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SONAR CLASS ADAPTIVE SAILING JIB TRANSFER SYSTEM

Matthew Brunelle
Rochester Institute of Technology
Rochester, NY, USA

Nicole Conway
Rochester Institute of Technology
Rochester, NY, USA

Michael Kennedy
Rochester Institute of Technology
Rochester, NY, USA

Kathryn Wurman
Rochester Institute of Technology
Rochester, NY, USA

Faculty Advisors

Kate Leipold
Rochester Institute of Technology
Rochester, NY, USA

Elizabeth DeBartolo
Rochester Institute of Technology
Rochester, NY, USA

INTRODUCTION

Sailing is an activity that promotes lifelong wellness and a sense of freedom not easily experienced on land. People with limited or no leg mobility who would like to participate in this activity have additional challenges when faced with the need to move about the boat. A crewmember in the role of a jib trimmer plays a pivotal role in the sailing activity. He is not only responsible for the adjusting the tautness of the jib sail, but he is also responsible for being the 'eyes' of the boat for the entire crew, as well as traversing the width of the boat in order to provide crucial weight distribution. For a person with limited or no leg mobility, these tasks become severely taxing, or even impossible, without the use of an assistive device. This undergraduate engineering capstone project focuses on designing a jib transfer system to address these challenges.

The jib transfer system is an assistive device that enables a jib trimmer to move transversely across the width of the sailboat without the use of their legs, and limited use of their core muscles. A jib transfer bench was created in Rochester Institute of Technology's Spring 2013 term that is heavy, expensive, labor-intensive to assemble, and accommodating of a strict size constraint imposed by the customer at that time. This size constraint limited the design opportunities to achieve the desired functions, but is no longer a constraint for this iteration.

This iteration (started September 2013 and ending May 2014) involves a complete re-design, changing the old 'bench' design to a rotational system. This design was chosen for multiple reasons – in order to better meet customer needs, to comply with a significantly reduced project budget, and to increase the potential customer base. Additionally, this iteration improves upon the original design by making the device 40% lighter and far less complicated to assemble.

The system is being designed specifically for use in a Sonar class sailboat, which is recognized as the premier sailboat class for Paralympic racing. The end result in May 2014 will be a functional prototype and design documentation. In order to help the greatest number of people possible, the device itself will not be sold. Instead, the design documentation and easy-to-use assembly instructions will be publicly available in a free, downloadable format. There is market potential for this assistive device among disabled sailors or adaptive sailing programs that desire to have their own device.

PRODUCT DESIGN

The proposed prototype design enables the jib trimmer to rotationally swing around from one side of the boat to the other (hovering over the Sonar's native bench). It positions the disabled jib trimmer in almost the exact same position in which he would normally sit, except approximately five inches higher. It keeps him close to the jib lines so access to these is not reduced. It also ensures that line of sight is not reduced, as the jib trimmer is also the 'eyes' of the boat, alerting the skipper and crew to hazards or boat traffic. The system automatically locks the user into position at these far port and starboard sides so he stays stationary until he releases the brake mechanism and swings to the other side at will. This design also accounts for securing the user's legs in a safe position. The ability to secure the limbs that the user cannot control was a concern for the prior jib transfer bench that this re-design addresses and solves.

The system is made primarily of two-inch diameter, schedule 40, PVC piping. This material was chosen for a number of reasons. Through independent research and consultation with Piers Park Sailing Center in Boston, MA, we determined that PVC is a popular and commonly used material for pre-existing adaptive sailing devices. It is well liked for its water resistance, its relatively lightweight nature, and

its cost-effectiveness. Additionally, it is a familiar, easy-to-access, and easy to work with material. Its 'unprofessional' look creates a more inviting feel for users. Alternative materials, such as wood, carbon fiber, metal, or fiberglass, do not have the same combination of ideal properties.

The main PVC structure sits atop a wooden, circular platform, constructed of marine-grade plywood. This platform is mounted atop a lazy susan circular bearing. The underside of the bearing is mounted on a marine-grade plywood base. This base supports the bearing, stabilizes the entire system, and protects the boat deck from damage. The base is securely mounted to the boat deck via the Sonar's bilge access port. This approximately 16" x 7" access port in the foredeck allows for stabilizing mechanisms to be fed through the access port and positioned under the main deck. The stabilizing mechanism consists primarily of two, one-inch square aluminum rods, cushioned by four rubber stand-offs.

