Stow-Away Pool Table

Team Number: 6

Deliverable #4: Midterm I Report

Submission Date:

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Submitted To:

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Abstract

Throughout the existence of the game of pool, there have been two reoccurring issues that have caused pool table owners to have to get rid of their table: the room is needed for another purpose and the playing surface must be leveled for proper play whenever moved. Our goal is to design and produce a system to stow and automatically level a fully functional pool table for immediate use. Some objectives for this semester are: finalize CAD drawings for the mechanisms, and source long-lead items. Some constraints were established as well: the table must be moveable by one person, and the surface must be self-leveled in under 5 minutes. Decision matrices are provided in this report. They were used to choose between stowing mechanisms and also between leveling components. Finally, a Gantt chart is presented as documentation of the team's schedule of tasks.

1 Introduction

In order to allow the room used for a pool table to be quickly and easily repurposed without sacrificing the pool player's recreation, the pool table must stow away and level itself at the push of a button. The purpose of our project is to redesign last year's self-stabilizing and stow-away pool table to be more economical, more easily manufactured, and more marketable overall. Alexander York, the entrepreneur/engineer who started this project last year, is sponsoring this project and the funding is provided by him and by the FSU-FAMU College of Engineering.

In this report, the desired specifications and the plan for our design will be discussed. The first steps to this design process is the project planning stage. This begins with background research of previous designs for similar problems. Next, a need statement must be developed that expresses the situation at hand. This will lead to creating a goal statement in which an ideal situation that solves the problem discussed in the need statement. This goal can only be reached if objectives and constraints are recognized. Setting objectives aids in reaching goals in small steps and avoiding becoming overwhelmed. Recognizing constraints of the design allows you to design potential concepts that are practical and effective. These constraints are formed by analyzing the design and performance specifications. Finally, a schedule must be made in order to help get the objectives achieved in a timely fashion. A Gantt chart is a great way to form a schedule and it allows the group to visualize the tasks at hand and stay on track with completing the objectives.

2 Project Definition

2.1 Background research

The inspiration behind the design idea comes from two mechanical engineering students Alexander York and Norman Gross who graduated from the FSU/FAMU College of Engineering in 2013. Their Group 19 Senior Design project, led by Alexander York, was sponsored by Beyond Innovation LLC to design a self-leveling pool table that was also "*capable of vertically stowing itself in a discrete housing whenever additional space is needed in the area the table is kept*." [i]

The team utilized stepper motors located on each of the four legs and a control system programmed with a stabilizing algorithm to stabilize the pool table with just the push of a button. The group was very successful with their design, and ended up winning the senior design project competition. We will be creating a pool table with similar functions by using improved methods of storing and leveling as well as a more marketable look. We plan on rotating the table about its longitudinal axis rather than its latitudinal axis as in the original design. We plan on focusing more on the stow-away capabilities of the pool table and less on the stabilizing capabilities, however we will be looking at improving the leveling function for opportunities to improve its overall time to level.

The main difference between our goal and the goal last year is to improve the design of the pool table to be more production friendly and marketable going beyond building the first prototype which proved the design was practical. This practicality is evidenced in the budget report from last year's team shown in Table 1[ii].

Table 1. Last year's final Budget Report

Total spent	**$2,723**
Budget	$3,000
Funds remaining	$277

This stow-away pool table is the first of its kind so there is no opposition to our design. There are, however other applications for leveling mechanisms such as for water vessels (Fig. 1) and space saving furniture like wall beds. Group 19's original "Self-Stabilizing Pool Table" (Fig. 2) lifts the pool table vertically until the playing surface is perpendicular to the ground and the table is fully in the housing.

Figure 1. David Hall's self-leveling boat platform[iii]

This design has the potential to be revolutionary because of its wide range of possibilities. It could be of great use to sports bars, hotels and homes. Basically, anywhere that can't afford to permanently sacrifice the large amount of room needed to comfortably house a pool table can benefit greatly from this design. Perhaps in the future, a more robust model with real time active leveling could be marketable to seafaring vessels but since that is a smaller market, it will not be included in the scope of the current model.

