PROTECTIVE FOLDING

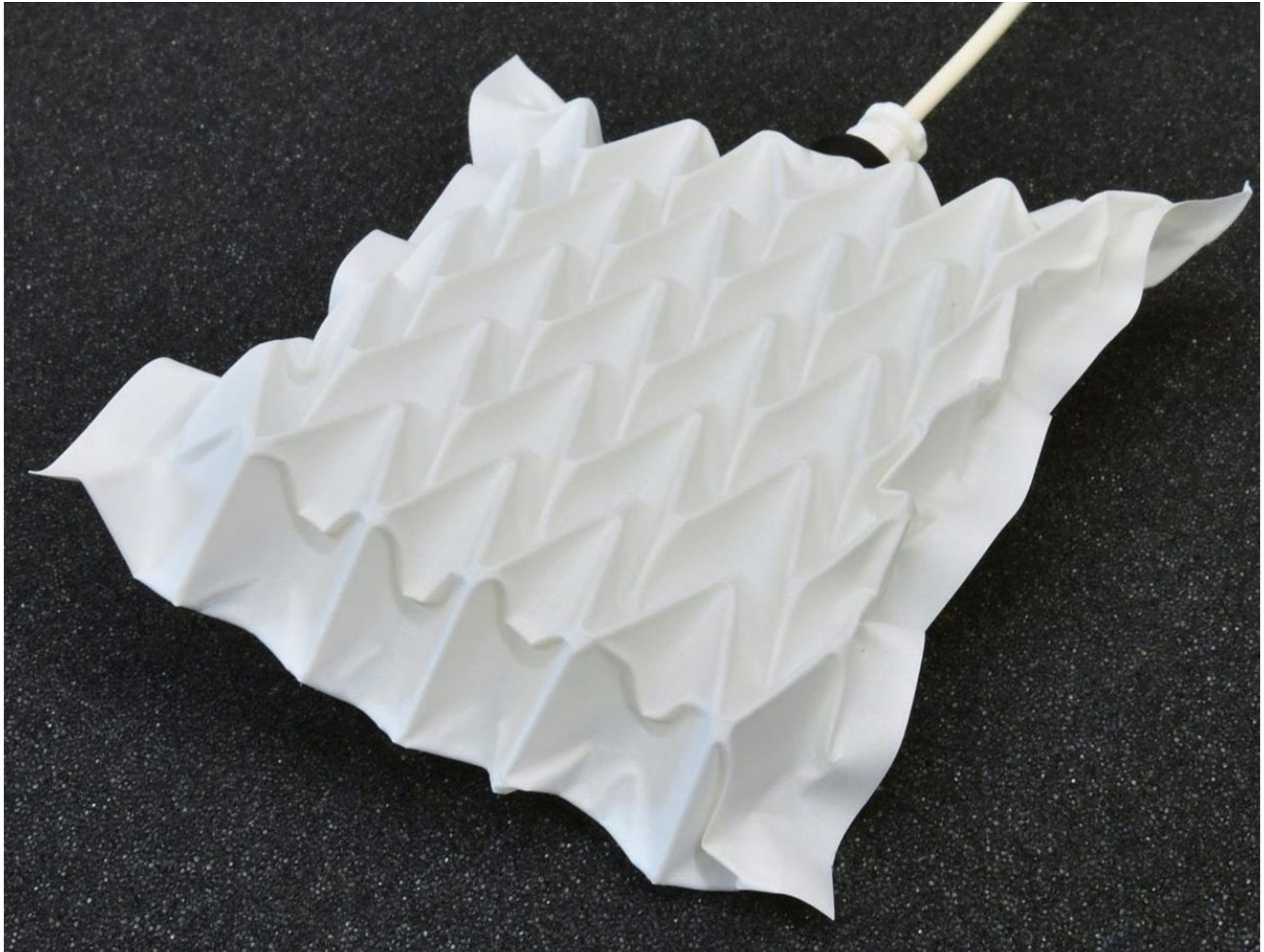
This project explores the different ways protective luggage can be built to be effective but also lightweight. Most protective luggage today is either unusually heavy or extremely expensive. By creating luggage that has inflatable or deflatable padding, objects can be contained in a safe environment that is lightweight and relatively cheap to produce. Adding rigid elements to this padding can further aid the durability and effectiveness of these structures.

