RESNA
Student Design Competition

Kayak Transporter (Duke University)

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Figure 1: Kayak Transporter

ABSTRACT

The goal of this project is to construct a device that will enable individuals with lower body disabilities to independently transport their kayak between their vehicle and the water. The device consists of four parts: 1) a Modified Wheelchair, 2) a Front Attachment, 3) a Combing Lasso, and 4) a Rear Attachment. The Modified Wheelchair includes wider rear and caster wheels and a hitch that secures onto the Front Attachment. The Front Attachment functions as a sheath to grip the kayak nose, and the body of the kayak is strapped onto the Rear Attachment. The Combing Lasso connects and secures the separate attachments to each other. The Kayak Transporter consists of lightweight, portable components. It is safe and easy to assemble, and it offers users the possibility of transporting their kayaks independently and efficiently.

BACKGROUND

Our client is a competitive kayaker who hopes to qualify for the 2016 Paralympic Games. She wishes to train for upcoming kayak meets, but her ability to transport her kayak to the lake where she trains is constrained by her limited lower body usage. Moreover, our client strongly prefers to kayak early in the morning when outside assistance is scarce. In order to solve these problems, our client needs a safe and durable kayak transportation system that she can utilize by herself. The transportation system must also be appropriate for the terrain she encounters. For our client, the process of moving the kayak to the dock usually entails moving the kayak across uneven terrain containing rocks, tree roots, mud, and sand. While all-terrain wheelchairs are designed to overcome these geographical barriers, they are bulky and expensive. Traditionally, two-wheeled kayak dollies have been used to transport kayaks across difficult terrain. However, kayak dollies require users to be mobile enough to carry the kayak nose while travelling, rendering dollies unfeasible for wheelchair users. Neither the all-terrain wheelchair nor the kayak dolly can transport both the user and the kayak simultaneously. Unless a device is adapted to surmount these challenges, our client will be unable to train and compete at the level she desires.

PROBLEM STATEMENT

This project aims to provide individuals, whose disabilities limit their lower body usage, the ability to independently transport their kayak between their vehicle and the water.

DESIGN AND DEVELOPMENT

In considering the design for the Kayak Transporter, the key priorities considered included portability, ease of assembly/disassembly, ease-of-use, protection of the kayak, weight, suitability for the terrain, and safety of the client. Each of the four parts of the device was designed and built to reflect these priorities. The four major parts (Fig. 1) of the Kayak Transporter are: 1) the Modified Wheelchair, 2) the Front Attachment, 3) the Rear Attachment, and 4) the Combing Lasso.

Modified Wheelchair

Conventional wheelchairs are unable to navigate effectively across gravelly roads, grass, and other rough landscapes because the standard wheels they use are not designed for such terrains. Our client's standard wheelchair frame is reequipped with 6" pneumatic caster wheels and knobby tires (Fig. 2) to give our client the ability to traverse the uneven terrain typically found around loading docks. A hitch pin is also attached to the rear handle bar of the wheelchair frame to allow hitch-towing of the kayak. The hitch pin itself is screwed onto an aluminum block, which consists of two fitted brackets bolted together. The primary advantage offered by this hitch system is that the Front Attachment no longer touches the ground. This dramatically reduces friction and allows our client to maneuver more easily.