Figure 2. Group 19's original prototype[iv]

2.2 Need Statement

The sponsor for our project is Alexander York, with additional funds managed by Dr. Michael Devine, Professor at the College of Engineering. This project is a continuation of Alexander's 2013-2014 Senior Design, which needs higher aesthetics value and improved functionality. The proof of concept was successful, but the product cannot be sold until the quality and aesthetics are enhanced. Additionally, the nature of the vertically stowed design posed a higher risk of serious injury to the common user, while also requiring vertical space that may not be available in households.

"Pool tables take up too much space and require professional leveling."

2.3 Goal Statement & Objectives

Our goal for this project is to design and produce a system to stow away a fully functional pool table, and to level it automatically when ready to use. This goal will be reached by the end of the spring 2015 semester.

Objectives for the fall semester:

- Finalize CAD model of the structural elements and translating mechanism.
- Select materials for the translating mechanism considering its structural design analysis.
- Source long-lead items.

2.4 Constraints

The entire concept of this design in based around making storing of the pool table quick and easy. In order to satisfy these requirements the pool table must be movable and must be ready to play on within minutes of moving it. The project as a whole must meet the customer needs specified in the original 2013-2014 project, since this product is meant to be sold to the public eventually. To guide some future decisions, here is a recollection of such needs:

1. Easy to move
2. Must be able to stow away to save space

3. The operation of the system should create minimal noise
4. Needs to be a regulation sized table
5. Easy to use by the average person
6. Must feel no different than a regular pool table
7. System needs to be aesthetically appealing
8. System needs to be durable (long-lasting)

More specific goals have been decided on. This design must be more production friendly and thus it must be affordable from a manufacturing perspective. With this being said, we have set our constraints as follows:

- The pool table must be movable by one person on a hard surface.
- The total cost must not exceed $11,000.
- The system must self-level in less than 5 minutes.

2.4.1 Design Specifications

As per regulation the table dimensions must follow these requirements:

- Must have a length to width ratio of 2:1
- Outside dimensions: 86 inches x 48 inches
- Playing Field: 78 inches x 39 inches
- Height Restriction: Between the range of 29 inches to 31 inches

In line with those specifications, the housing must fit our 7’ X 3.5’ table, being no more than 6 inches bigger per side, except for the width, for which we have allowed 2 ft.

Considering that our slate will weigh approximately 650 lb., the system will be kept under 1,000 lb. This weight will be reevaluated as the design evolves.

2.4.2 Performance Specifications

Expectations of performance in the field or when used by consumer including: instrumentations output requirements (operation range, accuracy, and resolution), display features, detection capability, energy and fuel consumption, data transmission, efficiency.

Following the successful readings of the inclinometers used last year, their ±10º will be sufficient again. Since these inclinometers have a resolution of 200 mV/º, a reading of 2 mV will yield a measurement approximately equivalent to 0.0125” for the long span of the table.

The leveling system must finish its task in less than 5 minutes. This means that the players will not be made to wait more than that after the table has been set horizontally. The system will have a graphic user interface so that the player knows when the leveling system is working, and when it is finished.

3 Design and Analysis

3.1 Functional Analysis

One of the biggest changes we are making to the original prototype that was created last year is that instead of flipping the table about its latitudinal axis, we are flipping it about its longitudinal axis. When the pool table is ready to be stowed-away, the user will be able to attach it to the stow-away component and manually rotate it 90º so that the playing surface is perpendicular to the ground and facing away from the housing. Once it is in the stow-away position, the user will then push it into the housing were it can be secured. We believe that this change will improve the practicality and effectiveness of the design. Extensive research into this change has been conducted by the team before making the decision to pursue this design alteration.

The issue with having the pool table rotated about its latitudinal axis is that is required a structure at least 8 ft tall to house the table. This makes the design impractical because it would be too tall to fit in most normal rooms especially when the goal of the design is to reduce the amount of space that the pool takes up. Rotating the pool table about its longitudinal axis and storing it would only require a structure about 5 ft tall. Granted the structure will still have to be 8 ft wide rather than tall, this method of storage will be easier to install and operate than the former one.

