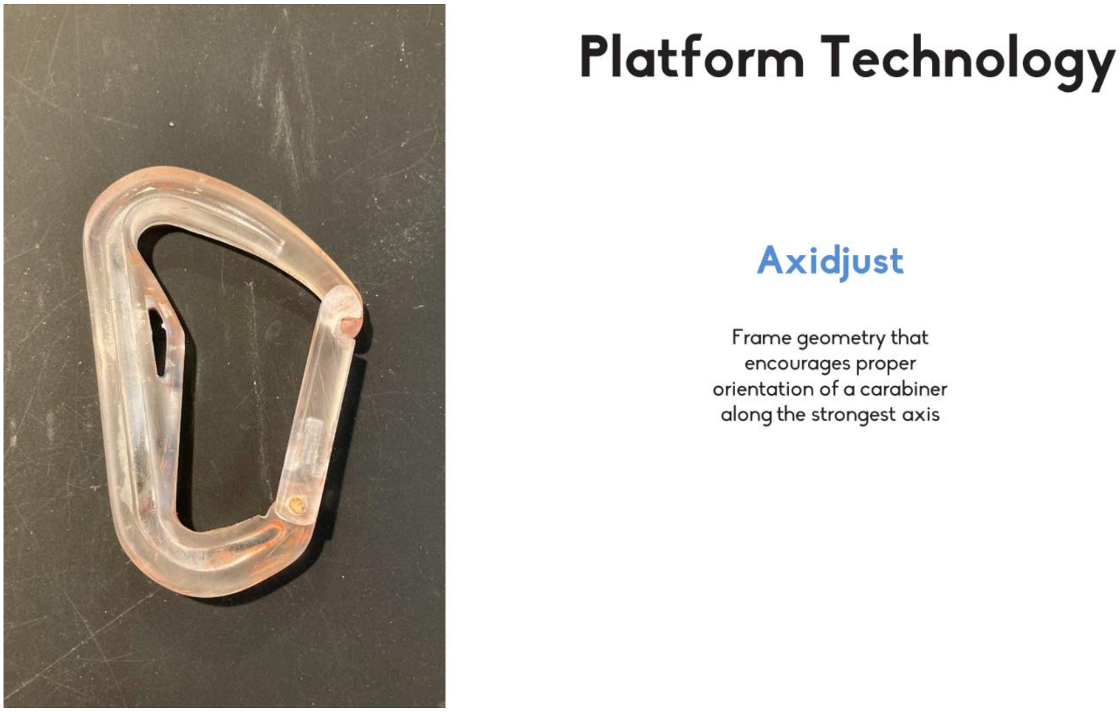
Alpine Loop



Note. A platform technology developed to help accomplish the testing goals. AlpineLoop refers to a UHMWPE static rope that is doubled over at its attachment point to the SLCD. The name “AlpineLoop” is derived from a commonly used piece of equipment in climbing called an “alpine quickdraw,” which is a webbing sling that is folded into three loops and has a carabiner attached to either end. Both an alpine quickdraw and AlpineLoop can be extended by fully drawing out one of the loops, causing the rest of the stored loops to contract. By pairing ChockStem and AlpineLoop, the sling can extend to match the length of a quickdraw attached to a conventional SLCD. As a result, fewer quickdraws need to be carried to accomplish the same sling extension, reducing the weight carried by the user for every extra carabiner removed.

Figure 29.

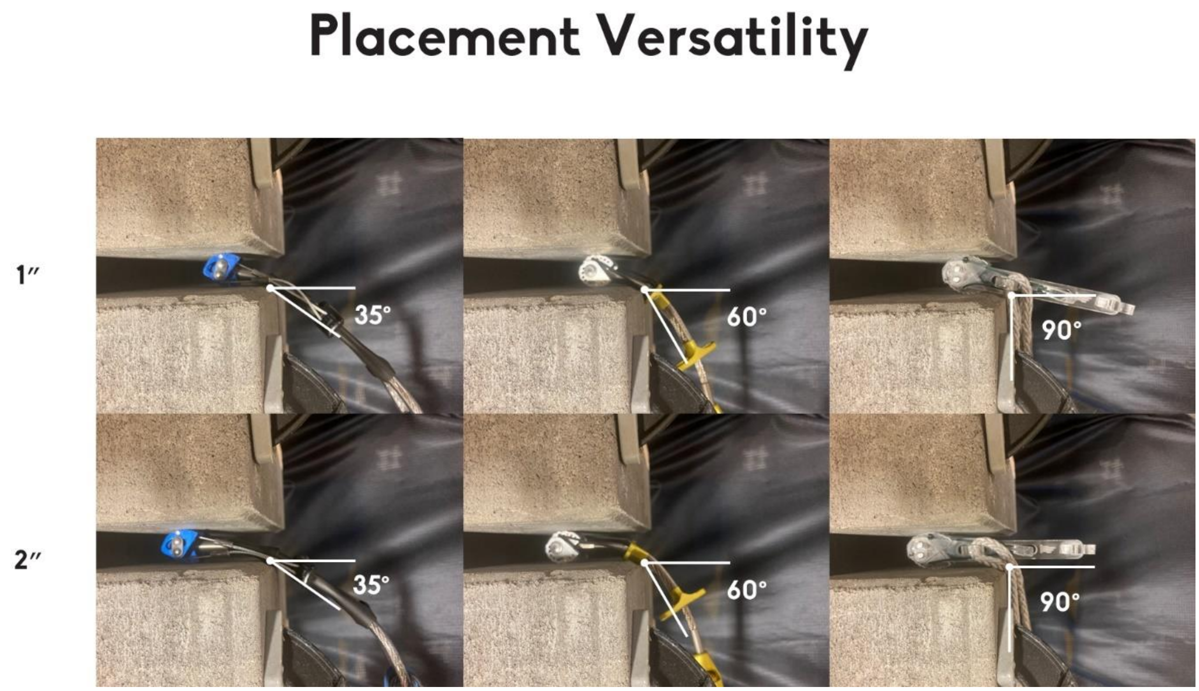
Axidjust



Note. A platform technology developed to help accomplish the testing goals. Axidjust refers to a fin shaped protrusion added to the interior of the frame of a carabiner. This extra geometry significantly decreases the possibility of a carabiner ending up in or staying in a horizontal orientation necessary for the device to be cross loaded. The name “Axidjust” is derived from a portmanteau of the words “axis” and “adjust,” because the carabiner will move in response be being loaded on its horizontal axis where it’s weakest, in order to achieve loading on its vertical axis where it’s strongest.

Figure 30.