CONTENTS

PHASE 1
REFERENCE PICTURE 005
RESEARCH MATERIAL 007
CONCEPT SKETCHES 009

PHASE 2
MATERIAL TESTS 013
FOLDING TESTS 015
OVERALL SHAPE 017

PHASE 3
FINAL PROTOTYPE 019

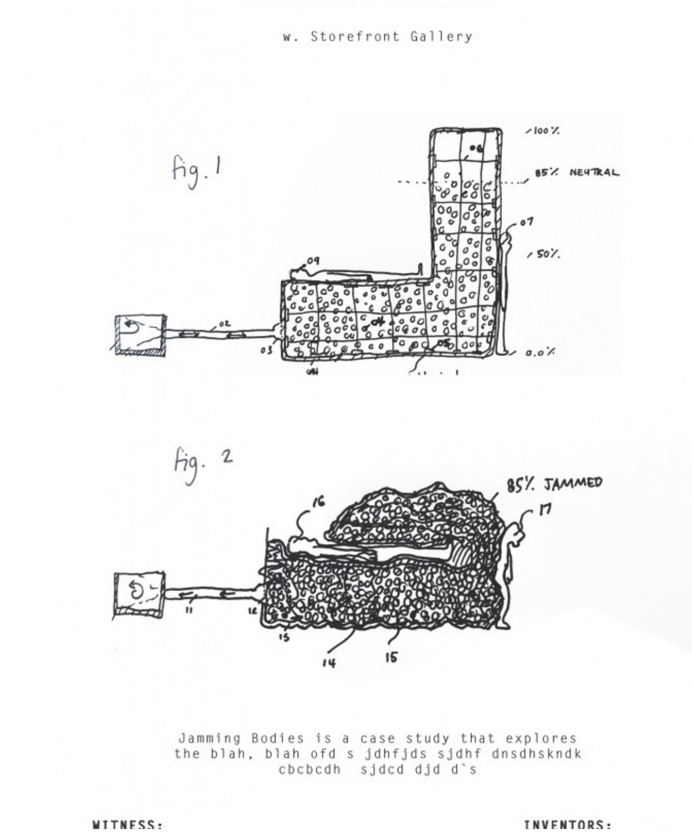

Origami-Inspired Muscle / Harvard Wyss Institute

Deflatable Jamming

This is a process developed by researchers at Harvard that uses a vacuum to pull the air out of a bag, exposing the rigid structures beneath. These structures can be designed to compress around other objects as air is pulled out, or to contract like a muscle.

PUMA Jamming Soles/ PUMA

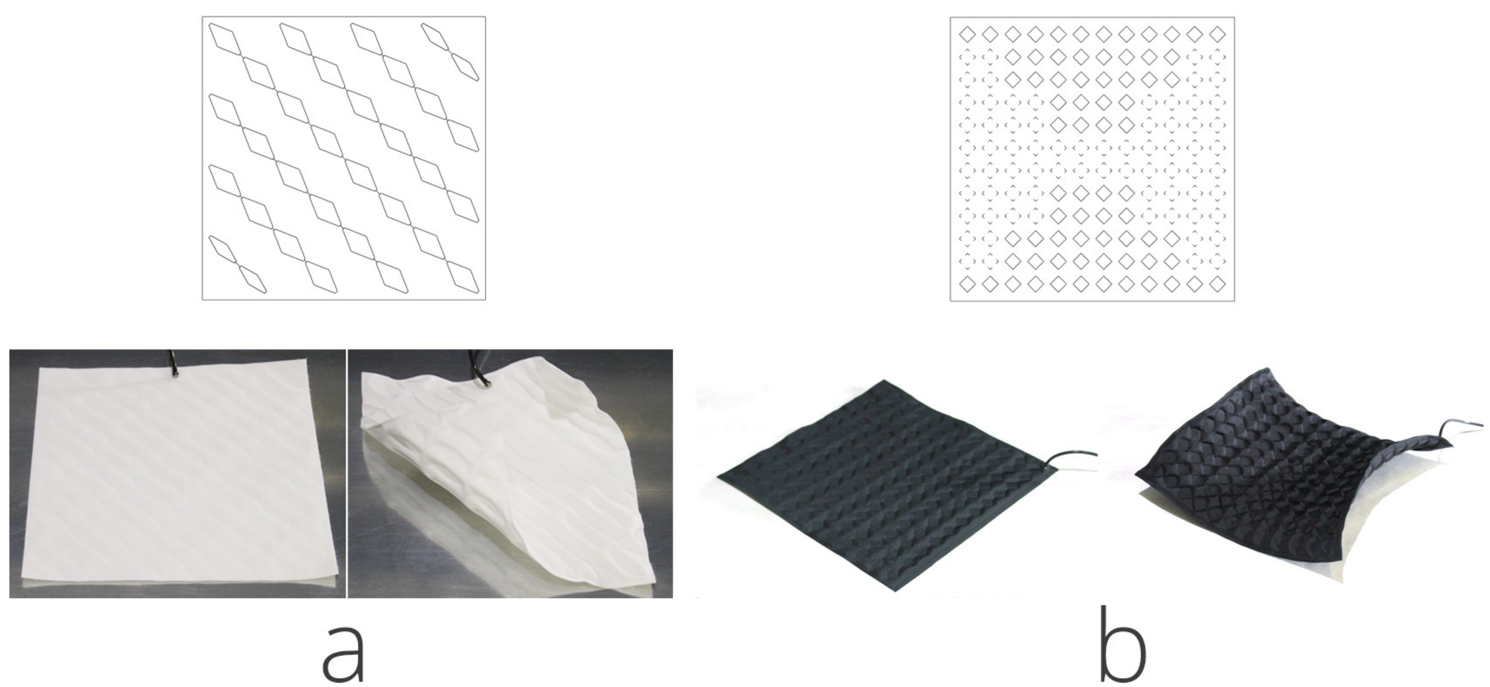
Jamming Gripper / Creative Machines Lab, Cornell



