

Standards for Enclosed Canopies on Small Passenger Vessels

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Abstract

This project, done in conjunction with the United States Coast Guard (USCG), addressed the issue of passenger egress on small passenger vessels with canopies or enclosures. We investigated several factors involved in the design and operation of these vessels by interviewing USCG representatives and reviewing prior marine casualties. After completing this investigation, we developed recommendations and outlined areas for further research to assist the USCG in their mission of preserving passenger safety.

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Executive Summary

Marine travel remains one of the most important forms of transportation in the world today. The movement of both passengers and cargo across harbors, bays, and oceans forms an integral part of life for people around the world. The potential for danger is always present in marine travel, as a marine vessel is at risk of sinking even in ideal boating conditions. Several issues affect the safety of marine vessels, and many groups have devoted a great amount of time and effort to improving safety features and procedures. Several industries in the United States utilize small passenger vessels (SPV), one of several classifications of marine vessels, as a mode of transportation and primary source of income. These vessels often have canopies installed on their decks to provide shade and to protect passengers from inclement weather conditions. In marine casualties in the past, these canopies have restricted passenger egress during evacuation, resulting in many fatalities.

Passenger safety is a vital issue in the marine transportation industry, and the Coast Guard has done extensive research to prevent casualties and minimize the injuries that result from casualties that do occur. The United States Coast Guard (USCG) is responsible for promoting safety on SPVs, and in the past has fully investigated many possible contributing factors to marine casualties, including overloading, passenger behavior, and master negligence. The *Miss Majestic* and *Lady D* are just two incidents that have shown that canopy design has the potential to affect passenger safety negatively. Our project thoroughly investigated this problem to reduce the risk of injuries or fatalities in future marine casualties due to the presence of a canopy or enclosure.

The goal of this project was to develop recommendations to improve the safety of passengers on vessels with canopies in the event of a casualty. In order to accomplish this, we investigated several aspects of passenger safety and canopy design to identify possible improvements to regulations and behavior that would reduce the risk of fatalities. We established three primary objectives that would allow us to make the most comprehensive recommendations to the Coast Guard. These objectives were

to evaluate typical canopy design and use, with a particular emphasis on the safety features of various canopies, to determine the effectiveness of current government policy with regard to canopies, and to research the effect that human factors have in marine casualties involving canopies. The completion of these objectives provided us with information on the topic of passenger safety on SPVs.

To accomplish our objectives, we devised several strategies to obtain information while working with the USCG. We conducted interviews with experts within the USCG to understand various aspects of the USCG's function and responsibilities. We also interviewed owners and operators in the SPV industry to learn about how this industry operates and what considerations vessel owners make with regard to passenger safety. We engaged in direct observation by boarding several SPVs to obtain personal experience in the routine operation of small commercial vessels and to understand the behavior of passengers aboard these vessels. Lastly, we analyzed written resources, including regulations and casualty reports provided by the USCG. The completion of these methods gave us further information about the problem of passenger egress and possible solutions to this problem.

We used this information to develop an analysis of several aspects of vessel operation in our attempt to identify possible improvements to vessel design and procedures. We analyzed the lessons we learned from past casualty reports by noting common trends across incidents. We examined Coast Guard regulations and policies for gaps that exist regarding passenger egress and considered how the Coast Guard can apply guidance from NVIC 1-01 to all small excursion vessels. Finally, we defined and analyzed the effect of human factors, such as crew and passenger behavior, on passenger egress and identified possible changes that could improve this behavior. This analysis supported our recommendations regarding the changes the Coast Guard could make to improve passenger safety with regard to emergency egress.

Based on our analysis, we developed recommendations for the USCG that we believe will improve the safety of passengers aboard SPVs. These recommendations outlined possible improvements to canopy design, including new design features such as quick-release windows, to make passenger egress easier. These recommendations also identified the issues regarding the use of personal flotation devices on SPVs that we hope will improve passenger survivability in the event of a casualty. Finally, these recommendations addressed the need for better education regarding emergency egress, both for crewmembers through training and for passengers through signage and safety orientations. We believe that the enactment of these recommendations will make passengers aboard SPVs better equipped to evacuate from a vessel if an emergency were to occur.

We anticipate that the results and recommendations that come from our work on this project will provide the USCG with further insight on the issue of passenger safety, and will reduce the risk of injuries or fatalities in marine casualties in the future.

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1. Introduction

Marine travel remains one of the most important forms of transportation in the world today. The movement of both passengers and cargo across harbors, bays, and oceans form an integral part of life for people around the world. The potential for danger is always present in marine travel, as a marine vessel is at risk of a casualty even in ideal boating conditions. Several issues affect the safety of marine vessels, and many groups within the marine transportation industry have devoted a great amount of time and effort to improving safety features and procedures. These groups have designed features both to prevent marine casualties and to minimize any injuries or damage that might result from these incidents.

Several businesses in the United States utilize small passenger vessels (SPV), one of several classifications of marine vessels, as a mode of transportation and primary source of income. Ferries, water taxis, and tour boats are three examples of small passenger vessels used for commercial purposes. These vessels often have canopies installed on their decks to provide shade and to protect passengers from inclement weather conditions. In the past, these canopies have placed passengers in dangerous situations should the vessel sink or capsize. The United States Coast Guard (USCG) is responsible for promoting safety on SPVs. They are currently searching for ways to develop further any regulations regarding canopies. These regulations could reduce the chance of fatalities or injuries occurring in a casualty due to the presence of a canopy.

Passenger safety is a vital issue in the marine transportation industry, and the USCG has done extensive research to prevent casualties and minimize injuries resulting from those that do occur. The USCG has examined the effects of many possible factors that have contributed to marine casualties, including overloading, passenger behavior, and crew negligence. Passenger vessels often employ many different types of canopies as part of their vessel design. Although the USCG has never identified a

canopy as the cause of a casualty, previous incidents, such as the Lady D and Miss Majestic casualties, have demonstrated that canopies have had a negative effect on passenger safety (NTSB, 2002 and 2006).

There has been little research analyzing the effect of a canopy on passenger safety in the event of an incident. The USCG has not investigated the possible connection between canopies on SPVs and injuries or fatalities that result from marine casualties, and has not looked into possible ways to make canopies safer. It is unclear whether passengers are being educated properly on safety procedures in the event of a casualty. It is also unclear how existing USCG regulations apply to the use of canopies on vessels. By gaining more knowledge in these areas, the USCG will be better equipped to ensure the safety of passengers.

In an effort to extend the USCG's knowledge of marine casualties and their causes, our project group investigated passenger safety and canopy design in an attempt to establish a connection between the two. Based on this investigation, we developed recommendations to improve the safety of passengers on vessels with canopies in the event of a casualty. We based our recommendations on thorough research of common canopy designs, installation, and use, as well as a review of past incidents where vessel canopies have contributed to injuries or fatalities. In the course of our research, we answered the following questions: What are common types of canopies used on SPVs, and what specific safety features do they have? How have canopies contributed to injuries and fatalities in marine casualties? What are the most appropriate government regulations and approval standards for the use of canopies on SPVs? How can a vessel's crew and passengers be better educated to react in the event of an incident? By answering these questions, our project group developed recommendations that we believe will improve passenger safety in the event of a casualty, thus reducing the likelihood of fatalities.

2. Background

In this chapter, we will present general information about vessels as well as specific information regarding the use of canopies and the effect canopies have in marine casualties. The first section introduces important information regarding vessels and the marine transportation industry. We also discussed small passenger vessels (SPV), passenger safety on vessels, and the design and use of canopies on vessels. We presented the pertinent federal regulations and policies that apply to SPVs. Finally, we reviewed marine casualties by introducing general information regarding the causes and aftermath of incidents, as well as by presenting actual cases where there was a connection between marine casualties and the use of a canopy.

2.1 Vessels

Marine transportation remains a vital part of today's economy. It benefits the global economy by providing a method for the transportation of goods and people from one location to another. It also benefits local economies, as many small commercial enterprises rely on marine transportation to bring in customers. In this section, we will cover different SPV designs and passenger safety in the marine industry.

2.1.1 Small Passenger Vessels

Small passenger vessels, as defined by the United States Coast Guard (USCG) criteria in Title 46 Code of Federal Regulation Subchapter T (Subchapter T), are vessels of less than 100 gross tons that carry less than 150 passengers (USCG, 2009c). In addition to these criteria, the USCG defines an SPV as having more than six passengers on board with at least one passenger for hire. There are several varieties of SPVs in operation today, each providing some service to waterfront communities.

Ferries

Ferries, as defined by the USCG (2009c) in Subchapter T, are vessels that operate in a body of water other than the ocean, have accommodations only for deck passengers or vehicles, conduct business between two locations on a frequent schedule, and offer a mode of transportation to the public.

Water Taxis

According to the City Water Taxi Corporation (2008), located in Boston, Massachusetts, a water taxi operates like a land-based taxi. Passengers call for a pick up, travel via water to their destination, and pay the driver a specified fee.

Tour Boats

According to The Great Rivers Tour Boat Company (2009), located in Grafton, Illinois, tour boats are vessels that take passengers on a tour on a body of water. Generally, there is a master who navigates the vessel and a narrator who entertains the passengers with interesting information and points out places of interest.

DUKWs

DUKWS are a type of amphibious passenger vehicle originally built during World War II for the United States Army to allow troops to transport supplies over land and water (USCG, 2008a). DUKW stands for 1942 (D), amphibious (U), front-wheel drive (K), and rear-wheel drive (W) (NTSB, 2002). By 1970, however, the military disposed of DUKWs after determining the vessels were not cost-effective. Tour boat industries in the United States have converted these vehicles for commercial use. Known

around the country as the “Duck Tours”, DUKWs offer an interesting view of a city and its environs (Boston Duck Tours, 2006).

2.1.2 Passenger Safety

Passenger safety is a fundamental principle the USCG strives to preserve. Through the enforcement of their statutory mission, the USCG implements and enforces regulations to help protect passengers on all vessels and saves those in peril (USCG, 2009d). If vessel operators follow all evacuation procedures and vessel owners abide by all Coast Guard regulations, they will reduce the likelihood of a marine casualty. Within the USCG, the Marine Safety Center is in charge of ensuring that each commercial vessel is constructed and maintained according to United States regulations and standards. Crew and passenger education is just one of the ways in which the USCG can satisfy its mission of preserving marine safety.

Crew Training

The USCG requires a master to hold an operating license and have training to comply with federal regulations (USCG, 2009c). If this licensed master commits an act of misconduct, negligence, or incompetence, or fails to comply with any federal regulation, their license will be suspended or revoked. USCG regulations also require vessel owners to provide training to all crewmembers before they begin working on a vessel and every three months thereafter. Each crewmember should have designated duties to perform in the case of an emergency and should complete training drills regularly. These drills must be logged and available for the marine inspector to access.

Emergency Procedures

It is important for passengers to escape easily from a vessel in an emergency. Egress, which is the means of escape from a vessel, is a vital issue the USCG addresses in its regulations. By defining and enforcing standards regarding the maximum number of passengers and the minimum means of egress on a vessel, the USCG ensures that every passenger on a vessel should have the ability to escape safely in the event of an incident. The master and crew are responsible for informing passengers of these means of escape either by printed signage or by verbal instruction.

The most obvious piece of equipment that improves passenger safety is the life jacket. According to the Small Passenger Vessel Pre-Inspection Check-Off Guide (USCG, 2003), life jacket placards should be posted in visible locations, the numbers and types of life jackets in each compartment should be clearly noted, and life jackets should always meet current regulations regarding reflective material and strength. Although life jackets are important, the donning of life jackets prior to the evacuation of a vessel with a canopy has the potential to put passengers in danger, since it could limit their ability to escape from an enclosed area. Because the buoyancy of life jackets can either help or hinder passenger safety, crewmembers must inform the passengers of the proper time to don life jackets.

Vessels and the Americans with Disabilities Act

In 1990, Congress passed the Americans with Disabilities Act (ADA), which sought to eliminate discrimination against individuals with disabilities. This law included provisions stating that individuals with disabilities cannot be discriminated against based on their disability in accessing places of public accommodation or modes of public transportation. Although the ADA applies to passenger vessels as a mode of public transportation, the passenger vessel industry has been slow to provide this kind of accessibility in their businesses (Volpe National Transportation Systems Center, 1996). This can be

attributed both to the government's lack of enforcement of the ADA in the marine transportation industry and to the inherent difficulty in making vessels accessible to disabled passengers. Studies have shown that the cost of retrofitting vessels to comply with the ADA or the cost of replacing vessels with newer, ADA-compliant vessels would be restrictively expensive, especially for the owners of SPVs.

Another consideration needed when determining the feasibility of making passenger vessels compliant with the ADA is the safety of individuals with disabilities. One study reported, "The Coast Guard and some operators have expressed concern on the efficacy of emergency evacuation of persons with disabilities" (Volpe National Transportation Systems Center, 1996). This concern relates both to the safety of all passengers and to the cost of added accommodations needed for the egress of persons with disabilities. It is unclear whether the current standards required by the USCG regarding emergency egress would be sufficient when disabled passengers are present. Vessel owners would have to consider the cost of further accommodations, such as additional crewmembers or wider means of escape, if they found these accommodations necessary to preserving passenger safety.

2.1.3 Canopies

A canopy is a structure extending over or in front of an object to provide protection and shelter. Vessel owners often install canopies on the exterior of a vessel to limit the effect of weather conditions encountered while on the water. Canopies provide shade during sunny days, and protect passengers from rain during storms. Some canopies also extend to the sides of the vessel, thus providing protection from windy conditions. This protection is of great use to SPVs, as ensuring passenger satisfaction is one of the primary objectives of the owners of these vessels.

Many different kinds of vessel canopies are in use today, each varying in aspects of design, construction, and installation. Some canopies consist of canvas or vinyl supported by a metallic frame.

These canopies provide overhead shade and shelter while maintaining access to the open air. The DUKW shown in Figure 1 has an example of a canopy made of canvas.



Figure 1 - "Canvas canopy on DUKW" (Source: BigLorryBlog, 2009).

Other canopies, referred to as deckhouse enclosures, are permanent structures. These enclosures have walls and a ceiling, creating a small room aboard the vessel. There are often windows that passengers can open or close and doors that lead to an open deck. The water taxi shown in Figure 2 has an example of an enclosure.



Figure 2 – "Enclosure on a water taxi" (Source: Potomac River Boat Company, 2009).

2.2 United States Coast Guard Regulations and Policies

The USCG is constantly creating and updating standards and regulations to ensure the safety of all vessel passengers. After speaking with Bill Peters, of the Design and Engineering Standards division, we gained a better understanding of the regulatory process (personal communication, November 9, 2009). Mr. Peters explained that the Constitution is the highest level of rule in the United States. The second tier below the Constitution is international treaties, which has precedence over federal laws. Federal law is the third tier of rule, which governs how agencies write federal regulations, the fourth tier. The USCG writes and updates federal regulations to comply with all federal laws at least once each year. The USCG also circulates policy, or guidance, to help people comply with the federal regulations. Policy can come in many different forms, such as a Commandant Instruction or a Navigation and Vessel Inspection Circular (NVIC).

2.2.2 Title 46 Code of Federal Regulations Subchapter T

The USCG uses Subchapter T to complete inspections and certifications of SPVs. The Officer in Charge, Marine Inspection (OCMI) is in charge of a designated marine inspection zone and is responsible for verifying the safety of vessels by using the inspection process outlined in Subchapter T Part 176. The USCG recognizes that regulations cannot accommodate all SPVs because of the large range in their size and usage, and therefore grants the OCMI the discretion to permit equivalencies. Such equivalencies may include approved alternatives to equipment that the OCMI deems to provide an equivalent level of safety (USCG, 2009c).

Subchapter T also provides standards that regulate passenger egress and defines capacity restrictions for SPVs. These standards ensure that the vessel is stable and that passengers have the means to escape if necessary. Subchapter T requires that all means of escape must not be less than 32

inches in width and that passengers can open all doors or windows used as egress with minimal force. Marine inspectors also use several different criteria to calculate passenger capacity restrictions to prevent overloading and to ensure means of egress are not congested.

Marine inspectors complete inspections every five years in order to issue a Certificate of Inspection (COI). During the inspection process, the marine inspector completes a number of tests and surveys to test the hull strength and look for deficiencies. The hull is the bottom of the vessel. Some of these examinations include drydock examinations, during which the vessel owner has the vessel removed from the water, and underwater surveys, which utilize divers. The marine inspectors also assess mechanical, electrical, and safety facets to confirm passenger safety on the vessel. After completing the inspection, the OCMI issues a COI that describes the vessel, the route(s) that the vessel travels, the minimum staffing requirements, the minimum life jackets needed, and a number of other requirements. The OCMI must note equivalencies on the COI as well as any required updates and timelines for completion. The COI ensures the vessel complies with USCG standards. Marine inspectors also complete reinspections annually to ensure the vessel still complies with its COI (USCG, 2009c).

2.2.3 Navigation and Vessel Inspection Circular 1-01

NVIC 1-01 is guidance for the certifications of amphibious passenger vehicles (APV) (USCG, 2001). In this paper, we refer only to the DUKW type of APV. The USCG created NVIC 1-01 as a result of a recommendation made by the USCG Marine Board of Investigation. This recommendation stated that the USCG and APV industry should develop guidelines for the best practices regarding the inspection and certification of DUKWs. In short, NVIC 1-01 is a basis for determining equivalencies of DUKWs to the standard SPVs.

A major focus of NVIC 1-01 is the means of escape from a DUKW in the event of a casualty (USCG, 2001). It is human nature to escape via the stern, or back of the vessel, where one entered, but DUKWs usually sink stern first. Because of this, the master on all DUKW should instruct the passengers that the primary egress is over the side. NVIC 1-01 also explains that canopy supports and overhead life jackets should not impede passenger egress. Should a canopy support be directly located next to a passenger's seat, there should be clear instructions describing to the passenger how to easily egress. It was also determined that 32 inches from the side of the boat to the canopy is enough space for easy egress. If the owner decides to install windows or side curtains, the master should be able to open all of the windows or curtains on each side from one point located at the control station and the windshield should be able to fold down with minimal force.

NVIC 1-01 lists details that should be included in the safety orientation aboard DUKWs (USCG, 2001). Some of the major points that should be included are the location of life jackets and the ring buoy, the method of disembarking during emergency egress, the location of emergency exits, and the method of removing egress obstructions, such as windows or curtains. These safety orientation guidelines are in place to ensure proper operation and passenger safety aboard DUKWs.

2.3 Marine Casualties

One of the primary responsibilities of the USCG is to promote passenger safety by reducing the number of marine casualties and by minimizing fatalities and injuries in those that do occur. There are many statistics available concerning marine casualties, which we will cover in the following section. Recent incidents in the United States include the Miss Majestic, Lady Duck, Lady D, Ethan Allen, and Taki-Too. These incidents demonstrate how a canopy or enclosure can have an impact on the safety of passengers after a casualty has taken place.

2.3.1 Casualty Statistics

As the deaths that can result from marine casualties are of great significance to organizations worldwide, there is a wide variety of statistics available concerning these incidents. These statistics analyze the frequency and severity of casualties in the marine industry.

Studies have shown that when human actions, as opposed to environmental causes or vessel failure, cause a passenger vessel casualty, the number of injured, deceased, or missing passengers is greater (Talley et al., 2006). Talley's study found that incidents in vessels transporting both passengers and freight incur more injuries and fatalities than other types of passenger vessels. In addition, this study found that the number of fatalities is greater in inclement weather conditions, such as precipitation and low visibility.