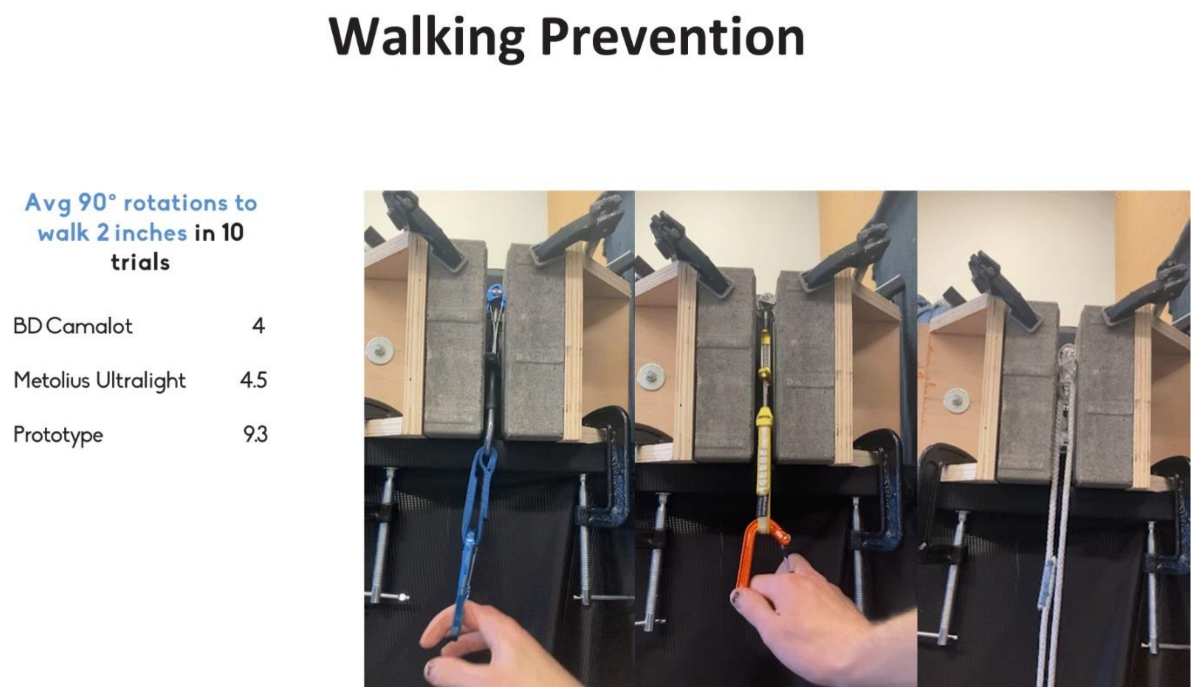
ChockStem in action



Note. A representation of the baseline products alongside the works-like prototype of the "compass" SLCD being placed in a simulated horizontal crack. The baseline products each have a limit to the angle that their semi-rigid stems can bend to before there is risk of damage to parts of the stem or disengagement of the cam lobes from the surface of the crack. The works-like prototype can freely extend over and around edges due to the sling that operates separately from the stem.

Figure 31.

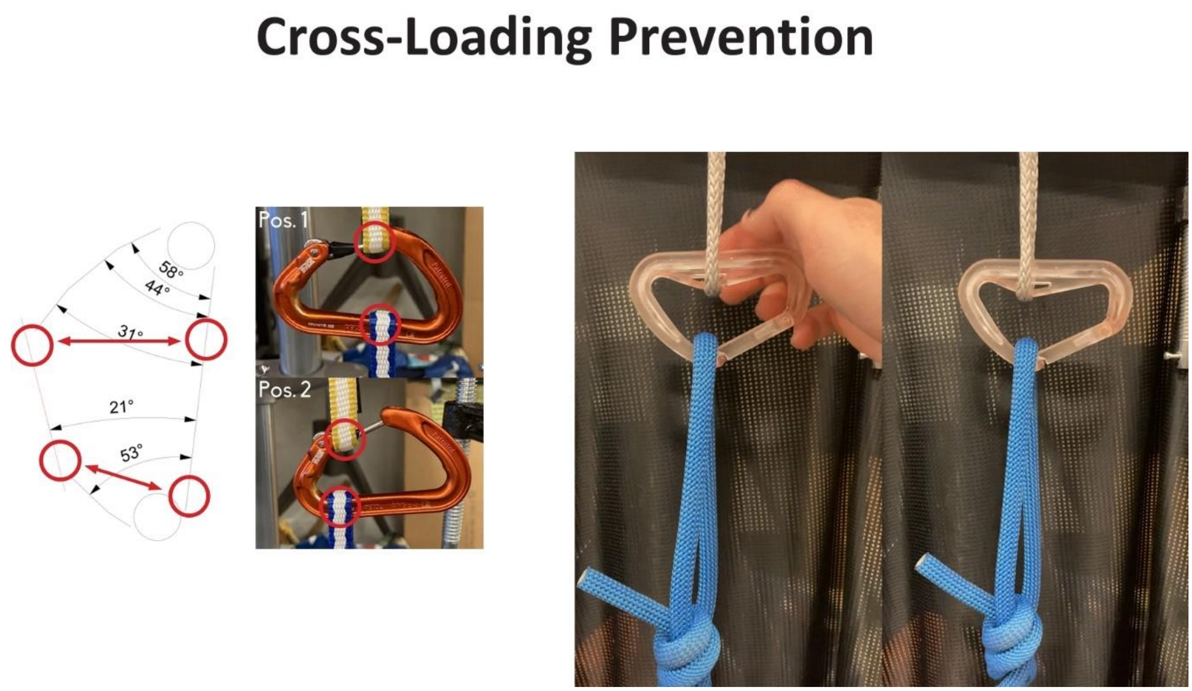
AlpineLoop in action



Note. The works-like prototype of the "compass" SLCD tested against the baseline products for walking prevention. Walking is a phenomenon that can occur when an SLCD wiggles forwards and backwards, causing the device to move up or further into a crack. This is more prevalent in cracks that widen above the device. The works-like prototype took twice as many wiggles (bringing the device fully extended to 90°, or perpendicular to the simulated crack, and then back to 0°, or parallel to the simulated crack) to cause it to walk 2" up the crack that it was placed in. The full extension of the AlpineLoop greatly reduces the likelihood of the rigid components of the works-like prototype from moving.

Figure 32.

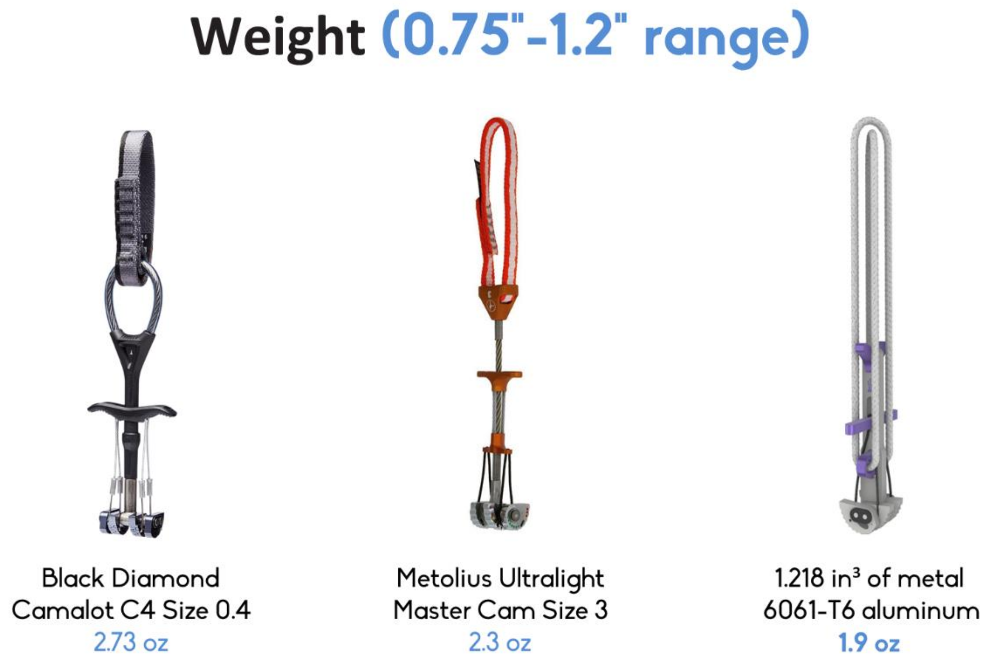
Axidjust in action



Note. The works-like prototype of the "chaperon" carabiner tested for cross loading prevention. An analysis of the Petzl Ange carabiner was conducted to show the positions that carabiners are frequently able to become stuck in a cross loaded orientation. Conversely, the "chaperon" carabiner prototype when tested was unable to be left in those or other positions without re-orienting itself into proper alignment.

Figure 33.

Weight Comparison



Note. The minimum and maximum width that an SLCDs lobes can be properly placed in constitute its range. The brands which manufacture the baseline products that were tested each have an SLCD unit whose range is comparably to the works-like prototype of the “compass” SLCD. In Rhino 3D, the volume of the prototype design as of March 17, 2023 was found to be 1.218 in^3, which in solid 6061-T6 aluminum is 0.4 oz less than the lightest comparable baseline.

Figure 34.