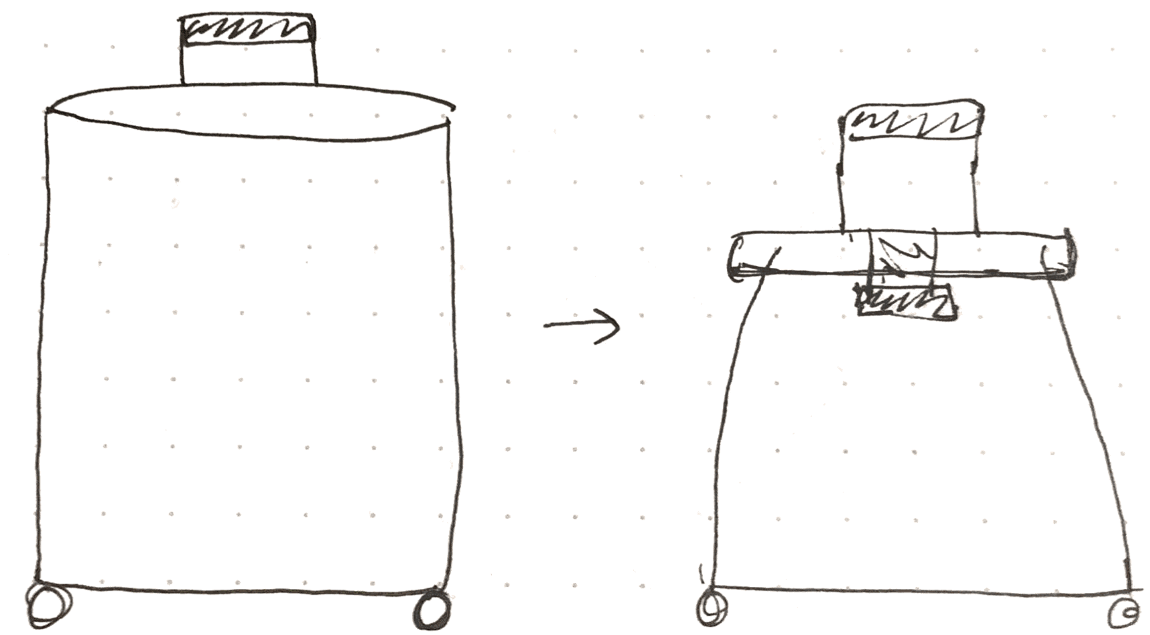
Jamming Bodies / Self-Assembly Lab, MIT

There has been a lot of research on the concept of granular jamming. At Cornell, a jamming gripper was developed that deflates the air out of a balloon filled with granules to jam around objetcs to hold them. PUMA also used this concept to create sneakers that form to the shape of your foot to increase comfort.

