Guided Boat Docking System

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by

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ABSTRACT

Boat repairs are a costly mistake that most boaters make when docking a boat. With the average boat prices rising every year and the cost to repair them increasing as well, people need a safe, stress free way to dock a boat in a slip. With only a few options currently on the market and none of them completely solving the goal set here. The goal is to engineer a system that will guide a boat into the slip, while bringing the boat to a halt in the correct position within the slip. Using engineering design processes to ultimately design this system.

The interview process leads to the most important features in the design process are: One person operational, Safety, and Ease of Use. Taking all the customers input with engineering characteristics three concepts were derived. These three concepts were then analyzed using the weighted decision matrix and the V-Guided concept was chosen. The guiding aspect and stopping power proved to be the deciding variables.

The stopping force required to stop a completely loaded boat going idle speed was calculated. Using the water as resistance to stop the boat was utilized by designing a down rigger with a plate in the water. The plate size was calculated by the stopping force required. Different size plates will be used for different size boats. This ensures the proper stopping force is delivered for each sized boat.

Materials were chosen based on the outdoor use and the repeated loading they will see. Garage door springs were utilized based on their reliability and the distance they can be extended. All components were analyzed based on loading conditions they could see during extreme use. Hard stops were built in to ensure safety when coming to a stop. Modifying this assembly to fit a different size boat can be done in less than 2 hours.
INTRODUCTION

BACKGROUND

Many factors come into play while trying to pull a boat into a slip. If the wind is blowing the boat might be coming in from an angle and at a faster speed than usual. This predicament is all too common for the average boat driver. Damage from hitting or nicking a dock can cost a boat owner anywhere from a couple hundred dollars, up to and over a thousand dollars. These costs could be avoided with a guidance system that would control the boat while entering the dock. This controlling system would guide the boat into the slip while slowing the boat to a completed stop. This guided system would alleviate a lot of the headaches that go with docking a boat in a slip. Currently there are no products that can accomplish these tasks without some sort of risk to the boat or a passenger.

EXISTING PRODUCTS

BOAT DOCKING SYSTEMS

There are only a few systems that are available to purchase to help alleviate the pressures of docking a boat. A drive-on floating system figure (1) is the only product to guide and stop while docking a boat. This docking system works better for wave runners than full size watercrafts. When pulling up on these floats the front of the boat goes skyward and then comes back down when pulled up completely. Wave runners are much smaller and lighter which makes pulling them up on these floating ramps easier and less scary. For this model you are not only paying for a guide and stop for the boat, but also using it for a lift. This makes the floating drive on dry dock system very pricey.

Figure 1 Drive on Docking System (1)
A patent was filed that uses a V-shaped guide figure (2) that is mounted to the front of the dock. The V is held into place by two flexible fiberglass U-shaped pieces. There is also a support that lets holds the side of the guidance system to the dock. The springiness of the fiberglass would have to be precise in order to stop a boat coming in at idle speed. If this were to fail the front of the boat could hit the dock and damage the boat. The guidance aspect of this design seems sound, but continually contact with the boat hull could cause wear to the boat or too this mechanism. This design could be improved upon to work in a slip.
Another type of docking system would be the “landing loop” figure (3) which someone would have to pull the boat in using a long pole. While pulling the boat in, the person pulling could fall into the water if not careful. This is not the most ideal way to dock a boat in a slip. A boat slip is in the shape of a U, so the boat has something it can hit on 3 sides. While pulling a boat in with this product you must be conscious of the surrounding to make sure no impact is made with the dock. On a windy day, this task would be very difficult.

Figure 3 Landing Loop (3)

Docking a boat shouldn’t lead to a headache or costly repairs. A boat docking system should guide the boat in while slowing the boat down all in a safe manner. The ideal situation is when the boat driver is the only one controlling the boat and other passengers can remain seated until stopped. This would reduce the chance for injury to a passenger and also the boat. Currently, boat drivers would have to pull the boat in going idle speed, to keep control of the boat and then when in the dock put the boat in reverse to keep from hitting the bow of the boat. When the boat is thrown into reverse the back of the boat wants to kick one way or another and damage could occur to the boat. While all these products have certain features that are desirable while docking, none of them have every positive feature. Combining the catching feature and the stopping feature while not having any relative motion between this product and the boat would be ideal.
CUSTOMER FEEDBACK, FEATURES, AND OBJECTIVES

INTERVIEWS

Multiple experts in the field of boating were interviewed and asked multiple questions. With over 80 years combined experience on the water, these individuals have experienced almost everything boating has to offer. They all talk about reducing the risk of scratching the boat while docking a boat into a slip. John Viltro (4) says “I would have loved to have something to guide and catch my boat when it slammed into the dock.” His throttle cable broke while entering the slip and caused damage to the boat, the dock, and an injury to his passenger. Al Manning (5) states it must be durable being on the water that constantly oscillates. All interviewed say how important safety is while docking the boat.