User Feedback Summary

User Testing/Feedback

"Feels solid in hand, but **nimble and easy to manipulate**"

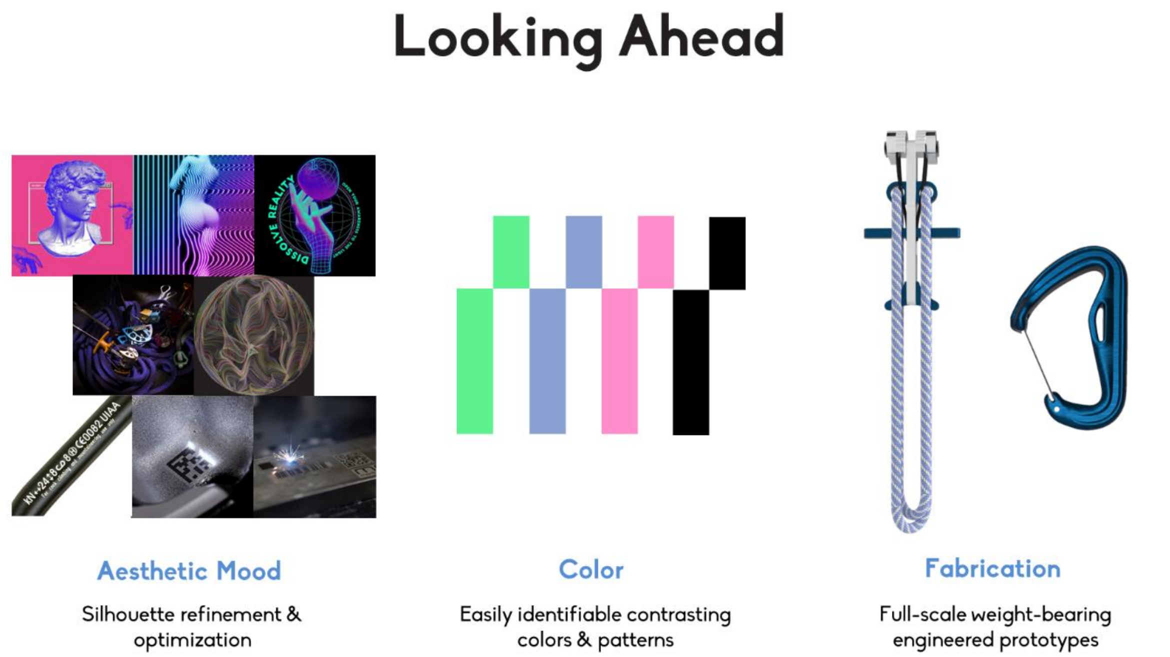
"**Easier to place** without the sling in the way"

No slower to place and remove than baseline ±1 second

Note. A summary of notable responses from athletes surveyed and tested interacting with the "compass" SLCD works-like prototype.

Figure 35.

Looking Ahead



Note. Plans for the Spring term of this project, including a focus on aesthetic direction, use of color for communicating with the user, and metals fabrication methods.

Figure 36.

Cost Analysis

Cost Analysis

Competitor Estimate (BD/Metolius)

Machine operator pay:	$3,190/month ($19.14/hr)
6061al 1/4" x 1x 2':	$68.74 (18 pc/sheet)
6061al 3/4" x 1x 2':	$268.66 (144 pc/sheet)
3-Axis CNC Machining:	$7,000/month ($40/hr)
Welding/Brazing:	$4,375/month ($25.00/hr)

1,500 cams/month

$15.40/unit
MSRP: $79.95

Prototype Estimate

Machine operator pay:	$3,190/month ($19.14/hr)
6061 aluminum 1/4" x 1x 2':	$68.74 (26 units/sheet)
Low End Waterjet Cutting:	$2,626/month ($15/hr)
or	
High End Waterjet Cutting:	$5,250/month ($30/hr)

1,500 cams/month

$6.52 or 8.27/unit
MSRP: $33.85 or $42.95
57.7 or 46.3% decrease

Note. A summary of estimated costs associated with the baseline SLCDs tested based on information available online and from interviews with relevant industry professionals who operate in the climbing protection product space, as compared with the estimated costs of alternative manufacturing of the “compass” SLCD in order to drastically reduce end cost to users.

In-Person User Feedback

User	Product	Notes

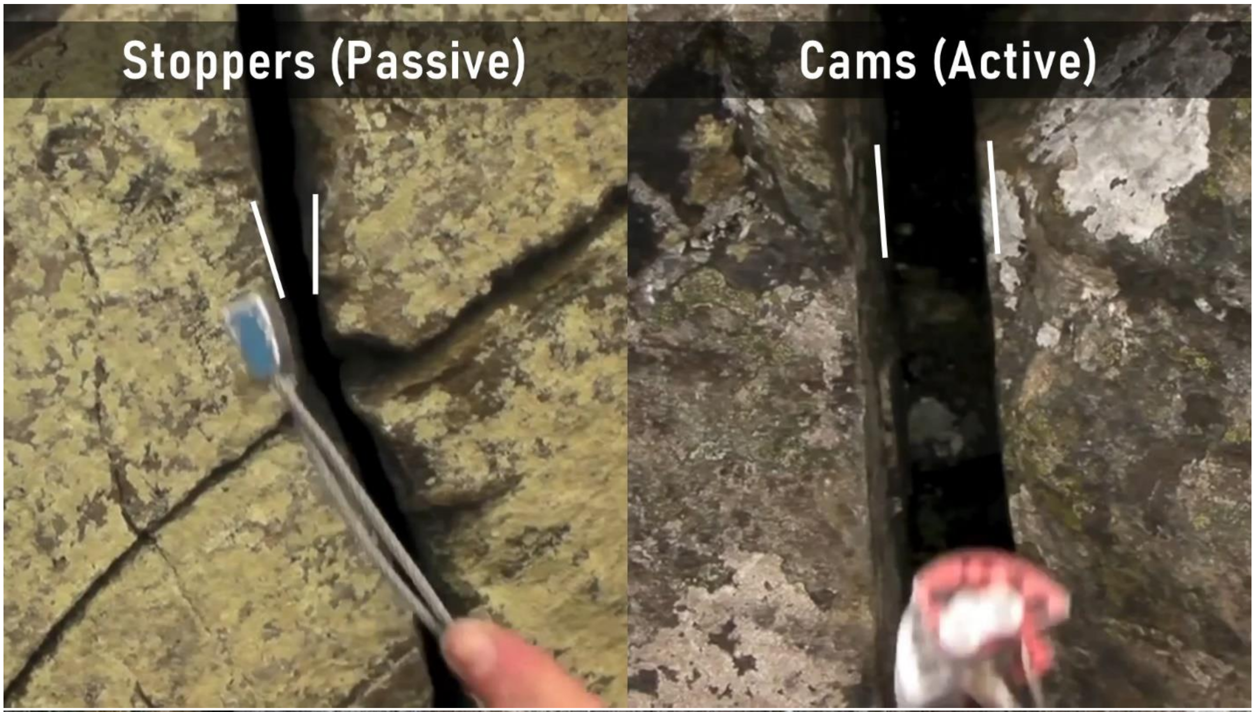
Makena (Female, 26) 3/9/23	BD Camalot	• Hesitancy over plastic components
		    ○ Feels cheaper
		• Cam assembly moderately complex
		• Preference for placing at eye level and from below
		    ○ Difficult to see from above
		• Liked spring action

	Metolius Ultralight	• Dislike initial appearance, fit in hand, & trigger size • Liked full metal construction ○ Feeling of security • Liked wide thumb rest • Angled edge of thumb rest digs into hand when placing • Stem movement made placement somewhat difficult
	Totem	• N/A
	Wild Country Helium	• A little bit too big in hand • Spring sound is appealing • Wiregate perceived as less strong
	Petzl Ange	• Small size good for fit in hand • Easy to grab single wire gate • Not enough gate clearance • Preferred pinching nose • Easy to clip into
	Petzl Spirit	• N/A
	CAMP Dyon	• N/A
	Proto Cam	• Short, solid stem is easy to manipulate and place with • Desire for no side-to-side movement of trigger ○ Concern over pinching finger between components • No components below trigger makes placement easier • Deeper placement made somewhat difficult by trigger movement • When placing from below, hanging sling can block line of sight with cams
	Proto Carabiner	• Unclear purpose of frame shape without being told • Size fills hand, solid and easy to manipulate • Solid gate feels stronger

Robert (Male, 29) 4/11/23	BD Camalot	• Used due to cost & exposure • Like spring action • Want extendable sling • Small head easy to place in smaller cracks • Softer lobes good on sandstone, granite, quartzite equally
	Metolius Ultralight	• Likes size range indicator
	Totem	• Likes fit in narrower, unique cracks that others cannot
	Wild Country Helium	• Color variation • Gate clearance good • No snagging good
	Petzl Ange	• Smaller carabiner keeps racked equipment more compact • Small gate clearance sometimes annoying • No snagging good
	Petzl Spirit	• Anti snagging good • Primarily used on sport climbing for bolt interaction • Heavier
	CAMP Dyon	•
	Proto Cam	• Sling attachment interesting • When taking off harness, concern over interaction with sling getting in the way ○ Action of putting cam in hand from holding carabiner odd with lightweight plastic • Extended sling catches on trigger and thumb rest currently • Considering how cam lays and moves on harness when climbing • Like horizontal placement and weight in sling for anchor building
	Proto Carabiner	• Like anti-cross-loading ○ Traverse use case ○ Ideally locking in some way

