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University of Utah Health's Global Adaptive Program

Adaptive Snow Scooter

Technical Advisors: Ken d'Entremont, Ph. D
Design Team: Brandon Carroll, Nathan Carroll, Olivia Hutten, Kevin Lee, Benjamin Minor, Joey Thomas

Department of MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

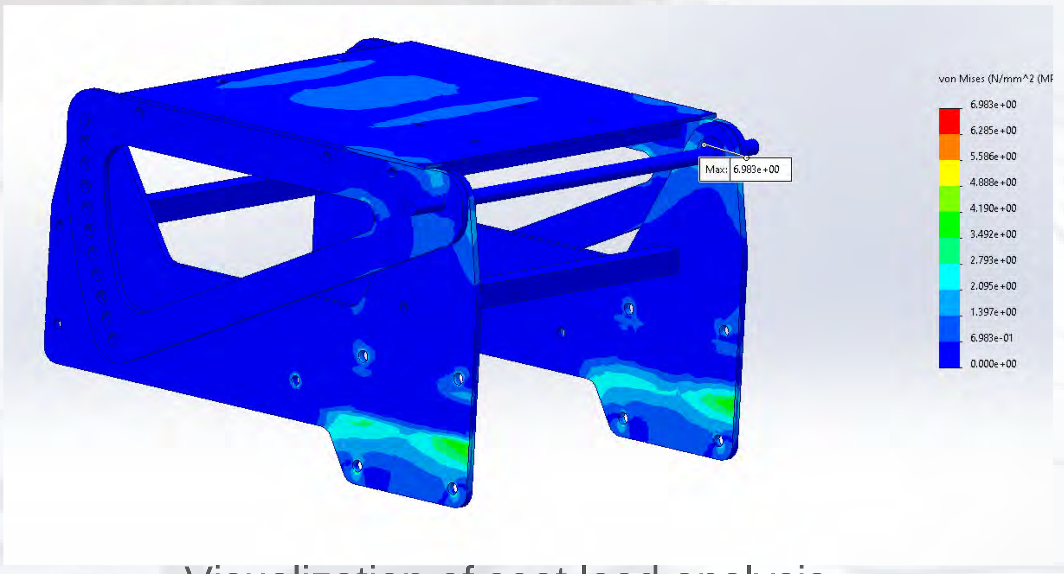
Introduction

The TRAILS group makes outdoor recreation sports accessible for people with complex physical injuries. There are currently no devices that allow those with complex disabilities to enjoy a cross country skiing experience. We worked with TRAILS to modify an Elyly electric snow scooter to accommodate independent use in a cross country environment for people with complex disabilities. To achieve accessibility, we designed seating, stability, and an actuated steering systems.

Seating Design

The design intent for the seating was to be highly adjustable, fully removable, and lightweight. By utilizing t-slot rails we achieved a system for longitudinal adjustment that can be performed on the fly using cam levers. Additionally there are discrete "dump angle" positions ranging from 5-30°.

