

Ski Haus Tow Rope

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Abstract

The Objective: Develop a mechanical and portable towing device for skiing and snowboard competitions to decrease fatigue and potential injury.

The Ski Haus Tow Rope is a portable mechanical system to transport skiers and snowboarders up a slope. Traditional chairlifts have been found to be too slow for riders who want to complete multiple runs, therefore, this device was designed to be used in ski and snowboard competitions to quickly transport competitors up the hill during their heat. Freestyle competitions are inherently dangerous, but constant hiking up the slope causes fatigue in the competitors and a larger risk in potential injury. This tow rope eliminates the factor of fatigue from hiking. The device utilizes a high-powered combustion engine that is geared down to effectively tow 60 people per hour at a minimum distance of 150 feet. It is under 300 pounds and able to fit in a standard truck bed for ease of transportation. Once on the slopes, built-in wheels and skis make for easy placement and installation in any weather condition. Ski Haus is sponsoring this project and Davis Bendient, part owner of Ski Haus, is our client. They prioritize the skiing and snowboarding community with the goal of giving everybody a chance to build their skillset and have fun through these competitions. Implementing this tow rope improves professionalism in competitions while preventing potential injury.

Requirements

The presented customer requirements are the specifications deemed necessary by our sponsor, Ski Haus. Based on the project description, quality requirements were generated to set a baseline for concept generation. The following customer requirements are the **specific design targets that our team must ensure are met through the project. Through communication with Ski Haus, it was apparent that safety for all riders and operators was the most important aspect of the design.**

Customer Requirements:

- This device is safe for all riders
- Minimum towability of 5 people at one time
- The device is durable
- The device is portable
- That this device is easy to operate and needs minimal training to run
- The distance of the tow rope covers the ground of a typical rail jam competition
- Compact design
- The device maintains a constant speed with varying loads

Engineering Requirements:

- The motor can tow 60 people per hour +/- 10
- The device must be suitable for 8 people +/- 2
- Includes a minimum of two safety features
- Can travel 250 feet +/- 50 ft
- The overall weight is 300 lbs +/- 50 lbs
- Aluminum and steel must make up the frame
- Factor of safety must be 3

Design Iterations

- The drive unit gearing was altered due to gearbox ratios and pulley availability
- Frame was changed significantly to accommodate component adjustments

