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Advanced Marketing Solutions

COMPREHENSIVE REVIEW OF THE STEAMSHIP AUTHORITY'S OPERATIONS

13 December 2018

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Executive Summary

In the spring of 2018, the Steamship Authority experienced three blackouts, a grounding, and a number of critical IT system outages. The resulting trip delays and cancellations, coupled with breakdowns in communication to the public, resulted in a public relations crisis and a call to action by the SSA's governing Board on behalf of their constituents. This study is the response to that call. Following a public RFP process, HMS Consulting, Glosten, and Rigor Analytics were charged with performing a comprehensive review of SSA operations, with a focus on five subject areas: fleet maintenance, vessel operations, management structure, public communications, and IT systems.

In July of 2018, a team of experts in these subject areas visited the SSA. The team conducted interviews with employees throughout the organization, observed vessel operations, and inspected the vessels, terminals, maintenance facilities, and IT infrastructure. Based on material gathered during and after the reconnaissance visit, the team utilized root cause analysis techniques to identify critical errors that directly and indirectly resulted in the incidents that led to the crisis.

The goal of this study was to understand the underlying causes of the SSA's failures to deliver on its public service commitments and develop recommendations for how to prevent similar incidents from occurring in the future. This executive summary describes the most critical areas for improvement that emerged from the investigation.

Public Perception

While public backlash was justified by the series of incidents in early 2018, it wasn't due to a lack of commitment by the employees of the SSA to provide reliable service. This is deeply ingrained in the SSA's culture. The problems in the spring of 2018 were despite this commitment to service. In fact, the organization excels in many areas that should be acknowledged. Unfortunately, the public perception is perhaps ill-informed and not properly managed.

For example, the SSA's budget is supported by operating revenues of approximately $100 million annually. Since 1962, the SSA has had only four annual operating deficits, and it has not had to assess the taxpayers of the participating communities for monetary support since 1963. Impressively, the SSA has never relied on annual government subsidies. For a service that is mandated by legislation to provide critical services to the public, to not receive sizable financial support is extremely unique in the industry. Few public ferry services in the US, and globally for that matter, are able to achieve similar success while providing a quality service. This is an impressive accomplishment that is not fully understood or appreciated by the public they serve.

Vision and Leadership

A primary responsibility of an organization's leadership is to manage the culture of the organization. This is accomplished by publicizing the organization's vision, actively promoting it, and reinforcing it with actions.

By contrast, the SSA does not actively publicize its mission, so it is left to interpretation by the workforce and the public's perceptions of the actions of SSA leadership. For decades, the message from leadership has been narrowly focused on frugality. While fiscal responsibility is critical for an organization that operates without operating subsidies, it should not define what the organization aspires to accomplish. A broader vision may include financial aspects but should also seek to achieve the high quality and safe delivery of a service as primary objectives.

The lack of a clear and aspirational vision at the SSA has led to competing factions within the organization. This appears in regular interactions between various departments and individuals, resulting in different factions undermining and working against each other at the expense of the organization's performance.

The SSA's leadership needs to develop a clear vision for the organization that will promote a more cohesive culture. This vision should be captured in an updated mission statement, which should be actively promoted to employees and the general public and reinforced with actions.

Counter-Productive Frugality

Perhaps in response to operating without subsidies, SSA management exhibits a level of frugality, or "penny pinching," that hinders its ability to implement best practices and function properly. SSA's frugality is based on admirable goals, but its overemphasis on cost reductions has been penny wise and pound foolish.

Excessive frugality has resulted in understaffing across the organization, but especially in key technical roles within vessel operations and engineering. This has directly and indirectly contributed to vessel incidents. These incidents end up costing SSA due to unplanned maintenance and lost revenue.

Understaffing of upper management is also problematic. SSA is over reliant on a small number of individuals who hold inordinate amounts of knowledge and power, resulting in an executive team that is stuck in a perpetual mode of day-to-day firefighting. The primary focus of these roles should be long-term sustainability and improvement of the organization, but almost no long-term planning is currently being performed.

Smart investments in safety and quality will actually reduce overall costs, while improving public perception and employee morale. Investing in the most valuable asset, the employees, will become a force multiplier. Right-sizing management by <u>adding</u> key positions with critical skills will increase capabilities. Investing in a safety management system (SMS) and a high-quality enterprise asset management system will significantly reduce risk and liability, reduce unplanned downtime, and improve the efficiency of repairs. Restored trust in the system by both vessel crews and the general public will positively impact morale and revenue.

Moving to a Process-Based Culture

There are many latent issues with SSA operations that could result in future incidents. To prevent a repeat of the spate of incidents that instigated this study, or worse, it is necessary to evolve from a reactive culture to a process-based culture.

The SSA operates almost entirely reactively, rather than actively identifying and attempting to mitigate risks. SSA standards for vessel operations and maintenance illustrate this culture, where the de facto standards for safety and quality assurance are the minimum requirements enforced by the US Coast Guard. Internal investigations of incidents and near misses are valuable learning opportunities and considered a best practice but are not required by these quality standards.

Modern maritime organizations require processes and standards. This was identified in the formal investigation of the capsizing of the ferry M/V *Herald of Free Enterprise* on March 6, 1987 which resulted in the death of 193 passengers and crew (Reference 8). In the investigation, the root cause was identified as a "disease of sloppiness" on the part of the vessel's management. This assessment was centered on the company's lack of process-based management. Since this incident, the industry has evolved significantly, but evidence suggests that the SSA has not.

Several key personnel at the SSA do not endorse this theory, as illustrated by the following quotes:

- "We have operated this ferry system for years and years without problems like we had in the spring of 2018, and we will operate for years and years without any similar issues."
- "This was a perfect storm of events."
- "There's nothing broken here, it's always worked."

But from our experience, this could not be further from the truth.

The root cause analysis (RCA) performed on the March 17th *MV Martha's Vineyard* blackout identified twenty-one individual issues with the vessel plant and the way it was operated. The net result of all of these issues was an unsafe condition on the vessel that led to the incident. While the blackout did not result in any serious casualties, had it occurred minutes later, while the vessel was maneuvering into the dock, the consequences could have been dire.

Quality and safety processes inherent to most modern marine operations are designed to identify and correct issues before they manifest into a potentially unsafe condition. The identification and correction of just one of the twenty-one issues mentioned above may have prevented the incident entirely. Currently, there is no system in place at the SSA to accomplish this. The SSA's reactive culture is designed to address the immediate cause, but not the root cause.

Greater Accountability

A lack of accountability for the performance of the organization was observed within SSA management. Underperformance is being tolerated because the SSA lacks a system to adequately measure employee performance and the resolve to address obvious underperformers. SSA managers demonstrated the tendency to place blame for vessel incidents on individual crew members, rather than taking responsibility for the tools or systems they lack but require in order to succeed.

Concluding that an incident is simply due to operator error is a missed opportunity to understand why the error occurred and how to improve system resilience so that future consequences of errors are minimized. The human element and mechanical failures can never be completely eliminated. It is management's role to develop and maintain systems that minimize the occurrence of incidents, and the consequences of incidents when they do occur.

The Board should be held accountable for developing and enforcing a strategic plan, and management should be held accountable for meeting the goals of the strategic plan. To invoke this accountability, managers should be evaluated on objective performance metrics and goals that are directly tied to the objectives of the strategic plan.

Holding managers accountable to performance metrics based on a strategic plan will improve efficiency by aligning efforts, improving the allocation of human resources, and rewarding excellence while identifying and correcting underperformance.

SSA frontline employees, including maintenance personnel and vessel crew, need to be given the tools to succeed, beginning with adequate training and equipment that is adequately maintained.

Section 1 Introduction

1.1 Purpose of Study

The Steamship Authority (SSA) is the primary ferry system providing service to the islands of Martha's Vineyard and Nantucket from Cape Cod. In March and early April 2018, an unprecedented series of mechanical and operational problems occurred on the ferries, resulting in many unexpected trip cancellations. The events led to an erosion in public confidence and raised questions about the SSA's vessel maintenance practices, fleet rotations, public communications and other aspects of its operations.

The purpose of this study is to understand any systematic problems and organizational circumstances that allowed or encouraged the problems SSA experienced in the spring of 2018, and develop practical and effective recommendations that will reduce the chances of any such problems in the future.

1.2 Scope of Study

The scope of the study was limited to five areas of focus, as defined below:

- **Vessel operations.** Vessel operations encompasses the management of the vessels: fleet scheduling and planning, support logistics, crew scheduling, policies, and procedures. It also includes onboard vessel operations, such as navigation, passenger management, deck operations, engineering, and standard operating procedures.
- **Fleet maintenance.** The evaluation of fleet maintenance includes both planned and unplanned maintenance events. Planned maintenance events cover both the routine maintenance items performed by the SSA personnel and depot-level maintenance that is outsourced to contractors and shipyards. The evaluation also includes the methods by which the SSA determines maintenance requirements, how resources such as time, budget, and personnel training are allocated to conduct maintenance, and how the effectiveness of the SSA's maintenance program is determined.
- **Management structure**. Management structure is defined as the relationship between organizational culture and organizational structure that results in the overall organizational climate. This relationship determines the effectiveness of management to perform well and meet its objectives. These three elements function in a similar fashion as gears in a machine, whereby if they don't integrate the machine will not run properly. A review of the SSA's management structure focuses on how well integrated these three elements are and the resulting performance of the organization. Additionally, this review looks closely at recent changes, how management has adapted and the effect they have had on its performance.
- **Information technology systems**. The evaluation of IT Systems includes a complete review of the SSA's IT architecture, including its website/reservation system, finance system, phone system, asset maintenance system, email or alert systems and how each system is integrated with the other, as well as the redundancy, security and hosting/reliability of each system. The SSA has purchased new financial and hardware/software recently and implemented redundancy and disaster recovery processes. Therefore, much of the review focuses on the integration of information, the collection and accuracy of the information, the ease of use and updating the information, and the timing or speed in which the information is disseminated to end users.

- **Public communications**. Public communications will be addressed in a supplemental document to this report.

1.3 The Steamship Authority

The Woods Hole, Martha's Vineyard and Nantucket Steamship Authority's statutory mission is to serve as the "Lifeline to the Islands" for everyone from year-round residents, who depend on the ferries for all commerce and transportation to and from the mainland, to a significant seasonal population, to the tourists who visit for a day, a week or longer.

The Steamship Authority (SSA) is the primary ferry system providing service to the islands of Martha's Vineyard and Nantucket from Cape Cod and the only service that carries vehicles. Established as an independent public authority in 1960, the authority is governed by a five-member board with representation from each island (Martha's Vineyard and Nantucket) and the mainland communities of Falmouth, Barnstable, and New Bedford. The Port Council, a seven-member advisory board, consists of appointed members representing the municipal authorities of the following communities: Barnstable, Fairhaven, Falmouth, Nantucket, New Bedford, Oak Bluffs, and Tisbury.

The SSA has its principle administrative offices in Falmouth, MA with ferry terminals in Woods Hole and Hyannis on Cape Cod, Vineyard Haven and Oak Bluffs on Martha's Vineyard, and a terminal on the island of Nantucket. They own and operate year-round parking lots in Woods Hole, Falmouth, and Hyannis and operate seasonal off-site parking lots in Falmouth, Bourne, and Hyannis. The SSA also has a vessel maintenance facility in Fairhaven and a receiving warehouse in Falmouth, and it rents property in Mashpee for its reservation office.

The SSA currently services two primary routes; Woods Hole to Martha's Vineyard (both Vineyard Haven and Oak Bluffs depending on schedule and season) and Hyannis to Nantucket. They operate a total of ten vessels carrying passengers, vehicles, and commercial freight trucks. These ten vessels include five passenger-vehicle ferries, four roll-on/roll-off freight vessels that carry a limited number of passengers and commercial trucks, and one high-speed passenger-only catamaran ferry.

The SSA's budget is supported by operating revenues of about $100 million. Since 1962, the SSA has had only four annual operating deficits, and it has not had to assess the taxpayers of the participating communities for monetary support since 1963.

1.4 The Study Team

The study team was made up of consultants from three firms; HMS Consulting and Technical, Glosten, and Rigor Analytics. The team consisted of subject matter experts, management consultants, IT consultants, marine engineers, and maritime professionals with experience in ferry system management. During the course of this independent study, the SSA provided documentation and information, but did not participate in the analysis or conclusions.

Section 2 Methodology

This study focused on four primary areas of the SSA's operations: vessel operations, fleet maintenance, management structure, and information technology systems. The methods used in this study were designed to identify the most valuable recommendations to improve these areas of their operations. This was accomplished through a combination of data review, general observations by subject matter experts, and root cause analysis.

2.1 Project Plan

A formal project plan document, approved by the SSA as the project sponsor, was agreed upon and utilized to guide project execution, facilitate communication among stakeholders, and document the scope and schedule. This was done to align the goals of all parties and ensure a clear focus on the objectives throughout the project.

The project planning process cooperatively established project objectives and measures for success before work on the project commenced. The organization of the project team was defined, and guidelines for decision making and managing conflict and change were established in writing. The project plan also contained communications protocols and project meeting schedules.

2.2 Data Requests

Data that was needed to perform analyses was requested from the SSA early in the project schedule. The SSA provided timely response to requests, allowing the study team to become familiar with SSA operations in advance of their site visit. Requested data included:

- Paper records – logs, paper charts, correspondences, procedures, policies, administrative controls, etc.
- Electronic records – procedures, policies, administrative controls, drawings, performance and operational data, analysis results, procurement specifications, etc.
- People – discussions with employees, management, participants, etc.

2.3 Site Visit and General Observations

The project team performed a site visit during a five-day period from Monday July 23rd through Friday July 27th to make observations and gather data that could not be acquired remotely. One of the key objectives during the visit was to identify areas in which the SSA excels and what their key challenges are. General observations were made throughout the visit to gain insights regarding the culture at the SSA, general operating practices, and the underlying causes and impacts of recent incidents.

Meetings and interviews were conducted with a broad cross-section of management, staff, front line workers, ship's officers and crew, and members of the SSA's Board and Port Council. Interview questions were developed in advance, incorporating the best available knowledge at the time of inception. During the meetings, additional inquiries were made as new information emerged.

2.4 Root Cause Analysis

This study utilized root cause analysis (RCA) to examine incidents with high potential learning value, particularly incidents that were likely to be representative of systemic problems across the organization.

The study team selected an RCA process derived from the American Bureau of Shipping (ABS) Marine Root Cause Analysis Technique (MaRCAT, Reference 2). In this technique, causal factors of marine incidents are identified and analyzed in order to identify the underlying root causes of the incidents.

The objective of the RCA process is to identify where improvements in management systems could have prevented the causal factors from occurring. Even in instances where individual personal performance (the human element) or mechanical failures are identified as causal factors of an incident, this technique shows how the root cause of incidents is almost always the absence, neglect, or deficiencies of management systems.

A review period was held with the SSA in order to verify the facts surrounding each incident investigated through the RCA process. This review was performed by conducting videoconferences with appropriate stakeholders identified by the SSA. The presentation included a synopsis of each event, demonstration of the causal chain of events, identification of the key causal factors, and a review of the root cause mapping process. Where necessary, facts were confirmed or reinvestigated.

More information on the root cause analysis method is presented in Section 3.1.

2.5 Development of Recommendations

The methods described above provided the study team with two primary sources of data with which to identify challenges at the SSA. This in turn allowed the study team to develop a set of potential solutions for each challenge.

Solutions to the problems identified by the RCAs are intended to provide systematic improvements that address the intermediate and root causes of each incident:

- Intermediate solutions – Address the explicit reasons why a causal factor occurred, providing quick fixes, but do not address the root cause.
- Root cause solutions – Address underlying deficiencies in management that allow causal factors to occur. Typically represent longer term efforts and results.

Solutions were also developed to address problems identified from observations made during the reconnaissance and data collection process.

The set of solutions from RCAs and General Observations were evaluated for conflicts, similarities, and synergies. This resulted in a subset of recommendations.

Recommendations were then evaluated for their potential impact and ease of implementation. Impact represents the net benefit a recommendation has on the organization, in terms of overcoming one or more of the problems identified in our investigation. Ease of implementation measures how easily a recommendation can be implemented, based on cost, schedule, labor, and other potential barriers.

The final recommendations presented in Section 5 are those which maximize impact and minimize barriers to implementation.

Section 3 Root Cause Analysis

3.1 Introduction to the Root Cause Analysis Process

The root cause analysis technique used by the study team is a structured approach to investigating events that was derived from ABS guidance and is a widely accepted standard across the marine industry (Reference 2). After selecting incidents for analysis and gathering and preserving the necessary data, a data analysis technique must be adopted.

The analysis technique adopted for this study combines the 'five-why's' technique with causal factor charting. Combined, this technique charts a chain of building blocks that establishes a timeline and the relationships between known events and conditions, as illustrated in Figure 1.

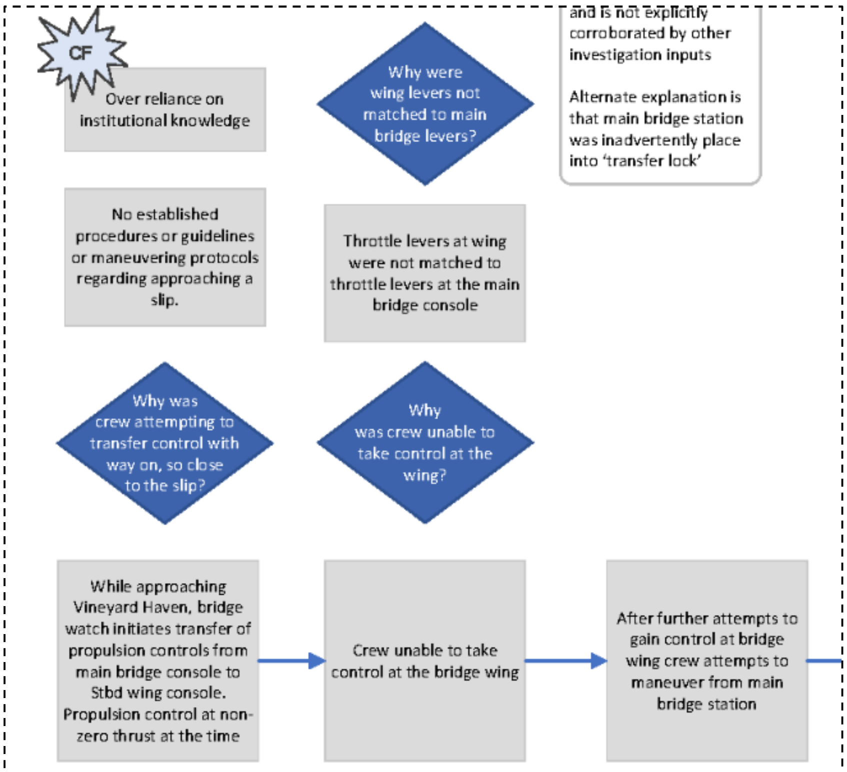


Figure 1 Sample causal factor building blocks

Building blocks lead to causal factors, which include structure, machinery, equipment, outfitting, human errors, and external factors. Incidents may have multiple causal factors.

Intermediate and root causes of the incident are derived from the causal factors using ABS's root cause analysis map (see Appendix A). A given causal factor may take a single path through the map to lead to a root cause, or it may follow multiple paths leading to multiple intermediate and root causes.

In the following sections, summaries of each root cause analysis are presented. Each summary provides a synopsis of the incident, identifies the causal factors, and illustrates how the causal factors were mapped to intermediate and root causes. Specific solutions are presented for each intermediate and root cause, and a concise list of both immediate solutions and root cause solutions is presented in Appendix B. Solutions to both the intermediate and root causes were used to inform the study's Final Recommendations.

In several cases it was not possible for the team to answer every question or determine the immediate cause of equipment failures. However, the focus of a root cause analysis is to determine the failures in management systems which allowed for the immediate cause to have a negative impact. While it would be nice to know why a particular piece of equipment failed or a decision was made, the true value of root cause analysis is to identify how that failure could have been sustained without it resulting in an incident. In each case, the team was successful in accomplishing this.

3.2 March 15th Grounding of the M/V *Woods Hole*

On March 15, 2018 at approximately 9:30 am, upon approach to Vineyard Haven Slip #1, the M/V *Woods Hole* experienced a temporary loss of main propulsion engine control that resulted in a soft grounding of the bulbous bow.

Upon approach to the slip, the captain initiated a final maneuver to reach alignment from the main bridge controls. In the middle of the maneuver, the bridge crew attempted to transfer control to the starboard wing station. The pilot/mate initiated transfer by going out to the wing station to take control. The pilot/mate reported to the captain that he was unable to take control on the bridge wing. At that point, the captain, at the main bridge console, was also unable to retake control. The captain notified the chief engineer (who was stationed in the Engine Control Room) to take control locally and attempt to resend it back to the main bridge console. The chief engineer did so with success, and the captain was able to regain control at the main bridge console. By this time, the vessel's bulbous bow had a soft grounding. The vessel was then able to continue into the slip without further issues.

The main propulsion controls are a newer system from Prime Mover Controls (PMC) with which the crew had limited experience and had never received formal training .

The chain of events is based on information provided by vessel crew through written statements and verbal discussions. Additional discussions were held with technical representatives from PMC and engineering staff. Unfortunately, the M/V *Woods Hole* is not equipped with a Voyage Data Recorder (VDR), which may have provided additional insight as to the cause of the failure to transfer control. Therefore, it was not possible to definitively determine the cause of the immediate failure of the main propulsion control system. The most likely immediate cause (not a causal factor) was a failure of the control system itself, which could not be replicated or verified by PMC technicians, or operator error. While the cause could not be confirmed, the immediate cause was found to be irrelevant to the root cause of the incident.

