Shape Memory Alloy Wheels for Rough Terrain Wheelchair

Team Hyperion

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Background

Wheelchair users currently must pick between indoor convenience and outdoor accessibility, limiting their mobility.

Figure 1. Outdoor Wheelchair

Figure 2. Indoor Wheelchair

Problem Identified

- Outdoor wheelchairs are expensive and unrealistic for many users
- Indoor wheelchairs cannot be used outside

Limited Existing Solutions

- Outdoor wheelchairs that can navigate difficult terrain
- Indoor lightweight and cost-effective wheelchairs

Currently, no existing solutions solve all identified problems

This problem led to our research question

Can we make a wheelchair/tire that can navigate indoor and outdoor terrain, all in one design, using NASA tech?

The NASA IP/Research

LEWS-TOPS-161: Shape Memory Alloy

Existing NASA tech used to make tires that can easily navigate rough terrain.

- Uses metal alloys that return to set position even if bent
- Currently used in NASA trucks

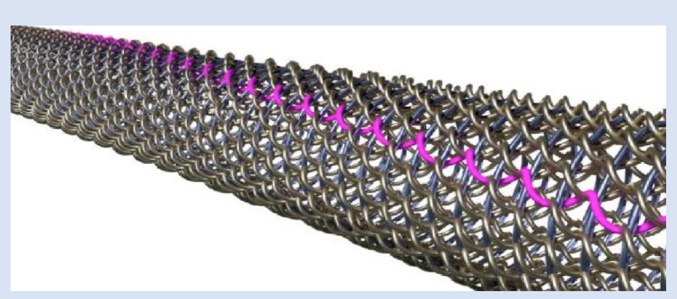


Figure 3. Tubular Shape Memory Alloy

The team utilized SMA for our tire's outdoor capabilities; using proven NASA tech helped in our model's development and timeline.

Custom Designed SMA Sheath

- Designed using a "coil" system to increase terrain management capabilities
- Concise and small for easy packaging
- Super Elastic NiTi Alloy
  - Nickel Titanium is the NASA standard
- 1-2 mm diameter chosen for structural support
- Set temp of -20*C to 50*C for super elastic range

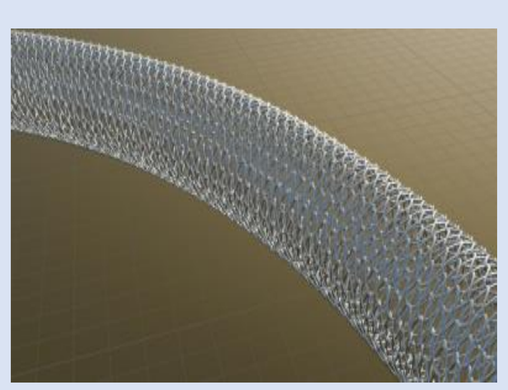
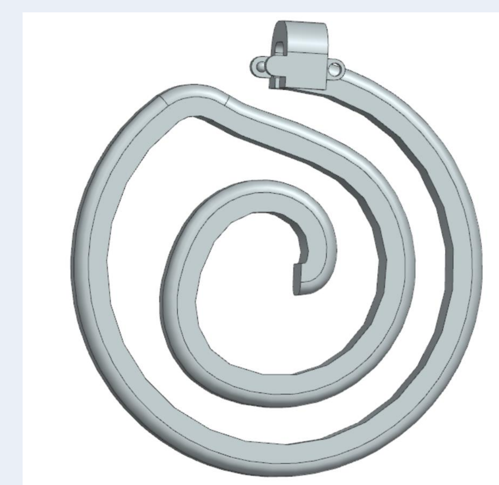
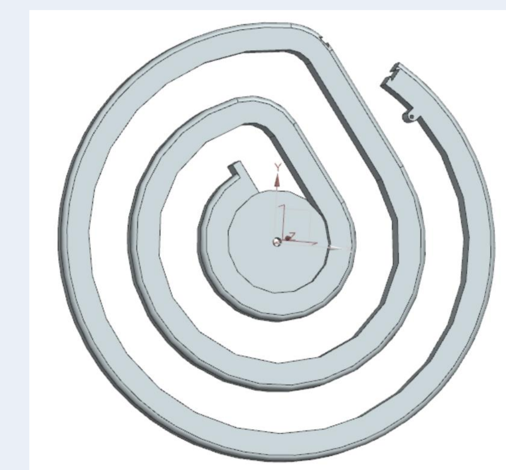