By having the axis of rotation pass through the center of gravity of the pool table, we hope to reduce all net forces and moments on the pool table when it is supported by the stow-away mechanism. By doing this, the pool table will require very little applied force in order to rotate it 90º so that the playing surface is perpendicular to the ground and then it can be stored in the housing. The stow-away mechanism will also need to feature assisted rotating components that will allow the user to slowly and safely rotate the pool table to its stow-away position in a controlled manner. If the system doesn't have this feature it would make the stow-away process extremely dangerous because of the immense weight of the pool table. Various methods of assistance are being researched. These methods include using counterweights, hydraulics or torsional springs. Once we complete testing with both physical models and computer analysis, a decision will be made on which method to use.

3.2 Design Concepts

3.2.1 Design #1

This system has two main components: a pool table, and a housing. The project is consequently divided into those two as subsystems, where the former integrates the leveling components, and the latter handling the stowing mechanism. The table's legs have deployable caster wheels so that it can be moved close to the housing when ready to be stowed. The legs also integrate a power screw that serves as the mechanisms that raises and lowers the table to respond to the leveling system's demands. Lastly, when the table is using the stowing mechanism as support the legs cease to act as vertical support, which allows the user to fold the legs in. With the legs folded, the profile of the table can be reduced to approximately 12 inches.

The housing contains a sideways-laid scissor-style mechanism that extends outward to a position that matches the neutral longitudinal axis of the table; the table is then pin secured to the scissor. Before collapsing the scissor (effectively bringing the table into the housing), the table must be rotated 90 degrees. Two potential problems have been identified. The first is that the calculations of the location of the neutral axis require homogeneous material assumptions, which could lead to the table not being properly balanced when suspended. Such scenario would require post assembly rebalancing of the table. If the addition of counterweights do not suffice, a torsional spring or other force assistance might be needed to accomplish effortless rotation of the table. The second potential problem would be the scissors not staying in the open or closed position without the user holding it, which would mean that the opening or closing of the scissor would require a considerable force input. The backup plan that we will develop consists of a linear actuator to aid in the in/out movement of the table. Figure 3 shows the whole system in its stowed position.

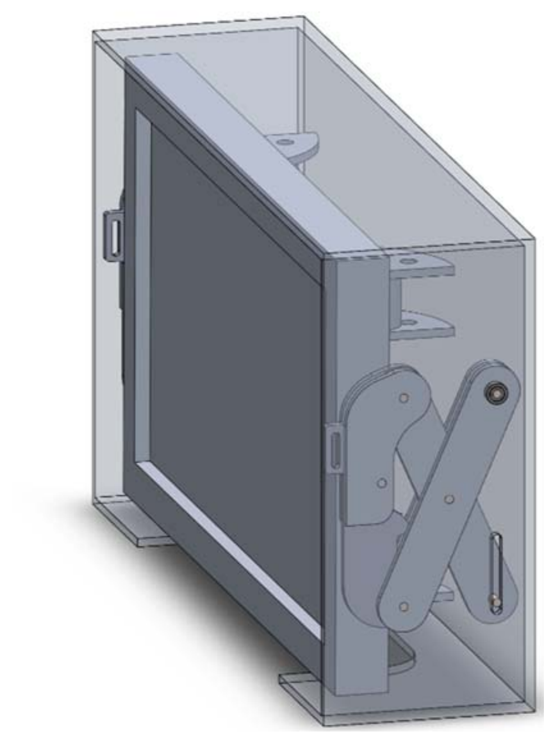


Figure 3. CAD of design #1 stowed.