The root cause analysis of this event resulted in the causal factor chart illustrated in Appendix A, and identification of the following causal factors:

Causal Factor #1: Overreliance on institutional knowledge.

Causal Factor #2: Insufficient training on new equipment.

Causal Factor #3: No established procedure.

Causal Factor #4: No process to communicate a potential problem.

Determinations of root causes for these causal factors are described below.

3.2.1 Causal Factor #1: Overreliance on Institutional Knowledge

Control transfer was initiated in close proximity to the slip with no established procedures, guidelines, or protocols for maneuvering in a way to mitigate risk posed by equipment failures or human error. The experience of the crew was considered a substitute for risk identification and training. Guidelines on vessel maneuvering should identify potential risks, including mechanical failures and operator errors, and ensure vessel maneuvers are initiated in such a way as to mitigate these risks. In this particular case, if the attempt to transfer control had been initiated prior to reaching a ‘point of no return’, an opportunity to recover from a failure in the system would have been provided. As it was, regardless of the cause of the transfer failure, by the time control was reestablished it was too late to avoid a grounding. Rather than a procedure or guidelines, the SSA relied solely on the experience of their vessel operators without taking into account that the control system had been changed in the recent repair period.

This causal factor follows multiple paths when mapped to the root causes:

Root Cause Mapping: Overreliance on Institutional Knowledge (a)

Category	Mapping	Description
Problem	Human (4)	The nature of the problem was that a human(s) relied on their experience in the organization rather than training and therefore did not recognize the need for training.
Problem Category	Company Employee (12)	The individuals responsible for identifying training needs were company employees.
Cause Category	Training Personnel Qualifications (178)	Sufficient training was not provided to successfully perform the task.
Cause Type	No Training (179)	No decision was made to identify training requirements.
Intermediate Cause	Training Need Not Identified (183)	The grounding event wrongly served to identify the training need. A memo was distributed after the event entitled “*MV Woods Hole* Captains Training Checklist” that included a successful demonstration of PMC Control Station Transfers.
Solution to Intermediate Cause	A risk assessment for approaching and departing each terminal should be performed, identifying potential risks, and providing a means to mitigate each identified risk.	
Root Cause Type	SPACS Issue (256)	SPACs inadequate, confusing, incomplete, or unclear.
Root Cause	SPAC / Confusing Contradictory or Incomplete (259)	SPACs not specific enough

Root Cause Mapping: Overreliance on Institutional Knowledge (b)

Category	Mapping	Description
Problem	Human (4)	The nature of the problem was that a human(s) relied on their experience in the organization and did not identify the risks associated with the task.
Problem Category	Company Employee (12)	The individuals responsible for identifying risks were company employees.
Cause Category	Human Factor (143)	The capabilities and limitations of the individuals involved were not considered in the design and development of the control system.

Root Cause Mapping: Overreliance on Institutional Knowledge (b)		
Category	**Mapping**	**Description**
Cause Type	Situational Awareness (150)	The crew was not aware of the risk potential associated with transferring control in close proximity to fixed objects.
Intermediate Cause	Knowledge Based Decision Required (157)	Personnel had to make decisions based on specific knowledge of the system for a successful outcome, but no procedure existed and no one else on board had a sufficient level of experience with the system.
Solution to Intermediate Cause	Tools such as decision trees, job risk assessments and flow charts should be provided to aid decision making. Unusual events should be used as a learning and training tool. Personnel should be trained to use the information they are provided.	
Root Cause Type	SPACS issue (256)	SPACs inadequate, confusing, incomplete, or unclear.
Root Cause	SPAC / Confusing Contradictory or Incomplete (259)	SPACs not specific enough

Root Cause Mapping: Overreliance on Institutional Knowledge (c)		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human(s) relied on their experience in the organization and did not identify the unique, vessel specific training needs associated with the equipment on board the vessel.
Problem Category	Company Employee (12)	The individuals responsible for identifying these training needs were company employees.
Cause Category	Training Personnel Qualifications (178)	The training was not sufficient to perform the task.
Cause Type	Training Issue (187)	The task was not analyzed, and no testing was performed to measure the ability of the crew to perform the task.
Intermediate Cause	Training Program Design Objectives Issue (188)	The existing training design does not include vessel specific familiarization procedures. The SSA's Pilot Training Manual addresses route familiarization but not vessel familiarization. The "Operations and Safety Manual" (published in 1997) includes an operational checklist entitled "Familiarization with Bridge Equipment "and a "New Crewmember Orientation Checklist". The checklists are not vessel specific, they do not address transfer control and there is scanty evidence that the 1997 manual is in use.
Solution to Intermediate Cause	The training needs for deck officers should be analyzed, and training criteria and curriculum should be established based on those needs.	
Root Cause Type	SPACS Issue (256)	SPACs inadequate, confusing, incomplete, or unclear.
Root Cause	SPAC / Not Strict Enough (258)	SPACs not specific enough

3.2.2 Causal Factor #2: Insufficient Equipment Training

SSA management assumed that the task of understanding the transfer of control on the new system was a skill that would be gained through experience. As a result, risks were not identified and training procedures were not developed.

Root Cause Mapping: Insufficient Training on New Equipment		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human(s) did not identify the training needs on new equipment associated with the transfer of control to the wing stations.
Problem Category	Company Employee (12)	The individuals responsible for identifying training needs were company employees.
Cause Category	Training / Personnel Qualifications (178)	The training was not sufficient to perform the task.
Cause Type	No Training (179)	
Intermediate Cause	Decision Not to Train (180)	No decision was made to identify training requirements because the risks were not well understood.
Solution to Intermediate Cause	The hazards of the process and tasks associated with approaching a dock or pier under normal operations, non-routine operations, and emergency operations should be identified.	
Root Cause Type	SPACS Issue (256)	SPACs inadequate, confusing, incomplete, or unclear.
Root Cause	No SPAC / Issue Not Addressed (257)	SPACs not specific enough.

3.2.3 Causal Factor #3: Lack of Established Procedures

A vessel-specific transfer control procedure did not exist at the time of the incident.

Root Cause Mapping: No Established Procedure		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human(s) did not consider the importance of having a written procedure for the task.
Problem Category	Company Employee (12)	The individuals responsible for identifying the need for procedures on new equipment in order to maintain operational discipline were company employees.
Cause Category	Procedures (120)	No procedure to perform the task existed.
Cause Type	Not Used (121)	
Intermediate Cause	No Procedure for task or operation (122)	
Solution to Intermediate Cause	A procedure should be developed for transfer control. All modes of operation and maintenance procedures should be addressed.	
Root Cause Type	SPACS Issue (256)	SPACs inadequate, confusing, incomplete, or unclear.

Root Cause Mapping: No Established Procedure		
Category	**Mapping**	**Description**
Root Cause	No SPAC / Issue Not Addressed (257)	No SPAC existed for the situation involved.

3.2.4 Causal Factor #4: No Communication Process

The new control system was not well understood by the crew and there was no means to communicate this problem to management in order to seek a remedy.

Root Cause Mapping: No Process to Communicate the Problem		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human(s) knew that the control system was not well understood by crew members responsible for operating it and did not communicate the issue to management because there was no established protocol to do so.
Problem Category	Company Employee (12)	The individuals responsible for ensuring positive two-way communication between the crew and management were company employees.
Cause Category	Human Factor (143)	Crew understood a training deficit existed but there was no formal means of reporting and tracking these observations to management.
Cause Type	Problem Identification and Control Issue (89)	
Intermediate Cause	Problem Reporting Issue (90)	
Solution to Intermediate Cause	A simple method should be established for vessel personnel to provide suggestions and feedback to shore management. Event reporting guidelines should be developed and vessel crews should be trained on the types of events that should be reported.	
Root Cause Type	SPACS issue (256)	SPACs inadequate, confusing, incomplete, or unclear.
Root Cause	No SPAC / Issue Not Addressed (257)	No SPAC existed for the situation involved.

3.2.5 Solutions to Root Causes – March 15th Grounding of the M/V *Woods Hole*

Causal Factor	Solutions
1(a). Overreliance on Institutional Knowledge	Solicit comments and recommendations from operations and maintenance personnel regarding the proper function and operation of the transfer control system and resolve each comment. Utilize all available information and knowledge to establish vessel specific instructions regarding how to properly transfer control. Incorporate these instructions into a vessel specific training and familiarization program that addresses recency.
1(b).	Provide adequate staffing with the necessary knowledge and experience.
1(c).	Improve the level of detail in all training material. Provide vessel specific familiarization procedures that includes physical demonstration if competencies.
2. Insufficient Training on New Equipment	Compile a list of vessel specific procedures and compare them to the existing list. Define and document any missing procedures and communicate them to fleet.
3. No Established Procedure	Establish a system of document control that clearly indexes the current library of procedures. OEM manuals do not replace vessel specific procedures.
4. No Process to Communicate Problem	Develop an enhanced reporting process to ensure risk recognition, share recognized hazards and gather data.

3.3 Delays to M/V *Island Home* Return to Service

In the winter and spring of 2018 the M/V *Island Home* went through an overhaul and repair period which began at a local shipyard and ended at the Fairhaven repair facility. The *Island Home* was scheduled to return to service on March 24th but was delayed a total of 12 days and did not return to service until April 5th. While delays are common in shipyard periods, in this case in particular the impact was felt throughout the system as other vessels were out of service for mechanical and other reasons, stretching the capacity of the system.

On October 23, 2017 the contract for repair work on the M/V *Island Home* was awarded to Senesco Marine for a planned haul-out on January 12, 2018. The scope of work included standard drydock items such as hull cleaning, preparation and painting, sea valves, shafts and seals, propellers, rudders, as well as allowances for potential discovery items such as hull plating replacement. In addition to standard overhaul items, there were a few projects which would require additional planning and close coordination between the shipyard and the SSA. These projects included the replacement of the bow thruster prime movers (converting from electrically-driven to diesel engine-driven), a critical system.

The bow thruster project became the critical path of the repair schedule due to delays in that specific project. These delays eventually resulted in late delivery of the M/V *Island Home* into service. While this is obvious in hindsight, it may not have been obvious during the course of the project because a project schedule did not exist. While it is normally considered best practice to develop, monitor and maintain a project schedule in a GANTT chart format which identifies the critical path, it was not a requirement in the contract with Senesco Marine and one was not provided.

Between contract award and delivery of the M/V *Island Home* to the shipyard, a period of approximately 80 days, a considerable amount of planning, procurement of long lead time items and coordination between the contractor, their subcontractors and the SSA was necessary. Typically, a key step to this coordination is to convene a kick-off meeting including all relevant parties. This would allow the project team to confirm the scope of work, identify risks to the project (such as long lead time items), define quality assurance expectations, and confirm engineering and procurement responsibilities, among other things. However, a kick-off meeting was not held and formal communication between parties could not be confirmed.

In accordance with the contract, the M/V *Island Home* was delivered to the shipyard on January 12th. On the same date, the bow thruster engine gears, which were owner furnished equipment (OFE), were also delivered to the shipyard. Other components of the bow thruster project were the responsibility of the shipyard to procure. Of these, the gear couplings were ordered late and the prime mover engines were delivered late. Reasons for these delays are unknown, but both of these lapses created delay in the schedule (without a project schedule it is difficult to identify the exact impact).

Routine repair projects were completed by the shipyard without notable delays or impacts to the overall schedule. Upon delayed receipt of the bow thruster engines on February 7th, it was discovered that the engine foundations which had been fabricated by Senesco according to drawings provided by the engine manufacturer did not fit the engines and would require rework. This event introduced additional delay on the critical path.

On March 9th, the M/V *Island Home* departed the shipyard for the Fairhaven repair facility. All routine work was complete at this time, including some additional work items introduced via discovery (a typical occurrence in drydockings) and addressed with change orders. The bow thruster project and some topside painting was not complete at this time. Senesco planned to mobilize their team (including their subcontractors) to Fairhaven to complete these outstanding tasks. This was approximately 15 days past the planned departure. As delays in shipyard are common, the practice of follow-up dockside repair work in Fairhaven provides the SSA with flexibility to adjust the work performed in order to meet the schedule for returning vessels to service. In this particular case, the scope of work at Fairhaven was adjusted but the bow thruster project remained the critical path overall and extended the delay past the planned departure from Fairhaven.

Work on the bow thruster project at Fairhaven continued through the month of March. A US Coast Guard inspection scheduled for March 29th was cancelled as initial testing on the prime movers identified issues with the control system. Further testing proved successful and the USCG attended testing on April 3rd, at which point several issues with bridge controls of the system were identified. These issues were addressed by technicians and on April 5th the USCG returned for testing and trials and cleared the vessel for service. Later that day the M/V *Island Home* entered revenue service.

Root cause analysis of this event resulted in the causal factor chart illustrated in Appendix A and identification of the following causal factors:

Causal Factor #1: Management of project not fully defined.

Causal Factor #2: Inability to accurately track progress against a project schedule, specifically the critical path.

Causal Factor #3: Ongoing monitoring (quality control) of shipyard's activities was inadequate.

Determinations of root causes for these causal factors are described below.

3.3.1 Causal Factor #1: Lack of Project Management Definition

When the contract for the drydocking and repairs of the M/V *Island Home* was awarded to Senesco Marine, there were approximately 80 days until the vessel was to be delivered. The scope of work contained several projects that were not routine and would require careful planning and coordination between the SSA, Senesco and their subcontractors, in particular the bow thruster project. This project alone was particularly complex because there were components and engineering required to be provided by both the SSA (as OFE) and Senesco, rather than one party being fully responsible for the entire project. The SSA engineering team failed to identify the risks associated with this complexity and develop a project plan which would define all aspects of the project, including responsibilities, expectations, communications protocols, scheduling, procurement, and quality assurance. A kick-off meeting with Senesco and the subcontractors was not held to communicate these critical aspects of the project to all and confirm all parties were in agreement and mutual understanding.

Fully defining the management of the project would have clarified any questions or doubts among Senesco, their subcontractors and the SSA project team. It is likely this would have prevented missteps by the team, such as Senesco's failure to order critical components on time, inaccurate drawings being utilized, or testing failures.

This causal factor follows multiple paths when mapped to the root cause(s).

Root Cause Mapping: Management of Project Not Fully Defined (a)		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that human(s) did not take proper steps to coordinate with contractors and define responsibilities, scope of work and project schedule.
Problem Category	Company Employee (12)	The individuals responsible for defining the project were company employees.
Cause Category	Procedures (120)	A process or procedure for defining the project was necessary to guide company employees.
Cause Type	Not Used (121)	A procedure was not used.
Intermediate Cause	No Procedure for Task / Operation (122)	The lapses in management of the project by both company employees and contractors were due to not fully defining the project itself. The company did not have a procedure for this task, to provide guidance on fully defining an overhaul project from its outset.
Solution to Intermediate Cause	A Project Plan should be developed for the proper and full definition of any major repair project. All parties should participate in a kick-off meeting to review the plan and confirm its definition.	
Root Cause Type	SPACS Issue (256)	The issue was not identified and therefore no SPACs existed to address it. It was apparent that the management of routine overhauls and repairs is based solely on institutional knowledge with no established process to address project management by a team, such as developing and communicating a project plan.
Root Cause	No SPACs / Issue Not Addressed (257)	

Root Cause Mapping: Management of Project Not Fully Defined (b)		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that human(s) did not take proper steps to coordinate with contractors, define responsibilities, scope of work and project schedule.
Problem Category	Company Employee (12) Permanent Officers (10) Third Party (13)	The individuals responsible for defining the project were company employees.
Cause Category	Responsibility / Authority (200)	The responsibility and authority of individuals involved in the project should be clearly defined and established in writing to avoid confusion.
Cause Type	Responsibility / Authority Not Defined (201)	The Owner's project team was loosely defined. Responsibilities and authority were based on past experiences and not clearly established. Responsibilities of contractors were not confirmed.
Intermediate Cause	Responsibility / Authority Not Defined (201)	A critical part of defining a project is to clearly define the responsibilities and authority of all parties involved in order to avoid confusion and hold team members accountable.
Solution to Intermediate Cause	In developing a project plan, all responsibilities and authority should be clearly defined. Communicate to all parties in order to confirm and address any conflicts.	
Root Cause Type	SPACS Issue (256)	The issue was not identified and therefore no SPACs existed to address it. Although the engineering managers and senior vessel crew members have extensive experience with routine overhauls and repair projects, without clearly defined roles and responsibilities there is a high risk of miscommunication and failures of individuals, contributing to unnecessary delays or additional costs.
Root Cause	No SPACs / Issue Not Addressed (257)	

3.3.2 Causal Factor #2: No Project Schedule Tracking

For any project there are four basic elements that must be monitored, adjusted, and balanced in order to ensure success: scope of work, quality of work, cost, and schedule. For any given project these elements are prioritized in order to aid the project team in decision-making. For the M/V *Island Home* overhaul period in general and the bow thruster project in particular, schedule should have been a priority, considering the demand placed on the vessels in preparation for the busy season. This cannot be definitively affirmed at this time without a project plan, but it was implied by a liquidated damages provision contained within the contract. A critical provision which the contract did not contain was a requirement for the prime contractor to provide a project schedule. Without a project schedule it is impossible to accurately monitor progress and the impact of delays.

Root Cause Mapping: Project Schedule		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human(s) did not identify the need for a project schedule.

Root Cause Mapping: Project Schedule		
Category	**Mapping**	**Description**
Problem Category	Company Employee (12)	The individuals responsible for identifying the need were company employees.
Cause Category	Procedures (120)	The problem was caused by the lack of a policy or procedure for requiring a project schedule to be developed for any project over certain thresholds.
Cause Type	Not Used (121)	A procedure was not used.
Intermediate Cause	No Procedure for Task / Operation (122)	The inability of the project team to accurately forecast delivery, track progress, and make adjustments was due to the lack of a project schedule identifying a critical path.
Solution to Intermediate Cause	Develop a policy to require that all projects over certain thresholds have a project schedule which identifies the critical path. Monitor and update the schedule regularly.	
Root Cause Type	SPACS Issue (256)	The issue was not identified and therefore no SPACs existed to address it. The lack of a policy requiring a project schedule, whether provided by the contractor or developed by the SSA project team, contributed to the project team's inability to accurately track progress, and identify the impact of delays.
Root Cause	No SPAC / Issue Not Addressed (257)	

3.3.3 Causal Factor #3: Insufficient Shipyard Management

Even for the most routine overhaul projects it is necessary to monitor the activities of the contractor(s). Complex projects require additional oversight. Shipyards may perform some level of quality control and project management, but none should be assumed. Even if they do, the shipyard's priorities are not always aligned with their clients. Monitoring of a shipyard project necessitates more than simply having personnel on site. Due to the lack of a project plan, a project schedule and routine project meetings, personnel on site were unable to perform adequate monitoring.

This causal factor follows multiple paths when mapped to the root cause(s).

Root Cause Mapping: Quality Control (a)		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human(s) underestimated the need for monitoring of the contractor.
Problem Category	Company Employee (12)	The individuals responsible for identifying the need were company employees.
Cause Category	Procedures (120)	A policy or procedure for establishing minimum monitoring of contractors.
Cause Type	Not Used (121)	A procedure was not used.
Intermediate Cause	No Procedure for task or operation (122)	Inadequate monitoring of the shipyard's progress contributed to delays and inappropriate responses or adjustments.
Solution to Intermediate Cause	Develop a policy or procedure identifying required levels of project monitoring, based on specific thresholds.	
Root Cause Type	SPACS Issue (256)	The issue was not identified and therefore no SPAC existed for the situation. As the level of monitoring of

Root Cause Mapping: Quality Control (a)		
Category	**Mapping**	**Description**
Root Cause	No SPAC / Issue Not Addressed (257)	the shipyard was inadequate, several missteps on the shipyard's part were not identified in time to prevent them, resulting in delays.

Root Cause Mapping: Quality Control (b)		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human(s) underestimated the need for monitoring of the contractor.
Problem Category	Company Employee (12)	The individuals responsible for identifying the need were company employees.
Cause Category	Training / Personnel Qualifications (178)	Training was not provided to project team. Qualifications were not established.
Cause Type	No Training (179)	
Intermediate Cause	Training Need Not Identified (183)	Training for project team was not provided and necessary qualifications were not determined in order to ensure team was prepared or equipped to perform adequate monitoring of the shipyard.
Solution to Intermediate Cause	Develop a policy identifying necessary qualifications required of project team and provide adequate training where identified.	
Root Cause Type	SPACS Issue (256)	The issue was not identified and therefore no SPAC existed for the situation. Without the proper qualifications or training, the project team was unable to perform adequate quality control of the shipyard's work and progress.
Root Cause	No SPAC / Issue Not Addressed (257)	

3.3.4 Solutions to Root Causes – Delays to M/V *Island Home* Return to Service

Causal Factor	Solutions
1(a). Management of Project Not Fully Defined	Develop a Project Plan template to be used for all projects meeting or exceeding certain thresholds, such as capital value or complexity. Establish a policy requiring a project plan and basic levels of documentation and communications commensurate with the specific project.
1(b).	Clearly define the roles and responsibilities of every team member involved in an overhaul project. Identify authority levels and decision-making protocols. Communicate these with all parties involved, including contractors and subcontractors.
2. Project Schedule	Develop a policy requiring a project schedule with specific requirements (i.e. critical path identified) be developed for all projects exceeding certain thresholds. Ensure that the project schedule is updated on a predetermined frequency, changes or delays are

Causal Factor	Solutions
	communicated to the project team and adjustments are made when necessary.
3(a). Project Monitoring	Develop a policy and supporting procedures which identify project monitoring requirements. Ensure that proper resources and personnel are provided to accomplish the necessary level of monitoring.
3(b).	Develop a policy to ensure all project team personnel are trained in project management disciplines and meet the proper qualifications for individual responsibilities as assigned. Designated project managers should receive formal project management training.