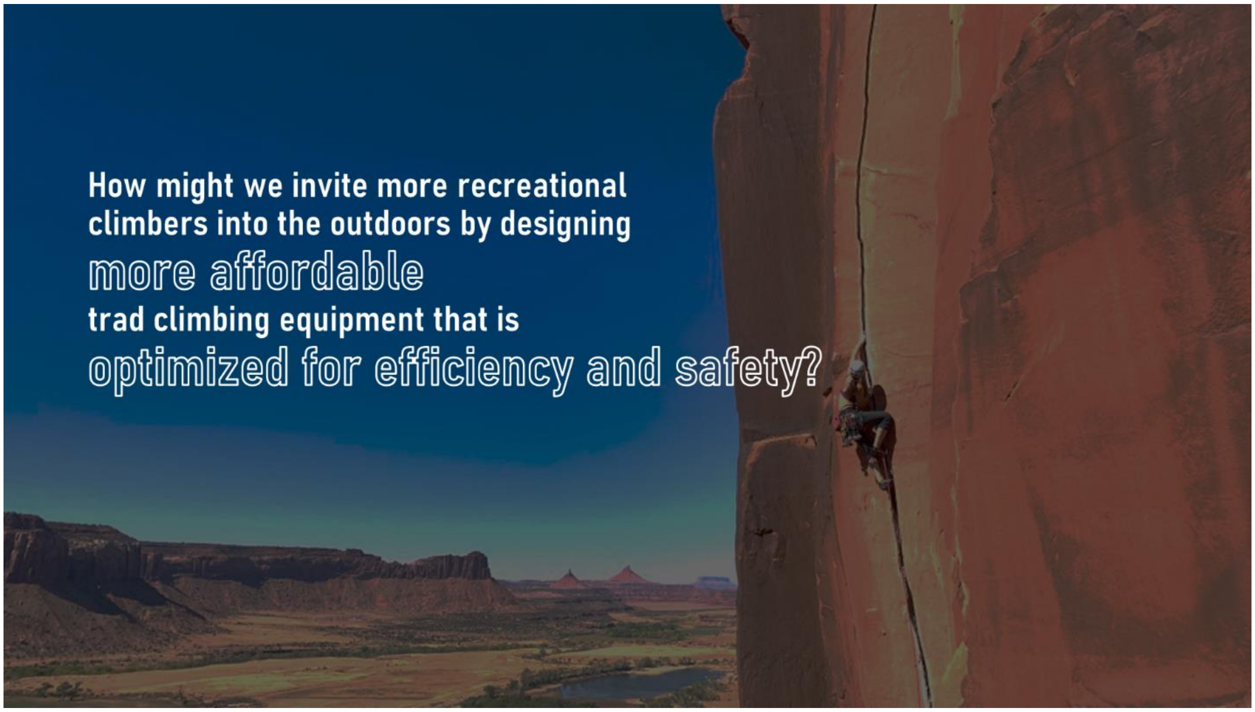
Final Presentation

The following presentation was given on June 12. 2023 to a panel of sports industry professionals.


Stoppers (Passive)
Cams (Active)

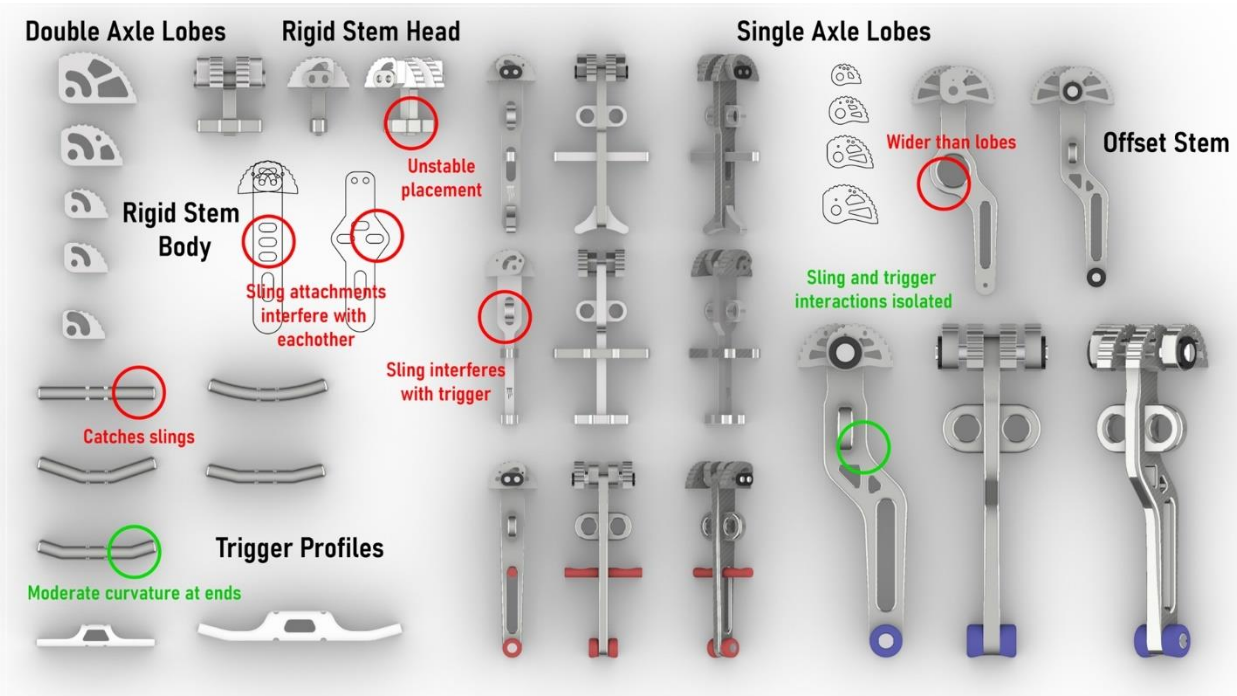

10 Stoppers
$15-25/pc
($150-$250)
5-10 Cams
$70-$90/pc
($350-$900)
20-25 Carabiners
$10-$13/pc
($200-$325)
5-10 Quickdraws
$17-20/pc
($85-$200)
Total
$785-$1,675