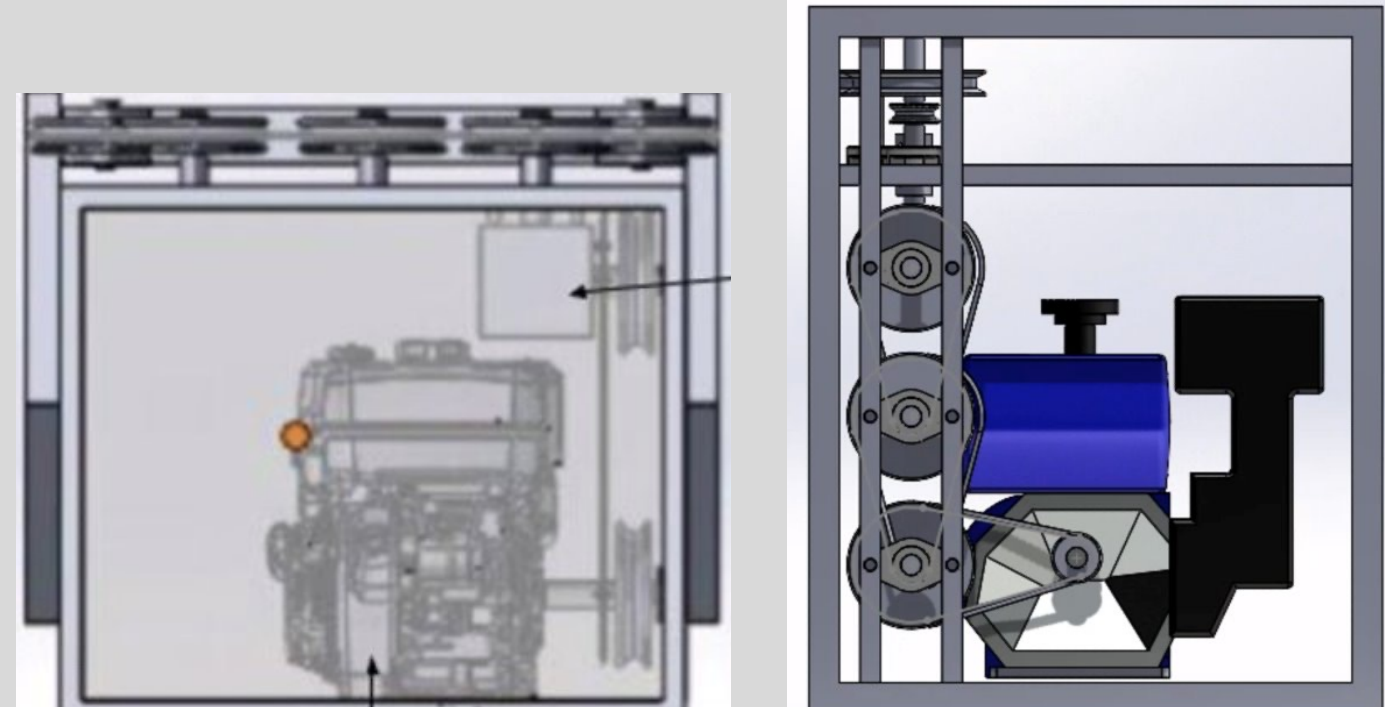


Figure 1: original drive unit design Figure 2: original drive unit design

Methods

Preliminary Calculations

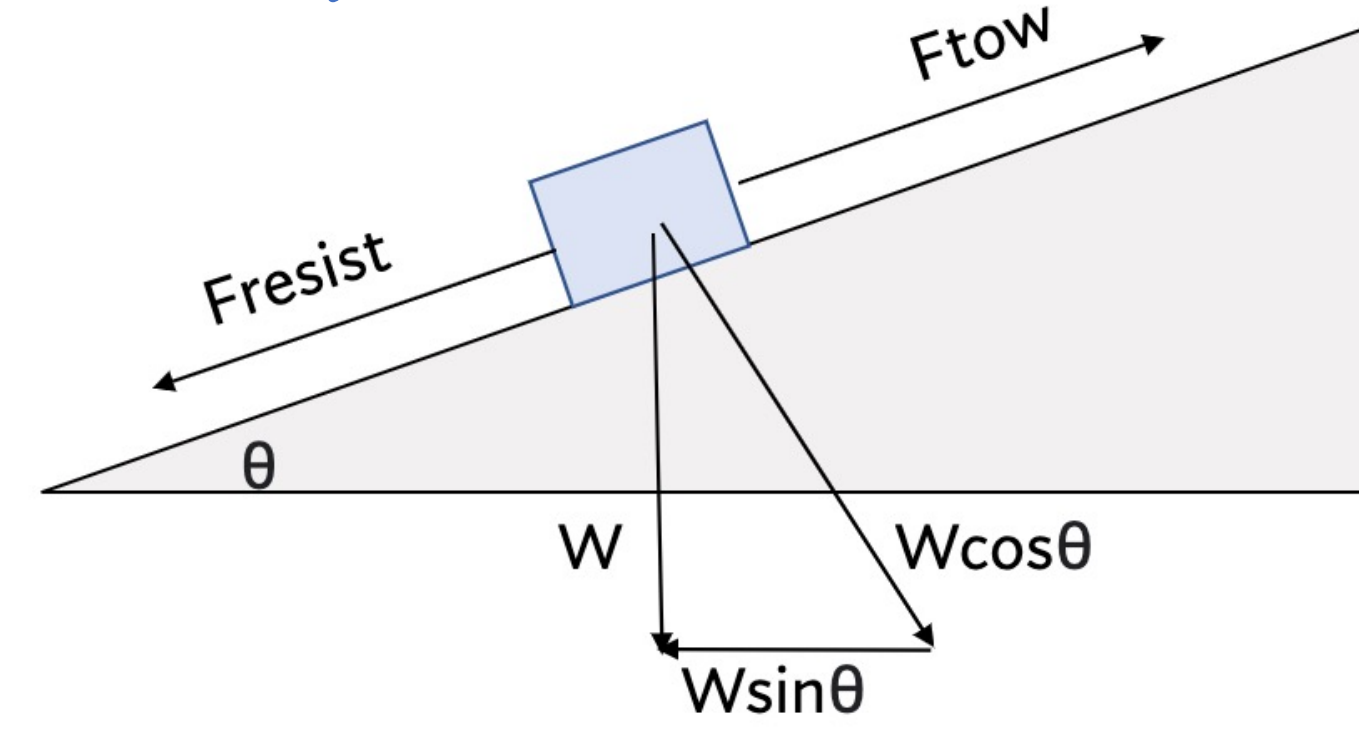


Figure 3: Free body diagram for speed, and force analysis

- Angle is 16 degrees
- Mass considered is 2,000 lbs
- Motor torque is 28.5 Nm
- Calculated towing force needed is 3308.5N

