Haul - A - Day

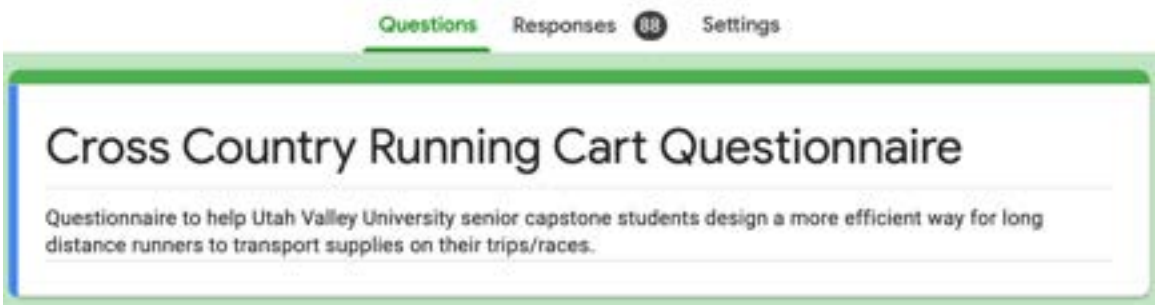
Kevin Adams, Robbie Brewer, Cade Engemann, Allyson Marchant, and Elzi Nielsen
Project Coach: Professor Jaafar
April 22, 2022

Abstract

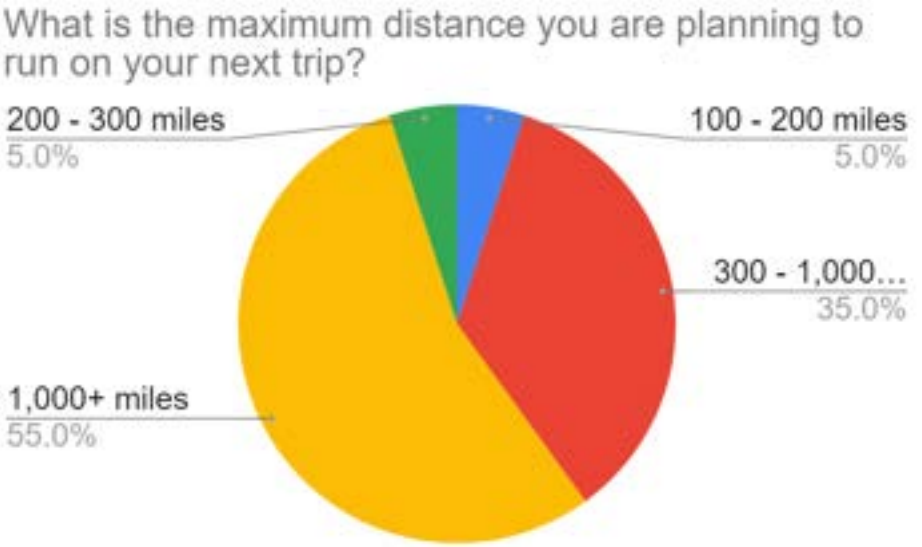
- Extremely long distance runners lack a sufficient way to carry their supplies on long trips

Problem Definition: Design and manufacture a vehicle to carry supplies for self-sufficient multi-day running trips.

Research

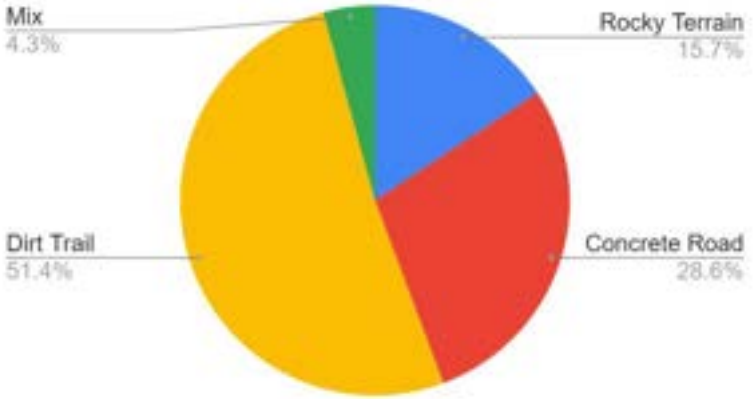


- Online survey posted to Facebook and other forums
  - Zwift Long Distance Runners
  - Trail and Ultra Running
  - Wasatch Mountain Wranglers
  - USA Crossers
- Online messaging with long distance runners