3.2.2 Design #2

Design #2 features a removable U-shaped cart that attaches to pins extruding from the pool table or alternatively pins on the U-cart may be inserted into slots in the sides of the table. Figure #4 illustrates the steps of the stow-away process for this design. The cart can be kept out of the way while the pool table is in use. Once it is time to stow-away the pool table, the cart is wheeled out and one end of the upright arms can be adjusted through the use of a hinge joint to allow the cart to be rolled under the pool table. Once it is time to stow-away the pool table, the cart is wheeled out and one end of the upright arms can be adjusted through the use of a hinge joint to allow the cart to be rolled under the pool table. Once the cart is under the table with the uprights at opposite ends, the hinged upright is swung back into its original position where it is connected to the pin on that side. Once both arms are secured in their upright positions and on the pins, the legs of the pool table are retracted completely into the table so that the full weight of the pool table is supported by the cart. The table can then be manually rotated 90° so that the playing surface is perpendicular with the ground. The legs of the pool table will also be connected with pins so that they can fold into compartments under the pool table. These compartments will have doors that open to place the legs in and conceal them along with racks to place the cues and balls when they are not in use.

This design would reduce the footprint of the table by 71% after stowing away the table and the wheeled cart allows for the pool table to be easily movable. The lightweight cart allows for quick and easy storage of the pool table. However, due to the fact the cart is so slim and lightweight, it has potential to create a hazardous situation while being moved. The pool table is extremely heavy and when in the stow-away position, it could easily become

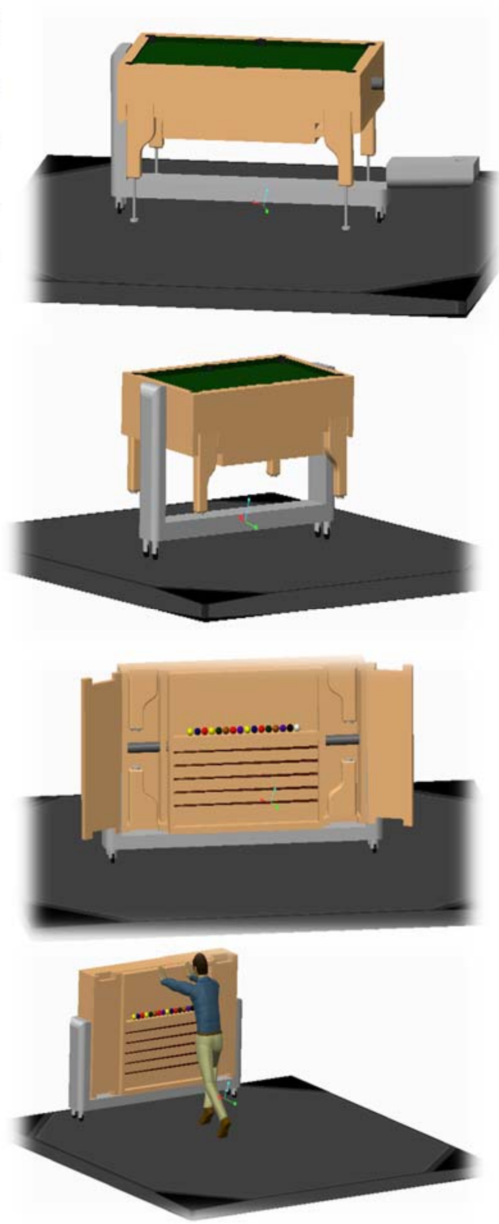


Figure 4. 4 step process of design #2

unbalanced and fall over. Also, this design lacks the room for motors or hydraulic systems to comfortably fit and assist with the rotating portion of the stow-away process. In order to allow adequate space to house these components, the percentage of footprint reduction must be sacrificed.

3.2.1 Design #3

Design #3 transforms from a bench and shelf combo to a pool table. Figure #5 illustrates the steps of the transformation leading to the final step of activating the leveling system. The rotation of the table may be handled easily by hand and the same for the legs that fold down. The front legs may be folded out at any time as they do not interfere with the bench at any time. The back legs, however, must be folded down after the table is rotated enough for them to come out. Once the legs are locked in place the user simply pushes a button for the system of linear actuators to extend to the floor and level the pool table. The mechatronics of this system are to be described in the next report. When converting the table back into its bench-shelf combo mode, the user pushes a button to retract the feet of the linear actuators, folds up the legs and then rotates the table to its vertical position. The wide base and weight of the bench on the side opposite the slate when the pool table is rotated up adds stability to the system while it is being moved. One could even sit on the seat while pushing the bench-shelf combo to the desired location. The underside of the bench would also likely feature a system of easy to pull out drawers, the hardware for which would add more weight.