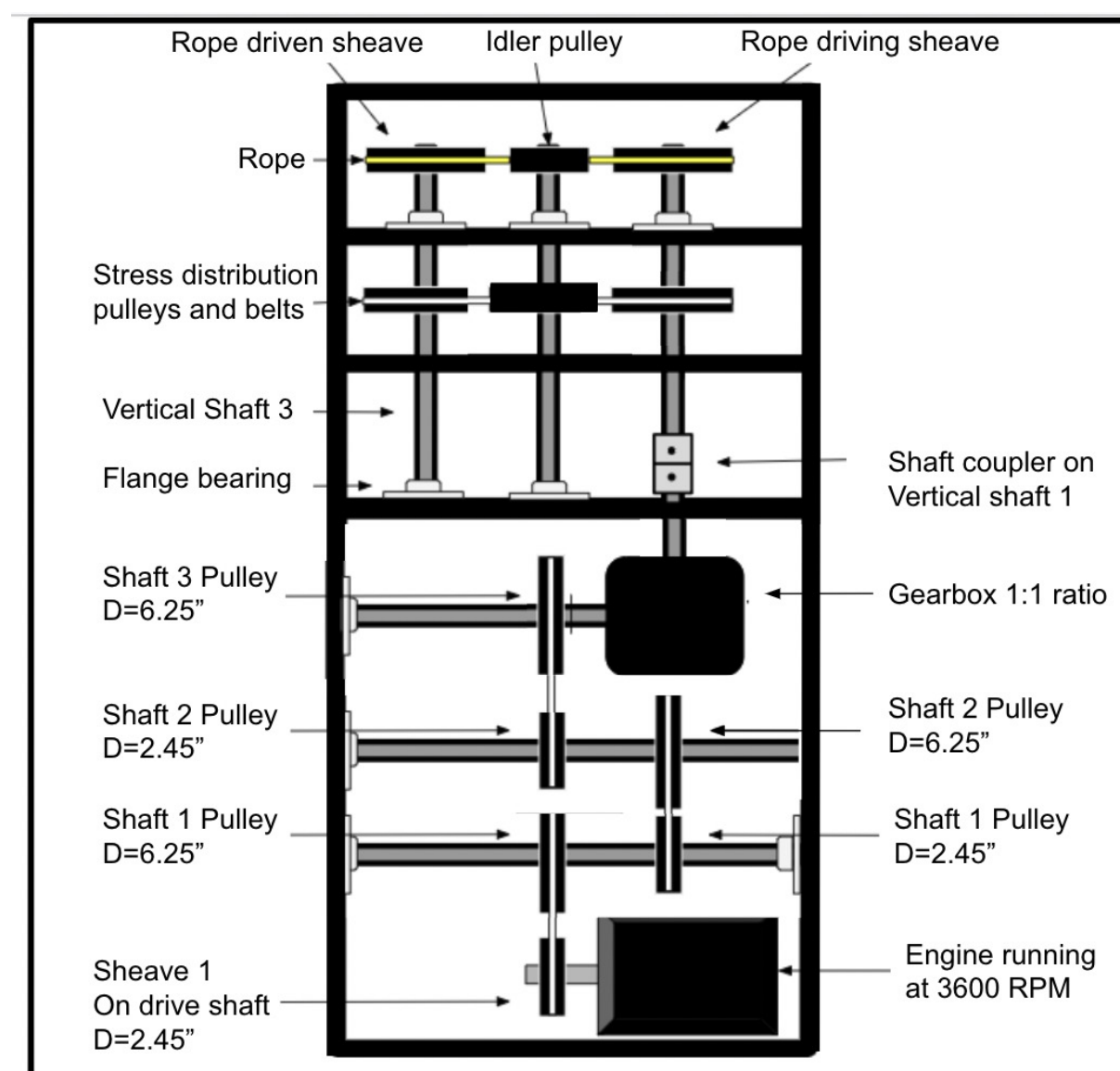


Figure 4: Drive unit schematic used in calculating gearing ratios and speed

- Series of 2 diameters of pulleys 2.45" and 6.25" respectively
- Using velocity ratios and output speed values from the gearbox to the driving sheave, the speed is calculated to be 1.73 m/s
- Torque is increased 10:1

Manufacturing Process