SURVEY ANALYSIS

Surveys were sent out to boat owners who use boat slips frequently. The idea to send the survey to existing slip owners was to get the best possible results to aid in the design of a guided docking system. Over 40 surveys were sent out and 32 surveys were completed and tallied (See appendix B for complete survey results).

For the survey, users were asked to circle 1-5 on how important features were to them on current and on a potential new product. A designer’s multiplier of 1.1 was added to one person operational and safety. These two features are the driver behind this product. If one person operational and safety weren’t the highest, the customer wouldn’t need this product. The planned satisfaction is what the designer would like the satisfaction of the user to be after the product is used. The improvement ratio is the difference between the current satisfaction of the user and the planned satisfaction. A relative weight is then calculated by taking the individual feature modified importance by the total for that column. The rows were then sorted by highest relative weight to the lowest. The end result is the customer.

Table 1 Customer Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Customer Importance</th>
<th>Designer’s Multiplier</th>
<th>Current Satisfaction</th>
<th>Planned Satisfaction</th>
<th>Improvement Ratio</th>
<th>Modified Importance</th>
<th>Relative Weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Person Operational</td>
<td>4.50</td>
<td>1.1</td>
<td>2.5</td>
<td>4.1</td>
<td>1.6</td>
<td>8.1</td>
<td>0.17</td>
</tr>
<tr>
<td>Safety</td>
<td>4.50</td>
<td>1.1</td>
<td>3.0</td>
<td>4.5</td>
<td>1.5</td>
<td>7.4</td>
<td>0.16</td>
</tr>
<tr>
<td>Easy to Use</td>
<td>4.00</td>
<td>1.0</td>
<td>2.8</td>
<td>4.3</td>
<td>1.5</td>
<td>6.2</td>
<td>0.13</td>
</tr>
<tr>
<td>Reliability</td>
<td>4.50</td>
<td>1.0</td>
<td>3.4</td>
<td>4.5</td>
<td>1.3</td>
<td>6.0</td>
<td>0.13</td>
</tr>
<tr>
<td>Durability</td>
<td>4.50</td>
<td>1.0</td>
<td>3.5</td>
<td>4.4</td>
<td>1.3</td>
<td>5.7</td>
<td>0.12</td>
</tr>
<tr>
<td>Compatible with existing boat docks</td>
<td>4.00</td>
<td>1.0</td>
<td>3.7</td>
<td>4.1</td>
<td>1.1</td>
<td>4.4</td>
<td>0.10</td>
</tr>
<tr>
<td>Easy to Adjust</td>
<td>3.50</td>
<td>1.0</td>
<td>3.0</td>
<td>3.5</td>
<td>1.2</td>
<td>4.1</td>
<td>0.09</td>
</tr>
<tr>
<td>Price</td>
<td>3.00</td>
<td>1.0</td>
<td>3.9</td>
<td>3.3</td>
<td>0.8</td>
<td>2.6</td>
<td>0.05</td>
</tr>
<tr>
<td>Accepts multiple types of boats</td>
<td>2.50</td>
<td>1.0</td>
<td>3.7</td>
<td>3.0</td>
<td>0.8</td>
<td>2.0</td>
<td>0.04</td>
</tr>
</tbody>
</table>
**PRODUCT FEATURES AND OBJECTIVES**

The product objectives listed below will allow for a better definition of what the “customer” wants out of the product that will be used in a slip dock. This list will help ensure that all objectives are met and they can be obtained.

1. One Person Operational 17%
   a. Automatically guides you in with no help

2. Safety-16%
   a. No dock personnel operation required
   b. No more than 400 lbs
   c. Similar deceleration to a car going 5mph to stopped in 2-5 sec

3. Ease of use-13%
   a. Doesn’t require reverse throttle under 5 mph
   b. Contains boat when docked
   c. Aligns with slip

4. Durability/Reliability-13%/11%
   a. Life cycle (specification sheet) of certain components-10 years of Life
   b. Rust Proof materials
   c. Thermal resistant materials(specification sheet)
   d. Water resistant materials
   e. Reuse proven materials

5. Ease of Adjustment-9%
   a. 2 person width adjustable within 2 hours

6. Compatibility with existing boat docks-10%
   a. Mounts to steel, aluminum, or wood dock
   b. Works in slips up to 12’ in width

7. Price-6%
   a. Prototype to cost less than $2000

8. Accepts multiple types of boats-6%
   a. 18’-25’ boat capacity
   b. V-hull boats
   c. Inboard/outboard, outboard, and ski boats compatible
These product features must be met to ensure the customer receives the quality product that they want. The product features are rated from highest importance to lowest. Each feature then has certain requirements listed under the features that the product must meet. Some of the information used was provided by interviewing Ron Boneau (6) and John Viltro (4). This information collected in the interview will help design a product that customers want.

