Project Readiness Package

ADMINISTRATIVE INFORMATION:

- Project Name (tentative): Jib Transfer Bench: Design for Manufacturability
- Project Number, if known: P14031
- Preferred Start/End Semester in Senior Design:
  ☒ Fall/Spring ☐ Spring/Fall
- **Faculty Champion:**

Name	Dept.	Email	Phone
Dr. DeBartolo	ME	eademe@rit.edu	

- **Other Support, if known:**

Name	Dept.	Email	Phone
Prof. Kate Leipold	ME	knleme@rit.edu	

- **Project "Guide":** Dr. Elizabeth DeBartolo
- **Primary Customer** (name, phone, email):
  - Caitlyn Connolly(Adaptive Recreation Director at Piers Park Sailing Center), 1-617-561-6677 ext: 15, cconnolly@piersparksailing.org
- **Stakeholders:**
  - Richard Ramos, junglebuzz@gmail.com
  - Magnus Liljedahl, magnusliljedahl@me.com
  - Peter Goldman, jgasf@juddgoldmansailing.org
- **Sponsor(s):** (*provider(s) of financial support)*

Name/Organization	Contact Info.	Type & Amount of Support Committed
RIT		TBD
NSF	eademe@rit.edu	RAPD grant

PROJECT OVERVIEW:

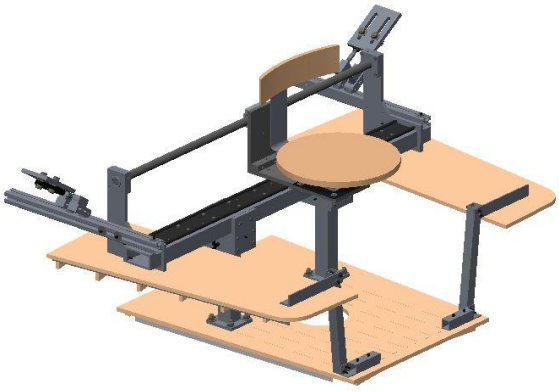
Last spring, a group of engineers (including the writer of this PRP) completed a project to create a device that would assist a disabled jib trimmer move from one side of the boat to the other without the use of their legs (P13031). The jib trimmer's job is to tend to the lines which control the sail at the forward portion of the boat and adjust them as needed in order to sail more effectively and gain the competitive edge during a race. Most of these disabled sailors have lost the use of their legs in some sort of accident, but still want to maintain a healthy and active lifestyle. Sailing is a great way to do this, as there are many ways to assist people with a wide range of disabilities. As you can imagine, it is very difficult, if not impossible for people with certain disabilities or limitations to move across the width of the boat without the use of their legs or core muscles, especially. A successful jib transfer bench was created in the spring, but it was done so under very strict size constraints, which severely limited the ways in which to create a device that serves the required functions. The system that was designed in the spring was built as such in order to fit in the same boat as another project, which was a Captain's Chair (P13032, a redesign of another project, P12031) which facilitated the skipper of the boat, who is a quadriplegic. Going forward, this design constraint does not have to be continued to be followed, because future recipients of these systems will not be sailing together in the same boat. This was confirmed by Caitlyn Connolly, who is the Adaptive Recreation Director at the sailing center where the customer of the Captain's Chair often sails.

The purpose of this project is to create a device that satisfies all of the same functions as the previous jib transfer bench, but is much more manufacturable. The previous system was extremely labor-intensive to make, requiring well over two hundred man-hours of machining, and many hours assembling and troubleshooting. The design was also fairly expensive (~$3000) and was quite heavy. A lot of these design and corresponding manufacturing/cost/weight problems arose from the size constraints that were mentioned earlier. The design required many custom-made and designed parts, some of which had to be made from solid, hardened, stainless steel in order to be strong enough to support the high loads, but still meet the minute size constraints. The relaxation of these constraints will open the doors to many creative ideas and different ways of solving the problems that are posed by this kind of design. As was talked about above, the goal of this MSD project will be to create a functional, effective jib transfer bench which is much more easily manufacturable, cheaper, and lighter than the previous iteration.

Primary boat of interest: Sonar
This is a very common boat, especially for disabled sailors. This is the boat which all of the previous RIT adaptive sailing devices have been designed for, and will continue to do so.