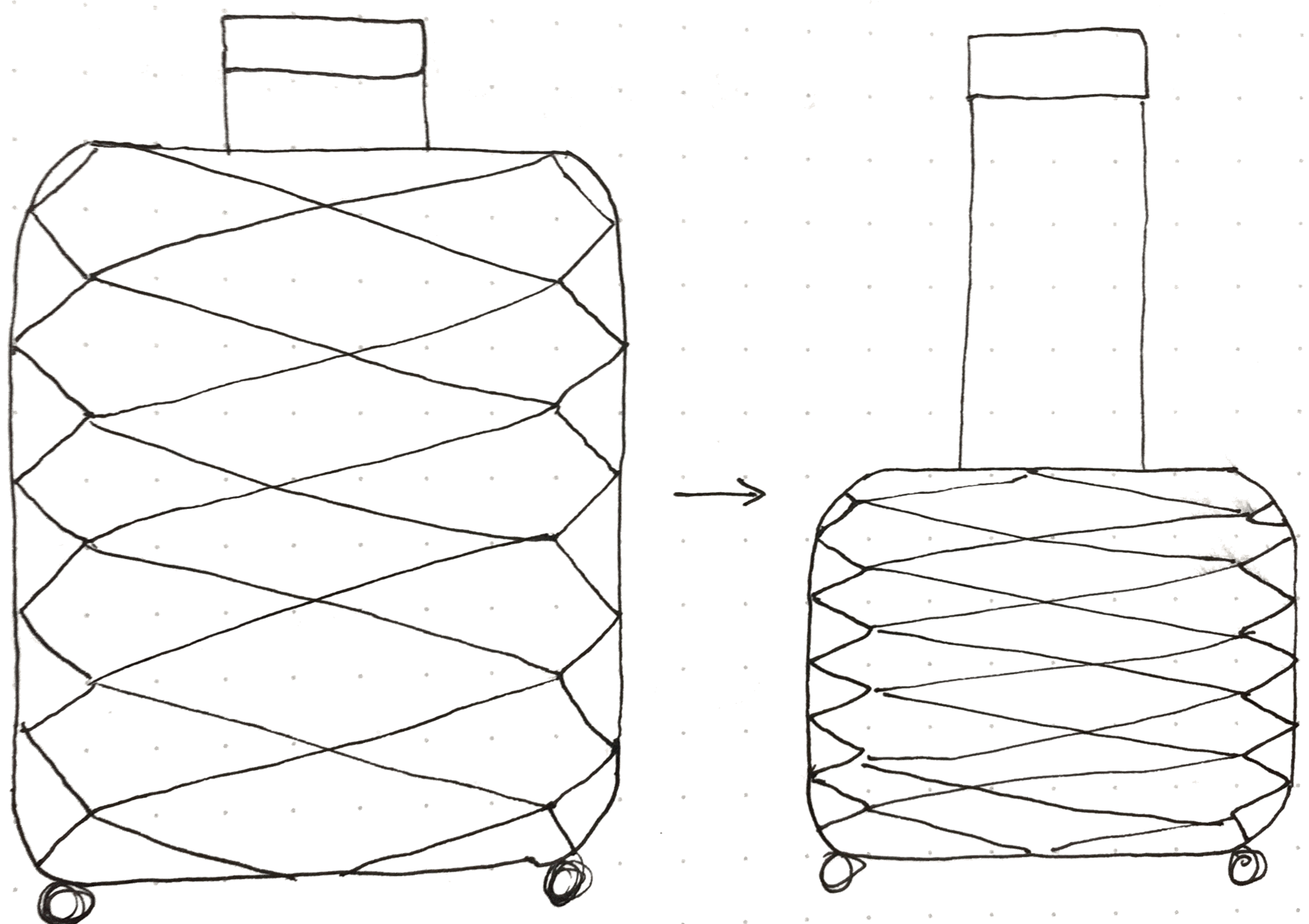
Shape-changing inflatables have also been studied, and are often combined with jamming to create more complex, stronger shape-changing prototypes.