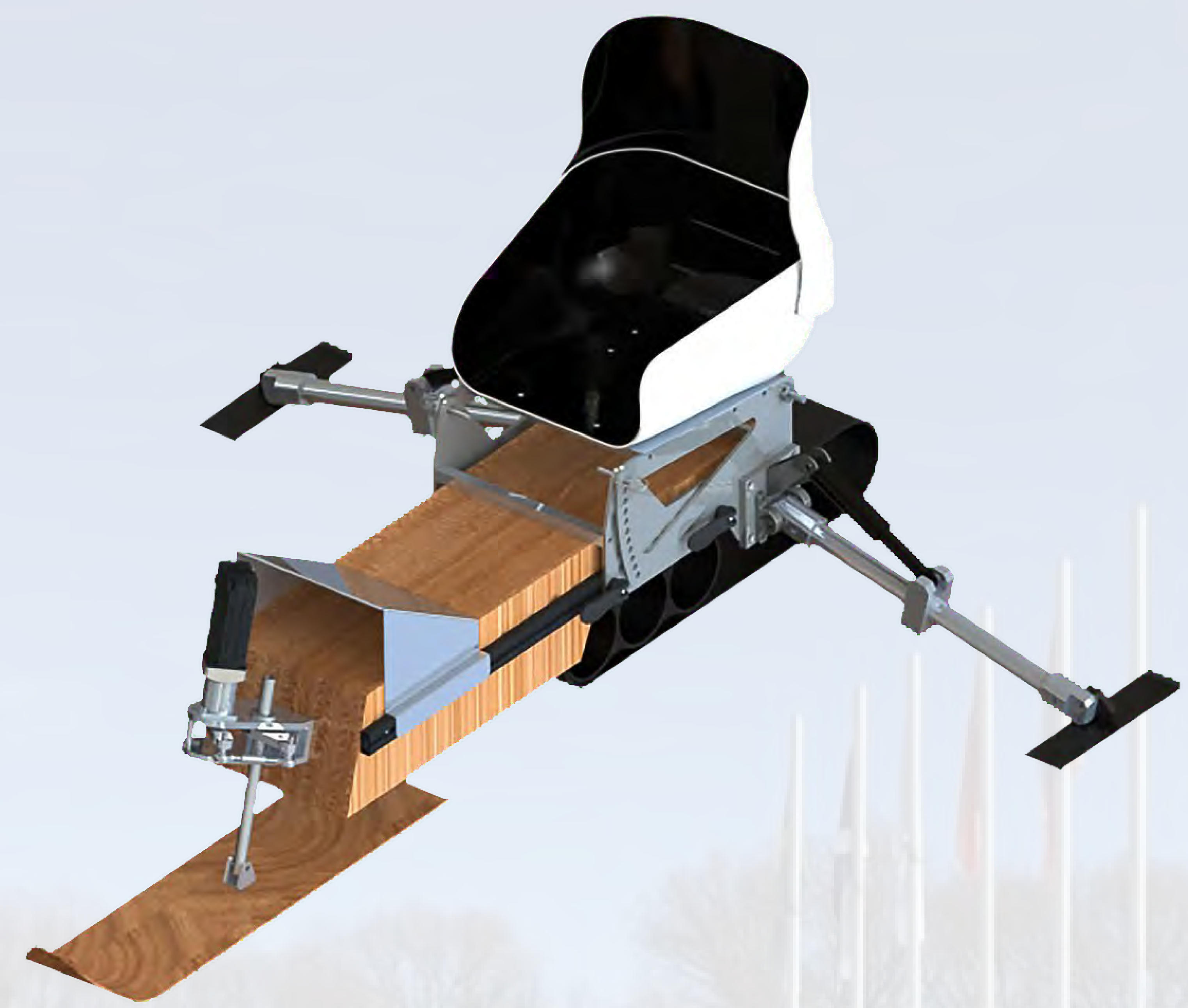
The 6061 frame has a safety factor of 34.5 when loaded under a maximum passenger weight and maximum reaction forces from the outriggers. Other components such as bearings and fasteners were specified to be able to individually support this maximum load.



Visualization of seat load analysis

Steering Design

We chose a completely motor-driven steering system for three reasons: accommodating the widest range of users, easy integration into the adjustable design, and a potential for power steering in a future physically actuated iteration. To choose a motor, we used published formulas for ski turn force to find the necessary torque to overcome the force of digging into the snow.