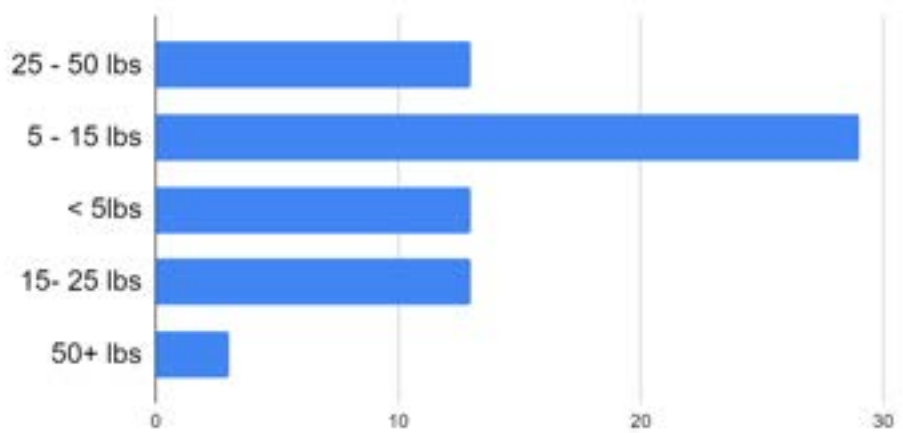


Data Overview

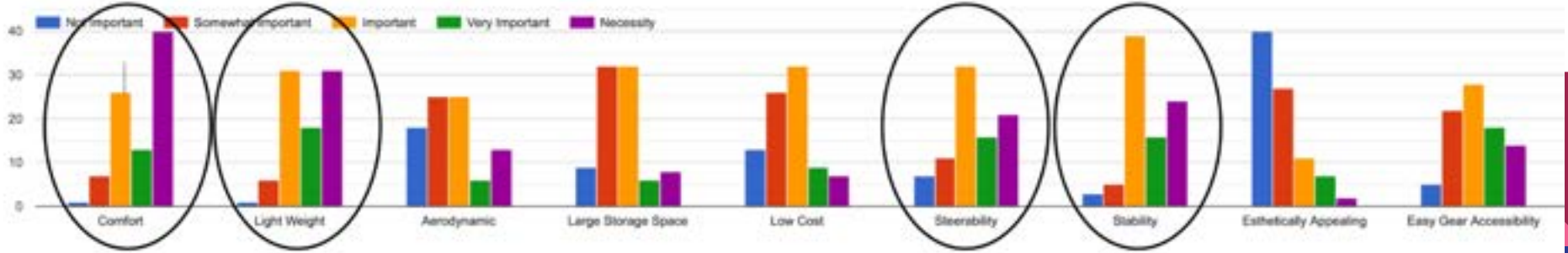
What type of terrain do you primarily run on?



What is the average weight of your total gear load?



Rate the importance of the following features:



Regulations and Standards
ASTM - Bicycles and Baby Strollers

FIG. 28 Swivel Assembly

7.13.2.3 Apply a pull force of 45 lbf (200 N) to the swivel assembly in line with the direction normally associated with removal of the swivel assembly, Fig. 28. Gradually apply the pull force within a period of 5 s and maintain for an additional 10 s.

6.2.1 A carriage shall support a static load of 50 lbf (222 N) when placed in the approximate center of the area intended to support the infant occupant.

5.7.1 The unit, when in the manufacturer's recommended use position, shall be designed and constructed so as to prevent injury to the occupant from any scissoring, shearing, or pinching when members or components rotate about a common axis or fastening point, slide, pivot, fold, or otherwise move relative to one another. Scissoring, shearing, or pinching that may cause injury exists when the edges of the rigid parts admit a 0.210-in. (5.33-mm) diameter probe but do not admit a 0.375-in. (9.53-mm) diameter probe at any accessible point throughout the range of motion of such parts. This excludes the adjustment of accessory items such as storage latches, baskets, etc.

