Warren J. Baker Endowment
for Excellence in Project-Based Learning
Robert D. Koob Endowment *for Student Success*

FINAL REPORT

Final reports will be published on the Cal Poly Digital Commons website (http://digitalcommons.calpoly.edu).

I. Project Title: Avalon Submersible Support Structure

II. Project Completion Date: June 2, 2017

III. Student(s), Department(s), and Major(s)

(1) Alexandra Zaragoza, Mechanical Engineering, Mechanical Engineering

(2) Octavio Mendoza, Mechanical Engineering, Mechanical Engineering

(3) Austin Eslinger, Mechanical Engineering, Mechanical Engineering

IV. Faculty Advisor and Department:
Eileen Rossman, Mechanical Engineering

V. Cooperating Industry, Agency, Non-Profit, or University Organization(s):
The Morro Bay Maritime Museum (MBMM), represented by Bob McCay

VI. Executive Summary

The MBMM, is currently looking for a new way to support the Deep Submergence Rescue Vehicle (DSRV), that they have on display. The DSRV is sitting on a Short Haul Vehicle (SHV) trailer and the total weight is being supported by the SHV's tires, which is a source of concern for the MBMM. The MBMM is looking for a support structure that will take the weight off of the tires so that they can be removed at their convenience. Our goal for this senior project was to design a structure that will allow the museum to support the DSRV, maximize visibility, and allow the museum to transport it to its final location at their proposed Interpretive Center. First, background research was conducted. Next, idea generation sessions were held, and potential solutions were selected. The decision regarding the final design was left to the MBMM, as our weighted decision matrix indicated that aesthetics was the driving factor. After the final design was selected, extensive analysis was conducted to determine whether it was feasible. To validate the design, we built a steel scaled model of the most critical portion of our design and tested it under the anticipated load case. We also built a wooden, full-scale model of our design for geometric testing. Our original plan was to construct the wooden, full-scale

model and to 3D print a scaled model. However, to better meet the requirements of the senior project course, our advisor required us to construct a steel scaled model that could be structurally tested. This model replaced the anticipated 3D printed model. Our testing on the steel scaled model indicated that the design did not meet the strict seismic requirement in our engineering specifications. After discussing this with the MBMM, they agreed to loosen the seismic requirement.

VII. Major Accomplishments

(1) With guidance from our sponsor, we developed a final design, which consists of four independent structures that attach to the trailer that the DSRV currently sits on. These structures will both support the weight of the DSRV and the trailer, as well as lift the DSRV up an additional foot from the ground. This will make it easier for people to enter the DSRV when taking a tour, as the entrance is on the bottom of the DSRV. An image of the CAD model of our design as it would interface with the trailer has been provided in Figure 1.