3.4 March 17th Blackout of M/V *Martha's Vineyard*

On March 17th, 2018, an improperly attached starter wire on Generator #3 caused the electrical plant of the M/V *Martha's Vineyard* to black out. The blackout was accompanied by a small fire at the generator which was handled by vessel crew. Following the incident, the crew put Generator #1 and Generator #2 online and restored the plant. The USCG attended and allowed the vessel to proceed with passenger operations based on the availability of the other two generators. When restoring the plant on Generator #1 and Generator #2, the crew did not start the fuel oil transfer pump, which maintains the fuel service tank in a full state. The level in the fuel oil service tank dropped throughout the day until all engines shut down from lack of fuel, while the vessel was approximately 15 minutes into a trip to Woods Hole from Vineyard Haven. No low fuel level alarm was annunciated by the vessel automation and the vessel crew failed to notice the dropping fuel level throughout the day.

Root cause analysis of this event resulted in the causal factor chart illustrated in Appendix A, and identification of the following causal factors:

Causal Factor #1: The fuel pump was not restarted when restarting the vessel plant.

Causal Factor #2: A formal evaluation of the initial blackout casualty was not performed.

Causal Factor #3: Changes to the vessel configuration were not adequately conveyed to management and circulated with crew.

Causal Factor #4: The periodic safety test procedure did not include tests it should have.

Causal Factor #5: There was inadequate testing of the vessel prior to returning the vessel to service.

Determinations of root causes for these causal factors are described below.

3.4.1 Causal Factor #1: Fuel Pump not Restarted with Plant

Fuel for the main engines and generators is pulled from a fuel oil service tank. A fuel transfer pump continuously transfers fuel from the storage tank to the service tank. The fuel transfer pump is intended to be always on. The service tank overflow pipe is routed back to the storage tank, such that if the service tank is full, the excess fuel transferred from the storage tank to the service tank is returned to the storage tank.

The startup procedure for M/V *Martha's Vineyard* includes starting the fuel transfer pump. In this incident, some vessel auxiliary machinery was restarted, but the fuel transfer pump was not restarted. Eventually, this led to a complete depletion of the service tank. If the standard vessel startup procedure had followed the blackout, the incident would not have occurred.

This causal factor follows multiple paths when mapped to the root cause.

Root Cause Mapping: Fuel Pump Not Restarted (a)		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human (the vessel crew) did not restart the fuel transfer pump following blackout.
Problem Category	Permanent Crew (10)	The crew who were responsible for restoring power to the vessel after blackout and did not restart the pump were permanent SSA vessel crew.
Cause Category	Procedures (120)	There was no standard operating procedure for how to restore normal operation of the vessel after a blackout.
Cause Type	Wrong / Incomplete (135)	
Intermediate Cause	Incomplete / Situation Not Covered (141)	Although there was a procedure for starting the vessel from deadship that includes starting the fuel transfer pump, there was not a checklist for ensuring normal operation of the vessel after startup from any condition, including restart from a blackout.
Solution to Intermediate Cause	The vessel should have a checklist for normal operation after startup.	
Root Cause Type	SPACs Issue (256)	Inadequate company policies, procedures, and checklists for how to ensure continuous, normal operation of the vessel contributed to the occurrence of this incident.
Root Cause	SPACs Confusing, Contradictory, or Incomplete (259)	At the root of this causal factor was a lack of standard vessel operating procedures to ensure continuous, normal operation of the vessel. Such operating procedures are particularly important for ensuring recovery from unusual events, such as an unexpected plant blackout. It was observed that vessel procedures and checklists generally only targeted and were utilized by new vessel crew, whereas experienced crew relied on their experience and memory. Certain critical "catch-all" checklists should be implemented as part of company policy.

Root Cause Mapping: Fuel Pump Not Restarted (b)		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human (the vessel crew) did not restart the fuel transfer pump following blackout.
Problem Category	Permanent Crew (10)	The crew who were responsible for restoring power to the vessel after blackout and did not restart the pump were permanent SSA vessel crew.

Root Cause Mapping: Fuel Pump Not Restarted (b)		
Category	**Mapping**	**Description**
Cause Category	Training/Personnel Qualifications (178)	The crew members were not trained to ensure normal operation of the vessel in the event of restarting due to a plant blackout. Following the normal startup procedure would have resulted in the fuel pump being restarted.
Cause Type	No Training (179)	Crew were not trained on a procedure to follow to ensure normal operation of the vessel after restarting the plant.
Intermediate Cause	Training Need Not Identified (183)	Vessel management did not recognize the need to train its crew to utilize checklists to ensure normal operation of the vessel after starting the plant.
Solution to Intermediate Cause	The crew should be trained to run through a checklist to ensure normal operation of the vessel after any start or restart of the vessel's plant.	
Root Cause Type	SPACs Issue (256)	Inadequate company policies, procedures, and checklists for how to ensure continuous, normal operation of the vessel contributed to the occurrence of this incident.
Root Cause	SPACs Confusing, Contradictory, or Incomplete (259)	At the root of this causal factor was the lack of management system policies governing training at the SSA. More specifically, the SSA is lacking crew training on procedures for how to ensure normal operation of the vessel at any given point in time. It was observed that vessel procedures and checklists generally only targeted and were utilized by new vessel crew, whereas experienced crew relied on their experience and memory.

3.4.2 Causal Factor #2: Formal Evaluation of Initial Blackout Casualty Not Performed

After the crew extinguished the fire and restored power to the plant by placing Generators #1 and #2 online in parallel, the USCG was notified of the incident. The USCG issued a CGForm835 identifying a deficiency for Generator #3 but allowed the vessel to return to service based on the availability of two working generators and the assumption that all other systems were operating normally. In fact, the vessel was not operating normally. In addition to undetected damage to certain systems, fuel was being depleted from the service tank but not being refilled from the storage tank because the fuel transfer pump had not been restarted.

A formal and thorough process for completing incident investigations would have identified all the consequences of the plant blackout, including that the fuel transfer pump was offline and required a restart. The SSA relied on institutional knowledge of its vessel crew to return the vessel to normal operation. An opportunity to recognize that the vessel was not operating normally was missed, which eventually led to the incident.

Root Cause Mapping: Incident Evaluation Not Performed		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that humans (SSA Management) did not develop or institute policies requiring investigations of incidents.
Problem Category	Company Employee (12)	Development of policies is the responsibility of management.
Cause Category	Procedures (120)	If an adequate procedure for conducting an incident investigation had been in place and utilized, the abnormal operation would have been identified.
Cause Type	Not Used (121)	An adequate procedure for conducting an incident investigation was not used.
Intermediate Cause	No Procedure for Task / Operation (122)	There was no standard procedure for conducting an incident investigation.
Solution to Intermediate Cause	A standard operation procedure for conducting thorough incident investigations should be developed, to ensure all systems are operating normally, identify remedial actions, and immediately begin data collection that may be helpful in identifying any persistent, hidden issues.	
Root Cause Type	SPACs Issue (256)	Inadequate company policies, procedures, and checklists for how to ensure continuous, normal operation of the vessel contributed to the occurrence of this incident.
Root Cause	No SPAC / Issue Not Addressed (257)	At the root of this causal factor was the lack of company policies for conducting thorough investigations immediately after incidents or near misses occur.

3.4.3 Causal Factor #3: Vessel Configuration Changes Not Communicated

Fuel is pumped to the main engines and generators at a constant rate, and any excess fuel not demanded by the engines is returned to fuel tanks through return fuel piping. Valving allows the crew to direct the return fuel to either the storage tank or the service tank. When the service tank is full and the fuel return is directed back to the service tank, the service tank will provide enough fuel for more than a normal operating day without the fuel transfer pump. When the service tank is full and the fuel return is directed to the storage tank, the service tank will provide enough fuel for just under 12 hours of operation without the fuel transfer pump.

Following normal operating procedures, the vessel crew sounded the service tank on the morning of the incident and found that it was full. However, the vessel crew was not aware that the fuel return had recently been redirected to the storage tank instead of the service tank. The crew did not notice that the level of fuel in the service tank was steadily dropping throughout the day.

Had the changes to the fuel return piping been communicated to the crew effectively, the crew would have understood that the tank sounding that morning did not guarantee adequate fuel in the service tank to last the entire day. This may have resulted in the crew paying closer attention to the service tank fuel level throughout the day, observation that the fuel level was dropping, and investigation and resolution of the problem prior to the incident occurring.

This causal factor follows multiple paths when mapped to the root cause.

Root Cause Mapping: Changes to Configuration Not Communicated (a)		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human (a crew member) changed the lineup of the fuel system piping configuration of the fuel return but did not adequately communicate that change to others in the organization who needed to know.
Problem Category	Permanent Crew (10)	The crew who did not adequately communicate the changes was a permanent SSA vessel crew member.
Cause Category	Communications (220)	The problem was caused by a communication failure.
Cause Type	Duty / Watch Handover Issue (241)	The communication failed to occur during a handover of responsibilities from one crew member to another.
Intermediate Cause	Communication at the Watch Handover Issue (243)	The communication failure occurred when a change that was made to the configuration of the vessel was not adequately communicated to the rest of the crew, or to management.
Solution to Intermediate Cause	Watch processes and communication tools should be modified to ensure that all plant configuration changes are documented in a way that is useful to vessel crews. For example, include ‘fuel returns to storage tank’ on a wipe board, along with information like ‘#1 pumps online/#2 pumps standby’.	
Root Cause Type	SPAC Issue (256)	Inadequate company policies and administrative controls contributed to the occurrence of this incident.
Root Cause	No SPAC / Issue Not Address (257)	At the root of this causal factor were inadequate company policies for documenting changes to vessel configurations and procedures for changes of watch.

Root Cause Mapping: Changes to Configuration Not Communicated (b)		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human (a crew member) changed the lineup of the fuel system piping configuration of the fuel return but did not adequately communicate that change to others in the organization who needed to know.

Root Cause Mapping: Changes to Configuration Not Communicated (b)		
Category	**Mapping**	**Description**
Problem Category	Permanent Crew (10)	The crew who did not adequately communicate the changes was a permanent SSA vessel crew member.
Cause Category	Management Systems (72)	The problem resulted from a lack of policies regarding authorization and documentation of operational changes.
Cause Type	Change Control Issue (95)	Vessel operation was changed without review and/or authorization, and without documentation.
Intermediate Cause	Change Not Identified (96)	The crew made a change to the plant configuration with impacts to vessel operation without communicating it to management for review or documenting it in a way that would allow management to identify and review it. The change would not have been approved by management.
Solution to Intermediate Cause	Management must have active control of how the vessel plants are operated. Develop policies that explain what plant configuration changes are allowed at the discretion of the crew, what configuration changes are not allowed, and how all such changes are communicated and documented.	
Root Cause Type	SPAC Issue (256)	Inadequate company policies and administrative controls contributed to the occurrence of this incident.
Root Cause	No SPAC / Issue Not Address (257)	At the root of this causal factor were inadequate company policies for understanding and controlling how their crews operate their vessels.

3.4.4 Causal Factor #4: Incomplete PSTP

The service tank on M/V *Martha's Vineyard* is required to have an alarm that annunciates when fuel level drops to a dangerously low level. The alarm system for the service tank was not properly configured and did not annunciate when fuel was running low.

In accordance with USCG requirements, testing was undertaken following the vessel's periodic safety test procedures (PSTP). Fuel oil service tank level alarms, which are considered by the USCG to be vital automation and are required to have been part of this PSTP, were not. If they had been, the improperly configured service tank alarm system would have been identified and rectified, and the low-level alarm would have notified the crew of the problem prior to the blackout.

Root Cause Mapping: Incomplete PSTP		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human failed to include adequate testing of the service tank fuel level alarm system in the development of the PSTP.
Problem Category	Company Employee (12)	A member of the SSA management was responsible for the development of the PSTP (either by other SSA employees or a contractor).

Root Cause Mapping: Incomplete PSTP		
Category	**Mapping**	**Description**
Cause Category	Management Systems (72)	A failure in management systems resulted in the approval of a PSTP that should not have been approved.
Cause Type	Document / Drawing Control Issue (100)	The issue was contained in the PSTP, which is a controlled engineering document.
Intermediate Cause	Documentation Content Inaccurate or Incomplete (101)	The PSTP did not include a test that is required by relevant regulatory authorities.
Solution to Intermediate Cause	The PSTP should be revised to include all tests required per USCG rules. If the SSA does not possess sufficient engineering capability to ensure completeness and accuracy of the test document, external engineering resources should be used.	
Root Cause Type	SPACs Issue (256)	Inadequate company policies and administrative controls contributed to the occurrence of this incident.
Root Cause	SPACs Confusing, Contradictory, or Incomplete (259)	At the root of this causal factor were ineffective company policies for overseeing shipyard work, specifically the maintenance of critical regulatory documents, such as the PSTP.

3.4.5 Causal Factor #5: Inadequate Vessel Testing

After a vessel undergoes modifications, especially significant ones like a midlife refit, it should not be accepted from the shipyard until adequate testing is performed by the shipyard to prove satisfactory operation.

Testing of vital alarm systems, including the service tank low level alarm, should have been required by the SSA before accepting delivery of the vessel from its midlife refit. If rigorous testing had been completed, the improperly configured service tank alarm system would have been identified and rectified, and the low-level alarm would have notified the crew of the problem prior to the blackout.

Root Cause Mapping: Inadequate Testing		
Category	**Mapping**	**Description**
Problem	Machinery / Equipment (2)	The nature of the problem was an improperly functioning tank level alarm system for the fuel service tank.
Problem Category	Installation / Fabrication Problem (9)	The fuel alarm system was improperly configured during modification associated with the shipyard project, such that it would not annunciate when fuel was running low.

Root Cause Mapping: Inadequate Testing		
Category	**Mapping**	**Description**
Cause Category	Management Systems (72)	Inadequate procurement control resulted in the acceptance of the improperly configured alarm system.
Cause Type	Purchasing Issue (112)	Acceptance of the improperly configured alarm system was a result of a purchasing issue.
Intermediate Cause	Inspection on Receipt Issue (116)	Inadequate acceptance criteria and approval for the alarm system resulted in the acceptance of the improperly configured alarm system.
Solutions to Intermediate Causes	SSA personnel or contractors acting as the owner's representative during shipyard or repair periods must be sufficiently involved with all vessel modifications to critical systems and equipment to monitor the quality of the work. Formalized test and inspection plans should be utilized to ensure all inspections and tests are thorough, and to provide a record of all inspections/tests.	
Root Cause Type	SPACs Issue (256)	Inadequate company policies and administrative controls contributed to the occurrence of this incident.
Root Cause	SPACs Confusing, Contradictory, or Incomplete (259)	At the root of this causal factor were inadequate company policies for overseeing shipyard work, specifically acceptance approval of procured equipment and completed work.

3.4.6 Solutions to Root Causes - March 17th Blackout of M/V *Martha's Vineyard*

Causal Factor	Solutions
1. Fuel Pump Not Restarted	• Develop a comprehensive set of vessel policies/checklists to provide crew with direction on how to perform routine operations and respond to all likely casualty scenarios associated with each vessel. • Make these policies/checklists available to all vessel crew in a place where they can access them while on watch. • Train the vessel crew to utilize the procedures. Educate experienced crew, who may not feel the need to utilize such prescriptive procedures, on the impact that procedures, used as checklists, can have on error avoidance.

Causal Factor	Solutions
2. Incident Evaluation Not Performed	A formal and documented process should be developed that is automatically invoked when any vessel experiences a deviation from normal operations that impacted, or could have impacted, vessel critical systems. The process output should examine and document the following: • Investigation of the cause of the incident (or near miss) and recommendations for follow-up actions or policy/procedural changes to prevent reoccurrences (i.e. inspect other similar equipment in the fleet). • Investigation of the effects of the incident, to ensure all possible consequences have been identified and corrected (i.e. identify damage which occurred as a result of the incident, which may not be evident during recovery from the incident). • Recognizing the limitations of situational awareness in the aftermath of an incident, develop checklists to ensure vessel is restored to full normal operating condition before authorization to return to service is issued (e.g. restart fuel transfer pump).
3(a). Changes to Configuration Not Communicated	The SSA should implement engineering management processes that: • For all aspects of vessel plant configuration that may change during the vessel's service, provide a means of communicating current configuration to all watch-standers (such as a wipe board or magnetic status board). • Train crews to always 'hand-over' configuration changes at watch turn over.
3(b).	The SSA should implement engineering management processes that: • Develop a set of standard operating procedures for each vessel that prescribes how vessel equipment is operated, deferring to manufacturer's guidelines and other references where appropriate. This document would include details such as system line-up, equipment rotation conventions, etc. • Make these standard operating procedures available to all vessel crew in a place where they can access them while on watch. • Train vessel crews on the details of the SOPs and the fact that deviations from the policies require explicit permission from engineering management. Ensure, as part of the training, that the SOPs are understood. • Check back with vessel crews to ensure they are operating the vessels in accordance with the SOPs.

Causal Factor	Solutions
4. PSTP Incomplete	The SSA should implement engineering management processes that: • Identifies critical record plans and documents like PSTPs • Forces individuals within the organization to consider how these documents may be impacted by system modifications during maintenance, repair, upgrade activities, and ensure that impacted documents are updated to reflect changes • Requires review of updated documents by individuals other than those responsible for the update efforts, who have the technical ability to confirm accuracy and completeness of the changes. Where the SSA lacks the expertise and/or bandwidth required to maintain this process, external resources should be applied.
5. Inadequate Testing	For all vital equipment/systems that are installed or modified during a shipyard or repair period, the SSA should develop a detailed inspection and test plan. This test plan should be completed in conjunction with vendor and/or shipyard sign-off of the task and regulatory testing of the equipment/systems. Inspection and test plans may be developed by the shipyard or vendors, but such plans should be reviewed and approved by the SSA prior to any inspections or testing. Where the SSA lacks the technical expertise to develop or approve inspection/test plans, external contractors should be utilized.

3.5 May 5th Blackout of M/V *Martha's Vineyard*

The capacity of the M/V *Martha's Vineyard* fuel service tank (day tank) is 2,974 gallons and the capacity of its fuel storage tank is 6,848 gallons, for a total combined capacity of 9,822 gallons. When the vessel is in regular service, the vessel typically consumes around 1,000 gallons of fuel per day and it is usually fueled three times per week. As a result, the vessel usually has more than 6,000 gallons of fuel on hand, and the total amount of fuel in the tanks is only infrequently less than 5,500 gallons. In normal operation, a fuel transfer pump constantly transfers fuel from the storage tank to the service tank. When the service tank is full, excess fuel pumped by the transfer pump flows back to the storage tank through fixed overflow piping.

On the morning of May 3rd, 2018, one of the *Martha's Vineyard*'s three crews started the plant and placed Generator #1 online by itself. At 0500 fuel oil pressure to the generator, final fuel pressure (the pressure downstream of the on-engine fuel filters) was recorded as 95 psi, which is below the normal operating range of 100-110 psi. The vessel was recorded to have approximately 3,920 gallons of fuel (about 2,974 gallons in the service tank and 946 gallons in the storage tank), which is unusually low. The watch changed mid-day to the second of three crews. The final fuel pressure to the generator continued to slowly drop throughout the day, down to 87 psi at 2000 hours. Despite watch oiler recordings showing final fuel pressure out of the normal operating range, no remedial actions were taken.

The second of three crews started the plant at 0500 on May 4th and placed Generator #1 online by itself. The vessel received 1700 gallons of fuel at 0930. Final fuel pressure to the generator was recorded as 87 psi at 1000. The watch changed mid-day, and the third of three crews took over the watch. The next recorded reading of final fuel pressure to the generator was taken at

1500, indicating that final fuel pressure had dropped off more dramatically, to 51 psi. Despite watch oiler recordings showing final pressure out of range, no remedial actions were taken.

The third of three crews started the plant at 0500 on May 5th, and again placed Generator #1 online by itself. No final fuel pressure readings were taken for the generator on May 5th. At 1700, the low fuel pressure alarm on Generator #1 sounded. The chief engineer checked the fuel filters upstream of the engine and found that they were not causing the drop in fuel pressure. Thirty seconds later, Generator #1 was starved of fuel and shut down. The vessel lost all electrical power and propulsion, requiring it to drop anchor while the plant was restored on an alternate generator.

It was determined that the fuel filters integral to the John Deere generator were plugged. The John Deere filters have finer mesh than the upstream fuel filters, explaining how they could be plugged when the upstream 'Racor' fuel filters were not. It is possible that the unusually low level in the fuel storage tank prior to bunkering on May 4th allowed sediment from the bottom of the storage tank to pass to the service tank, contributing to the fouling of the fuel filters.

The low fuel pressure alarm for the vessel's alarm management system (AMS) was set to 25 psi, which is lower than the operating pressure for the vessel's generators, explaining why the chief engineer had just thirty seconds to try to investigate and remediate the cause of the alarm before the engine was starved of fuel and the vessel lost power.

Root cause analysis of this event resulted in the causal factor chart illustrated in Appendix A, and identification of the following causal factors:

Causal Factor #1: Watch processes do not force engineer on watch to ensure readings are within normal operating ranges.

Causal Factor #2: Management of third-party vendor in shipyard lacked sufficient controls to ensure alarm points were properly set.

Causal Factor #3: Incorrect specification of critical design parameters, which resulted in an ineffective PSTP.

Determinations of root causes for these causal factors are described below.

3.5.1 Causal Factor #1: Insufficient Watch Processes

On May 3rd at 0500, 60 hours prior to the incident, fuel pressure downstream of the fuel filters (final fuel pressure) fell below the normal operating range of 100-110 psi. Fuel pressure continued to drop steadily, with the last reading prior to the incident recorded as 50 psi on May 4th at 1900. On the day of the incident, May 5th, no final fuel pressure recordings were made until after the incident.