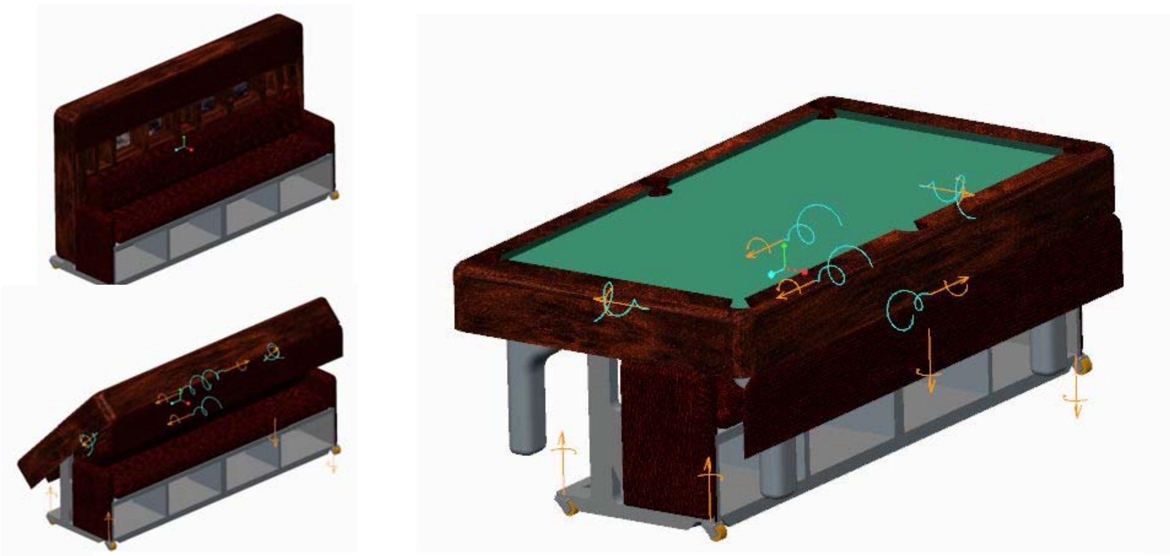


Figure 5. CAD drawings showing the 3 step set up process of Design #3

With this design the system one whole piece rather than having removable parts that take up space in the room while the pool table is out. It may be possible to design the bench to be removable while the table is out, providing some seating on the side. Though the base of the bench might be larger than the other designs the space taken up is made useful with the shelf-bench combo reducing the need to bring in more seating for the room now being used as something other than a billiard room.

3.3 Evaluation of Designs

3.3.1 Criteria, Method

After speaking with our sponsor, Alex, about possible design ideas for the stow-away component of the pool table we came up with various criteria and weighed them in accordance with their importance to our design constraints. Each team member filled out an individual decision matrix but giving each design a score from 1 to 3 for each criteria. A score of 1 means the design meets the criteria poorly and 3 means the design meets the criteria sufficiently. Our top priorities for criteria were safety, footprint reduction and visual appeal. Safety was weighed so heavily because we are dealing with a very heavy apparatus which could weigh up to 1000lbs; when moving something so heavy, all the necessary precautions must be taken. Footprint reduction is basically a measure of how effective our design is, since our goal statement was to “reduce the footprint of the pool table” this is a vital aspect for our design. Visual appeal is important because we are placing emphasis on the marketability of the product. We want this pool table to catch the customers’ eye and be something that they would be proud to have in their house. The product must be sleek, all nuts and bolts must be out of sight, and there shouldn’t be any unnecessary parts extruding from the table.

Manufacturability and design simplicity are related but they are not the same. The manufacturability of a design describes the ease and timeliness of which the product could be reproduced for sale. Design simplicity takes into account the difficulty to create a working physical prototype of the design. Each design will require extensive calculations, simulations and testing. Once you have successfully created the design, in order to manufacture it, all that is needed is the dimensions and specifications for the components so a design can be easily manufactured but complex at the same time. We are willing to put the necessary time and effort in order to design the best product possible so we weighed simplicity lightly.