Between 1996 and 2003 there were 41 fatalities resulting from small passenger vessel casualties. There have been more fatalities on small passenger vessels, but these related to causes other than a specific vessel incident. Figure 3 is a graph outlining the number of vessel-related deaths. The high number of deaths in 1999 is a result of the Miss Majestic incident, in which thirteen people died, and the high number of deaths in 2003 is a result of the Taki-Too incident.

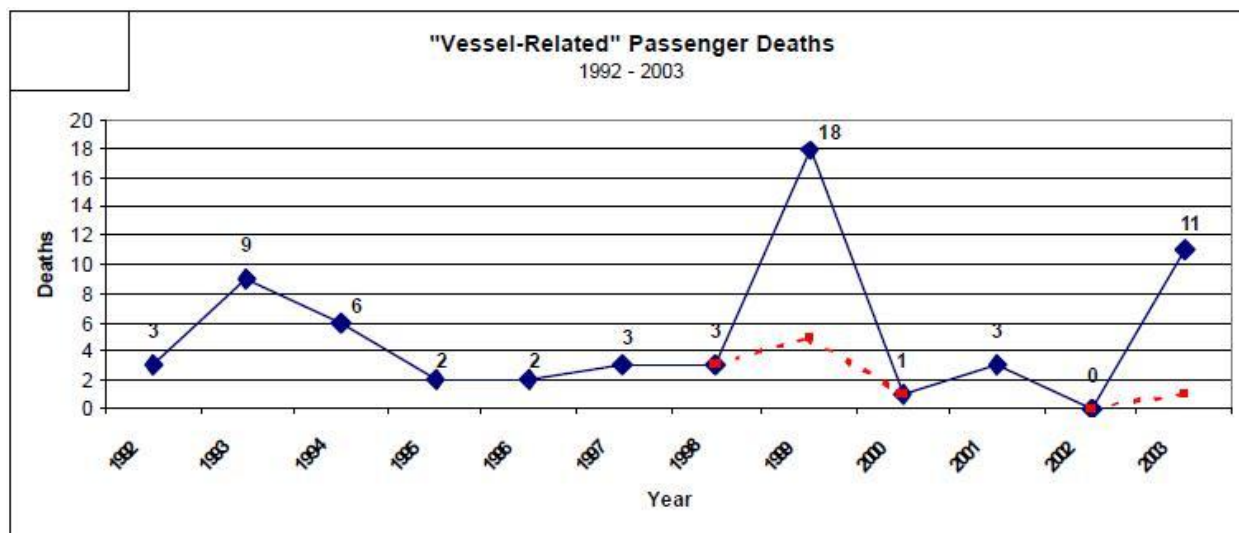


Figure 3 – “Vessel Related Passenger Deaths 1992-2003.” (Source: U.S. Department of Homeland Security, 2005, p. 9).

2.3.2 Miss Majestic

On May 1, 1999, an APV, the Miss Majestic, sank on Lake Hamilton, just outside of Hot Springs, Arkansas (NTSB, 2002). The Miss Majestic was a DUKW owned and operated by Land and Lakes Tours, Inc. Figure 4 is an image of a vessel identical to the Miss Majestic also owned by this company. The Miss Majestic was a duck tour carrying the vessel master and twenty passengers. Thirteen passengers died in her sinking, including a disabled passenger and three children, ages 3, 4, and 5.



Figure 4 – “Boat similar to Miss Majestic owned by Land and Lakes Tours Inc.” (Source: National Transportation Safety Board, 2008, p. 36).

Coast Guard Incident Report

The USCG incident report cited many causes of the sinking of the Miss Majestic and made recommendations regarding ways to prevent future incidents (USCG, 1999). The report found that the root cause was the unchecked flooding of the Miss Majestic but also cited many contributing factors, such as erroneous repairs to the vessel, master experience, faulty bilge pumps, lack of compartmentation, or subdivisions in the hull, and passenger entrapment within the vessel. These conclusions resulted in a number of recommendations that the Commandant addressed, including the

need for standards regarding inspections, canopy use, and crew requirements. After a meeting with a group of industry experts, the USCG developed guidelines specific to DUWKs, now known as NVIC 1-01 (USCG, 2001).

NTSB Incident Report

The National Transportation Safety Board (NTSB) noted four major factors in the cause of the sinking of the Miss Majestic. They determined that inadequate repairs by Land and Lakes Tour, Inc., insufficient reserve buoyancy, lack of proper supervision by the USCG, and entrapment of passengers in the canopy were contributing factors to the casualty. While the NTSB concluded that the primary cause of the sinking was inadequate hull repairs, they also determined that passengers were in even more danger due to the canopy design and lack of proper egress (NTSB, 2002).

The NSTB made several recommendations to the USCG at the conclusion of the investigation. They recommended that all APVs have adequate reserve buoyancy, that all canopies either be approved by the USCG or removed, that high water alarms be installed on all APVs, that the USCG enforce compliance with NVIC 1-01, and that passengers don life jackets for the duration of the trip if the canopy has been removed (NTSB, 2002).

2.3.3 Lady Duck

On June 23, 2002, the Lady Duck began taking on water and rapidly sank on the Ottawa River in Gatineau, Quebec (TSB of Canada, 2004). The Lady Duck was a DUKW vessel that was carrying 12 people on a tour of the National Capital Region when the incident occurred. The vessel trapped four passengers, who subsequently drowned. The fatalities included two younger victims, ages 6 and 13. The

sinking was unique in that the vessel sank bow first, rather than stern first as seen in the Miss Majestic.

Figure 5 is an image of the Lady Duck after Canadian officials recovered it from the water.



Figure 5 – “Lady Duck after recovery at the Hull Marina” (Source: Transportation Safety Board of Canada, 2004, p. 2).

TSB of Canada Incident Report

The Transportation Safety Board of Canada (TSB) conducted an investigation into the sinking of the Lady Duck. The TSB determined that the vehicle sank because it had no watertight integrity, which allowed water to enter the vessel, and because the company incorrectly installed the bilge pumps (TSB of Canada, 2004). The fact that the “...rear exit did not meet human engineering standards to permit easy egress for a full range of users” and that the buoyancy of those fatally injured forced them into the overhead canopy contributed to the fatalities.

The TSB made several recommendations to Transport Canada (TC) in their report. The TSB recommended that TC consider making changes to regulations currently in place regarding signage, safety orientations, and crew training (TSB of Canada, 2004). The TSB also suggested that TC ensure that SPVs incorporate design features that would allow for the “safe, timely and unimpeded evacuation of passengers and crew in the event of an emergency.”

2.3.4 Lady D

On March 6, 2004, the Lady D capsized during a routine trip on Baltimore's Inner Harbor (NTSB, 2006b). The Lady D was a water taxi operated by Seaport Taxi, LLC, licensed to operate on the Patapsco River in Maryland. Figure 6 is an image of the Lady D at port prior to the casualty. The pontoon vessel was traveling from Fort McHenry to Fells Point, Maryland, and was carrying 23 passengers and 2 crewmembers at the time of the casualty. While en route, a severe storm rapidly developed, drastically reducing the stability of the vessel and causing it to capsize. In total, five passengers died, ages 6, 26, 27, 30 and 60.



Figure 6 – “Lady D, Baltimore, MD.” (Source: National Transportation Safety Board, 2006, p. 13).

Coast Guard Incident Report

The USCG identified the operator's failure to assess the severe weather conditions properly as the primary cause of the Lady D casualty (USCG, 2009a). The developing storm created conditions where the master could not operate the vessel safely and the USCG determined that the master's decision to leave port, despite the growing storm, initiated the sequence of events that resulted in the casualty. Although the National Weather Service and senior captains at the port failed to issue weather advisories, the master should have used his discretion and ceased operation. The USCG report also cited improper procedures in assessing the Lady D's stability as a contributing factor in the casualty.

At the conclusion of their investigation, the Coast Guard developed and approved recommendations based on their findings (USCG, 2009a). The report recommended the USCG study and revise existing assumed passenger weights to a level that accurately reflects the average weight of Americans today. The report also recommended the USCG consider providing guidance for the use of enclosed canopies on pontoon vessels, especially to allow rapid passenger egress in the event of a capsizing. This recommendation included positioning supports to allow unobstructed egress and designing windows and curtains so that one person can open them with minimal force. Finally, the report recommended the USCG study whether all passenger vessels, regardless of distance from shore, should be equipped with radios to receive weather alerts on a continuous basis.

NTSB Incident Report

The NTSB (2006b) determined that the probable cause of the Lady D capsizing was its “lack of intact stability,” which prevented the vessel from withstanding the strong winds and waves that it encountered. The NTSB found the Coast Guard incorrectly granted the Lady D sister status, or structural equivalency, to a vessel with different design characteristics, thus allowing the Lady D to carry a greater number of passengers than would be considered safe. In addition, the Coast Guard calculated the passenger allowance using an outdated average passenger weight, contributing even further to the Lady D’s lack of stability. This lack of stability prevented the Lady D from navigating the stormy weather safely, eventually causing it to capsize.

At the conclusion of its investigation, the NTSB made recommendations to the Coast Guard based on its determination of the probable causes of the Lady D casualty (NTSB, 2006b). The NTSB recommended the Coast Guard revise regulations to calculate passenger capacity based on an average passenger weight that is statistically representative and periodically updated. The NTSB also recommended the Coast Guard revise the stability criteria for pontoon vessels for all loading conditions

to minimize the potential for capsizing in adverse weather conditions. Finally, the NTSB recommended the Coast Guard identify a method to determine the maximum safe loading capacity on a vessel at the time of loading, such as a mark indicating the waterline where the vessel is at maximum capacity.

2.3.5 Ethan Allen

On October 2, 2005, the Ethan Allen capsized and sank in Lake George, killing twenty people. The state of New York certified the vessel to operate on Lake George. Because the lake is not navigable waters, the USCG did not have jurisdiction of the vessel. As the Ethan Allen was attempting to turn, waves created by boat nearby hit the vessel, causing it to capsize. After several minutes, the vessel righted itself and began sinking. There was one operator on board and forty-seven passengers, most of whom were members of a senior group (NTSB, 2006a). Figure 7 is an image of the Ethan Allen after the incident.



Figure 7 - "Ethan Allen after the incident" (Source: National Transportation Safety Board, 2006, p. 1)

NTSB Incident Report

The NTSB (2006a) determined that the main cause of the casualty was the insufficient stability of the vessel to “resist the combined forces of a passing wave..., a sharp turn, and the resulting involuntary shift of passengers to the port side of the vessel.” The state of New York should have permitted the vessel to carry only fourteen passengers, but there were forty-eight occupants at the time of the incident. Also, there was no clear requirement that the vessel’s stability be reassessed after modifications. Shoreline Cruises, the company that owned the Ethan Allen, added and subsequently modified a canopy to the vessel, adversely affecting the ships stability.

2.3.6 Taki-Tooo

On June 14, 2003, the Taki-Tooo, a U.S. chartered fishing vessel with 2 crewmembers and 17 passengers on board, capsized while en route to the Pacific Ocean (NTSB, 2005). The vessel was navigating the Tillamook Bay bar during a rough bar warning when she encountered a wave, causing the vessel to capsize. The master and 10 passengers died in this incident and the Taki-Tooo was a total loss. The day after it capsized, an NTSB investigator, a chief warrant officer of the Coast Guard, and a deputy from the Tillamook County sheriff’s office conducted an on-site investigation of the vessel (NTSB, 2005). Figure 8 below shows the Taki-Tooo on that day beached on the shore.



Figure 8 - "Taki-Tooo on beach after incident" (Source: National Transportation Safety Board, 2005, p. 16).

NTSB Incident Report

Following their investigation into the Taki-Tooo casualty, the NTSB made several recommendations to the USCG. The NTSB determined that the probable causes of the capsizing were the master's decision to cross the Tillamook Bay bar despite the hazardous conditions as well as the master's failure to require all passengers and crew aboard the vessel to don life jackets prior to crossing the bar. These conclusions resulted in recommendations for the USCG to require vessel owners operating in Coast Guard designated surf stations and areas regulated for boating in the West Coast to develop go/no-go policies and for the USCG to provide guidance requiring the donning of life jackets during rough bar warnings until the USCG developed additional regulations.

2.4 Summary

The Coast Guard and other organizations have completed substantial research on the topic of marine casualties. However, there has been very little research concerning the effect of canopies on passenger safety in the event of a casualty. As the safety of passengers in all situations is critical, it is in the best interest of the United States Coast Guard to investigate the effect of canopies on passenger safety.

3. Methodology

Our main goal in this project was to develop recommendations to improve the safety of passengers on small passenger vessels (SPVs) with canopies in the event of a casualty. These recommendations relied on research of common canopy designs and installation, as well as investigation of past incidents where vessel canopies contributed to injuries or fatalities. We completed the following objectives throughout the course of our research, which resulted in recommendations to the United States Coast Guard (USCG).

- a) Evaluated typical canopy design and use, with a particular emphasis on the safety features of various canopies.
- b) Determined the efficiency of current government policy with regard to canopies.
- c) Determined the extent of the effect human factors have in marine casualties involving a canopy.

We anticipate that the resulting recommendations will improve passenger safety on SPVs and will allow the United States Coast Guard to understand more thoroughly the safety features on various types of canopies.

3.1 Canopy Design and Use

Our first objective was to identify common types of canopies used on SPVs. By direct observation of SPVs and interviews with experts in the passenger vessel industry, we researched canopies currently used on SPVs and their safety features. We compiled information about the different types of canopies used on SPVs in our background chapter, and we used this list in completing our research.

3.1.1 Direct Observation

Direct observation was one of our first approaches in identifying common types of canopies used on SPVs. We boarded a number of SPVs, where we saw canopies and enclosures on USCG approved vessels and experienced the real-world significance of our problem. The first vessel that we boarded was the Commander Jacques, a water taxi based in Alexandria, Virginia, as seen in Figure 9. On this vessel, we noted several features of an SPV, including enclosure design and ease of passenger egress.



Figure 9 - Alexandria - National Harbor Water Taxi

Another vessel that we boarded was the Boston Duck Tour. We took note of the side curtain zippers and Velcro, which could impede passenger egress. We also boarded two small vessels in Alexandria, VA, each of which had two enclosed decks. In Baltimore, MD, we boarded a water taxi and a larger Spirit boat. The water taxi operated on Baltimore Harbor, the same place where the Lady D incident occurred.

3.1.2 Interviews

We interviewed a vessel operator in Baltimore, MD who was familiar with SPVs and had experience with canopies. Captain Jimmy was the operator of the Baltimore Commuter Water Taxi and explained his experience on Baltimore Inner Harbor. In addition, we interviewed marine inspectors from Sector Baltimore. These marine inspectors were knowledgeable about government regulations and

identified which canopies are most prevalent in the commercial vessel industry. The summaries of these interviews are located in Appendix A.

3.1.3 Qualitative Analysis

We used the information gathered to analyze the features of typical canopy designs. We looked at the quick release feature used on some DUKW vessels today, emergency windows on school buses, and underwater lighting. We then identified the benefits and problems of each feature, which allowed us to make recommendations based on the comparisons.

3.2 Government Regulations and Policies

In order to make recommendations to the USCG, we needed to understand the regulations that are currently in place. We interviewed members of the USCG and examined the current standards in the United States, which enhanced our knowledge of these regulations. These regulations extended beyond standards for canopies to standards for crew training, passenger safety, and stability requirements.

3.2.1 Interviews

With the help of our liaisons, we consulted with the USCG Marine Safety Center (MSC). We had an interview with Lieutenant Commander Ben Gates and a panel of four other MSC engineers. This interview provided us with a better understanding of how regulations restrict vessel design and construction, and how the MSC engineers interpret these regulations. In this interview, we discussed equivalencies in the inspection process, means of escape requirements, and the need for flexible solutions to our problem. We have included a summary of this interview in Appendix D.

We interviewed Bill Peters from the Naval Architecture division in the Office of Design and Engineering Standards. He helped us understand that regulations abide by US laws and that policy is guidance on these regulations. Mr. Peters also explained how the USCG creates regulations. This knowledge will allow us to make recommendations regarding regulations and policies that are already in place.

We also interviewed Jim Law who is an Operations Research Analyst in the Compliance Analysis Division of the Office of Investigations and Analysis. He has access to statistics in previous marine casualties and was able to provide us with information that we will use in our analysis.

3.2.2 Written Resources

With the help of Coast Guard personnel, we looked into current government standards, as well as their origin and limitations. We read Title 46 Code of Federal Regulations Subchapter T (Subchapter T) and Navigation and Vessel Inspection Circular (NVIC) 1-01. Subchapter T provided us with a background of the federal regulations regarding SPVs. The NVICs are guidance to help owners and operators comply with Subchapter T. This research provided us with knowledge and perspective about why the USCG implements these regulations and how they can improve them.

3.2.3 Direct Observation

To understand how marine inspectors apply regulations during the inspection process, we observed a marine inspection. Our liaisons put us in contact with LCDR John Dittmar, the Chief of the Inspection Division in Baltimore, Maryland, and LT Matt Layman, the Chief of the Small Passenger Vessel Branch, who allowed us to shadow marine inspections. While on these inspections, we observed a

drydock inspection of two excursion vessels in Annapolis, MD and boarded two small passenger vessels in Alexandria, VA. We witnessed how marine inspectors interpret the federal regulations and policies on an individual basis, as well as the relationship between marine inspectors and vessel owners. We also spoke with them about the inspection process and their relationship with vessel owners.

3.3 Human Factors

Our next objective looked at the effect of passenger behavior in marine casualties. While the technological aspects of marine safety are relatively consistent, passenger behavior is less predictable and thus differs from case to case. To analyze the effects of passenger behavior, we examined examples of behavior in previous incidents and identified possible improvements to behavior in future casualties to reduce the risk of injuries and fatalities.

3.3.1 Written Resources

We analyzed previous incident reports provided by the Coast Guard and National Transportation Safety Board (NTSB) to identify the behavior of crewmembers and passengers in previous marine casualties. We read the Miss Majestic, Lady D, Ethan Allen, and Taki-Too incident reports provided by the USCG and the NTSB. We also read the Transportation Safety Board of Canada's (TSB) incident report for the Lady Duck. We provided an overview of these incidents in our background section and we will use this knowledge to make recommendations to the Coast Guard.

3.3.2 Interviews

We identified common human behavior on vessels by interviewing operators of SPVs and trade industry representatives. We spoke with Captain Beth Gedney and Captain Peter Lauridsen of the Passenger Vessel Association (PVA), a lobby group that represents owners of passenger vessels. During this interview, we also spoke with Frank English from Ride the Ducks, a manufacturer for DUKW vehicles. In this interview, we discussed the effects that Coast Guard regulations have on the marine industry. We learned that DUKWs manufactured by Ride the Ducks comply with NVIC 1-01, while other manufacturers have not made the appropriate changes. The summary of this interview is located in Appendix D.

We interviewed Luke Harden from the Licensing Division of the USCG. In this interview, we discussed the qualifications needed by mariners in order to obtain a license to operate a vessel and the process by which the USCG awards these licenses. We learned that there was little training required to become the master of an SPV and that there was no training required to become a deckhand.

We interviewed Captain Jimmy from the Baltimore Commuter Taxi. We discussed the Lady D incident and the procedures he follows as the master of a SPV. Captain Jimmy operated Lady D in the past and was operating another vessel on the Harbor when the incident occurred. He was able to give us insight into what he believed were the causes of the incident.

3.3.3 Direct Observation

In order to understand current safety orientation standards and posted signage, we boarded several vessels in the DC area. In Baltimore, MD, we boarded a large Spirit boat to understand how the masters of larger vessels educate their passengers. There was signage detailing how to evacuate the vessel in the event of an emergency and how to don personal flotation devices (PFD). While on the

Boston Duck Tours and the Commander Jacques, we noticed that the safety orientations provided by the master were not thorough and did not present information regarding what a passenger would need to do in an emergency.