All three of the permanent crews assigned to the vessel stood watch during the 60-hour period where the fuel pressure was below normal, but none recognized the difference between normal fuel oil pressure and critically low fuel oil pressure. This suggests that the existing policies and procedures governing how watch standers perform their duties are failing to:

- Ensure that watch oilers record all critical plant parameters on a regular basis.
- Ensure that watch chief engineers review all plant readings, and consider whether or not they are correct and indicative of normal operation.
- Provide watch standers with the tools and/or training they need to be able to differentiate between a 'normal' process value vs. a process value that is 'out of range.'

Root Cause Mapping: Watch Processes		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that humans (SSA engineering management) have not instituted watch policies that ensure the safe operation of the SSA vessels.
Problem Category	Company Employee (12)	SSA engineering management, who are company employees, are responsible for the performance of watch standers.
Cause Category	Procedures (120)	Watch processes in place onboard the SSA vessels do not force watch standers to observe, record, and evaluate plant process variables.
Cause Type	Wrong / Incomplete (135)	
Intermediate Cause	Incomplete / Situation Not Covered (141)	
Solution to Intermediate Cause	Watch stander logging requirements should be changed to highlight critical plant parameters, and define their normal ranges, such that process deviations critical to operations are more readily identified.	
Root Cause Type	SPAC Issue (256)	Inadequate company policies, procedures, and checklists for how to ensure continuous, normal operation of the vessel contributed to the occurrence of this incident.
Root Cause	No SPAC / Issue Not Addressed (257)	At the root of this causal factor was a lack of standard vessel operating procedures to ensure continuous, normal operation of the vessel.

3.5.2 Causal Factor #2: Insufficient Shipyard Management

Generator fuel oil pressure alarms, which are considered by the USCG to be vital automation and are required for vessels such as the M/V *Martha's Vineyard*, were incorrectly configured by the automation contractor who modified the vessel alarm system as part of the vessel's midlife upgrade project. The improper configuration prevented the alarm system from annunciating an audible and visual alarm before the fuel engine shut down from lack of sufficient fuel supply.

Root Cause Mapping: Shipyard Management		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human (SSA engineering management), failed to ensure the quality of work performed by a contractor during a shipyard repair period.
Problem Category	Company Employee (12)	SSA engineering management, who are company employees, are responsible for quality of work performed by vendors and contractors during shipyard periods.

Root Cause Mapping: Shipyard Management		
Category	**Mapping**	**Description**
Cause Category	Management Systems (72)	The SSA's technical specification for the M/V *Martha's Vineyard* mid-life refit project instructed the shipyard to hire a specific automation contractor to modify the existing vessel alarm system, but provides no further technical direction on functional requirements. Management of that vendor during the shipyard period also failed to convey functional requirements. The SSA also failed to require or conduct testing that would have proven critical functionalities.
Cause Type	Purchasing Issue (112)	
Intermediate Cause	Inspection on Receipt Issue (116)	
Solution to Intermediate Cause	SSA personnel acting as an owner's representative during shipyard or repair periods must be sufficiently involved with all vessel modifications to critical systems and equipment to monitor quality of work. When critical systems are modified, such as the installation of new generators, technical details like alarm setpoints should be reviewed and documented in technical specifications or commissioning check lists. The SSA should require shipyards performing work on their vessels to submit detailed specifications to the SSA for all work (including work done by subcontractors and equipment vendors), which the SSA should review in detail. The SSA should also require shipyards to submit detailed test procedures for proving functionality of all new or modified equipment, to be reviewed in detail and approved by the SSA, and then carried out with a representative of the SSA witnessing the tests.	
Root Cause Type	SPACs Issue (256)	Inadequate company policies, procedures, and checklists for how to ensure procured equipment have the appropriate specifications contributed to the occurrence of this incident.
Root Cause	SPACs Confusing, Contradictory, or Incomplete (259)	Company policies for the management of contractors and vendors are inadequate. Technical details should be reviewed in detail to ensure critical elements are designed correctly and appropriately.

3.5.3 Causal Factor #3: Incomplete PSTP

Alarms associated with low fuel oil pressure to the ship service generators are considered to be 'vital automation' by the USCG, and therefore are required to be included on the vessel's periodic safety test procedure (PSTP), and tested annually to confirm proper function. The set points for these alarms on the M/V *Martha's Vineyard* were incorrectly specified on the vessel's PSTP, allowing the annual functional tests to be performed without identifying the fact that the alarms were not providing any protection from a low fuel pressure shutdown.

Root Cause Mapping: Ineffective PSTP		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human (SSA engineering management) incorrectly specified the set point for the vessel's generator low fuel pressure alarm on the vessel's Periodic Safety Testing Procedure (PSTP)

Root Cause Mapping: Ineffective PSTP		
Category	**Mapping**	**Description**
Problem Category	Company Employee (12)	SSA engineering management, who are company employees, are responsible for maintaining the accuracy of critical documents such as the PSTP
Cause Category	Procedures (120)	The incorrect specification of the low fuel oil pressure setpoint on the PSTP prevented the SSA from discovering the fact that they lacked an effective alarm as protection against low fuel pressure situations, despite the fact that the test dedicated to the identification of such situations was performed as directed on the test procedure.
Cause Type	Wrong/Incomplete (135)	
Intermediate Cause	Facts Wrong/Requirements Incorrect	
Solution to Intermediate Cause	SSA engineering management should ensure the accuracy of critical documents like vessel periodic safety test procedures by establishing quality processes specific to those documents. Quality processes should designate 'owners' responsible for such critical documents and provide for independent technical review when these documents are created or modified. Where the SSA does not possess sufficient technical resources to perform this review, external contractors shall be utilized.	
Root Cause Type	SPAC Issue (256)	Inadequate company policies, procedures, and checklists to ensure the accuracy of critical documents such as the vessel's PSTP contributed to the occurrence of this incident.
Root Cause	SPACs Confusing, Contradictory, or Incomplete (259)	SSA engineering management lacks a functional process to ensure that critical quality backstops, like the annual testing of vessel automation that is required by the USCG, is performed successfully.

3.5.4 Solutions to Root Causes - May 5th Blackout of M/V *Martha's Vineyard*

<table>
<tr><th>Causal Factor</th><th>Solutions</th></tr>
<tr><td>1. Watch Processes</td><td>Develop and implement policies and procedures related to engine room watch standers that collectively:
Make the chief engineer on watch responsible for the safe operation of the vessel during their watch and prescribe the tasks that they must perform during their watch.
Make the watch oiler responsible to the watch chief engineer for reporting any deviations from 'normal operations' observed in the plant, prescribe the tasks that they must perform during their watch.
Designate an engineering manager as being responsible for the performance of engine department watch standers and empower that individual to control the training and assignment of individuals to watches.
Implement vessel-specific logging processes that identify the critical parameters that watch standers must monitor and define the normal and abnormal ranges of each.</td></tr>
<tr><td>2. Shipyard Management</td><td>For all vital equipment / systems that are installed or modified during a shipyard or repair period, the SSA should develop a detailed inspection / test plan. These test plans should be completed in conjunction with vendor/shipyard sign-off of the task and regulatory testing of the equipment/systems. Inspection/Test plans may be developed by the shipyard or vendors, but such plans should be reviewed prior to any inspections/testing. Where the SSA lacks the technical expertise to develop or approve inspection/test plans, external contractors should be utilized.</td></tr>
<tr><td>3. Ineffective PSTP</td><td>Implement specific engineering quality processes that identify and manage policies, procedures, and documents associated with quality backstops like the annual automation tests associated with the USCG-required Periodic Safety Test Procedures. These quality backstops are more critical to the safe operation of vessels than most other repair activities associated with annual shipyard and repair periods and require extra diligence and independent review to ensure accuracy.

Additional resources and/or external contractor assistance should be employed to support the additional effort associated.</td></tr>
</table>

3.6 IT - Website Slowdown

On January 11th, the SSA's website was subject to a high amount of traffic due to the release of the new 2018 sailing schedule. The levels of traffic were much higher than usual, although the exact amount is not known. User access to the website was extremely slow.

After being notified of the issue, the SSA assigned several in-house personnel from IT as well as outside support from the website vendor and a hardware manufacturer to investigate and attempt to remedy the situation. Eventually the cause was determined to be a single line of code in place that had handled all website database connections successfully since March 26th, 2013. This code had been tested but not to the point of failure, resulting in the weakness not being identified. Although the system employs multiple firewalls and other backup systems to protect against high traffic, this particular code acted as a bridge between the website and the internal reservation system, [redacted], which utilized only one connection to the multiple webservers.

The root cause analysis of this event resulted in identification of the following causal factors:

Causal Factor #1: Adequate load testing was not performed.

Causal Factor #2: Secondary and mirrored cloud-based website not utilized.

Determinations of root causes for these causal factors are described below.

3.6.1 Causal Factor #1: Inadequate Load Testing

Although the system had not failed in almost five years since the suspect code had been in place, the system had also not been adequately load tested. Load testing to the point of failure by a reputable firm which aids in identifying any issues as well as providing solutions should be conducted on a routine basis as well as on an ad hoc basis prior to significant events that may stress the system.

This causal factor follows multiple paths when mapped to the root cause(s).

Root Cause Mapping: Adequate Load Testing Not Performed (a)

Category	Mapping	Description
Problem	Human (4)	The nature of the problem was that a human(s) relied on inadequate load testing of the system.
Problem Category	Company Employee (12)	The individuals responsible for determining testing requirements were company employees.
Cause Category	Procedures (120)	A procedure should identify the testing requirements for the system.
Cause Type	Wrong / Incomplete (135)	The unwritten procedure followed was inadequate / incorrect.
Intermediate Cause	Incomplete / Situation Not Covered (141)	An adequate procedure for load testing the system does not exist.
Solution to Intermediate Cause	Adequate load testing should be performed on the system prior to the next major event.	
Root Cause Type	SPACS Issue (256)	No procedure exists to ensure that adequate load testing is performed on the reservation system on a predetermined and established severity of tests.
Root Cause	No SPACs / Issue not Addressed (257)	

Root Cause Mapping: Adequate Load Testing Not Performed (b)

Category	Mapping	Description
Problem	Human (4)	The nature of the problem was that a human(s) relied on inadequate load testing of the system.
Problem Category	Company Employee (12)	The individuals responsible for determining testing requirements were company employees.

Root Cause Mapping: Adequate Load Testing Not Performed (b)		
Category	**Mapping**	**Description**
Cause Category	Maintenance Program Implementation (40)	The maintenance program was not fully implemented.
Cause Type	Servicing and Routine Inspection Issue (64)	The routine inspections (testing) of the system were not adequate.
Intermediate Cause	Scheduling/Frequency Issue (65), Scope Issue (64)	The scheduling of load testing as well as the scope of testing was inadequate.
Solution to Intermediate Cause	Determine an adequate frequency of load testing, identify major events, and determine an adequate scope of testing.	
Root Cause Type	SPACS issue (256)	No procedure exists to implement the proper levels and frequency of load testing.
Root Cause	No SPACs / Issue not Addressed (257)	

3.6.2 Causal Factor #2: Lack of System Redundancy

At the time of the incident the website was hosted internally by the SSA. This presented a single point of failure for a mission critical system as a secondary and mirrored cloud-based website was not being utilized for redundancy.

Root Cause Mapping: Secondary and Mirrored Cloud-Based Website Not Utilized		
Category	**Mapping**	**Description**
Problem	Machinery / Equipment (2)	The nature of the problem was that the system / equipment was insufficient.
Problem Category	Design Problem (6)	The system design was insufficient.
Cause Category	Design Input / Output (20)	Design input did not ensure adequate redundancy in the system.
Cause Type	Design Input Issue (21)	
Intermediate Cause	Design Input Incorrect (24)	Design input did not ensure adequate redundancy in the system.
Solution to Intermediate Cause	The system design should be reviewed in order to determine the feasibility of attaining redundancy in the system.	
Root Cause Type	SPACS Issue (256)	The design process is not administered to ensure mission critical systems meet established standards, such as redundancy. Quality control is not in place to ensure established standards are met.
Root Cause	Not Strict Enough (258)	

3.6.3 Solutions to Root Causes – January 11th Website Slowdown

Causal Factor	Solutions
1. Adequate Load Testing Not Performed	Develop a procedure to ensure that adequate load testing is performed on the reservation system. Confirm a schedule and severity of tests.
2. Secondary and Mirrored Cloud-Based System	The design process should be administered to ensure mission critical systems meet established standards, such as redundancy. Quality control should be introduced to ensure established standards are met.

3.7 IT - Trip Alert Emails Blocked

On March 9th, after several periods of ferry service disruptions, it was discovered that a large volume of trip alert emails had been blocked by email service providers. Some trip alerts were blocked entirely while others were delayed.

The trip alert system was utilizing an internal email server and the SSA domain for sending the trip alert emails. These were being flagged as spam by the Internet Service Providers (ISPs).

The root cause analysis of this event resulted in identification of the following causal factors:

Causal Factor #1: Inadequate system design.

Causal Factor #2: Insufficient email list analysis.

Determinations of root causes for these causal factors are described below.

3.7.1 Causal Factor #1: Inadequate System Design

Although the email system had not experienced serious issues up to this point, it had not been tested to this extent. Considering the critical nature of the communications system, the design process should have established a much higher minimum standard. The limitations of utilizing an internal email server and the SSA domain should have been identified as insufficient.

Root Cause Mapping: System Not Adequately Designed		
Category	**Mapping**	**Description**
Problem	Machinery / Equipment (2)	The nature of the problem was that the system was insufficient.
Problem Category	Design Problem (6)	The system design was insufficient.
Cause Category	Design Input / Output (20)	Design input did not ensure adequate functionality of the system.
Cause Type	Design Input Issue (21)	
Intermediate Cause	Design Input Incorrect (24)	Design input did not ensure adequate functionality of the system.
Solution to Intermediate Cause	The system design should be reviewed in order to identify a more reliable email distribution server and domain.	
Root Cause Type	SPACS Issue (256)	The design process is not administered to ensure mission critical systems meet established standards, such as

Root Cause Mapping: System Not Adequately Designed		
Category	**Mapping**	**Description**
Root Cause	Not Strict Enough (258)	reliability. Quality control is not in place to ensure established standards are met.

3.7.2 Causal Factor #2: Insufficient Email List Analysis

The SSA's internal email list was not analyzed by an outside vendor for integrity to ensure all emails are legitimate and accurate. Doing so would have avoided the sending of emails to false addresses, thus triggering spam alerts by the ISP.

Root Cause Mapping: Outside Vendor Not Utilized to Analyze Internal Email List		
Category	**Mapping**	**Description**
Problem	Human (4)	The nature of the problem was that a human(s) relied on inadequate testing of the system.
Problem Category	Company Employee (12)	The individuals responsible for determining testing requirements were company employees.
Cause Category	Procedures (120)	A procedure should identify the testing requirements for the system.
Cause Type	Not used (121)	A procedure for establishing the testing requirements was not used.
Intermediate Cause	No Procedure for Task / Operation (122)	A procedure for establishing the testing requirements did not exist.
Solution to Intermediate Cause	Develop a procedure for establishing the testing requirements of the trip alert email system.	
Root Cause Type	SPACS Issue (256)	No procedure exists to ensure that adequate testing is performed on the trip alert email system.
Root Cause	No SPACs / Issue not Addressed (257)	

3.7.3 Solutions to Root Causes – March 9th Trip Alert Emails Blocked

Causal Factor	Solutions
1. Inadequate System Design	The design process should be administered to ensure mission critical systems meet established standards, such as reliability. Quality control should be introduced to ensure established standards are met.
2. Insufficient Email List Analysis	Develop a procedure to ensure that adequate testing is performed on the trip alert email system.

3.8 IT - Loss of Connectivity due to Storm

In March of 2018, a Nor'Easter storm caused the SSA to lose all connectivity to its website. Power to the website server was maintained during this period due to backup generators, but the loss of internet from SSA's sole ISP caused the website and other essential services to be unavailable to the public.

The root cause analysis of this event resulted in identification of the following causal factors:

Causal Factor #1: System design allowed for a single-point-of-failure.

Determinations of root causes for these causal factors are described below.

3.8.1 Causal Factor #1: Lack of System Redundancy

Due to the location of the SSA administration building where the website server is located, it is not possible to have redundant ISPs using varied routing to ensure connectivity. When hosting web-based systems internally, such ISP redundancy is generally considered a standard design requirement. Another acceptable alternative is to employ a secondary cloud-based system that is not subject to natural disasters or regional power outages. As it was designed, neither method of redundancy was employed, exposing the system to single point failure.

<table>
<tr><th colspan="3">Root Cause Mapping: System Design Allowed for Single-Point-Of-Failure</th></tr>
<tr><th>Category</th><th>Mapping</th><th>Description</th></tr>
<tr><td>Problem</td><td>Machinery / Equipment (2)</td><td>The nature of the problem was that the system was not adequately protected from acts of nature.</td></tr>
<tr><td>Problem Category</td><td>Design Problem (6)</td><td>The system design was insufficient.</td></tr>
<tr><td>Cause Category</td><td>Design Input / Output (20)</td><td>Design input did not ensure adequate redundancy of the system.</td></tr>
<tr><td>Cause Type</td><td>Design Input Issue (21)</td><td rowspan="2">Design input did not ensure adequate redundancy of the system.</td></tr>
<tr><td>Intermediate Cause</td><td>Design Input Incorrect (24)</td></tr>
<tr><td>Solution to Intermediate Cause</td><td colspan="2">The system design should be reviewed in order to determine a more reliable internet source in event of natural disasters or other interruptions of service.</td></tr>
<tr><td>Root Cause Type</td><td>SPACS Issue (256)</td><td rowspan="2">The design process is not administered to ensure mission critical systems meet established standards, such as redundancy. Quality control is not in place to ensure established standards are met.</td></tr>
<tr><td>Root Cause</td><td>Not Strict Enough (258)</td></tr>
</table>

3.8.2 Solutions to Root Causes – Connectivity Issues Due to Storm

Causal Factor	Solutions
1. System Design Allowed for SPoF	The design process should be administered to ensure mission critical systems meet established standards, such as redundancy. Quality control should be introduced to ensure established standards are met.

Section 4 General Observations

4.1 Management Structure

4.1.1 Mission Statement

It is important for any organization to have clearly established goals and a means by which to measure its progress toward achieving them. Advertising a common mission statement at all levels of the organization ensures the entire team is working toward the same end. Mission success is achieved by establishing organizational key performance indicators (KPIs), periodically measuring them, and making adjustments to address any unsatisfactory results.

Interviews with employees from multiple departments and at all levels of the SSA revealed that there is not a consistent mission statement that provides a common direction to the organization that is well advertised and highly visible throughout the organization and to the public.

Section I of SSA's Enabling Act contains the following statement (Reference 7):

> ***"In order to provide adequate transportation of persons and necessaries of life for the islands of Nantucket and Martha's Vineyard, the Authority is hereby authorized and empowered to purchase, construct, maintain and operate necessary vessels, docks, wharves, other vessels, equipment, furniture and supplies and to issue its revenue bonds payable solely from revenues, or funds as hereinafter authorized in section nine of this act."***

This statement is not publicly advertised throughout the organization and does not provide an inspiring direction by which employees at all levels can rally.

On the SSA's website, the following statement is made on the History & Organization page:

> ***"The Steamship Authority's statutory mission is to serve as the "Lifeline to the Islands" for everyone from year-round residents, who depend on the ferries for all commerce and transportation to and from the mainland, to a significant seasonal population, to the tourists who visit for a day, a week or longer."***

While this identifies a 'statutory mission', it doesn't actually contain a complete mission statement identifying how it is accomplished, what value is provided, or what the organization strives for.

The website is the only place this statement was observed; however, even there it was not easily identifiable and it is not advertised to employees.

There is also a lack of established performance objectives for the organization as a whole. Some senior executives who are aware of the statement contained in the Enabling Act have a common objective, but there does not appear to be a clear method by which to measure progress, success, or failure of the organization to succeed in its mission.

4.1.1.1 Issues

Organizational issues associated with the lack of a mission statement are wide ranging. Many companies exist without established mission statements, however the benefits realized by those who develop, embrace, and frequently reference one are clear and impactful. The benefits a mission statement provides include:

- A common direction.
- Focus of the company's future (commonly referred to as 'Vision').

- Establishment of priorities and aid for decision-making at all levels.
- Alignment of team, from new-hires to long-tenured executives.
- Support for necessary change.
- Guidance for strategy.
- A basis for measuring performance.

Multiple competing interests are creating confusion and misdirection amongst SSA employees. For example, the root cause analysis performed on the delay in return from the repair period of the M/V *Island Home* (Section 3.3) underscores how decision-making was hampered by a lack of clear direction. In other cases, covered in more detail in other general observations included in this study, there were indications of a lack of common direction, resistance to change, and a lack of strategic planning.

4.1.1.2 Industry Standards/Best Practices

A well-crafted, advertised, and frequently revisited mission statement that provides a common goal, combined with measurable performance objectives, provides numerous benefits to any organization. Public and private ferry systems, including near-monopolies similar to the SSA that are not influenced by the same competitive environment as most, have established mission statements and employ performance objectives. Examples include Washington State Ferries and the Delaware River and Bridge Authority (Cape May-Lewes Ferry). Typically, these mission statements are simple and to the point, communicating a common direction to the employees, leadership, and the public.

Performance objectives are also common in the industry as a way to measure progress toward the mission, identify shortcomings, and make necessary adjustments. These objectives and the organization's progress are commonly completely transparent and communicated to employees and the public. See Section 4.3.7 for further information on this topic.