5.8 *Exposed Coil Springs*—Any exposed coil spring which is accessible to the occupant, having or capable of generating a space between coils of 0.210 in. (5.33 mm) or greater during static load testing (see 6.2 and 7.3) shall be covered or otherwise designed to prevent injury from entrapment.

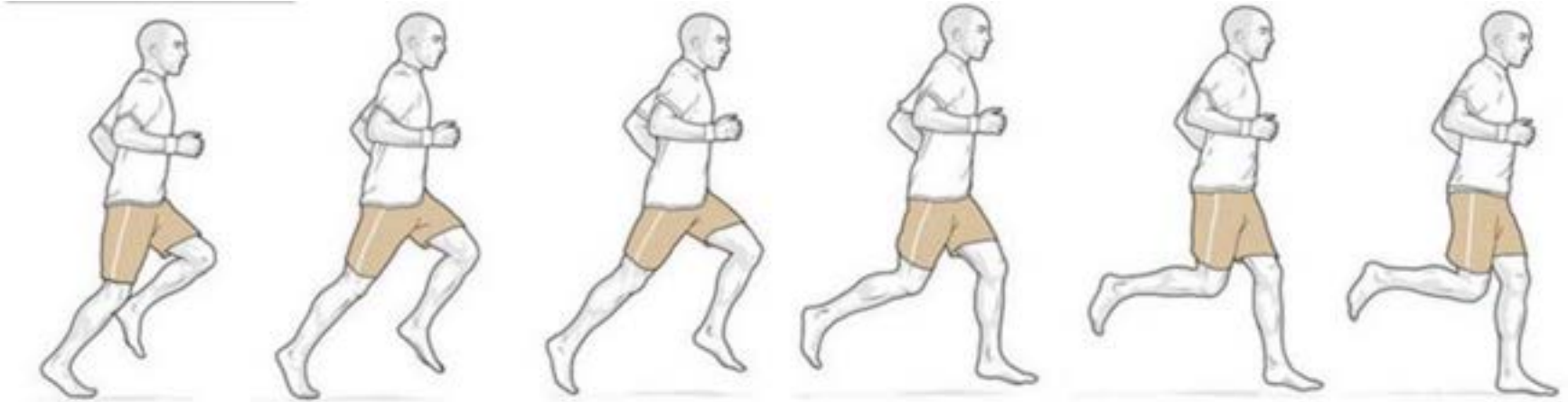
UT bike code 41-6a-1113 - Every bicycle shall be equipped with a brake or brakes which enable its driver to stop the bicycle within 25 feet from a speed of 10 miles per hour on dry, level, clean pavement.

Design Criteria: Vehicle Structure

1. Carries a maximum load of 100 pounds
2. Less than 30 minutes of maintenance per thousand miles
3. Costs $800 or less for customer purchase
4. Gear needed while running can be accessed while running
5. Gear not needed while running can be accessed within 20 seconds after stopping

Design Criteria: Comfort and Running Performance

1. Less chafing and trapping of heat than a backpack/vest weighing 20 lbs
2. Runner can run with cart 75% of their uninhibited max running distance
3. Allows runner proper running form
4. Can easily pull/push cart up and down grades of 15% or less



Design Criteria: Safety

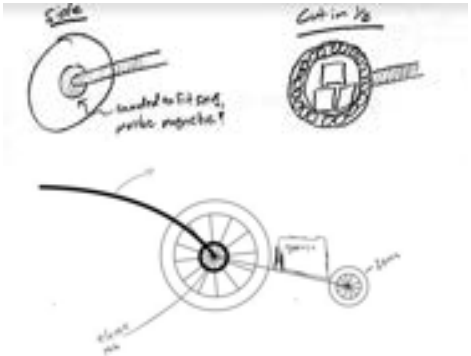
1. Visible from at least 150 feet in all lighting
2. Detaches in under 1-3 second