We also conducted an experiment using a Type I PFD, which we received from Jacqueline Papapietro in the Life Saving and Fire Safety Division. For this experiment, we asked people to don the PFD and asked some of these participants to read the donning instructions. We recorded the time it took each person to don the PFD properly. We also asked some of the people at USCG headquarters to walk through a 32-inch opening, both forward and sideways, to see if the PFD would impede their movement in any way.

3.4 Summary

The completion of the methods given in this section provided us with further knowledge on the problem of passenger safety in marine casualties. We used this knowledge to make recommendations to the USCG to fill gaps in information regarding safety on SPVs with canopies. We anticipate that these recommendations will prove beneficial to the USCG, and will help reduce the risk of injuries and fatalities in future incidents.

4. Results and Analysis

Through interviews, direct observation, and analysis of written resources, we have obtained information on the topic of passenger egress on vessels with enclosed areas. In this chapter, we present the results of these methods and analyze them with regard to our problem. We analyzed the lessons we have learned from past casualty reports by noting common trends found across these incidents and considering how these trends may be present in future casualties. We examined United States Coast Guard (USCG) regulations and policies for possible gaps that exist regarding passenger egress, particularly looking at how the USCG can apply guidance from Navigation and Vessel Inspection Circular (NVIC) 1-01 to all small passenger vessels (SPV). Finally, we defined and analyzed the effect of human factors on passenger egress and identified possible changes that could improve this behavior.

4.1 Past Incidents

In this section, we analyze trends from the cases we have researched citing USCG, National Transportation Safety Board (NTSB), and Transportation Safety Board of Canada (TSB) investigations. While the conclusions and recommendations of the USCG and the NTSB do not always align, we identified common conclusions in the reports. By analyzing the canopy involvement in each incident, we can determine the most effective changes the USCG can make to improve passenger safety on SPVs. The three trends we found were the use of personal flotation devices (PFD), emergency exits, and passenger education.

4.1.1 Case I: Miss Majestic

The Miss Majestic incident was the rapid sinking of a DUKW vehicle that fatally injured thirteen passengers. The NTSB (2002) incident report noted that as the Miss Majestic began to sink, one

passenger jumped out of the side of the vessel, while the canopy pulled the others underwater. The canopy was determined to be a major cause of the fatalities after divers found six passengers trapped within the canopy. The diver investigating the scene of the incident also found seven passengers outside the vessel (USCG, 1999). The diver almost did not find one of these passengers because of Land and Lakes Tours, Inc's faulty record keeping. The passengers fatally injured included a disabled person and three children, ages 3, 4, and 5. There were two other children on board the vessel, ages 8 and 15, who survived the incident. As noted in the USCG incident report, the donning of life jackets prior to egress would have prevented escape from under the canopy because of the added buoyancy, and thus could have resulted in the loss of even more lives. This case presents the possibility that life jackets can hinder passenger egress from under a canopy in instances where rapid evacuation is necessary and that the age of a passenger can affect his or her ability to egress.

Another factor we considered in the Miss Majestic incident was the arrangement of passengers within the vessel. As seen in Figure 10 below from the NTSB report (2002), the passengers' location on the vessel cannot be associated with their ability to survive. The table represents the passengers fatally injured by a red fill, those who survived with a blue fill, and empty seats with a white fill.

Port Side	Operator's Position		Firefighting Equipment and Controls	
Row 1	Adult Female	Empty	Adult Female	3-year-old child
Row 2	Adult Male	Adult Female	Empty	Empty
Row 3	15-year-old Male	Empty	Adult Female	Adult Female
Row 4	Adult Male	Empty	Empty	Empty
Row 5	Adult Female	Empty	Empty	Empty
Row 6	Adult Male	8-year-old child	Adult Female	Adult Male
			STEP	
Row 7	Adult Female	4-year-old child	Adult Male	Empty
Row 8	Empty	Adult Male	EXIT	Adult Female 5-year-old child

Figure 10 - Miss Majestic Seating Arrangement

The NTSB report (2002) provided detailed accounts of how the survivors evacuated the vessel. Using these witness statements, we have accounted for the actions of most passengers on board the vessel. The witness statement did not account for the passengers in Row 1, an adult male, an adult female, and a 3-year-old child. However, the adult male in Row 6 on the port side stated that “water rushing into the vehicle swept him forward and pinned him against the windshield” and that he could not recall how he exited the vehicle. The two passengers in Row 2, an adult male and an adult female, exited through the port side window next to their seat. The adult female in Row 2 first tried to exit through the front of the vehicle but upon noticing the congestion, returned to the window that her

husband exited. Upon surfacing from the water, the adult female noticed that the 8-year-old child from Row 6 was holding onto her. The 8-year-old child lost her father when the water swept him to the front of the vessel, so she grabbed onto the woman to get to safety.

The 15-year-old passenger, who was in Row 3, was distributing life jackets to the other passengers but exited the vehicle through a port side window just before the vehicle was submerged. The husband of the adult female in Row 5 told the NTSB that his wife did not know how to swim, so this likely contributed to her death. The adult male seated in Row 6 on the port side noted that when he first noticed the vessel was sinking, he yelled for all the passengers to get out, but the adult male and female in Row 6 on the starboard side of the vehicle did not move. The delayed reaction of the adult male and female in Row 6 could have taken away the few seconds they had to egress before the vehicle was submerged.

The adult female in Row 7 on the port side told the NTSB that the incoming water was almost immediately over her head. She remembered holding onto the metal frame of the canopy before the water swept her out the stern window opening. The adult male and female located on the starboard side in Rows 7 and 8 were attempting to put a life jacket on their 5-year-old child when the water rushed in. The adult male who was in Row 7 on the starboard side thought he was swimming forward but was not sure how he evacuated the vessel and noted that it took him a long time to reach the surface. The operator of the vessel swam through an opening in the canopy but believed that she did not escape until the vehicle was on the bottom of lake because of the mud on her clothing. These accounts provide insight into the chaos inside the Miss Majestic when she sank.

Based on the statements of the survivors, we can draw conclusions about the deceased passengers. The adult male on the port side in Row 6 told the NTSB that the incoming water swept him to the front of the vehicle and the adult female seated in Row 2 said there was congestion at the front of

the vehicle (NTSB, 2002). Based on these statements, we concluded that the rushing water and congestion could account for the three passengers in the front of the vessel especially since divers investigating the scene of the incident found five bodies near the windshield of the vehicle.

Rows 7 and 8 were slightly higher than the rest of the vessel, as seen in Figure 11 below, and the accounts of the passengers seated in these rows can help us draw conclusions about the four deceased passengers seated in Rows 7 and 8. Since the vessel sank stern first and the passengers seated in Rows 7 and 8 noted how the water rushed in so quickly that it was almost immediately over their heads, we concluded that the adult male, the adult female, and the two children, ages 4 and 5, had no time to egress and thus drowned. The exact circumstance cannot be determined but we believe that these passengers, along with the adult male in Row 4 and the two adult females in Row 3, did not react quickly enough to egress the vehicle. Divers investigating the scene of the incident found all 13 fatally injured passengers inside and outside of the vessel. Of the thirteen fatally injured passengers, divers found three victims still in their seats or on the deck, four victims floating in the canopy, and six bodies outside the vessel on the lake bottom.



Figure 11: Photo of Miss Majestic post-incident. (Source: National Transportation Safety Board, 2002, p. 1).

The thirteen deceased passengers of the Miss Majestic prove that rapid egress on DUKW vessels is an issue of concern. The detailed witness accounts provide the reader with an understanding of the chaos inside the sinking vessel. The passengers' decisions to evacuate through windows or just remain in their seats ultimately affected their fate. Following this incident, the USCG created NVIC 1-01. NVIC 1-01, which we analyze further in the following sections, provides guidance to DUWK owners regarding mechanical features and passenger safety.

After understanding the various scenarios surrounding the survivors' egress, we determined that many passengers did not don PFDs. All of the passengers on the vehicle should have had access to PFDs because they were stored above each passenger's seat. However, the 15-year-old male in Row 3 and the adult male on the port side of Row 6 told NTSB investigators that the life jackets were hard to remove from the overhead storage. The USCG resolved the issue of life jacket storage on DUWKs with NVIC 1-01. Although the passengers should have had access to life jackets, the NTSB incident report (2002) noted that donning life jackets they would have trapped passengers in the canopy.

The NTSB report (2002) also cited survivor statements that described the master's safety orientation. Before entering the water, the master attempted to get a life jacket out of the overhead storage but could not remove it and then said, "They're up there." Passengers also noted that the master never offered any passengers life jackets nor did she educate them on how to evacuate the vessel in the event of an emergency. This lack of safety briefing led to chaos within the Miss Majestic when the vehicle began to sink. Had the master instructed passengers to find the nearest emergency exit or informed them that they should exit through the windows, there may not have been as many fatalities.

4.1.2 Case II: Lady Duck

The Lady Duck was a Ford F-350 truck converted into an APV that sank in Gatineau, Quebec in 2002. The vehicle had a fabric canopy and roll-down transparent windows that provided shelter for passengers. This canopy limited passenger egress during the rapid evacuation and fatally injured 4 of the 12 passengers on board the vehicle. The Transportation Safety Board of Canada (TSB) incident report noted that two of the roll-down windows on the canopy were securely zipped in the lowered position upon recovery of the vessel, which impeded passenger egress through the windows. The congestion near the aft exits, as seen in Figure 12, inhibited passenger egress from within the canopy.



Figure 12: Stern of Lady Duck from inside the vehicle. (Source: Transportation Safety Board of Canada. 2004. p. 42).

The TSB reports also noted deficiencies in the safety briefing provided by the tour guide. The tour guide told passengers that child size life jackets were located at the stern of the vessel and adult life jackets were located under their seats (TSB, 2004). In addition, the tour guide also told passengers that the emergency exits were the windows along each side of the vessel as well as the window at the stern

above the retractable stairs. The TSB noted that the tour guide did not demonstrate how to don a PFD or tell passengers about the location or use of life buoys or distress equipment. In addition, the tour guide could have instructed the passengers what to do in the event of abandonment, such as how to open windows or that the nearest exit may not be their point of entry.

Another issue of importance was personal flotation device (PFD) use on the Lady Duck. The TSB report (2004) states the following: one survivor held on to a life jacket, two other survivors wore unfastened life jackets, one survivor was given a child size life jacket and it was too small, one survivor obtained a child life jacket upon surfacing, the master did not access a life jacket because he was swept out a window, and one other survivor did not have a life jacket because he exited through the stern and could not access one. Two of the fatally injured passengers, ages 43 and 66, fully donned their life jackets. Of the other two fatally injured passengers, ages 6 and 13, one was wearing a partially donned adult life jacket and the other was not wearing a life jacket. This shows that fully donning life jackets can trap passengers within the canopy. This is just one example of how passenger behavior and split-second decisions affect survivability.

Another factor that affected survivability on the Lady Duck was the storage location of PFDs. The adult life jackets were located under the passengers' seats in metal bins. These metal bins had sharp edges that could penetrate life jackets. The life jackets within these bins also had rope and other items on top of them, which further impeded passenger access to them. These storage containers and the various items stored on top of life jackets, made it more difficult for passengers to access life jackets in the emergency.

4.1.3 Case III: Lady D

The Lady D was a water taxi that capsized after encountering a rapidly developing storm, fatally injuring five passengers and seriously injuring four others. The enclosure on the Lady D was made of bulkhead and had twelve slider windows, six on each side of the vessel. When the Lady D capsized, none of the passengers donned life jackets. According to the NTSB (2008), life jacket use on vessels with a canopy is a difficult issue to address. Requiring passengers to wear a life jacket as soon as they board a vessel with a canopy might put them in danger should the vessel rapidly sink. However, it is difficult for passengers to react quickly enough to put on a life jacket in a moment of distress, such as in the Lady D incident.

In addition, the NTSB (2006b) determined that “the vessel’s normal means of egress from the deckhouse... posed evacuation problems for the vessel’s occupants.” The enclosed deckhouse had two doors at opposite ends of the area, and had windows along the sides of the deckhouse that passengers used as a means of emergency egress. Several survivors of the incident reported having difficulty getting out of the deckhouse. Three passengers told NTSB investigators that the doors and windows were difficult to open in the panic situation that resulted from the Lady D’s capsizing. The fact that the door at the bow was a sliding door and the door at the stern was a hinged door contributed to this difficulty. The windows on the vessel may have also impeded egress because one of the panes slid and the other remained stationary. The master never showed passengers how to open the doors or windows and that led to further confusion during egress.

The Lady D sank so rapidly that passengers did not have time to access or don life jackets. Investigators found many life jackets floating around the vessel after it capsized, so the life jackets were likely stored in an area that was easily accessible. The master did find a life jacket floating near the canopy and used it to help pull him to the surface once he was out of the vessel. The USCG incident report (2009) of the Lady D incident noted that there might have been more fatalities if passengers had

donned life jackets. Unlike canopies, such as the one on the Miss Majestic, the enclosure of the Lady D was not removable. Permanent enclosures present added difficulty to passenger egress and because of this, the USCG report of the Lady D incident recommended that there be guidance, similar to that of NVIC 1-01, for the use of enclosed canopies on small passenger vessels to make passenger egress in an emergency easier (USCG 2009a).

4.1.4 Case IV: Ethan Allen

The Ethan Allen, a vessel that capsized and sank in Lake George, NY, had a wood canopy with Plexiglas windows that opened up and attached to the canopy. Forty-eight passengers were on the vessel and twenty were fatally injured. After the vessel capsized, survivors described that within the canopy there was “total confusion” and darkness. Incoming water swept several passengers out of the vessel’s opened windows. According to the NTSB (2006a), one passenger said she attempted to swim towards the light, but other passengers tried to “crawl up [her], so they pulled [her] down.” The canopy was a factor in this marine casualty because it prohibited passengers from freely escaping.

Life jackets were also an issue in the Ethan Allen incident. Survivors of the incident told NTSB investigators that they had no time to don life jackets, but if they had it would have been more difficult to escape. Additionally, the location of the life jackets could have affected passenger survivability. The adult life jackets were located in a cabinet at the stern of the vessel and child life jackets were located at the bow of the vessel. Since there were no children on the vessel, there would not have been a problem accessing child life jackets. However, if all the adults had to go to the stern of the vessel to retrieve life jackets there would have been congestion. Since the vessel listed port and capsized, passengers did not have the opportunity to access life jackets.

The NTSB report (2006) cited a discrepancy in whether the master gave a safety briefing. The master said he delivered the usual briefing. Passengers said they did not receive any safety briefing, however, passengers admitted that they were talking and it was noisy so they could have missed it. If the master did deliver a safety briefing, he should have made sure all of the passengers were paying attention and able to hear him.

4.1.5 Case V: Taki-Tooo

The Taki-Tooo was a chartered fishing vessel that capsized when crossing a rough bar off the coast of Oregon. The vessel had a master, a deckhand, and 17 passengers on board; 10 passengers and the master died in the incident. After interviewing survivors of the incident, the NTSB was able to compile a table identifying the following information about each passenger: age and gender, location before and after the capsizing, use of life jackets, and additional comments, as seen in Table 1 below (NTSB, 2005).

Table 1: Table of injuries sustained in Taki-Tooo incident

Age/ Gender	Location		Use of Life jackets	Remarks
	Precapsize	Postcapsize		
Fatality Victims				
66/M	Flying Bridge	Water	No	Master of vessel. Body recovered by Coast Guard lifeboat; taken to Station Tillamock Bay.
66/M	Cabin	Cabin	Yes	Donned life jacket. Unable to exit cabin. Body recovered from cabin when vessel washed up on beach.
70/M	Open Deck	Water	No	Body recovered.
49/F	Open Deck	Water	No	Body recovered.
53/M	Open Deck	Water	No	Body recovered.
65/M	Open Deck	Water	No	Body recovered.
54/M	Open Deck	Water	No	Body recovered.
61/M	Open Deck	Water	No	Body recovered.
46/M	Open Deck	Water	No	Body recovered.
52/M	Open Deck	Water	No	Body not recovered.
43/M	Open Deck	Water	No	Body not recovered.
Survivors				
22/F	Flying Bridge	Water	No	Deckhand on vessel. Removed boots and outer clothing gear; made it to shore.
18/M	Open Deck	Cabin	Yes	Held onto life jacket as exited through window. Made way to shore. Aided out of surf by bystanders.
28/M	Open Deck	Water	No	Reached life float 5-6 times but unable to hold on. Washed to shore by wave action.
52/M	Cabin	Cabin	Yes	While Taki-Tooo was upside down, pulled out life jackets and passed them out. Removed life jacket to exit through window; put life jacket on over his head. Floated to shore. Aided out of water by standers
23/M	Cabin	Cabin	Yes	Tied life jacket about arm. Exited through window. Floated to shore. Aided out of water by bystanders.
34/M	Cabin	Cabin	Yes	Assisted in handing out life jackets. Removed life jacket to exit through window. Lost hold of life jacket during exit. Swam to shore.
48/M	Cabin	Cabin	Yes	Put life jacket around neck, exited through window. Floated to shore handing onto life jacket.
47/M	Cabin	Cabin	Yes	Exited through window; made it to shore.

The enclosure of the Taki-Tooo housed all the life jackets available on board the vessel. Since these life jackets were only available within the enclosure, the passengers on the deck of the vessel were unable to access life jackets when the vessel capsized. All but one of the passengers within the enclosure survived the casualty. As seen in Table 1, these surviving passengers did not fully don their life jackets; instead, they secured their life jackets to one part of their body or held onto the life jacket as they exited the vessel. The enclosure of the Taki-Tooo came to rest upside down and filled with

approximately four feet of water allowing the passengers slightly more time to access the life jackets, which was critical to their survival.

The master of the Taki-Tooo delivered the safety briefing to passengers prior to departure. He included the location of life jackets, which were inside the cabin in labeled bins, and told passengers that they could don a PFD if they wanted and to “just ask if they needed help getting [life jackets] on or anything” (NTSB, 2005). The master also told passengers that the vessel was equipped with a life raft and throw ring. The master did not demonstrate how to don a life jacket, but the deckhand told the NTSB that there was a placard inside the cabin with instructions. Although this safety briefing did not include an emergency evacuation plan, the vessel capsized before passengers even knew they were in trouble so a briefing with an evacuation plan would not have helped.

4.1.6 Comparison of Cases

After analyzing each of these five incident reports, we noticed a number of trends. By linking common problems in these five marine casualties, we were able to develop recommendations to the USCG. One main problem that we found in our research was that some reports contained more information than others did and the inconsistency in the investigation process makes analysis of these reports difficult. Table 2 represents the data collected in the USCG reports and Table 3 represents the data collected in the NTSB reports.

Table 2: Data Collected by USCG

	Data Collected by USCG			
	<i>DUKW Vehicle</i>		<i>Small Excursion Vessel</i>	
	Miss Majestic		Lady D	
	Survivors	Fatalities	Survivors	Fatalities
Total Number	✓	✓	✓	✓
Age		✓	✓	✓
Weight				
Gender		✓	✓	✓
Location on Vessel				
Number that donned PFD				
Statement collected by investigators	✓		✓	

Table 3: Data Collected by NTSB

	Data Collected by NTSB							
	<i>DUKW Vehicle</i>		<i>Small Excursion Vessels</i>					
	Miss Majestic		Lady D		Taki-Too		Ethan Allen	
	Survivors	Fatalities	Survivors	Fatalities	Survivors	Fatalities	Survivors	Fatalities
Total Number	✓	✓	✓	✓	✓	✓	✓	✓
Age			✓	✓	✓	✓	✓	✓
Weight							✓	✓
Gender	✓	✓			✓	✓	✓	✓
Location on Vessel	✓	✓			✓	✓		
Number that donned PFD	✓	✓	✓	✓	✓	✓	✓	✓
Statement collected by investigators	✓		✓		✓		✓	

In the USCG investigation of the Miss Majestic (1999) incident, investigators only collected age and gender data for fatalities. Since the investigations did not include the age and gender information for survivors, we were unable to make any conclusions about these attributes. The USCG investigations of the Miss Majestic and Lady D (2009) did not collect data on passenger weight, passenger location on the vessel, or the number of passengers who donned PFDs. The gaps in information here made passenger attribute comparisons very hard.