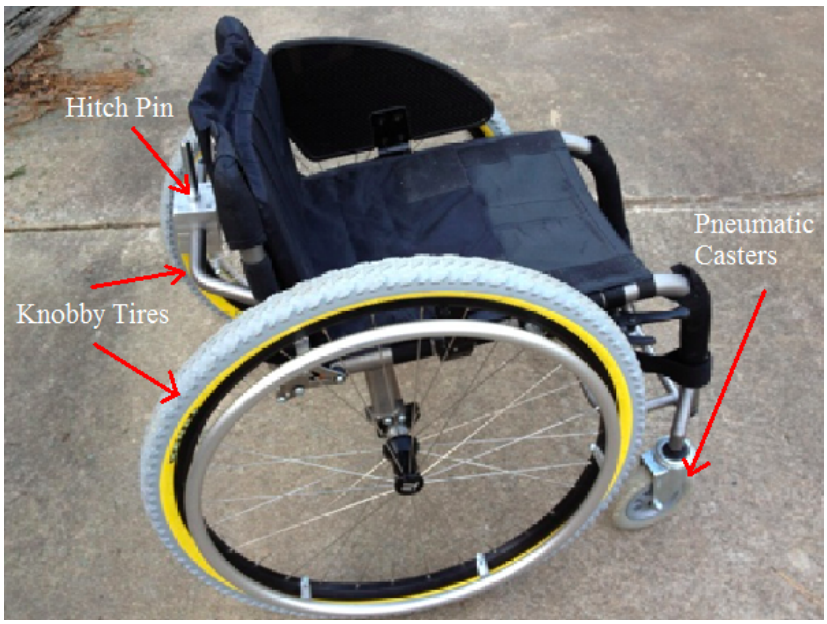

Figure 2: Modified Wheelchair

Front Attachment

The Front Attachment frame (Fig. 3) is constructed out of aluminum, which makes it strong and lightweight. The user can attach the Front Attachment to the Modified Wheelchair by slipping the hole in the hitch arm through the hitch pin on the Modified Wheelchair. The foam padding allows the kayak nose to fit snugly when it slides into the nose sheath. The hitch arm is made of 1" aluminum square tubing and holds the weight of the kayak on the hitch pin. The front wheel allows the kayak to be rolled on the dock whenever our client reaches the dock and must maneuver the kayak around the dock. Finally, the strap gives our client the option to pull the kayak from the Front Attachment across uneven terrain using the reel and rope system described below.

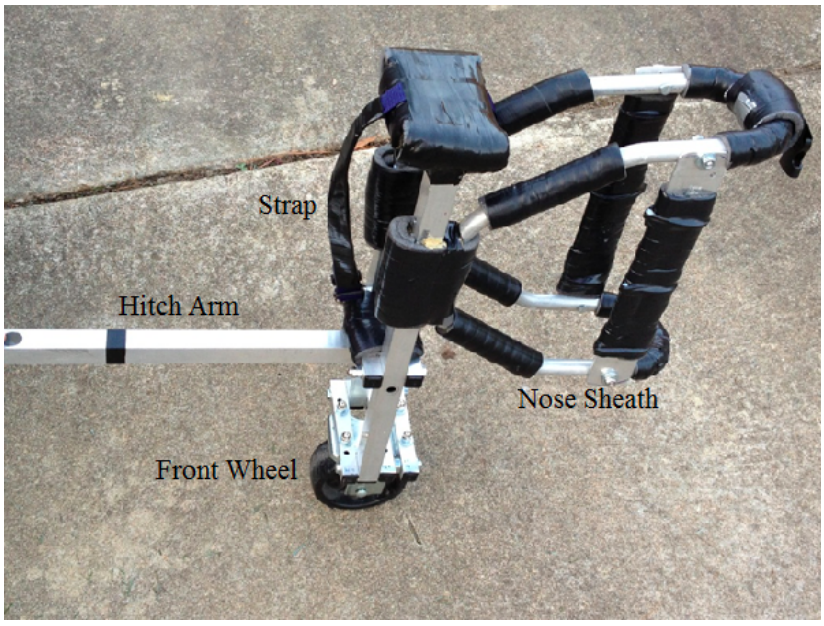

Figure 3: Front Attachment

Rear Attachment

The Rear Attachment (Fig. 4) frame is also made of aluminum for the lightness, durability, and strength. The rear wheels are bike wheels that are attached via a push-pin system, allowing for easy assembly/disassembly for portability. Additionally, the tires are capable of traversing the uneven terrain typically found around docks. The rear cradle receives the rear end of the kayak and is padded to hold the kayak securely. The rigid brake stand serves to keep the attachment in a proper orientation to receive the kayak. When the kayak is placed on the Rear Attachment, the Rear Attachment automatically shifts into an upright orientation, raising the brake stand to allow rolling of the Rear Attachment. A padded strap help secure the kayak on the rear cradle. Two buckles are added onto this strap: one buckle attaches to an extension from the Combing Lasso and the other buckle attaches to the reel and rope system (described below), allowing the user the option to pull the Kayak Transport from the Rear Attachment.