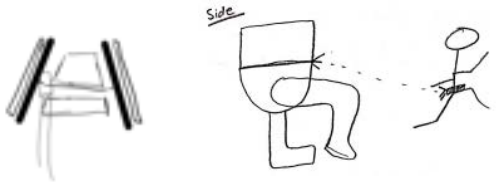
Design Criteria: Multiple Terrain Options

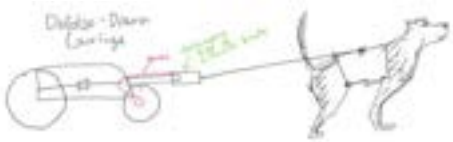
1. Less than 3 inches of unwanted lateral movement
2. Self stabilizes up to 30 degrees with minimal torsion on runner
3. Fits on single track trail 30 inches and narrower

Concept Generation

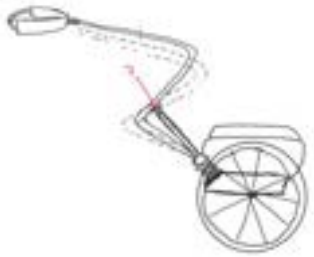
Chassis

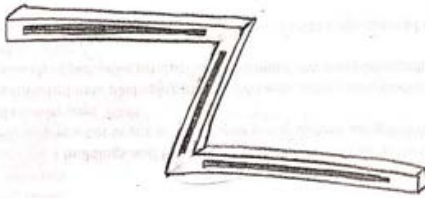


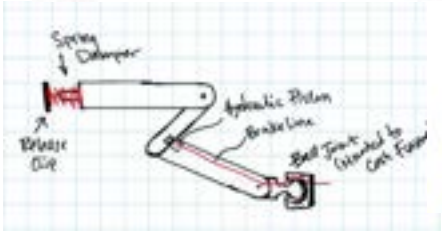


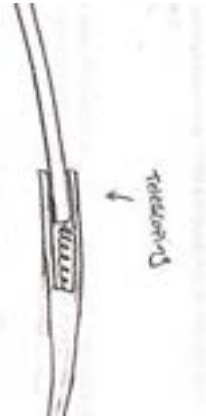


Misc.

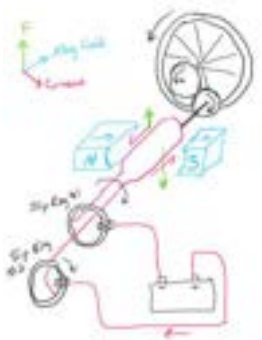


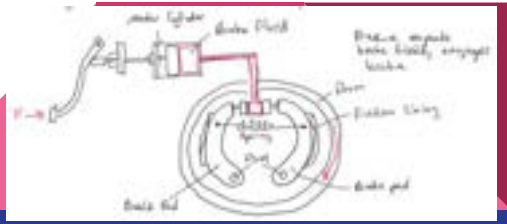






Connection Bar





Frame Scoring Matrix

- A scoring matrix was made for each main component
  - Chassis, Connection Bar, Braking System
- Each criteria was weighted by importance
- Close designs were prototyped before final decision

	Weight	Ball/ BB8	2 Wheel tube	2 wheels front	Big wheel	Single wheel	Sport chair	2 wheel cart	S. wheel w/ comp.	Tricycle
Needs vs Concepts										
Lightweight	5	5*1=5	5*3=15	5*2=10	5*4=20	5*5=25	5*4=20	5*4=20	5*5=25	5*5=25
Sturdy	5	5*3=15	5*5=25	5*5=25	5*4=20	5*5=25	5*4=20	5*4=20	5*3=15	5*5=25
Trail width or less	5	5*5=25	5*2=10	5*5=25	5*4=20	5*5=25	5*4=20	5*4=20	5*5=25	5*4=20
Limits bouncing	2	2*2=4	2*1=2	2*4=8	2*4=8	2*2=4	2*3=6	2*3=6	2*2=4	2*3=6
Road	5	5*5=25	5*5=25	5*3=15	5*5=25	5*5=25	5*5=25	5*5=25	5*5=25	5*5=25
Limits rotation	3	3*3=9	3*5=15	3*2=6	3*4=12	3*1=3	3*5=15	3*4=12	3*2=6	3*3=9
Manufactorablility	5	5*1=5	5*3=15	5*5=25	5*5=25	5*3=15	5*4=20	5*5=25	5*1=5	5*5=25
Collapsable	3	3*5=15	3*4=12	3*2=6	3*2=6	3*1=3	3*4=12	3*4=12	3*1=3	3*2=6
Cost	1	1*1=1	1*3=3	1*4=4	1*4=4	1*4=4	1*4=4	1*5=5	1*2=2	1*4=4
Push/Pull	2	2*2=4	2*5=10	2*2=4	2*4=8	2*1=2	2*5=10	2*5=10	2*1=2	2*5=10
Shelterable	3	3*0=0	3*2=6	3*4=12	3*3=9	3*0=0	3*4=12	3*4=12	3*0=0	3*4=12
Sum		108	138	115	157	131	164	167	112	167

