FINDING A SAFE ALTERNATIVE TO POLLUTANT-HEAVY RECREATIONAL VEHICLES

POLLUTION IN MARINE ENVIRONMENTS

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By
Colin Allison

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Technical Project Team Members
Justin Allen
Julianna Chaput
Miles Coe
David Gordon
Brian Lithen
Troy Meurer
Jonathan Ramirez
Bryce Shelton

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: Colin Allison Date: 10/31/19

Approved: Catherine D. Baritaud Date: Dec. 12, 2019
Catherine D. Baritaud, STS Division, Department of Engineering and Society

Approved: Date: 10/31/2019
Gavin Garner, Department of Mechanical Engineering

According to the Environmental Protection Agency (EPA), recreational boating is increasing in popularity along with the awareness of the environmental quality of the sources of water occupied by these boats (EPA, n.d). Activities like refueling or cleaning recreational boats create waste that cause harmful impacts on the marine environment. Some people have moved to use more environmentally friendly alternatives including physically powered vehicles like kayaks, canoes, and electric powered boats. The waste created by recreational boats is not as large as other merchant boats. The impact of the waste created by gas-powered recreational vehicles is not the largest threat to the environment.

After exploring the larger scale of pollution caused by various marine vehicles, a major contributor to the problem is determined to be the cruise ship industry. The overall impact of the luxury ships will be considered, in both an economic review and in consideration of environmental effects. Through a STS research paper, the effect of cruise ships on complex social systems will be analyzed. This topic is loosely coupled with the technical project as they share a common interest in exploring the impact of pollution in a marine setting. The goal of the technical project is to devise a boat system that is capable of being used in waters where gas-powered vehicles are prohibited. To achieve this final product, the body of a kayak will be considered and a propulsion system similar to that of a jet-ski will be mounted onto it. This technical project will be guided by Professor Gavin Garner and assisted by team members in the Mechanical Engineering Department: Justin Allen, Julianna Chaput, Miles Coe, David Gordon, Brian Lithen, Troy Meurer, Jonathan Ramirez, and Bryce Shelton. The timetable provided covers one-semester in which the technical project must be completed. The Gantt chart shown on Page 2 provides a timeline of checkpoints that must be completed by certain dates.