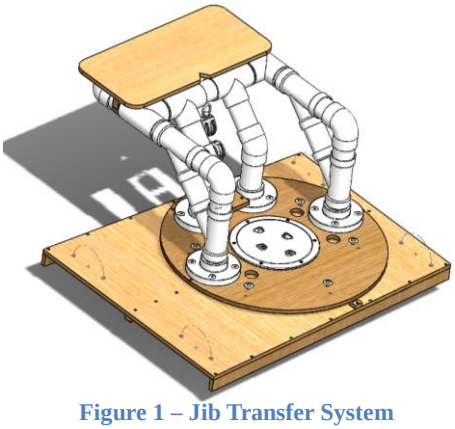

Figure 1 – Jib Transfer System (without seat)

The rotational system also has a braking and locking system. This system locks in place automatically at full port and starboard positions. User action is required to release the lock in order to swing to the other side. This mechanism consists of a pulley system attached to a spring, which surrounds a bolt with a wide, rubberized bolt head. The spring is tensioned to cause the bolt head to drag across the lower base plate during the entirety of the swinging motion. This dragging is the source of the constant braking force. When the user gets to full port or full starboard, the bolt head will automatically drop into a hole that has been drilled from the base plate, locking the user into place. The user will pull vertically on a line through a pulley system to disengage the lock.

At the top end of the PVC structure sits a marine-grade plywood platform to which a seat can be bolted. This seat can be almost any seat in order to best accommodate the specific person or groups of people using the system. The suggested seat for general-purpose use is a cushioned, weather resistant reclining seat with foldable armrests.

It should also be noted that the system was specifically designed for use in a saltwater environment. Although the design should not be completely submerged in saltwater at any point in its life, it is expected to be splashed with saltwater relatively frequently. As a result, the construction materials, including the specific types of metals used for the hardware, were carefully chosen to comply with this scenario and produce a system ready and able to withstand these conditions.

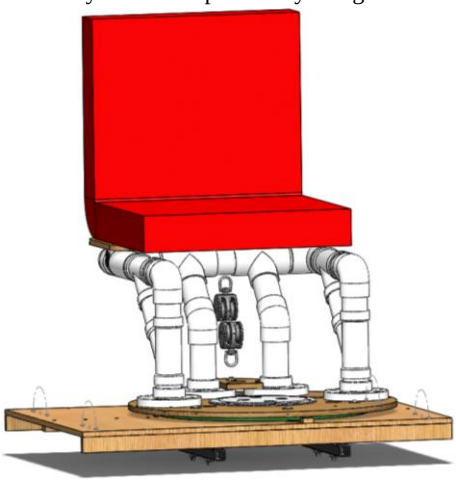

Figure 2 – Jib Transfer System (with seat)

Although a jib transfer bench was designed by a different group of RIT students the year prior, this is a complete re-design in almost every way. Last year's bench was a linear movement device, while the current iteration is based on a rotational platform. The rotational platform design actually increases ease of production, ease of installation, and takes up less space in the boat to allow for less interference with other crewmembers. Additionally, a major improvement is the total device weight, which is particularly crucial during boat installation. The previous transfer bench was made primarily of 6061 Aluminum. This material is not only heavy, but also costly. The current jib transfer system has reduced system weight by 40%, due primarily to the exclusion of Aluminum and inclusion of PVC.

BUDGET & MARKET ANALYSIS

The design team was granted a budget of $1000 through the RIT Multidisciplinary Design Fund to use for building and testing (a 60% reduction from the prior year's budget). However, due to the fact that the design, build plans, and assembly instructions will be freely available to the public, the goal is keep the system cost as low as possible. By keeping the cost as low as possible, this increases the number of potential users, and increases the possibility of introducing more people to the joys and thrills of sailing. The total cost of the entire system is estimated at $600. Due to the previous year's project going over budget, this is an 80% reduction of total system cost.

Minimizing the number of manufactured parts and processes was a main focus during the design phase. This is one of the crucial aspects to making the jib transfer system accessible to others. Only common construction techniques are needed (cutting and drilling), and even those are minimal. Once the system is constructed, assembly into the Sonar boat requires absolutely no tools.

The jib transfer system can be directly marketed to the user and to adaptive sailing centers. In the US alone, there are 59 organizations across 23 states that are recognized by US Sailing as offering certified adaptive sailing programs. Additionally, US Sailing also acknowledges more than 75 additional organizations offering adaptive sailing programs that have not yet undergone the certification process [1].

There is a 5.5% ambulatory (relating to or adapted for walking) disability prevalence among non-institutionalized working-age people (ages 21 to 64) in the United States, according to data from the 2011 American Community Survey [2]. This is an estimated 9.9 million people who have the potential to become sailors and who would have a need for this jib transfer system.

These statistics show that there is broad market potential for this system. The market for a product such as this jib transfer system is almost entirely untapped. Some individual adaptive programs have created their own devices, but a source of detailed plans and instructions on an analytically tested device seems to not exist. This jib transfer system would be the first readily accessible sailboat mobility device of its kind.

REFERENCES

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[2] Erickson, W., Lee, C., & von Schrader, S. (2012). 2011 Disability Status Report: United States. Ithaca, NY: Cornell University Employment and Disability Institute(EDI)