Below are pictures of the previous system:




DETAILED PROJECT DESCRIPTION:

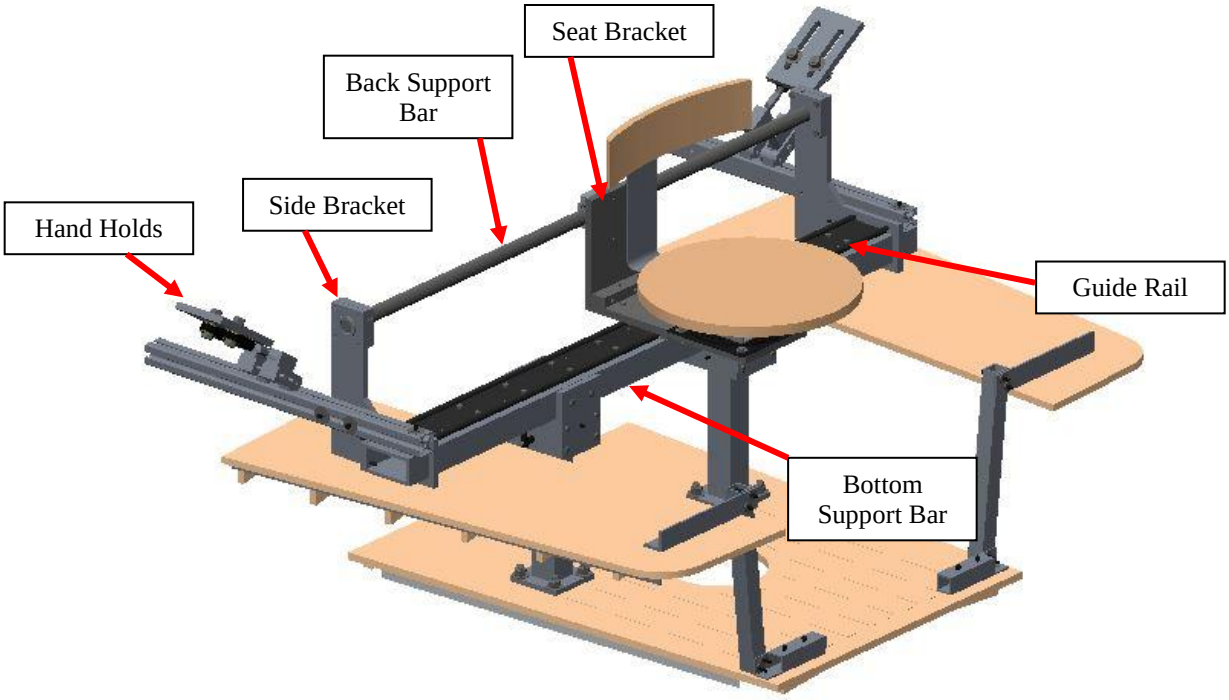
- **Customer Needs and Objectives:**

Customer Need #	Importance	Description
CN1	1	Make it easier (require less force) for the jib trimmer to get from port to starboard
CN2	2	Decrease the time for the jib trimmer to get from port to starboard compared to if they have no use of their legs and limited to no core strength
CN3	1	Design will be light weight
CN4	3	Eliminate the need for the person to make contact with the floor of the boat
CN5	1	Provides the user access to jib lines
CN6	2	Design is an entirely mechanical solution
CN7	1	Design is easy to use
CN8	1	Provides support for legs and core
CN9	2	Design is easy to install
CN10	1	Move between port and starboard
CN11	1	Corrosion resistant
CN12	1	Design must ensure safety for user
CN13	1	Do not hinder ability to see around the boat
CN14	1	Accepts customer's cushion
CN15	1	Design is safe to operate around for other people in the boat
CN16	1	Design keeps machining time of components to a minimum
CN17	2	Machining requires only tools that are easily available and useable
CN18	1	Design stays about the same cost (or less) as the current design

(1=high priority 2=medium priority 3=low priority)

- **Functional Decomposition:**

- **Potential Concepts*:***
  Below is an annotate figure of the current system with basic component names for clarity with the following analysis:



Due to the previous team's size constraint, the design was basically cornered into developing a cantilevered-beam-type-system, which caused many issues during production and design. Now that the future design will not have to be designed to work in conjunction with the Captain's Chair, there will be a lot of room for creative brainstorming and new potential design solutions.

- **Specifications (or Engineering/Functional Requirements):**

  - **Benchmarks**

	Lazy Susan design	Eagle Health XX Long Toilet to Tub Transfer Bench	Pivoting bath bench
Weight capacity	Proven approx. 200 lbs	350 lbs	400 lbs
Max transfer distance	Approx. 50”	34”	15”
Weight of device	Approx. 40 lbs	Light-approx. 20 lbs	17.5 lbs
material	Plywood/fiberglass/carbon fiber	Aluminum/Plastic	Aluminum/Plastic
Product foot print	600 sqr in	1430 sqr in	722 sqr in

http://eagletransferbench.blogspot.com/
http://www.dynamic-living.com/product/portable-pivoting-transfer-benches#name_tabsHref+clear

Below are the results of testing from the previous team/device. The future team/device should try to meet these goals and surpass them when possible. Please note that there were several "conditional failures" that occurred due to specifications being set at an unrealistic level. Also note that the specifications have been adjusted as necessary in the above house of quality in order to get them into a more realistic range. They have also been adjusted to meet the goals and scope of this future project (manufacturability).

