Portable Boat lift

by

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Transportable Boat Lift
(Frame and Moving Components)

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01 June 2007
ABSTRACT

Some of the most expensive costs with owning a boat today are yearly maintenance, storage, and transportation of large boats. Currently no way exists for private boat owners to lift their boats up and off a trailer, jack stands or cradle. Current methods of lifting a boat off of a trailer consist of a large crane which is only available at marinas and boat dealerships. The costs associated with these large cranes are very expensive, and these cranes are not always accessible in remote areas. The only other alternative is for the boat owner to build a makeshift contraption out of wood. This alternative is sometimes used; however, it is extremely dangerous and can be very costly or even deadly if not done right.

A transportable boat lift was proposed to allow private boat owners to easily perform their own maintenance without the fear of safety for a fraction of the cost. A survey was developed using promising features from current boat lifting methods. Through this survey a QFD was developed to determine what characteristics and features this new system might have to meet and exceed the customer’s main requirements of reliability and functionality. A detailed list of features and their objectives was then created using the results from the QFD. A detailed schedule was constructed to put a time table on the engineering and construction in respect to project deadlines. With a basic design created, a detailed budget was made. Deviation from this budget would be the resulted from different frame materials and or raised prices.
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INTRODUCTION

The costs associated with owning a boat increases steadily with all maintenance, storage and transport which are required to be done yearly to prevent damage to the boat and the trailer in and out of boat season. Boat ownership is relatively inexpensive if the boat owners can maintain the boat themselves and do not need to take it into the dealership, marina, repair facility or storage location for all work to be done.

It is plausible for mid size boat owners to perform yearly maintenance, store their boats, and transport the boat themselves if they had a portable lift to do so. Current boat owners are forced to either spend thousands of dollars for marinas to do the work or to create unstable and potentially dangerous contraptions to do the work themselves. Currently marinas use large and expensive lifts to pull the boat off the trailer and large forklifts to place the boat into storage.

Current methods of storage of boats are either by outdoor or indoor storage. As mentioned earlier, indoor storage requires a large forklift to place the boats on rails inside on a storage rack. Boats can be stored outdoors on either boat jack stands or above the water as shown below in Figure 1 also found in Appendix A. Pontoons which are filled and released of water are also used when storing boats above the water.

Figure 1 – Boat in storage using an electric winch [1]
Boats must be separated from their trailers during maintenance of the trailer or the boat itself. If work such as hull waxing is done while on the trailer, certain areas will be unprotected and could be subjected to damage. Proper maintenance requires the boat to be separate from the trailer to be easily moved to get the areas that are covered up by supports. Appendix A shows a variety of systems used to remove a boat from a trailer. These systems include large and expensive cranes to lift up boats using electric winches and a strap or by individual jacks. The large cranes are typically stationary but some models are movable with wheels Figure 2 shows several different options that marinas and other service stations have to lift boats.

Figure 2 Cranes and Jack used by Marinas to lift boat off of a trailer
FEATURES

Research was done by means of exploring industrial lifts and cranes to see how they work, mechanisms that make them work, and the features that are encompassed within these lifts. These lifts were analyzed and the features which would be beneficial in a portable lift were explored and are as follows:

- Safety mechanisms
- Boat transferable from trailer to jack stands or cradle
- Low cost
- Setup time
- Weather proof coating
- One person operation
- Portability / collapsible size
- Low weight for transportation
- Easy storage
- High lift height / range
- Part attachments for multiple size boats
- Appearance
- Lift speed
- Controlled by remote
- 3 ton max lift capacity

These features are further weighed and analyzed in the following sections. Specifically the customer survey section and the analysis tree explore which of these features are most important to the customer.
SURVEYS

A total of fifteen surveys were distributed to professionals in the field and private boat owners who perform yearly maintenance themselves. Five of these surveys were from sailboat dealerships, boat marinas, and fiberglass boat repair shops. The remaining 10 surveys were completed by private owners. It is believed that the most accurate results were obtained from these individuals because the target market is primarily private boat owners. From the results of the surveys we have obtained the analysis tree shown in appendix C.

The specific features within the survey were put into 5 different categories and from the analysis tree the most important aspects were developed as follows:

1. Reliability 26.28%
2. Functionality 20.91%
3. Ease of use 16.97%
4. Marketability 19.12%
5. Performance 16.97%

These five different categories were then divided up into different subcategories as follows:

Reliability
   Safety  56.8%
   Coating 43.2%

Functionality
   Transferability 34.3%
   Lift range 24.3%
   Attachments 22.9%
   Max capacity 18.6%

Performance
   Setup time 71.4%
   Lift speed 28.6%

Ease of use
   Single operation 28.2%
   Portability 18.3%
   Total weight 21.1%
   Easy storage 21.1%
   Remote 11.3%

Marketability
   Cost 59.4%
   Appearance 40.6%
QFD RESULTS

Within the QFD engineering characteristics were set aside to achieve each one of the customer features. To achieve the ability to transfer the boat off the trailer to jack stands or a cradle, the frame had been designed with this feature in mind. Setup time will be resolved with quick release kip handles, and one person operation will be achieved with a remote control mechanism. Safety will be achieved with the material selection, and a safety mechanism and or pin. Weather proofing will be solved with material selection also, and possibly a powder-coat paint. Small, heavy-duty, collapsible pieces will solve the customer requirement of portability, collapsible size, easy transportation, and easy storage. The ability to use on multiple size boats and a high lift range will be achieved by additional change parts with multiple size attachments for multiple size boats. Ease of use will depend on the remote control, and small collapsible pieces.

