

MOTIVATION

- 131 million wheelchair users worldwide [1]
- Many customizable aspects of wheelchairs.
- Footrests are vital to maintain stability, comfort, and safety of users.
- Current wheelchair models...
 - Do not account for varying levels or mobility
 - Are difficult or too heavy to use [2]



Figure 1: Quickie Q700M Wheelchair [3]

PROBLEM STATEMENT

- Currently no wheelchairs on the market that allow users who are not paralyzed to perform helpful movements.
- Current models of footrests are too heavy, bulky, and not easily able to be removed and stored when not in use.
- The updated footrests should be:
 - Able to adapt to a person's abilities
 - Easily removable and able to be stored when not in use
 - Lighter and less bulky
 - Still provide the benefits and support of a footrest when necessary

BACKGROUND

- Wheelchair Footrests offer support and play a significant role in supporting appropriate pelvic and lower limb positioning.



Figure 2: Competing Design (Invacare Hemi Elevating Leg Rests) [4]

- Existing Devices, Components, and Current Methods:
 - Footrest:
 - Consists of footrest hanger and footplate.
 - Footplate at 90 degrees
 - Leg Rest:
 - Consists of footrest hanger, footplate, and calf support component.

DESIGN CRITERIA

- Combined weight below 3-4 lbs.
- Ability to fold footrests up or easily remove and store them.
- Lifespan between 4-5 years.
- Must be able to withstand 14-80 °F [5], be waterproof, and have ground clearance of 3 inches.
- Must be able to support weight of clients feet, or 15.25 lbs [6], and footplate must be constructed of material that can withstand stress up to 0.424 lbs/in².
- Production cost should not exceed \$100.

FINAL DESIGN

- Final design consists of an aluminum footplate attached to a castor cap with a 90 degree hinge.
 - Aluminum Footplate:
 - AA6601-T6
 - Yield stress of $40.03 \times 10^3 \text{ lb/in}^2$ [7]
 - Each footplate is 6" x 6"
 - 9 Holes located on footplate in 3 rows, 1" from edge 2" apart
 - Castor Cap:
 - Designed on Autocad
 - Made of tough PLA (132 grams)
 - Placed into the holes of the the castor wheels of the wheelchair
 - Velcro straps added beneath each castor attached to cap for stability (12" x 1")
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 - 100 Degree Hinge:
 - Stainless steel
 - 3.35" L x 2.44" W
 - 5 ounces
 - Soft Close
 - Allows footplate to lock when in storage mode
 - Storage:
 - Footplate can fold up 90 degrees to be in storage mode
 - Detachment of footplate from castor cap or removing entire device from castor