ENGINEERING CHARACTERISTICS

Engineering characteristics that need to be met were defined, after the product features were defined and weighted. These characteristics received rankings based on how the features lined up with each characteristic. These ranked characteristics show the importance of each in the design (see Appendix C for complete quality function deployment analysis). The stopping and guidance of this design are the most important characteristic in the design. These two characteristics ensure the safety of the boat and passengers while entering and stopping in the slip. The material selected also accounts for the safety as well as the weight of the design acting on the dock. Docks are designed to hold extra weight, but this must be considered when adding any extra accessories. The size of the design must also be considered when adding to the dock. This has a lot to do with appearance within the dock. Containing the boat is also a key characteristic. When the boat is at a stop, the design must hold the boat into place while the boat is being tied up. If the boat started moving around while being tied up it could lead to injury. All engineering characteristics will be considered when designing the guided boat docking system.

<table>
<thead>
<tr>
<th>Engineering Characteristics</th>
<th>Relative Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stopping Power</td>
<td>20%</td>
</tr>
<tr>
<td>Guiding Design</td>
<td>19%</td>
</tr>
<tr>
<td>Material</td>
<td>18%</td>
</tr>
<tr>
<td>Size</td>
<td>17%</td>
</tr>
<tr>
<td>Containing a Boat</td>
<td>13%</td>
</tr>
<tr>
<td>Weight</td>
<td>6%</td>
</tr>
<tr>
<td>Easy to install</td>
<td>3%</td>
</tr>
<tr>
<td>Manufacturability</td>
<td>3%</td>
</tr>
</tbody>
</table>
CONCEPT GENERATION AND SELECTION

V-GUIDED STOPPING DESIGN

The V-guided stopping design is named by its shape. A boat's hull is shaped like a V, so it makes sense to use the V shape to an advantage. This design uses a bunk on either side to contact the boat. These bunks stay in contact with the boat from first contact till the boat is stopped. Boats have graphics on the side and the least amount of friction between the boat and friction will help. A mechanism will only allow the long rails to separate at the same rate. This will ensure that the boat stays centered in the dock while pulling in. A spring will be placed at the front of the V to apply force into the hull which will help slow the boat while pulling in. When the boat backs out, two return springs that will be mounted to the side of the dock will return the bunks to the correct position for a boat pulling in. These springs will also help assist the boat in stopping. Hard stops will be put into place to ensure the boat doesn’t travel too far and damage the boat. One hard stop mounted on the rail and one hard stop mounted near the spring in the front will ensure this design is safe for both the boat and the passengers.

Figure 4 V-Guided Stopping Design
SINGLE GUIDE STOPPING DESIGN

The next design is mimicking a boat trailer design. One cross member ties the dock together. A boat would come in and contact the bunks in the nose of the V. It would then push the cross-member forward. The bunks will help guide the boat into its proper docking position. A spring mechanism would be installed in both sides of the guide rail to help stop the boat. A return string would be attached to the other side of the cross member to return the bunk to its original location. Hard stops would be needed at each end to ensure the safety of this design. A mechanism would also need to be designed to keep each side of the cross member going into the dock at the same rate. One side going in quicker than the other could cause the back end of the boat to swing out and damage the boat.

Figure 5 Single Guide Stopping Design
4-BUNK STOPPING DESIGN

The final concept would use 4 bunks to guide and stop the boat. This design would utilize 4 bunks and 4 springs to stop the boat in the correct docking location. The boat would come into contact with the first two bunks which would align the boat while slowing it down. The next two bunks would catch the front end of the boat while the back bunks would hold the back end of the boat into place. This design would use the force of the springs and the friction of the back two bunks to stop the boat. The springs that are used to stop the boat would also be used to return the bunks to the original location after a boat backs out.

Figure 6 4 Bunk Stopping Design
A weighted decision matrix was then used to determine which design would best accomplish all design criteria. A five-point scale was used- 1 being the lowest and 5 being the highest. The relative weights from the QFD (See Appendix C) were used with a score for each design criterion. These two numbers combined for a rating. All the ratings for that design were added and the V-Guided Stopping Design was chosen with a score of 3.95. The 4 bunk design was second with 3.78 and the Single Guided Stop was third with 3.51.

<table>
<thead>
<tr>
<th>Design Criterion</th>
<th>Weight Factor</th>
<th>Units</th>
<th>V-Guided Stop</th>
<th>Single Guided Stop</th>
<th>Independent Guiding/Stopping</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Magnitude</td>
<td>Score</td>
<td>Rating</td>
</tr>
<tr>
<td>Size</td>
<td>0.17</td>
<td>ft³</td>
<td>75</td>
<td>3</td>
<td>0.50</td>
</tr>
<tr>
<td>Material</td>
<td>0.18</td>
<td>$</td>
<td>1500</td>
<td>3</td>
<td>0.55</td>
</tr>
<tr>
<td>Manufacturability</td>
<td>0.03</td>
<td>Exp.</td>
<td>Good</td>
<td>3</td>
<td>0.09</td>
</tr>
<tr>
<td>Guiding Design</td>
<td>0.19</td>
<td>Exp.</td>
<td>Excellent</td>
<td>5</td>
<td>0.95</td>
</tr>
<tr>
<td>Stopping Power</td>
<td>0.20</td>
<td>ft lbs</td>
<td>50</td>
<td>5</td>
<td>1.02</td>
</tr>
<tr>
<td>Containing a Boat</td>
<td>0.13</td>
<td>Exp.</td>
<td>Great</td>
<td>4</td>
<td>0.53</td>
</tr>
<tr>
<td>Easy to Install</td>
<td>0.03</td>
<td>hrs</td>
<td>4</td>
<td>4</td>
<td>0.13</td>
</tr>
<tr>
<td>Weight</td>
<td>0.06</td>
<td>lbs</td>
<td>200</td>
<td>3</td>
<td>0.19</td>
</tr>
<tr>
<td>Total</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 3 Weighted Decision Matrix