Prototyping

- Iterative prototyping was critical from the beginning of the project to completion
- Specific components and overall design

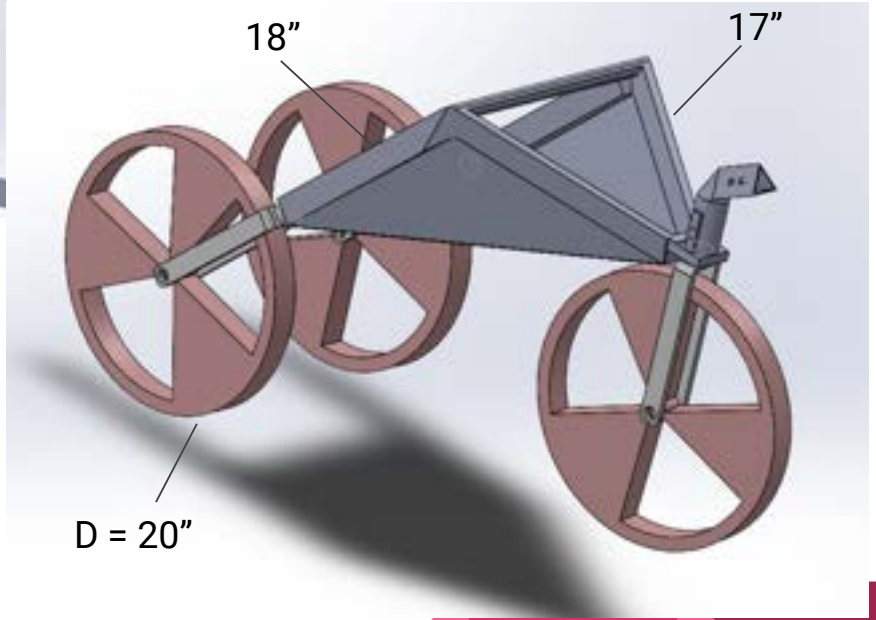
Carbon Fiber Compliant Arm

- Ashton Engineering

3D Modeling

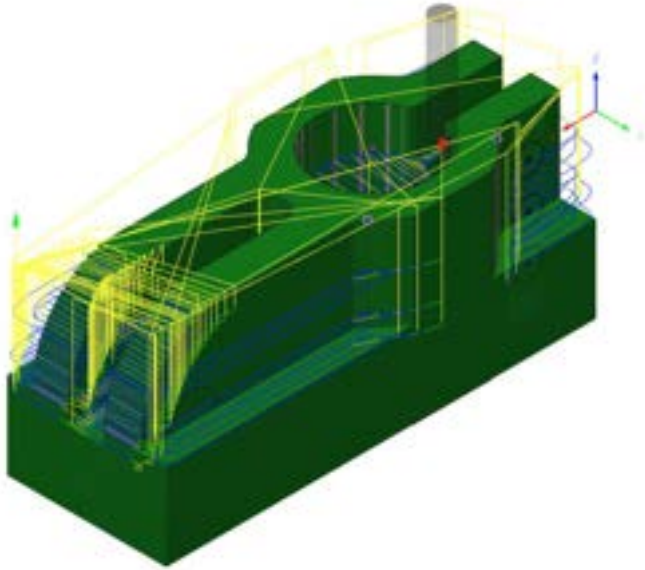
Compliant point

Z Bar Connection Arm from Cart to Runner