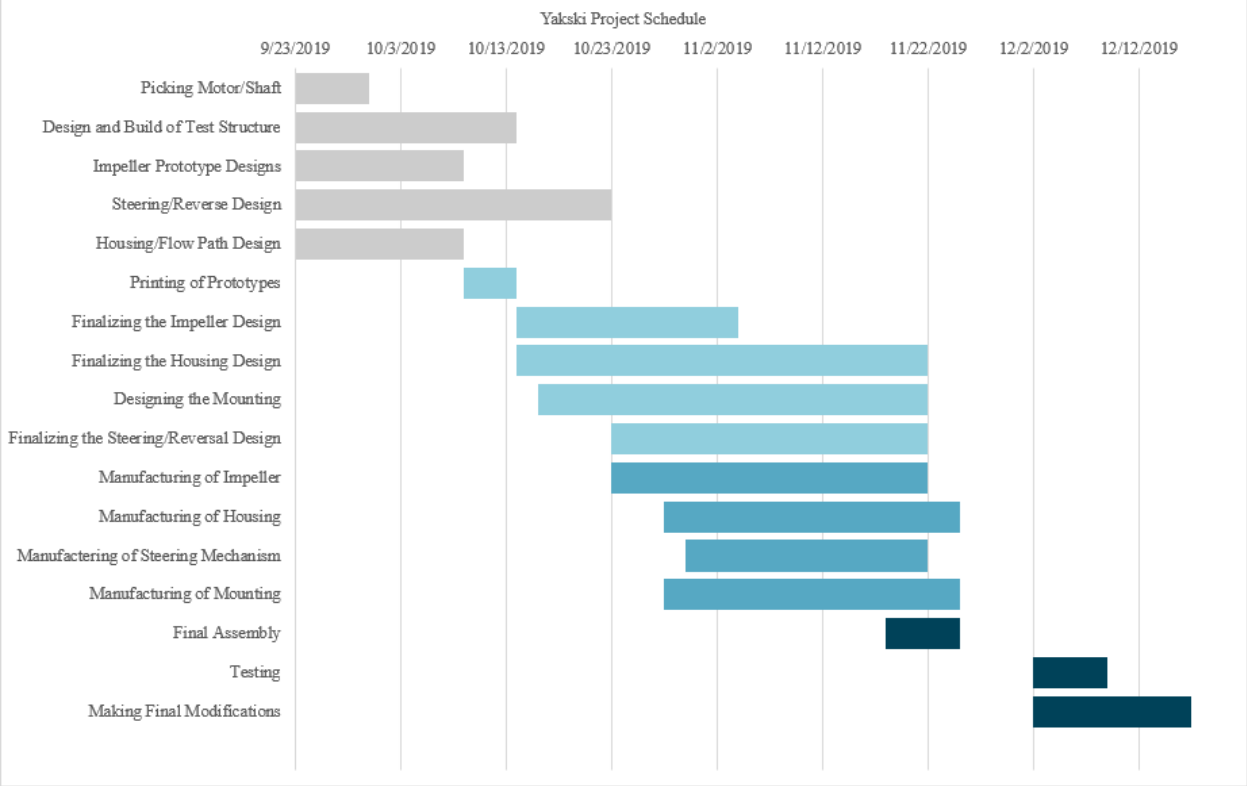

Figure 1: Technical project Gantt chart: This chart shows the amount of time allocated to complete numerous checkpoints (Chaput, 2019).

FINDING A SAFE ALTERNATIVE TO POLLUTANT-HEAVY RECREATIONAL VEHICLES

Motorized vehicles are efficient ways of getting around across bodies of water, however, water pollution is an increasingly concerning issue to the general public. According to the Environmental Protection Agency (EPA), recreational boating is growing in popularity and could lead to increased spills from boats during maintenance (Environmental Protection Agency, n.d.). To combat effects of harmful recreational boating, some bodies of water do not allow boats that are gas-powered. Regionally, the South Fork Rivanna follows this policy and only permits the use of kayaking and canoeing (Rivanna Authorities). Although this policy is environmentally conscious, it limits the user's ease to travel in and around the reservoir area as kayaks and canoes are physically demanding.

With the instruction of Mechanical Engineering Professor Gavin Garner and the assistance of Mechanical Engineers Justin Allen, Julianna Chaput, Miles Coe, David Gordon, Brian Lithen, Troy Meurer, Jonathan, and Bryce Shelton, the creation of the body of a kayak will be considered with design goals of a more efficient, environmentally conscious mode of transportation. The technical project will implement a water jet driven propulsion system similar to that of a jet ski attached to a kayak so that it may be used with ease and also act as an efficient vehicle (Watson, 1998).

Many different factors need to be considered when this complex system, so to simplify the process, the system was divided into smaller sections. Similar to a jet-ski, the system must include a subsystem including a housing, an impeller, and a stator which act together to accelerate water to create propulsion (Woodford, 2019). Starting with this propulsion system, various different versions of housings, impellers, and stators will be designed according to

modern jet-ski systems using SolidWorks computer aided modeling. Along with the design of the model, the subsystem can be assembled and analyzed in the same software using the SolidWorks Flow Simulation package to optimize the flow path of the waterjet. Due to the shape and balancing of a kayak, two propulsion systems will be implemented into the design with one free jet operating on each side of the kayak. A control system must be implemented along with the propulsion system so that the kayak has a steering and reversing capabilities. Once the propulsion and steering systems are optimized, the entire system must be mounted to the kayak to ensure the system can stay attached during use while also outputting thrust to propel the system forward.

This technical project requires many materials and resources to ensure its completion. The M.I.L.L laboratory in the basement of the Mechanical Engineering Building (MEC) at the University of Virginia will serve as a space to rapidly prototype different 3D printed structures and will allow for easy access to materials that may be used throughout the process. Within the bounds of the MEC, Lewis Steva, the in-house machinist, will assist in creating parts or specialized pieces that could be useful within the complex system. Professor Gavin Garner will work very closely on the project suggesting possible design ideas and modifications. A budget of $1200 has been provided by the University of Virginia and will be used to buy parts that cannot be manufactured by the machinist.

Based on the team's initial predictions, designs, and planning, this technical project aims to have a fully assembled propulsion system mounted to the kayak. The technical project also predicts to have a functional steering system with a propulsion system capable of moving the average person 10-15 miles per hour. An early computer-aided design assembly model is provided in Figure 2 on Page 5.