ASSEMBLY DESIGN DETAILS

KINEMATIC OF DESIGN

Figure 7 System Assembly
While designing the components for this assembly, certain considerations had to be thought of. The assembly is going to be located under a covered dock but near water. Corrosion was a major part of choosing aluminum for all structural parts. The weight of the assembly was also a consideration. Standard fasteners and commercially available parts were used to keep the costs down and parts readily available. These fasteners also needed to be corrosion resistant.

Welding aluminum can be a bit tricky if the right person isn’t welding it. Bolting all components together where possible will keep these parts together without the worry of a weld breaking. Using common fasteners were possible makes assembling easy and straightforward.

![Spring](image)

Figure 8 Bunk Return System

The completed design incorporates bunks to catch the boat when entering the slip. These bunks stay in the same relative position on the hull of the boat to minimize rubbing on the boat. Rubbing on the boat could cause the graphics on the side of the boat to be damaged. Garage door springs are used as return springs for the bunk system (see figure 8). While backing out of the slip the tension from the spring returns the bunks to the proper position.

![Figure 9 Pulley System](image)

Garage door springs are also used in the front to apply tension into the boat and keep the boat centered in the slip. A pulley system was designed to ensure that each guide rail would open the same as the other (see figure 9). If the boat hits the left bunk first, the right rail will open the same amount to ensure the boat will center itself within the slip.
The bunk assembly can be assembled separate from the rest of the system and slipped on the end of the I-beam after the I-beam is mounted to the dock. This will keep the weight down while assembling the I-beams. This will help ensure a two man team would be able to assemble this system without any problems of it weighing too much.

Using common parts for both sides of the bunk system would make the part cost decrease. Every part from the left hand bunk could be used on the right hand bunk. This makes assembling and machining parts very easy with little chance to make an error and have to rework a part.
**DRAWINGS**

Detailed drawings, assembly prints, and purchased components calling out material selection, tolerancing, and assembling. Please refer to **APPENDIX G** for the drawings and **APPENDIX H** for the purchased components.

**CALCULATIONS**

**CALCULATING STOPPING FORCE REQUIRED**

Calculating the stopping force \( F \) required to stop a 25ft boat going 5 mph will give the worst case stopping force required. For this calculation a mass, velocity, and distance are known and the force required to stop is needed.

\[
F = \frac{1}{2} \frac{m v^2}{d}
\]

\( F \) = Force required to stop

\( m \) = Mass of the boat

\( v \) = Velocity of the boat

\( d \) = Distance required to stop

\[
F = \frac{1}{2} \left( \frac{10000 \text{ lbs}}{32.2 \text{ ft/s}^2} \right) \left( \frac{7.33 \text{ ft}}{s} \right)^2 / 12 \text{ ft}
\]

\[
F = 695.3 \text{ lb}
\]

After calculating the force required to stop the boat in 12ft, the calculations for how much surface area for the down riggers was needed to accommodate this need. While calculating this, consideration for the return springs, which will be applying 50lbs to each side. The two front clamping springs will also be applying a force that contributes to the stopping power. The guide rails are at an angle of 15° and the springs produce a force of 60lbs a piece ( 60lbs * sin15 = 15.5lbs * 2 = 31lbs). Without doing anything with the down rigger, 131lbs of stopping force is already in place. An additional 564lbs would need to be created. With two plates being utilized 282lbs from each plate would be needed to make sure the boat comes to rest.
The next step is to calculate the area of the plate based on the drag force needed to stop the boat. Different size boats will be able to have different size plates to slow them down. The slower the plate is moving the less effective it is, but with the springs also assisting, plenty of stopping force will be supplied. Below is the Drag Force calculation used to calculate the area needed:

\[ A = \frac{F_D}{C_p v^2} \]

- \( A \) = Area of the plate
- \( F_D \) = Drag Force
- \( C_p \) = Constant used for flat plate perpendicular to the flow
- \( v \) = velocity of the Boat

\[ A = \frac{258.98 \text{ lbs}}{1.9 \left( \frac{ft}{s} \right)^2} \]

\[ A = 2.583 \text{ ft}^2 \]

At 5mph a 10,000 lb boat hitting the bunks would produce enough force needed to stop the boat in 12ft. Going slower into the dock would produce less force but would slow the boat down enough to make the stop comfortable. Going from 1.5mph to 0mph is like walking at a normal pace and then stopping. When coming into a dock without this system at 3mph the boat is thrown into reverse and stopped. This system improves upon that and also protects the boat. The plate size needs to be 2.583 ft\(^2\) for a 25 foot boat weighing 10,000 lbs. To make the initial hit comfortable, a plate sized for each individual boat would be required. Every size boat weighs a different amount and would need a different force to stop.
**CALCULATING THE STRESS IN THE BUNK**

An analysis of the bunk system was run with 695.3 lbs of force along the face of the bunk. The maximum stress seen in this analysis was 11.3 ksi (see figure 12). The yield strength for aluminum 6061-T6 is 40.0 ksi. The safety factor for this mechanism is 3.5 with the biggest boat at max capacity. The aluminum tubes are barely seeing any stress when the boat comes into contact with the bunks. The tubes can be optimized for cost savings.

