Lifespine

A compact fire escape ladder
enabling safe, easy evacuation
for individuals of all abilities.

00 Contents

1/8 of American homes will experience a housefire over a 50-year period.

Only 26 percent of families have actually developed and practiced a home fire escape plan.

Children and older adults are twice as likely to die in a home fire as the American population at large.

Current fire escape ladder designs are not accessible to disabled people, children, and the elderly.

Research

Portable and unfoldable

Price: $40–60
Weight: 7–12 lbs.
Material: Steel or aluminum, nylon
Length: Two-story, 13–14 ft.
Location: Portable, for window
Usages: Single-use

Portable options that require setup to use but cost and weigh less are far more common in today's market. Storage and stability are not a priority because they are single-use.

Mounted in place

Price: $270+
Weight: 20+ lbs.
Material: Steel or aluminum
Length: Two- to four-story, 12–32 ft.
Location: Window; permanently mounted
Usages: Reusable

Less common options come ready to use and can accommodate various house sizes but cost more. Storage and stability are much more considered because they are reusable.

02 Market Evaluation

Evan K., 20
Full-time student

Quotes

“I feel like I’m going to fall off the whole time.”

“None of the process is smooth, I feel like it all would have taken a lot of time in the event of an actual fire.”

Pain Points

01 Two separate hooks swing around, making carrying around house or apartment very unwieldy.

02 Hard to deploy ladder because release cord hangs below windowsill.

03 Very difficult to maneuver body over windowsill and begin climbing down.

04 Carrying a baby or animal would be very difficult; descending was difficult even using both hands.

01 Retrieve ladder

02 Set up on windowsill

03 Maneuver out of window

04 Descend

03 Task Analysis

Key Takeaways

—Most participants didn't have a concrete plan in case a fire was blocking the primary exit of their house or apartment.

—Participants all agreed that speed was the most important factor in the evacuation process.

—Participants expressed concern for evacuating children and elderly household members, particularly in terms of speed and physical ability.

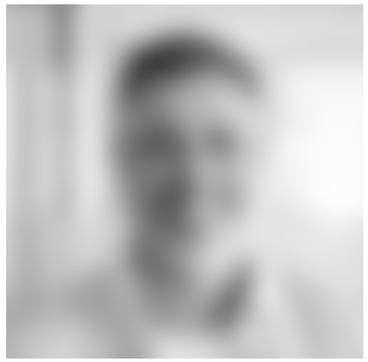
—Some barriers to fire ladder use in an emergency included complicated setup, perception of safety, and accessibility.

—One participant expressed that the main factor they would consider when purchasing a ladder would be usability for children and the elderly.

"If I had my mom staying with us at the time and a fire did break out, I would be pretty concerned for her safety because she would need help...to make it out in a reasonably quick time."

"I think evacuating quickly is in itself a way of preventing any injuries, so it's probably my biggest concern."

— Lindsay D., 48, travel agent



"...When my kids were younger [evacuating] would have been more of a challenge. Also, my wife's parents have lived with us in the past..."

"Speed and being able to navigate around [are my biggest concerns]; if there's a lot of smoke I think it would be hard to find and set up an escape ladder..."

— Julio C., 53, software engineer

04 Interviews

There appears to be a market gap for a home fire escape ladder that is **accessible**, **easily storable**, and **stable**.

For All Abilities

Using a fire escape ladder is a difficult task, further exacerbated by stress and injury in an emergency situation. Many people, including children and the elderly, may be left without a viable evacuation route. Our design should enable users of all abilities to exit safely and quickly.

Compact Storage

Currently available fire escape ladders are made with loose nylon straps and metal rungs that nest awkwardly and often tangle. All parts are loose and would be difficult to store and set up in an emergency. Our design should nest cleanly for easy transport and quick, straightforward deployment.

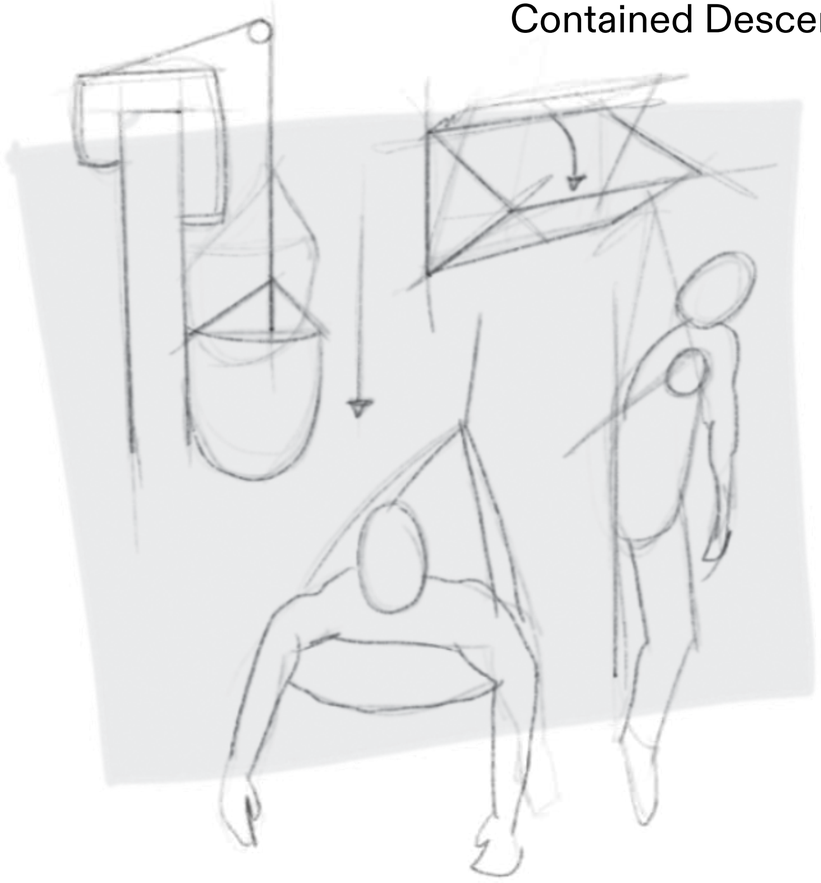
Stable Descent

The nylon straps of current ladders make descending shaky, twisting, and unnecessarily frightening. Our design should have a more rigid structure and wall offsets to create a stable, controlled descent for a safe and more confident evacuation—for all users.