One thing our sponsor stressed was the familiarity of the product. He wants it to look and feel like a traditional, high-end pool table rather than a tacky attempt at appearing futuristic. He strongly believes that the familiarity of will improve the marketability of it so he wants to spare no expense in satisfying this criteria. With a budget of $11,000, there will be plenty of resources available for testing, researching and developing. In order to satisfy our sponsor's request, we placed familiarity among our criteria. We also place cost on are our list of criteria because it is always important to consider although we do not see it as a large constraint for our design.

3.3.2 Selection of Optimum Ones

The scores for the individual decision matrices were averaged together for each design to get the team average stow-away design decision matrix seen in Table 3. The final scores were close but Design 1 came out supreme because of its safety, visual appeal and familiarity. We will proceed with Design 1 as our designated prototype but we are well aware of the fact that this decision is subject to change as we come across unforeseen circumstances. As the testing and prototyping process begins we may be forced to revisit this design matrix, add new criteria, rescore the designs or even create another design concept.

Table 2. : Team Average Stow-away Design Decision Matrix

Decision Criteria								
	Safety	**Low Cost**	**Manufacturability**	**Visual Appeal**	**Familiarity**	**Design Simplicity**	**Footprint Reduction**	**Total**
Weights	3	2	2	3	2	1	3	16
Design 1	2.75	1.75	1.75	2.5	3	1.75	1	**34.25**
Design 2	1.5	2.5	2.75	1.25	2.5	2.75	2.25	**33.75**
Design 3	2	2	1.5	2.25	1.75	2.5	2.75	**32.75**

4 Methodology

Our strategy for the completion of this project begins with team brainstorming and organization. It is necessary to then plan out our financial situation and determine a budget. We will prepare our workspace, located at TCC's campus by cleaning up and acquiring all needed tools, supplies, etc. From there we will begin our selection process for ideas and start creating designs for our table.

After our designs are complete, the building process will commence and we will work together through the issues and obstacles to a final product. Throughout all of these steps we will be meeting up as a team regularly and constantly be updating our strategy and plans. The designing process we be starting with the completion of the product specifications report and the finalization of the planning process. Although the official start of the build will occur next semester, we already have plans to receive our most basic part: the slate. We will receive the slate from our sponsor before the 30th of October, which will allow us to take real dimensions and draw our system around it.

4.1 Schedule

To help plan out our project for this semester, we have created a Gantt chart and detailed table of events. Both of these will keep us on top of our deliverables and enable us to manage our time well while staying on top of our objectives. The detailed Gantt chart can be found in the Appendix.

4.2 Resource Allocation

The team meets regularly to brainstorm on all aspects of the project. We have found that great suggestions come even when the subject is somewhat trivial. Each member is leading a subsystem: Jarboe handles financial and procurement aspects, Manahan is in charge of the leveling subsystem, McHugh takes care of assembling the components that increase esthetic value, and Silva develops the stowing mechanism. The Gantt chart and Resource Allocation Table in the appendix lays out expectations that can be easily traced back to a subsystem or the person ultimately responsible for its execution. To successfully put together the system as a whole, we have agreed to personally devote our time to our assigned subsystems before dedicating efforts to other tasks.

5 Conclusion

With abundant information from last year's project, and with a team member who had direct involvement in its development, our Senior Design project has the potential to greatly improve on specific features developed previously. While researching the end purpose of this project, we found that there is a strong desire to take the product to market, which further motivates the team to create a product that is both functional and visually appealing to potential buyers.

The objectives and Gantt chart for the Fall semester were laid out to function as a guide that the team must adhere to. We will work to finalize CAD drawings for an ideal system, along with the selection of structural materials that satisfy a Finite Element Analysis for an appropriate factor of safety. Materials that have a long lead-time will be procured before the beginning of the Spring semester. Some of the key strategies we will implement are clear communication between members and sponsor (for which we have set up rules in our Code of Conduct), clean workspace and organized meetings, and frequent reviews of our progress toward our goals. This document will serve to set up expectations for our Project Plans and Project Specs report.