4.1.1.3 Specific Solutions

SSA management, in cooperation with the Board and Port Council, should craft a mission statement which identifies the organization's purpose and direction. A strong mission statement is clear and concise, and answers four basic questions:

- What do we do?
- How do we do it?
- Whom do we do it for?
- What value are we providing?

It is also important to emphasize specific elements of the company culture that should be reinforced. For example, a common theme in the maritime industry is safety. If safe operations is a paramount concern, it should be reflected in the mission statement.

After the mission statement is crafted, performance objectives should be developed so that the organization's alignment with the mission can be continually monitored. Performance objectives must be measurable and have a term assigned to them, such as annually (see Section 4.1.2).

The mission statement and performance objectives should be advertised to all levels of the organization frequently. It is critical to give consistent and high-profile reinforcement in order to attain buy-in from the employees. This is accomplished by making the statement and objectives highly visible and, most importantly, following them in actions and decision-making. The more affirmation and exposure they receive, the more buy-in they will generate and the more effective they will be in establishing a cohesive team working toward a common direction.

4.1.2 Strategic Planning

SSA is excellent at reacting to situations or "putting out fires." However, the evidence and consensus opinion is also that the SSA suffers from an absence of strategic planning. The result is an organization that lacks meaningful goals, has employees working against each other, and does not adapt to the evolving needs of its customers.

> ***"We're spread so thin, we're stuck at reactionary versus looking forward."* - SSA Executive**

> ***"We are trying to get out of the weeds before we look down the road."* -SSA Executive**

Strategic planning provides a framework for making long-term decisions, aligns goals across an organization, and helps to ensure the long-term availability of the resources critical to organizational success. Each of these have been problem areas for the SSA.

The only observed planning process with a time horizon beyond one year was capital budget planning, with a two- or three-year horizon. This exercise omits key factors from the decision-making process due to both its limited breadth and time horizon. For example, when deciding whether or not to add a run to the schedule, three critical dimensions need to be weighed: quantity of service, cost of service, and quality of service. A capital budget plan will only provide limited guidance on goals for cost of service. A strategic plan will provide guidance on the desirable tradeoffs between quantity, quality, and cost, as well as any other metrics that are important to the strategy of the organization.

The SSA management generally understands that more planning would provide a net benefit to the organization. Despite this understanding, there are two primary reasons why strategic planning has not been prioritized. First, the daily schedules of management appear to be generally overburdened (see Section 4.1.4 Staffing). Without more management bandwidth, it will be hard for management to transition resources from reacting to planning.

Secondly, management is disincentivized to perform long-term strategic planning. In any successful organization, management is held accountable for operational performance. At the SSA, management is not adequately held accountable, because there are no objective performance metrics against which to be measured. One of the benefits of a strategic plan is that it provides a basis for creating and maintaining performance metrics. The lack of performance metrics provides management with job security. Despite this, we observed that the SSA managers generally appreciated the need for more planning and wished they did a better job at it, as it would improve their ability to manage. Additionally, we observed that management is devoted to organizational success for many admirable reasons, such as pride, compassion, morality, and ethics. However, the incentives for management to not perform strategic planning should not be ignored as a barrier to implementation.

4.1.2.1 Issues

Without a clear strategic plan, making informed decisions that will have long-term effects on the organization is difficult or impossible. For example, consider the optimization of ferry schedules. As illustrated in Figure 2, a basic tradeoff has to be made between affordability, reliability, and quantity. Each of these performance metrics affects the others. To increase affordability requires the elimination of unprofitable runs (reduce quantity) or to divest of backup vessels (reduce reliability). To increase reliability requires investing in new vessels (reduce affordability) or eliminating runs to increase backup capacity (reduce quantity). To increase the quantity of service requires increasing unprofitable runs (reduce affordability) or divesting of backup vessels (reduce reliability). A strategic plan will define the correct balance of affordability, reliability, and quantity.

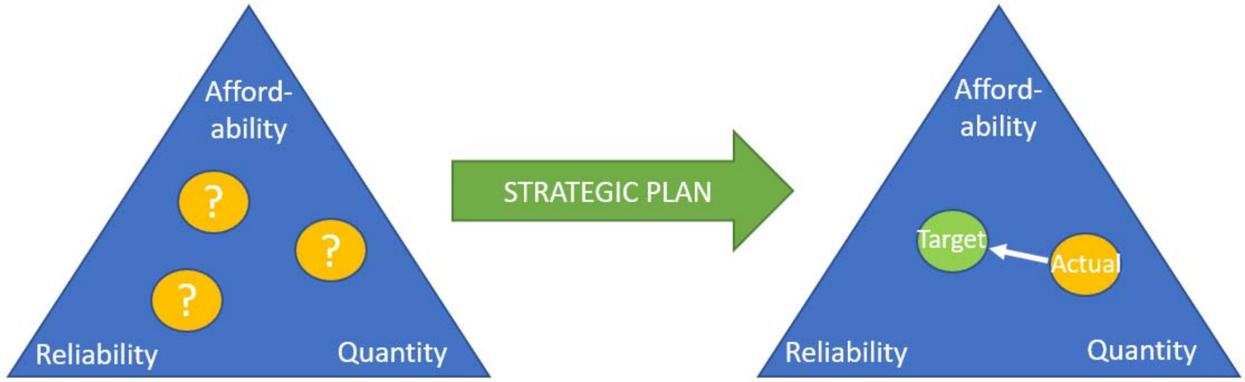


Figure 2 Cost, reliability, and quantity tradeoffs

A strategic plan allows for meaningful key performance indicators (KPIs) to be developed and tracked. In the example above, there are three KPIs: affordability, reliability, and quantity of service. These KPIs will be reviewed periodically, and if the appropriate balance is not struck by meeting performance goals for each metric, remedial actions can be taken to align the actual service with the targets set by the strategic plan.

A lack of a clear strategic plan makes it difficult to align the goals of employees across the organization. Without a clear strategy, front-line employees cannot effectively communicate to customers why the organization is operating the way it is. It also hinders employee-management communication. Employee feedback is an extremely valuable tool for an organization to utilize, but will tend to be incohesive and difficult for management to respond to if there is not a unified strategic vision for the company on which to rely. This may contribute to the feeling by employees that their feedback is currently unappreciated and underutilized (see Section 4.1.9 Tenure).

A strategic plan helps to ensure the necessary resources are available to the organization over the long run. For example, ferries are assets with service lives of well over thirty years. Without an understanding of how the organization intends to utilize these fundamental assets to address the evolving needs of its customers and work force in the future, the optimality of the vessel design over its service life is impossible to measure.

Strategic planning also plays a crucial role for capital planning of major capital projects such as terminal modifications and ferry acquisitions, by identifying well in advance when assets should be acquired and retired so that fundraising efforts can be conducted. For example, the SSA appears to be missing out on federal grant funding due to its lack of long-term planning.

> ***"We haven't gone after more federal money because it wasn't needed based on our old formula"*** **-SSA Executive**

Without a clear strategic vision, an organization will be stuck in a reactive mode, only changing when latent issues manifest themselves as incidents (such as the events of the spring of 2018), or exogenous events force a change (such as increasing populations of the islands). Decisions are uninformed, avoidable incidents occur, employees work towards different goals, and opportunities are missed.

4.1.2.2 Industry Standards/Best Practices

Strategic planning is a standard practice of successful ferry operators across North America. Typically, strategic planning is communicated via a strategic plan report that is periodically updated, although there are different formats in which to convey a strategic plan and each organization should select the format which best meets their unique needs.

Strategic plans also provide a framework for more specific planning exercises, including capital planning and maintenance planning.

There are many publicly-available examples of ferry services publishing and implementing effective strategic plans. The following examples are provided for inspiration and reference:

- **Washington State Ferries**, the largest ferry operator in the United States, develops and publishes a comprehensive long range plan every decade, intended to guide internal planning, inform investment and fundraising decisions, and facilitate coordination with other agencies that are stakeholders of the service they provide.
    - *"The WSF 2040 Long Range Plan (the Plan) provides a vision intended to guide the future service and capital investment decisions for this critical part of the State highway system."* (Reference 13)
- **San Francisco Bay Area Water Emergency Transportation Authority (WETA)** operates 12 passenger-only ferries between 7 terminals in the San Francisco Bay Area and is in the midst of surging ridership due to roadway congestion. Their 20-year plan, last published in 2016, *"sets forth a vision, mission and priorities for the next 20 years of SF Bay Ferry Service."* (Reference 14).
- **BC Ferries**, one of the largest ferry operators in the world, publishes strategic goals and its KPI results in its annual report (Reference 4):

Strategic Goals	Key Performance Indicators
• Ensure safe, reliable, and efficient operations	• Employee Safety
• Deliver a customer-focused travel experience	• Passenger Safety
• Foster a productive, motivated, & engaged work force	• Vessel Reliability
• Be a leader in environmental and social governance	• Customer Satisfaction
• Grow and profitably diversify our revenue base	• Net Earnings
• Drive prudent investment in our capital assets	

- **Casco Bay Lines** operates five ferries on eight routes in Casco Bay, Maine, and recently began publishing their KPI results and long-range capital plans. Their KPIs are reported in six categories: financial, productivity, ridership & vehicles, marketing, customer service, and safety.
- **Pierce County Ferry** operates two ferries and periodically commissions a Waterborne Transportation Study in order *"to identify key issues facing the Pierce County ferry system and make recommendations to ensure the long-term financial sustainability of the service."* (Reference 1). The most recent study included an assessment of the current and future states of the demand on the ferry service, assessment of future challenges and opportunities, and recommendations for short- and long-term success.

4.1.2.3 Specific Solutions

The following solutions would address the problems that were observed as a result of inadequate strategic planning:

- **Develop a strategic plan**. Doing this properly will require significant resources, including approximately four of the SSA executives, one of whom is directly responsible for executing its development, as well as the Board of Directors and the Port Council. This task is also frequently outsourced to management consultants experienced in the process, but at least half of the development effort must belong to the SSA personnel to be effective.
- **Implement management performance metrics** based on the goals laid out in the strategic plan. Managers should be held accountable to the organization for meeting performance metrics that are approved by the Board of Directors on an annual basis. One or more of the SSA executives should also be held accountable for the periodic updating of the strategic plan. These performance criteria will change the incentive structure such that development of the strategic plan will be prioritized and management's actions will be aligned with the strategic goals of the organization.

4.1.3 Operations Structure

Several factors of SSA's organizational structure were observed to contribute to varying levels of disfunction within the operations group and the organization as a whole.

The vessel operations and vessel engineering functions are in separate departments. As illustrated by the 6/26/18 Organization Chart (Figure 3), while vessel operations is in the Vessel Operations Department and reports to the Operations Manager (through the Port Captain), vessel engineering is in the Engineering and Maintenance Department and reports to the Director of Engineering and Maintenance (through the Port Engineer). Discussions with crew and other personnel made it clear that this creates ongoing confusion and friction at times. Most vessel engineering crew understood the chain of command on board and the authority of the captain, but it was clear that having multiple direct lines of reporting off the vessel creates confusion. There should only be one direct line of reporting off the vessel, from the Captain to the Port Captain. Indirect reporting between the vessel crew and support functions is necessary and of great value to the crew. But the current structure identifies the reporting between vessel engineers and the Port Engineer as a direct line. This was evidenced by several of the root cause analyses performed as a part of this study.

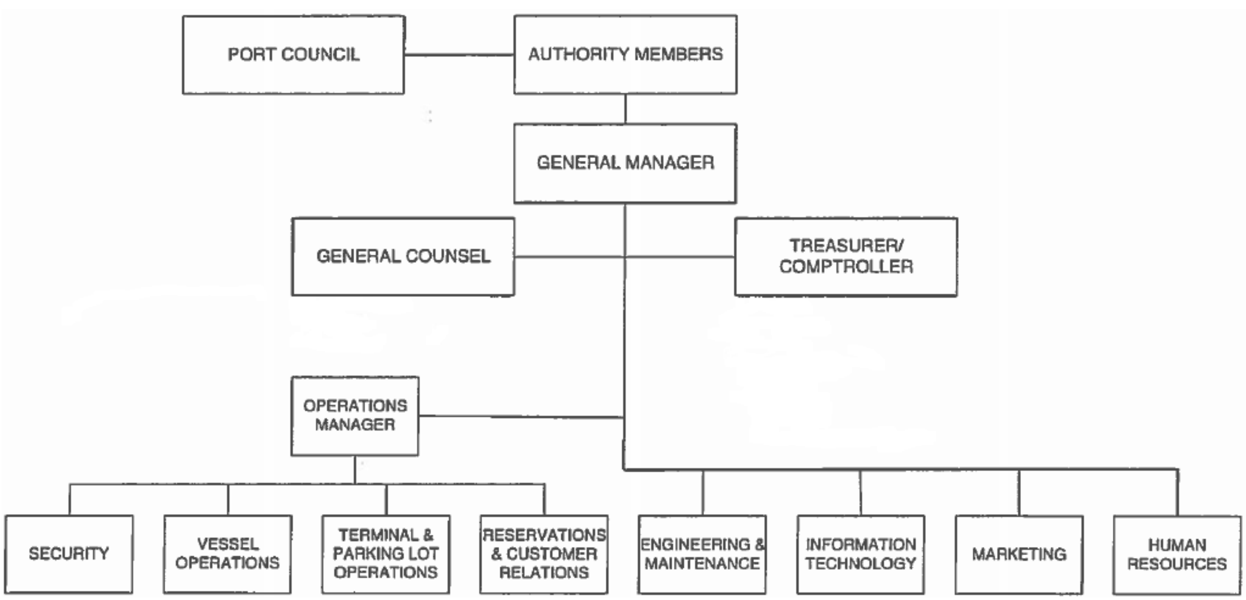


Figure 3 Current organizational structure

The same organizational chart, supported by conversations with crew and other documents reviewed, indicates that the Engineering and Maintenance Department functions as a 'line' department[1] within the chain of command, rather than a 'staff' department[2]. This causes confusion about authority and decision-making within vessel operations.

Vessel Operations is a core function of the SSA, but is under-represented at the executive and director levels of the organization. The highest representation of the Vessel Operations Department in the management structure is the Port Captain (currently an unfilled position, thereby deferring to the Assistant Port Captain), who reports to and is heavily relied upon by the Operations Manager. The Engineering and Maintenance Department, by contrast, is represented at the director level, which amplifies the confusion about authority and frictions between staff members discussed above.

4.1.3.1 Issues

Clear communication between Vessel Operations and Engineering and Maintenance is critical to the SSA mission, as those two departments must be able to efficiently collaborate on functions critical to the SSA, including vessel maintenance, training sequences, and scheduling. When the vessel engineers' reporting structure is either confusing or short-circuited, this communication becomes strained and complex, hindering any collaboration required.

As a line function, the Engineering and Maintenance Department has the authority to make critical decisions that directly affect the vessels and their operation. This complicates communications and creates unnecessary friction with the Vessel Operations Department, which should have the ultimate authority over how the vessels are operated. The Engineering and Maintenance Department should advise the Vessel Operations Department as a staff function.

Vessel Operations is a primary function of the SSA. The absence of maritime operations expertise at a high level of authority within the organization marginalizes the functionality of the Vessel Operations Department.

As currently structured, the Operations Manager must balance their time between managing reservations, terminal and parking lot operations, security, and vessel operations. This situation, combined with the authority given to engineering, further reduces the ability of Vessel Operations personnel to exercise their authority and advance their priority issues.

4.1.3.2 Industry Standards/Best Practices

Many maritime operations struggle with organizational issues due to the complexities of communication between vessels, shoreside management, and various operational support functions. All maritime operations are unique; however, the following best practices have proven to be consistently effective in this rapidly evolving industry:

1. A clearly defined chain of command on the vessel.
2. Acknowledgement and support of the vessel master's authority and responsibility.
3. Clear and concise communications protocols.
4. Minimized off-vessel reporting outside the chain of command (short circuits).
5. Clearly defined line and staff roles.

[1] A line department or function is one which directly advances an organization in its core work.
[2] A staff department or function is one which supports the organization with specialized advisory and support services.

4.1.3.3 Specific Solutions

The following solutions are intended to improve the lines of communication between Vessel Operations, Engineering and Maintenance, and leadership of the SSA:

- Reinforce the chain of command on board and eliminate any additional direct reporting off the vessels. All direct reporting should follow the chain of command through the vessel captain to ensure those with the responsibility and authority are fully informed. While some indirect reporting will remain necessary, it should be minimized and should never circumvent direct reporting.
- Designate the Engineering and Maintenance Department as a staff function, providing advisory service and support to the various departments requiring it. This is similar to IT, HR, and other staff functions. This is not intended to diminish the highly important role of the department and the critical services it provides but rather to acknowledge that the line authority remains with Vessel Operations and does not compete with additional authority levels in engineering.
- Increase maritime operations experience at the director or executive level by adding a position. This should be a position in the direct chain of command between the Port Captain and leadership as well as between the Director of Engineering and leadership. This position would reduce the immediate burden on leadership while ensuring the priorities of vessel operations are properly represented at the highest levels of authority. See Section 5.3.

4.1.4 Staffing

As a ferry operator that covers 100% of its operating expenses through fare box revenue, the SSA's ticket prices are directly related to its operating costs. The SSA management therefore takes pride in minimizing costs in order to minimize fares. One way that the SSA keeps costs down is to minimize staffing. This lean mentality is admirable, but the organizational breakdowns in the spring of 2018 illuminated that some aspects of the effort leaves the organization vulnerable. Management staff levels have not kept pace with growth, leaving the organization understaffed.

This section describes how the SSA management in general may be understaffed. Also see Section 4.2.2 Engineering Resources, for observations about how the engineering department in particular is suffering from deficient human resources.

Being an organization focused on cost-cutting has long been part of the SSA culture. However, as demand on the organization has grown over the past decade, the capacity of management has not kept up. This is illustrated by Figure 4 and Figure 5 below, in which it is shown that over the last ten years the number of administrators has decreased by 16% relative to operating revenues (normalized to 2017 dollars using the Consumer Price Index), and by 7% relative to the number of passenger trips and vehicle trips made.

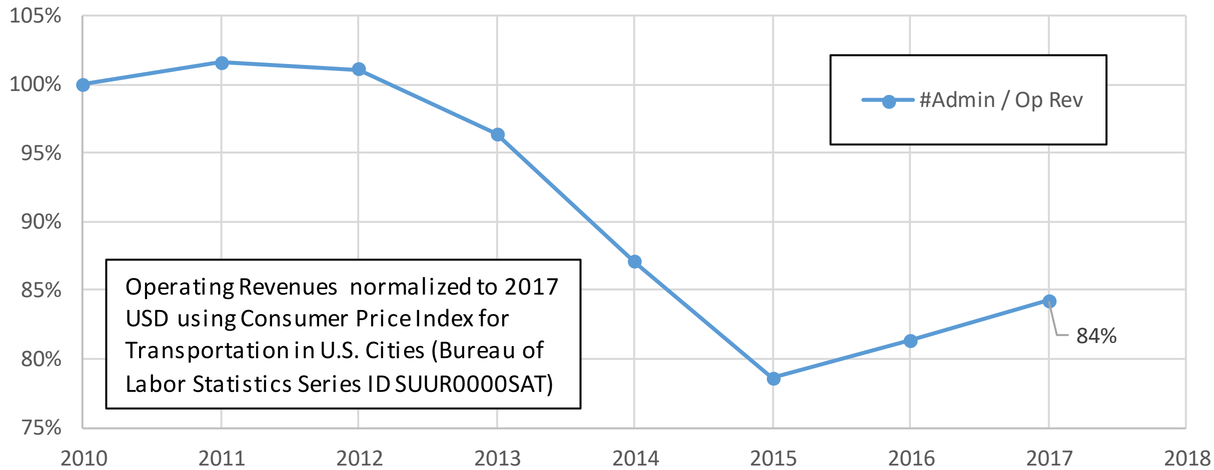


Figure 4 Staffing versus operating revenue as a percentage of 2010 levels

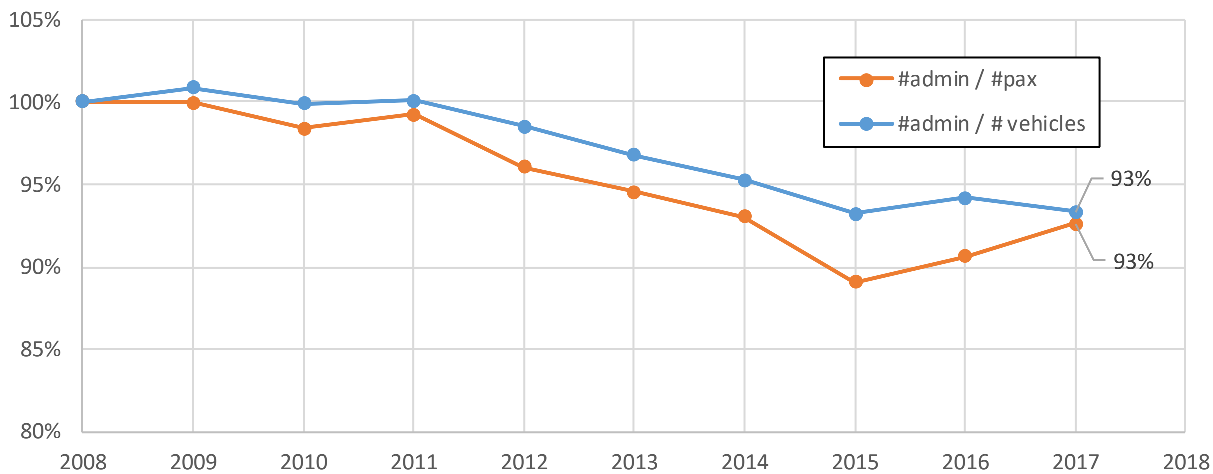


Figure 5 Staffing versus passenger and vehicle demand as a percentage of 2008 levels

In addition to increased traffic, customer expectations have increased. For example, an SSA executive noted that over the years, runs have been added to the ferry schedule, some of which are unprofitable. Adding runs increases the demand on management and raises fares if the runs are unprofitable. The only way to manage this increased level of service without increasing fares is to increase the workload on the existing members of the organization.