Figure 4. Custom SMA Sheath CAD

Design Goals

Goals	Parameters
Convenience (Easy and comfortable experience for user)	• Comfortable for the user • Quick Transition between tire modes (<5 Steps) • Compact (<5,000 in^3)
Independence (Can be operated completely independently)	• Lightweight • No Assistance; Can be used independently
Accessibility (Affordable for both consumer and company)	• Reduced materials required • Reduced manufacturing costs (<$300) • Functional between –20*C to 50*C

The Design Process

Iteration #1	Iteration #2
- SMA sheath follows internal spiral - Connected via locked slides - Pulled out by hand	- Adjusted spiral provides less slide jamming - Used ball bearings for smoother glide
 Figure 5. Iteration #1	 Figure 6. Iteration #2
Pros: • Efficient internal storage • Unique design	**Pros:** • Less jamming
Cons: • Slide jammed	**Cons:** • Material cost • Geometric constraints

Cons of both products led us to develop a system that reduced jamming with less materials.

Two Dot System

Problem

- Changing curvature on rails means one end of slider will travel further than the other
- Cannot used a curved rail bar; these follow a set trajectory

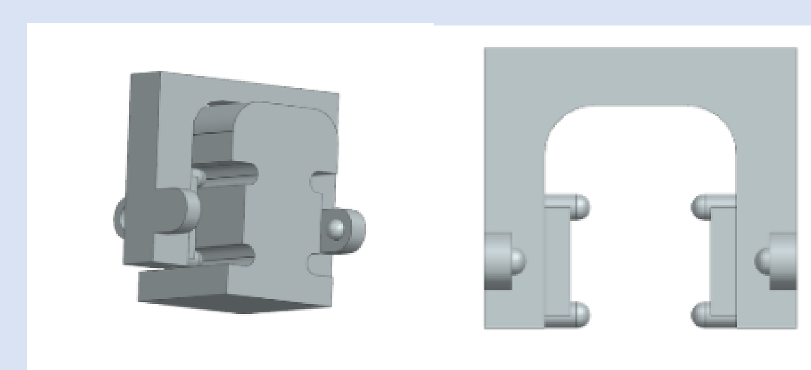


Figure 7. Two Dot System CAD

Our Solution

- Slider follows any curved rail by sliding on two rounded points instead of a bar
- Uses a pair of rounded knobs that keep the slider aligned as it travels
- This system allows the SMA sheath to be unrolled without jamming, creating a smoother user experience

Prototype/Testing

Figure 8. Prototype #1

First Prototype:

- Thick sliders often jammed
- Inconsistent outdoor to indoor mode transition
- Less detailed wheel frame
- No two dot system
- No gear and crank system

Hyperion Design Process

Brainstorm → **CAD** → **Assemble/Test** → **Review**

Figure 9. Assembling Prototype #2

Latest Prototype:

- Thinner sliders cause no jamming
- Smoother outdoor to indoor mode transition
- Two dot system implemented
- Gear and crank implemented
- Alternative prototype implemented ball bearings for an even smoother transition
- Larger and to scale model