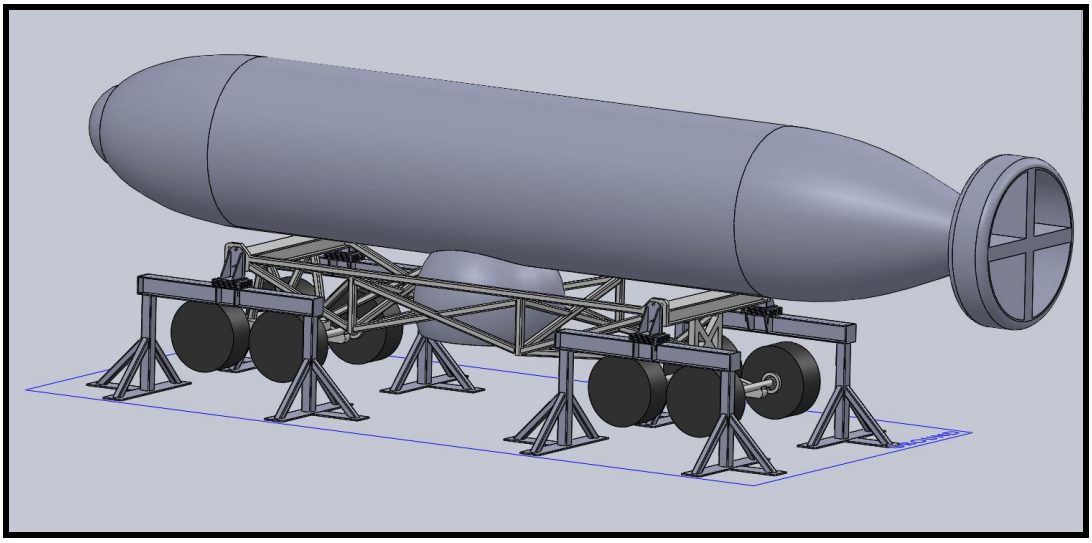

Figure 1. An image, produced in SolidWorks, of our four structures attached to the trailer that the DSRV currently sits on.

(2) A steel scaled model of a portion of our design was constructed, and tested in the Composites Lab (192-135) against the anticipated load case. The model we created was a 1:4.28 scaled version of the final design. To test the model under both static and seismic conditions simultaneously, we loaded the model at 45 degrees using a hydraulic ram. Our structure yielded under the strict requirement of 0.52g, or the USGS Maximum Expected Peak Lateral Acceleration for our conditions. We therefore recommended that the MBMM relax the seismic requirement to 0.36g, or the Maximum Design Peak Lateral Acceleration for our conditions. This seismic requirement is a more commonly used value. An image of our completed steel scaled model can be found in Figure 2.

Figure 2. An image of the completed steel scaled model of our design

(3) A wooden, full-scale model of our design was also constructed and geometrically tested alongside the actual trailer supporting the DSRV in Morro Bay. We placed the entire structure up against the trailer to determine how far the structures will extend from the trailer when installed. We also verified that sufficient clearance exists between the structure and the tires, to ensure that the tires can easily be removed in the future. Finally, we also verified the sizing on two pieces of the structure. An image of our completed full-scale model can be found in Figure 3.

Figure 3. An image of our completed full-scale, wooden model.

VIII. Expenditure of Funds

An image of the spreadsheet used to keep track of our team's budget can be found below:

Starting Budget		$500.00			
Category		**Item**	**Quantity**	**Planned Expense**	**Actual Expense**
Materials for Steel Prototype					
	Supplier	**Item**			
	Metals Depot	S 3" x 5.7# Steel I-beam	1	N/A	$45.65
	Metals Depot	1-1/2" x 1-1/2" x 11GA Steel Square Tube	3	N/A	$25.53
	Metals Depot	1" x 1" x 16GA Steel Square Tube	7	N/A	$37.52
	Metals Depot	3/16" A-36 Steel Plate	1	N/A	$32.06
	Metals Depot	Shipping on Metals Depot Order	1	N/A	$38.86
	McMaster-Carr	1215 1-1/2" Square, 1' Length Carbon Steel Square	1	N/A	$23.38
	McMaster-Carr	Zinc Yellow-Chromate Plated Hex Head Screw Grade 8	1	N/A	$11.90
	McMaster-Carr	Shipping on McMaster-Carr Order	1	N/A	$0.00
	Mustang 60 Scrap	7/8" Steel Plate	1	N/A	$30.00
	Orchard Supply Hardware	Grade 8 Bolt, Split Washers, Hex Nut, Nylon Lock Nuts	1	N/A	$3.22
	Orchard Supply Hardware	Metal Cutoff 4-1/2 Wheeel	1	N/A	$3.59
	Miner's Ace Hardware	60 Grit 4-1/2 Flap Disk	1	N/A	$5.99
	Orchard Supply Hardware	Hex Nuts, Bolts, and Washers	2	N/A	$4.56
	ACE Hardware	Grade 8 Nuts, Bolts and Washers	1	N/A	$44.37
Materials for Wooden Model					
	Supplier	Item			
	Home Depot	4x4x8" #2 Douglas Fir	3	N/A	$27.90
	Home Depot	2x4x96" #2 Pressure Treated Pine	2	$35.46	$6.10
	Home Depot	15/32" x 4' x 8' Sheathing Plywood	2	$47.55	$31.70
	Home Depot	Glidden Speed-Wall White Latex Paint & Supplies	1	$14.98	$15.72
	Home Depot	23/32" x 4' x 8' Plywood	1	N/A	$26.48
	Home Depot	3" screws box, 1 1/4"screws box, 1/4 x 3" lag screws	1	NA	$9.68
	Home Depot	California Lumber Fees	4	N/A	$0.89
	Home Depot	Sales Tax	N/A	N/A	$9.27
					Total Spent
					$434.37

IX. Impact on Student Learning

What follows are reflections, one written by each team member, outlining how this project impacted his or her student learning.