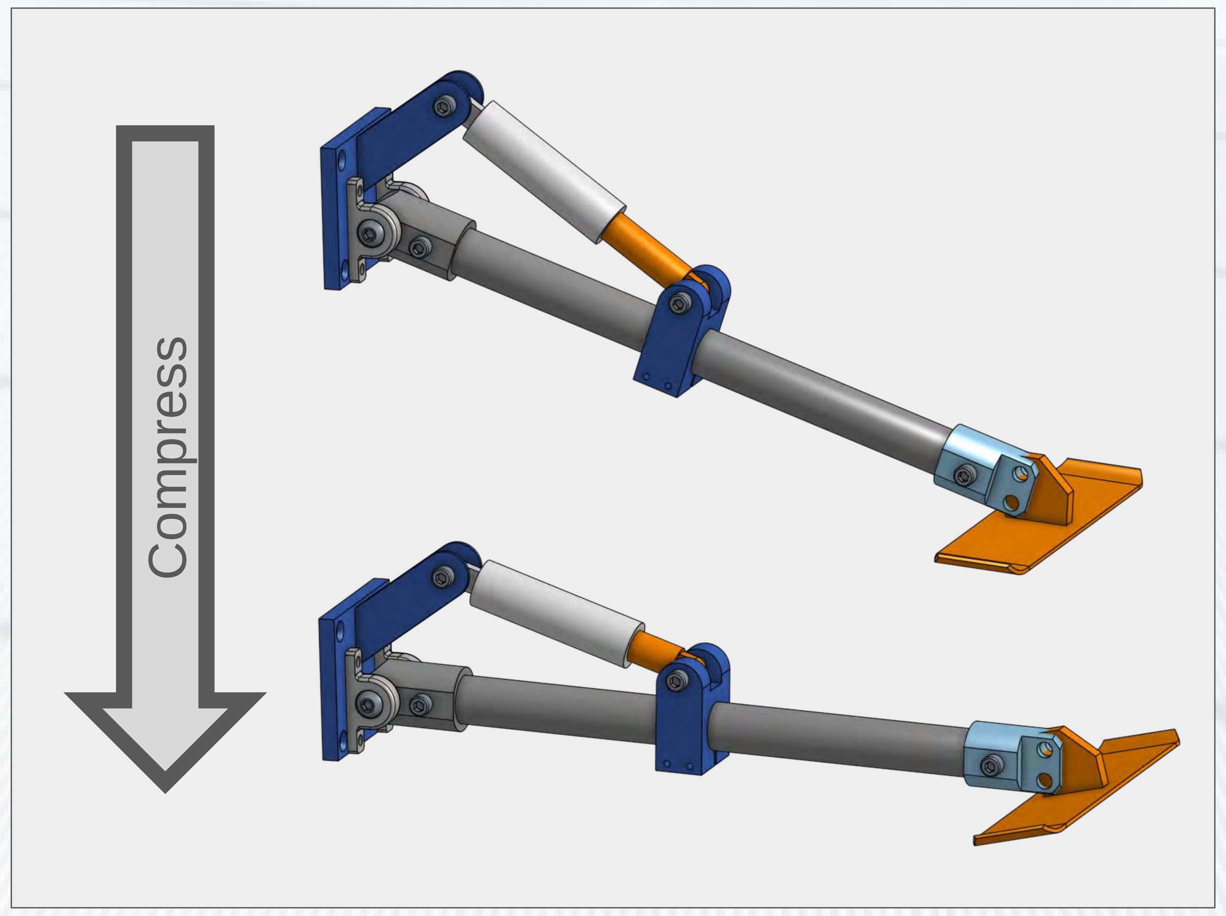
Trimetric view of the Adaptive Snow Scooter

Stability Design:

The outriggers consist of two 6061 aluminum tubes, two DNM mountain bike tail shocks, and various mounting brackets and hardware. The design allows for:

- Tunable damping and stiffness values for the shocks
- A shock lockout (makes the shocks rigid)
- Adjustable shock height

The variety of tunable factors allow the outriggers to be tuned to a specific user's needs.



Visualization of outrigger shock compression

Testing

We used a tilt table test to find the maximum angle that the scooter can lean without tipping over. We set the scooter on top of a large plywood board and lifted the board on one side until the scooter separated from contact with the board. We repeated this with different user weights, user positions, and outrigger positions. This test allowed us to ensure that the user will be safe from tipping over in the maximum expected scenario. We also used the results to calculate the maximum speed that a user can drive through the minimum track turn radius (10 ft) without tipping.

Results

Scenario	Static Stability Factor	Tilt Table Angle [deg]	Center of Mass Height [in]	Max Speed Through 10 ft Radius [mph]
Heavy Front	0.601	37.33	39.95	8.86
Heavy Back	0.647	32.5	40.18	9.77
Light Front	0.806	45.67	29.76	10.98
Light Back	0.904	41.67	28.76	11.54

Design Metric	Unit	Target value	Test Value
Tipping angle	Degrees	> 25	32
Dump angle	Degrees	> 20	5 - 30
Static Stability Factor (SSF)	Unitless	> 0.5	.643
Allowable user tilt angle	Degrees	~ 7	0 - ~15
Max Speed Through 10 ft Radius	Mph	> 5	9.56
Max Turn Angle	Degrees	45	45

Conclusion

Our prototype meets or exceeds all of our target metrics in stability and safety. We believe that the current designs will be easy to integrate to the existing scooters upon their arrival and that the control integration will allow for safe use by those with complex disabilities. The current model is a synthesis of user feedback and engineering analysis and we believe that it provides an optimal way forward for cross-country skiing with the TRAILS program.