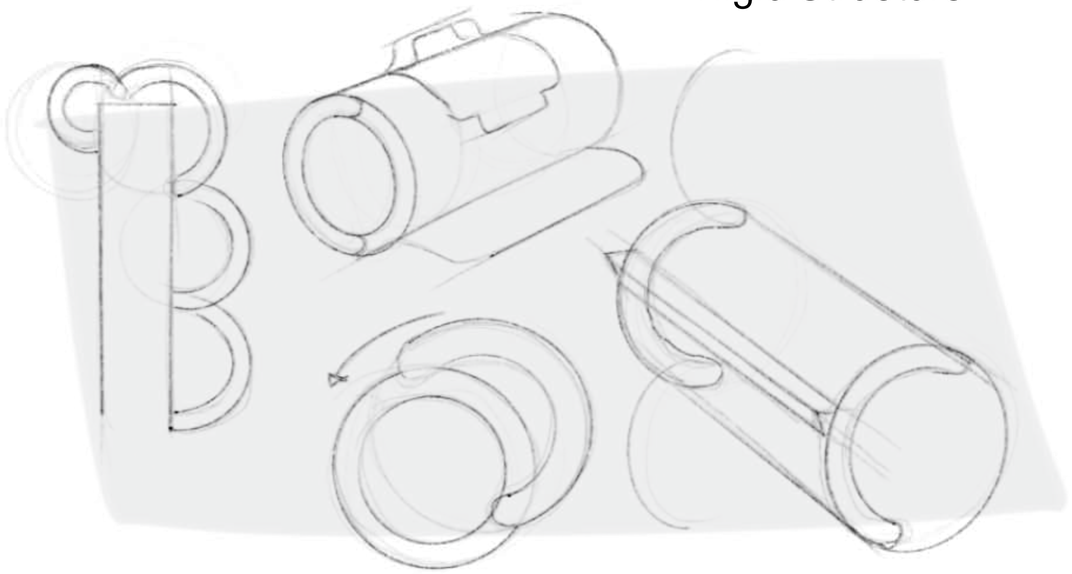
05 Problem Framing

Development

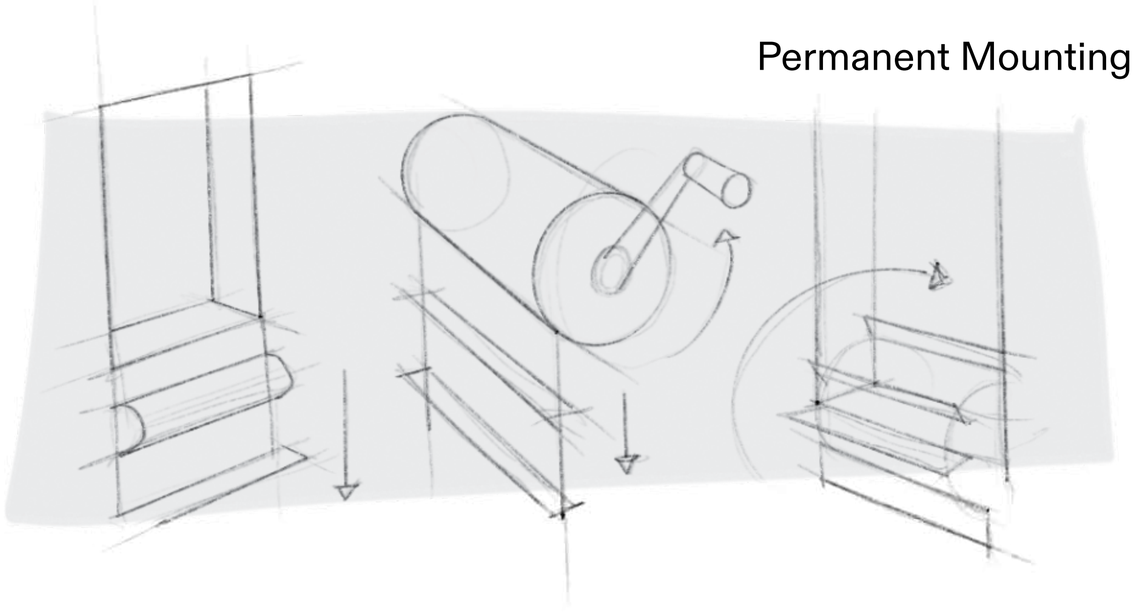
Contained Descent



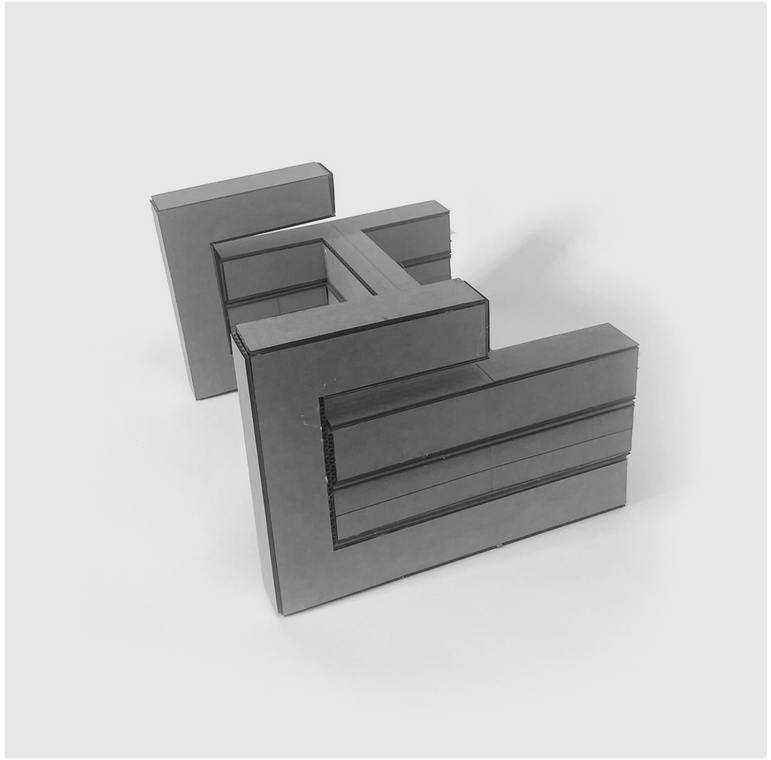
Rigid Structure



Permanent Mounting

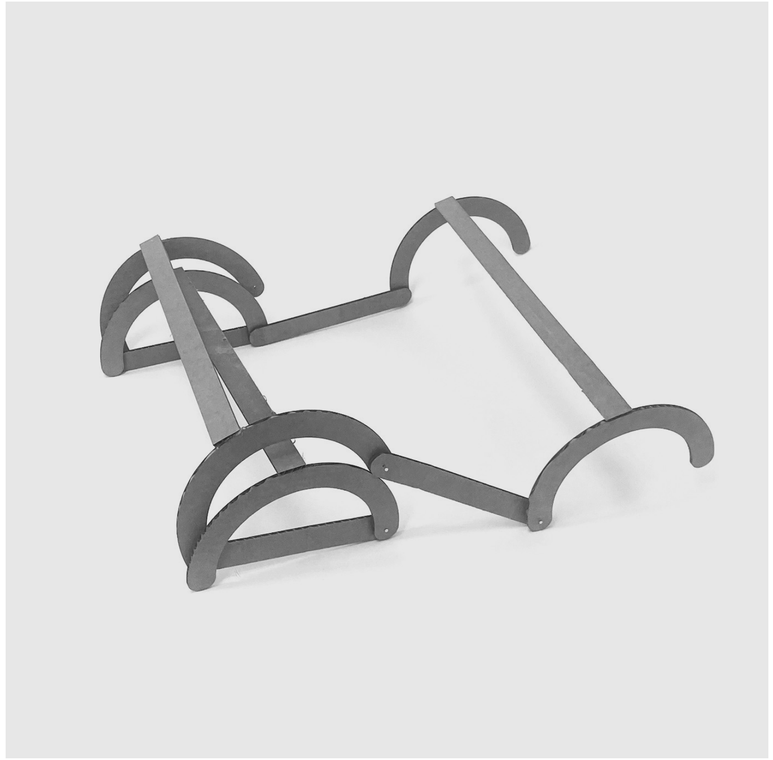


07 Rapid Visualization



Accordion-style nesting into hooks

A nesting style that enabled a completely rigid ladder from a relatively small stored state. We determined that the hinging mechanism was too complex, and would be too heavy for use as a portable ladder.