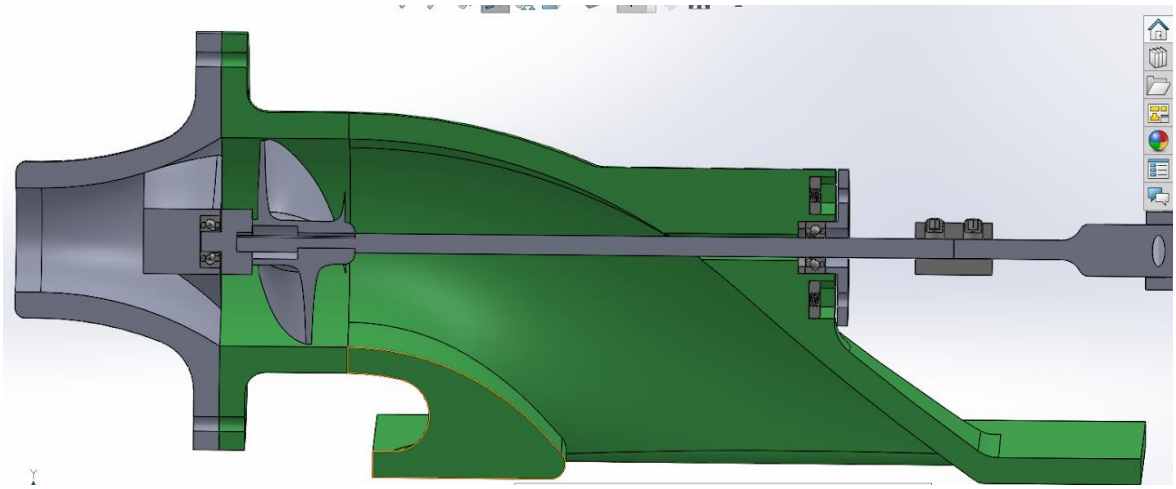

Figure 2: Section View of the Propulsion System: This assembly shows the housing, impeller, and stator in a system together by cutting open the system to show the inside to make it easier to understand how the system may work together (Allison, 2019).

The intricacies of computer aided design and manufacturing will be explored through the designing and creation of the jet ski propulsion system mounted to a kayak. Furthermore, the design process will give helpful insight into the difficulty of rapid prototyping and choosing a final design. In a technical report, the project will be presented with accompanying research, design, prototyping and decisions made along the way.

THE CRUISE INDUSTRY: THE SILENT GIANT

Pollution has always been a byproduct of technologies which require energy in order to function. As energy is expended to power a machine or technology, no matter how large or how small, it creates pollutants that may be harmful to the environment or to those who reside in a given area. Historically, pollution has been largely ignored so that the company or technology may reap economic benefits. Many years of pollution have shown to be especially destructive in the marine field as many ecosystems are experiencing adverse effects including waste and even forms of noise pollution from larger boats (Maxwell et al., 2018). In the instance of marine pollution, the blame is often pointed at the commercial shipping industry as they are transporting thousands of products across the world's oceans every day, however, the cruise ship industry contributes more waste to the overall pollution problem (Butt, 2007). Contrary to popular belief, the luxury liner business does not only pollute the ocean's waters, it also contributes pollution through mediums such as air pollution. Upon a closer look into the cruise ship industry, the resulting environmental effects add to the rising global climate and the health of marine ecosystems.

FRAMING THE CRUISE SHIP INDUSTRY

The issue of pollution caused by the luxury liner business seems to go unnoticed as the public has not been properly educated on the wide scope of the problem. Even though concerns of the cruise ship industry's impact on the environment have been gradually increasing, the organization shows no signs of slowing down as it transported over 26 million customers in 2018 (Ellsmoor, 2019). The immense size of the cruise industry poses a scaling threat to the marine environment, surrounding ports' environments, and other unnoticeable affected areas. To assess the widespread effects of the luxury ship industry, a visual aid adapted from the conceptual

framework of Social Construction is provided in Figure 3 below. The figure below adapts the cruise ship industry's impact on relevant stakeholders by examining several case studies that outline important relationships.

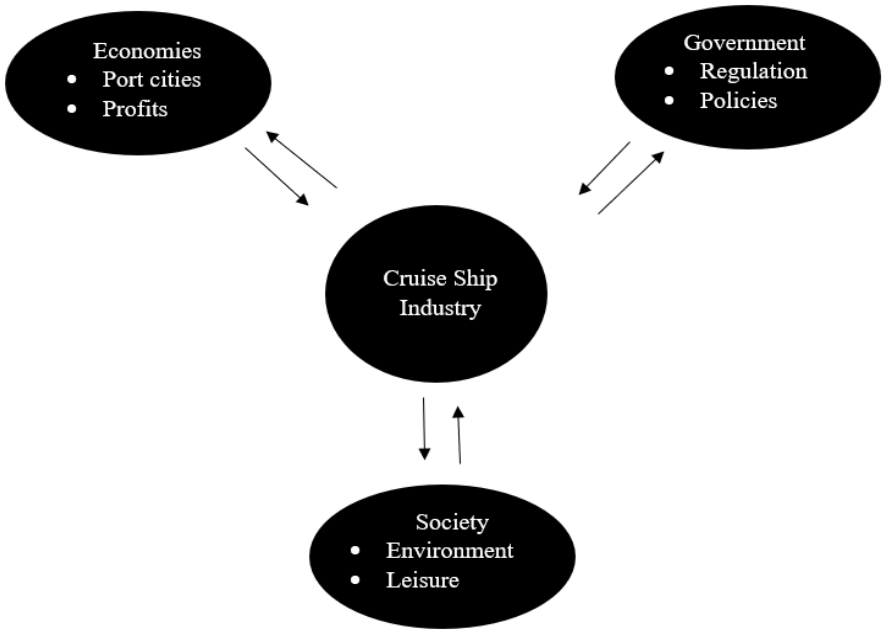

Figure 3: Cruise ship social technology concept framework model
(Adapted by Colin Allison from W. B. Carlson, 2019)