The NTSB incident reports (2002, 2005, 2006a, 2006b) included more information regarding egress than the USCG reports, which we found useful. However, there were still gaps. All of the reports included the total number of survivors and fatalities, which enabled us to see the percentage of fatalities in each incident. Some of the reports did not include age and gender information and only the Ethan Allen report included weight data. The lack of information about these passenger attributes, along with the other circumstances of the incidents, made it impossible for us to draw conclusions about passenger attributes. The Miss Majestic and Taki-Too incidents included the location of passengers on the vessel. This data, along with the survivor statements, helped us understand the egress scenarios of these casualties. After knowing these egress scenarios, we were able to conclude that passengers can react in a number of different ways. Some passengers will not move when the crew tells them to egress, while other will immediately exit. The information collected about the number of passengers who donned PFDs, allowed us to see the problems that PFDs can create in these emergency egress scenarios.

Each USCG and NTSB incident report presented information that supported their recommendations and conclusions. However, the lack of information about passenger attributes and the inconsistency in information provided hindered our research into passenger attributes. Because of this hindrance, we were unable to make conclusions regarding if a passenger's age, weight, or physical ability could impede egress. However, it is still likely that these attributes could impede passenger egress.

In order to show the trends we found in the casualties, we made a table to show which problems existed in which casualties. There were four problems with emergency egress we found over the 5 casualties: location and donning of PFDs, exit confusion, and the lack of a safety briefing. Table 4 shows the all of the information we gathered.

Table 4: Problems Related to Egress in Each Incident

Problem related to egress	Miss Majestic	Lady Duck	Lady D	Taki-Tooo	Ethan Allen
Location of PFD	✓	✓		✓	
Donning PFD	✓	✓	✓	✓	✓
Exit Confusion	✓		✓		✓
Safety Briefing	✓	✓	✓	✓	✓

One of the trends we found involved life jackets, specifically their location or storage on SPVs. The location of PFDs was a problem on the Miss Majestic, the Lady Duck, and the Taki-Tooo. On the Miss Majestic (NTSB, 2002), the master and passengers had a hard time getting PFDs out of storage racks. The locations of the life jackets on the Lady Duck and the Taki-Tooo slowed down passenger egress and contributed to higher fatality rates.

The second trend we found was the issue of when to don a life jacket. All of the incident reports noted how difficult it is to determine the best time to don a life jacket. Some reports considered having passengers obtain a life jacket and wait to don it until they are safely outside the vessel, while others only cited the fact that life jackets can impede passenger egress from inside a canopy.. On the Miss Majestic, Lady D, and Ethan Allen, no one had time to don a life jacket. On the Lady Duck, investigators found four passengers trapped inside the canopy of the sunken vessel wearing their life jackets. On the Taki-Tooo, five survivors had to remove their PFDs to exit.

The third trend we found was about exit confusion. Exit confusion was a problem in the Miss Majestic, the Lady D, and the Ethan Allen. In these three incidents, survivors said the water was so dark they could not see where to exit. On the Lady D, survivors noted having trouble opening the doors because one was a slider door and one was a hinged door.

The final problem concerned the lack of or a confusion regarding the safety briefing in all the incidents. On the Miss Majestic and Taki-Tooo, the master only told passengers where the life jackets were located. On the Lady Duck, the master told passengers the location of PFDs and that emergency exits were through windows, but passengers still used their point of entry to try to escape. On the Lady

D and Ethan Allen, the master claimed to have given a safety briefing, but the passengers said they do not remember hearing one.

After finding these four trends, we were able to develop three areas that required further exploration. The use of personal flotation devices (PFDs) on SPVs, design elements, and passenger education were the three areas we expanded upon.

4.2 Use of Personal Flotation Devices

After analyzing the data collected in various incident reports, it is evident that the donning of PFDs can either hinder or aid passenger egress from SPVs. The location and accessibility of PFDs are critical factors, as well as the amount of time passengers have to don their PFDs. PFDs are an integral tool for survival once a passenger has safely evacuated the vessel and the recommendations made below consider the effect that PFDs have on survivability.

4.2.1 Location and Storage of PFDs

The location and storage of PFDs can affect the amount of time passengers take to access PFDs and evacuate the vessel. In the case of the Taki-Tooo, all the PFDs were stored within the cabin and passengers on the open deck were unable to access PFDs (NTSB, 2005). Only three of the thirteen passengers on the open deck survived as opposed to five of the six passengers who were in the cabin. There was no time for the passengers on the deck to access the PFDs because they were located in the cabin. Additionally, if passengers had entered the cabin to access the PFDs, they would have been placing themselves in more danger.

On the Lady Duck vehicle in Canada, the adults PFDs were stored under the seats and the child size PFDs were located at the stern of the vessel. The adult PFDs under the seats were not easily accessible because of the sharp metal edges on their storage boxes and the various items stored on top of the PFDs, as seen in Figure 13 below. Vessel operators also need to consider the locations of child size PFDs at the start of each voyage. If the children are sitting in the front of the vessel and cannot access the child size PFDs at the stern of the vessel, then operators should provide the children with PFDs at the start of the voyage. Conversely, if adults sitting at the stern of the vessel only have access to child size PFDs that will not support their weight in the water, then they need to have access to adult PFDs.



Figure 13: PFD with cables on top of it on Lady Duck. (Source: Transportation Safety Board of Canada, 2004, p. 40)

On the Admiral Tilp, a vessel we boarded in Alexandria, VA, we noticed how the location and access to PFDs could inhibit passenger egress on vessels. As seen in Figure 14 below, in order to access the PFDs on this vessel, passengers need to remove the seat cushions. By putting these cushions in the aisles, passengers are further narrowing the evacuation routes and preventing egress from within the canopy. For this vessel, the Officer in Charge, Marine Inspection (OCMI) could require that hinges attach seat cushions to the bench to ensure that the cushions do not block the aisles.



Figure 14: PFD storage on vessel in Alexandria, VA.

The location and storage of PFDs can impede passenger egress in the event of a rapid evacuation. Since all vessels are different, it is the OCMI's discretion to determine if the storage of PFDs would impede passenger egress in the event of an emergency. The marine inspector and vessel operator should be aware of all possible obstructions, such as if the evacuation route will remain clear or if all passengers can access the correct size PFD.

4.2.2 Donning PFDs

The donning of PFDs during a marine casualty is a difficult issue to address (NTSB, 2008). The Miss Majestic incident report noted how the buoyancy of PFDs could have trapped passengers within the canopy, resulting in the loss of more lives (USCG, 1999). Similarly, the Lady D investigation found that the passengers' inability to don PFDs allowed them to maneuver with less difficulty and evacuate the vessel (USCG, 2009a). However, after analysis of the Taki-Too incident, where all but one of the passengers who donned PFDs survived, we concluded that PFDs do in fact improve passenger

survivability once they safely evacuate the vessel (NSTB, 2005). Based on these findings, we concluded that the use of PFDs can hinder passenger egress from the vessel, but they are still vital to survival after egress.

4.2.3 Alternatives

Because life jackets are vital to survival once a passenger has evacuated the vessel, we looked into the use of other types of PFDs such as inflatable PFDs and Type IV PFDs. Inflatable PFDs use carbon dioxide containers to automatically or manually inflate. Inflatable PFDs are less bulky than typical Type I PFDs. However, they are not suitable for non-swimmers and have hefty maintenance costs. The inflatable PFD we determined to be most effective is one with a hydrostatic release and LIFT Technology, seen in Figure 15 below.



Figure 15: Inflatable PFD (Source: <http://www.landfallnavigation.com/liftvestpfd.html>)

The hydrostatic release on this inflatable PFD automatically inflates the life jacket under water pressure and the LIFT technology allows the wearer's mouth to be 9 inches above the water, which keeps water out of his or her mouth in severe conditions. This inflatable PFD costs \$299.99 as compared to the same inflatable PFD without LIFT technology that cost \$229.99. LIFT technology would provide the

added buoyancy that unconscious passengers need to keep their faces out of the water. Although inflatable PFDs would help with congestion during egress, if the vessel were to sink, the canopy would still have trapped passengers within the canopy and life jackets would likely inflate (Landfall Navigation, 2009).

Type IV PFDs are throwable devices. Passengers should use Type IV PFDs for emergencies, but the USCG does not approve of their use for non-swimmers or unconscious people. Despite this, Type IV PFDs, in addition to the Type I PFDs and throw rings already required, may improve passenger safety. In emergencies where passengers cannot access a life jacket, these PFDs would likely float to the surface of the water, where passengers could access them after they have evacuated the vessel. The costs of these Type IV alternatives are much cheaper, as seen in Table 5 below.

Table 5: Average Costs of Type IV PFDs (Source: Landfall Navigation, 2009).

Type IV PFD	Average Cost
Horseshoe	\$93.49
Seat Cushions	\$16.49
Ring Buoy	\$66.49

4.2.4 PFD Education

PFDs are a critical means used to improve passenger safety once they have evacuated a vessel. However, these life-saving devices are less effective if passengers cannot don them. Based on recommendations found in the Lady Duck investigation, we feel that the USCG needs to reevaluate how passengers are educated regarding PFDs.

Currently, Title 46 Code of Federal Regulations Subchapter T (Subchapter T) states that passengers should see a demonstration of how to don a PFD, be aware that they can ask for a demonstration, or know the location of the instruction placard detailing how to don a PFD (USCG,

2009c). After boarding several vessels, we noted that many vessels used small signs with instructions on how to don PFDs. These signs were not always located in conspicuous places on the vessel and passengers could easily overlook them.

In the life jacket experiment that we conducted, we allowed some participants to read signage detailing how to don a PFD. This signage is located in Appendix E. Some of the participants who did not read the signage or had never donned a PFD incorrectly donned the life jacket and took much longer to do so. A passenger who has never seen the life jackets available on an SPV and does not read the signage posted will not be as prepared to don their life jacket in an emergency.

We understand that not all voyages could logically incorporate a demonstration of how to don a PFD. However, by making passengers aware of the posted signage, passengers would be better equipped to don a PFD in the event of rapid egress. This signage should be located both inside the canopy or enclosure and on the deck, if applicable, and should include images in order to allow for universal comprehension.

4.3 Design Elements

As a part of our analysis, we looked at different design elements of SPVs. We researched the current regulations in place for seating arrangements and aisle width, the possibility of requiring emergency release windows, and the possible lighting of a vessel underwater should it sink or capsize. This research helped us make recommendations based on our findings.

4.3.1 Seating Arrangements

Subchapter T has regulations regarding passenger accommodations aboard SPVs (USCG, 2009c). It states that an aisle on an SPV must be 24 inches in width if the length of the aisle is less than 15 feet or 30 inches in width if the length is more than 15 feet. In determining if this is adequate, we considered the dimensions of the Miss Majestic vehicle. The aisle in the vessel was 18 feet 4 inches in length, which would mean the aisle width would need to be at least 30 inches. The actual aisle width was 12 inches, making the accommodations on board extremely cramped for the passengers. Subchapter T also states that the distance from seat front to seat front must be no less than 30 inches. On the Miss Majestic, the distance from seat front to seat front was 26 inches, restricting even more the movement of passengers. The discretion of the OCMI is very important in granting equivalencies for DUKW vessels due to their unique design. Following the Miss Majestic incident, the USCG wrote policy in the form of NVIC 1-01 to provide further guidance in this area. Figure 16 is the inside of the Miss Majestic vehicle.



Figure 16 - Post accident view of the Miss Majestic's main passenger compartment. (Source: USCG, 2001, p. 4)

NVIC 1-01 includes details regarding passenger accommodations aboard a DUKW vehicle (USCG, 2009b). The USCG determined that the aisle width could be no less than 14 inches and that the distance from seat front to seat front could be no less than 28 inches. These numbers are lower than the number

stated in Subchapter T due to the unique design of DUKWs and the fact that the primary means of egress from a DUKW is over the sides.

In determining if the current regulations regarding aisle width and seating arrangements are adequate, we looked at two studies regarding egress from aircraft. In one conducted by McLean, Chittum, Funkhouser, Fairlie, and Folk in 1992, they determined that passageway width had a relatively small effect on egress flow rate, with single passageways of intermediate width being similar in their ability to support evacuations (Chittum, et. al., 1992). In another study conducted by Muir, Bottomley, and Hall in 1992, trials again found no significant improvement in egress flow rates between aisle widths and that there was no difference in egress time with aisles 13" and 18" wide (Muir, et. al., 1992). The authors suggested that this was due to passengers perceiving the wider aisle as capable of allowing more than one passenger to egress simultaneously, producing further competition for egress workspace. They further suggested that the 13" wide aisle might have appeared as only large enough for a single file line, creating a faster, more orderly evacuation.

4.3.2 Windows

Subchapter T details the inspection process and the requirements the USCG must enforce in order to certify a vessel (USCG, 2009c). The USCG touches upon several aspects of passenger egress that we must analyze in order to understand the efficiency of the regulations and to find any gaps that may exist. In Subchapter T, section 177.500 details all escape requirements on an SPV. These requirements ensure that there are sufficient means of escape that allow passengers to escape in an emergency.

One requirement is that there must be two means of escape, preferably located at opposite ends of the vessel (USCG, 2009c). All the vessels that we observed had several windows, as well as two doors. These windows could be means of escape but they must meet the thirty-two inch minimum

width requirement. The regulations also state that the size of all means of escape should not impede the movement of passengers wearing life jackets, but it is important to consider the fact that a large person wearing a life jacket may not fit through that opening. In order to determine if the size of a person affected their ability to fit through 32 inches of emergency egress, we obtained a Type I PFD from Jacqueline Papapietro in the Life Saving and Fire Safety Division. We asked several employees from the Office of Vessel Activities to don the life jacket and walk through a 32-inch opening. There was a wide range in the sizes of people and every person fit through the opening with no problem, both forward and sideways. Based on this experiment, we have determined that the 32-inch minimum for emergency exits required by Subchapter is adequate. Table 6 outlines the information we gathered during our experiment.

Table 6 - PFD experiment

	Gender	Age	Weight (lb)	Height (in)	Fit through 32 in?
Subject 1	male	29	210	74	yes
Subject 2	male	49	240	72	yes
Subject 3	male	35	185	68	yes
Subject 4	male	53	190	67	yes
Subject 5	male	34	160	69	yes
Subject 6	male	36	205	74	yes
Subject 7	female	36	125	62	yes
Subject 8	male	52	165	68	yes
Subject 9	female	21	170	69	yes
Subject 10	female	20	160	64	yes
Subject 11	male	20	215	73	yes

As detailed in our background, NVIC 1-01 is guidance for the certification of APVs, specifically DUKWs (USCG, 2001). The USCG created this guidance in 2001 in response to the Miss Majestic incident. Eight years later, when the USCG released its investigation report of the Lady D, they recommended that

there be guidance similar to NVIC 1-01 for other SPVs, such as water taxis and small tour boats. NVIC 1-01 gives marine inspectors and DUKW owners a better understanding of what to do to DUKW vessels to make them safe for passengers. Owners and manufacturers now attempt to comply fully with this guidance. Frank English of Ride the Ducks explained that all DUKW vessels manufactured by Ride the Ducks have quick release windows (personal communication, November 5, 2009). Since the DUKW industry has implemented NVIC 1-01 almost fully and successfully, we will attempt to find parallels between DUKWs and other SPVs, such as water taxis. On the Baltimore Commuter Taxi, we noticed that the only way to open the side curtains was to unzip them, which we determined might not have been easy during an emergency. Figure 17 is the zipper used to open the side curtains on the Baltimore Commuter Taxi.



Figure 17 - Canopy zipper on Baltimore Commuter Taxi

The canopy on the Baltimore Commuter Taxi is similar to a canopy found on DUKW vessels. Because of this similarity, it is possible for these types of vessels to have the quick release feature recommended for DUKWs in NVIC 1-01. The USCG recommends in NVIC 1-01 that DUKW owners either have their canopies approved with a quick release feature or remove the canopy completely. On

vehicles owned by Ride the Ducks, the handle to activate the curtain release system is located near the master, most likely at the operator station. When the master removes the safety pin and pulls the red handle, the curtains release from the vessel, leaving a clear space for emergency egress. Mr. English told us that the cost of installing the emergency curtain release system on DUKW vessels manufactured by Ride the Ducks is between \$12,000 and \$15,000. He also explained to us that vessel owners of other small excursion vessels could apply the quick release feature to their vessels, but the cost may vary and that they would need to modify the feature specifically for their vessels.

Whether it is doors or windows, a passenger must be able to open easily any means of escape in the event of an emergency (USCG, 2009c). After boarding several vessels, we became aware that this is not always the case. When we rode the Commander Jacques water taxi in Alexandria, VA, we tried to open the windows and found that it was extremely difficult to do so. There were also two doors located on the vessel, one at each end, which were the emergency exits. We realized that if passengers filled the taxi and we were sitting in the middle of the vessel, we would need to use the windows rather than the doors in order to escape during an emergency. Figure 18 shows the inside of the Commander Jacques.

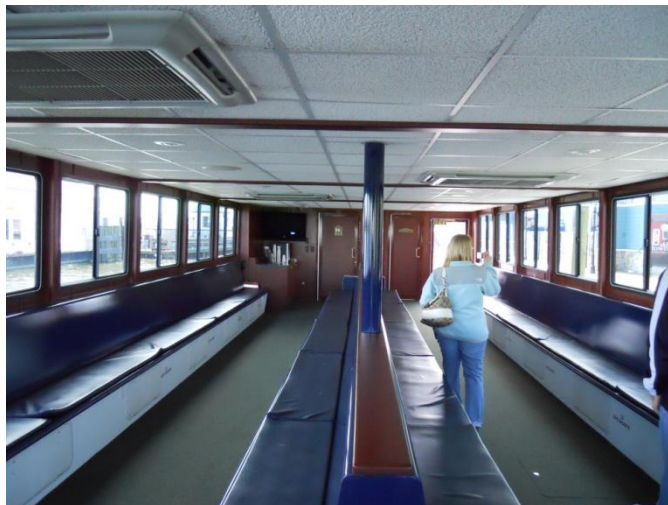


Figure 18 - Inside Commander Jacques

Based on incidents like the Lady D and the Ethan Allen, as well as our personal observation aboard the Commander Jacques, we explored the possibility of having emergency windows on vessels that have a deckhouse enclosure rather than a canopy. According to United States regulations, all buses must have emergency exits, including both windows and doors, to allow for rapid passenger egress (Federal Motor Carrier Safety Administration, 2009). The number and type of these exits vary depending on the size and the type of the bus. There have been several school bus accidents where students were not able to escape from the vehicle due to a lack of emergency exits.

On March 28, 1988, a pick-up truck collided head on with a school bus carrying 67 people (NTSB, 1989). The bus's fuel tank punctured during the accident, causing a fire that engulfed the bus in flames. The driver of the bus and 26 passengers died because of the incident. The NTSB determined that emergency egress on school buses was a major safety issue after this accident.

On September 21, 1989, a truck owned by the Valley Coca-Cola Bottling Company collided with a school bus carrying 81 students (NTSB, 1990). The school bus fell into an excavation pit and was below 10 feet of water. The NTSB determined that no fatalities occurred from the collision, but that the "...21 fatalities were the result of drowning or complications related to the submersion." Several passengers on the bus were unable to escape the vehicle because the front exit was blocked, leaving only the back exit accessible.