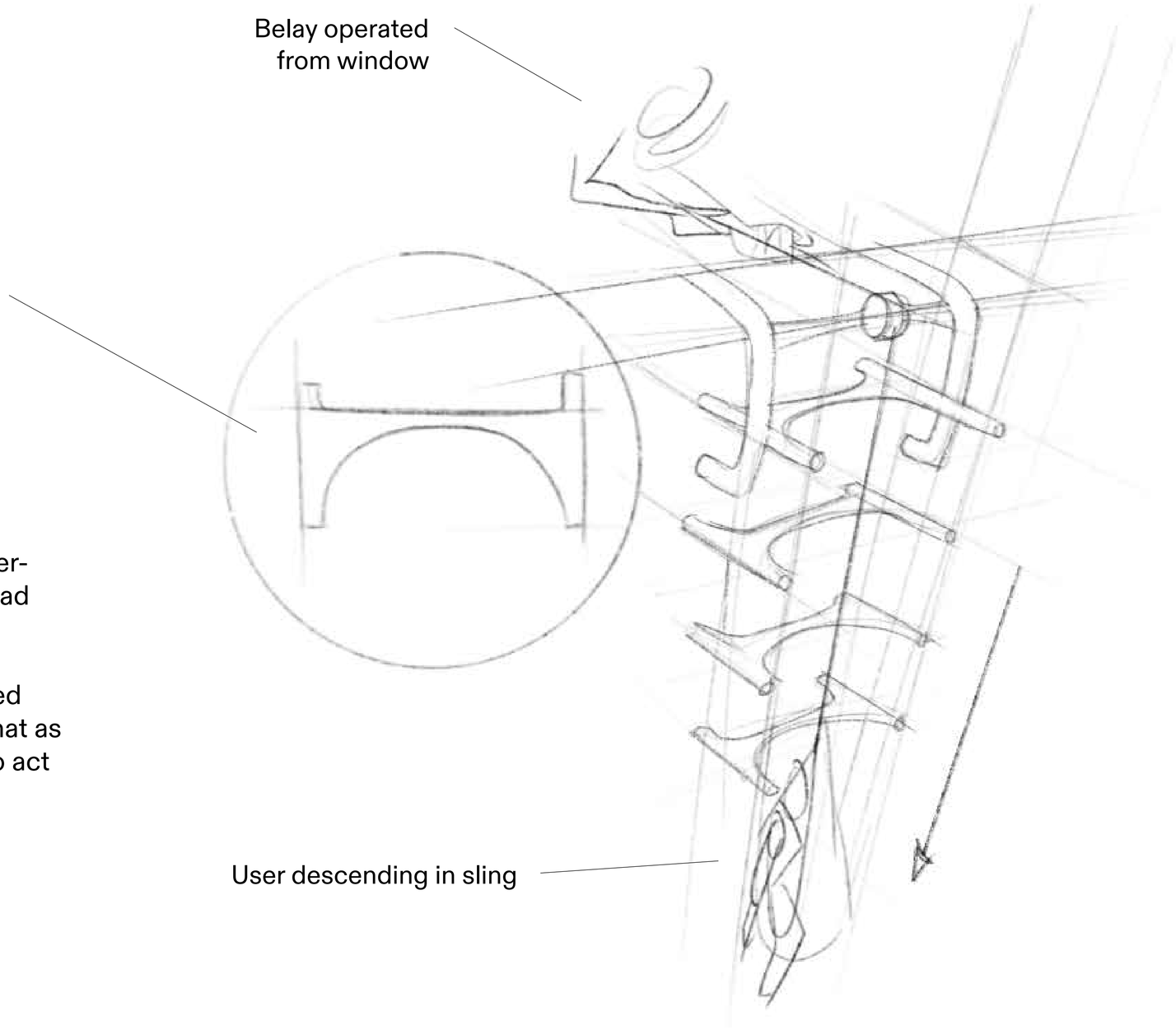
Inwardly-staggered nesting

Exploration into a staggered nesting style, in which rungs would become incrementally narrower toward the ground. All hinges would lock with a pin, creating a rigid ladder. We determined that this was too complex, with many load-bearing hinges.

Decreasing offset nesting

Another exploration into nesting style, in which the rungs' wall offset would become incrementally shallower to allow rungs to nest in the closed form's negative space. We determined that this would be too heavy, as well as quite large in its stored state.

08 Rough Prototyping

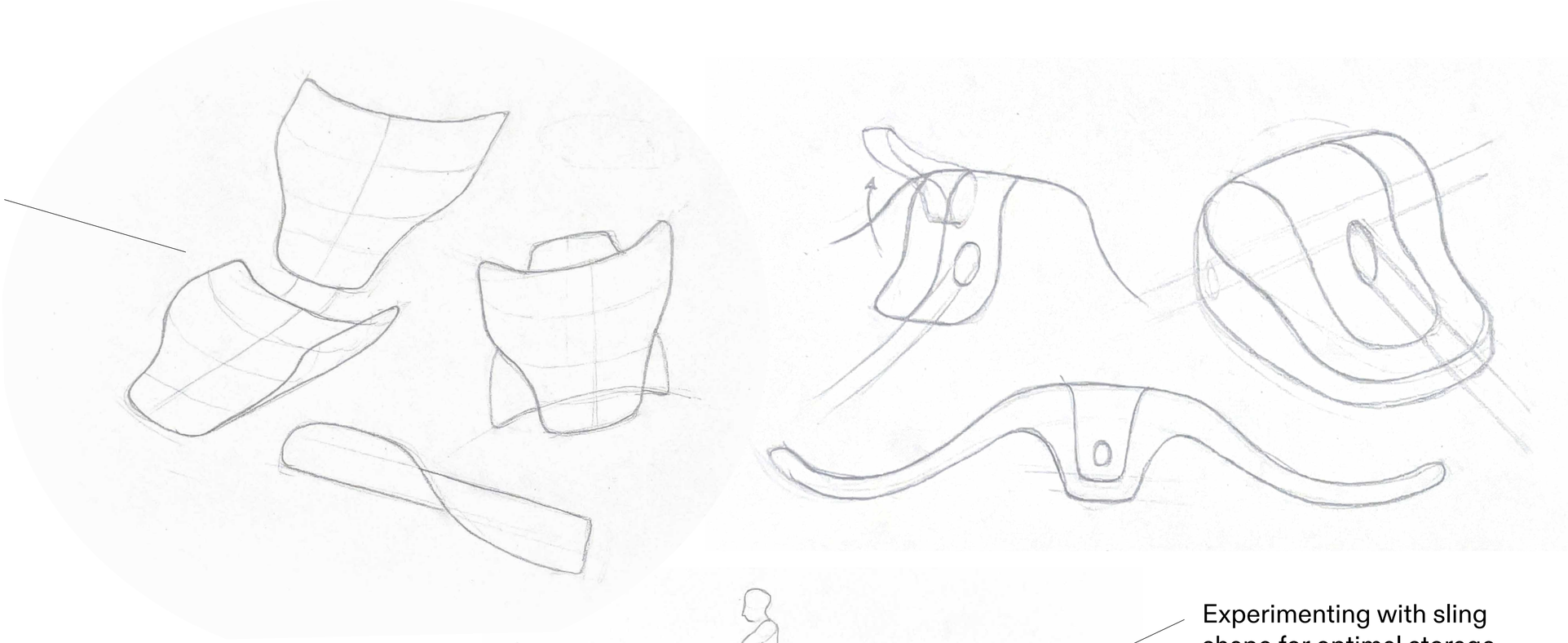


At this point, we reflected on our rough prototypes and determined that accessibility was an important opportunity we had overlooked in pursuit of a nicely-nesting, rigid ladder.