Final Design

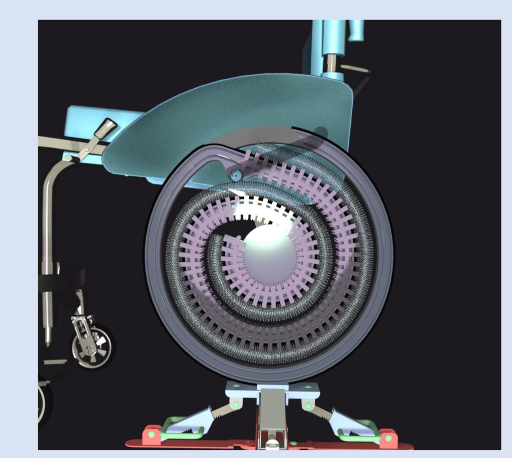
The Wheel Switch

- SMA sheath travels on changing curve rail on spiral using "two dot system"
- Wheel is stored inside by turning the entire frame inside and out into a single rail
- Utilizes plug to contain and release sheath
- Crank rotated on wheel mechanism pushes on each slider, forcing the sheath around the swirl rail for unrolling and storing

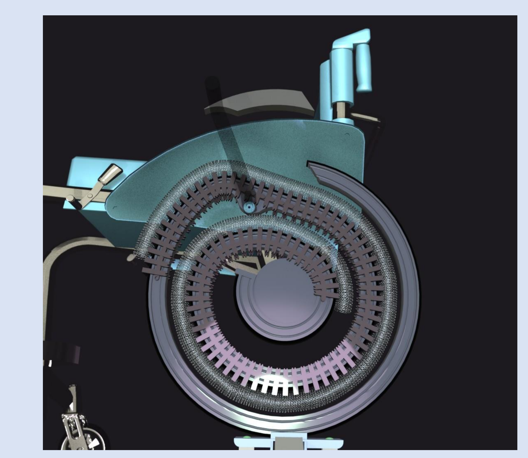
Figure 10. Standard Wheelchair Tire vs. Hyperion's Tire

Tire Switch Process

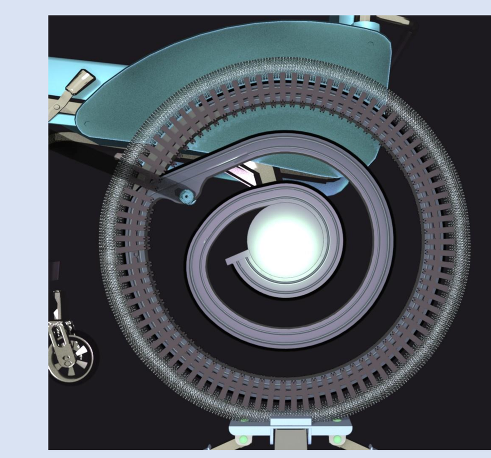
The tire can switch between indoor and outdoor tires by unplugging the plug and cranking the tire to deploy the SMA sheath, which wraps around the indoor hard tire.



Indoor Tire Activated



SMA Sheath Unrolling



Outdoor SMA Deployed

Future Directions

Our team has identified many next steps, such as improving our engineering design, testing manufacturing prices, and more.

- Research cost effectiveness
- Complete the business plan
- Manufacture and test product with SMA
- Reiterate design
- Compare ball bearing design

Conclusion

In conclusion, the team has designed and tested a potential solution for increasing accessibility for wheelchair users. The team has found that our solution is viable and can become a tech startup, meeting our TSGC and MITTIC goals.

The use of NASA tech has allowed for our team to quickly develop an innovative solution in shorter time; by using proven tech, we were able to save time on the research phase and begin prototype planning sooner. This empowered us to make a solution that met our design goals quickly and efficiently.

Acknowledgements

The researchers would like to thank Dr. Yiheng Wang and Professor Sara McAdam for their insight and guidance. Thank you to the Honors College for their access to opportunities. Thank you to TSGC for providing this experience and opportunity to learn.

Questions and References

Our team would be happy to take any questions you may have. Please feel free to reach out to anipwilhelm@gmail.com (Team Lead Email) if you have any questions that could not be answered at the poster session. Our references are in the QR Code to the right.