Within the QFD the improvement ratios were significant and the planned design is at or over the customer importance. The results for relative weights can be seen in appendix D
SCHEDULE

The schedule for the frame design (shown in Appendix E-3) was as follows: Proof of design was submitted on Jan 12th and design started on 1/15/07 and ended on 2/12/07. Feb 23rd was a design freeze. Smoothing out the design and testing followed the remaining two weeks. March 9th the design report was due, and March 16th Oral design presentations took place. Building then took place until April 27th. Tech Expo was on May 17th and the final Project report was due on June 4th.

A final revised schedule is as follows:

<table>
<thead>
<tr>
<th>Combined Team Schedule</th>
<th>Winter Quarter</th>
<th>Spring Block</th>
<th>Spring Quarter</th>
</tr>
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<tbody>
<tr>
<td>Week of</td>
<td>1/10</td>
<td>1/15</td>
<td>2/12</td>
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<tr>
<td>Tasks</td>
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<tr>
<td>Concept &amp; Selection</td>
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<tr>
<td>Proof of Design</td>
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<td>Design of base frame</td>
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<td>Design of power source</td>
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<tr>
<td>Design of main frame</td>
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<tr>
<td>Design of power source</td>
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<tr>
<td>Design of main frame</td>
<td>12-Jan</td>
<td></td>
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<tr>
<td>Design of components</td>
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<td></td>
<td></td>
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<tr>
<td>Design of transmission system</td>
<td>12-Feb</td>
<td></td>
<td>Res = Rosing, Blue = Blankenship, Black = Boat</td>
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<tr>
<td>Design of control system</td>
<td></td>
<td>Blue = Blankenship, Black = Boat</td>
<td></td>
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<tr>
<td>Design of trailer attachment</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Design Freeze</td>
<td>22-Feb</td>
<td>9-Mar</td>
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<tr>
<td>Smoothen out design</td>
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<td>16-Mar</td>
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<tr>
<td>Prepare design report</td>
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<tr>
<td>Design Report</td>
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<tr>
<td>Prepare for oral presentation</td>
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<tr>
<td>Oral Design Presentation (16Mar)</td>
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<tr>
<td>Order material</td>
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<tr>
<td>Finalize Design</td>
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<tr>
<td>Cut all raw material to fabrication length (Sand saw)</td>
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<tr>
<td>Leg Support base fabrication (Drill Press/Hole Drilling)</td>
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<tr>
<td>Crankcase fabrication (Drill Press/Hole Drilling)</td>
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<td>Cylinder &amp; Pump mounting plates fabrication (Drill Press/Hole Drilling)</td>
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<tr>
<td>Outer Telescoping Member Slot fabrication (Drill Press/Hole Drilling)</td>
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<tr>
<td>Outer Telescoping Member Slot Fabrication (Vertical Mill)</td>
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<tr>
<td>Flange spacer fabrication (Lake Operation)</td>
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<tr>
<td>Welding (Gaskets, Leveling Plates, Crankcase, Coupler, Mounting Plates)</td>
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<tr>
<td>Inner Telescoping Member Bearing Locating Holes Fabrication (Vertical Mill)</td>
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<tr>
<td>Lift Assembly (Hydraulic &amp; Frame Assembly) &amp; Test</td>
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<td></td>
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<tr>
<td>Lift Test with Boat</td>
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<tr>
<td>Fix any issues + Final</td>
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<tr>
<td>Summarization of Design</td>
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</tr>
<tr>
<td>Final Project report</td>
<td></td>
<td></td>
<td>1-Jun</td>
</tr>
<tr>
<td>Oral Presentation (12 min)</td>
<td></td>
<td>16-Mar</td>
<td>4-Jun</td>
</tr>
</tbody>
</table>
The budget for the Frame and moving components (Appendix E) was as follows:

Frame components was be made from Structural steel tubing. An estimate was put together with assuming 4” X 4” structural steel tubing and approximated @ 26’ needed. The cost of this tubing was quoted by Industrial steel tubing in Cincinnati Ohio on 10/08/06 @ 7.95 per foot. This totals out at $206.70 for the structural steel tubing.
Kip handles, washers, and all other hardware were budgeted @ $79.99
Welding supplies were budgeted at around $80.00
Leveling feet with locknuts were quoted @ 23.27 x 4 = $93.80
Boat contact pads were estimated at $45.00 and will be custom fabricated.
The total cost for the frame and moving parts was estimated at $505.49
DESIGN OPTION NUMBER 1

The following was the first design option. It consists of a sling type mechanism which is held in place by two telescoping uprights. The uprights are held in place by a base with a cross-member which is flat, so a trailer would be able to be pulled out of the lift once it is lifted.