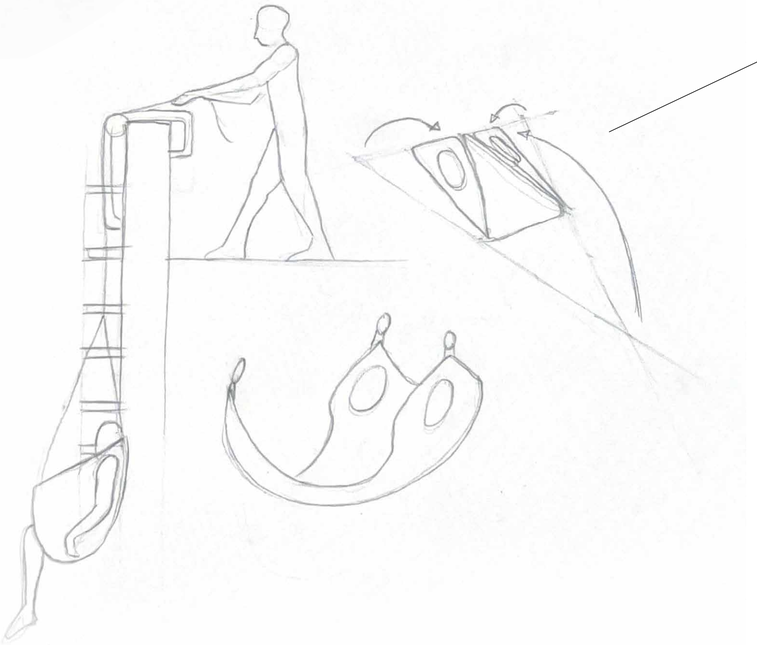
We set about ideating on how to create a product that united both ladder and belay system, and eventually determined that as a part of this union, the ladder's rungs should be concave to act as a channel for users being belayed.

09 Unifying Concepts

Vertically extruded rung shape to facilitate outward unrolling and more channel surface area



Experimenting with sling shape for optimal storage within closed form



In our research, we were inspired by the simple and efficient slings used in airlift rescues to replace harnesses in existing climbing belays.

We also found that the ideal belay mechanism was a simplified version of the Petzl GriGri, a cam device with a lever that reduces friction on a rope as the lever is pulled back.

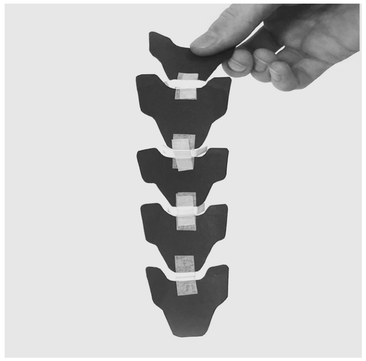
10 Concept Development

Ripstop fabric, steel rings, heavy rope

Combination of injection molded plastic and aluminum

Colors: black primary; high-vis red accent

11 Aesthetic Direction

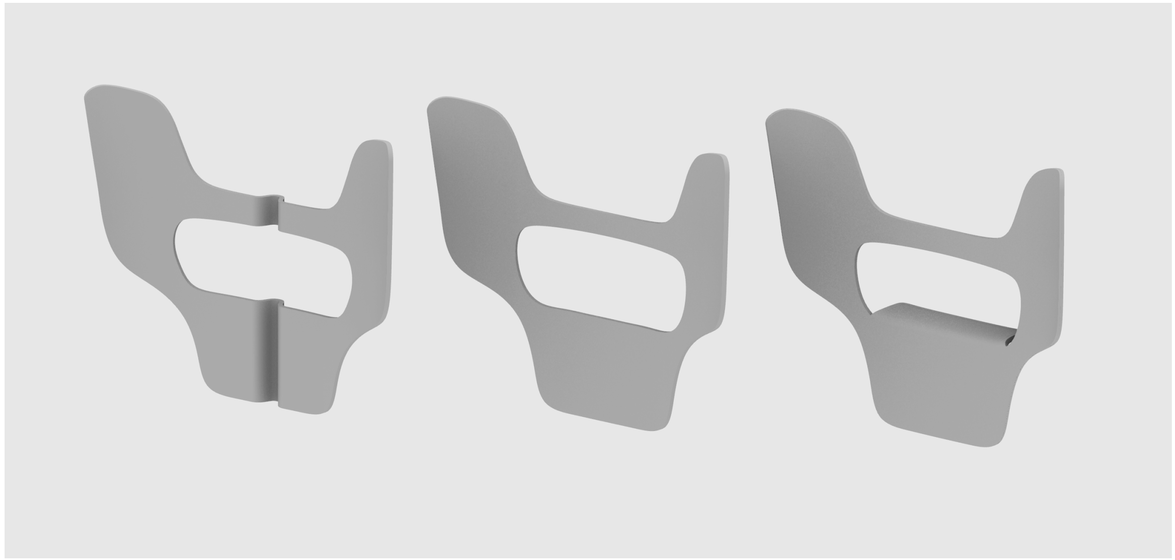


Quick experimentation with the shape of the rungs led us to settle on a more angular form with rounded corners. Taping and folding them showed us that we needed to drop the base of the “ears” to allow for more compact folding.