![Figure 12 Bunk analysis](image-url)
CALCULATING THE STRESS IN THE DOWN RIGGER

The down rigger of the system was also analyzed for strength with 564lbs of force being distributed over the face of the plate. Rectangular tubes were used for the main structure as all the force is going in one direction and extra weight is not needed in this design. The maximum stress seen in this analysis was 29.3 ksi (see figure 13). The yield strength for aluminum 6061-T6 is 40.0 ksi. The safety factor for this mechanism is 1.4 with the biggest boat at max capacity. Some of these components are over designed and can be optimized for cost savings.

Figure 13 Down rigger analysis
CALCULATING THE STRESS IN THE I-BEAM

The I-beam will be seeing quite a bit of load when the boat comes into contact with the bunks. To ensure no failure of the I-beam an analysis was completed with 695.3 lbs of force being applied at the bunk location. This load at the bunks puts a twisting force on the I-beam. The maximum stress seen in this analysis was 19.6 ksi (see figure 14). The yield strength for aluminum 6061-T6 is 40.0 ksi. The safety factor for this mechanism is 2.0 with the biggest boat at max capacity. This component is accurately sized for its application in this design.

TESTING

After assembling the system final testing must be completed to verify a safe and reliable docking method was achieved. The following must be tested to ensure proper design of the guided docking system.

- Stopping of the boat in 2-5 seconds from initial contact @5mph
- No damage to the boat
- One person operational (Boat operator only)
- Contains boat when completely stopped

Figure 14 I-Beam analysis
A boat will be run into the guided docking system 10 times with all data being recorded. The boat will be running at 3-5 mph and must come to a complete stop in what would be the correct docking position. When testing is complete, a complete evaluation of the system will be completed. All bolts, joints, and critical components will be evaluated to ensure no damage or premature wear to the system.

**RECOMMENDATIONS**

After pulling a boat into the mechanism several times, some issues were noticed with the design. The carpet on the bunks would allow the bunks to slide down the hull of the boat causing the I-beam to twist (See Figure 15). This twisting in the I-beam was causing the rollers to lock up. If the bunk had a rubbery coating that would want to grab the hull of the boat instead of the carpet that would allow it to slide down the hull. By eliminating this issue, the boat will grab the bunks and push them forward allowing the mechanism to work as intended.

Another recommendation would be to make the plate used in the down rigger to be made out of a float. The surface area would be the required area, but the buoyancy would help with the sagging of the I-beam. It would add cost into the system, but the benefits of adding this feature outweigh the additional cost.
SCHEDULE AND BUDGET

The project schedule begins October 20, 2012 with a proof of design and product objectives. The schedule covers 27 weeks and ends on April 18, 2013 with the presentation of the completed design.

Table 4 Schedule

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A budget of expenses documents the costs associated with this project (see Appendix F). The guiding system, the stopping system, and other miscellaneous pieces are priced. The budget for this project was $2000 and the total amount spent was $1660. The savings came from the simplistic design of the stopping system. The downriggers didn’t cost much money compared to the original idea of using garage door springs or a hydraulic setup to stop the boat.

Table 5 Budget

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WORKS CITED
APPENDIX A: RESEARCH

Interview with boat lift builder and boat dock owner John Viltro. 305 Deerfield Way Lafallete, TN 37766; 9/02/12
He has over 35 years boating experience along with designing and building a front mount lift for his 22’ Supra wakeboarding boat. He states that the design must guide you in with no help from anyone on the boat or off. This would make it quite easier to dock the boat with no one else in the boat. The design should have a guidance system that eliminates scratches from hitting the dock. With multiple style boat lifts, must consider when the boat lift raises from the water. Possibly modifying some lifts. He would have loved to have one when throttle cable broke and his boat slammed into the dock. He mentioned the floating ramp that you pull your boat onto as an existing design.

Interview with Al Manning of Manning Custom Homes and boat dock owner. 317 Deerfield Way Lafallete, TN 37766; 9/08/12
He has over 20 years boating experience with a house and dock located at Norris Lake. This design would take away stress from the driver while docking the boat. Hardest time to dock a boat is on a windy day and you must come in fast. It is inevitable that you will put a scratch on your boat or someone could get injured trying to catch the boat. He mentions the variability when boating and how anything to make something simpler is better. Must be durable, being on the water with constant oscillation.