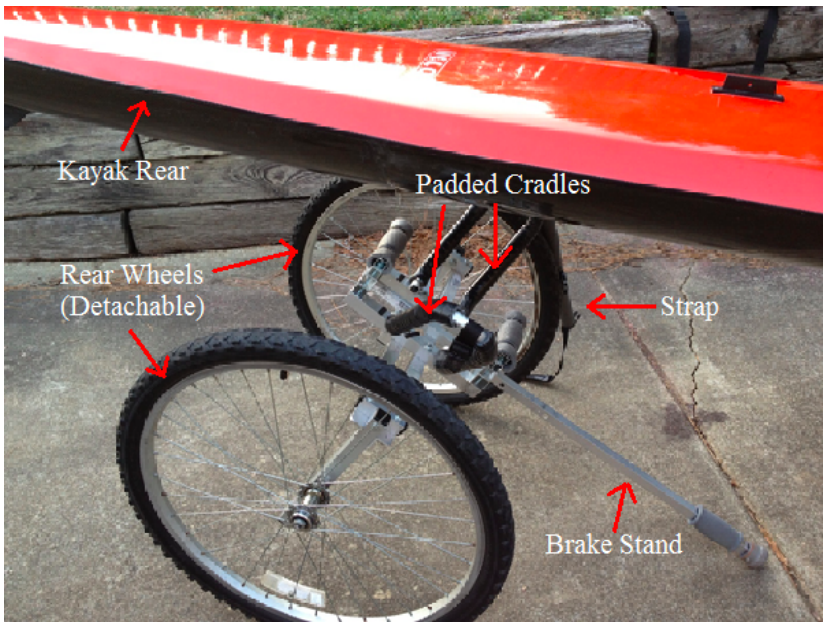

Figure 4: Rear Attachment

The Combing Lasso

The Combing Lasso (Fig. 5) is used as an additional safety mechanism to prevent the Front and Rear Attachments from slipping off the kayak. The Combing Lasso loops around the kayak combing and buckles to the Front and Rear Attachments. The lasso is adjustable, which allows our client to tighten the lasso and secure the kayak.

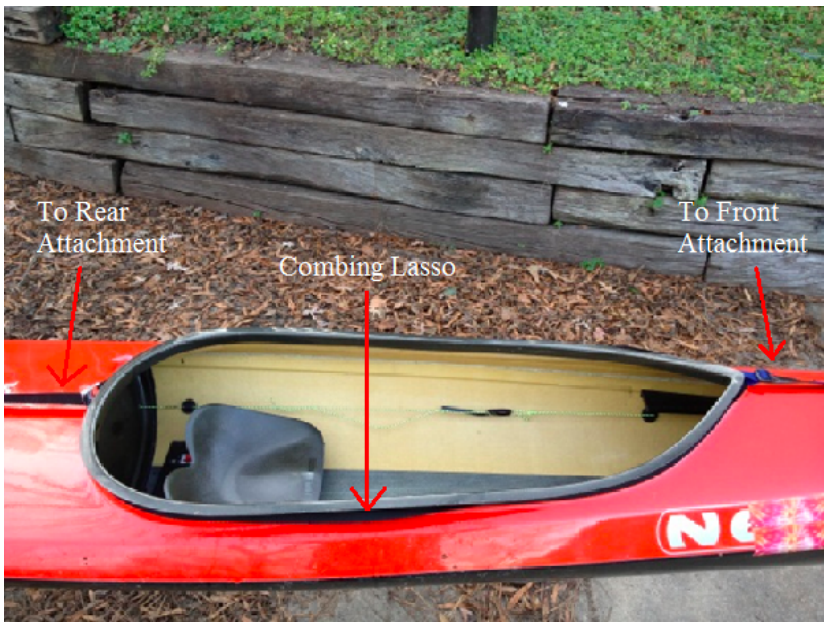

Figure 5: Combing Lasso

The reel and rope system (Fig. 6) is a supplemental item designed to help our client move the kayak up uneven slopes. Our client first clips the system to the Front or the Rear Attachment and places the system on the hitch pin. Then she traverses the upslope in her wheelchair without towing the kayak, all while automatically spooling out rope behind her. Then, she "reels" the kayak to her position. The system allows the user to bear less physical strain than towing the kayak upslope and makes moving the kayak upslope safe and easy.