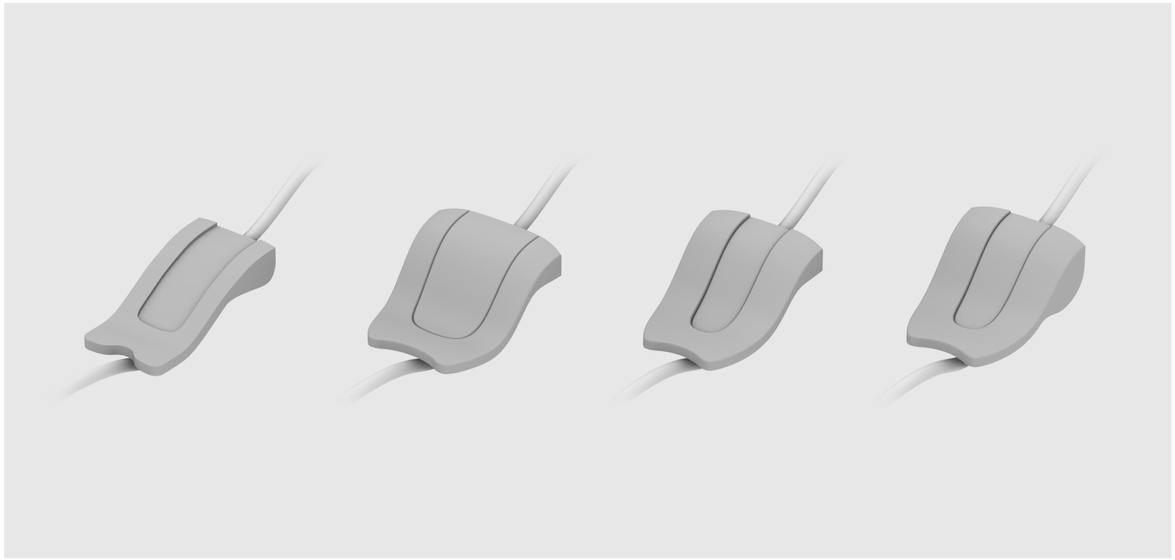
We increased the width of the rung segments to be slightly larger than the average person’s shoulder span and made a large cutout to make foot placement easier when descending.

A 3D-printed, scaled model of our final ladder rung shape showed us the rough proportional size and volume, and acted as proof of concept for the nesting mechanism.

12 Form Refinement

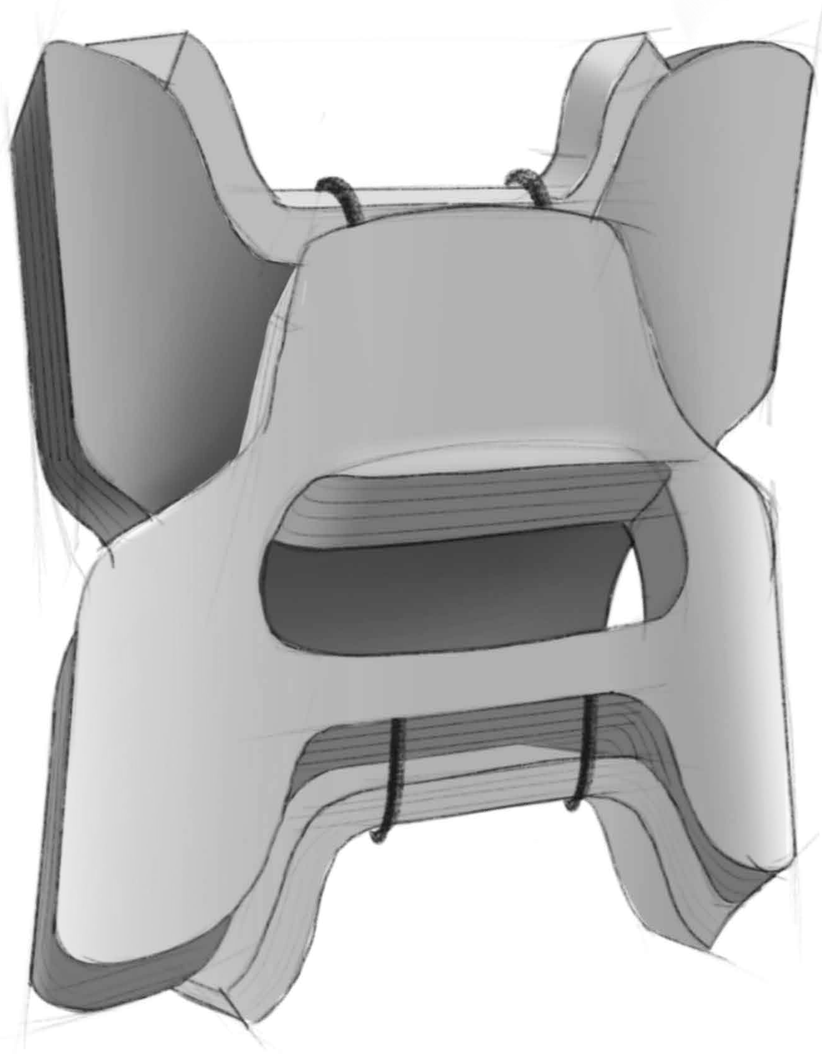


We removed the rung divot after routing the rope to run in front of the sling user rather than behind, and decided on a bent-back rung shape to allow the rung segments to nest.