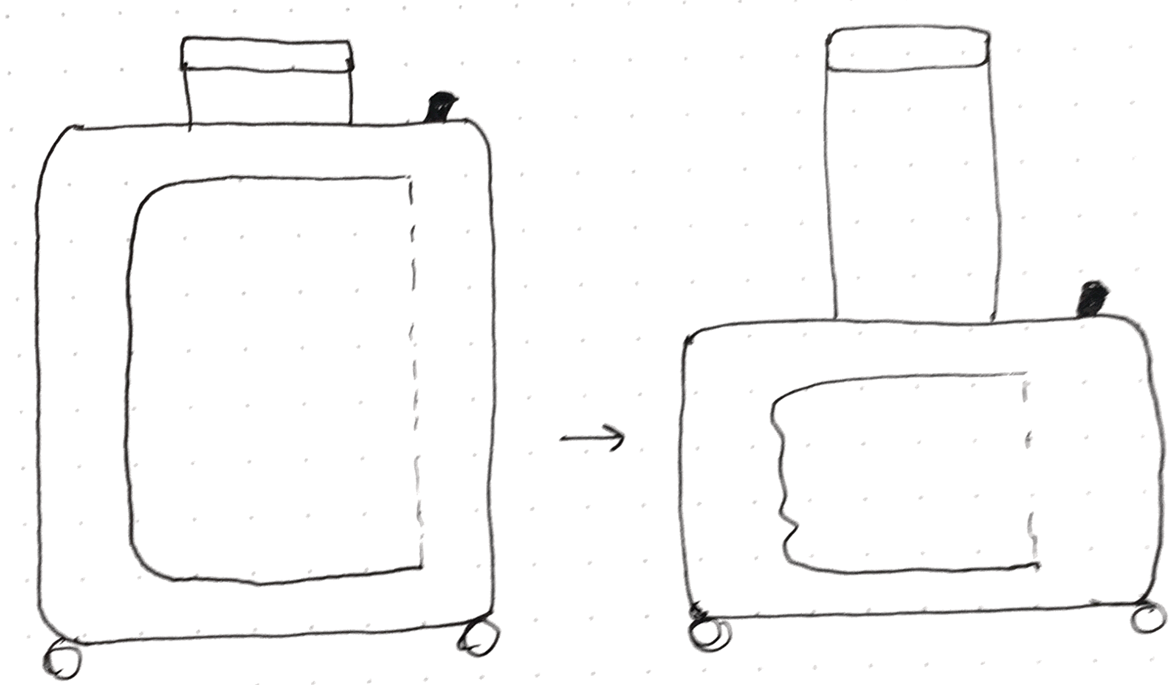


aeromorph / Tangible Media Group, MIT Media Lab



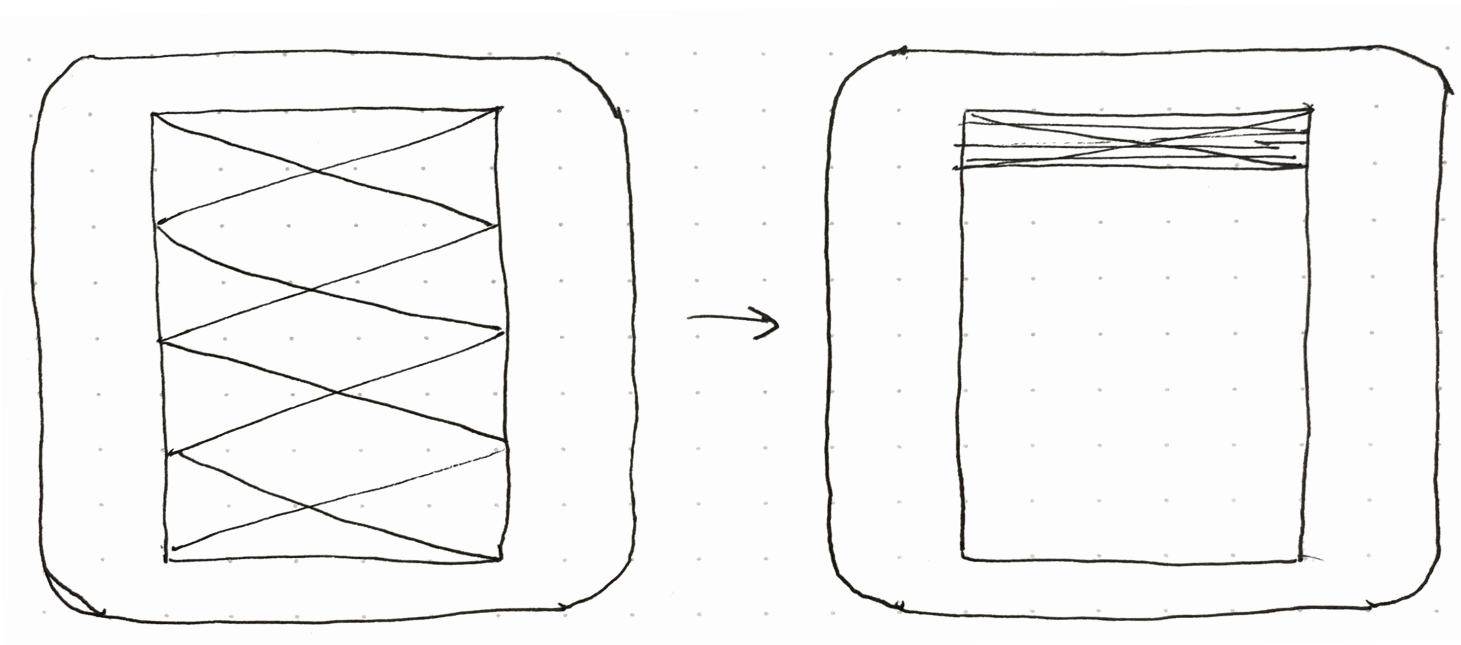