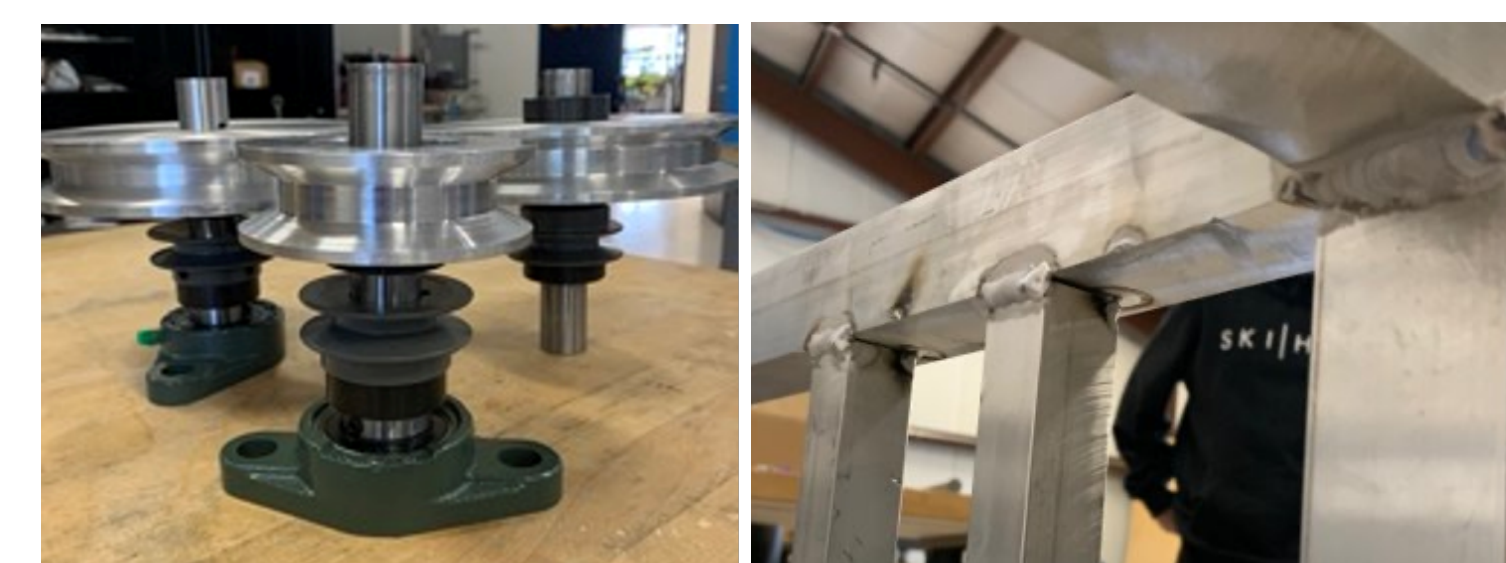


Figure 5: sheaves and pulleys for the rope

Figure 6: welds on the frame

Iterations in Manufacturing

- Many design iterations were created through the process of the manufacturing
- Issues with tolerancing led to different ways of securing pulleys and sheaves
- Gearbox mount ran into issues with frame and location