Pros
- Conforms to the shape of the boat
- Stability with most types of boats

Cons
- Unable to use with certain hull types
- Hard to transport
- May not be possible to design with sufficient stresses in lower crossbeam
- Contact mechanism not adjustable.
DESIGN OPTION NUMBER 2

The following is the second design option. It consists of a small compact jacking system which would hook into the bow eye of the boat. It would then jack up with either a hydraulic or electric jacking system. This system would be very portable and would be used in conjunction with two jack stands in the rear to pivot the boat. Once lifted the trailer would be pulled out and around the jack in front.

**Pros**
- Very compact
- Lightweight
- Cost effective

**Cons**
- Not suitable for boats over 1 ton
- Not suitable for boats over 20’ in length
- Not all boats have bow-eyes
- Boats can be, but are not rated to be lifted with bow-eyes

![Diagram relating to design option number 2]
DESIGN OPTION NUMBER 3

The following is the third design option. It consists of a crossbeam and two telescoping uprights with hydraulics inside of them. It can either be used with one jack at the bow of the boat by pivoting the rear of the boat on jack stands. It can also be used with two different jack stands by using one at the bow and one at the stern.

Pros
- Compact
- Easy to transport
- User friendly
- Can lift almost any kind of boat / Adjustable

Cons
- Over suited for extremely small boats (under 18’ / under 800lbs)
  - However will work with these boats
CHOSEN DESIGN OPTION:

The chosen design option is design option number 3. This option was chosen because it is best suited for all applications. It will enable lifting up to a 3 ton boat with ease, and still allow for easy transportation and storage because it is collapsible and has three easy pieces for transportation. This design will also allow for different change parts which will enable for use on many different type boats.
INITIAL ANALYSIS / CALCULATIONS:

The following are calculations that were initial calculations that were done to determine the practicality of this design. Further more detailed analysis will be shown in the following pages done with cosmos.

FORCES WHEN LIFTED:
FORCES WHEN LIFTED: (CONTINUED)

\[ F_{Gx} = \text{mass} \times \sin \theta \Rightarrow 1360(0.85) \sin(5) = -1161 \]
\[ F_{Gy} = \text{mass} \times \cos \theta \Rightarrow 1360(0.85) \cos(5) = 1327 \]

\[ F_{Gx} = 1161 \text{ Newtons} \]
\[ F_{Gy} = 1327 \text{ Newtons} \]

\[ \text{Coefficient of friction on surface of table} = 0.7 \]
\[ \mu_s = 0.7 \]
FORCES: (CONTINUED)

Moments About A & D

\[ M_A = (1500 \text{ ft}) (3.5 \text{ ft}) \]

\[ M_A = F_C \cdot d_A \]

\[ M_C = 63000 \text{ ft-lb} \]

\[ M_D = (1500 \text{ ft}) (3.5 \text{ ft}) \]

\[ M_D = 63000 \text{ ft-lb} \]

\[ F_{Ax} = 1500 \text{ ft} \]

\[ F_{Ay} = F_{By} \]

\[ F_{By} = 1500 \text{ ft} \]
FORCES / MAX POSSIBLE DEFLECTION:

FOR PORPOSED 3” X 3” X .25” CROSSBEAM

The results from this size crossbeam has a high deflection so we will examine the results from a 3.5” x 3.5” x .25” crossbeam on the next page.
FORCES / MAX POSSIBLE DEFLECTION:

FOR PORPOSED 3.5” X 3.5” X .25” CROSSBEAM

This max possible deflection seems much more suitable and we will further explore the stresses in cosmos on the next couple of pages.
FORCES ANALYSIS IN COSMOS (CROSSBEAM AND UPRIGHTS)

The following are results from cosmos so we can fully examine the structure under all loading conditions.

This analysis is done with 1500 lbs of force on each of the boat contact points, and with 250# of force on each boat contact points in the transverse direction of the boat. This was the force calculated when the boat is lifted. (See previous hand calculations). The factor of safety is right around 3.5 as seen in the picture. The highest stress concentration in this design is about 14285 MPa. The yield stress of the ASTM-A500 structural steel that was used is around 50,000mpa.
FORCES ANALYSIS IN COSMOS: (BASE / LEG)

The following are results from cosmos so we can fully examine the structure under all loading conditions.

This analysis continues the previous analysis and assumes all loads transferred to this member from the previous calculation.

The factor of safety is right around 8.5 as seen in the picture. The highest stress concentration in this design is about 5882 MPA. The yield stress of the ASTM-A500 structural steel that we are using is right around 50,000mpa.
MAIN ASSEMBLY
## 3 Ton Hydraulic Portable Boat Lift Part Numbers