Metric Number	Engineering Metrics	Marginal Targets	Technical Targets	Result	Pass/Fail	How tested	Reason for Failure	Test Improvement Recommendations
1	Device weight	100 lbs	50 lbs	125 lbs	Fail	Place all components on scale in Machine Shop	Space constraint drove product to robust design, required heavy metals	n/a
2	Transfer time	5 sec	3 sec	2.9 sec avg	Pass	Sit in device and translate back and forth while timing, took average	n/a	n/a
3	Vertical translation	3 in	0 in	0 in	Pass	Measure	n/a	If linear guide is used, eliminate entirely.
4	Product footprint	1000 in^2	800 in^2	1242 in^2	Fail	Measured the dimensions	Spec was incorrect, only took baseplate into account, not overall area needed for bench	Evaluate specs more closely
5	Mechanical Solution	Meets IFDS standards	Meets IFDS standards	Pass, per Appendix B of IFDS Standards	Pass	Researched IFDS Standards for assistive decives	n/a	Research more in depth, call IFDS or disabled sailors for clarification on what is legal
6	Time to get into the seat	4 min	2 min 40 s	<2 min 40 s	Pass	Simulated with able-bodied person getting into seat with no leg movement and adjustments made prior to entry	n/a	Test with customer or disabled person
7	Time to get out of the seat	4 min	2 min 40 s	<2 min 40 s	Pass	Simulated with able-bodied person getting out of seat with no leg movement	n/a	Test with customer or disabled person
8	Force to start movement (boat is not tilted)	150 N (33.7 lbs of force)	120 N (27 lbs of force)	26 lbs (w/ 2:1 ratio)	Pass	Sit in device - Pull purchase system with spring-scale	n/a	Test with customer or disabled person
9	Weight capacity	220 lbs	265 lbs	270 lbs	Pass	Calculate first - then put weights on the seat	n/a	n/a
10	Comfort	3 on a 0-5 scale	5 on a 0-5 scale	~4	Pass	Poll of at least 25 people	Needs perfect from every person	Change to lower spec. Just cannot be harmful to user
11	Installation time	10 min	5 min	8 min	Pass	Do several installations on sailboat and average times w two able bodied people & no adjustability	Need able-bodied to install, need multiple people	Change to install with adjustments
12	Transfer Distance	40 in	50 in	39 in	Fail	Measure the maximum travel distance	Flaw in spec, didn't consider the actual travel. 50 is impossible with 48" bar and some features limit overall travel	Revisit spec
13	Time in a salt chamber without rust	12 hrs	24 hrs	n/a	n/a	Test in environmental chamber	Time and cost prohibitive	Further iteration can improve life and corrosion resistance of product
14	Product width	20 in	18 in	22.75	Fail	Measure front to back distance of system	Footprint changed during design phase and this was never revisited	n/a
15	Accepts customer's cushion	W- 18 in L- 18 in	W- 20 in L- 20 in	Cushion supplied	Pass	Install cushion on seat or get a modified cushion	n/a	n/a
16	Weight at a 45 degree angle forward	220 lbs	265 lbs	180 lbs	n/a	Tip seat 45°, add weight to shoulder harnesses to model worst case scenario	Inadequate test equipment	Investigate early, see if it is actually needed
17	Emergency release time to activate	3 sec	1 sec	<1 sec	Pass	Press emergency release on 5-point harness and lap belt	n/a	n/a
18	Rotate in final positions	10°	20°	>20°	Pass	Sit in the seat at positions A and B, and rotate the seat	n/a	n/a
19	Clamping force provided to maintain position	830 N (186.6 lbs of force)	850 N (192 lbs of force)	330 lbs	Pass	Apply force to locking mechanism and make sure seat doesn't move	n/a	n/a

- **Constraints:**
  - Can not hinder the ability of the sailor to operate the Jib lines due to positioning or introduction of barriers
  - Must remain within budget
  - Cannot contain support components requiring **alteration or damage** of the boat itself
  - Must be easily manufacturable and reproducible on a medium scale. This means that there will be as few custom-made parts as possible

- **Project Deliverables:**
  By the end of this project, the team will produce a fully-functioning, effective jib transfer bench that performs all of the functions within the functional decomposition. This device must support a user up to 265lbs. This jib transfer bench will be easily manufacturable and reproducible on a medium scale, requiring as little custom-made parts as possible. This jib transfer bench will have a matching 3D CAD model, as well as all of the corresponding technical drawings associated with it. There will be

manufacturing and assembly plans that go along with all of the subsystems required to make this device. In addition, there will be a installation and user's manual that goes along with the device, for the use of the customer(s).