Dry bag concept for overall shape





Compression in overall shape

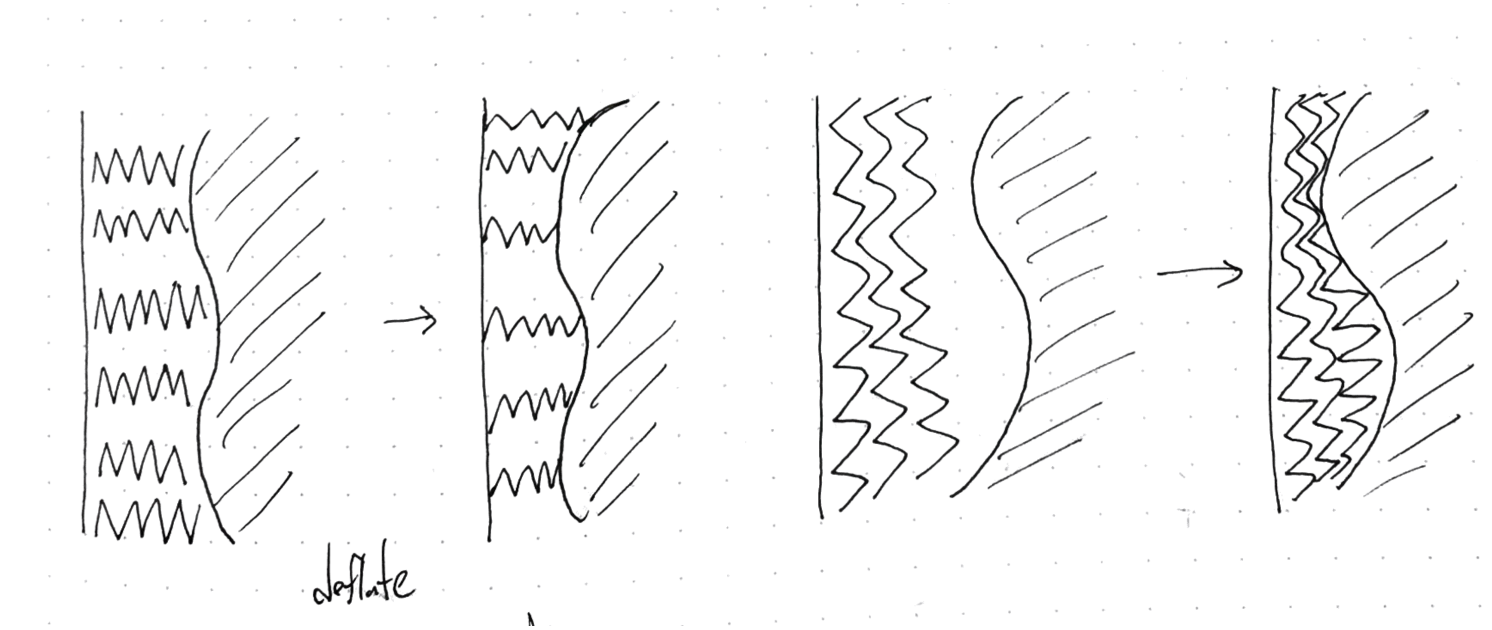
Door and valve concept for overall shape