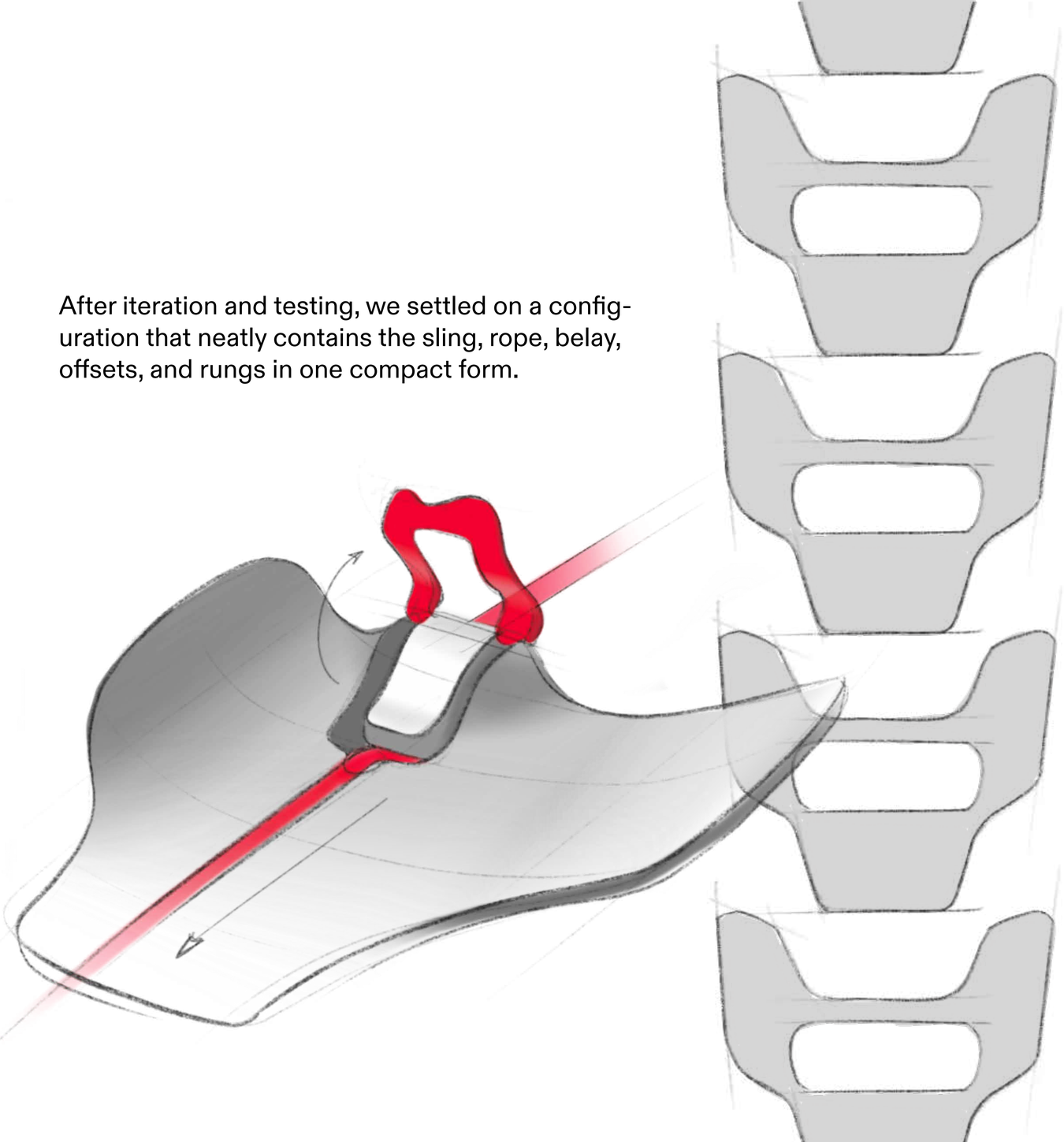


We rounded the belay device to reflect the curves of the overall form. The body of the device was narrowed as much as possible while the handle was enlarged to ease user interaction.

13 Detail Iteration



After iteration and testing, we settled on a configuration that neatly contains the sling, rope, belay, offsets, and rungs in one compact form.



14 Final Concept

Solution

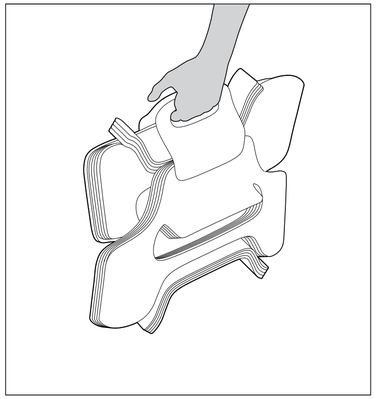
Because the baseplate’s outer hook is longer, any weight on the ladder increases the normal contact force, and in turn the friction, between the hooks and the wall, creating a self-tightening effect that secures the ladder in place.

Users can be quickly clipped into the prepared sling and lowered by another household member. By gradually lifting the integrated belay device’s handle upwards, the speed at which the sling user is descending can be easily and intuitively controlled.

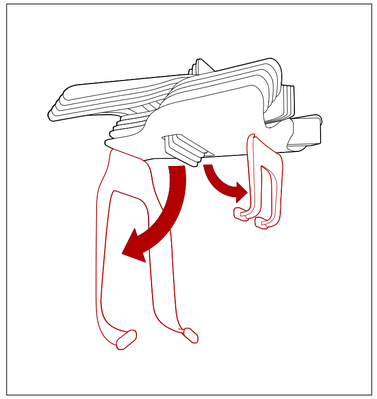
The curved rung segments enable a slim profile when nested while allowing the sling, rope, and hooks to be enclosed within.

To maintain a uniform silhouette, the handle of the belay device when stored lays flush with the raised profile of the device's housing. We chose to make the parts of the ladder that users physically interact with bright red for visibility and clear communication.