6 References

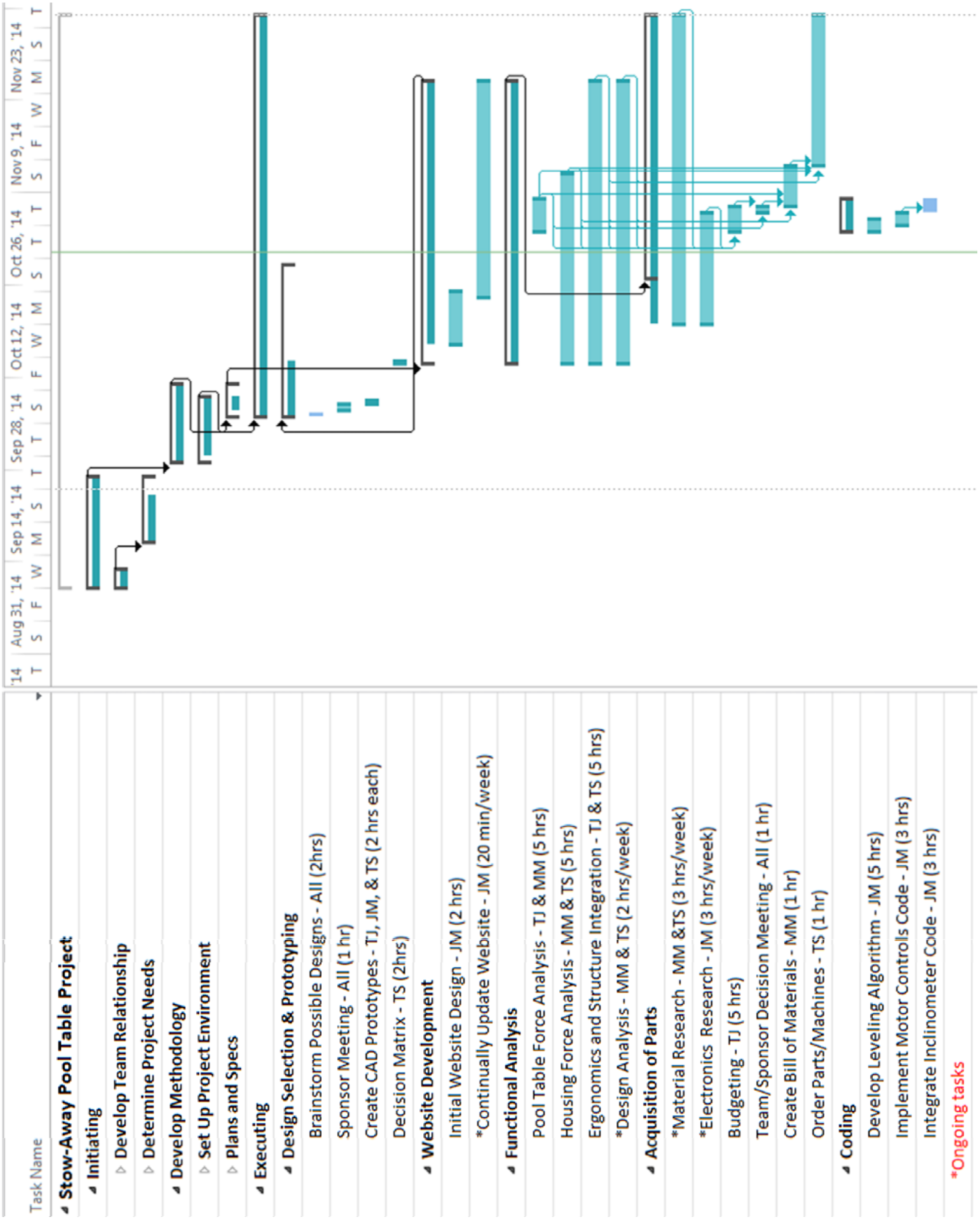
[i] Gross, Norman, and Alexander York. "Deliverables 2014 Final Report." *2013/2014 Senior Design Team19*. Beyond Innovation, LLC, n.d. Web. 26 Sept. 2014. <http://eng.fsu.edu/me/senior_design/2014/team19/deliverable.html>.