The regulations that govern school buses and motor coaches with regard to emergency egress are in Title 49 CFR Subpart B Standard 217 – Bus Emergency Exits and Window Retention and Release (FMSCA, 2009). This standard first became effective on September 1, 1973, but did not apply to school buses. Because of the incidents detailed above, the Federal Motor Carrier Safety Administration updated the regulations to require school buses to have emergency windows. In the past ten years,

there were 50 deaths in the five incidents we researched. Now it is time that the USCG take a closer look at the regulations regarding emergency egress from SPVs with enclosures.

We looked into the possibility of SPVs having emergency windows similar to those found on buses. Since vessels do not have an emergency window equivalent to those found on buses, we analyzed the cost of these windows on buses, as well as the cost of typical windows found on commercial vessels. We spoke with a sales representative from Central State Bus Sales and found out the prices and sizes of a regular window and an emergency window on a school bus (personal communication, 2009). Since the windows can vary in size and type, the representative gave us information about their most commonly used windows. The price of a regular window on a school bus is \$10.38 and the price of an emergency release window on a school bus is \$19.74. The representative explained to us that a regular window could not just be equipped as an emergency window, as it is a completely different window.

In order to determine the price of a typical window on commercial vessels, we contacted various manufacturers to get price quotes. We received quotes from USA Marine Windows, AJR Windows, Motion Windows, and Waterway Systems (personal communication, 2009) that ranged in price from \$300 to \$450. Based on the quotes we found that the average cost of a regular window that is 32 inches in height and length is \$343.75. We used the ratio of the price of a regular window to an emergency window on school buses to estimate the cost of an emergency window on a vessel. Using the ratio, we determined a possible price of \$653.72 for an emergency window on a vessel. This number is not a definite price, so the cost of an actual emergency on vessel could be higher or lower. Table 7 shows the comparison of prices between buses and vessels.

Table 7 - Estimated Cost of Emergency Windows on Vessels

	Bus		Vessel	
	Price (\$)	Size (in)	Price (\$)	Size (in)
Regular	10.38	12.13 x 25	343.75	32 x 32
Emergency	19.74	12.13 x 23.67	653.72	32 x 32

4.3.3 Lighting

On aircraft, there is emergency lighting in place to guide passengers to the emergency exits should an emergency occur. We looked into the possibility of using lighting on SPVs to help passengers find the emergency exit if a vessel sinks or capsizes in dark water. According to a study on emergency egress from an aircraft conducted by Helen Muir and Ann Cobbett at Cranfield University in October of 1996, passengers take longer to escape in darker conditions (Muir and Cobbett, 1996). Table 8 contains information about the lightness in an aircraft cabin, the type of aisle, and the time it takes passengers to evacuate. The definition of a jog aisle is an aisle that changes direction. The time needed for 75% of the passengers to exit the cabin in a dark straight aisle is about 19 seconds longer than it takes for 75% of the passengers to exit the cabin in a light straight aisle.

Table 8- Cooperative Evacuations: Mean Evacuation Rates for Each Participant (time in seconds). (Source: Muir and Cobbett, 1996).

Cabin Conditions		Last Participant Receiving Bonus*:	Mean Evacuation Rate**:	Standard Deviation:
Lightness	Aisle Type			
Bright	Straight	30.5	0.79	0.05
Bright	Jog	49.07	0.82	0.05
Dark	Straight	49.37	0.85	0.14
Dark	Jog	51.66	0.91	0.097

*Last Participant Receiving Bonus: the time needed for 75% of passengers to safely evacuate the cabin

**Mean Evacuation Rate: the rate at which passengers exited the cabin.

In order to understand the feasibility of using underwater lighting, we looked at the cost and effectiveness of incandescent lights and light-emitting diode (LED) lights. The first type of lighting we considered was water-activated lights used on PFDs. Some of the water-activated lights use

incandescent lighting (ACR Electronics, 2009). ACR Electronics manufactures a water-activated light for PFDs that is visible up to two miles away in ideal conditions. The cost of incandescent lights ranges in price from \$10 to \$40.

Underwater Kinetics (2009) has manufactured high performance underwater lights since 1971. On their website, they state, "...LED light penetrates water better than light from conventional incandescent lamps allowing greater visibility underwater." Underwater Kinetics primarily uses the LED technology to manufacture dive lights, but it is important to note their use of LED lighting. Another company, OceanLED (2009), also manufactures underwater LED lighting. They mainly manufacture lights that recreational boat and commercial vessel owners install on the outside of the vessel for aesthetic purposes. One of the lines of lights they manufacture, the Pro-Series, penetrates up to nearly 50 feet in average water conditions, depending on the model. The least expensive model, which penetrates up to 10 feet in average water conditions, is the X-520. Figure 19 is a boat that has two X-520 LED lights installed on the back.



Figure 19 - Monterey with 2 x X520s Blues. (Source: OceanLED, 2009).

There are six models of this type of light that each come in blue, white, or green (OceanLED, 2009). In terms of color, OceanLED states, "...blue and green are also more perceptible to the cones in the human eye, making them seem brighter than white lights with a better beam spread." Table 9 lists

all six models of the Pro-Series, the price of each, and the light penetration of each in average and perfect water conditions.

Table 9 - OceanLED Pro-Series LED Light Penetration. (Source: OceanLED, 2009).

Model	X-520	1010	1520	2010	3010	Super Nova
Price (\$)	~500	~700	~1,000	~1,350	~2,100	~3,400
Approx. Light Penetration in average water conditions (ft)	10	11.5	16.5	23	33	49
Approx. Light Penetration in perfect water conditions (ft)	23	30	42	82	100	115

After comparing the different prices and light penetrations, we analyzed how effective this type of light would have been on Lady D. According to the NTSB report of the Lady D casualty, one passenger said he “...could not see anything in the murky water” (NTSB, 2006b). The deckhouse on the Lady D was 24 feet, ½ inch long and 7 feet, 8 inches wide. There were two doors in the deckhouse located at each end of the vessel and six windows on each side. Some survivors of the casualty told investigators that they escaped by opening the windows and jumping out, while other survivors said they were able to get to the door to escape. Had there been an OceanLED Pro-Series X-520 light, or a similar light, located above the each door at either end of the vessel, it is likely passengers would have been able to locate the doors. The light would have penetrated approximately 10 feet, almost half the length of the vessel. Figure 20 is an approximate scaled model of the Lady D deckhouse with the distance the lights would have most likely penetrated. The dotted lines represent how wide the light could have penetrated, but since there is no clear method of calculating this, we estimated using the typical path of light.

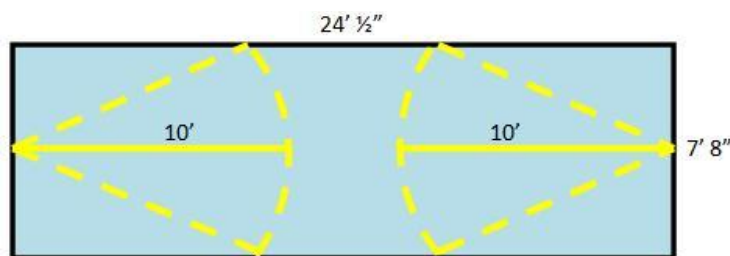


Figure 20- Possible Light Penetration on Lady D Deckhouse

As stated earlier in our analysis, NVIC 1-01 recommends that DUKWs have a quick release feature to release the side curtains (USCG, 2001). A switch located at the operator station should control this feature. As soon as the vessel master realizes there is an emergency, he or she should activate the switch, thus releasing the side curtains from the vessel. Deckhouse enclosures cannot have the quick release canopy because the enclosure is a permanent structure, so it would be possible to have a switch for the emergency lights at the operator station.

4.4 Passenger Behavior

One significant human factor that we identified in our investigation of marine casualties was the behavior of passengers as the vessel came under distress. The casualty investigation reports we have read indicate a common trend of chaos and confusion in the behavior of passengers aboard these vessels. The rapid sinking of these vessels created a panic situation in which passengers needed to evacuate from the vessel as quickly as possible. This resulted in a disorganized struggle to access life jackets and emergency exits that in many cases were not readily accessible for the frantic passengers. The NTSB, (2006a), report on the Ethan Allen casualty highlighted this fact, noting that in the ‘total confusion’ inside the overturned Ethan Allen people were stepping on and crawling over each other in an attempt to evacuate. One woman even indicated that people were clutching on to her as she tried to

escape the vessel, pulling her back away from the means of escape. These reports demonstrate that passenger behavior is a significant factor in the survivability of marine casualties.

While there is a gap in research pertaining to vessel evacuations, there have been many studies detailing the different factors involved in emergency evacuations on airplanes. These evacuations have much in common with evacuations on SPVs, as airplane cabins have many of the same qualities as the enclosed areas of the vessels we have examined. Thus, these studies can provide further information on the behavior of passengers during evacuations. Many studies have examined the effect of several factors on passenger egress by simulating evacuations under a variety of circumstances. Some of these trials developed a sense of motivation and competitiveness in passengers by offering bonuses to those who evacuated first, thus simulating the actions of passengers who felt their lives were threatened (McLean, 2001). Several trials from these studies needed to be aborted due to passengers becoming trapped, falling, or otherwise becoming endangered, demonstrating that even under simulated circumstances, evacuations can become disorganized and dangerous for the passengers involved.

Research on evacuations has identified some common types of reactions when faced with an emergency and the need to evacuate to be fear, anxiety, disorientation, inaction, and aggressiveness (Directorate General of Civil Aviation of France, 1999). This research also indicated that panic behavior presents itself as soon as passengers' lives are threatened, and that some factors shown to cause panic include fire, smoke, absence of clear and precise guidance, and propagation of panic reactions among passengers. In these panic situations, evacuations often become non-cooperative and even competitive, detrimentally affecting the overall safety and effectiveness of these evacuations.

If passenger behavior during the casualties that we have examined had been more calm and organized, it is possible that more passengers would have been able to safely escape the enclosed area and survive the incident. To this end, we have identified three potential adjustments to improve

passenger behavior in marine casualties. These adjustments are to extend current methods of crew training, signage, and safety orientations to include information about emergency evacuation procedures. These adjustments would aim to make both passengers and crewmembers more prepared to evacuate from a vessel safely and efficiently if needed.

4.4.1 Crew Training

One possible method for improving passenger behavior is through proper crew training to ensure crewmembers are properly prepared to organize and direct passenger evacuation. Research on emergency evacuations has shown that “strong leadership by operating personnel, involving firm direction and appropriate behavior, serves to decrease evacuation times and reduce panic among passengers” (TSB, 2004). One study on airplane evacuations showed that the rate of evacuation was significantly faster when a flight attendant was present to organize and focus passenger egress (McLean, 1998). Table 10 shows the results of this study, with the numbers representing the average amount of time that passed between individual passengers as they exited the cabin. The improvement in the rate of egress was especially evident in trials involving higher passenger density in the cabin of the airplane.

Table 10 - Results from McLean Study, 1998

Passenger Management (Flight Attendant) Effects on Mean Egress Times		
Density	Present	Absent
Low	1.44	1.53
High	1.52	1.80

(times in seconds)

Researchers have identified the number and assertiveness of crewmembers in directing passengers through evacuation procedures as anti-panic factors for passengers in emergencies (Directorate General of Civil Aviation of France, 1999). This indicates a need for crowd-control training

for crewmembers to prepare themselves for their duties in an evacuation. Since vessel casualties are extremely uncommon, having previous experience in directing passengers during an emergency is essentially impossible. Thus crew training, through quality and repetitiveness, should “play the role of a successful past experience (improvement of knowledge and self-confidence) and should permit the cabin crews to get to be used to stressing situations, and to automatically execute the actions to carry out during an emergency evacuation” (Directorate General of Civil Aviation of France, 1999). Vessel owners should train crewmembers to direct passengers in a strong and authoritarian manner during an evacuation, contrary to the usual polite behavior of crew on SPVs, in order to contain panic and obtain an orderly evacuation.

Our interview with Luke Harden from the Licensing division clarified the requirements needed to obtain a mariner license (personal communication, November 9, 2009). We learned that the USCG requires a mariner to have logged 360 days of service and to have passed a written exam or equivalent courses in order to obtain a license to operate an SPV. This license is valid for five years, and a master can renew his license without re-demonstrating his ability and knowledge, unless he has not operated a vessel for a considerable length of time.

While the Coast Guard has requirements to obtain a license to operate an SPV, the Coast Guard does not require any sort of training or experience to become a crewmember of an SPV. Thus, vessel owners currently have the responsibility of developing and requiring appropriate training and education of potential crewmembers. Current USCG regulations state that the owner or master of an SPV must instruct crewmembers of the duties they must perform in an emergency and have emergency instructions posted at the operating station (USCG, 2009c). These must at least include instructions for handling situations involving rough weather, man overboard, and fire. These regulations do not include

any requirements for the owner of an SPV to provide instructions to crewmembers for handling emergency evacuations.

Our review of crew training videos provided to us by the Passenger Vessel Association (PVA) that are used to train new employees in the passenger vessel industry found that these videos covered the basic features of a boat and general precautions, but had very little information concerning emergency egress. Based on these training videos, we determined that a new crewmember would not be properly equipped to handle the emergency egress required during rapid evacuation from training based solely on these videos.

There are limiting factors in the SPV industry that account for the lack of required training for crewmembers by the USCG. Some SPVs, especially water taxis, have only the master of the vessel and no other crewmembers. In this case, all the responsibilities of operating the vessel fall on the master. In addition, the seasonal nature of the passenger vessel industry makes the education of new crewmembers difficult. Most passenger vessels only operate during the warmer months of the year, when passenger demand for marine travel and tourist activities is at its highest. Thus, the owners of passenger vessels generally focus on bringing new employees on in the spring to work during the summer. This high turnover of new, inexperienced employees increases the need for crewmembers to be educated on how to handle a situation where rapid egress is necessary. Since vessel owners already are required to provide training to crewmembers in other areas such as man overboard and fire situations, it would not be difficult or costly to extend this training to include the proper procedures to follow to direct passenger evacuations.

4.4.2 Signage

Another method we identified to potentially improve passenger behavior during casualties is by extending signage on vessels to include information on procedures to follow during emergency evacuations. According to Subchapter T, a vessel must indicate through signage where adult and child personal flotation devices are located, and every vessel that we have boarded has clearly done so (USCG, 2009c). Some of the larger vessels we boarded also included signage indicating emergency procedures, but this was neither required nor present for the SPVs that are the focus of this project.

There has been much research in this area to determine what types of signage are most effective in conveying information to passengers. In general, the extent to which safety signage enhances passenger action and survival in emergencies directly relates to the clarity and comprehension of the safety information provided, thus there is a need to address these qualities to assure passengers are well served (Corbett and McLean, 2008). Johnson (1980) reported that pictograms, which are series of associated action pictures or pictorials, are more effective than text in conveying information as they are language-neutral and generally require less space to represent the same message. Coskuntuna and Mauro (1980) developed several ideal rules to follow in airplane signage that the aviation industry adheres to today to educate passengers effectively. These principles included avoiding information overload, using concrete information, prioritizing important ideas, and focusing on actions rather than reasons.

Subchapter T require the owners of SPVs to post placards in conspicuous locations on the vessel containing information for the donning and use of PFDs and for the launching and inflating of inflatable survival craft (if used on the vessel) (USCG, 2009c). The USCG currently has no regulations requiring signage to indicate the procedures passengers would need to follow during emergency evacuations. We have found that other modes of transportation, such as trains and airplanes, do have detailed signage

with this kind of emergency evacuation information. Figure 21 is the Emergency Evacuation Instructions seen on the Washington, D.C. Metro trains.



Figure 21 - Emergency Evacuation Instructions on the Washington, D.C. Metro

This signage indicates the procedures to follow in case an emergency were to occur on the train and evacuation became necessary. It is very detailed and includes all the relevant information a passenger would need to know to carry out an evacuation. However, this signage also relies heavily on text, which research has found to be a relatively ineffective way of communicating information to passengers. The aviation industry has done a better job of implementing pictograms into signage to explain to passengers what they must do during an emergency. Figure 22 shows an example of a safety brochure provided to all passengers on a JetBlue flight. This signage relies much more heavily on the concept of pictograms to convey information, and follows the principle of focusing on actions by showing series of pictures completing important evacuation procedures.



Figure 22 - JetBlue Safety Information Brochure

Vessel owners could apply these principles used in signage on airplanes to the signage that they use on their vessels to include information on evacuation procedures. There are two possible ways for vessel owners to accomplish this: through individual brochures and through bulkhead signage. Since the designs of different SPVs are often unique, vessel owners may need to have custom-made signage designed and ordered for use on their vessels. The cost of developing such signage would be minimal, and there would only be minimal maintenance costs to replace signs that may become worn and difficult to read. While some types of signage, such as the proper method for donning a life jacket, could follow the same standard for all small passenger vessels, the unique design and operation of many SPVs may prevent vessel owners from developing standardized signage for evacuation information. In some cases, vessel owners may need to design their signage to have information specific to their vessel, requiring custom-made signs that may have a higher cost. Appendix D shows some examples of signage that vessel owners could display on their SPVs.

4.4.3 Safety Orientations

The final method we identified to potentially improve passenger behavior during an emergency is by extending safety orientations to include evacuation procedures. Safety orientations, given either in person by a master or crewmember, or by an audio recording played over a loudspeaker, provide passengers with basic safety information. This information includes the use and donning of life jackets and the location of emergency exits. Vessels could extend this safety orientation to include the procedures to follow in an emergency, including the use of emergency exits and the evacuation routes to follow. The presentation of this information at the beginning of a voyage would inform passengers of what actions they would need to make if emergency egress became necessary.

Subchapter T requires the master of a vessel to ensure that appropriate public announcements be made providing passengers with the following information: the location of emergency exits and survival craft, the location and proper use of PFDs, and the location of the required information placards (USCG, 2009c). As an alternative to this, the master of a vessel may provide individual pamphlets to each passenger detailing this information and make an abbreviated announcement instructing passengers to refer to these pamphlets and to follow the instructions of crewmembers in an emergency. In addition, OCMI's can exempt ferries operating on short runs of less than 15 minutes from having any sort of orientation, instead relying on bulkhead signage, if they determine the announcements are not practical due to the vessel's unique operation.

This exemption raises the issue of the practicality of having detailed safety orientations on SPVs. Most of the vessels that are the focus of this project, especially ferries and water taxis, make many short voyages during a typical day of operation. Having a long, detailed briefing on each voyage completely explaining the emergency procedures to follow may not be possible on these vessels. Current regulations allow OCMI's to make exemptions that they deem appropriate regarding orientations to

accommodate these situations. However, these SPVs should not be able to dismiss all sorts of orientation, as this would leave a large gap in passenger education that could detrimentally affect possible evacuations. Instead, it would be reasonable to give the abbreviated announcement as described above that relies on individual brochures to convey information to passengers.

Another factor to consider in safety orientations is the concern of many in the transportation industry that these orientations may worry passengers unnecessarily. "Interviews with a number of cabin safety professionals on airlines suggested that commercial and marketing pressures act to subdue the safety information presented to passengers" (Thomas, 2007). Airlines generally aim to reduce exposure to information that passengers may perceive as scary, in case it unsettles nervous passengers. This could also be true for the owners of SPVs, especially those primarily engaged in tourist activities, as the passengers on these vessels may be unaccustomed to marine travel. Hearing about the possible danger involved in a vessel's operation may unsettle inexperienced passengers, and may even result in passengers choosing not to use the services of the vessel. However, vessel owners need to understand that the proper briefing of passengers about the potential risks of marine travel and the procedures to follow in an evacuation benefits these passengers by improving their chances of surviving a possible casualty.