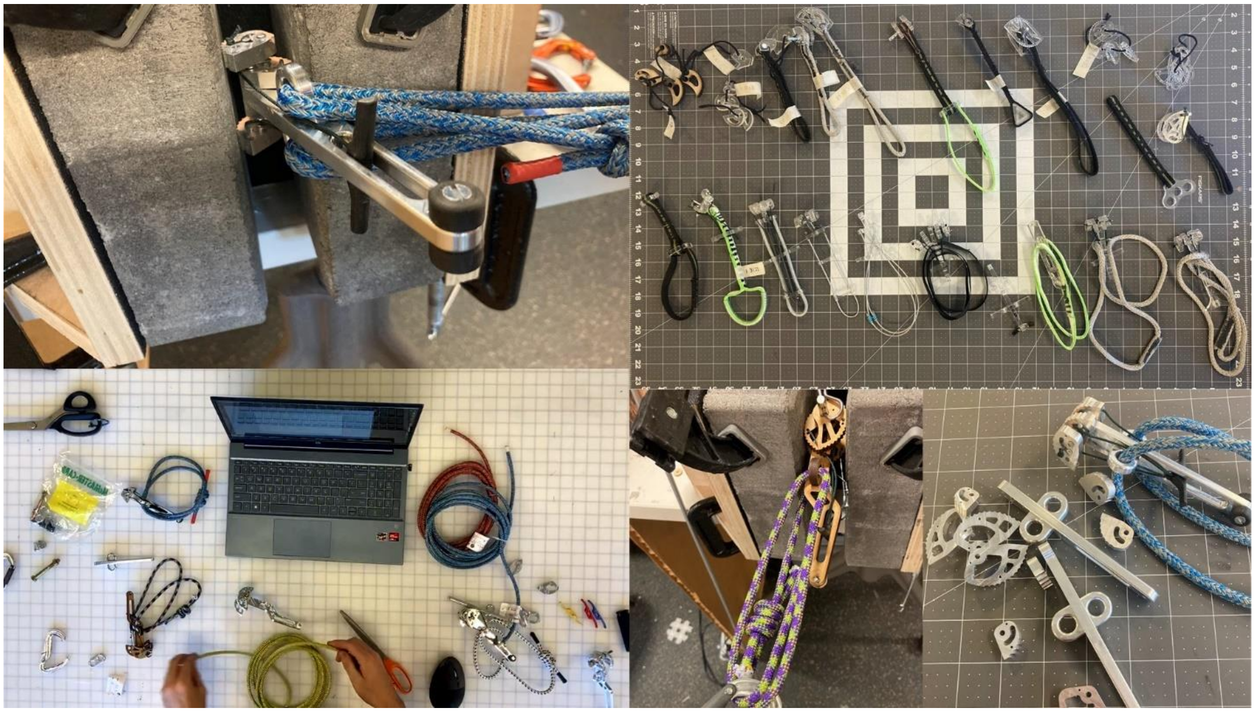

Athlete Survey
Preferred Equipment
2
11
Cams
Nuts

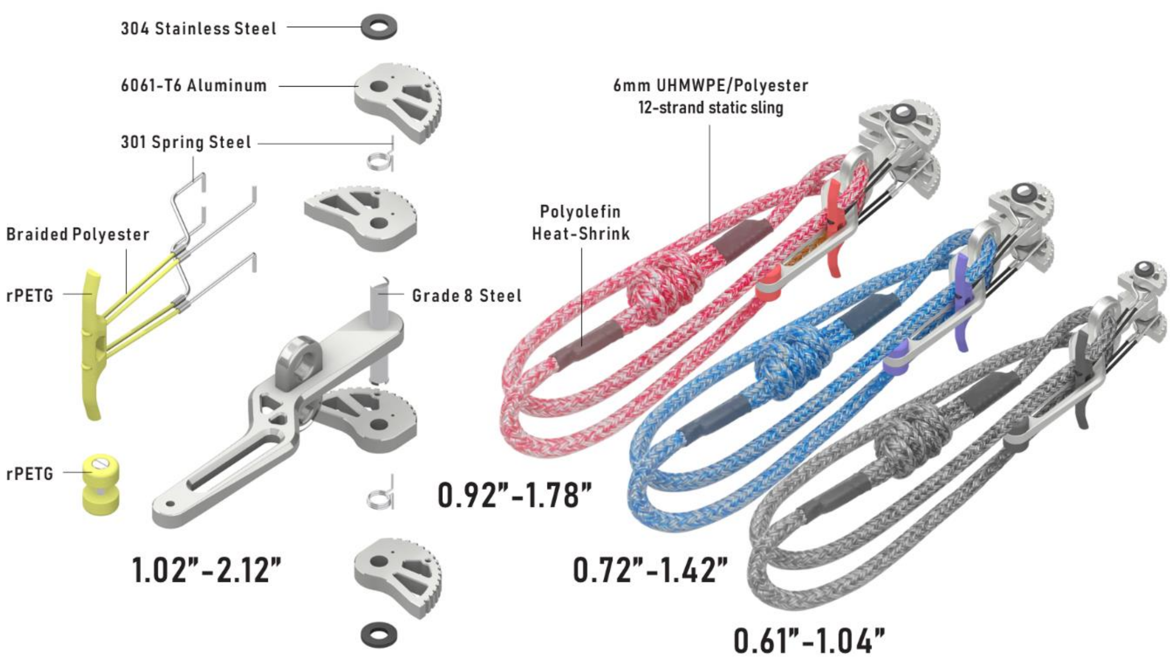

How might we invite more recreational
climbers into the outdoors by designing
more affordable
trad climbing equipment that is
optimized for efficiency and safety?

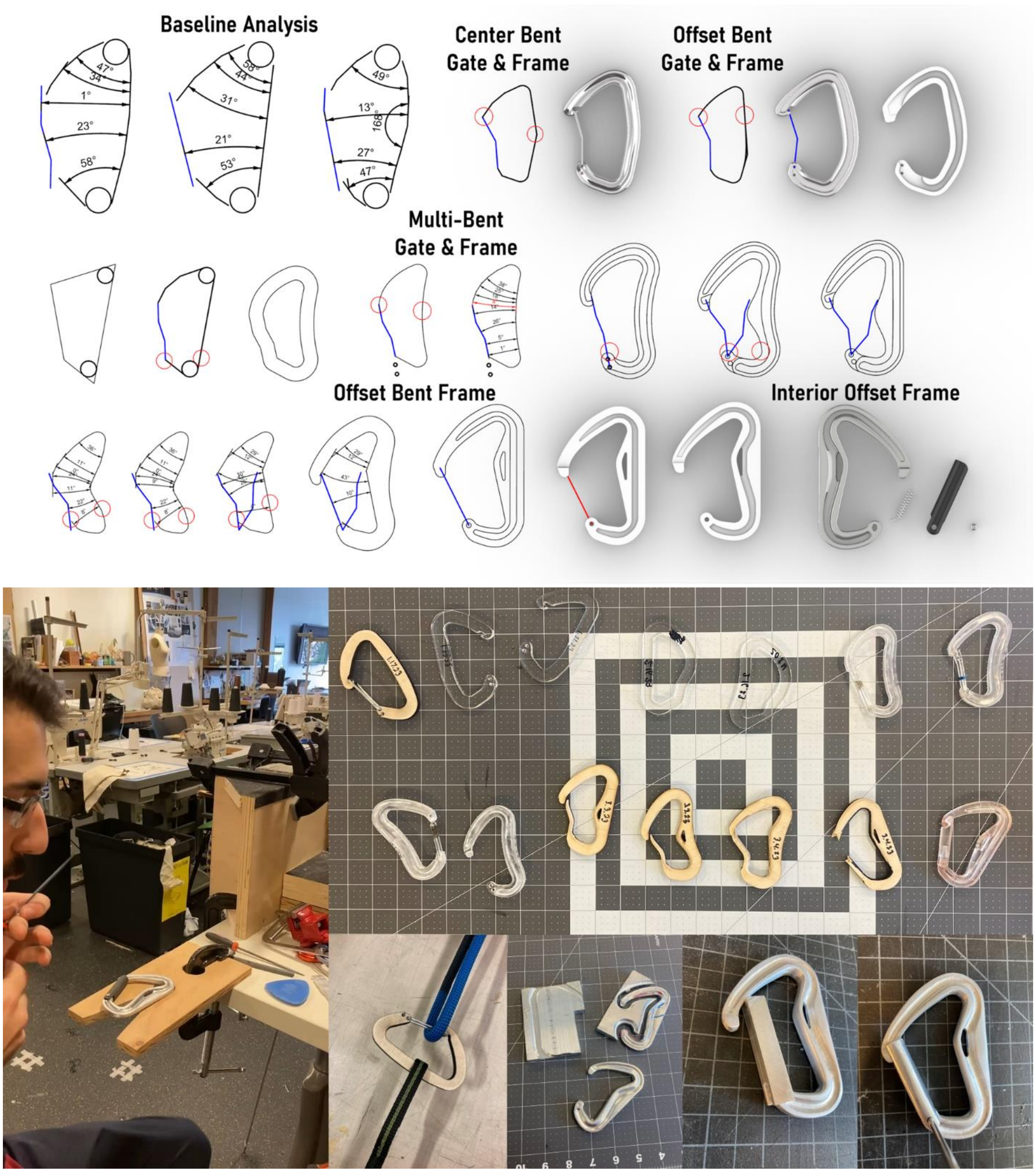

Versatility
Efficiency
Safety
Fit in a variety of crack shapes
Cut out excess gear and weight
Prevent catastrophic failure scenarios