Figure 7: original Prototype



Figure 8: halfway through the building process

Final Design

- Final CAD contains interchangeable wheels and skis for portability on asphalt and snow
- Top pulley fits over the side profile of the frame for compact transportation

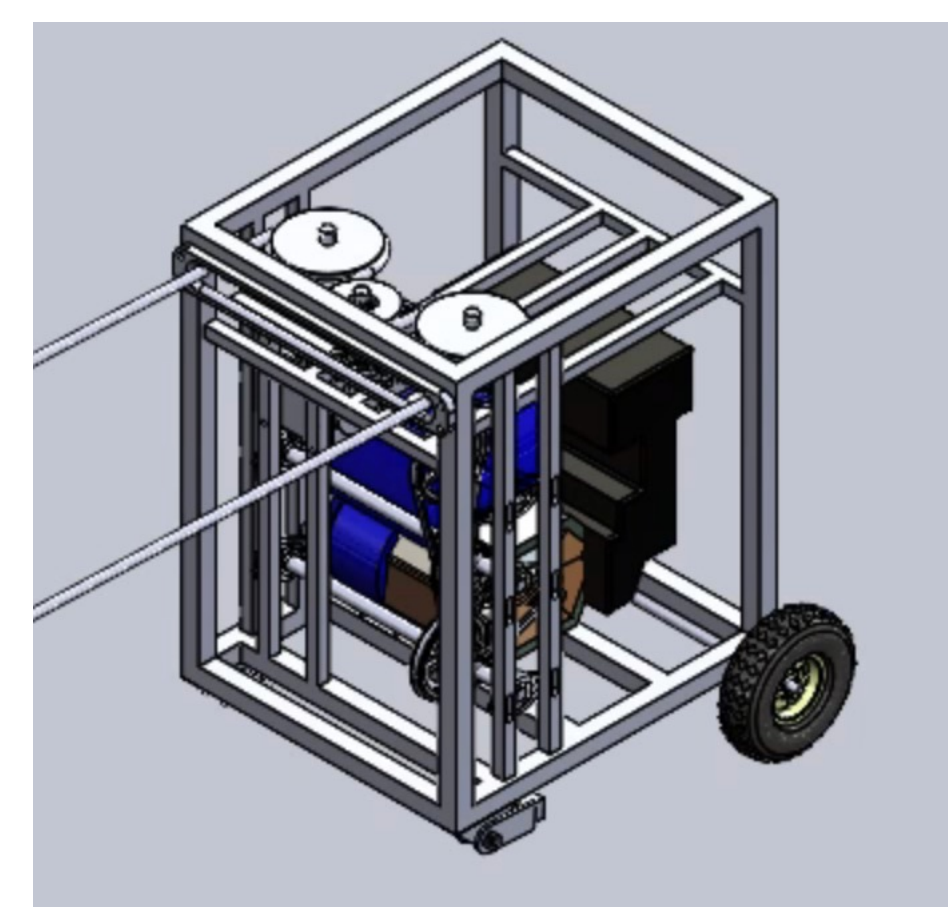


Figure 9: Final CAD of the drive unit

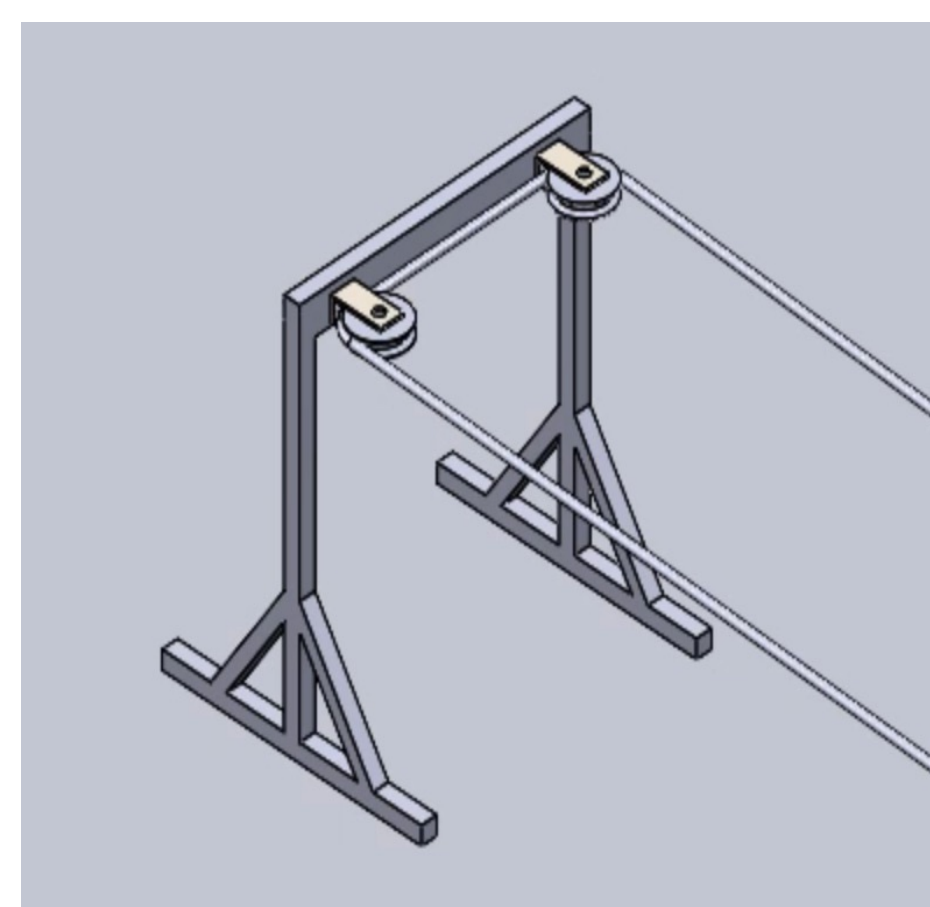


Figure 10: Final CAD of the top pulley

Results

Testing Results

Engineering Requirement	Target	Tolerance	Measured/Calculated value	ER met? (✓ or X)	Client acceptable? (✓ or X)
ER1 –people on the rope	5 people	+/- 2 people	5	✓	✓
ER2 – people/ hour travel	60 people/hour	+/- 10 people	60 people/hour	✓	✓
ER3 – distance traveled	250 ft	+/- 50 feet	300 ft	✓	✓
ER4 – weight of unit	300 lbs.	+/- 50 lbs.	291 lbs	✓	✓
ER5 – number of safety features	2 features	- 1 feature (no limit for maximum)	2 features	✓	✓
ER6 – factor of safety	3	+/- 1	3	✓	✓
ER7 – material durability	250 MPa	+/-50 Mpa	276 MPa	✓	✓



Figure 11: Final manufactured top Pulley



Figure 12: Final manufactured drive unit

Conclusion

This towing device is capable of transporting multiple people up a slope for competition use. All requirements were compiled into a house of quality and used to create the necessary testing procedures. These requirements focused on safety, durability, portability, and towing capacity. All customer and engineering requirements were achieved thus this final production of the tow rope and will be used by Ski Haus and the skiing community. The final design can tow 8-10 people at one time at a rate of 1.75 m/s which was found through our testing procedures. The tow rope in use will greatly affect this skiing and snowboarding community as there is already a high desire for a commercial tow rope in town. The Arizona Nordic center will allow for the tow ropes use, both recreationally and in competition. Ultimately, the tow rope allows for a safer skiing and snowboarding experience, especially in competition. This device will bring the community together while providing an equal opportunity for everyone to ride to their capability.

References

[1] American National Standard for passenger Ropeways – Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors – Safety Requirements, ANSI B77.1-2011, 2011.

Acknowledgments

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