Interview with Ron Boneau; Coast Guard Inspector and boat dock owner. 297 Deerfield Way Lafallete 37766; 09/08/12
Has heard stories and seen people damage boats pulling into dock. When pulling into a dock you must be aware of multiple things. Something to guide a boat and help it stop would eliminate a lot of stress. To have something that would improve safety for passenger on board. 90% of the boats he inspects are between 18’-25’. Anything bigger they back into a slip. He wouldn’t have a problem modifying lift to accomplish design. Prefer not to have extra electricity run to dock. Must be robust enough to last on the water. Very excited to see design completed and operational.
Interview with Brian Hoffman Mechanical Engineer and boat owner. 3545 Lakeview Dr, Hidden Valley, IN 47025
Docking is the most difficult thing to do when boating. Making docking convenient with a guidance system would ease stress. No need to get fenders and lines out to help catch the boat. Making a system to stop the boat when in the slip would make passengers safer. Keeping them from helping catch the boat would be a relief. All the scratches and dings from his boat have come from docking. He stated it’s a couple hundred dollars for each scratch and even more if it’s deep scratch. Anything that would decrease the maneuverability of a boat when coming into a slip.

**Boat Docking System**

This boat docking system uses a V-shaped structure with two fiberglass structures to connect them. These fiberglass pieces are flexible to allow different shaped boats to dock. This is a patent that was filed in 1991 and has expired. I was not able to find any more information on this design. [http://www.patentbuddy.com/Patent/5174234](http://www.patentbuddy.com/Patent/5174234)

The springiness of the fiberglass would have to calculate precisely if this is intended to stop the boat. If sprung too much the boat would hit the dock. The floats used to keep the system afloat could mark up the boat with continual rubbing every time docking.
### Landing loop
This boat docking system uses a pole with a hook on the end of it. Someone has to reach off the boat and grab a cleat to pull the boat in. It claims you “never have to jump off your boat again while docking.”

While making docking easy, someone on the boat still has to help guide the boat in. This could lead to injury if the boat were to move in an unpredicted way. This could be caused by wind, driver, or something going wrong in the boat. This device also needs to be stored in the boat, which takes up room.

http://www.landingloop.com/

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### Floating drive-on dry dock assembly
This docking system uses two kinds of floatation units, tall and short, to accommodate a small craft. The floats are arranged in a way to support the hull of the craft on each side.

These types of lifts both align and stop the craft. It is used more for personal watercraft than boats. The design could be made much simpler and cheaper. This design would not work with a wakeboarding boat, as the prop is under the boat, not in the back like most boats.

http://www.patentbuddy.com/Patent/5682833

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Figure 2 Floating drive on dock

Figure 3
APPENDIX B: CUSTOMER SURVEY WITH RESULTS

Currently there’s no easy or stress free way to pull a boat into a slip. The information gathered from this survey will help pinpoint key features important to a guided docking system.

**How important is each feature to you for the design of a guided docking system?**

Please circle the appropriate answer.  
1 = low importance  
5 = high importance  

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**How satisfied are you with the current way to pull a boat into a slip?**

Please circle the appropriate answer.  
1 = very Unsatisfied  
5 = very satisfied  

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**How much would you be willing to spend on a guided docking system?**

$50-$100   $100-$200   $200-$500(3)   $500-$1000(25)   $1000-$2000(4)

Thank you for your time.
# Appendix C: Quality Function Deployment Analysis

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Appendix C1
APPENDIX D: PRODUCT OBJECTIVES

OBJECTIVES
The product objectives listed below will allow for a better definition of what the “customer” wants out of the product that will be used in a slip dock. This list will help ensure that all objectives are met and they can be obtained.

1. **One Person Operational- 17%**
   b. Automatically guides you in with no help

2. **Safety- 16%**
   d. No dock personnel operation required
   e. No more than 400 lbs
   f. Similar deceleration to a car going 5mph to stopped in 2-5 sec

3. **Easy to use- 13%**
   d. Doesn’t require reverse throttle under 5 mph
   e. Contains boat when docked
   f. Aligns with slip

4. **Durability/Reliability- 13%/11%**
   f. Life cycle (specification sheet) of certain components-10 years of life
   g. Rust Proof materials
   h. Thermal resistant materials (specification sheet)
   i. Water resistant materials
   j. Reuse proven materials

5. **Compatibility with existing boat docks- 10%**
   c. Mounts to steel, aluminum, or wood dock
   d. Works in slips up to 10’ in width

6. **Easy to Adjust- 9%**
   b. 2 person width adjustable within 2 hours

7. **Price- 6%**
   b. Prototype cost less than $2000

8. **Accepts multiple types of boats- 6%**
   d. 18’-25’ boat capacity
   e. V-hull boats
   f. Inboard/outboard, outboard, and ski boats compatible
# APPENDIX E: SCHEDULE