With the cruise ship industry in the middle of the framework as the acting technology, the luxury boating business holds influence on all of the surrounding groups. The connections between groups and the industry are two-way networks representing the relationship provided by the Social Construction conceptual framework. In this two-way relationship, the Social Construction framework depicts that the technology and the outer groups communicate in which the technology shapes the groups and the groups also shape the technology. Although the links between the cruise ship industry and the groups are depicted as two-way relationships, often the cruise ship's impact on the groups dominates the relationship. In the instance of the relationship between business and society, the industry provides a great amount of pleasure to the user with the cruel exchange of the adverse impact on the environment.

Cruise ships have been proven to create a disproportionate amount of waste while analyzing the scope of pollution created by manned boats and have "been found dumping illegally even with lenient ruling surrounding waste removal (Moscovici, 2017, para. 6). According to Butt, "cruise ships represent less than 1% of the global merchant fleet yet it has been estimated that they are responsible for 25% of all waste generated by merchant vessels" (Butt, 2007, para. 1). Along with the waste creation in marine environments, these ships also have a concerning impact on the air quality around popular cruise routes. The consumption of fuel by cruise ships has been proven to be especially detrimental. For example, the Sapphire Princess, a popular Alaskan liner, was estimated to "emit the same amount of sulfur dioxide as 13.1 million cars" (Eilperin, 2012, para. 1). Ironically, the very same liner advertises to the public "to see Alaska's pristine landscapes" while contributing to the destruction of these landscapes along the trip (Eilperin 2012, para. 1). While the government has never needed to maintain a close relationship with the luxury liner business, findings like those from the Sapphire Princess study have forced them to take action.

In a case study examining the city of Venice, there is a growing concern with pollution caused by cruise ships along popular water routes to the city (Pesce et al., 2018). The case study fits very nicely with the relationships outlined in Figure 3 on Page 7 as the case study acknowledges these relevant stakeholders. The article begins by explaining the relationship between the cruise ship industry and Venice, where the business and the city both positively impact each other. Even though this tradeoff has worked for a while, the recent pollution caused by cruise ships traveling through the surrounding ports of Venice has opened a conversation for the possibility of alternate routes. Venice holds historical significance with areas that are certified as historical centers and ecologically sensitive areas by the United Nations Educational,

Scientific and Cultural Organization (UNESCO). The government aims to keep this historical certification as it is a large draw to many of the tourists that come through Venice each and every year. It is very apparent to see the Social Construction network in this case study as the economic, cultural, and governmental aspects at play as they all hold stakes in the cruise ship industry. In Venice's case, the system acts equally where the technology, the cruise ship industry, effects the surrounding stakeholders and they influence the technology in turn.

Within the cruise industry lie other smaller players in the larger groups including nations that are solely dependent on the tourism brought by the luxury liners. What many people do not realize is that the cruise ships have a much larger impact on the small nation than expected as the cruise industry grows larger than ever seen before. Nations are chosen because they are desirable destinations, but are then sucked of their biodiversity due to the antibiotic relationship between the cruise ship business and the nation. The toxic relationship allows the cruise ships to "extract the goods they came for and leave behind little more than waste" (Moscovici, 2017, para. 6). Even though the link between the two groups is a two-way relationship, it can be easily determined that it is not a healthy relationship. As the cruise ship industry continues to grow, so does the environmental impact of the liners (Eilperin, 2012, para. 1). The impact of the pollution and hazardous destruction of the beautiful small nations is unfair as the land is ravaged and there is little that the nations can do as they hold a small amount of power in the relationship but also solely depend on the industry.

Further exploring the exploitation of small island nations, some solutions have been offered to possibly lessen the burden of the cruise ship industry. Some possible solutions to decrease the environmental impact of the cruise ships include using technology to research the overall impact of the luxury liners on small island nations to determine biodiversity impacts and

other veins of pollution (Moscovici, 2017). Additionally, government involvement between the cruise ships and island nations could enact regulatory fees to work toward paying back the affected nations. Although this approach would be a step in the right direction, the small island nations would have to be wary of their demands as the cruise ship industry still holds all the power in the relationship (Moscovici, 2017). Carefully managing their relationship with the luxury liner industries, the small island nations could preserve the beauty of the islands while still reaping the economic benefits.

Through the exploration of the harmful effects of the cruise ship industry on the environment, the underlying impacts will be unveiled. The STS research project will be a scholarly article describing the negative impacts of the cruise ship industry and will explore possible solutions to fixing these problems.

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