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Specifications</th>
<th>Supplier</th>
<th>Supplier Part number</th>
<th>Quantity</th>
<th>File Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Assembly</td>
<td>Main Assy</td>
<td></td>
<td>Industrial Tube and Steel Corp</td>
<td>ASTM A-500</td>
<td>2</td>
<td>Assy</td>
</tr>
<tr>
<td>10001</td>
<td>Lower Frame member</td>
<td>4&quot; x 4&quot; O.D. structural steel tubing, 186 wall thickness 30&quot; long</td>
<td>Industrial Tube and Steel Corp</td>
<td>ASTM A-500</td>
<td>2</td>
<td>Part, 1,2,3, Assy</td>
</tr>
<tr>
<td>10002</td>
<td>Upright outer Frame member</td>
<td>4&quot; x 4&quot; O.D. structural steel tubing, 186 wall thickness 24&quot; long</td>
<td>Industrial Tube and Steel Corp</td>
<td>ASTM A-500</td>
<td>2</td>
<td>Part</td>
</tr>
<tr>
<td>10003</td>
<td>Upright inner Frame member</td>
<td>3.5&quot; x 3.5&quot; O.D. structural steel tubing, 25 wall thickness 24&quot; long (angled)</td>
<td>Industrial Tube and Steel Corp</td>
<td>ASTM A-500</td>
<td>2</td>
<td>Part</td>
</tr>
<tr>
<td>10004</td>
<td>Upright Assembly</td>
<td>Upright Assembly (45th angle)</td>
<td></td>
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<tr>
<td>10005</td>
<td>Upright Frame member</td>
<td>4&quot; x 4&quot; O.D. structural steel tubing, 186 wall thickness (other Angle)</td>
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<td>ASTM A-500</td>
<td>2</td>
<td>Part</td>
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<td>10006</td>
<td>Upright Assembly</td>
<td>Upright Assembly (With cut angle)</td>
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<td>2</td>
<td>Assy</td>
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<td>10007</td>
<td>Upright inner Frame member</td>
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<td>ASTM A-500</td>
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<td>4&quot; x 4&quot; O.D. structural steel tubing, 186 wall thickness (Coupler)</td>
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<td>ASTM A-500</td>
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<td>10009</td>
<td>Reinforcement corner Welds</td>
<td>25&quot; structural steel</td>
<td>Scrap</td>
<td>ASTM A-500</td>
<td>8</td>
<td>Psm</td>
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<td>10010</td>
<td>Reinforcement side Welds</td>
<td>25&quot; structural steel</td>
<td>Scrap</td>
<td>ASTM A-500</td>
<td>4</td>
<td>Psm</td>
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<tr>
<td>10011</td>
<td>Bearing</td>
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<tr>
<td>10012</td>
<td>Cross beam</td>
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<td>Industrial Tube and Steel Corp</td>
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<tr>
<td>10016</td>
<td>Wood pad for boat contact</td>
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<td>Scrap</td>
<td></td>
<td>2</td>
<td>Psm</td>
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<tr>
<td>10017</td>
<td>Assy for boat contact</td>
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<td></td>
<td></td>
<td></td>
<td>Assy</td>
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<tr>
<td>10018</td>
<td>Inner reinforcement @ connect</td>
<td></td>
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</tbody>
</table>
FABRICATION

Fabrication started the first week of spring quarter. Raw stock was ordered winter quarter, and picked up the week before spring quarter started. Raw stock consisted of (3) 12’ sections, (2) 3.5” x 3.5” x .25” structural steel tubing, and (1) section of 4” x 4” x 1.88” structural steel tubing. Other material was purchased as needed from Metal Supermarkets in Blue Ash Ohio. Fabrication was done with a machine oriented process. All raw stock was cut into sizes needed before further fabrication was proceeded. This was in an effort to conserve time and stay on schedule. If each part was completely fabricated before the next we would have had trouble with the time alluded to finish the project. After all stock was cut to raw sizes, drilling and tapping were done. Stock was cleaned up and grinded, tolerances were checked, and layouts and final calculations were done on before machining took place. After all machining was done, all materials were prepped and grinded prior to welding. Welding took place the 5th week of the quarter. Welds were checked, and insufficient welds were grinded and re-welded for safety and integrity.

ASSEMBLY

Assembly was completed the 6th week of the quarter. All fabricated and purchase parts were dry fitted before assembling and necessary changes were made as needed. The only necessary changes were that of grinding and cleaning up previously fabricated parts. The first step to assembly was testing and bleeding the cylinders and hydraulic components. The hydraulic components were fitted and tested before any installation took place. It was found that the fittings, hoses, and manifolds needed to be torqued extremely high so that hydraulic fluid did not leak out of the 10,000 psi system. After an initial test was completed and lines
were tightened the hydraulic cylinders were installed within the uprights and housing. Hoses were once again installed, and the safety check valves were installed. Shortly after the cylinders, hoses, and check valves were installed, bearings were put in place. Feet were installed and then it was time to put the crossbeam and two uprights together and test the system.

TESTING

An initial test was done after the first assembly was completed. This test was completed without a load on the system. The results showed what was originally determined and verified that the valves on the manifold would need to be adjusted on the fly to ensure each cylinder would get the correct amount of fluid to ensure one cylinder from extending before the other one. The first test was completed with out any problems, so a test with a boat then proceeded. The second test with the boat was completed as follows:

- Boat was backed into place. (For shoal keel boats, and boats that sit low on the trailer below the minimum lift height, back the boat on ramps)
- Place the rear of the boat on jackstands.
- Assemble and install the lift above the trailer at the bow of the boat.
- Snug up jackstands in the rear.
- Remove the bow safety line and
winch from the boat to the trailer.