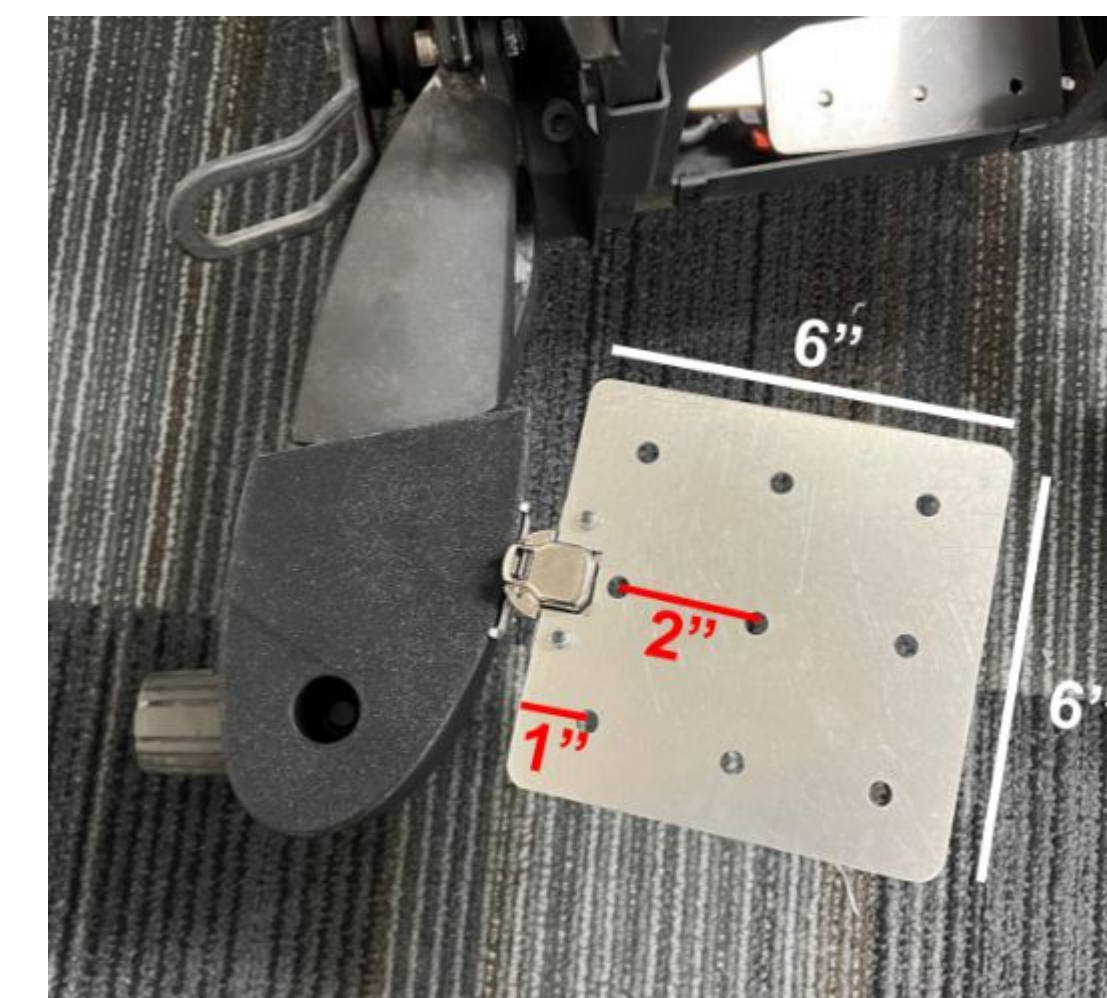


Figure 3: Footplate in position for use

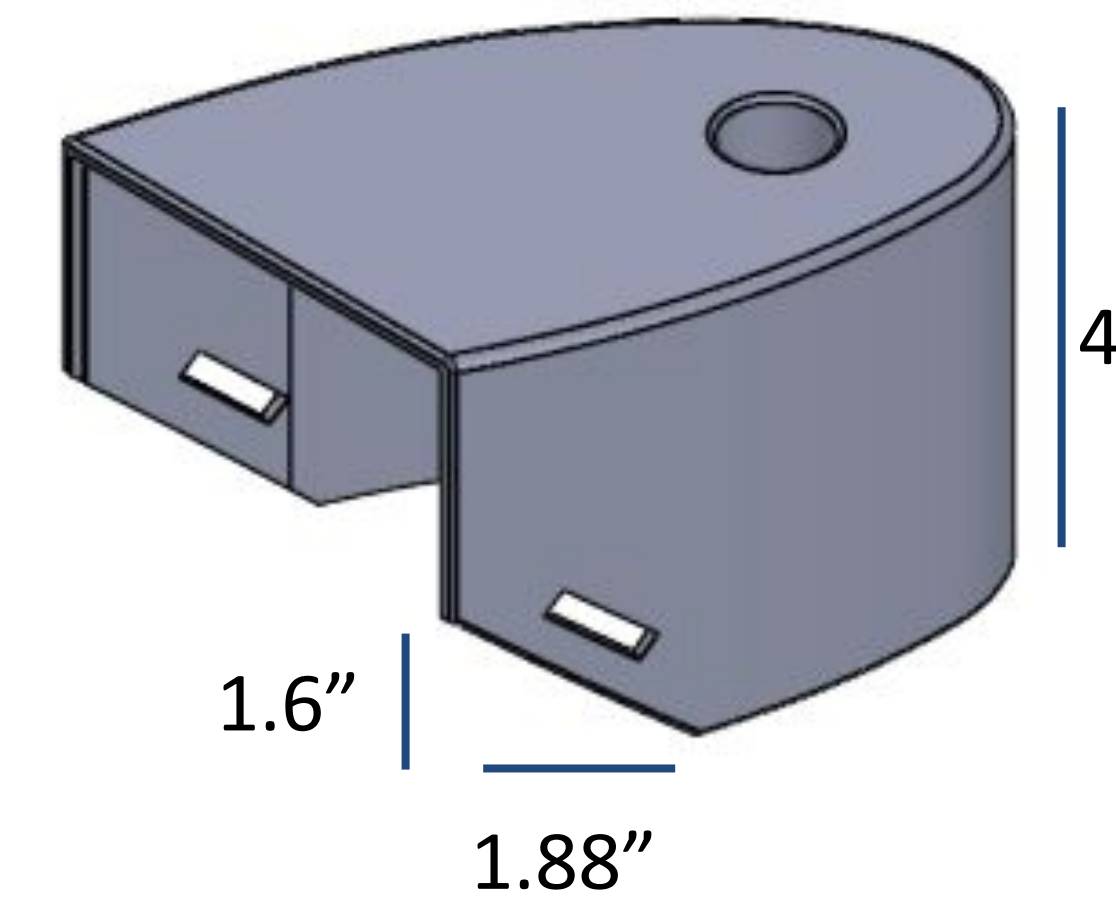


Figure 4: Final CAD Drawing for Cap

TESTING

- Ground Clearance Test:
 - Team member pushes wheelchair base with prototype on various terrain for 1 minute intervals. The prototype's ground clearance is then rated on a scale from 1-10.
- Force Test:
 - Performed to ensure the footrests are able to support the force of the clients legs while maintaining structural integrity.
 - Various weights are placed on the footrests and deflection of the footrest is measured.
- Ease of Use Test - Maneuvering Footplate:
 - Tests ease of use of moving the footplate between stored position and folded down position.
 - Participants move the footplate up and down and rate ease on a scale from 1-10.