The safety orientations that have proven to be most successful in preparing passengers for evacuations are those that actively engage passengers in the briefing. Studies have shown that passengers on airplanes feel more confident and prepared to handle emergency evacuations when flight attendants gave interactive safety briefings that asked passengers to become involved in the presentation by pointing out exits and demonstrating an understanding of procedures (Thomas, 2007). Therefore, whenever possible the master of a vessel should present detailed safety information through a live orientation rather than an audio recording in order to engage passengers and hold their attention.

This orientation should instruct each passenger to individually identify their most accessible means of escape and run through the procedures needed to access and use these points of egress. By personally engaging each passenger, the master will ensure that the passengers will consciously consider their own safety in case an emergency were to happen, and to internalize the information that they would need to recall to safely remove themselves from the enclosed area of the vessel. We developed a safety briefing to demonstrate how vessel operators could implement an effective and engaging safety orientation on their voyages. This briefing asked passengers to locate their nearest exit and the location of life jackets. It also included a demonstration of the proper procedure to follow to don a life jacket. This briefing has been included in Appendix C.

4.5 Summary

While analyzing the information we obtained through the course of our project, we identified possible changes that would improve emergency egress of passengers on SPVs. We used these ideas to develop the recommendations that we present to the USCG. In the next chapter of this report, we will define and explain these recommendations.

5. Conclusions and Recommendations

After analysis of our results, we developed several recommendations to present to the United States Coast Guard (USCG). We believe these recommendations will improve passenger egress on small passenger vessels (SPV). We made recommendations addressing the use of personal flotation devices (PFD), design elements of SPVs, and passenger education.

5.1 Use of Personal Flotation Devices

After completing our analysis, we developed four recommendations to make to the USCG regarding the use of PFDs on SPVs with canopies or enclosures. The issues surrounding when to don a PFD are complicated. The location and storage of PFDs have provided impediments to egress in past incidents. By requiring alternative PFDs, in addition to the Type I PFDs already required, the USCG can improve passenger safety. Finally, improving PFD education on vessels can increase passenger survivability.

5.1.1 Location and Storage of PFDs

When we boarded vessels and looked at the photos of PFD storage containers in the incident reports, we immediately noticed a problem. Storage containers could impede passenger egress by being difficult to access and causing congestion in aisles. Subchapter T says that vessel owners should place PFDs throughout the vessel and that adult life jackets have to be stored separately from child life jackets. These regulations leave it up to the discretion of the Office in Charge, Marine Inspection (OCMI) to determine how accessible PFDs are. We recommend that the USCG continue to ensure that PFDs are easily accessible to all passengers in all egress scenarios, especially with regard to size. Additionally, the USCG should require that stowage arrangements do not impede passenger egress.

5.1.2 Donning PFDs

After comparing the data collected in the USCG and NTSB reports, we realized that the issue of when to don a PFD was hard to address. We believe that the USCG should encourage vessel owners and operators to tell their passengers to obtain a life jacket and safely evacuate the vessel before they don their life jacket. However, we understand that passengers will not always have time to obtain a life jacket and some passengers will not be able to don a PFD once they are in the water, so this recommendation may not always apply. Since we had incident reports stating both the pros and cons regarding whether PFDs impede egress, we did not make a conclusion about this issue.

5.1.3 Alternatives

After determining that PFDs save passengers' lives and that without life jackets passenger survivability decreases, we realized that alternatives to Type I PFDs should be required. Originally, we considered the possibility of inflatable PFDs, but our research was limited in this area. We recommend that the USCG require the use of Type IV PFDs, in addition to the Type I PFDs already required and conduct further research on inflatable PFDs and their feasibility on SPVs.

5.1.4 PFD Education

After completing our life jacket experiment, we realized that passengers who had never donned a PFD or seen signage detailing how to don a PFD were at a severe disadvantage. This lack of knowledge could waste valuable seconds that passengers have to don a life jacket in the event of emergency egress. We recommend that the USCG provide further guidance to passengers on PFD education in all

egress scenarios. This may include demonstrations or signage informing passengers of the correct way to don PFDs.

5.2 Design Elements

After analyzing our results, we have made recommendations to the USCG regarding data collection and emergency exits. We have recommended several design features that we believe the USCG should encourage vessels owners to incorporate on new vessels, as well as those already constructed, if possible. Recommendations regarding data collection, quick release canopies, emergency release windows, and lighted windows are included in this section.

5.2.1 Data Collection

Based on our analysis of the data collected by the USCG and NTSB during their investigations, we believe that the USCG needs to include more data regarding passenger attributes in their final investigation reports. Such attributes include, but are not limited to, age, weight, gender, and physical ability of both the survivors and the fatalities. The USCG should also try to collect information about where passengers were located on the vessel, whether or not they donned a life jacket, and as much detail as possible about their evacuation from the vessel. By collecting data more consistently and more thoroughly, the USCG can ensure that research regarding passenger egress will be more comprehensive in the future.

5.2.2 Seating Arrangements

Based on our analysis of Title 46 Code of Federal Regulations Subchapter T (Subchapter T) and studies about egress from aircraft, we feel that the required minimums for aisle width and seat front to

seat front distance are adequate as stated in the regulations. It is important that marine inspectors continue to provide equivalencies with discretion in order to avoid the cramping and possible entrapment of passengers in the vessel. The NVIC allows DUKW vehicles to have smaller aisle widths and seat front to seat front distances (USCG, 2001). We agree that, while the numbers are smaller, they are adequate because the primary means of egress from a DUKW vessel is over the side.

5.2.3 Windows

Based on our analysis of the quick release feature on DUKW vessels, we recommend that the USCG require all vessels with a canopy similar to that on DUKWs have the quick release feature for the side curtains. On a vessel that has a deckhouse enclosure like the Lady D, we recommend that the USCG consider requiring emergency release windows on SPVs. By requiring vessels to have these emergency release windows, there would be more means of escape should the vessel sink or capsize.

5.2.4 Lighting

Based on our analysis of incandescent and light-emitting diode (LED) lights, we recommend that vessels should have underwater LED lights, similar to those manufactured by OceanLED, which allow passengers to locate the exits. This light should be either blue or green, to allow for maximum visibility by most passengers. The master can control the light from the operator station, similar to the way the master operates the quick release feature on DUKW vessels.

5.3 Passenger Education

Through our analysis of the factors that affect the behavior of passengers on a vessel in distress, we have identified three recommendations that we feel would improve this behavior. These recommendations address the need for improved passenger education to better prepare passengers for emergency evacuations. We believe that this improvement in behavior would reduce the risk of passenger fatalities in future casualties involving vessels with canopies or enclosures.

5.3.1 Crew Training

Our analysis showed that the presence of crewmembers to direct passengers through an emergency evacuation improved passenger behavior and made the evacuation both faster and safer. To ensure that the crew is prepared to handle such a situation, vessel owners should ensure that all crewmembers receive training that covers the procedures they will need to follow in an emergency. This training would benefit from a thoroughly developed plan for how the vessel will handle emergencies. Thus, we recommend that the USCG require all vessel owners to prepare thorough evacuation plans, and provide training to ensure all personnel on the vessel are capable of directing passengers through these plans.

5.3.2 Safety Briefings

Safety briefings present important safety information to passengers at the beginning of the voyage. Current USCG regulations require vessel owners to provide proper announcements informing passengers of the location of exits and the location and proper donning procedure of life jackets. We believe that vessel masters need to inform passengers of the proper procedures to follow to evacuate from the vessel in an emergency. This would prepare passengers mentally for such an event, and would

improve the likelihood that passengers would behave responsibly and efficiently during an evacuation. Therefore, we recommend that the USCG require all vessel owners to provide a safety briefing at the beginning of every voyage informing passengers of the evacuation procedures they must follow in the event of an emergency.

5.3.3 Signage

We have found that other modes of transportation, such as trains and airplanes, make use of signage to deliver important safety information to passengers. The USCG currently requires vessels to have signage indicating the location and use of life jackets. Vessel owners can easily extend the signage on their vessels to include important information about passenger egress, such as the expected behavior of passengers in an emergency as well as the location of exits and evacuation routes. This information would provide additional preparation to passengers for how to handle an evacuation. Thus, we recommend that vessel owners post effective signage on their vessel detailing evacuation procedures to be followed on that vessel. We also recommend that the USCG adopt standardized signage that makes use of commonly known pictograms.

5.4 Summary

After completing our project, we concluded that the main issue that the USCG needs to address is the awareness of problems that may arise during emergency egress scenarios on SPVs with canopies or enclosures. We understand that there are costs associated with enhancements, but our recommendations emphasize the importance of preserving passenger safety on these SPVs. It is the USCG's responsibility to make vessel owners and operators aware of the ways that they can protect passengers. One way they can inform vessel owners and operators is through industry associations, such as the PVA. By being aware of emergency egress issues, the USCG and vessel owners and operators can

better prepare passengers for a safe and fun ride aboard small passenger vessels with canopies or enclosures.

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Appendix A – Interview Summaries

This appendix contains summaries of interviews we have conducted as part of our background research. These summaries include information about where and when the interview took place, the questions that we asked, and the information provided by the interviewee.

Ken Stafford – WPI Professor

Date: September 25, 2009

Location: Worcester Polytechnic Institute, Higgins Labs 002

Secretary: Stephanie Munion

Attendee: Ryan Doherty

Start Time: 1000 End Time: 1100

Interview Purpose: To better understand important background information concerning vessel design and operation.

1. What are your prior boating experiences?
 - a. Ken has been a sailor since 1974. He has built and sailed sailboats, over 12000 miles of open water sailing, including bodies of water such as the Atlantic, the Caribbean, the Gulf of Panama, and the Great Lakes. He has owned vessels from wind surfers to 52 ft 40,000 pound sailboat.
 - b. Ken Stafford noted that his biggest experience was a 9000 miles trek on 52 ft sailboat with his wife, two kids, and two cats. He has been in rough conditions, experiencing 60 knot winds and 32 foot breaking waves.
 - c. Currently, Ken Stafford teaches sailing at WPI and sails for recreation.
2. Have you ever been in a boating accident?
 - a. Ken has been in what he called “survival conditions.” He witnessed others abandoning their vessels and being injured, but he was always able to continue on his journey.
 - b. There were instances where he was rescued off of rocks but he was never rescued while on board the vessel.
3. What do you know about boat design?
 - a. Ken is quite experienced in sailboat design because he has built sailboats before. Below are some of the areas he covered:
 - i. Stability & metrics for sailboats, which are the safest boats in terms of stability
 1. Hull design will have stability beyond 90 degree keel
 2. Power boats have about 60 degrees keel until they turn and capsize because of their flat bottoms

- ii. Ken had a prior interest in marine architecture, but because a Mechanical Engineer instead.
- 4. What experience, if any, have you had with the use of canopies on boats?
 - a. Ken had very limited canopies – he had an emergency life raft with a canopy but since it was not a full scale boat the features are not the same. Also, he never had to resort to using this emergency raft so he only saw it in test scenarios.
 - i. In general, Ken noted that the pros and cons of canopies.
 - 1. Pro – keep out of weather to survive without exposure problems.
 - 2. Con – make boat less stable in heavy wind
 - ii. Ken also has experience on Air Force lifeboats with canopies, but again only in practice scenarios.
- 5. What prior boat safety training have you had?
 - a. Ken noted that he has taken Coast Guard safety courses but he is mostly self-taught. In fact, he gain insurance coverage for his year-long journey by demonstrating self-education.
- 6. Have you seen boat safety training courses advertised?
 - a. He said that he has occasionally seen advertisements at marinas, but not on a consistent basis.
- 7. Have you ever been on a ferry or tour boat?
 - a. Ken said he has been on lots of ferries and tour boats.
- 8. Did the crew instruct you on safety procedures prior to departure?
 - i. He said they always perform a small cursory introduction, where they tell passengers where their life jackets are. However there are no drills of escape.
- 9. What safety features are commonly used on boats?
 - a. Ken Stafford had an extensive list of safety features – listed below:
 - i. Emergency life raft sufficient for crew
 - ii. Emergency positions locations beacons
 - 1. Which have improved over last decade as they now transmit to a satellite every 90 minutes.
 - iii. Overboard kit
 - 1. Which should be easy to access when abandoning the vessel and should include a radio, water purifier, and other necessities.
 - iv. Man overboard pole
 - 1. Which is a strobe light for the man over board to swim to and then return to the vessel.
 - v. Man Over Board GPS button
 - 1. Which is essential for the captain to track men that fall overboard
 - vi. Fire suppressant
 - vii. Life sling – life ring like
 - 1. Tied to boat
 - viii. Bilge pumps (4 on his)
 - 1. One needs to be available from outside of the boat

2. Electrical bilge pumps tend to fail when it is the worst time
 3. Motor run
 4. Hand operated bilge pumps work best when the crew is scared because they can go much faster.
 - a. Ken experiences this when the bow of his sailboat went down into wave at 2am and block of water landed in cockpit completely full. He used a bucket to get the water out.
10. What interaction, if any, have you had with the U.S. Coast Guard?
- a. Limited, the one safety course and other information.
11. Have you ever heard of any of these accidents? (The Lady D, The Miss Majestic, The Bayside Blaster)
- a. NEVER
12. Is there any other information that you think would be valuable to our research?
- a. Boating Terminology
 - i. Stability ranges – are published numbers for all boats. They note stability limitations for degrees of leaning it can tolerate before it will no longer self right and deals with limiting recovery angles for tipping. The higher the **ballast ratio** the more stable the boat is, intrinsic weight at bottom of boat.
 - ii. Freeboard – is the amount of boat above water. High freeboard is good if you are afraid of going straight under the water.
 - iii. Ultimately, the longer the water line from the front to the back beam at boat (horizontal) less pitching better to ride over waves
 - iv. Form stability – A catamaran takes effort to sink, because it has a huge initial resistance to capsize and no natural righting configuration. Essentially, catamarans are more will stay upside down because they are more stable that way. A mono hulled vessel, however, can capsize and then right itself with little damage or effort.

LCDR Matt Edwards – Coast Guard Academy Professor

Date: October 1st, 2009

Location: United States Coast Guard Academy, McAllister 225

Secretary: Anthony DiGenio

Attendees: Ryan Doherty, Stephanie Munion

Start Time: 1330 End Time: 1420

Interview Purpose: To understand some of the significant design features on vessels, especially with regard to the use of canopies on these vessels.

- What is your previous experience with the United States Coast Guard?
 - Graduated from the United States Coast Guard Academy, attended graduate school at the University of Michigan as an aerospace engineering major.
 - Worked for 4 years at the Marine Safety Center as a ship inspector
 - Became member of USCGA faculty this year, teaching structural engineering.
- What experience do you have with the Miss Majestic and Lady D accidents?
 - Miss Majestic is required reading for Coast Guard inspectors.
 - DUKW (amphibious) boats are very popular in Baltimore area.
 - Awning needs to come off quickly in case of emergency, Coast Guard inspections check for this.
 - Worked as inspector in Baltimore during Lady D accident.
 - Inspectors examined operational, engineering failures after accident.
 - Coast Guard created new criteria for standards in 1980s, not followed by operators of Lady D, but still would have passed all USCG testing.
 - In “protected routes” (safe waters like harbors) – weight on board calculated by 140 pounds per person, which underestimates average Americans weight.
 - Similar miscalculation occurred with an airliner out of South Carolina.
- Have you ever been involved in a boat accident, or witnessed a boat capsizing?
 - No experience with either scenario.
- What information can you give us about boat design and canopies?
 - Small passenger vessels are classified as T-boats, and are less heavily regulated than larger vessels.
 - Canopies would not be allowed on larger vessels, present a risk in case of a fire.
 - Primary purpose of canopies is to provide shade from sun for passengers.
 - Owners can't just install a canopy, has to be approved by USCG inspectors.
 - Inspectors look at stability, and inspect assuming that there are sides even if there are none, to ensure canopy is stable in windy conditions
 - Examine the number of egress; canopy is safer if there are more ways to escape.
 - A possible recommendation to improve safety would be to force windows to remain open – make escape easier.

- Examine Coast Guard inspection manual for regulations and standards.
 - A plain language version of inspection manual is available on Baltimore Homeport website – “Small Passenger Vessel Guidebook”.
- On DUKW boats, there is usually a lever that pulls brackets, open canopy up.
- On canopies, the top is usually metal, while the sides are softer.
- What safety features are commonly used on boats?
 - There are currently no regulations that specifically control canopy safety features.
 - High water alarms – audible and visual signal on bridge that warns operator that water is entering the boat. - Miss Majestic did not have this.
 - Bilge pumps – removes water from interior, needs to be fast to stop inflow of water.
- What are some common elements of boating accidents?
 - In most accidents involving casualties, the ship is designed well and does not sink.
 - Passengers are often confused how to escape in an emergency situation.
 - The snaps on canopies can corrode and become hard to open.
 - Regulations and inspections usually focus on engineering components first, and then look at human components – humans are expected not to be perfect.
- What would be some possible recommendations to improve safety on boats with canopies?
 - Hydrostatic releases – too much water pressure will cause canopy to release, preventing passengers from becoming trapped underneath.
 - Weak links – canopy will release and slide off boat if boat tips too much to one side.
 - For pontoon boats – a trap door to allow another means of egress if the boat capsizes.
 - Design canopy with high buoyancy (for example, with a water-tight air pocket) so it would be more difficult to become submerged.
- Is there any other information that you feel would be valuable to our research?
 - Ships are more stable with a lower center of gravity – ballast is often used in the lower area of a boat to lower center of gravity.
 - If canopy adds more weight to top of boat, more weight should be added lower in the ship to maintain stable center of gravity.
 - A challenge of our research will be to define what is a canopy, what is an enclosure, and what is just a boat designed to have internal regions.
 - Have to consider mobility of passengers, how will old or disabled passengers escape?
 - Need to have knowledge of how Coast Guard regulations are made.
 - Economic considerations – how feasible are safety features?
 - Notice of Proposed Rule-Making – required process for making regulations.
 - DUKW boats – Annapolis has many, DC has some too.
 - Would be helpful to visit and analyze these boats.
 - Naval Architecture for Non-Naval Architects – book with basic definitions of common naval terms.
 - Try to get to go out on a Coast Guard inspection, gain valuable information.
 - More boats in Baltimore, so try to do it there.
 - Fewer inspections are done in colder weather, so try as soon as possible.