[ii] Gross, Norman, and Alexander York. "Deliverables 2014 Final Report." *2013/2014 Senior Design Team19*. Beyond Innovation, LLC, n.d. Web. 26 Sept. 2014. <http://eng.fsu.edu/me/senior_design/2014/team19/deliverable.html>.

[iii] Vescia, Paolo. "Velodyne Inventor Builds Self-leveling Boats." *Widgets RSS*. San Francisco Business Times, 15 Apr. 2014. Web. 26 Sept. 2014. <http://www.bizjournals.com/sanfrancisco/gallery/22511>.

[iv] Gross, Norman, and Alexander York. "Deliverables 2014 Fall Midterm Report." *2013/2014 Senior Design Team19*. Beyond Innovation, LLC, n.d. Web. 26 Sept. 2014. <http://eng.fsu.edu/me/senior_design/2014/team19/image_21.html>.

Appendix


Task Name
Stow-Away Pool Table Project
Initiating
Develop Team Relationship
Determine Project Needs
Develop Methodology
Set Up Project Environment
Plans and Specs
Executing
Design Selection & Prototyping
Brainstorm Possible Designs - All (2hrs)
Sponsor Meeting - All (1 hr)
Create CAD Prototypes - TJ, JM, & TS (2 hrs each)
Decision Matrix - TS (2hrs)
Website Development
Initial Website Design - JM (2 hrs)
*Continually Update Website - JM (20 min/week)
Functional Analysis
Pool Table Force Analysis - TJ & MM (5 hrs)
Housing Force Analysis - MM & TS (5 hrs)
Ergonomics and Structure Integration - TJ & TS (5 hrs)
*Design Analysis - MM & TS (2 hrs/week)
Acquisition of Parts
*Material Research - MM &TS (3 hrs/week)
*Electronics Research - JM (3 hrs/week)
Budgeting - TJ (5 hrs)
Team/Sponsor Decision Meeting - All (1 hr)
Create Bill of Materials - MM (1 hr)
Order Parts/Machines - TS (1 hr)
Coding
Develop Leveling Algorithm - JM (5 hrs)
Implement Motor Controls Code - JM (3 hrs)
Integrate Inclinometer Code - JM (3 hrs)
*Ongoing tasks
'14
Aug 31, '14
Sep 14, '14
Sep 28, '14
Oct 12, '14
Oct 26, '14
Nov 9, '14
Nov 23, '14

Resource Allocation			
Category	**Task**	**Lead**	**Time**
Design Selection & Prototyping	Brainstorm Possible Designs	All	2 hours
	Sponsor Meeting	All	1 hour
	Create CAD Prototypes	Travis Jarboe, Joel Manahan & Thomas Silva	2 hours each
	Decision Matrix	Thomas Silva	1 hour
Website Development	Initial Website Design	Joel Manahan	2 hours
	*Continually Update Website	Joel Manahan	20 min/week
Functional Analysis	Pool Table Force Analysis	Travis Jarboe & Matthew McHugh	5 hours
	Housing Force Analysis	Matthew McHugh & Thomas Silva	5 hours
	Ergonomics and Structure Integration	Travis Jarboe & Thomas Silva	5 hours
	*Design Analysis	Matthew McHugh & Thomas Silva	2 hours/week
Acquisition of Parts	*Material Research	Matthew McHugh & Thomas Silva	3 hours/week
	*Electronics Research	Joel Manahan	3 hours/week
	Budgeting	Travis Jarboe	5 hours
	Team/Sponsor Decision Meeting	All	1 hour
	Create Bill of Materials	Matthew McHugh	1 hour
	Order Parts/Machines	Thomas Silva	1 hour
Coding	Develop Leveling Algorithm	Joel Manahan	5 hours
	Implement Motor Controls Code	Joel Manahan	3 hours
	Integrate Inclinometer Code	Joel Manahan	3 hours
*Ongoing Tasks			