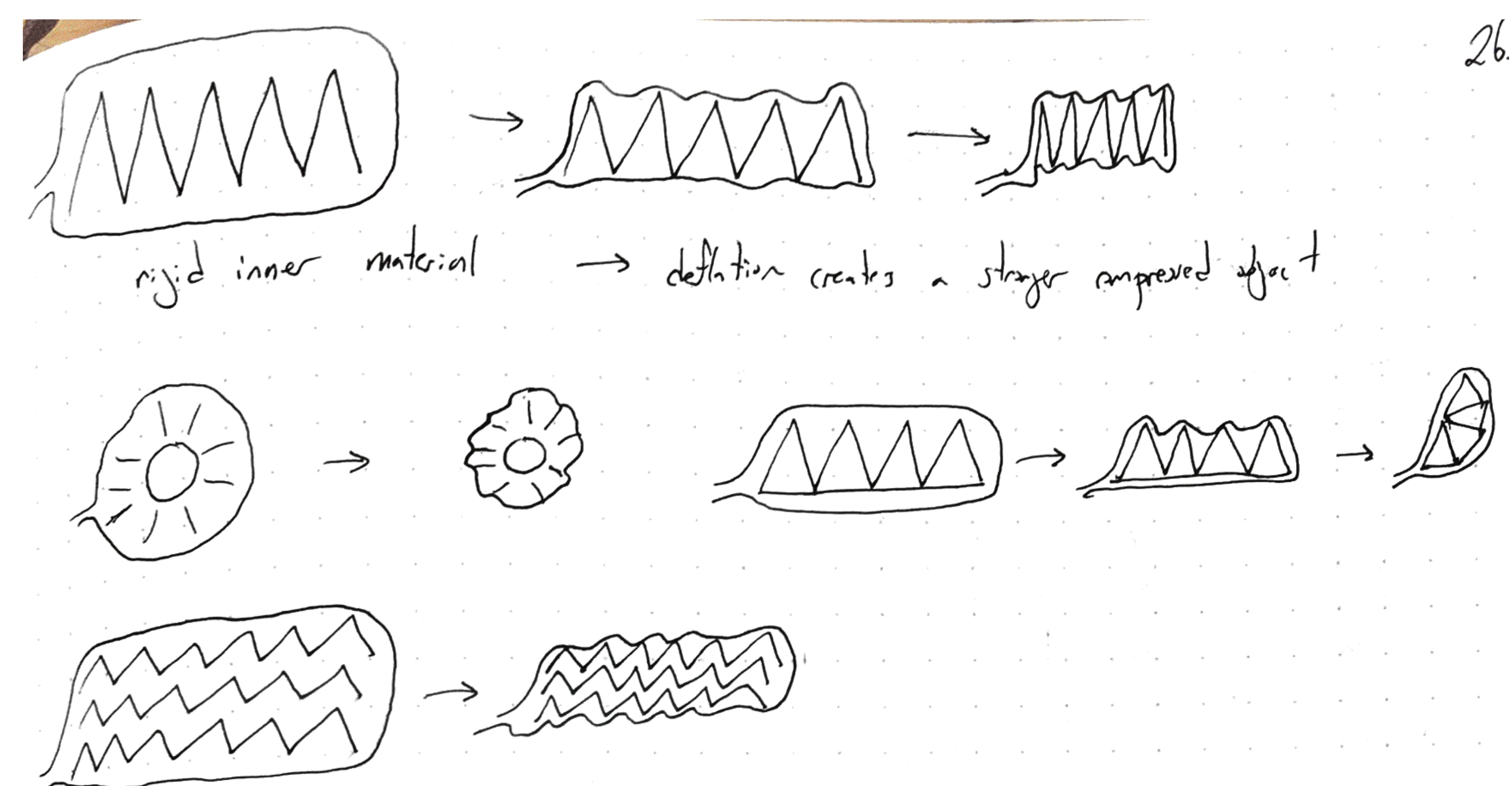
Door concept

Several shapes were considered for the overall structure of the luggage. These included one like a dry bag, which would have one circular opening at the top that could be folded over during compression. Another had a door on the front, like typical wheeled luggage, and a valve at the top which could be opened and closed for compression. When closed, the valve would keep the bag airtight, either allowing it to remain compressed or inflated.

Once the bag is deflated, the accordion-shaped rigid structures will act as a flexible, shock-absorbing padding that can form to the shape of the object they're protecting.