- **Budget Estimate:** ***~$2500***

  Please see the BOM+Budget file on EDGE for a full cost breakdown of the previous jib transfer benches (2 were built by the previous team).
  By reducing the complexity of the system as well as relaxing the size constraint, the future team should be able to reduce the cost of the system to under $2500.

  The big-cost items will most likely be:
  - Precision motion devices (tracks/rods and rolling linear bearings or sliding bearings)
  - Purchase system (if it is used again)
  - Back Support Bar (if it is used again)
  - Seat Bracket material (most highly loaded piece, needs to be made of strong stainless steel or some other tough material)
  - Fasteners (stainless steel)
  - Seat

- **Intellectual Property (IP) considerations:** Possible patent opportunity, but the overall goal of these assistive devices is to make these designs open to the public in order to help out people.

- **Other Information:**
  As far as liabilities go, I am not sure if the designers are held liable if any injuries happen on the device that is created for the customer.

  There are some risks associated with this project that were seen in the previous iteration of the project. These types of risks seem pretty commonplace with systems of this nature. Some of these risks include:
  - Subsystems not interfacing as originally intended (binding, interference, gaps, etc)
  - System does not remain securely fastened to the boat (system bends, especially the wooden pieces)
  - Purchased part failure (not durable enough, not strong enough)
  - System, despite the best intentions, does not translate/rotate as well as originally intended

  Hopefully, as the summer progresses, feedback on the original systems will be acquired from the customers, which will give the future team some information about what was liked/disliked about the previous design. This will point them in the right direction, going forward in their design process and concept selection.

- **Continuation Project Information:**
  Much of the information presented in this PRP was adapted from P13031's PRP and the development of their jib transfer bench. Please see EDGE website for P13031 for more specific information about the original jib transfer bench, if desired: http://edge.rit.edu/edge/P13031/public/Home

STUDENT STAFFING:

Appendix (PRP): Skills Checklist

Project Name (tentative): Jib Transfer Bench: Design for Manufacturability

Checklist Completed by (name): Zeb Koch

*For each discipline, indicate which skills or knowledge will be needed by students working on the associated project, and **rank the skills in order of importance** (1=highest priority). You may use the same number multiple times to indicate equal rank.*

Mechanical Engineering

1	3D CAD		Aerodynamics
3	MATLAB programming		CFD
1	Machining (basic)		Biomaterials
2	Stress analysis (2D)		Vibrations
1	Statics/dynamic analysis (2D)		Combustion engines
	Thermodynamics	3	GD&T (geometic dimensioning & tolerancing)
	Fluid dynamics (CV)		Linear controls
	LabView (data acquisition, etc.)		Composites
	Statistics	1	DFM
			Robotics (motion control)
2	FEA		Composites
	Heat transfer		Other:
	Modeling of electromechanical & fluid systems		Other:
1	Fatigue & static failure criteria (DME)		Other:
1	Specifying machine elements		

Reviewed by (ME faculty):

Industrial & Systems Engineering

	Statistical analysis of data – regression		Shop floor IE – methods, time study
	Materials science		Programming (C++)
	Materials processing – machining lab		
	Facilities planning – layout, material handling	2	DOE
	Production systems design – lean, process improvement		Systems design – product/process design
1	Ergonomics – interface of people & equipment (procedures, training, maintenance)		Data analysis, data mining
	Math modeling – linear programming), simulation		Manufacturing engr.
	Project management	1	DFx -- Manuf., environment,

☐		☐	sustainability
☐	Engineering economy – ROI	☐	Other:
☐	Quality tools – SPC	☐	Other:
☐	Production control – scheduling	☐	Other:

Reviewed by (ISE faculty): _____

- Anticipated Staffing Levels by Discipline:

Discipline	How Many?	Anticipated Skills Needed (*concise descriptions*)
EE		
ME	3	CAD modeling, machining, statics/dynamics and stress analysis
CE		
ISE	1-2	Ergonomics, Human Factors, Design for Manufacturability
Other		Sailing experience is definitely helpful

OTHER RESOURCES ANTICIPATED:

Describe resources needed to support successful development, implementation, and utilization of the project. This could include specific faculty expertise, laboratory space and equipment, outside services, customer facilities, etc. Indicate if resources are available, to your knowledge.

Category	Description	Resource Available?
Faculty		☐
		☐
		☐
Environment	**A large workspace is preferable. Maybe a reserved table in the MSD lab**	☐
		☐
		☐
Equipment	**Machining Equipment**	☒
	Environment chamber for corrosion testing	☐
		☐

Materials		☐
		☐
		☐
Other		☐
		☐
		☐

Prepared by: Zeb Koch Date: 5/8/13