- Ease of Use Test - Attaching and Removing Prototype:
 - Participants attach and remove the device from the wheelchair and rate ease on a scale from 1-10.



Figure 5: Force Test



Figure 6: Ease of Use of Maneuvering Footplate Test

RESULTS

- ✓ Combined weight below 3-4 pounds.
- ✓ Lifespan between 4-5 years.
- ✓ Must be able to withstand 14-80 °F.
- ✓ Be waterproof.
- ✓ Ground clearance of 3 inches.
- ❑ Must be able to support a weight of 30.5 lbs.
- ✓ Footplate must be constructed of material that can withstand stress of 0.423 lb/in².
- ✓ Production cost should not exceed \$100.
- ✓ Ability to fold footrests out of the way.
- ❑ Ability to easily remove and reattach footrests.

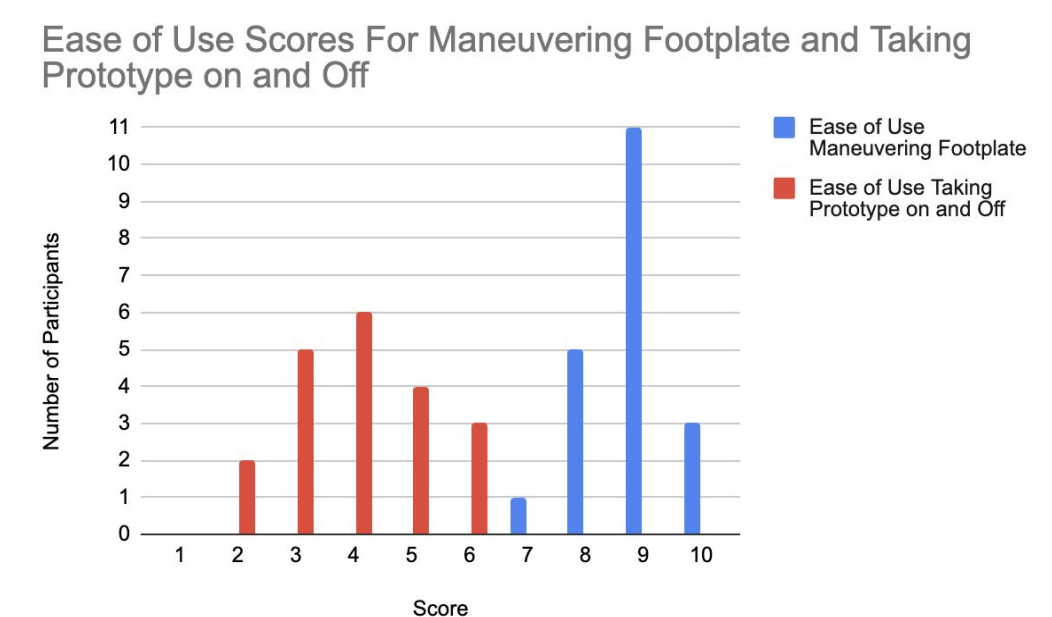


Figure 7: Graph detailing ease of use scores assigned by UW-Madison Students.