- Attach the quick release hydraulic fittings and start lifting the boat off the trailer.
- Pump the lift until the trailer is no longer touching the boat and the boat is completely supported by the lift at the bow and the stands at the rear.
- Slowly and carefully start pulling out the trailer.
- Place jackstands at the bow of the boat.
- Lower the lift until the boat is sitting completely on jackstands.
- Remove the lift, complete hull work, storage, or maintenance on boat or trailer.
- Reverse and repeat the process to get the boat back on the trailer.

After the first test was completed, the lift was completely disassembled and all parts were cleaned prior to painting. Enamel coating paint was used due to the minimal time to powder coat parts. All parts were painted separately, and a curing time of 24 hrs was needed before the lift could be re-assembled. After all parts were done curing, the lift was re-assembled, and a final test was completed with our advisor onsite. The same process was used in previous test.

**RECOMMENDATIONS**

Numerous recommendations will be made if the 3-Ton Portable Boat lift is ever put into production. The following are some of the recommendations which will be made:

- Lift will use double stage cylinders and a double stage housing to improve stroke, and minimum height of lift.
- Uprights will be machined using water jet cutting or plasma cutting, and will have movable guides for the bearings to ride on.
- Crossbeam and uprights will be made of custom extruded composites to enable the same load capacity with half the weight and also help to ensure tolerances.
- Boat contact mechanism will be made of a plastic composite to make it lightweight, as well as durable.
- Lift will be powder coated to further insure rust protection.
CONCLUSIONS

The lift worked excellent and flawlessly. Efforts to bring the lift to market may be made at some point further down the road, however at this time funds to patent the lift are not available. Many guests at Tech Expo have encouraged us to patent the Three Ton Portable Boat Lift. Reactions have been very supportive, and many have stated that they would be willing to purchase such a lift if it was on the market. Bringing a product to the market of this sort is easier done by a company which specializes in this industry, and would be extrodinarily costly for a new company to break into the market.
REFERENCES

1 Shuttle Lift [online- seller for overhead marine lifts] 11/20/06
http://www.martinwalterco.com/industrial/martin_walter_industrial_mobil_hoist.htm

1 Lift out of water lifts [online site for lifts which pull boats out of water] 11/20/06
http://www.boatlifts4less.com/boathoistusa/images/800_liftpic1.jpg

1 Yardarm Lifts [Online site for portable powerboat lifts] 11/20/06
http://www.yardarm.com/marine_products/boat_handling_jacks.htm

1 TMT marine Transportation [industrial boat lifts] 11/20/06
http://www.tmt-llc.com/Travel%20Lifts/TM1658TL.htm
APPENDIX A – RESEARCH / SIMILAR PRODUCTS

http://www.martinwalterco.com/industrial/martin_walter_industrial_mobil_hoist.htm, 10/2/06

- Extremely Expensive
- Not Transportable
- Only for use by marinas and boat dealers
- Need Professional operators

- Lifting straps contour to the boat
- Can handle many sizes of boats
- Able to lift onto trailer, jack stands, or cradle

- Single/Double Traversing Hook Models or Four and Six Fixed Hook Models.
- Rigid Structural Frame... With Pivot Pivot Joint... No Frame Member Overstress During Rough Ground Travel.
- Fast Hoisting and Operating Speeds... More Efficiency... Improved Profits.
- Four Travel Alarms, to Aid in Safer Operation.
- Load Gauges for Safe Operations.
- Reliable and Rugged Gear Type Hydraulics... Added Durability... Less Downtime.
- Stainless Steel Hydraulic Lines... Improved Quality... Longer Service Life.
- Enclosed Weatherized Cab... More Operator Comfort and Safety.
- Smooth Controls... One Person Operation With All Controls at Your Fingertips.
- Custom Heights and Widths to Meet Your Exact Needs.
- Four Wheel Drive Available.

http://www.boathoist4less.com/boathoist4usa/images/800_liftpic1.jpg, 10/2/06

- Not Transportable
- Not transferable to trailer
- For House/Water Storage only

- Cheap
- Able to be used by average owner
- Conforms to a variety of boats

Side Mount Kit includes:
- complete hoist matched for capacity
- 2 dual pipe supports
- 2" or 4" ball bearing blocks
- 12" strap hangers
- 8 galvanized 7x19 aircraft cable
- 8 galvanized cable clamps
- 4 galvanized cable thimbles
- 1 set of 4x14 ft. slings or 8' v hull lift, cradle mounting hardware
**Model**: Marine Travel Lift 30 AMO open end

- **90 degree steering**
- **Hydraulic adjustable sling spacing**

**Capacity**: 30 tons

- **Inside Clear Width**: 17'
- **Inside Clear Height**: 18'
- **Engine**: Allis Chalmers diesel

- Not Portable
- Not for private ownership
- Expensive
- For experienced use only

- Able to lift boat off of jack stands, cradle, trailer
- Conforms to a variety of boats
<table>
<thead>
<tr>
<th>Not transportable</th>
<th>Safety mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not usable with all boat types</td>
<td>Portable</td>
</tr>
<tr>
<td>Not usable on any sailboat</td>
<td>Able to lift boat vertically off trailer</td>
</tr>
<tr>
<td>Need 4 to use</td>
<td></td>
</tr>
<tr>
<td>Expensive</td>
<td></td>
</tr>
</tbody>
</table>