Nearly every SSA administrator that was interviewed expressed that they were performing a significant number of tasks that they believed they should not be performing, due to one or more of the following reasons:

- A task has to get done, but nobody else is responsible for or willing to do it.
- Processes that should be automated are done manually.
- The employee who is supposed to perform the task is unqualified to perform it.

The SSA managers are overwhelmingly willing to perform tasks that they feel are not their responsibility. However, it was also widely observed that taking on so many tasks outside of their job descriptions is hindering their ability to properly perform their own responsibilities (see Section 4.1.5 Allocation of Human Resources).

4.1.4.1 Issues

Understaffed management is a primary reason that the organization is stuck in a mode of reacting instead of planning (see Section 4.1.2 Strategic Planning). The lack of planning has resulted in inefficiencies that put management even further behind. For example, shipyard planning, including the midlife refit of M/V *Martha's Vineyard*, has suffered (see Section 4.2.4 Project Planning).

Understaffed management has also resulted in inadequate quality control. For example:

- Documents not getting reviewed by the appropriate people.
- Inadequate oversight of major capital projects, including shipyard overhauls.

The morale of the management team at the SSA has been negatively impacted, due to overwork and feelings of inequity amongst some employees who feel they are pulling more than their weight while others are underperforming without consequence.

Understaffed management also limits the ability of upper management to adequately train those employees who may eventually be promoted into their roles. This is not only problematic in terms of limiting the ability for those upper managers to delegate their own responsibilities when necessary, but puts the organization at risk for when those upper managers leave the organization.

4.1.4.2 Industry Standards/Best Practices

Staffing levels should be adequate such that employees are engaged and productive without being burned out.

Successful organizations provide their employees with ample support and training, but also recognize that sometimes underperformers need to be removed.

Customer expectations need to be managed. The tradeoffs between cost, quality of service, and frequency of service need to be clear to the public.

It is common in the maritime industry for organizations to realize some economies of scale within their management structure as the size of the fleet and/or demand grows. This comes with some important caveats, however. At the SSA, the factors limiting these economies of scale are inconsistencies in operations and a lack of management systems.

Operational inconsistencies are partly due to the unique requirements of the two routes as well as the diversity of the vessels. An important consideration when maintaining a ferry fleet is "fleet standardization". That is, if the composition of a fleet is similar then management and operation of that fleet is more efficient than if the composition of the fleet is diverse. Since the composition of the SSA's fleet is mixed, efforts at all levels must be tailored in order to maintain the same level of service.

When organizations grow their fleet they count on achieving some economies of scale as they expect that their staff can effectively manage more vessels of a similar or consistent class or service by utilizing the existing management systems. However, if these established management systems do not exist, it is not reasonable to expect the same levels of efficiencies.

4.1.4.3 Specific Solutions

The SSA can and should confidently hire one or two additional management staff in order to obtain adequate management capacity to efficiently perform its mission.

The SSA should routinely invest in a study (conducted internally or by external consultants) to determine how its staff are actually being utilized so that it can redistribute roles and responsibilities more efficiently. This management structure audit is described in Section 4.1.5 Allocation of Human Resources.

To leverage its latent economies of scale, the SSA should invest in management systems such as a safety management system (see Section 4.1.6 Health, Safety, Quality, and Environment Policies). The SSA should also invest in new technologies and automation to lighten the workload on its existing staff, such as an improved enterprise asset management system (see Section 4.2.1).

4.1.5 Allocation of Human Resources

The SSA managers are overwhelmingly willing to perform tasks that they feel are not their responsibility. On the one hand, this is an admirable characteristic and fortunate for the organization, because the practice was found to be widespread within the SSA. On the other hand, the pervasive misalignment between job title and role performed has enabled and even fueled the perpetuation of an inefficient allocation of resources at the organization.

There is excellent employee breadth, flexibility, and willingness to take on other tasks within the SSA's administrative team. The SSA can and should continue to harness the benefits of these cultural assets, while correcting the issues that inadvertently take advantage of them and even turn them into liabilities.

4.1.5.1 Issues

The degree to which the SSA employees are performing duties outside of their job descriptions is hindering their ability to properly and efficiently perform their own responsibilities. The disconnect between job title and job role also makes it difficult to manage employees time because their actual roles are unclear.

Mismanaged work assignments can also result in deficiencies not being addressed because they are hidden. For example, if an employee is incapable of performing a task that is their responsibility, and nobody else is willing to perform the task, then this deficiency will be illuminated when the task is not completed (or is completed poorly). Although this example suggests other cultural issues (a lack of teamwork), the problem will at least be identifiable and can therefore be managed. On the contrary, if an employee is incapable of performing a task that is their responsibility and another employee does perform the task for them, the deficiency is likely to go unnoticed. The problem is likely to reoccur, and the cultural norm of one employee doing another employee's work is reinforced, exacerbating the problem in the future.

4.1.5.2 Industry Standards/Best Practices

In order to properly manage the size and duties of a workforce, there must be good alignment between prescribed job roles and duties actually performed. Otherwise, it is difficult or impossible for managers to know if their human resources are being deployed efficiently and if they are staffed at adequate levels. Job responsibilities should be clear, and each employee's actual duties should align well with their job description. If this is not the case, either the job description or the actual duties performed need to change.

4.1.5.3 Specific Solutions

In order to achieve better alignment between prescribed job duties for each job title and the actual work performed by those titles, the SSA needs to understand how each administrator is actually spending their time. There are two ways to perform this management structure audit:

1. Survey each employee for their best estimate of the amount of time they spend on each task or type of task. This can be done quickly but may have some inaccuracies.
2. Implement a daily timesheet system to collect near-real time data on how each employee is spending their time. Require timesheets to be submitted at the end of each day or week recording how much time was spent on each task. Collect data for 8-12 weeks, until an accurate sample of each employee's responsibilities has been collected.

In either method, it is important to standardize time spent into a manageable number of clearly-defined categories and sub-categories, or "buckets," to ensure data integrity and allow for results to be efficiently analyzed. For example, categories might include Vessel operations, human resources, office administration, accounting, information technology, etc. Sub-categories for vessel operations might include discussions with vessel crew, vessel maintenance planning, vessel budget planning, etc. The goal is to create a manageable number of sub-categories that cover most of the daily work performed by the organization (aim for no more than 50 sub-categories that cover at least 90% of the daily work performed). "Other" or "General" subcategories can be added to each category to allow 100% of time to be recorded- just require that if that option is used, comments are included detailing how that other time was used.

In either method, to obtain accurate and meaningful results, it is important that everyone involved understands the value of the process. Employees should not be evaluated on the results.

Once the SSA has obtained reliable data on how time is actually used, the data can be analyzed to see how the organization actually functions, and to answer the following questions:

- Are the right people performing the right job functions?
- Are there duties that are currently spread around the office that can instead be concentrated on one or two specialists?
- Is anyone overworked? Is anyone under-worked?
- Are there job functions that should be added?
- Are our job descriptions accurate?

4.1.6 Health, Safety, Quality, and Environment Policies

Health, safety, and environmental (HSE) programs are policies and processes that companies put in place to ensure that no harm is done to people or the environment as the company pursues its stated mission. As preserving these goals can be difficult and expensive, HSE policies must be implemented with mechanisms that provide independence from corporate chains of command, whose objectives are not always in alignment with HSE goals. Without such independence, commercial or mission-related pressures can undermine HSE objectives.

Quality policies, which focus on systematic improvement of the processes a business uses to achieve its mission, also require independence from the business-focused chain of command and utilize similar policy frameworks as HSE programs. This commonality of purpose and implementation often result in combined HSQE programs.

The SSA has no formalized HSQE program, and the policies in place that do address HSQE goals are inadequate. Specifically:

- **Health**. Inadequate; for example, a lack of documented policies for meeting OHSA guidelines at Fairhaven Maintenance Facility.
- **Safety**. Inadequate; some specific policies, such as lock-out/tag-out, are in use, but not within formal process or system.
- **Quality**. Inadequate; no formal processes or system.

- **Environmental Protection**. The SSA appears to comply with specific environmental regulations that are applicable to vessels and facilities, but no formal process or system is in place.

Obstacles to the SSA's pursuit of HSQE goals were observed in several areas, including the lack of leadership in prioritizing these goals, the lack of resources dedicated to HSQE programs, and cultural attitudes.

Lack of Leadership. The SSA senior management have not prioritized HSQE goals or communicated to the organization the importance of such goals. This is evidenced by the lack of a formal HSQE program. In many cases where HSQE activities were observed, the efforts were designed to meet minimum regulatory requirements.

There is no comprehensive safety manual documenting SSA safety policies to be used throughout the organization, so what polices do exist are not available to personnel onboard SSA vessels, within the vessel maintenance facility, and at vessel terminals. An incomplete Operations and Safety Management Manual was developed in 1997 but has not been updated since, and according to most accounts, is not used. Similarly, an Engineering & Maintenance Safety Management Procedures Manual was developed, but never approved by management or officially released, although some specific policies in it are in use. Most employees were unaware of the existence of either manual.

Individual managers have made attempts to establish policies and procedures independently within their own departments but those that were witnessed were mostly created without executive approvals and lack document control.

Lack of Resources. The SSA does not have any employees/positions dedicated to health, safety, quality, and the environment (HSQE) management. Instead, efforts that are being made are spread around the organization as secondary duties with no real accountability or authority. For example, the facilities engineer has some responsibilities for ensuring environmental compliance of the facilities, however this position is also responsible for the maintenance and upkeep of numerous facilities. The amount of time the facilities engineer can devote to environmental compliance is tightly constrained, and the role is focused on compliance with specific regulations, not the pursuit of defined HSQE goals.

Multiple employees across the organization expressed a desire for an HSQE position to be added, in order to mitigate latent environmental and safety risks that they feared could result in disaster.

Cultural Attitudes. When questioned about the events that occurred in the spring of 2018, multiple SSA executives pointed out that the issues experienced were unprecedented in their breadth and severity, and largely a function of external forces (weather, shipyard problems) and unfortunate timing. Although they acknowledged specific internal failures and mistakes, they implied that the issues were the result of a 'perfect storm' of independently unlikely circumstances, without which the issues would not have occurred to the degree that they did. A common view among managers is that the SSA had successfully operated for many years without such problems, and now that the unfortunate events are in the past, the SSA will continue to operate for many years into the future without any similar events. This view suggests that no systematic changes to the SSA's management of their operations are necessary to operate the fleet at an acceptable level of reliability.

By contrast, our investigation suggests that the SSA may, in fact, have had good luck not to have had more frequent and severe incidents. This 'luck' over the years may be attributed to the high quality and dedication of its employees. But as the pace of change in the industry increases, coupled with the increase in recent turnover at the SSA, they will likely experience more frequent incidents. This is based on the breadth of quality issues observed, as evidenced by the example in the Issues section below.

4.1.6.1 Issues

Many, if not all, of the vessel-related casualties that occurred this past spring at the SSA could have been avoided if the SSA had an effective management system in place with stated health, safety, quality, and environmental protection goals. How such a system can prevent incidents can be explained by understanding two key elements of management systems that are not effectively in place at the SSA: hierarchical control and continuous improvement.

Hierarchical control: Management explicitly defines the roles and responsibilities of all personnel, develops policies and procedures that prescribe how personnel perform their jobs, and builds a system of accountability that ensures that work gets done in the way that management has prescribed.

All companies, including the SSA, use hierarchical structures to organize their work force, define roles and responsibilities, and enable day-to-day operations. Observations of the SSA's operations suggests that what they do not do is prescribe how they expect vessel crews to perform their jobs. The SSA lacks a comprehensive set of policies and procedures that enumerate the expectations and define how routine tasks and operations should be performed. Without management prescribing the 'best' way for crews to perform their jobs, the organization is reliant upon the training and judgement of the individual watch standers to decide. This takes the control of quality outcomes out of the hands of management and gives it directly to vessel crews.

Considering that this review of the SSA's management identified serious shortcomings in crew operational training, and observed circumstances where new crew members were put on watch with little or no training, the need for the SSA management to take direct control of quality outcomes, versus relying on crew judgement, becomes more urgent.

Continuous improvement: The management imperative to continually evaluate policies and procedures with the stated goal of improving outcomes, using a standardized framework. As implemented by quality management systems, continuous improvement often involves the proactive identification and analysis of instances where prescribed policies and procedures are found to be incorrect or ineffective.

HSQE management systems manage risk by forcing organizations to identify any issue that could contribute to an undesirable HSQE outcome, understand how and why that issue came about, and adjust policies and procedures to protect against the recurrence of that issue. In nearly all cases, issues that are identified and reviewed would not, in and of themselves, lead to an undesirable outcome, but if they have potential to do so, given another system failure or mistake, then they are investigated and prevented from recurring.

By systematically eliminating circumstances that could lead to undesirable outcomes, continuous improvement programs increase the resiliency of operations, adding levels of protection against undesirable outcomes and reducing the likelihood that operational mistakes or equipment failures (which inevitably will occur, even in the most diligently managed operations) will not result in a serious incident.

It is the prevailing attitude among some members of the SSA management that the vessel casualties experienced in the spring of 2018 were the result of a confluence of external factors, bad timing, and bad luck; and that no systematic changes to the organization are required to prevent recurrence of such incidents. Our review of the way that the SSA manages risks associated with the maintenance and operation of their vessels suggests the opposite: that future incidents are likely, based on the SSA's lack of process related to the identification and correction of quality and safety issues in the area of vessel management.

The following is a list of quality issues related to the March 17th blackout of the M/V *Martha's Vineyard* that were identified during the root cause analysis of that casualty. None of these issues, in isolation, would cause a casualty. All of these issues, however, represent breakdowns in the way the SSA manages quality and safety onboard their vessels. In the context of a functional HSQE management system, each one of the listed items would be considered a 'non-conformity', which would trigger investigation, corrective action to fix the problem and prevent future occurrences, and documentation that the issue was resolved.

- Lack of vendor controls during the shipyard allowed non-critical alarms to be configured as generator shutdowns.
- Lack of testing of generator controls allowed vessel to leave the shipyard without engineering management identifying the above issue.
- Shipyard oversight failed to identify incorrect crimp on Generator #3 connection to the generator starter.
- No procedure or checklist was in place to provide instruction to crew on how to restore the plant from a blackout condition.
- Vessel crew failed to restart the fuel oil transfer pump when restarting the plant from a blackout condition.
- The vessel was released to service after a major casualty with unidentified damage to the switchboard.
- The vessel was released to service after a major casualty with inadequate operational review of the plant (*e.g.*, fuel pump was not restarted).
- Fuel transfer pump pressure gauge was ineffective.
- There was no indication of fuel transfer pump running.
- The change in fuel system configuration was not known by crew.
- The change in fuel system configuration not known or evaluated by management.
- Vessel crew did not recognize dropping fuel tank level until the tank was empty.
- Shipyard specification drawings of the fuel system were incorrect.
- Shipyard oversight of automation vendor failed to ensure that fuel level alarms were correctly configured.
- The vessel was released from shipyard without having tested USCG-required fuel level alarms.
- Vessel PSTP was incorrect – it did not include required low fuel level alarms.
- Vessel was released from shipyard without having completed a comprehensive test of the modified alarm and monitoring system.
- PSTP used during the vessel's COI was not USCG approved.
- Crew lacked training on back-feeding power from EDG to main switchboard.
- There was no procedure available to vessel crew on how to back-feed power from EDG to main switchboard.
- One of the vessel's two fuel transfer pumps had been electrically installed on a fuel supply circuit that was not isolated by the remote fuel shutoff.

While many of these issues are typical details that all vessel operators struggle to manage, the number of issues that were identified in association with a single vessel incident suggests that the SSA's operation has an unusually high level of unobserved or 'latent' issues, any one of which could contribute to a future incident. Since the spring of 2018, the SSA has resolved some of the specific deficiencies identified on this list. For example, the M/V *Martha's Vineyard* PSTP has been submitted to, and approved by, the USCG. As a regulatory requirement, it was crucial to address this with urgency. This investigation of the SSA's operations discovered no sign, however, that the SSA was making any systematic changes to policies or procedures that would address the root cause failures associated with this incident. They have not, for example, made any fundamental change to crew training systems, engine department watch processes, or their approach to shipyard project management. This fact reinforces the observation that the SSA is focused, in large part due to a lack of resources, on meeting the minimum compliance standards rather than pursuing proactive improvement.

4.1.6.2 Industry Standards/Best Practices

Formalized and documented HSQE programs are mandated for passenger vessels operating in international waters under the ISM Code, and are common, but not required, among domestic ferry operators. Current best practices for ferry vessel operators of the SSA's size is to have a formalized HSQE program implemented in an ISO quality management style and fully supported by leadership at the highest levels.

A majority of organizations in the maritime industry, both globally and domestically, have identified the need to set and work actively to achieve HSQE goals. Most of these organizations have realized the benefits of using a management system to do so. The management systems employed take many forms and represent a variety of approaches tailored to the industry segment and individual operation, but they consistently follow the ISO format for management systems and ensure that the following functional requirements are accomplished:

- A clear and concise policy is provided.
- Communications protocols are established.
- An individual independent of the chain-of-command is designated and given proper authority and responsibility to manage the system and ensure effective communication.
- A means of verifying the effectiveness of the system is provided.

Within the maritime community the ISM Code has been adopted to address safety and environmental protection management. Organizations have incorporated elements of the ISO 9001 standard for quality management systems, as well as other standards, into their program. This has been a very effective way to address issues through a single platform, commonly referred to as a safety management system (SMS) or other name suitable to the elements incorporated.

The ABS Guide for Marine Health, Safety, Quality, Environmental, and Energy Management (Reference 11) provides guidance on implementing an HSQE program in the maritime industry.

The ISM Code and related code sections specific to the maritime industry that address safety, environment, security, and quality have been adopted by some of the nation's largest ferry operators. While the ISM Code is not a regulatory requirement for domestic maritime operations, it is becoming an industry standard/best practice, adopted by ferry operators such as:

- Washington State Ferries, since 1998.
- Staten Island Ferries, since 2005.
- HMS Ferries, since 2003.
- NYC Ferry, since 2017 (ISO standards 9001, 14002 and 45001).

4.1.6.3 Specific Solutions

The SSA should strongly consider developing and implementing an externally-audited ISM Code-compliant safety management system (SMS) as a management system foundation. An SMS system, and the continuous improvement processes that come with it, would force the organization to identify quality gaps across the organization and track each to a resolution. This system could then provide the infrastructure to support additional management programs to address quality, health, and other challenges they may face in the future.

Developing and implementing an SMS requires human, financial and IT infrastructure resources. A designated person (DP) must be identified. The role of the DP is to facilitate communications between employees and management (a crucial element of the SMS), verify and monitor the system as it strives for continuous improvement, and coordinate and prepare for external audits. In order for the DP to effectively perform these functions they must remain independent of the chain-of-command, have direct access to the highest levels of authority in the organization, and be provided with adequate resources.

A full time DP with administrative assistance is typical for an organization of this size. There is an inherent advantage to assigning this and only this role to a single individual. When individuals are responsible for both the short-term operational performance of the organization and its long-term commitment to healthy, safety, quality, and the environment, the short-term operational performance often conflicts and overrides the HSQE goals. An employee dedicated to the title and given sufficient organizational independence would be able to support quality imperatives in the face of commercial and organizational pressure. The DP should report directly to the General Manager.

4.1.7 Hero Culture

The SSA is led by a small group of hard working individuals who spend significant portions of their time performing duties that are outside of their job descriptions. These individuals carry a significant amount of institutional knowledge (see Section 4.1.1), and in many cases they are the only employees capable of fulfilling certain duties. All of these observations are aspects of a pervasive hero culture: a culture in which the organization is overly-reliant on a small number of individuals.

There are several factors fueling the hero culture:

- The SSA workplace is highly visible and scrutinized by its customers. The appearance of hard work and long hours is celebrated by customers and the organization, even if the allocation of resources is grossly inefficient.
- The SSA is laser-focused on cost-cutting. An unintended consequence has been to cut out its own ability to do adequate planning.
- A hero culture creates a vicious cycle. While the culture of cost-cutting has resulted in vastly inadequate organizational planning, breaking out of the hero culture ironically requires significant planning.
- Fighting fires is easier than planning.

4.1.7.1 Issues

There are numerous issues associated with a hero culture, including:

- Being perpetually stuck in a reactionary “firefighting” mode.
- The lack of process-based, institutionalized operations.
- Difficulty managing people’s time, due to a disconnect between job titles and duties actually performed (see Section 4.1.5 Allocation of Human Resources).
- A stressful, rigid work environment, where it seems like everyone is busy but nothing gets done or gets done well.
- Resistance to change, planning exercises, or anything that gets in the way of the most urgent and visible needs.
- Tribal knowledge - knowledge that is only known by a few employees.

- Lack of scalability, since knowledge and power is concentrated within a small group of "heroes."
- Lack of adaptability to evolving customer demands and industry dynamics.
- Burned out employees and low morale, due to unrelenting workload and the feeling of wasted time due to inefficiencies.
- Lack of oversight and increased risk for mistakes.
- Lack of trust and empowerment, due to a lack of processes for sharing information and a lack of processes for institutionalizing how the organization operates.
- Inefficiency due to employees performing tasks below their paygrade or that other employees are better suited to handle.
- Self-perpetuation, because the hero culture is easier and more rewarding than planning.