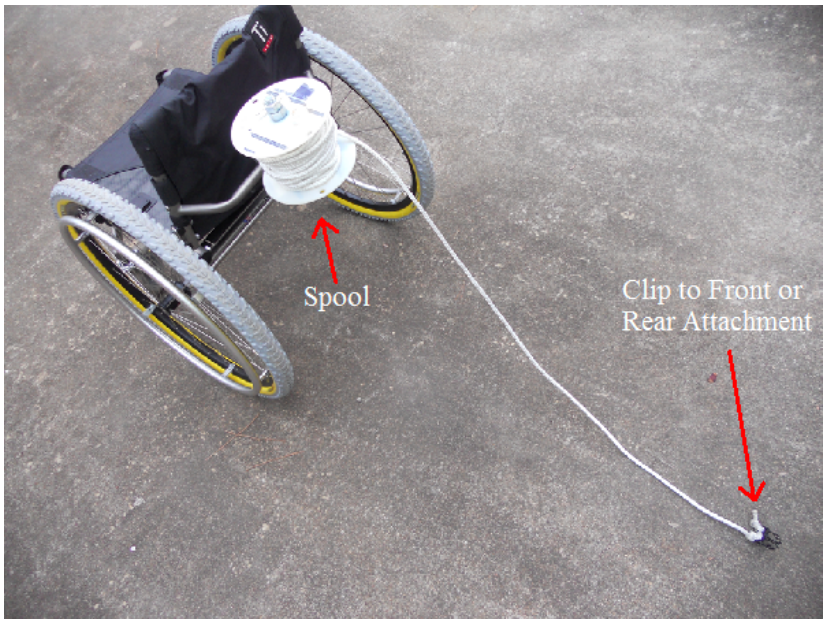

Figure 6: Spool

EVALUATION

To assess the ease of use and effectiveness of the final device, our client tested the Kayak Transporter with our client at the site where she kayaks. The entire process of our client getting the kayak from her vehicle to the water and back was timed and recorded. Where our client was unable to perform the task previously, she can now able to unload her vehicle, prepare for kayaking and transport the kayak to the water within 20-25 minutes.

Prior to the Kayak Transporter, our client was unable to train independently because she could not carry her kayak manually to the water. When asked what she thought of the Kayak Transporter, our client replied "It's fantastic! … I think there is a product to this. We need to think about this [commercializing the product] for the future advancement of parakayaking. I feel very comfortable and safe [using the product]".

DISCUSSION

The Kayak Transporter met all of the design criteria below in creating an effective assistive device for parakayakers.

- Ability to transport kayak from vehicle to water and back
- No external assistance by others required
- Ease of use
- Ease of storage and assembly
- Protection of the kayak
- Durability
- Safety

It may seem strange that the Kayak Transporter comes in two pieces (Front and Rear Attachments) rather than in one piece. However, this is actually a design feature necessary to allow ergonomic loading and unloading of the kayak onto the vehicle kayak rack. Our client loads/unloads the kayak by holding onto the combing at the center of the kayak. The most ergonomic position will be the position where her wheelchair and legs are directly beneath the kayak. A one-piece kayak transporter would rest directly beneath the kayak during both loading and unloading, crowding out the space necessary for our client to place the kayak onto the vehicular kayak rack. With two pieces, there is empty space beneath the kayak so that the user can ergonomically load the kayak onto the vehicular kayak rack.

Many design additions are implemented to minimize safety hazards. The chosen width of the Rear Attachment prevents lateral tipping. Plastic end caps are placed on the ends of all the aluminum tubes used in the frames, and bolt/screw ends are capped with round end caps. Finally, rubber grips are added to allow easier handling of the different device parts, and padding and cross-straps are used to ensure protection of the kayak.

COSTS

The most expensive components of this device were the wheels. The large diameter caster wheels and knobby tires cost $136 and wheel bearing materials cost $38, making the total for wheel components at $174. Parts for the frame – aluminum, nuts, bolts, washers, and rods – cost $110. Miscellaneous items such as tape, plastic end caps, foam padding, lashings, buckles, and silicon gel cost $69. This puts the replacement cost for this device at a total of $353.

It is noted that this total amount does not include the labor required to create and implement the custom aluminum or wheel bearing pieces. It also does not include the wheelchair frame used in the Modified Wheelchair or the push-pins used in the Rear Attachment. These items were donated by the client, and the additional price of these items would dramatically increase the total cost of the device. Finally, the bike tires of the Rear Attachment were purchased cheaply ($15) at a local bike co-op: purchasing new bike tires from a manufacturer could also increase the total cost of the device depending on the type of tires purchased.

FUTURE DIRECTIONS

There are several aspects of the device that can be improved upon in future work to reach a greater audience. First, the

Front Attachment of the device has been customized to fit one particular kayak, and must be manually adjusted through tightening or loosening screws to fit other kayaks. Making these adjustments easier to use would make the device more ergonomic and flexible. Second, the device is designed for users who have good trunk control, and thus more work will be required to tailor the device to users with weaker or no trunk control.

CONCLUSIONS

In conclusion, the Kayak Transporter has enabled our client to conduct personal kayaking training at her site of choice independently. We hope that this device will help her to reach her goal of competing in the 2016 Paralympic Games.

ACKNOWLEDGEMENTS

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