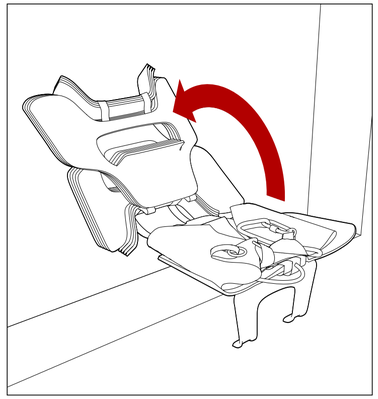
In order to minimize the volume of the closed form, the wall offsets stack within the negative space of the rungs, hardly adding height to the stored ladder.



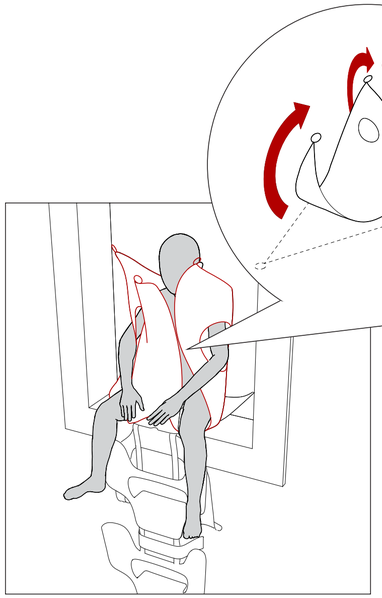
In the event of a fire or other emergency, carry ladder to window.



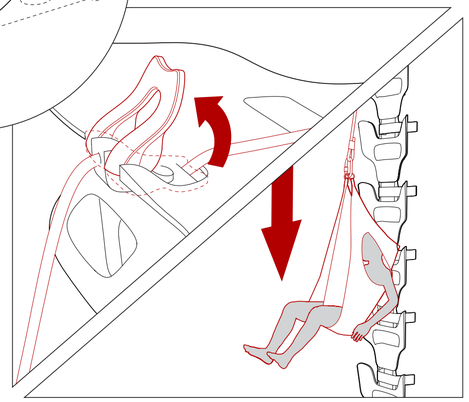
Unfold window hooks and place on sill, with longer hook against outer wall.



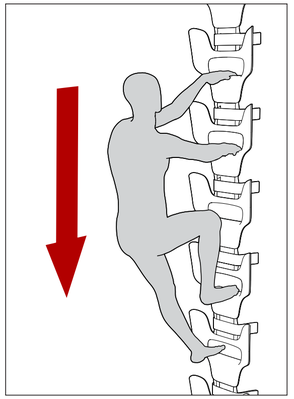
Flip stacked rungs out of window and release to allow them to unfurl.



Unfold sling on base-plate, seat user, and secure sling by clipping rings into carabiner.



Gradually lift belay lever to begin lowering sling user and control their descent speed.



Able-bodied users descend via ladder.

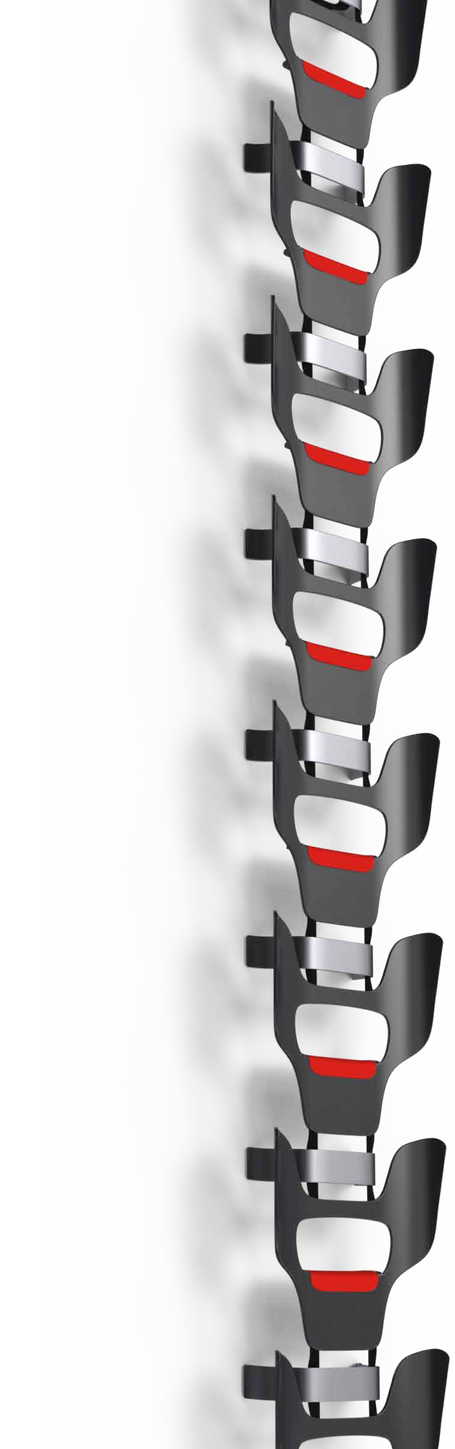
*flame-retardant material—NFPA 701 certified

20”

22”

8”

Lifespine provides a quick and simple escape route for users of all abilities in the event of a housefire. Using its integrated belay and sling, users can first lower any household members with physical limitations or disabilities (e.g. wheelchair users, infants, elderly, or pets) before descending the ladder themselves via the rung cutouts. The curved rung segments of this two-story ladder gently guide anyone being belayed to the ground and fold into themselves for easy, compact storage.



Sources

American Red Cross

National Fire Prevention Association

U.S. Fire Administration

Kidde

First Alert

X-It

Safelincs