**Work station for bottom repair and cleaning**
- Trailer rolls in or out past jacks, allowing you to take boats on or off trailers easily
- Jacks have a safety lock allowing boats to be left on jacks indefinitely
- Jacks can be used on dirt, gravel, black top or cement
- Jacks can be used anywhere: shop, yard, showroom
- Lifts boats up to 40,000 lbs. (with 4 jacks)
- 10 minute boat placement
- 20” vertical lift
- Lifts big boats right off the transport truck
- Allows fast and easy trailer to trailer exchange
- Expedite boat show setup. No waiting for a crane
### APPENDIX B – CUSTOMER FEATURES

<table>
<thead>
<tr>
<th>Feature</th>
<th>Design/Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transferability off trailer or stands</td>
<td>Frame design</td>
</tr>
<tr>
<td></td>
<td>Frame will be designed so that it will allow the user to move the trailer out from under the boat after the boat is lifted. This will also allow the user to place a cradle under the boat, and or place the boat on jackstands after it is lifted. This will allow for easy maintenance of the trailer and boat hull for yearly maintenance.</td>
</tr>
<tr>
<td>Setup time</td>
<td>Easy to use hardware</td>
</tr>
<tr>
<td></td>
<td>System will be designed with easy to use removable, latch, or clip in parts such as kip handles so that setup will take minimal time. System should take no longer than 20 minutes to set up.</td>
</tr>
<tr>
<td>One person operation</td>
<td>Control mechanism / Remote</td>
</tr>
<tr>
<td></td>
<td>System will have a control system which can be operated by one person, possibly a handheld remote which will control the hydraulic system automatically.</td>
</tr>
<tr>
<td>Safety</td>
<td>Safety system / Safety device</td>
</tr>
<tr>
<td></td>
<td>System will be equipped with a safety mechanism or sets of safety pins which will prevent the system failing and causing injury.</td>
</tr>
<tr>
<td>Weather proof</td>
<td>Paint / Coating</td>
</tr>
<tr>
<td></td>
<td>Frame and components will be coated with weather resistant paint or coating.</td>
</tr>
<tr>
<td>Portability / collapsible size</td>
<td>Small Heavy duty Collapsible Frame Pieces</td>
</tr>
<tr>
<td></td>
<td>Frame will have lightweight collapsible members which will allow for easy storage and transportation in the back of a suv or pickup truck.</td>
</tr>
<tr>
<td>Easy to transport</td>
<td>Small Heavy duty Collapsible Frame Pieces</td>
</tr>
<tr>
<td></td>
<td>Frame will have collapsible members which will allow an average boat owner to transport and setup the lift with only one person.</td>
</tr>
<tr>
<td>Easy to storage</td>
<td>Small Heavy duty Collapsible Frame Pieces</td>
</tr>
<tr>
<td></td>
<td>Frame will have collapsible members which will allow for storage and transportation by only one person.</td>
</tr>
<tr>
<td>Lift range / Lift height</td>
<td>1-2 sets of change parts</td>
</tr>
<tr>
<td></td>
<td>Will have sets of change parts and or extension parts for multiple size boats.</td>
</tr>
<tr>
<td>Appearance</td>
<td>Paint / Coating</td>
</tr>
<tr>
<td></td>
<td>Frame will be coated with a paint which will allow corrosion resistance and have a presentable appearance to satisfy builders.</td>
</tr>
<tr>
<td>Lift speed</td>
<td>Lift system (Hydraulic, electric, or airbags)</td>
</tr>
<tr>
<td></td>
<td>System will be designed to meet a minimum lift speed of at least 120 seconds per foot of lift.</td>
</tr>
<tr>
<td>Easy to use</td>
<td>Control mechanism / Remote</td>
</tr>
<tr>
<td></td>
<td>System will have an easy to use control system, possibly a handheld remote which will control the hydraulic system automatically.</td>
</tr>
<tr>
<td>able to use on multiple size boats</td>
<td>Part attachment for multiple size boats</td>
</tr>
<tr>
<td></td>
<td>Will have extra parts and extension parts for multiple size parts with multiple heights from boats sizes (15-26 feet) and boats up to 3500 Lbs.</td>
</tr>
<tr>
<td>Low Initial price</td>
<td>Low manufacture cost</td>
</tr>
<tr>
<td></td>
<td>Frame and hydraulics will be designed so that the procedures needed to build the system will be cost effective and still achieve optimal results. Initial cost of the system will fall into the range of $1050.45 +/- $315.00</td>
</tr>
</tbody>
</table>
APPENDIX C – CUSTOMER SURVEY

Customer Survey

Transportable / Portable boat lift.

As seniors at the University of Cincinnati, we are developing a senior design project which will enable boat owners to lift boats by the use of a transportable system. This would allow owners to perform yearly maintenance such as bottom painting, hull work, storage on jack stands and transferring to cradles or trailers.

Please take a few minutes to fill out this survey. Thank you for your time.