Concept for compression in accordion shapes post-inflation



Mechanism of deflation in accordion-shaped structures

Cardboard prototype with accordion fold

Cardboard prototype with triangluar fold

Paper prototype with triangluar fold

Mylar prototype with triangluar fold

Folded accordion fold

Folded triangular fold

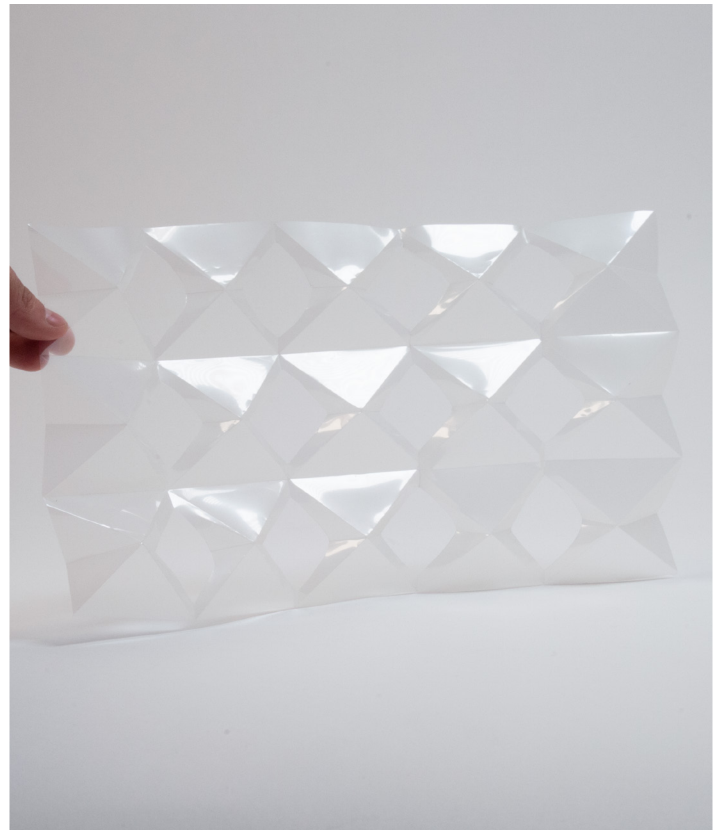
Folded paper prototype

Folded mylar prototype

Model of a wall, where triangles are adhered to a sheet

These prototypes focused on the inner rigid structure of the deflatables. As air is pulled out of the plastic bags, the structures are forced upward and compress to flatter shapes. The amount they compress can be changed depending on the shape they're pressed against, and the extent to which air is pulled out of them.

They also explored the different kinds of materials that could be used for the folds. Mylar was originally chosen as a material, but was hard to manufacture in larger scale models, so thick paper was used for the final prototype.

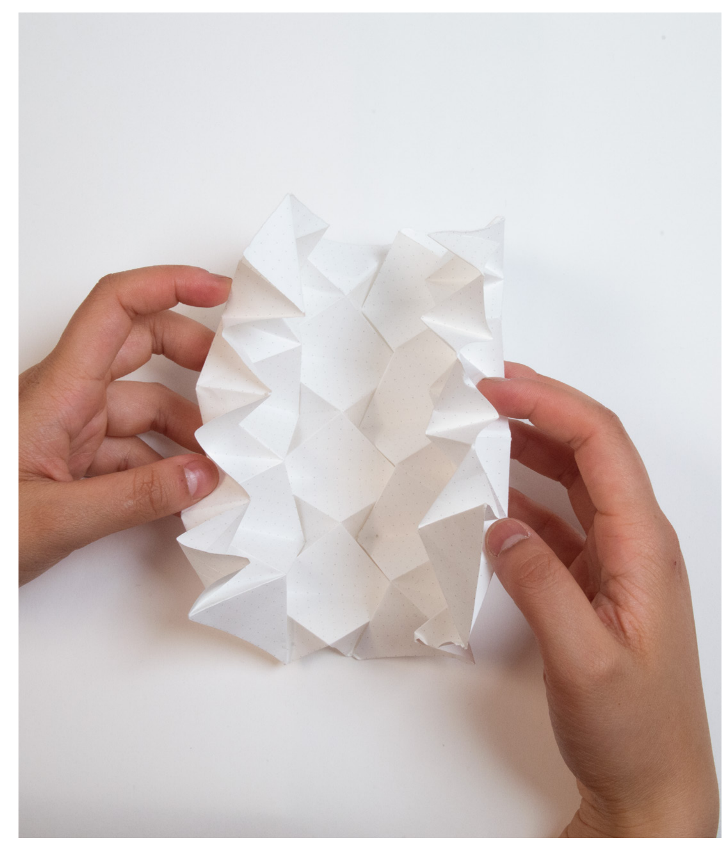


Model of a wall, with holes cut in the triangular pattern

From there, the structure of the folds had to be figured out so corners and surfaces could be created that still compressed uniformly. It was found that, when folded correctly, the triangle pattern naturally curved inwards, creating a corner-like shape. The direction of the curve depended on the way in which the triangular folds were sized (shown to the right). For the walls, holes had to be cut in the pattern, to allow it to fold uniformly.

A folding test, which caved in on itself

A folding test that created a corner



Expanded folding test

Compressed corner folding test

Concept of full bag structure (minus a door and lid) - with two curves and two walls

Compressed full bag structure

Other concept for full bag structure - with four corners and four walls

Seveal designs were considered for the overall structure of the luggage. One consisted of four corners and four walls, much like typical luggage - however this structure had scaling issues and was misproportioned when brought to full scale. Another was having two full curves, and two walls, so the luggage would be almost oval shaped. This was able to scale better, so it was chosen for the final structure.

Final full-scale prototype

The door of the luggage, which can be compressed so it stays open

Compressed full-scale luggage

Back of the luggage - the top and bottom have tabs that would hold the telescoping handle

Side view of full-scale luggage

The luggage door, uncompressed

Compressed luggage door

Detail view of the luggage corner

The final prototype of the luggage added a valve detail that would allow the user to compress and decompress the bag easily. This detail was mirrored on the door, which would make it so the door could be opened, and then its valve closed, allowing the door to remain open as long as desired. In the future, a zipper would also be installed along the edge of the door. The top and bottom pieces of the luggage have tabs on the back, which the telescoping handle would fit through. The bottom would also hold the bag's 4 wheels.