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## APPENDIX F: BUDGET

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<thead>
<tr>
<th>Materials, Components or Labor</th>
<th>Forecasted Amount</th>
<th>Actual Amount</th>
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<tr>
<td>Guidance System</td>
<td>$1,200.00</td>
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<tr>
<td>Stopping System</td>
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<td>Misc</td>
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<td>Total</td>
<td>$2,000.00</td>
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</tbody>
</table>
Appendix G1
APPENDIX H: PURCHASED COMPONENTS

EXTENSION SPRING #SPEX-60-21-7D (DDM GARAGE DOORS)

Extension Springs 6' Door. 21X36" 70 lbs. Double-loop

Price: $33.07 each

Product Description:
Extension Springs
For use with 6' Doors
21X36" Stretch
21" long
70 lbs
Orange
Double-loop Ends

Quantity Discounts:
4+: $27.98 each
8+: $22.89 each
16+: $20.35 each

EXTENSION SPRING #SPEX-12-53-10D (DDM GARAGE DOORS)

Extension Springs 12' Door. 53X72" 100 lbs. Double-loop

Price: $43.87 each

Product Description:
Extension Springs
For use with 12' Doors
53X72" Stretch
53" long
100 lbs
Tan
Double-loop Ends

Quantity Discounts:
4+: $37.12 each
8+: $30.37 each
16+: $26.99 each
MOUNTED PULLEY #3099T34 (McMASTER-CARR)

Heavy duty pulleys have a thick, durable frame for high capacities and long life. Their easy-turn bearings create less friction than other pulleys for easier pulling. Style 12 pivots 200° for different pull directions. Stainless steel pulley offers the most corrosion resistance.

Warning! Never exceed work load limits. Never use to lift people or items over people.

<table>
<thead>
<tr>
<th>For Rope Dia.</th>
<th>Work Load Limit, lbs.</th>
<th>Groove Dia. (C)</th>
<th>For Shaft Dia. (D)</th>
<th>Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
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PULLEY #3434T117 (McMASTER-CARR)

Pulleys with easy-turn bearings have low-friction bearings for easy pulling.

Stainless steel pulleys offer the most corrosion resistance.

Heavy duty pulleys have a thick, durable frame for high capacities and long life.

Warning! Never exceed work load limits. Never use to lift people or items over people.

<table>
<thead>
<tr>
<th>For Rope Dia.</th>
<th>Work Load Limit, lbs.</th>
<th>Groove Dia. (C)</th>
<th>For Shaft Dia. (D)</th>
<th>Each</th>
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<td>Steel</td>
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Appendix H1
VINYL ROPING #8912T324 (McMASTER CARR)

Vinyl-Coated Wire Rope
More flexible with better UV resistance than nylon-coated rope. The vinyl coating not only protects the rope from abrasion, but also pulleys and drums from wear. Temperature range is -30°F to +180°F. All are preformed and un lubricated. Type 302/304 stainless steel is more corrosion resistant than galvanized steel.

7 x 7 Strand Core—Rope is moderately flexible and commonly used in controls and mechanical applications.

7 x 18 Strand Core—More flexible and fatigue resistant than the 7 x 7 construction.

To Order: Please specify length from those listed; continuous lengths greater than the longest length listed are also available. Please also specify coating color: clear, opaque black, opaque orange, opaque yellow, or translucent.

View additional information about selecting wire rope.

Warning: Breaking strength should never be considered the rope's working load. When attaching fittings to coated wire rope, the coating must be removed from the installation area.

Rope Dia. —

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<th>Rope Dia.</th>
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<th>Available Lengths, ft.</th>
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<th>8 x 7 T126</th>
<th>8 x 7 T125</th>
<th>8 x 7 T146</th>
<th>8 x 7 T154</th>
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FASTENERS:

#0149999 (FASTENAL)
Appendix H1

#15026 (FASTENAL)

1/4"-20 x 6-1/2" Yellow Zinc Finish SAE J429 Grade 8 Hex Cap Screw

Fastenal Approved Vendor
Fastenal Part No., (SKU): 15026
UNSPSC: 31161501
Manufacturer: Fastenal Approved Vendor
Category: Fasteners > Bolts > Cap Screws & Hex Bolts

Wholesale Price: $1.48
Package Quantity: 1 (EA)

Show Inventory Availability for my local Fastenal store
I do not have an account with Fastenal - show Inventory Availability for Web Store
* Check another store for availability

Quantity 1 x 1 (EA)

Add to Cart

#15215 (FASTENAL)

1/2"-13 x 3" Yellow Zinc Finish SAE J429 Grade 8 Hex Cap Screw

Fastenal Approved Vendor
Fastenal Part No. (SKU): 15215
UNSPSC: 31161501
Manufacturer: Fastenal Approved Vendor
Category: Fasteners > Bolts > Cap Screws & Hex Bolts

Wholesale Price: $1.40
Package Quantity: 1 (EA)

Show Inventory Availability for my local Fastenal store
I do not have an account with Fastenal - show Inventory Availability for Web Store
* Check another store for availability

Quantity 1 x 1 (EA)

Add to Cart

#15221 (FASTENAL)