3rd Wheel Design for Chassis

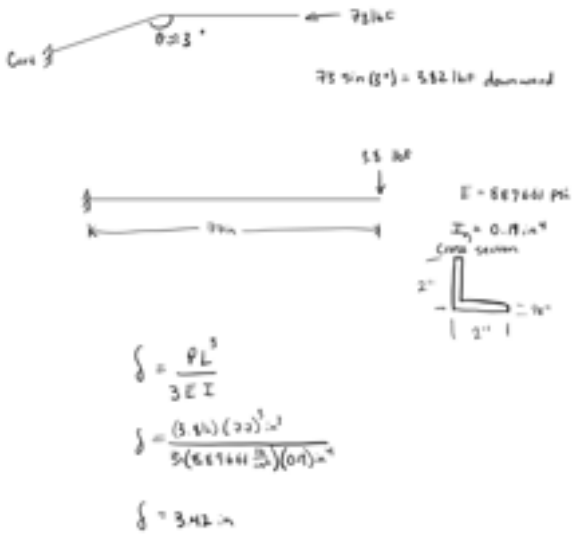
Computer Aided Manufacturing



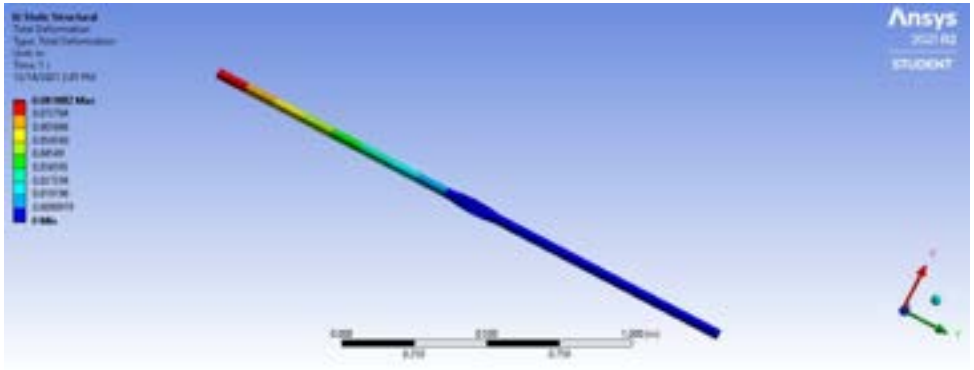
Generating Toolpaths

Assembly of Braking System

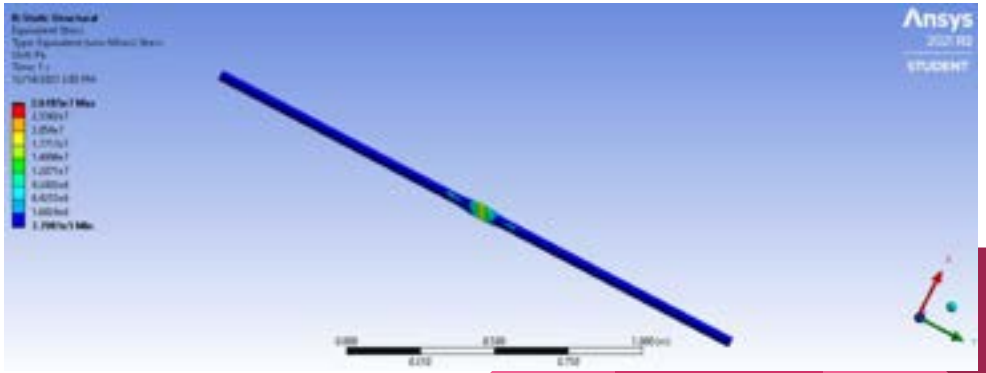
Analysis - Compliant Bar



Deformation hand calculations



Total deformation 3.14in.