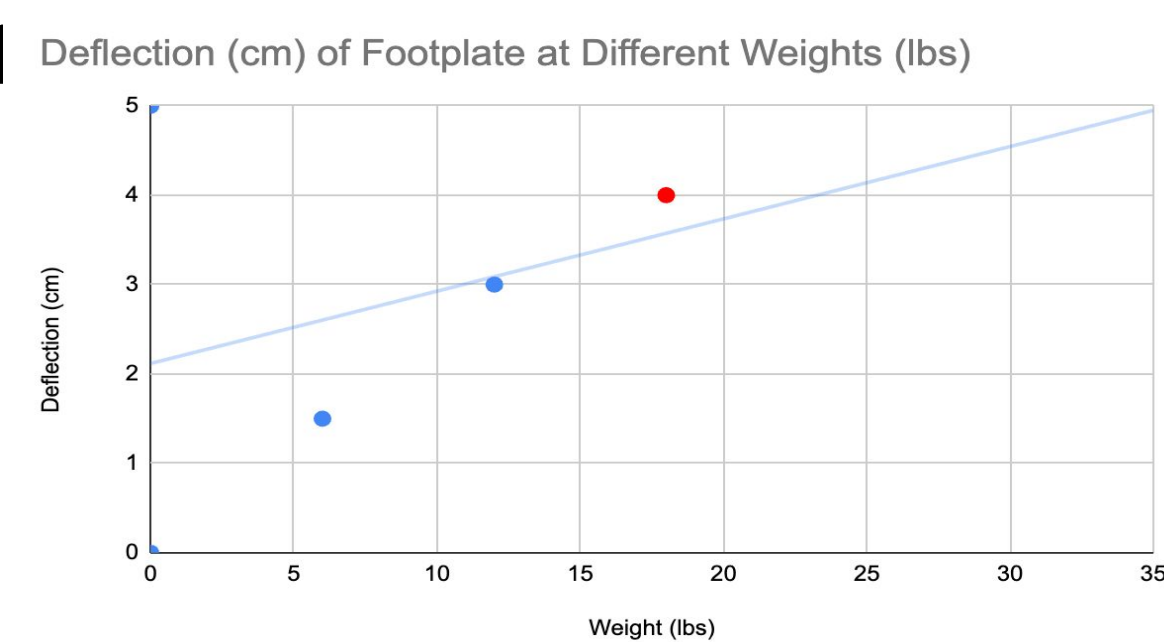


Figure 8: Graph detailing results of force testing.

DISCUSSION

- Ease of use interpretations mimicking vertical lifting of the foot is subjective and requires testing with the client to confirm operability.
- Design maintained a ground clearance of 3 in with minor wobbling.
- The AA6601-T6 footplate will not deform since the Factor of Safety is 9448.
- Large deflections questions hinge durability.
- Stress simulation of cap is a point of concern and the torsion due to eccentric loadings.
- Spent \$71.00, but not all items utilized.

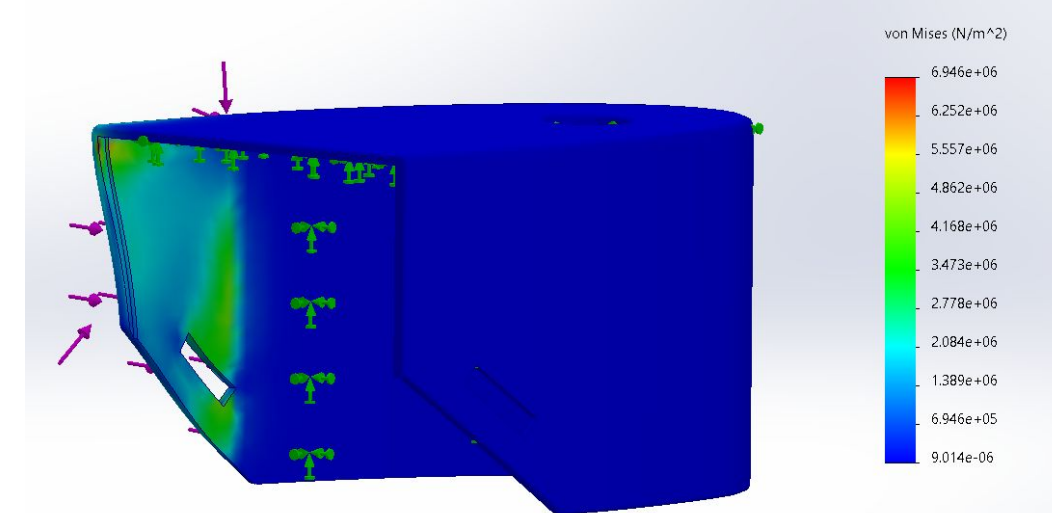


Figure 9: Simulation of applied loads onto cap

FUTURE WORK

- Improvements to design:
 - Hinge quality to address concerns about stress concentrations/deflection.
 - Modify fold angle to 90 degrees or less to counteract deflection.
 - Resize the cap for a better fit and thicker walls to maximize durability.
 - Explore alternatives mechanisms for supporting the cap beyond Velcro.
- Test functionality on client's current wheelchair.
- Perform long term usage stress tests.

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REFERENCES

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