Alexandra Zaragoza

While I have participated in numerous projects throughout my career at Cal Poly, this project was the first where I really felt like I was able to see the project all the way through -- from design, to manufacturing, to testing, to presentation. Through the course of the project, I learned a lot about what it takes to make a larger scale project come together. First, it is critical to communicate often and have a good relationship with the customer or, in this case, the sponsor. It is also critical that engineers be able to communicate their ideas and

designs effectively to others through writing. If an engineer can't communicate his or her design to others, then it will not be of any use. It is also important that all aspects of the design process are documented thoroughly as the process proceeds. Our team was very good about documenting its progress and I believe this showed in our Final Design Report. It is also very important that a team sets deadlines for itself, and then sticks to them. We set a few hard deadlines during the course of the project and we gave 110% in the days leading up to the deadlines to make sure that they were met. Another important aspect of teamwork that became apparent to us during the course of the project is being able to play to each team member's strengths. By the third quarter of our project, our team members were very familiar with each other's strengths, and we divvied up the work accordingly. This allowed us to finish our project much earlier than other teams. Overall, this experience has taught me many things about working on a team project and I will take these lessons with me in my career after graduation.

Octavio Mendoza

There were many things that I have taken away from completing this three quarter project that have benefitted me as an engineering student and as a future engineer. There is of course, the opportunity to tackle a real-life problem that has to be taken from conceptual design to manufacturing and testing. As a mechanical engineering student at Cal Poly, we have had the opportunity to engage in many projects, but never to the extent of our senior project. We were presented with a problem and it was expected that we apply all of our acquired knowledge in engineering to solve that problem. There were no guidelines on how to approach our project or how to go about solving it. It simulated a real-life situation in which an employer would simply hand over a project to you or your team and expect you to produce results with little to no guidance given. I really benefited from that experience in which you are essentially left on your own to solve the problem. We did not have to tackle this project on our own, however. We were placed in groups in order to accomplish a common goal. This simulated the common practice that engineers must collaborate with others. This allowed us to begin working on the personal skills that are required in order to work effectively with other individuals. The biggest realization from this project, however, and one that I believe will be an all too common occurrence in industry is the following: there were many instances in which a lot of time and work was put into developing ideas or designs that were never used or implemented. The sponsor, who represents the employer during our senior project, could simply have a change of mind or decide to go down another path that results in all your hard work being obsolete or no longer required. There is often not much that can be done to avoid such situations, other than learning to deal with the setbacks and keep pushing forward until the requirements have been met. It is a situation that allows you to work on abilities or emotions that are not taught in the classroom. Learning to deal with emotional setbacks positively is just as important as learning to deal with the technical ones.

Austin Eslinger

This project gave me a glimpse of how projects are done in the real world on an accelerated time frame. It taught me how to manage not only the technical portion of a project, but also the communication aspects and relationships necessary to keep the team and customers happy. This project was by far the most fulfilling, well rounded, and hardest project I've worked on while in school. We as a team needed to be creative designers, thoughtful analysts, effective communicators, quality fabricators, and safe test conductors. Learning each of

these skills may be taught in a classroom, but managing them all cannot. Senior Project is the only way to teach that, as well as the fact that technical competence is only one small piece of a good engineer. Looking forward, this project has made me appreciate the value of good management, good communication and hard work. It has shown me how fulfilling it is to work simultaneously with team members, customers, and the technical portion of an engineering project. My desire to work as a systems engineer, which deals with all of those directly, has strengthened.