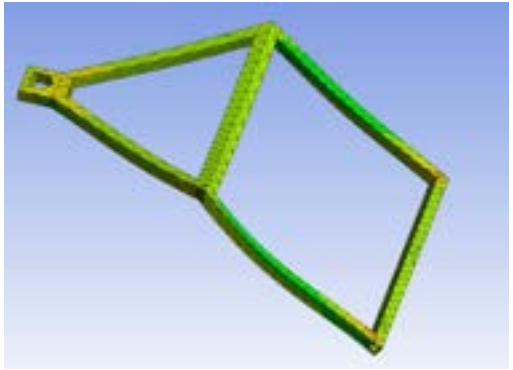


Total shear stress is 2Mpa

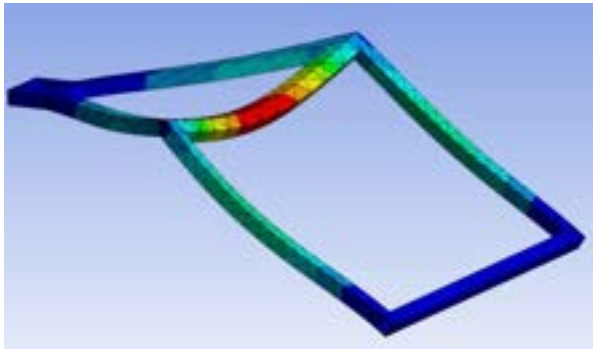
Analysis - Frame

Pressure in Y : 4775Pa
Force in X: 73.2lbf
Aluminum 6061: 276 MPa

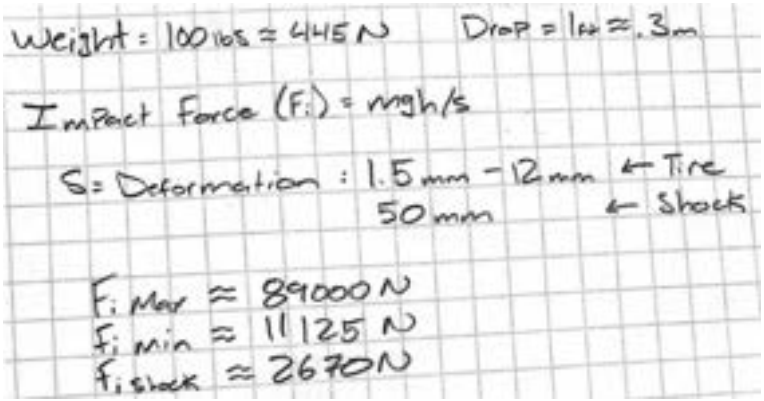
Lateral Force Analysis



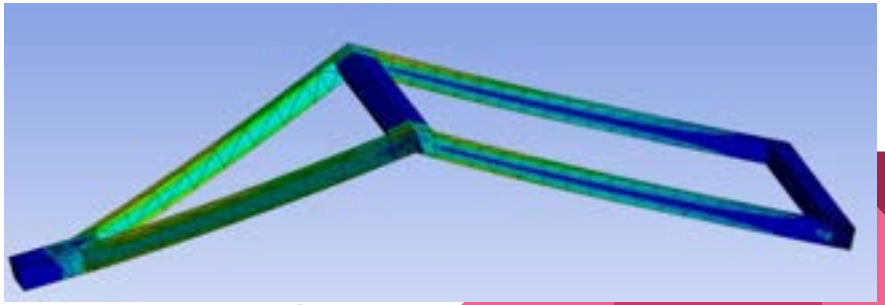
Max Stress: 2.4 MPa



Max Deformation: .001in



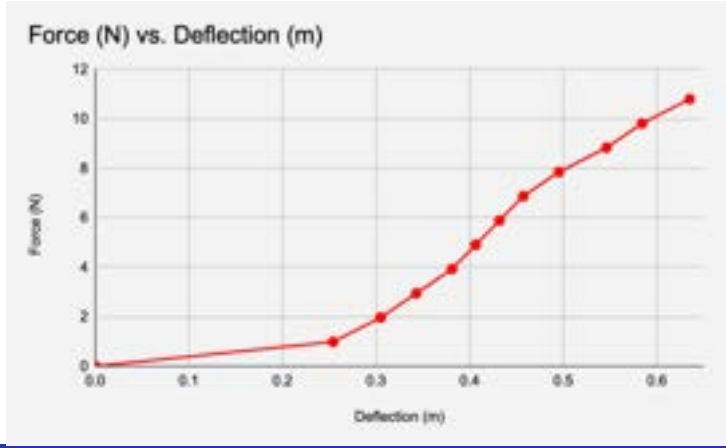
Vertical (Drop) Force Analysis

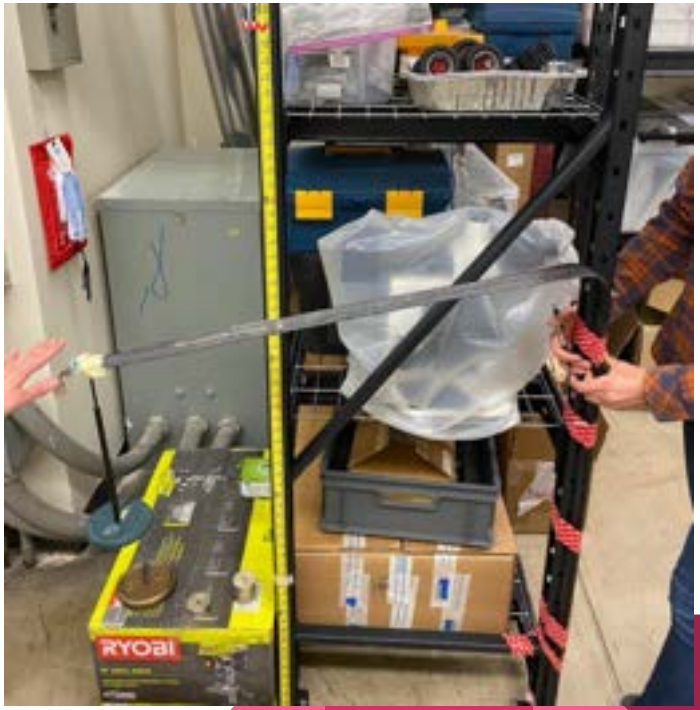


Max Shear Stress: 162 MPa

Compliant Arm Testing (v2)

- Tested for displacement to determine rigidity
- Max Deformation: 0.635m (25 in) from 10.8N (≈2.5lbs)
- Result: Too much deflection!
- Solution: Changed Geometry of compliant section
  - Added ridge down center





Manufacturing and Assembly

- Fabrication and Welding took much longer than anticipated.
- Minor adjustments to design were made along the way to accommodate.