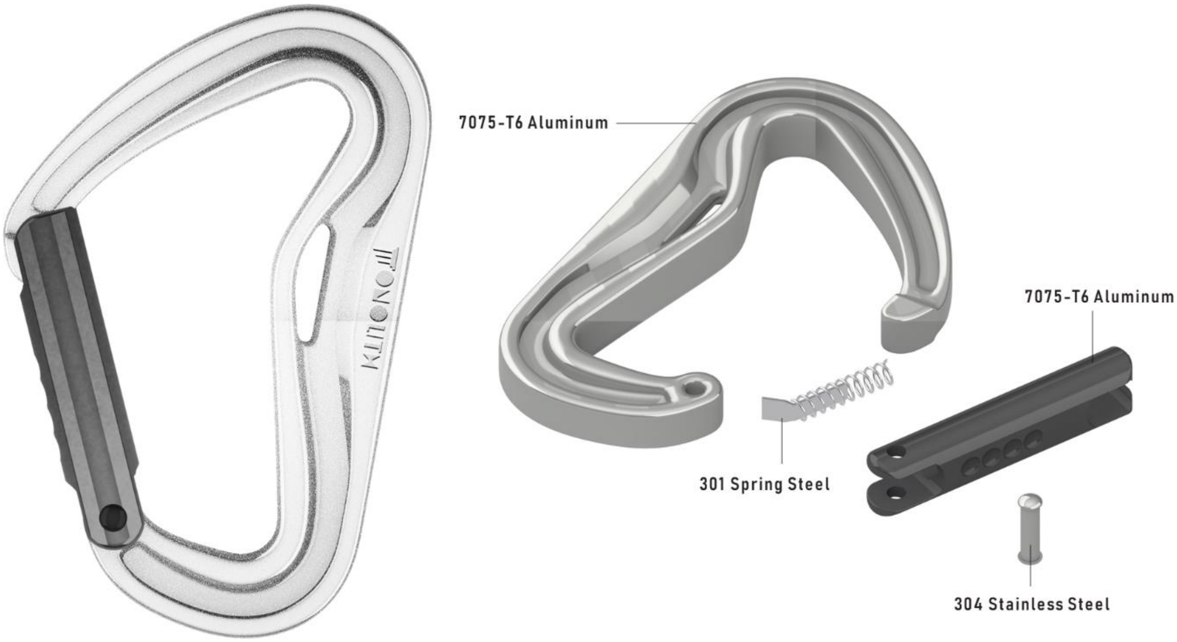

Mood
MOUNTAIN SAFETY RESEARCH
OP-1

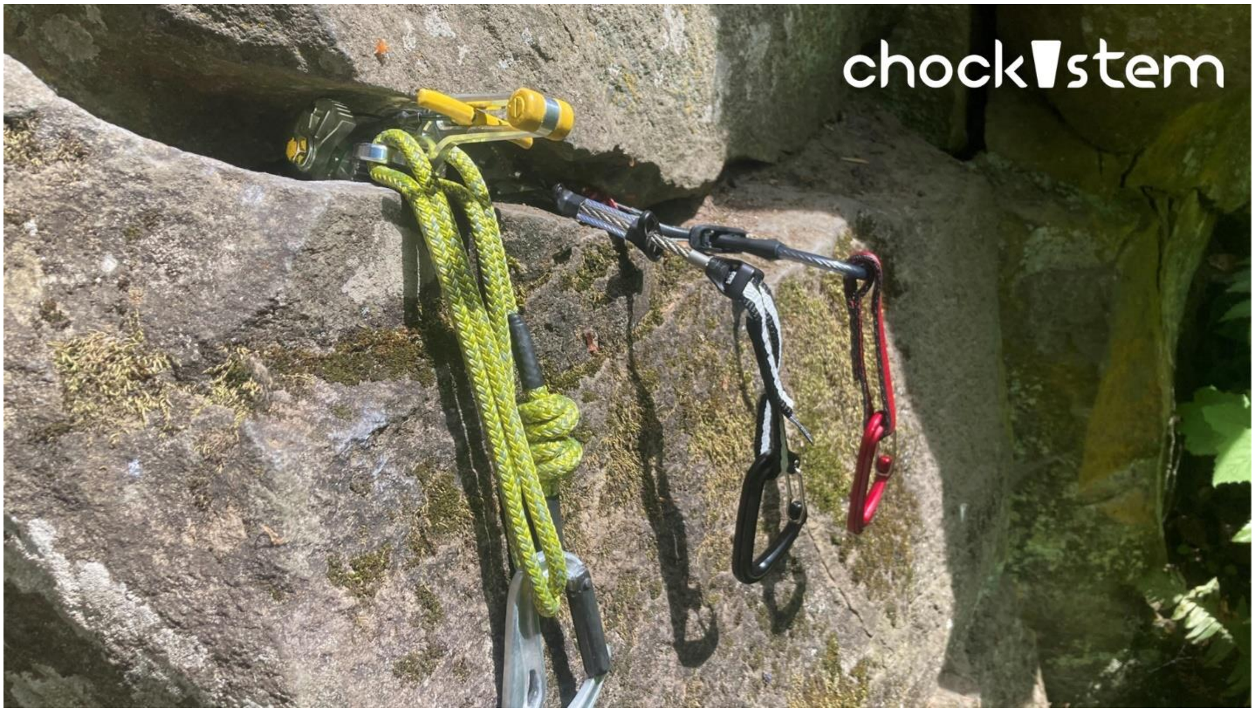

Double Axle Lobes
Rigid Stem Head
Single Axle Lobes
Unstable placement
Wider than lobes
Offset Stem
Rigid Stem Body
Sling attachments interfere with eachother
Sling interferes with trigger
Sling and trigger interactions isolated
Catches slings
Trigger Profiles
Moderate curvature at ends

