

# A Study in the use of Elastic Material in Expandable Containment Units

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# Who We Are

- Joby Anthony III
  - Junior
  - Mechanical Engineering Student
- Andrew Eisenman
  - Freshman
  - Mechanical Engineering Student
- David Satagaj
  - Freshman
  - Computer Engineering Student

# The Problem

- The current world population is over 7 Billion people
- By 2100 it has been projected that the world population will be 11.2 billion people\*
- As humanity grows, we are going to get closer to running out of space. The nearer we get to this, the greater a need we will have for containment units, whether it be shipping containers, domestic storage containers, or packaging. Containment units that can both expand or decrease to fit the situation will be in great demand

\*Max Roser and Esteban Ortiz-Ospina (2017) – 'World Population Growth'. Published online at OurWorldInData.org. Retrieved from: <https://ourworldindata.org/world-population-growth/> [Online Resource]

# The Solution

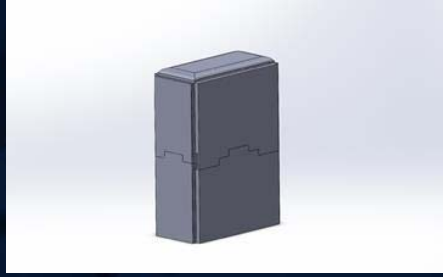
- There are many paths the scientific community can take, such as interlocking segments, hinged panels, or the use of elastic materials in the next generation of containers.
- Our purpose is not to find the final solution to this problem, but to lay a small bit of the foundation that later research will build upon
- The team selected elastic material as the path that we wanted to test
- As a scaled down case-study, a small backpack was designed to test the basic problems and concepts

# Design process

- The design started off as being created out of wood and nylon webbing, but PVC (polymer of vinyl chloride) and a more elastic cloth (a spandex/nylon mix) was decided upon due to their individual strengths.
- PVC is rigid, yet flexible, with the added benefit of being easy to cut and mold to a desired shape
- An elastic mix of Spandex and Nylon allows for flexibility and expansion, while the Nylon creates sturdiness between the joints



The original prototype was made out of cardboard and nylon



The knowledge gained was used to visualize it in Solidworks 3-D software



The final prototype was created out of PVC and elastic cloth

# Construction Process

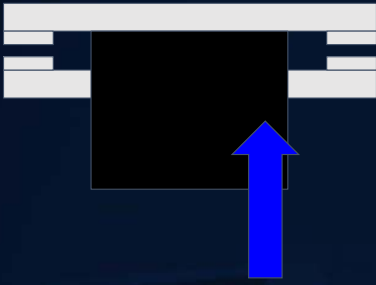
- Bought Materials

- Fabric (Spandex-Nylon mix) from “The Fabric Warehouse” in Harrisonburg, VA
- PVC (2' x4' sheets) from Online Metal Supply through Amazon
- “3M High Strength 90” Concrete Cement from Lowes
- Patterning paper and brass hinges from Walmart

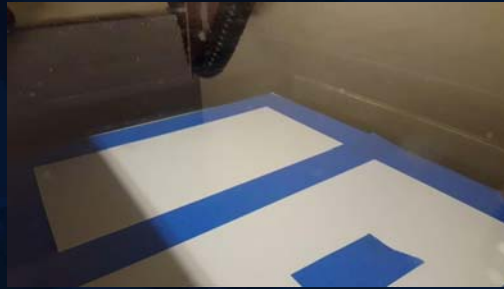
# Selecting the fabric

- 3 different fabrics were tested in the field.
- The testing process involved calculating each fabric's maximum length of stretch and how much force was required to pull it that length. After that, the minimum length of stretch was selected, and the fabric that took the greatest amount of force to stretch that length was selected.
- Our reasoning was that when it comes to a ratio of strength/elasticity, it would be more useful to work from one end of the spectrum backwards to a "perfect" compromise. We chose to start with strength > elasticity due to cost effectiveness and time-constraints.





Each piece was created with 2-3 layers of PVC with the cloth laying between each layer, all glued together by contact cement



Each piece of PVC was designed in Adobe Illustrator and cut out on the Universal Laser PLS.45



The final prototype was assembled over 3 days

# Procedure Plan

Calculate volume at rest: 0.87 cubic feet

Fill backpack with average amount of student gear

Conduct stress tests after 1 - 2 days

Calculate expansion at limits: 1.72 cubic feet

Calculate weight limit: 140 pounds

Volume Formula:

$$V_T = V_O + y_{fz_{fl}}[(y_f^2/96\Delta x) + \Delta x] + x_{fy_{fl}}[(y_f^2/96\Delta x) + \Delta x]$$

Weight Limit Formula:

$$M = \sqrt{[(388 * F^2/g^2) - 2m^2]}$$

# Results

- What happened?
- What did we learn?
- How should we respond to this outcome?
- What needs to be done next?

# What Happened?

- We wore the backpack for two days
- The backpack held up, and was able to expand to hold a much larger volume
- It held 8 - 12 pounds of books and supplies for hours at a time without trouble

# What Happened?

- The backpack held under normal stresses of a student's life for 24 hours; however, the glue bond on the straps was broken at the end of this 24 hour period.
- Given large initial state of pack, a large amount of material is required to cause expansion; does not compromise comfortability of wear.

# What Happened?

- Initial volume of backpack unexpanded is 1.72 cubic feet
- Expanded volume calculated with formula is 0.87 cubic feet
- Percent of volume increase between 45 and 50%
- Experiment determined success because projected expansion of volume goal was 5-10%

# What did we learn?

- Contact cement is not a strong enough adhesive for long-term use
- How each individual piece should be assembled

# How should we respond?

- The idea of using elastic material in partnership with hard materials such as plastics seems to be viable if a stronger method of adhesion is applied
- The problem of gaps between strips of fabric still needs to be addressed
- Create another, more complete prototype to continue testing and address these issues



# What's next?

What happened?

- A backpack was given stiff components, that allowed for expansion, without compromising structural integrity

What did we learn?

- The adhesive chemical must outlast expansive qualities of material

How should we respond to this outcome?

- Experiment a success because percent of increase higher than expected 5-10%

What needs to be done next?

- Redesign the expandable containment unit that allows for more efficient mass production

# Questions?