- Some of the aluminum components were not able to be welded and alternative fastening methods were required.
- Sewing and compartments

Final Product

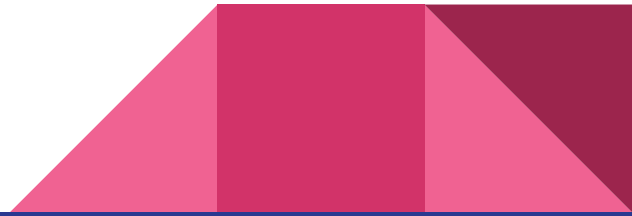
Design Criteria	Test Result
Carry 100lbs	Yes
Total Cost	$1100
Gear be accessed while running and within 20 sec of stop	Yes, easy zipper
Push and Pull	Yes
Allows proper running form	Yes
Can run 75% of max running	Yes

Design Criteria	Test Result
Less heat trapping than backpack	Yes
Visible from 150ft	Yes
Less than 3” of unwanted lateral movement	Yes
Detaches in under 3 seconds	Yes, belt clip
Stable up to 30 degrees of tilt	Yes
Less than 30” wide (single track)	Yes, Width: 28.5”

Future Improvements

- Better Brake Lever Integration
- Pressurized water delivery to runner
- Increased Storage Area
- Assisted Power Delivery

Questions?



Thanks to Everyone Involved!

Special thanks our voluntary team member Curtis Burgis for late nights in the shop aluminum tig welding and our Team Coach Dr. Jaafar!