1/2"-13 x 4-1/2" Yellow Zinc Finish SAE J429 Grade 8 Hex Cap Screw

Fastenal Approved Vendor
Fastenal Part No. (SKU): 15221
UNSPSC: 31161501
Manufacturer: Fastenal Approved Vendor
Category: Fasteners > Bolts > Cap Screws & Hex Bolts

Wholesale Price: $2.54
Package Quantity: 1 (EA)

Show Inventory Availability for my local Fastenal store
I do not have an account with Fastenal - show Inventory Availability for Web Store
* Check another store for availability

Quantity 1 x 1 (EA)

Add to Cart
#15223 (FASTENAL)

**1/2"-13 x 5" Yellow Zinc Finish SAE J429 Grade 8 Hex Cap Screw**

Fastenal Approved Vendor

Fastenal Part No. (SKU): 15223
UNSPSC: 31161501
Manufacturer: Fastenal Approved Vendor
Category: Fasteners > Bolts > Cap Screws & Hex Bolts

Wholesale Price: $3.15
Package Quantity: 1 (EA)

Show Inventory Availability for my local Fastenal store.
I do not have an account with Fastenal - show Inventory Availability for Web Store.
Check another store for availability.

Quantity 1 x 1 (EA)

Add to Cart

#15230 (FASTENAL)

**1/2"-13 x 8-1/2" Yellow Zinc Finish SAE J429 Grade 8 Hex Cap Screw**

Fastenal Approved Vendor

Fastenal Part No. (SKU): 15230
UNSPSC: 31161501
Manufacturer: Fastenal Approved Vendor
Category: Fasteners > Bolts > Cap Screws & Hex Bolts

Wholesale Price: $7.82
Package Quantity: 1 (EA)

Show Inventory Availability for my local Fastenal store.
I do not have an account with Fastenal - show Inventory Availability for Web Store.
Check another store for availability.

Quantity 1 x 1 (EA)

Add to Cart

#0137868 (FASTENAL)

**3/4"-10 x 4-1/2" Yellow Zinc Finish SAE J429 Grade 8 Hex Cap Screw Made In USA**

Fastenal Approved Vendor

Fastenal Part No. (SKU): 0137668
UNSPSC: 31161501
Manufacturer: Fastenal Approved Vendor
Category: Fasteners > Bolts > Cap Screws & Hex Bolts

Wholesale Price: $5.19
Package Quantity: 1 (EA)

Show Inventory Availability for my local Fastenal store.
I do not have an account with Fastenal - show Inventory Availability for Web Store.
Check another store for availability.

Quantity 1 x 1 (EA)

Add to Cart
#37183 (FASTENAL)

1/4"-20 Yellow Zinc Finish NE Grade 8 Nylon Insert Lock Nut

Fastenal Approved Vendor

Fastenal Part No. (SKU): 37183
UNSPSC: 31161714
Manufacturer: Fastenal Approved Vendor
Category: Fasteners > Nuts > Lock Nuts

Wholesale Price: $0.134
Package Quantity: 1 (EA)

Add to Cart

#37187 (FASTENAL)

1/2"-13 Yellow Zinc Finish NE Grade 8 Nylon Insert Lock Nut

Fastenal Approved Vendor

Fastenal Part No. (SKU): 37187
UNSPSC: 31161714
Manufacturer: Fastenal Approved Vendor
Category: Fasteners > Nuts > Lock Nuts

Wholesale Price: $0.526
Package Quantity: 1 (EA)

Add to Cart

#37190 (FASTENAL)

3/4"-10 Yellow Zinc Finish NE Grade 8 Nylon Insert Lock Nut

Fastenal Approved Vendor

Fastenal Part No. (SKU): 37190
UNSPSC: 31161714
Manufacturer: Fastenal Approved Vendor
Category: Fasteners > Nuts > Lock Nuts

Wholesale Price: $1.54
Package Quantity: 1 (EA)

Add to Cart
## APPENDIX J: BILL OF MATERIALS

<table>
<thead>
<tr>
<th>ITEM</th>
<th>PART NO.</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>End Pivot Bracket</td>
<td>End Pivot Bracket</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Guide Rail</td>
<td>Guide Rail</td>
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</tr>
<tr>
<td>3</td>
<td>Bunk Guide Ext Outside</td>
<td>Bunk Guide Ext Outside</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Bunk Guide Ext Inside</td>
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</tr>
<tr>
<td>6</td>
<td>Bunk Attachment</td>
<td>Bunk Attachment</td>
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<tr>
<td>7</td>
<td>Bunk</td>
<td>Bunk</td>
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<td>8</td>
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<td>9</td>
<td>Top Roller</td>
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<td>11</td>
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<tr>
<td>12</td>
<td>Spacer for Guide Rail</td>
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</tr>
<tr>
<td>13</td>
<td>Bearing Guide Rail</td>
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<td>Guide Stop Bumper</td>
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<td>Spacer One Pulley</td>
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<td>19</td>
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<td>21</td>
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<td>22</td>
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<tr>
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<td>NUT 0.75</td>
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<td>NYLON CABLE</td>
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