LCDR Ben Gates and Staff - Marine Safety Center, Small Vessels Branch

Date: October 30, 2009

Location: Jemal Building, Washington, DC

Secretary: Stephanie Munion

Attendees: Anthony DiGenio, Ryan Doherty

Start Time: 0900 End Time: 1000

Interview Purpose

- To better understand the safety procedures and features that are currently in place to ensure the safety of passengers on SPVs

Questions:

1. How long have you worked for the Coast Guard?
 - a. Mike -- Engineering mostly, marine inspector, naval architect
 - b. Mark – marine inspector, naval architect master (engineering), plan review
 - c. Mechanical bachelors, tour facilities engineering, masters – naval architecture, 1.5 years spv
 - d. Czarniak – 4 years on ship and a few months on ships
 - e. Ben – couple more years than others
2. What are the duties you perform in your position?
 - a. Staff naval architects structure and stability review
 - b. Review plans of commercial vessels
 - i. General arrangement, fire protection, stability
 - c. Verify compliance of design before its built
 - i. Does design meet what's in book?
 1. OCMI has more judgment where as they are black and white does it meet
 - a. If boat operated in 4 feet of water, then some stability recommendations may not apply
 - d. Answer questions on regulatory interpretation
 - i. Engineering analysis for others
3. What are your current responsibilities in SPV safety?
4. Were you involved in the investigation of the Miss Majestic or Lady D incidents?
 - a. NO
 - i. All military so tour last 3 or 4 years so will have to look for some who were around
5. What is your knowledge of the Miss Majestic and Lady D incidents?
 - a. Canopies on SPVs
 - i. Standards in subchapter t – means of escape requirements
 1. Review means of escape all the time

- a. Marine inspector – look at windows and alternative means of escape, but there isn't a lot of guidance
 - 2. NVIC 1-01
 - a. DUKW boats looked at, windows easy means of escape
 - 3. Good marine practice, sound judgment
 - ii. Canopies through stability tests
 - b. Pontoon boats have curtains of glass windows but larger boats have a super structure
 - i. Separating the terminology, permanent vs. temporary
 - c. When bus falls it stops, boats cannot just stay on sides turtle
 - i. Canopies cannot
6. What is your knowledge of the use of canopies on boats?
7. What design features are there that ensure the safety of passengers on SPVs?
 - a. Canopy on escape not generally a concern
 - i. Means of escape – canopies not considered means of escape
 - b. Windows not going to shatter so people cannot get injured 177.1010 (window construction)
 - c. Trying to design so we don't need to use canopies if horizontal you need doors and others to get out
 - d. Root – if vessel is upright then doors are fine, but other ways through canopy
8. How do Coast Guard regulations enforce the use of safety features on SPVs?
 - a. Conditions printed on COI, no one size fits all to compliances
 - i. Equivalencies given at discretion of OCMI
 - b. Bilge pump requirements but if you can meet all stabilities with a space flooded then what do you do then
 - c. Owners can make modifications without CG knowledge
 - d. 46 CFR 175.550 – Special Considerations
 - i. Address in field unit – sector Baltimore
 - 1. What such equivalencies are granted?
9. Commander
 - a. Keep in mind that regs and standards used to be very rigid – now more performance based
 - i. Easily evacuated – doesn't give specifics because the variations
 - 1. Discretion to inspectors more and more
 - ii. Novel craft – cannot be too descriptive
10. How does the crew of an SPV respond to an emergency situation?
 - a. Marine inspection experience – it is important that they do drills on their own and make it realistic, test the crews competence and get windows and doors open quickly, make sure everything is working
 - b. Every boat is different so you cannot be too prescriptive, marine inspector can make sure they are testing themselves
 - i. Cannot guarantee how passengers will react so need to plan

1. Checks and balances between design and performance
 - a. Reqs of passenger vessel association is prevalent because obviously they are worried about complying
 - c. Reqs built with able bodies seamen in mind and not always the case
 - i. More deckhands should be necessary
11. What are they trained to do to enable passengers to egress in the event of an emergency? (ask man at headquarters)
 - a. Only reqs is you are on a drug test, but that's all
 - i. Crowd control
12. Is there any other information that you feel would be valuable to our research?
 - a. Everything is vessel specific – inspectors need to be aware and considerate
 - i. Are safety briefing reqs approp
 - b. Inspector said you aren't doing safety brief and many boats were over lapping
 - c. Some issues are straight forward and simple
 - i. But in the real world they aren't always thinking about them all the time
 - ii. If compliance brings it to everyone's conscience
 - d. What failure modes are we talking about and we are talking about very fast evacuations, if inspectors are thinking about then good.
 - e. Emergency release windows, pressure pens – may be feasible
 - i. Sense of confusion – may need something like quick release because visibility is not good
 - ii. Situations where letting water in through windows may cause it to sink rapidly
 - f. Interesting to look into the risk consequences – CG-545
 - g. NVIC 1-01
 - i. Control station quick release for windows – only for semi-permanent
 1. Baltimore DUKWs had quick release
 - a. New DUKWs being built
 - b. DUKWs - Handholds under the boats

Passenger Vessel Association Conference Call

- Peter Lauridsen, Beth Gedney – PVA
- Frank English – Ride the Ducks Manufacturer

Date: November 5, 2009

Location: USCG Headquarters, Washington, DC

Secretary: Anthony DiGenio

Attendees: Ryan Doherty, Stephanie Munion

Start Time: 1000 End Time: 1130

Interview Purpose:

- o To understand the issues of importance for the PVA
- o To gain insight into how regulations affect the members of PVA

Questions:

Captain Peter Lauridsen

Regulatory Affairs Consultant –Passenger Vessel Association

29 years – Coast Guard, marine safety

Captain Beth Gedney

Director – Safety, Security, and Risk Management – Passenger Vessel Association

Frank English

Ride the Ducks Manufacturer

14 years – Manager of Fleet Operations – technical assistance

1. How long have you worked for the PVA, and what are the duties you perform in your position?
 - a. (Lauridsen) The PVA develops positions on public policy to help members of the passenger vessel industry understand regulations and interaction with the Coast Guard.
2. How does the PVA interact with the USCG?
 - a. (Lauridsen) In the public arena, the PVA makes comments at public hearings for proposed Coast Guard regulations.
 - b. The PVA has a partnership agreement with the Coast Guard, and meets with the USCG 3 times per year to work together to address problems of mutual concern.
 - c. The Coast Guard is invited to participate in PVA conferences by giving presentations and hosting courses and seminars with members of the vessel industry.
 - d. (Gedney) There is also informal communication at the lower sector level between the Coast Guard and the PVA.
3. What are the PVA's current responsibilities with regard to SPV safety?
 - a. (Lauridsen) The PVA represents members of the passenger vessel industry in the public arena.

- b. The PVA does not differentiate members by type of vessel, so there are no specific responsibilities for small passenger vessels.
4. How have the Miss Majestic and Lady D incidents affected how the PVA operates?
 - a. (Lauridsen) The Miss Majestic incident strengthened the PVA's relationship with the vessel industry.
 - b. The USCG and the NTSB sought the industry's support to amend regulations to fit DUKWs.
 - c. The Lady D incident made passenger weight an issue with the public docket.
 - d. The PVA did not participate directly in the investigation of the Lady D accident.
5. Have these incidents had any effect on how DUKW are designed or completed?
 - a. (English) After NVIC 1-01, modifications were made to the design of DUKWs, vessels being built today are built according to these standards.
 - b. In the original design of canopies, supports were not designed properly and thus obstructed passenger egress.
 - i. In current designs, these were moved to allow unobstructed access.
 - c. The height of canopy curtains were always controlled to have enough space for egress, but was originally less than the 32 in. required today.
 - d. A curtain release system is in place, there is a lever in place to release the sides in an emergency.
 - e. The windshield was also a part of the entrapment problem as it was originally locked in place; new designs allow the windshield to easily be pushed out.
6. How do the standards and regulations that apply to the use of canopies on boats affect the day-to-day operations of the operators you represent?
 - a. (Lauridsen) Canopies add danger, need to consider fire protection; smaller vessels do not have similar structural fire protection designs.
 - b. Canopies can affect stability negatively in adverse weather conditions, as shown in the Lady D incident where high winds created a capsizing force.
 - c. (English) There is a need to train for curtain releases and other new design features.
7. What crew training practices are currently in place on passenger vessels?
 - a. (Lauridsen) Ride the Ducks have an extensive crew training program, and requires licensed operators and periodic drills.
 - b. The person who developed this training program worked closely with the PVA and the USCG, and developed criteria for the license given out.
 - c. The requirement of a second crew member created the issue of how to train the second person with regard to his duties.
 - i. With one operator, duties are clear. With two operators, the second person interacts with passengers.

- d. In Coast Guard inspections, the master is required to conduct certain drills, including a man overboard drill, but it is unsure if these drills are as formal as those conducted by Ride the Ducks.
 - e. Most passenger vessels operate seasonally, and therefore focus on bringing new employees on in the spring to work during the summer.
 - f. Ride the Ducks prepares a training video for new employees.
 - i. This video has no specific instructions with regard to canopies.
 - g. (Gedney) These videos are available for us to watch to assist with our project.
 - i. We can possibly pick them up when we go to Alexandria 11/9.
8. Are there any changes or recommendations you would make regarding canopies/egress?
- a. (English) For DUKWs, not every DUKW has a curtain, this is covered by NVIC 1-01.
 - b. Spirit boats often have canopies on their upper deck, and on these vessels passenger egress is not as much of an issue.
 - c. The most common types of canopies seen are roll-up canopies, but those constructed by Ride the Ducks are more mechanized.
 - d. Ride the Ducks does not manufacture DC ducks.
 - e. Ride the Ducks have vessels in Philadelphia, and this is also where most of the work was done to develop the training programs.
 - i. Phone: Greg Blumenthal 215-351-0307
 - ii. 15 vessels in the Philadelphia fleet, only one is currently docked up.
 - f. Boston has a different configuration for their current system.
 - i. They have a new construction tier, and their curtain system is more similar to Velcro than Ride the Ducks' vessels.
 - ii. The Marine Safety Center has reviewed and accepted their different design.
9. Is there any other information that you feel would be valuable to our research?
- a. We should see a variety of vessels, including monohulls and pontoon vessels.

Other notes:

We can send our report to PVA around thanksgiving with results laid out to get feedback.

The PVA is willing to answer any further questions, they said to feel free to call.

Getting to Philadelphia may be a difficult logistical problem, perhaps schedule a phone interview?

Luke Harden - Licensing Division

Date: November 9, 2009

Location: USCG Headquarters, Washington, DC

Secretary: Ryan Doherty

Attendees: Anthony DiGenio, Ryan Doherty

Start Time: 1330 End Time: 1430

Interview Purpose:

- To understand training requirements for licensed mariners
- To determine the gaps in current training requirements

Questions:

1. What is the primary responsibility of the Licensing Division?
 - a. Develop all policy regarding mariner licensing, dealing with mariner appeals
 - b. Appeal process today last 30 days, at least try to keep it there, sometimes goes longer
 - c. Appeal process, a couple years ago, took 2 years
 - d. Still have appeals that are up to 2 years old
 - e. Averaging 60 days now for the appeal process
 - f. What causes someone to appeal? –being required training that isn't in the regulations
 - g. Some people have appealed, denied licenses based on arrests
2. What duties do you perform in the Licensing Division?
 - a. Review packages and make a recommendation, bring questions to Luke
 - b. There's a lawyer also, that looks at the appeal
 - c. Luke reviews all work before sending to the Admiral
3. How does the Coast Guard issue Licenses to mariners?
 - a. ISO 9000
 - b. Mariner submits paper application to local regional examiner – present character, physically qualified
 - c. Must get finger printed, photo, and documentation about citizenship
 - d. CG takes all information to run background check, looking for safety suitability, not terrorism, which local division looks at
 - e. If you murdered someone, you can get a merchant mariner license
 - f. Also looks at medical information – if there are medical issues, reviewed by a nurse
 - i. Top 5 medical reasons – heart conditions, epilepsy, use of drugs (pain), psychiatric, sleep apnea...etc
 - g. To prove work, can self certify or get approved by previous work
 - h. Column 17 to look at what's on an exam
4. What training is the master required to complete?
 - a. Depends on license, t boats, inland, get 360 days of service, and complete CG exam or course in lieu of exam, deck safety, rules of the road, navigation. Look at 10.910

Bill Peters - Office of Design and Engineering Standards, Naval Architecture Division

Date: November 9, 2009

Location: USCG Headquarters, Washington, DC

Secretary: Ryan Doherty

Attendees: Anthony DiGenio, Stephanie Munion

Start Time: 1430 End Time: 1600

Interview Purpose:

- Obtain information about the creation of regulations
- Learn more about the technical aspects of regulations

Questions:

13. What is the primary responsibility of the Naval Architecture Division?
 - a. Stability and structures, includes load lines
 - b. Vessels must be measured to calculate tonnages, simplified measurement system
 - c. *What are the duties you perform in your position?*
 - i. In every agency, the highest level is the constitution
 - ii. International treaties are below it – second tier, before laws
 - iii. Marine safety – most famous treaty, SOLAS
 - iv. Organized within 2 years of sinking of titanic
 - v. Third tier is the US laws
 - vi. SOLAS only deals with vessels that travel on international voyages
 - vii. Most US ships are domestic only
 - viii. Underneath federal law, comes federal regulations
 - ix. Try to change regulations to comply with US laws
 - x. Law is more important than the regs
 - xi. CG has promulgated policy
 - xii. Policy of USCG takes many different conflicting forms
 - xiii. Highest form of standard policy that CG has is called Commandant Instruction
 - xiv. Instruction manuals → Marine Safety Manual! (official policy)
 - xv. NVIC are policy, signed by an Admiral (2 star), assistant commandant for marine safety
 - xvi. There are programs of the CG and other federal agencies, that disseminate policy by way of advisory circulars
 - xvii. FAA has so many circulars, more than CG has NVICs
 1. Regulating by circular?
 - xviii. Capitol has way of changing way federal govt does business

- xix. Office of Management and Budget review all regulations to make sure everything complies with executive order
 - xx. Agency must develop regulatory analysis, is there an overall benefit?
 - 1. What are costs? What are the benefits? Value of a human life is attached!
 - xxi. 8-20 NVICs a year, but not anymore. 2 last year, but there's other ways to do policy
 - xxii. Captain will write a policy letter, MSC issues Marine Technical Notes, guidance of how to submit something to us, now you know what CG is looking for
 - xxiii. Whats the threshold for when we make you completely redo your vessel?
 - xxiv. Webb and others have issued a slew of policy letters
 - 1. Latest is directed toward industry. How to enforce standards
 - 2. Training and qualification of marine inspectors
 - xxv. Policy – CG officially responded to NTSB, should feel that you can rely on that response as policy
 - 1. Take responses as indicators of where to go
 - 2. Letters that go to NTSB is reviewed extensively before being sent
 - 3. Signed by senior managers, commander and above
14. How are regulations created?
- a. *How do they differ from policy?*
15. What is your knowledge of the Miss Majestic and Lady D casualties?
- a. *Do feel that NVIC 1-01 has been a success? If not, why?*
 - i. How well is it used? No position to answer
 - ii. Who operates these DUKWs? Webb can get us a list of all APV operators in US
 - iii. In Toronto, bus is an APV, board through rear, watertight hull, depth of water is 3 feet, 4-5 max. So if something were to happen, you could drive out – look up Toronto amphibious passenger vehicles
 - iv. UK Marine Accident Investigation Board (MAIB)
 - b. *Do you feel that the guidance is NVIC 1-01 would translate well to other small passenger vessels (i.e. water taxis and tour boats) with a canopy or enclosure?*
 - i.
16. What is your knowledge of the use of canopies on vessels?
- a. *What standards and regulations, if any, would apply to the use of canopies on vessels?*
 - i. How does one actually apply these regulations? This is where policy comes into play
 - ii. CG has its own MBI, sometimes are convened, membership is not always the same
 - iii. NTSB and CG both have MBIs and both make recommendations

- iv. MBI is conducted at the local level and local commander will be the one to sign off on an investigation report, report then goes to his boss, district commander, hands it down to investigation guys who reviews report and produces an endorsement which addresses each recommendation. After district finishes endorsement, area does same thing, area commander may write an endorsement of their own, which is forwarded to HQ, and commandant goes through same process. Commandant's action comes out of this
 - v. Population of vessel to which this is confined, is not just APVs. Any SPV with a canopy or enclosure. But casualties happen infrequently, but anything to prevent loss of life is worth it
17. What do you know about the technical aspects of canopy and enclosure design?
- a. Another group that comes to mind is canal boats
 - b. Towed up and down canals but horses or mules
 - c. Go to Great Falls to see canal boats
 - d. Whenever you're constructing something, you have competing objectives
 - i. i.e canopies, keep people in, then get people out
 - ii. For example, a prison barge?
 - e. Canopy can't be flimsy, keep people from the rain
 - f. Add some fiberglass tubes, then rig some canvas over it → most functional
 - g. If there a lot of wind or sun, will get brittle and give way
 - h. Construct something a little more rigid? Fiberglass, aluminum, glass, wood
 - i. Make sure my canopy doesn't blow away, but want to get out if vessel sinks or capsizes
 - j. If vessel gets to certain angle of tipping, enclosure releases
 - k. How do I make sure that the owner or operator doesn't rig it so he invalidates the break away
 - l. Canopy must still function to protect passengers, while still allowing them to get free
 - m. Hatch in the roof (bus), windows that pop out
 - n. Canopy did fall out and fell to bottom in Lady D
 - o. Natural tendency is to escape where you came in, unless you're told otherwise
 - i. Lady D and Miss Majestic didn't have information to look other places
 - p. On Boston Ducks, master introduced himself, more concerned with all fun
18. Is there any other information that you feel would be valuable to our research?
- a. Look at other transportation modes, namely regulations dealing with inner city busses, definitely with airplanes. Busses are closer situation as to SPVs.
 - b. Busses have an escape on the roof, windows used to get stuck but now don't
 - c. Apply some methods from busses to allow objectives to be met
 - d. Don't look at how things are done just in US, there are other governments who have been better at putting further policy and regulations

- i. Canada is close, UK and Australia are also good. Look at ISO, may have some project underway that may be associated with rapid egress on SPVs
- ii. How do naval engineering deal with this? Internal boats? David Sheppard
- iii. It's an enclosure, front door and rear door, windows too
- iv. When with Matt, ask to see RBS
- v. ANSI represents US at ISO
- vi. ISO has standards for processes
- vii. If there is some sort of a standard out there, could be a possible recommendation
- viii. Affects on children, small entities

Captain Jimmy – Baltimore Water Taxi Operator

Date: November 10, 2009

Location: Baltimore Harbor

Secretary: Stephanie Munion

Attendees: Anthony DiGenio, Ryan Doherty

Start Time: 1100 End Time: 1130

Interview Purpose:

- To understand the operator's perspective on passenger safety and Coast Guard Regulations, as well as the Lady D casualty which occurred in Baltimore Harbor

Questions:

1. How long have you been working as a vessel operator?
 - a. 12 years as a master
 - i. 3 main goals are safety, getting passengers from point a to point b, and keep passengers happy
2. What kinds of vessels have you operated?
 - a. Has operated 90 foot supply vessel in the Gulf of Mexico
 - b. Has operated 45 foot Chesapeake Bay vessel
 - c. Operated sailboats
 - d. 12 different water taxi (all different shapes and sizes)
 - e. Operated the Lady D (not during the accident)
 - i. Saw incident take place
 - f. LADY D
 - i. Series of bad mistakes led to the accident.
 - ii. Seaport Taxi boat, aluminum sides and Plexiglas windows
 - iii. Stability test and incorrect sister status led incident
 1. Vessel had a narrower beam and was lightweight
 2. Canopy was flimsy
 - iv. Captain of Lady D didn't know what he was doing
 1. The storm was very visible
3. What interaction have you had with the Coast Guard?
 - a. Minimal, thinks USCG relationship with vessel operators is a very well run operation.
 - b. USCG, boat owners, boat operators need to work together
4. How often is your vessel inspected?
 - a. Yearly, deck inspection
5. Have you had any safety training?
 - a. Man Overboard drills weekly
 - b. First Aid and CPR
6. What emergency procedures do you have in place in case of a casualty?

- a. Call ambulance, radio to office, pull into nearest dock
- b. In a capsize, it is impossible to train for, passengers just need to use commonsense
 - i. If the boat flips quickly, passengers just need to get life jackets
 - 1. He has never had any incidents occur

John Dittmar and Matt Layman – Marine Inspectors

Date: November 10, 2009

Location: Coast Guard Sector Baltimore

Secretary: Anthony DiGenio

Attendees: Ryan Doherty, Stephanie Munion

Start Time: 1400 End Time: 1500

Interview Purpose:

- Obtain information about the inspection process for SPVs
- Learn of the requirements for a vessel to become Coast Guard certified.