4.1.7.2 Industry Standards/Best Practices

Mature organizations like the SSA should have documented processes for every job function that is required to deliver their product or service. In the marine industry, companies which have successfully adopted process-based operations are leading the industry in operational efficiency and customer satisfaction.

No employee should be irreplaceable. This is critical to the reliability of the organization, but also a critical factor for breaking the self-perpetuating cycle of a hero culture.

The SSA is a complex organization that requires a highly skilled and competent workforce to accomplish its objectives. However, there are many other ferry services of similar or greater complexity that do not suffer from the same levels of employee stress and fatigue that we observed at the SSA.

4.1.7.3 Specific Solutions

The SSA management needs to change from a hero culture to a process-based culture. Culture is the hardest thing for any organization to change, which is why it is often precipitated by a crisis followed by demands for change by the customers or shareholders. In this case, the SSA's governing Board will need to closely oversee the implementation of the following solutions to ensure they are given the time, effort, and resources they require.

The first step is to align the job duties for each job title with the work actually performed. This will begin to illuminate key processes and any inefficiencies in accomplishing them, and help to balance workloads. The basic process is described in Section 4.1.5 Allocation of Human Resources.

The second step is to define the key processes that the SSA follows in order to accomplish its mission. This process mapping exercise will be a project of its own, requiring an internal champion or an experienced contractor. The processes will be broken into tasks such that somebody with reasonable qualifications and on-the-job training can perform them, and the organization chart will be mapped to the processes to define responsibilities.

The SSA should also improve its communications to the public to better illuminate what it is doing to perform its mission. By providing reliable operations and good communications, the SSA should be able to eliminate the need for employees to routinely work well over 40 hours per week.

4.1.8 Institutional Knowledge

Institutional knowledge is the wisdom held by an individual about how an organization or part of an organization functions. Institutional knowledge can be a tremendous asset to any organization if properly captured and managed.

It was generally observed that there are many long-tenured individuals with significant institutional knowledge at the SSA. Although it goes without saying that having knowledgeable employees is a great asset for any organization, a negative side effect of being able to rely on institutional knowledge is that it can be over-relied upon, resulting in a lack of documented work processes. Evidence of this was observed at the SSA. This lack of documented work processes has a number of ill effects, including putting the organization at risk of unnecessarily relying on unique individuals, causing inefficiencies, and preventing change.

The risks of this problem are amplified at the SSA due to the following related observations:

- **Management turnover.** The SSA is currently undergoing a high degree of management turnover (mostly due to retirements), which is amplifying the amount of information that is being lost and highlighting a lack of redundancy in key management roles.
- **Changing environment.** The industry and environment in which the SSA operates is rapidly changing, also amplifying the problem.
- **Inconsistencies in fleet.** The SSA ferry system is complex, with little consistency amongst the vessel fleet, crews, and equipment.
- **Overreliance on memos.** The primary mode of communicating new policies and procedures is with memos, which is not a reliable medium for document control and referencing.

4.1.8.1 Issues

The SSA is highly exposed to the risk of institutional knowledge loss when an employee leaves their job. With an aging workforce, especially amongst vessel crews, this issue will continue to amplify unless the overreliance on institutional knowledge is addressed.

Relying on institutional knowledge can result in the acceptance of bad practices or “bad habits.” Institutional knowledge is resistant to the adoption of best practices, evolving industry standards, and programs of continual improvement.

Relying on institutional knowledge is subject to a higher degree of individual interpretation than relying on documented standards and work processes. This results in inconsistencies and increases the opportunity for errors.

4.1.8.2 Industry Standards/Best Practices

Most industries, not just the maritime industry, are challenged by the overreliance on institutional knowledge. There are several standard approaches that can be employed to deal with the issue. Some common approaches are to:

- Identify leadership competencies in existing employees, and train the next generation of leaders well before the jobs are available.
- Ensure there is never just one person capable of performing any given job function within an organization. At a minimum, there should always be at least one backup.
- Document business practices within living documents, which are updated as best practices emerge and evolve.

4.1.8.3 Specific Solutions

The solution to an overreliance on institutional knowledge is to adopt the best practices detailed in the section above. At the SSA, this should start with documenting knowledge (how the critical functions of the business are performed successfully) and ensuring knowledge redundancy amongst the work force.

Specifically, the SSA should document its work processes, beginning with those that are the most critical to meeting its objectives. Memorandums are currently the dominant medium for disseminating policy changes throughout the organization, but these are inadequate as they can easily be overlooked and do not achieve version control. Instead, the SSA should maintain a database of policies. Memos should only be used to alert employees of new or amended policies, and direct employees to the appropriate version-controlled documents.

To ensure knowledge redundancy amongst its employees, the SSA should engage in succession planning, and ensure there is always at least one employee capable of filling every employee's role. Employees in management positions should be held accountable for training those who replace them. The SSA should also consider developing formal mentoring programs to train the next leaders.

4.1.9 Tenure

The SSA management contains a high number of long-tenured employees, as illustrated in Figure 6. While there are numerous positive qualities associated with organizations that are able to retain employees, the SSA suffers from an overemphasis on the tenure of its administrative and executive team as a grounds for career advancement.

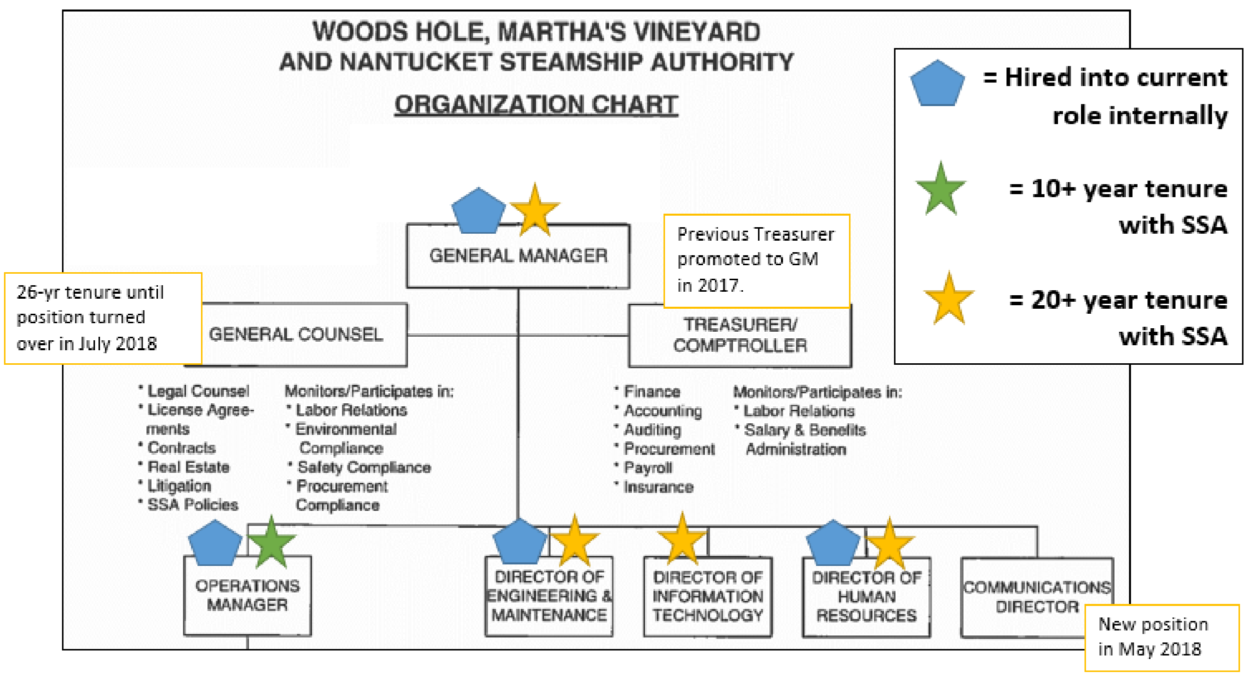


Figure 6 Tenure of the SSA executives

An important and valid reason for promotion of long-tenured SSA employees is that longevity is highly correlated with experience and wisdom, which are valid measures of merit. However, some cultural problem areas inflate the importance of tenure at the SSA for the wrong reasons. The SSA is overly reliant on institutional knowledge (see Section 4.1.8 Institutional Knowledge). Long-tenured employees tend to be the most reliant institutional knowledge.

The SSA also has a hero culture which has concentrated knowledge and power in a small number of executive-level employees. This concentration of power results in organizational inefficiencies for many reasons (see Section 4.1.5 Allocation of Human Resources).

Recruiting outside of the organization has been passive. For example, the Port Captain position has been open for a considerable time but has not been advertised externally, despite the fact that the SSA has only received one internal application.

The competitive environment in which the SSA recruits its employees is an important consideration. The SSA headquarters is in Falmouth, MA – a small town with a high cost of living (96.2% above the national average, Reference 5). The maritime industry also offers high-paying private sector jobs, such as oil industry jobs in the Gulf Coast region. These salaries cannot be matched by the SSA. However, recent salary audits of the SSA show that management salaries are in line with comparable positions in other public service organizations. The SSA is also in close proximity to a strong maritime community, including Massachusetts Maritime Academy. And, the geographic region is generally considered a very desirable place to live. Considering all of these factors and discussions with the SSA HR Department, the SSA's ability to recruit qualified candidates was not observed to be a major factor in the tenure of its employees.

4.1.9.1 Issues

Issues associated with the SSA's overemphasis on tenure as a grounds for advancement include the following:

- **Merit underemphasized.** The longest-tenured employees may be promoted instead of the best qualified candidates. This damages the performance and morale of the organization. In some cases, qualified candidates at the SSA did not even apply to positions out of deference to others in the organization who they believed were "next in line."
- **Insularity.** Fresh and outside perspectives are suppressed when there is a lack of hiring from outside an organization. Insular organizations experience difficulty adapting to their evolving surroundings. They are also at elevated risk of 'groupthink,' or making decisions as a group in a manner that discourages creativity and individual responsibility.
- **Toleration of underperformance.** There was evidence of underperformance not being remediated at the SSA due to a lack of management will to confront long-tenured employees.

4.1.9.2 Industry Standards/Best Practices

Decision making can be improved when natural coalitions are broken up. By assigning people with different interests and roles and who do not normally work together to shared tasks, fresh perspectives and ideas come to light. Recognizing this when hiring and promoting can positively influence those decisions.

Merit should be heavily weighted when making decisions about hiring, advancement, and incentive structures. Tenure is correlated with merit, so all else being equal, those with longer tenure have an advantage without the need to artificially inflate the value of tenure.

4.1.9.3 Specific Solutions

Greater emphasis should be made on recruiting outside of the organization for job vacancies, especially while the SSA continues to be managed by a core group of very long-tenured employees with limited experience outside of the organization.

In order to ensure that tenure is not overemphasized at the expense of merit, it is critical that management performance is tied to organizational performance. The solution to this is for the SSA to develop performance metrics on which its executive staff are measured on an annual basis (see Section 4.1.2). This starts at the top: the SSA's governing Board needs to develop operational performance objectives on which to evaluate the performance of the General Manager, Treasurer, Operations Manager, Director of Engineering & Maintenance, Director of Information Technology, and Director of Human Resources, at a minimum.

4.2 Fleet Maintenance

4.2.1 Engineering Policies and Procedures

Evaluation of the SSA's marine engineering operations included an investigation into what policies and procedures are in place and being utilized by the organization's personnel. The following procedures were identified:

- Procedures for the start-up of vessel machinery plants.
- Procedures for the securing of vessel machinery plants.
- A comprehensive Engineering & Maintenance Safety Management Procedures Manual.

The vessel start-up and securing procedures were observed to be available onboard fleet vessels and generally in use, despite several shortcomings, including:

Lack of document control. Policies were observed to have no revision numbering or date to allow for document control, or official formatting to suggest they are the current authorized procedures.

Inconsistencies across fleet. Procedures were observed to lack standardization and consistency across the fleet with regards to format, content, degree of detail, and objectives. For example, inconsistencies in the vessel startup and securing procedures were observed between M/V *Martha's Vineyard* and M/V *Woods Hole*. The *Martha's Vineyard* procedures were highly descriptive and provided familiarization information, which may be useful to new and inexperienced crew members, but reduce the value of the procedure as a working checklist. The M/V *Woods Hole* procedures were written much more like a working checklist, but lacked instructive information for new and inexperienced crew members. In both cases, the procedures were written in an informal, conversational tone, and lacked document control.

There was no evidence to suggest that the Engineering & Maintenance Safety Management Procedures Manual had been distributed throughout the organization, and procedures documented in this manual did not appear to be in active use within the organization. Discussions with engineering management indicated that the manual had never been officially released as policy, and was still under review by senior management, despite the revision date of **June 2012**.

Instances where the lack of standardized procedures directly contributed to a vessel incident were also observed, as described in Section 3. These included the following examples:

- In the aftermath of the generator fire on M/V *Martha's Vineyard*, the crew was called on to restore the plant from a blackout condition. There was no procedure or checklist for this operational transition. If there had been a formalized procedure or startup checklist, or if the crew had followed the plant startup procedure, then the fuel transfer pump would have been restarted, and the March 17th blackout would have been avoided.
- The SSA failed to perform an effective investigation into the cause and effects associated with the fire that occurred on the M/V *Martha's Vineyard*, and therefore failed to identify

latent damage to the switchboard and operational limitations that led to the blackout on March 17th. If the SSA had a procedure prescribing how such investigations must be performed, or if the SSA had followed the casualty investigation policies outlined in the draft Engineering & Maintenance Safety Management Procedures Manual, then these limitations would have been identified and subsequent vessel casualties or service interruptions possibly avoided.

- In the aftermath of the March 17th blackout of M/V *Martha's Vineyard*, the vessel was at anchor with the ability to only run the emergency diesel generator. Restoration of power to critical loads on the main switchboard were delayed because the crew did not know how to back-feed power from the emergency diesel generator to the main switchboard. The lack of a written procedure that was available to the onboard crew delayed the restoration of power and lighting to the vessel's main switchboard, and unnecessarily demanded the attention of the vessel Chief Engineer and Port Engineer at a critical time.

Multiple issues were observed with the periodic safety test procedures (PSTPs) associated with the SSA vessels. These procedures are special test documents that are explicitly required by regulation, which must be approved by the USCG Marine Safety Center (MSC), and performed to the satisfaction of the local Officer in Charge, Marine Inspection (OCMI) on an annual basis. The following problems associated with the PSTP for the M/V *Martha's Vineyard* were identified during the investigation of casualties onboard the vessel.

- The vessel did not have a USCG-approved PSTP at the end of shipyard period.
- Prior to June 2018, the vessel's PSTP consisted of several individual procedures for various systems, such as the propulsion control system and the alarm and monitoring system, instead of a single document.
- The procedure for the alarm and monitoring system was not complete or accurate. For example, generator fuel pressure alarm setpoints were not correct, and no fuel service tank level alarms were included.
- The procedure that was, according to the SSA management, performed for USCG was not marked to suggest that it was approved, and did not include a test date or name of the tester. The procedure form has a field for witnessed by and date, but it was not signed.
- The new, re-written version of the vessel's PSTP appears to be incomplete and/or inaccurate. For example, it does not include low generator fuel oil pressure alarms.

4.2.1.1 Issues

The absence of clear policies and procedures presented in a consistent format and with a clearly communicated expectation that these policies and procedures will be followed results in vessel crews and maintenance personnel applying their own personal preferences, experiences, and judgement about how best to perform a task or conduct an operation. The variability of many unique approaches to the same job function creates possibilities for misunderstanding and mistakes. It makes it difficult for management to consider the various options and decide on an optimal procedure. The lack of consistency also reduces efficiencies that could be gained if everyone was doing things the same way and makes it difficult to reinforce good practices and identify and eliminate bad practices.

A lack of policies and procedures also makes it difficult or impossible for vessel management to direct the actions of its crews. For example, the rate at which the M/V *Martha's Vineyard* fuel service tank level dropped during the March 17th incident was dramatically increased by the change in fuel system configuration that occurred prior to the incident and without the authorization of vessel crew management. If configuration of the fuel system was covered by vessel operational policies and/or documented watch processes, then the incident may have been avoided.

In the same way that vessel equipment operational policies ensure the safe operations of vessels, procedural approaches to engineering management processes ensure that critical job functions are accomplished, and that quality and performance goals are met. For example, many quality issues resulted from a lack of quality control procedures during the M/V *Martha's Vineyard* midlife refit project.

4.2.1.2 Industry Standards/Best Practices

Vessel managers operating fleets the size and complexity of the SSA typically employ a formalized management system to document and control the policies and procedures that are in place in their organizations. These systems force operators to develop and implement policies and procedures for all operational and managerial processes. A more detailed discussion of how and why operators implement such programs is included in Section 4.1.6 Health, Safety, Quality, and E).

4.2.1.3 Specific Solutions

It is unlikely that the SSA will be able to prevent future occurrences of the kinds of casualties that were experienced in the spring of 2018 without making a cultural and managerial shift from informal policies and procedures that rely on the judgement of individuals to a formalized management system that prescribes procedures related to all aspects of vessel operations. The SSA should strongly consider developing and implementing an externally audited ISM Code-compliant safety management system (SMS) as the basis of and controlling mechanism for all policies and procedures (see Section 4.1.6 Health, Safety, Quality, and Environment Policies).

Whether or not they are codified by an SMS, the SSA should develop a set of company policies and procedures that comprehensively define all critical tasks and processes that are required for the organization to operate safely and efficiently. The basic steps to implement these policies and procedures are:

1. Identify all operational and managerial sequences whose performance impacts vessel operations, condition, readiness, and reliability.
2. Develop individual procedures that specifically address all operational, safety, and quality concerns regarding the particular task or process.
3. Publish the policies in a standardized format and make them available to all personnel where they perform their work.
4. Communicate the polices such that all personnel understand the details of the policies; confirm their understanding in writing.
5. Establish feedback mechanisms that test the effectiveness of the policies and procedures and investigate all instances where they have failed to meet functional requirements (e.g. non-conformities, casualties, near-misses).
6. Adjust the polices based on feedback to make them more effective.
7. Control the policies so that changes are quickly communicated and adopted throughout the organization.

The adoption of a policy-based framework for the management of the SSA vessel operations represents a departure from the organization's current way of doing business. As such, it will require a cultural shift in both management and personnel to be efficiently and effectively implemented. Personnel are more likely to make the required cultural shift and embrace a policy-based framework when they are presented with convincing evidence of the value of the change. The implementation of new policies should include training that provides this evidence.

4.2.2 Engineering Resources

Shortcomings in the SSA's engineering operations identified by this investigation suggest that the SSA engineering and maintenance department may be understaffed for the responsibilities it is tasked with. The following three areas are particularly affected by this deficiency:

a. Engineering department crew training (see Section 4.2.2 Engineering Resources for more details).
b. Establishment and enforcement of vessel policies and procedures pertaining to engine room operations (see Section 4.2.1 Engineering Policies and Procedures for more details).
c. Vessel repair, refit, and construction project planning and management (see Section 4.2.4 Project Planning for more details).

The following is a summary of responsibilities of the SSA Director of Engineering and subordinates, based on the SSA's organizational chart, job descriptions, and observed functionality:

- **Engine department operations**: Oversight of the day-to-day engine room operations of the SSA fleet, including the development and management of all engine department policies and procedures, and all efforts associated with unplanned vessel maintenance or other departures from standard vessel operations.
- **Personnel training**: Development and execution of training programs for all engine department and maintenance personnel.
- **Asset maintenance**: Planning and execution of preventive and corrective maintenance for all physical assets of the SSA, including vessel, terminals, facilities, and all rolling stock. This also includes the implementation and management of the SSA's computerized asset management/maintenance system.
- **Management of maintenance division**: Management of the SSA's maintenance personnel and assets, including planning of vessel repair projects at the SSA facilities and all activities associated with purchasing, warehousing, and shipping and receiving for the warehouses.
- **Vessel repair projects**: Planning and management of vessel repair projects conducted at external shipyards, including specification development, contracting, and regulatory interfaces.
- **Vessel construction**: Planning and management of vessel construction projects including the management of design development, shipyard selection, contracting, and shipyard project management.
- **Regulatory compliance**: Regulatory compliance of vessels and vessel personnel, where engineering/technical matters are relevant to the compliance.

To discharge their responsibilities, the Director of Engineering has the following personnel available:

- A **Facilities Maintenance Manager**, who is responsible for all facilities and environmental compliance for all facilities. This role has no direct involvement in vessel operations or maintenance.
- A **Vehicle Maintenance Supervisor**, who is responsible for all rolling stock including 22 buses.
- A **Vessel Maintenance Manager**, who is responsible for a maintenance staff of 32 including 3 foremen, spread across three facilities.

- A **Port Engineer**, who is responsible for engine department training and performance, as well as fleet maintenance schedule planning, budget, and control.
- An **Assistant Port Engineer**, who assists the Port Engineer and the Maintenance Supervisor, and is responsible for ensuring that the SSA's computerized asset management system is utilized across the fleet.
- A **Project Manager**, who is dedicated full time to the Woods Hole Terminal project.
- A **Maximo Planner**, who is dedicated full time to the upkeep and management of the SSA's computerized asset management system (Maximo).
- An **Administrative Assistant**.
- A **Department Clerk/Secretary**.
- Contract employees, as needed.
- Vessel crew, who are sometimes used to assist in shipyard project execution.

This assessment suggests that all critical tasks associated with crew training, the establishment and management of engine department policies, and the planning and management of vessel repair and construction projects must be handled by the Director of Engineering and two additional FTE positions, the Port Engineer and Assistant Port Engineer, as well as the Vessel Maintenance Manager to assist with vessel maintenance planning.