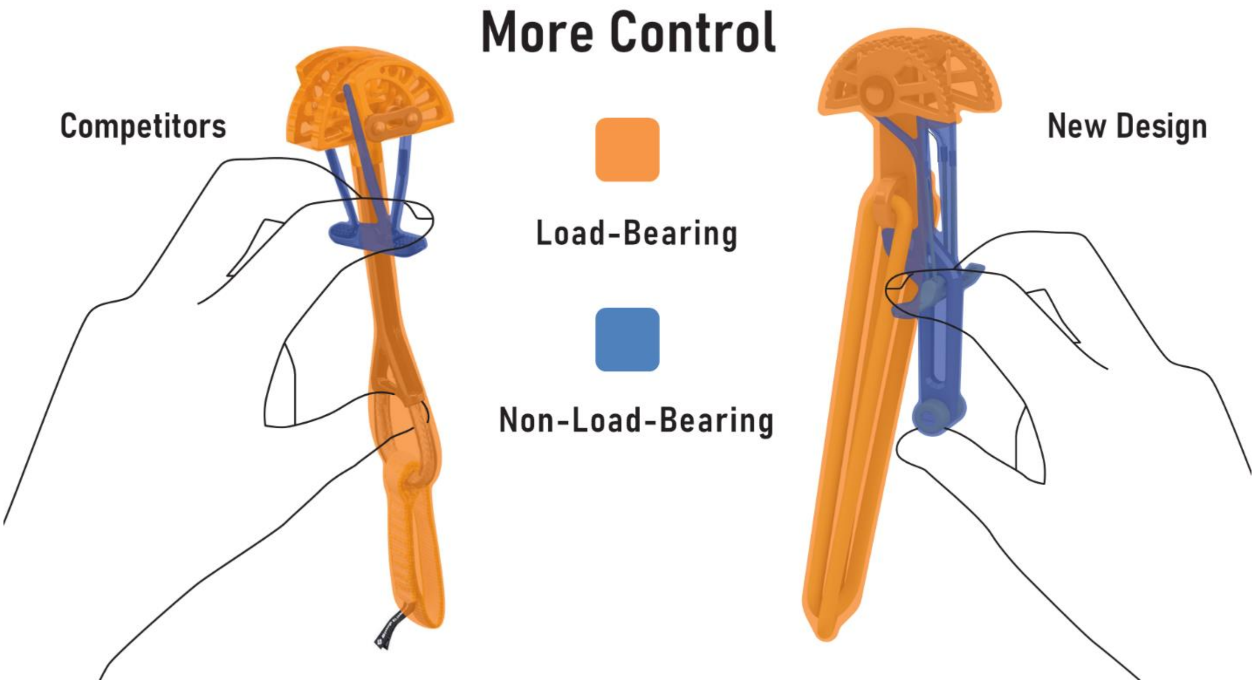


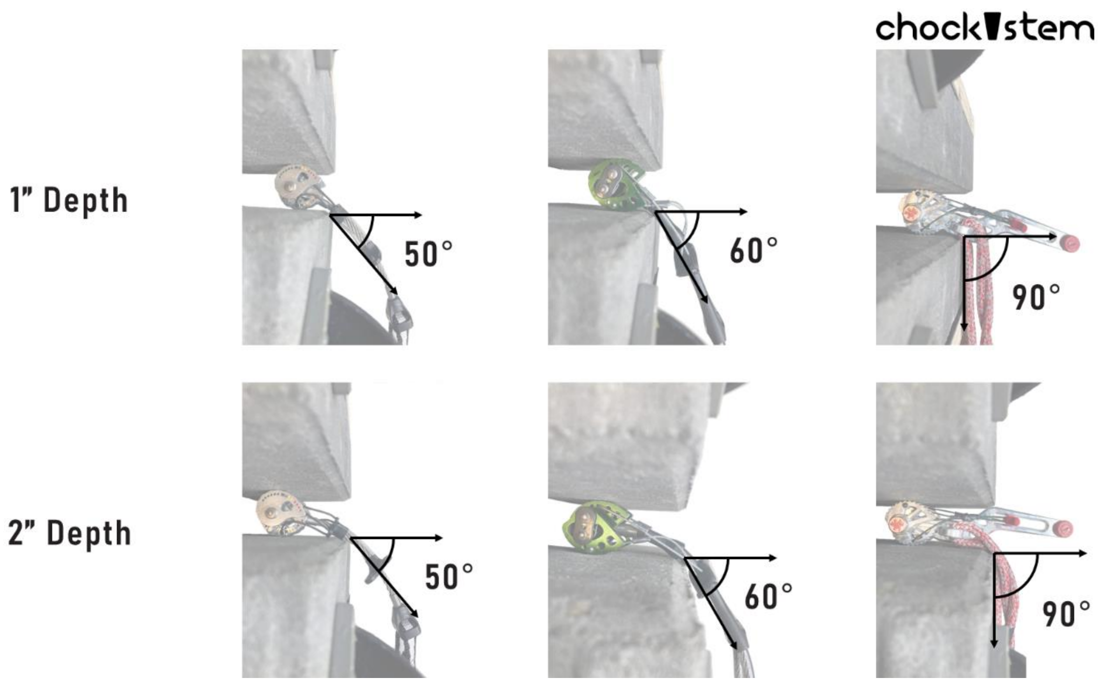

304 Stainless Steel
6061-T6 Aluminum
301 Spring Steel
Braided Polyester
rPETG
Grade 8 Steel
rPETG
1.02"-2.12"
6mm UHMWPE/Polyester
12-strand static sling
Polyolefin
Heat-Shrink
0.92"-1.78"
0.72"-1.42"
0.61"-1.04"


Baseline Analysis
Center Bent Gate & Frame
Offset Bent Gate & Frame
Multi-Bent Gate & Frame
Offset Bent Frame
Interior Offset Frame