Questions:

1. What standards are currently in place for vessels with regard to means of escape?
 - a. Different standards for windows
 - b. T-boats – 2 means of escape, not always a window
 - c. Exits sometimes are not properly marked, locked when they shouldn't be
2. How do you use regulations and policies during your inspections?
 - a. Problems are caused by things that are added after a boat is built
 - i. CG should be notified if any changes are made to the design
 - b. Regulations are minimum standards
 - i. Inspectors look for glaring abnormalities
3. How do you feel vessel owners could better ensure passenger safety during egress scenarios?
 - a. Layman – operators should take the time to properly give safety orientations to passengers
 - b. In cold waters, window of survivability is very low if emergency evacuation is needed
 - c. We should look at FAA regulations concerning evacuations
 - i. Especially standards for evacuations
 - d. Changes to orientation and signage are not expensive
 - i. Vessel owners would not have much of an issue with changes in these areas
4. What safety features have you seen used on vessels with canopies?
 - a. Majority of vessel owners don't have safety features for canopies
 - i. Not really feasible for small businesses – too expensive
 - ii. Cost is a big factor – vessel owners may fight costly new regulations
5. What is the relationship typically like between Coast Guard inspectors and vessel owners?
 - a. In Baltimore, each inspector has own vessels to inspect
 - i. Builds good working relationship with vessel owners
 - b. Inspector training is largely port-specific
 - i. Sector Baltimore specifically trains all its inspectors
6. What does the granting of sister status on vessels mean?

- a. Plans that have already been approved for one vessel can be used to build additional vessels beyond the original first vessel
 - b. Proper documentation and oversight is needed
 - i. Need to make sure they stick to the same plan
7. Other notes...
- a. Inspectors use NVIC 1-01 for DUKW inspections

LT James Law – Office of Investigations and Analysis

Date: November 31, 2009

Location: USCG Headquarters, Washington, DC

Secretary: Anthony DiGenio

Attendees: Ryan Doherty, Stephanie Munion

Start Time: 1300 End Time: 1400

Interview Purpose:

- Obtain information about the process of investigation and analysis for marine casualties.
- Identify potential trends in marine casualties that are relevant to our project.

Questions:

What is the primary responsibility of Investigations and Analysis?

- a. 3 divisions – Investigations Policies (5451) – casualty investigations – vessel, people, facilities, allusions
 - i. Boating Safety – programs, investigations of deaths on recreational boats
 - ii. Civil Penalty Enforcement – speeding (tickets – new)
 - iii. Oversee taking away licenses for negligence, etc. – 3 month process (hearing, etc.)
- b. 5452 – Analysis, statistical trends, awareness statistics
 - i. Deaths, pollution, lots of statistics
 - ii. Responsible for trends in marine casualties
- c. MISLE – Marine Information for Safety and Law Enforcement
 - i. Units – people on the field, do things with vessels, people, facilities
 - ii. All data from these activities stored in MISLE
 - iii. Case – report to scene, identify problem, identify cause and responsible parties, hold responsible
 - iv. Findings of facts – chain of events that led to casualty
 - v. Transactional system, limited analysis capabilities
- d. Coast Guard Business Intelligence – COGNOS information system
 - i. Sort incidents by base (Lake Erie = Buffalo) 8th district – Great Lakes
 - ii. Phrase questions simply, specific criteria we are looking for
 - iii. Who, what, when, where, why, and how for each casualty
 1. Several metrics for each, very detailed
- e. Microsoft SQL – query database into casualties, relational tables
- f. Lots of different backgrounds, look at analysis differently
- g. Can conduct minimal, medial, or maximal analyses of investigations
- h. Subchapter T – White’s Ferry on Potomac – small ferry/barge, would fit our definition of small passenger vessel
- i. Systems were very basic until 1991, MISLE developed in 2001

Search – small passenger vessels, under 65' with canopies, sinkings, capsizing, flooding (fire?), personnel casualties if present, 2002-2009 (if possible 1992-2001) – number and causes of fatalities

Business Performance Plan – goal is to prevent fatalities, show statistics to see trends on how successful this is

Marine Safety Performance Plan – Coast Guard site (OME?)

3rd division CG5453 – Freedom of Information Act requests – records releases

Take care of privacy issues – redacted sections of investigation reports

Appendix B – 46 CFR Subchapter T

Title 46 Code of Federal Regulations Subchapter T is the listing of all current Coast Guard regulations that apply to small passenger vessels. This document contains regulations that define the requirements for vessels to receive Coast Guard approval to operate on United States waters, including requirements for vessel design and operation. We have included the regulations that are relevant to passenger egress on vessels with canopies.

Sec. 177.500 Means of escape.

(a) Except as otherwise provided in this section, each space accessible to passengers or used by the crew on a regular basis, must have at least two means of escape, one of which must not be a watertight door.

(b) The two required means of escape must be widely separated and, if possible, at opposite ends or sides of the space to minimize the possibility of one incident blocking both escapes.

(c) Subject to the restrictions of this section, means of escape may include normal exits and emergency exits, passageways, stairways, ladders, deck scuttles, and windows.

(d) The number and dimensions of the means of escape from each space must be sufficient for rapid evacuation in an emergency for the number of persons served. In determining the number of persons served, a space must be considered to contain at least the number of persons as follows:

(1) Passenger overnight accommodation spaces: Designed capacity;

(2) Accommodation spaces having fixed seating for passengers:
Maximum seating capacity;

(3) Public spaces, including spaces such as casinos, restaurants, club rooms, and cinemas, and public accommodation spaces as defined in Sec. 175.400 of this subchapter, except overnight accommodation spaces: One person may be permitted for each 0.9 square meters (10 square feet) of deck area. In computing such deck area, the following areas must be excluded:

(i) Areas for which the number of persons permitted is determined using the fixed seating criterion;

(ii) Obstructions, including stairway and elevator enclosures, elevated stages, bars, and cashier stands, but not including slot machines, tables, or other room furnishings;

(iii) Toilets and washrooms;

(iv) Interior passageways less than 860 millimeters (34 inches) wide and passageways on open deck less than 710 millimeters (28 inches) wide;

(v) Spaces necessary for handling lifesaving equipment, anchor handling equipment, or line handling gear, or in way of sail booms or running rigging; and

(vi) Bow pulpits, swimming platforms, and areas that do not have a solid deck, such as netting on multi hull vessels;

(4) Crew overnight accommodation spaces: Two-thirds designed capacity; and

(5) Work spaces: Occupancy under normal operating conditions.

(e) The dimensions of a means of escape must be such as to allow easy movement of persons when wearing life jackets. There must be no protrusions in means of escape that could cause injury, ensnare clothing, or damage life jackets.

(f) The minimum clear opening of a door or passageway used as a means of escape must not be less than 810 millimeters (32 inches) in width, however, doors or passageways used solely by crew members must have a clear opening not less than 710 millimeters (28 inches). The sum of the width of all doors and passageways used as means of escape from a space must not be less than 8.4 millimeters (0.333 inches) multiplied by the number of passengers for which the space is designed.

(g) A dead end passageway, or the equivalent, of more than 6.1 meters (20 feet) in length is prohibited.

(h) Each door, hatch, or scuttle, used as a means of escape, must be capable of being opened by one person, from either side, in both light and dark conditions. The method of opening a means of escape must be obvious, rapid, and of adequate strength. Handles and securing devices must be permanently installed and not capable of being easily removed. A door, hatch or scuttle must open towards the expected direction of escape from the space served.

(i) A means of escape which is not readily apparent to a person from both inside and outside the space must be adequately marked in accordance with Sec. 185.606 of this chapter.

(j) A ladder leading to a deck scuttle may not be used as a means of escape except:

(1) On a vessel of not more than 19.8 meters (65 feet) in length, a vertical ladder and a deck scuttle may be used as not more than one of the means of escape from passenger accommodation space; or

(2) As not more than one of the means of escape from any crew accommodation space or work space.

(k) Each ladder used as a means of escape must be mounted at least 180 millimeters (7 inches) from the nearest permanent object in back of the ladder. Rungs must be:

(1) At least 405 millimeters (16 inches) in width; and

(2) Not more than 305 millimeters (12 inches) apart, and uniformly spaced for the length of the ladder with at least 114 millimeters (4.5 inches) clearance above each rung.

(1) When a deck scuttle serves as a means of escape, it must not be less than 455 millimeters (18 inches) in diameter and must be fitted with a quick acting release and a holdback device to hold the scuttle in an open position.

(m) Footholds, handholds, ladders, and similar means provided to aid escape, must be suitable for use in emergency conditions, of rigid construction, and permanently fixed in position, unless they can be folded, yet brought into immediate service in an emergency.

(n) On a vessel of not more than 19.8 meters (65 feet) in length, a window or windshield of sufficient size and proper accessibility may be used as one of the required means of escape from an enclosed space, provided it:

(1) Does not lead directly overboard;

(2) Can be opened or is designed to be kicked or pushed out; and

(3) Is suitably marked.

(o) Only one means of escape is required from a space where:

(1) The space has a deck area less than 30 square meters (322 square feet);

(2) There is no stove, heater, or other source of fire in the space;

(3) The means of escape is located as far as possible from a machinery space or fuel tank; and

(4) If an accommodation space, the single means of escape does not include a deck scuttle or a ladder.

(p) Alternative means of escape from spaces may be provided if acceptable to the cognizant OCMI.

Sec. 177.820 Seating.

(a) A seat must be provided for each passenger permitted in a space for which the fixed seating criterion in Sec. 176.113(b) (3) of this subchapter has been used to determine the number of passengers permitted.

(b) A seat must be constructed to minimize the possibility of injury and avoid trapping occupants.

(c) Installation of seats must provide for ready escape.

(d) Seats, including fixed, temporary, or portable seats, must be arranged as follows:

(1) An aisle of not more than 3.8 meters (15 feet) in overall length must be not less than 610 millimeters (24 inches) in width.

(2) An aisle of more than 3.8 meters (15 feet) in overall length must be not less than 760 millimeters (30 inches) in width.

(3) Where seats are in rows, the distance from seat front to seat front must be not less than 760 millimeters (30 inches) and the seats must be secured to a deck or bulkhead.

(4) Seats used to determine the number of passengers permitted, in accordance with Sec. 176.113(b) (3) of this chapter, must be secured to the deck, bulkhead, or bulwark.

Sec. 180.78 Stowage of life jackets.

(a) General. Unless otherwise stated in this section, life jackets must be stored in convenient places distributed throughout accommodation spaces.

(1) Each stowage container for life jackets must not be capable of being locked. If practicable, the container must be designed to allow the life jackets to float free.

(2) Each life jacket kept in a stowage container must be readily available.

(3) Each life jacket stowed overhead must be supported in a manner that allows quick release for distribution.

(4) If life jackets are stowed more than 2,130 millimeters (7 feet) above the deck, a means for quick release must be provided and must be capable of operation by a person standing on the deck.

(5) Each child size life jacket must be stowed in a location that is appropriately marked and separated from adult life jackets so the child size life jackets are not mistaken for adult life jackets.

(b) Additional personal flotation devices. The stowage locations of the personal flotation devices carried in addition to life jackets under Sec. 180.72, must be separate from the life jackets, and such as not to be easily confused with that of the life jackets.

Sec. 185.420 Crew training.

(a) The owner, charterer, master or managing operator shall instruct each crew member, upon first being employed and prior to getting underway for the first time on a particular vessel and at least once every three months, as to the duties that the crew member is expected to perform in an emergency including, but not limited to, the emergency instructions listed on the emergency instruction placard required by Sec. 185.510 of this part and, when applicable, the duties listed in the station bill required by Sec. 185.514 of this part.

(b) Training conducted on a sister vessel may be considered equivalent to the initial and quarterly training requirements contained in paragraph (a) of this section.

(c) Crew training shall be logged or otherwise documented for review by the Coast Guard upon request. The training entry shall include the following information.

- (1) Date of the training; and
- (2) General description of the training topics.

Sec. 185.506 Passenger safety orientation.

(a) Except as allowed by paragraphs (b) and (c) of this section, before getting underway on a voyage or as soon as practicable thereafter, the master of a vessel shall ensure that suitable public announcements are made informing all passengers of the following:

- (1) The location of emergency exits, survival craft embarkation areas, and ring life buoys;
- (2) The stowage location(s) of life jackets;
- (3) Either:
 - (i) The proper method of donning and adjusting life jackets of the type(s) carried on the vessel including a demonstration of the proper donning of a life jacket, or
 - (ii) That passengers may contact a crew member for a demonstration as appropriate, prior to beginning an oceans or coastwise voyage;
- (4) The location of the instruction placards for life jackets and other lifesaving devices;
- (5) That all passengers will be required to don life jackets when possible hazardous conditions exist, as directed by the master; and
- (6) If the vessel is operating with reduced manning or equipment requirements in Sec. 176.114 of this chapter.

(b) As an alternative to an announcement that complies with paragraph (a) of this section, the master or other designated person may--

(1) Prior to getting underway, deliver to each passenger or, on a vessel that does not carry vehicles and that has seats for each passenger, place near each seat, a card or pamphlet that has the information listed in paragraphs (a)(1) through (a)(6) of this section; and

- (2) Make an abbreviated announcement consisting of:
- (i) A statement that passengers should follow the instructions of the crew in an emergency;
 - (ii) The location of life jackets; and
 - (iii) That further information concerning emergency procedures including the donning of life jackets, location of other emergency equipment, and emergency evacuation procedures are located on the card or pamphlet that was given to each passenger or is located near each seat.

(c) Ferries operating on short runs of less than 15 minutes may

substitute bulkhead placards or signs for the announcement required in paragraphs (a) and (b) of this section if the OCMi determines that the announcements are not practical due to the vessel's unique operation.

(d) The master of a vessel shall ensure that a passenger, who boards the vessel on a voyage after the initial public announcement has been made as required by paragraphs (a) or (b) of this section, is also informed of the required safety information.

(e) On a vessel on a voyage of more than 24 hours duration, passengers shall be requested to don life jackets and go to the appropriate embarkation station during the safety orientation. If only a small number of passengers embark at a port after the original muster has been held, these passengers must be given the passenger safety orientation required by paragraphs (a) or (b) of this section if another muster is not held.

Sec. 185.508 Wearing of life jackets.

(a) The master of a vessel shall require passengers to don life jackets when possible hazardous conditions exist, including, but not limited to:

- (1) When transiting hazardous bars and inlets;
- (2) During severe weather;
- (3) In event of flooding, fire, or other events that may possibly call for evacuation; and
- (4) When the vessel is being towed, except a non-self-propelled vessel under normal operating conditions.

(b) The master or crew shall assist each passenger in obtaining a life jacket and donning it, as necessary.

Sec. 185.510 Emergency instructions.

(a) The master and crew of a vessel will be familiar with the content of and have mounted at the operating station, emergency instructions containing the actions to be taken in the event of fire, heavy weather, or man overboard conditions.

(b) Except when in the judgment of the cognizant OCMi the operation of a vessel does not present one of the hazards listed, the emergency instruction placard should contain at least the applicable portions of the ``Emergency Instructions'' listed in Sec. 185.512. The emergency instructions must be designed to address the particular equipment, arrangement, and operation of each individual vessel.

(c) If the cognizant OCMi determines that there is no suitable mounting surface aboard the vessel, the emergency instructions need not be posted but must be carried aboard the vessel and be available to the crew for familiarization.

Sec. 185.512 Recommended emergency instructions format.

An emergency instruction placard containing the following information will satisfy the requirements of Sec. 185.510.

(a) Emergency instructions--(1) Rough weather at sea, crossing hazardous bars, or flooding. (i) Close all watertight and weathertight doors, hatches, and airports to prevent taking water aboard or further

flooding in the vessel.

(ii) Keep bilges dry to prevent loss of stability due to water in bilges. Use power driven bilge pump, hand pump, and buckets to dewater.

(iii) Align fire pumps to use as bilge pump if possible.

(iv) Check all intake and discharge lines, which penetrate the hull, for leakage.

(v) Passengers must remain seated and evenly distributed.

(vi) Passengers must don life jackets if the going becomes very rough, the vessel is about to cross a hazardous bar, or when otherwise instructed by the master.

(vii) Never abandon the vessel unless actually forced to do so.

(viii) If assistance is needed follow the procedures on the emergency broadcast placard posted by the radiotelephone.

(ix) Prepare survival craft (life floats, (inflatable) rafts, (inflatable) buoyant apparatus, boats) for launching.

(2) Man overboard. (i) Throw a ring buoy overboard as close to the person as possible.

(ii) Post a lookout to keep the person overboard in sight.

(iii) Launch rescue boat and maneuver to pick up person in the water, or maneuver the vessel to pick up the person in the water.

(iv) Have crew member put on life jacket, attach a safety line to him or her, and have him or her stand by jump into the water to assist the person overboard if necessary.

(v) If person is not immediately located, notify Coast Guard and other vessels in vicinity by radiotelephone.

(vi) Continue search until released by Coast Guard.

(3) Fire. (i) Cut off air supply to fire--close items such as hatches, ports, doors, ventilators, and louvers, and shut off ventilation system.

(ii) Cut off electrical system supplying affected compartment if possible.

(iii) If safe, immediately use portable fire extinguishers at base of flames for flammable liquid or grease fires or water for fires in ordinary combustible materials. Do not use water on electrical fires.

(iv) If fire is in machinery spaces, shut off fuel supply and ventilation and activate fixed extinguishing system if installed.

(v) Maneuver vessel to minimize effect of wind on fire.

(vi) If unable to control fire, immediately notify the Coast Guard and other craft in the vicinity by radiotelephone.

(vii) Move passengers away from fire, have them put on life jackets, and if necessary, prepare to abandon the vessel.

(b) [Reserved]

Appendix C – Sample Briefing

Ladies and gentlemen, welcome aboard the *Commander Gompei*. Emergencies are extremely rare, but in the unlikely event of an evacuation, passengers who have paid attention to the safety briefing are better prepared to handle an emergency. Therefore, we ask you to give your full attention to this safety demonstration. The main exits are located at the front and back of the vessel. There are also emergency windows located along the sides of the vessels, which can be opened by pulling the red handle up and pushing the window out. Please take a second now to find the exit which is most accessible to you. Please also take a second to note the location of life jackets, which are located in storage areas underneath your seats. If emergency evacuation becomes necessary, a crewmember will direct you to locate and don a life jacket and to access your nearest exit. To don the life jacket, follow these steps. Place the life jacket over your head, and attach the Velcro connectors as shown. Then bring the strap around your body, connect the buckle, and pull the free end of the strap to create a tight fit. For further information, please refer to the informational signs found at the front and back of the vessel. If you need further assistance, crewmembers are available to answer any questions you have. Thank you for your attention, and we would like to wish you a pleasant voyage today.

Appendix D – Sample Signage

Sample Signage

EMERGENCY PROCEDURES:

- 1) follow directions of crew at all times
- 2) retrieve lifejacket from storage areas
- 3) don lifejacket
- 4) walk calmly and directly to nearest exit
- 5) open door / window and exit from vessel

EVACUATION PLAN

LIFEJACKET DONNING INSTRUCTIONS

PLACE THE LIFEJACKET OVER YOUR HEAD.	BRING THE STRAP AROUND YOUR BODY AND FASTEN THE CLOSURE.
ADJUST TO A SNUG FIT BY PULLING THE FREE END OF THE STRAP.	IF ENTERING THE WATER CROSS YOUR ARMS ACROSS YOUR CHEST AND ENTER FEET FIRST.

EMERGENCY ESCAPE WINDOW

EXIT

Appendix E – PFD Instructions used for PFD Experiment



Place PFD over head



Secure neck ring



Bring strap around body and fasten closure



Adjust to a snug fit by pulling free end of strap



Cross arms across chest and enter water feet first