Please rate your answers from 1-5  
1 = low importance  5 = High importance

1) Safety mechanism.  
2) Boat transferable from trailer to jack stands or cradle.  
3) Cost  
4) Setup Time  
5) Weather proof coating  
6) One person operation  
7) Portability; Collapsible size  
8) Total weight for transporting  
9) Easy Storage  
10) Lift range/ Lift height  
11) Part attachments for multiple size boats  
12) Appearance  
13) Lift speed  
14) Controlled by remote  

15) Preferred max lift capacity  
1.5 – 2 tons  2 – 2.5 tons  2.5 – 3 tons

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Functionality</th>
<th>Performance</th>
<th>Ease of Use</th>
<th>Marketability</th>
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<tr>
<td>4.4</td>
<td>3.5</td>
<td>2.8</td>
<td>2.84</td>
<td>3.2</td>
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<tr>
<td>26.28%</td>
<td>20.91%</td>
<td>16.73%</td>
<td>16.97%</td>
<td>19.12%</td>
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</table>

<table>
<thead>
<tr>
<th>Safety</th>
<th>Cost</th>
<th>Transferable</th>
<th>Lift Range</th>
<th>Attachments</th>
<th>Max Capacity</th>
<th>Setup Time</th>
<th>Lift Speed</th>
<th>Single Operation</th>
<th>Portability</th>
<th>Total Weight</th>
<th>Easy Storable</th>
<th>Remote</th>
<th>Cost</th>
<th>Appearance</th>
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</thead>
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<tr>
<td>5.5</td>
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<td>4.8</td>
<td>4.4</td>
<td>3.4</td>
<td>2.1</td>
<td>14.0</td>
<td>5.6</td>
<td>4.0</td>
<td>2.8</td>
<td>3.0</td>
<td>1.8</td>
<td>14.2</td>
<td>3.8</td>
<td>2.8</td>
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<tr>
<td>56.8%</td>
<td>43.2%</td>
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<td>24.3%</td>
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<td>18.6%</td>
<td>71.4%</td>
<td>28.6%</td>
<td>28.2%</td>
<td>18.3%</td>
<td>21.1%</td>
<td>21.1%</td>
<td>11.3%</td>
<td>59.4%</td>
<td>40.6%</td>
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</table>
## APPENDIX D – QFD

| Operation                  | Material | Frame design | Easy to use kil handles | Control mechanism / remote | Safety valve / safety pin | Powder coat painting | Small heavy duty collapsible frame pieces | Lift system (air bags or hydraulic) | Part attachment for multiple size boats | Geometry and setup of links | Cost of manufacture | Planned design | Improvement (Absolute weight) ratio | Relative weight |
|----------------------------|----------|--------------|-------------------------|----------------------------|--------------------------|-----------------------|----------------------|----------------------------------------|--------------------------------------|-------------------------------------|----------------------|---------------------|---------------------|----------------------------------|-------------------|
| Transferability off trailer or stands | 9        | 1            | 9                       |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 4.8 5 1.0 0.06          |                   |
| Setup time                 | 3        |              | 9                       |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 4 4 1.0 0.06            |                   |
| One person operation       |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 4 5 1.3 0.07            |                   |
| Features                   |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 5 5 1.0 0.06            |                   |
| Safety                     | 3        |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 3.8 4 1.1 0.06          |                   |
| Weather proof              | 3        |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 2.6 4 1.5 0.09          |                   |
| Portability / collapsible size | 9        |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 3 4 1.3 0.08            |                   |
| Easy to transport          |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 3 3.5 1.2 0.07          |                   |
| Lift range / Lift height   |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 3.4 5 1.5 0.09          |                   |
| Appearance                 |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 2.6 3 1.2 0.07          |                   |
| Lift speed                 |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 1.6 2 1.3 0.07          |                   |
| Easy to use                |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 1.6 3 1.9 0.11          |                   |
| able to use on multiple size boats |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 4.8 5 1.0 0.06          |                   |
| Cost                       |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     |                                  |                   |
| Initial price              | 3        |              | 1                       | 1                          | 1                        | 1                     | 3                    | 9                                      |                                       |                                     |                      |                     |                                  |                   |
| Absolute Importance        |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 0.05 0.5 10.20          | 17.2 1.00         |
| Relative importance        |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 0.05 0.5 0.02 0.12 0.15 |                   |
| Target Value               |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 0.05 0.05 0.08 0.06 0.06 |                   |
| Units                      |          |              |                         |                            |                          |                       |                      |                                        |                                       |                                     |                      |                     | 0.05 0.05 0.30 0.06 0.06 |                   |

Appendix F1
## APPENDIX E – PROJECT SCHEDULE

<table>
<thead>
<tr>
<th>Combined Team Schedule</th>
<th>Winter Quarter</th>
<th>Spring Break</th>
<th>Spring Quarter</th>
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</thead>
<tbody>
<tr>
<td>Week of</td>
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<td>1/15/07</td>
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<td>5/7/07</td>
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</tr>
<tr>
<td></td>
<td>5/28/07</td>
<td>6/4/07</td>
<td></td>
</tr>
</tbody>
</table>