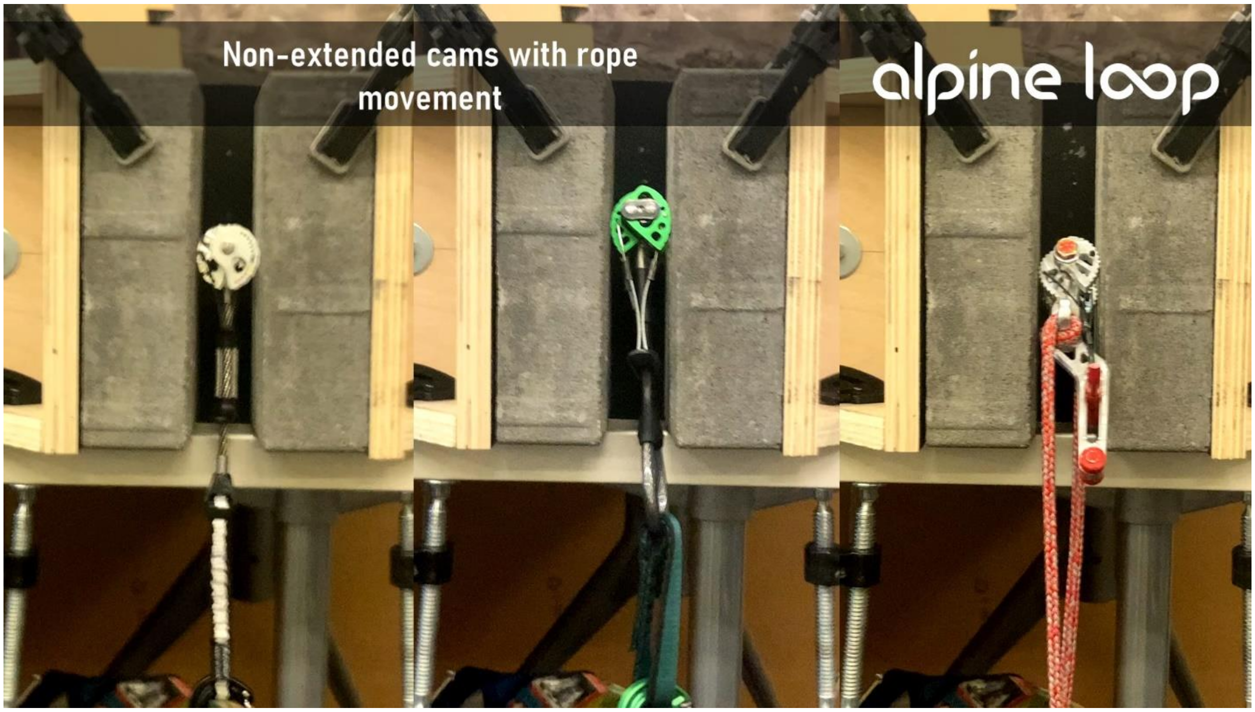

7075-T6 Aluminum
7075-T6 Aluminum
301 Spring Steel
304 Stainless Steel


chockstem

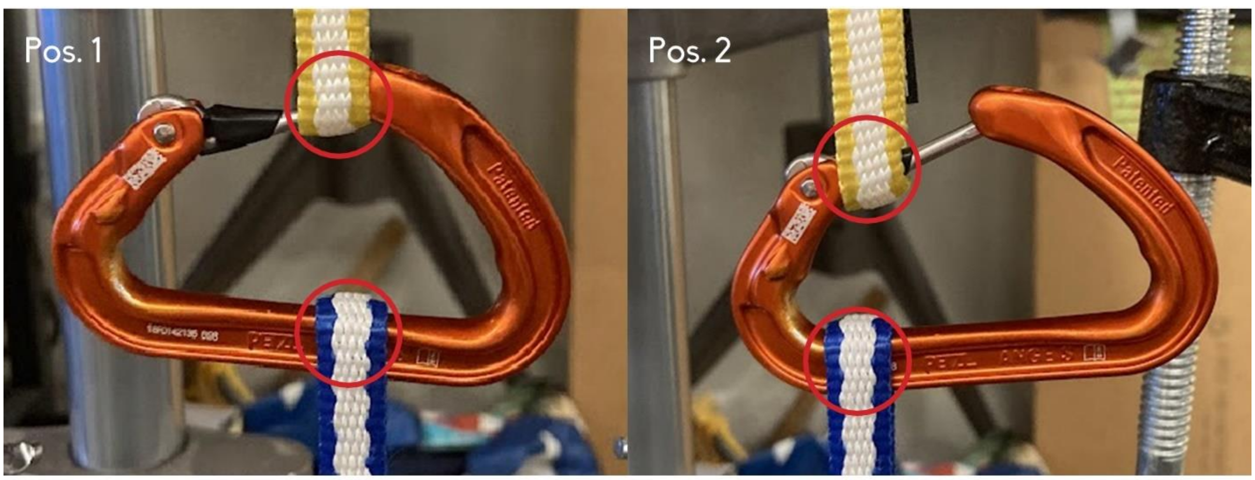

More Control
Competitors
New Design
Load-Bearing
Non-Load-Bearing


chockstem
1" Depth
2" Depth
50°
60°
90°
50°
60°
90°


alpine loop
Additional 3.5oz per
Quickdraw carried
No extra equipment
required

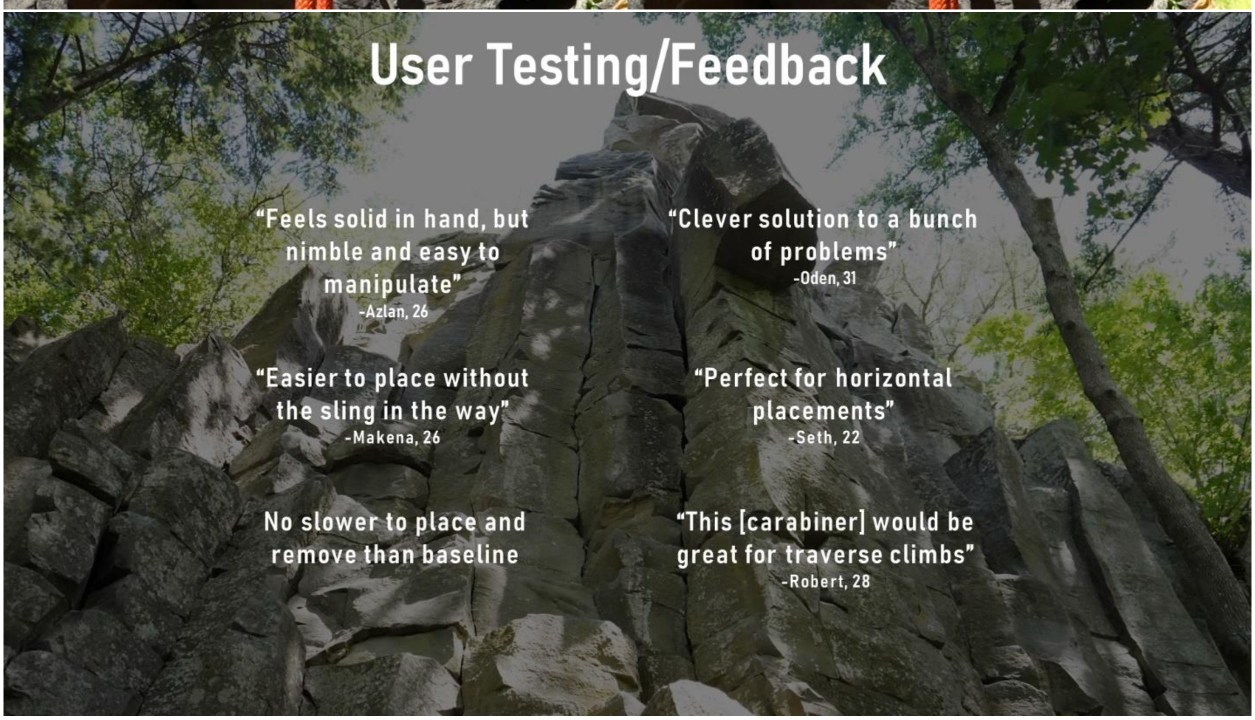


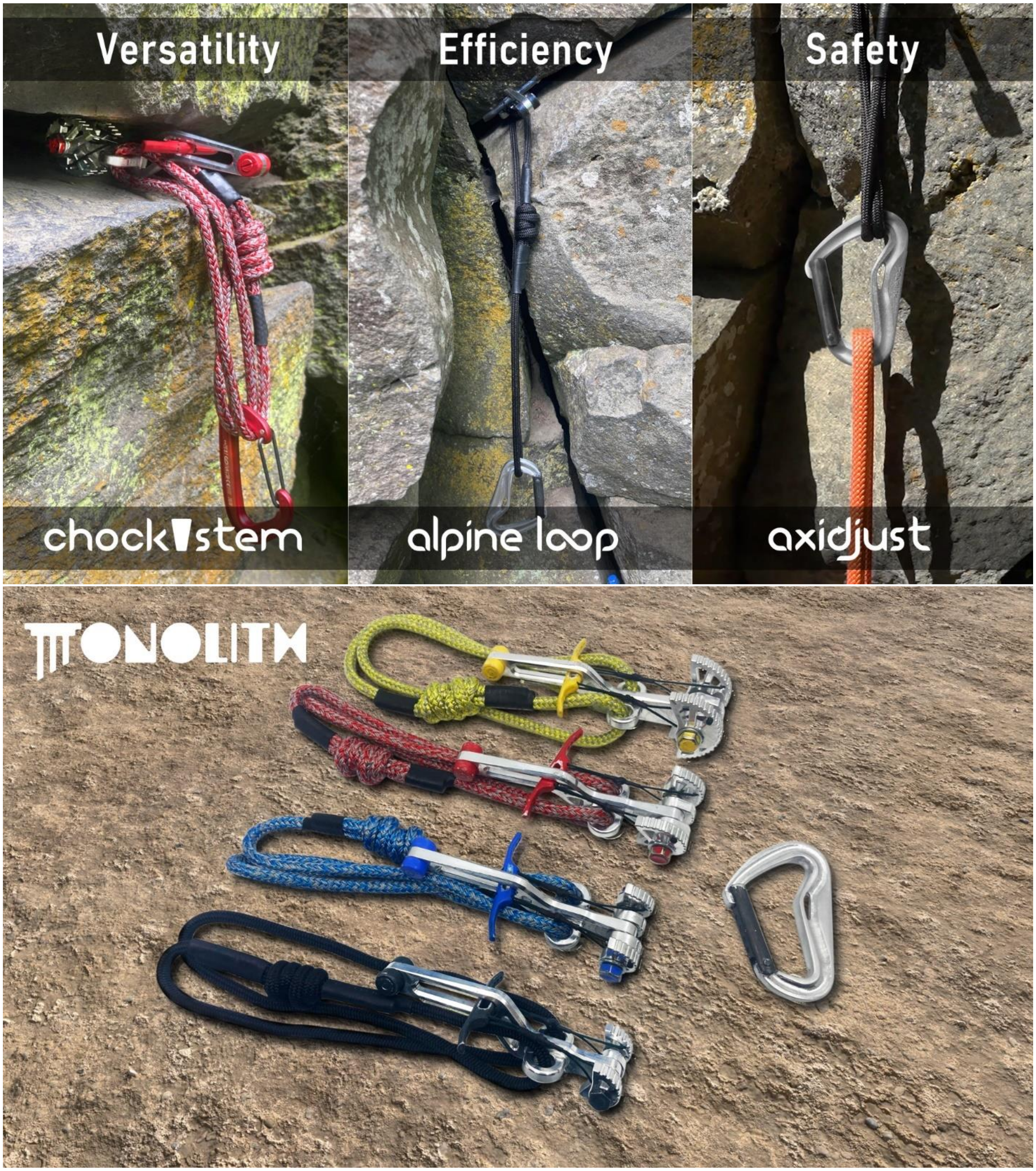
Pain Point



Stuck “cross-loaded,” reduces strength by half


axidjust


User Testing/Feedback
"Feels solid in hand, but nimble and easy to manipulate"
-Azlan, 26
"Clever solution to a bunch of problems"
-Oden, 31
"Easier to place without the sling in the way"
-Makena, 26
"Perfect for horizontal placements"
-Seth, 22
No slower to place and remove than baseline
"This [carabiner] would be great for traverse climbs"
-Robert, 28


Versatility
Efficiency
Safety
chockstem
alpine loop
axidjust
MONOLITH

Cost Analysis (Repeat Costs)

(1,500 units/1 month)

Competitor Estimate	
Machine operator pay	$3,190/month ($19.14/hr)
¼" x 1'x2' 6061-T6 Al	$9,263 ($111.16/18 pc/sheet)
¾" x 1'x2' 6061-T6 Al	$4,029 ($268.66/100 pc/sheet)
3-Axis CNC Machining	$7,000/month ($40/hr)
Welding/Brazing	$4,375/month ($25.00/hr)
Anodizing	$1,500 ($1/unit)
Sewing (Bar-Tacking)	$2,600/month ($15/hr)

(Labor costs from Glassdoor)

$21.30/unit
MSRP: $79.95
(3.75x)

Prototype Estimate	
Machine operator pay	$3,190/month ($19.14/hr)
¼" x 1'x2' 6061-T6 Al	$5,728 ($68.74/18 pc/sheet)
3-Axis CNC Machining	$7,000/month ($40/hr)
Welding	$4,375/month ($25.00/hr)

$13.50/unit
MSRP: $50.00
37.5% decrease

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