### Tasks

- **Concepts & Selection (Weighted objective method)**
- **Proof of Design**
- **Design of base frame**
- **Design of power source**
- **Design of moving frame components**
- **Design of power transmission system**
- **Design of boat contact system**
- **Design of control system**
- **Design of trailer attachment**
- **Design Freeze**
- **Smooth out design**
- **Prepare design report**
- **Design Report**
- **Prepare for oral presentation**
- **Oral Design Presentations (7min)**
- **Order material**
- **Finalize Design**
- **Build base frame**
- **Build power source**
- **Build moving components of frame**
- **Build power transfer system**
- **Build contact system**
- **Build control system / control box**
- **Demonstration of Design**
- **Fix any issues + Paint**
- **Tech Expo (May 17)**
- **Prepare for oral presentation**
- **Compile final report**
- **Oral Presentation (12 min)**
- **Final Project Report**

- **Red** = Novinc
- **Blue** = Brankamp
- **Black** = Both

Appendix F1
<table>
<thead>
<tr>
<th>Week of</th>
<th>Winter Quarter</th>
<th>Spring Break</th>
<th>Spring Quarter</th>
</tr>
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<tr>
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<tr>
<td>6/4/07</td>
<td></td>
<td></td>
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</tbody>
</table>

**Tasks**

- Concepts & Selection (Weighted objective method)
- Proof of Design
  - Design of power source
  - Design of power transmission system
  - Design of control system
  - Design Freeze
- Smooth out design
- Prepare design report
- Design Report
  - Prepare design report
  - Design Report
- Prepare for oral presentation
- Oral Design Presentations (7 min)
  - Order material
- Finalize Design
  - Build power system
  - Build control system / control box
- Demonstration of Design
  - Fix any issues + paint
- Tech Expo (May 17)
  - Prepare for oral presentation
- Compile final report
  - Oral Presentation (12 min)
  - Compile final report
  - Final Project Report

**Appendix F2**
<table>
<thead>
<tr>
<th>Novinc Schedule</th>
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<th>Spring Break</th>
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</tr>
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<tr>
<td>Tasks</td>
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<tr>
<td>Design Freeze</td>
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<tr>
<td>Smooth out design</td>
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<tr>
<td>Prepare design report</td>
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<tr>
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<td>16-Mar</td>
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<tr>
<td>Oral Design Presentations (7 min)</td>
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<tr>
<td>Finalize Design</td>
<td>27-Apr</td>
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<tr>
<td>Build base frame</td>
<td>27-Apr</td>
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<td>Build moving components of frame</td>
<td>27-Apr</td>
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<td>Build contact system</td>
<td>27-Apr</td>
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<tr>
<td>Demonstration of Design</td>
<td>27-Apr</td>
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<tr>
<td>Fix any issues + paint</td>
<td>27-Apr</td>
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<tr>
<td>Tech Expo (May 17)</td>
<td>17-May</td>
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<tr>
<td>Prepare for oral presentation</td>
<td>17-May</td>
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<tr>
<td>Compile final report</td>
<td>4-Jun</td>
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<tr>
<td>Oral Presentation (12 min)</td>
<td>4-Jun</td>
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<tr>
<td>Final Project Report</td>
<td>4-Jun</td>
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Appendix F3
APPENDIX F – PROJECT BUDGET

Budget Analysis
For 3 Ton boat lift
Brandon J. Novinc
David G. Brankamp
10/23/06

Note: Budget is subject to change depending on how many parts may be received
donated, used, or as reFab equipment.
Budget is also based on one lift

- Frame components
  Structural steel tubing 4” x 4” approximately 26’ needed @ $7.95 per foot
  = $206.70

- Kip handles, hardware, washers, etc.
  $7.99 each kip * (10 kips) = $79.90 total

- Welding supplies
  o $80.00 budgeted

- Misc. Metal and metal supplies
  o $75.00 budgeted

- Leveling feet with locknuts
  o $23.27 * (4 needed) = $93.08

- Hydraulics (used or reFab equipment)
  o 2 cylinders @ $65.00 each = $130.00
  o Lines $90.00 Budgeted
  o Hydraulic Fittings $87.68
  o Hydraulic Tank $20.00
  o Hydraulic Pump $143.00

- Boat contact pads
  o $45.00

Total estimated budget $1050.45
Budget Analysis
For 3 Ton boat lift
David G. Brankamp
10/23/06

Note: Budget is subject to change depending on how many parts may be received donated, used, or as refab equipment.

Budget is also based on one lift

- Misc. Metal and metal supplies
  - $75.00 budgeted

- Hydraulics (used or refab equipment)
  - 2 cylinders @ $65.00 each = $130.00
  - Lines $90.00 Budgeted
  - Hydraulic Fittings $87.68
  - Hydraulic Tank $20.00
  - Hydraulic Pump $143.00

Total estimated budget $545.68
Budget Analysis
For 3 Ton boat lift
Brandon J. Novinc
10/23/06

Note: Budget is subject to change depending on how many parts may be received donated, used, or as refab equipment.

Budget is also based on one lift

- Frame components
  Structural steel tubing 4” x 4” approximately 26’ needed @ $7.95 per foot
  = $206.70

- Kip handles, hardware, washers, etc.
  $7.99 each kip * (10 kips) = $79.99 total

- Welding supplies
  o $80.00 budgeted

- Leveling feet with locknuts
  o $23.27 * (4 needed) = $93.80

- Boat contact pads
  o $45.00

Total estimated budget $505.49