The SSA, as currently structured, lacks sufficient human resources in the area of middle-level engineering management to be successful in the discharge of assigned responsibilities, particularly in the three areas mentioned above. With a fleet of 10 aging vessels and a nearly constant rotation of those vessels through shipyard/repair periods, the effort associated with planning and executing these functions is far greater than what is currently available within the organization.

The SSA has relied on external contractors to assist in the development of shipyard specifications and the management of large shipyard projects. This has helped the SSA manage the workload associated with these projects but has been insufficient to close the capacity gap.

Discussions with various vessel crew suggested that the port engineers in particular are chronically over-committed, forcing them to ignore less urgent responsibilities. Numerous engineers indicated that they were reluctant to reach out to the Port Engineer, because they knew how busy the Port Engineer was.

4.2.2.1 Issues

It is difficult to attribute specific lapses by the SSA's engineering management to problems associated with shortages in human resources as it is impossible to determine what personnel would have done if they had had more time to perform their jobs. However, it is reasonable to conclude that the over-commitment of engineering management is a likely contributor to the organization's recent vessel reliability issues. Maintaining the status quo puts the organization at increased risk for future such incidents.

The engineering management team at the SSA appears to have the appropriate technical skills and background to successfully manage the engineering aspects of the SSA fleet. Yet, as this investigation has illuminated, the SSA has chronically neglected operational processes and critical engineering details in ways that have caused major vessel incidents. For example, two of the failures associated with root cause analyses performed as part of this study indicated incorrect implementation of vessel alarm systems modifications. Discussions with the vessel Port Engineers regarding shipyard projects suggest that, while they intend to be involved in technical details such as alarm system integration, their general lack of availability prevents them from having anything more than a cursory involvement in such matters. Absent their involvement, such details fall to others who may not be qualified to provide the correct answers, such as the controls vendor or the crew assigned to the shipyard project. Or, worse, verification of these details is not accomplished at all.

The Port Engineers and Director of Engineering are the individuals who are most closely involved with the response to, investigation of, and corrective actions associated with vessel casualties or unscheduled maintenance events. As such, any work that they are normally engaged in stops when they are needed to respond to emergent issues. During the organization's extensive issues in the spring of 2018, all three of these individuals spent a substantial amount of their time reacting to unplanned events, not tending to their normal responsibilities.

Interviews with all engineering management personnel suggest that the need to respond to emergent issues, and the general disparity between their work capacity and their assigned responsibilities, causes a prioritization of tasks that biases the manager's attention to the urgent rather than the important. The general effect of this prioritization is that quality management and mid- and long-term planning are neglected.

4.2.2.2 Industry Standards/Best Practices

Comparisons in manning levels between the SSA and other ferry system operators are difficult due to the lack of comparable vessel operators, in terms of organizational structure, vessel operations, and business capitalization. That said, a comparison with publicly available data from Washington State Ferries (WSF) in 2011 (Reference 6) allows for some useful observations with a highly regarded ferry system. At the time that this organizational chart was released, the WSF system consisted of approximately 23 vessels and the following staffing levels:

- 13 staff serving a Senior Port Engineer for Fleet Maintenance, with responsibilities for vessel crews and engineering operations.
- 21 staff serving a Senior Port Engineer for Vessel Preservation, with responsibilities for vessel upgrade and repair projects.
- 15 staff serving a Vessel Design Chief, with responsibilities for engineering associated with new vessel designs and modification of existing vessels.

WSF is a larger organization with a different mandate, larger and more diverse operations, and vastly greater revenues. However, it is reasonable to conclude, by comparing the level of resources that each organization dedicates to engineering operations, training, and vessel project planning and management, that the SSA's engineering management lacks sufficient resources. Also noteworthy is WSF's separation of 'Fleet Maintenance' crew responsible for operations, and 'Preservation' crew, responsible for vessel repair and upgrade projects. This deliberate segregation of responsibilities insulates planning and management efforts from urgent issues that can and do occur within the operations realm.

4.2.2.3 Specific Solutions

The following changes to the SSA management and practices would improve the organization's ability to successfully discharge the responsibilities allocated to the engineering management team:

- Increase the number of port engineers.
- Dedicate port engineers to specific vessels and make them responsible for the readiness of all vessel engineering crew and equipment.
- Create a project engineer position with responsibilities for the planning and management of vessel repair and modification projects. This position would interact with the vessel port engineers when planning projects, but the project engineer would be responsible for

all aspects of specification development, contracting, contract management, and quality control while being isolated from vessel operations. This position would be responsible for the successful execution of shipyard and repair facility projects, including outsourcing construction oversight services to third-party engineering firms.

- Have all port engineers report to the Director of Engineering and Maintenance, who would set quality objectives and manage fleet-wide policies, but not be involved in the day-to-day operation of the vessels.

See Section 4.1.3 Operations Structure for a more detailed discussion of the organizational restructuring suggested above.

4.2.3 Enterprise Asset Management System

Enterprise asset management systems (EAMS) are generally used by organizations to manage the maintenance of physical assets throughout their lifecycle. The SSA currently uses Maximo as its EAMS software, although the SSA management indicates that they are actively planning the transition from the Maximo EAMS to The Asset Guardian (TAG) computerized maintenance management system (CMMS). CMMS are similar to EAMS, although EAMS implementations can generally include a wider breadth of functionalities. The SSA management noted that they were planning the transition due to the recognized shortcomings of the current Maximo implementation, and the costs associated with upgrading it to meet their needs. Although many individuals within the organization mentioned that this transition was planned, the SSA did not seem to have started any implementation planning for this transition.

The functions that EAMS/CMMS perform within organizations can vary widely. The observations discussed below are limited to the aspects of the SSA's EAMS that have implications on vessel reliability and, to a lesser extent, organizational efficiency. Within these functions, a number of inadequacies with Maximo, and how the SSA utilizes Maximo, were observed.

The following shortcomings of the Maximo system currently implemented at the SSA were observed:

- **Access to the system is limited to senior vessel crew only**. An effective EAMS requires timely, two-way communication (information in and out of the system in near real time). Vessel crew members who should have access to the system do not. Only senior chief engineers and senior captains can log into the system. These senior crew members are then responsible for the dissemination/collection of all data to and from the Maximo, which is inefficient.
- '**After the fact' Maximo entries**. There are many situations where a planned or corrective maintenance task is performed, and then the item is input into Maximo retroactively. This differs from the intended work flow, where the EAMS initiates the task.
- **Loss of network connectivity.** The way that Maximo handles loss of network connectivity makes the use of the system while underway on a ferry impractical.
- **Lack of preventative maintenance automation.** The Maximo system is not configured to trigger preventative maintenance tasks based on operating hours, so vessel crews typically perform all hourly maintenance on equipment based on their own discretion.
- **Maximo is utilized more as an accounting tool than as an asset management tool.** The most disciplined aspect of the current EAMS implementation is its use as a tool to track maintenance labor hours, not to perform any explicit asset management functions.

- **No integration with spare parts inventory system.** The SSA has an inventory system for consumables, but not for vessel parts. Repair and maintenance parts are ordered by the maintenance or vessel personnel, which fails to leverage the asset database to eliminate errors and gain efficiencies associated with maintenance planning and parts procurement.

4.2.3.1 Issues

The following issues with the SSA's implementation of its EAMS were identified based on the observations discussed above:

- **Lack of preventative maintenance automation.** An essential function of a properly implemented EAMS is the automatic generation of routine maintenance tasks based on running hours of equipment. This function is particularly important for the SSA's vessels, where the most critical equipment (*e.g.*, diesel engines for propulsion and electrical generation) have maintenance schedules that are largely based on running hours. As currently implemented, the SSA's EAMS does not utilize a running hour feedback loop to trigger maintenance tasks. Vessel crews reported using hand-written logs in notebooks to track the maintenance of equipment such as diesel engines, which have significant maintenance requirements based on running hours.
- **Ineffective equipment history.** A key function of an EAMS is to capture relevant historical information about equipment and present it to operators and maintenance personnel such that they are better able to operate and/or maintain that equipment. When well implemented, the equipment history functionality of an EAMS becomes a knowledge base detailing not only preventive and corrective maintenance history, but also practical information regarding manufacturer's bulletins, clarifications to manufacturer's manuals, and special considerations regarding equipment operation. Histories allow crew and maintenance personnel to identify and address trends in equipment repair, enabling them to improve equipment reliability. The existing EAMS does not have this complete functionality, for the following reasons:
    - Only senior chiefs and senior captains have access to the system.
    - The lack of integration with a parts/inventory system greatly limits the value of the equipment history information.
    - Only preventative and corrective maintenance history is captured by the system. It does not capture useful crew observations, such as modifications made to the system that were not due to maintenance, out-of-range readings and how they were remediated, best practices on operating the piece of equipment, manufacturer updates to part numbers, etc.
    - The systems in place to ensure maintenance history is captured are unreliable (as discussed in the following two bullets).
- **No integration with spare parts inventory system.** Because the current EAMS has no interface to a parts inventory system, parts ordering is the responsibility of the person who is performing maintenance. This work flow is problematic for a number of reasons:
    - Allows for human error in ordering parts.
    - Does not account for impact to equipment availability associated with maintenance lead times.
    - Is inefficient, as maintenance personnel must repeatedly identify part numbers.
    - Does not leverage cost or time savings (*e.g.*, ordering parts when they are needed, not when they are on sale).
    - Concentrates critical details in the hands of individual maintenance personnel, whereas those details should be contained within the system.

- Is not a documented system process, so it is unlikely to be consistently performed.

- ‘**After the fact’ Maximo entries**. Entries into Maximo after the work is performed are outside the documented system process, and therefore are unlikely to be consistently performed. When ‘after the fact’ entries become the norm, the EAMS is at risk of becoming a documentation burden without substantial value. An observed example was that checkpoint maintenance on vessel generators was not triggered by planned maintenance items, but rather by the maintenance person who typically does that work.

None of the root cause analyses, vessel inspections, or reviews of vessel readiness performed in association with this investigation suggested that inconsistent maintenance activities had contributed to any of the recent vessel availability issues. This suggests that there are individuals within the organization who are taking personal responsibility for ensuring that equipment is maintained to the manufacturer’s standards, independent of the processes inherent to the EAMS. This is a credit to the SSA personnel and certainly worthy of note, but also a sign that the organization is at risk if these individuals leave the SSA (see Section 4.1.1).

4.2.3.2 Industry Standards/Best Practices

With respect to asset management and equipment maintenance, the ISM Code specifically requires that vessel operators:

- Identify critical equipment whose failure could impact vessel safety.
- Plan, perform, and document the maintenance required to ensure the reliable operation of that equipment.
- Periodically test the equipment and audit the systems that ensure the performance of maintenance on that equipment.

Despite the fact that the requirements detailed in the ISM Code are not a regulatory requirement for the SSA’s fleet of vessels, the practical need for processes that mitigate operational risk by ensuring vessel reliability suggest that these requirements are industry standard for operators of the SSA’s size and represent best practices.

The SSA is not the only operator to struggle with the implementation of a comprehensive and effective asset management system. Evaluation of similar ferry and small cruise vessel operators shows that, as important as these systems may be, they are difficult to implement and maintain.

In April 2017, in response to high profile vessel casualties that were traced to equipment failures, Washington State Ferries contracted for outside consultants to review the effectiveness of their CMMS, recommend changes, and develop a Request for Proposal package for a new system. The effort to upgrade their systems is currently underway.

Many of the key principals that a successful EAMS/CMMS relies upon, such as the need for documented processes, the concept of continuous improvement, and the shifting of responsibility for system operation from operators to managers, are also principles on which marine safety management systems (SMS) are built. Due to these commonalities, implementation of an effective EAMS may be easier in the context of a functional SMS, or put another way, implementation of an EAMS may be more difficult for an organization that does not have an active SMS. See Section 4.1.6 for further discussion of safety management systems.

4.2.3.3 Specific Solutions

The SSA’s stated plan to implement a new EAMS/CMMS is a positive step, and the added features and functionalities integral to their intended replacement system will address many of the issues highlighted here. However, implementation of EAMS or CMMS systems is notoriously difficult and expensive, and the value of the system is greatly impacted by how well the implementation is executed. The following two critical pieces of advice are offered:

- Make the required investment. Proper implementation often requires that implementation costs are much higher than annual operating costs.
- The system must be implemented in a way that ensures the maintenance functionalities are not secondary to other management priorities, such as accounting.

The SSA should ensure its new EAMS or CMMS includes the following:

- System for ensuring that all planned maintenance is performed in accordance with manufacturer's recommendations, and completion of all maintenance work is documented.
- Availability of all technical information related to vessel systems and equipment (manuals, drawings, service reports, equipment history, etc.) to all vessel crew and maintenance personnel when and where they need it.
- A mechanism for vessel crews and maintenance personnel to document any observed irregularities in the operation or maintenance of equipment, such that these irregularities are reviewed and either addressed by corrective action or noted in equipment histories.
- Mechanism that allows all users to check the status of all items tracked by the system. For example, an item originates as a work request, becomes a work order, and finally becomes an equipment history item.
- Features that prevent a single human error from impacting system effectiveness. For example, feedback loops should highlight areas where individuals have not completed work, or where entries into the system are incomplete.

The SSA has not indicated any timeline for the implementation of the new EAM/CMMS. Until a new system is procured and implemented, the following interim solutions should be considered to improve the functionality of the existing system:

- Implement a running-hour feedback loop from vessels to the Maximo planner, and begin triggering run-hour based maintenance activities on the actual run time. This will reduce the number of 'after the fact' maintenance entries and provide a check against missed maintenance.
- Expand access to the Maximo system from senior chiefs and senior captains to all permanent crew.

4.2.4 Project Planning

The way that the SSA currently plans and executes vessel construction, refit, and repair projects appears to be negatively impacting vessel reliability. This has resulted in SSA vessels returning to service from shipyard repair periods prior to adequate sea trials, equipment testing, and crew familiarization with new systems. For example, the SSA recorded 200 remaining outstanding, incomplete, or unacceptable items when M/V *Martha's Vineyard* left its midlife refit at Senesco in the spring of 2018. Although it is typical to have some remaining 'punch-list' items, and many of the listed issues were cosmetic in nature, the sheer volume of the incomplete work represented by this list indicates that the vessel was accepted from the shipyard prematurely. The issue of vessels being returned to service prior to completing repair work and performing adequate sea trials was also noted by many of the SSA personnel interviewed.

Investigation into the M/V *Island Home's* delayed return to service after her shipyard period in the spring of 2018 indicated that the SSA had failed to utilize basic project management tools and conventions when executing the project. For example, there is no evidence that either the SSA or the shipyard developed a project schedule identifying critical long-lead-time materials, project milestones, or task interdependencies. There is also no evidence to suggest that the SSA held any planning meetings with the shipyard in between contract award and the start of the project, even though the project relied on timely ordering of critical long-lead-time materials. In addition, formal production meetings with the shipyard were not held during the course of the project.

Investigations of recent shipyard projects suggest that the SSA is failing to control critical technical details of systems installed and modified during vessel repair projects, and the lack of control is resulting in vessel casualties. For example, the following technical issues resulted from inadequate management of the M/V *Martha's Vineyard* midlife refit:

- Alarm setpoints for the generator fuel low pressure alarms were set incorrectly.
- Fuel service tank low level alarms were not functional at the end of the yard period.
- Configuration of new generator controls included shutdown alarms that were not wanted by the SSA, not required by regulations, and did not serve any practical purpose. These shutdown alarms resulted in erroneous shutdowns of the generators.

As is discussed in more detail in the root cause analysis sections of this report (Section 3), these technical issues contributed to vessel incidents.

The SSA does not have a sufficient number of staff to properly manage major and concurrent shipyard projects, so they outsource some of the effort to external contractors. Projects were reported to be managed by a mix of SSA port engineers, vessel crew, and external contractors. It was observed that shipyard and repair project management roles and responsibilities were unclear, inconsistent, and in many cases insufficient. The reporting structure amongst the managing teams was also unclear. The following examples are provided:

- Port engineers are the most appropriate internal staff to manage shipyard projects, however they are also the first-tier responders to emergent issues with the fleet. The SSA only has two port engineers, who are already over-committed (see Section 4.2.2). Therefore, it is unlikely that port engineers can adequately manage ongoing shipyard projects, which require consistent involvement.
- The SSA's use of vessel crew to support shipyard projects is complicated by labor seniority rules, whereby senior crew can 'bump' less-senior crew as vessels go into repair, which often occurs due to desirable compensation and schedule benefits of working on a shipyard project. Although there is ample evidence that vessel crew adds value to shipyard projects by providing useful insight into vessel history and best operational practices, the use of crew to manage shipyard projects is unlikely to produce favorable outcomes due to the lack of particular experience in areas including project management, contracting, and regulatory requirements.
- During the M/V *Martha's Vineyard* midlife refit, the externally contracted project manager was unavailable at times ([redacted]), but they were not replaced by the SSA during their absence.

Both the M/V *Martha's Vineyard* and the M/V *Island Home* were returned to the SSA from their most recent shipyard periods after the planned delivery date. The SSA management contends that these delays were, to at least some degree, due to the shipyard's inability to perform the contracted work on schedule. Contracting tools such as liquidated damages, that penalize shipyards for non-performance and mitigate the risk that such delays pose to operations, were not effectively applied to either of these projects.

The SSA's vessel out-of-service schedules generally plan for an SSA repair period following a shipyard. This is good planning in that it provides a natural schedule contingency if shipyard periods extend past their planned completion dates. It appears, however, that allowing the shipyard to 'finish' incomplete shipyard period work at the SSA Fairhaven facility after vessels leave the shipyard has become commonplace.

4.2.4.1 Issues

The following list summarizes the most critical issues identified in the observations above:

- The SSA's failure to utilize basic project management tools such as master schedules and status meetings during some shipyard projects limits their influence on project schedules and reduces their ability to put contingencies in place when schedules are threatened by external factors.
- The SSA's inability to track critical technical details during shipyard projects has contributed to vessel casualties, such as the March 17th and May 5th blackouts that occurred onboard the M/V *Martha's Vineyard*.
- Lack of testing after the installation and integration of new systems is allowing vessels to return to service with unresolved and unknown issues.
- The SSA's failure to plan and manage shipyard project scope and schedule creates situations where they must either cut corners and take on additional risk to get vessels back into operation, or delay vessels and miss scheduled service. A combination of these choices has been made by the organization historically, which has resulted in both vessel casualties and schedule complications.

The ability of the SSA to return vessels from shipyard and repair periods to revenue service on schedule is critical to the SSA's operation. Shipyard schedules, however, are difficult to manage. Where project schedule delays can threaten vessel operational schedules, vessel managers typically employ contracting tools, such as liquidated damage provisions in shipyard contracts, to mitigate the risk that shipyards do not perform as expected. Although they require careful planning and diligent project management to maintain the documentation stream required to support liquidated damage claims, these provisions are very effective in mitigating the risk of shipyard non-performance. At a minimum, these provisions motivate shipyards to maintain schedules and hold shipyards accountable for mistakes that may affect vessel delivery. Although contract provisions such as liquidated damages have been included in some of the SSA's shipyard contracts, shipyard project management has been unable to leverage these tools to hold shipyards accountable for schedule growth.

The lack of a project schedule for the M/V *Island Home* shipyard period prevented the SSA from holding the shipyard accountable for delays. The M/V *Martha's Vineyard* mid-life refit included a liquidated damages clause in the shipyard contract, and schedule changes were tracked during the course of the project, but there did not appear to be a connection between the specific change orders and schedule extensions. Instead, a 14-day extension to the delivery schedule was granted to the shipyard on November 7th, at no cost and without connection to any additional work. As typically applied, whenever 'change' work (e.g. work outside the scope of the original contract) is proposed to the vessel owner, it is proposed with both a dollar cost and a schedule impact. For the SSA to leverage contract provisions to maintain project schedules, they must manage both schedule and budget together.

The routine practice of allowing shipyards to complete work at the SSA Fairhaven repair facility after the vessel departs the shipyard is problematic in that it removes the urgency that the vessel's departure places on the shipyard, and may obfuscate responsibilities for completion of work, quality control, and testing while both shipyard and the SSA personnel work on the vessel at the SSA facility.

4.2.4.2 Industry Standards/Best Practices

Shipyard project management is very hard to do well. It requires diligent control and attention to details, and the negative effects of badly managing projects are often not evident until long after the shipyard project, when an incident occurs. The requirements of shipyard project management demand adequate staffing levels, and are better suited for employees with project management experience or training, who are good at multi-tasking, have a breadth of knowledge, and have good attention to details.

Vessel repair shipyards are low-margin businesses, with large cost uncertainties. As such, it is very easy for them to get behind on projects. When working with a shipyard that is 'behind,' the project manager needs to be very careful to control impacts to schedule, quality, and cost. Where vessel schedule is critical, vessel managers typically include liquidated damages into shipyard contracts to mitigate risk of delayed project completion.

Contingency schedule and budget should be incorporated into any major maintenance project and shipyard period to accommodate additional scope, due to the nature of 'discovery.' For example, it is common to find wasted steel after removing deck coverings or joiner bulkheads. This is work that cannot be precisely and explicitly planned for, and cannot be deferred once it has been discovered.

4.2.4.3 Specific Solutions

By changing the way that they plan and manage shipyard and repair projects, it is likely that the SSA can substantially improve project quality outcomes, reduce the incidence of impactful delays, and exert more control over external factors that threaten project schedules. The following changes to current practices are recommended:

- Train all personnel tasked with managing shipyard and repair projects in project management fundamentals; consider Project Management Professional (PMP) or similar certification.
- Dedicate a full-time employee to the management of shipyard and repair projects. This individual would be fully responsible and accountable for the success of all such projects, and manage all of the SSA and/or subcontracted resources allocated to each project. This recommendation, which is discussed in more detail in Section 4.2.2 Engineering Resources, would leverage the fact that the SSA vessels are continuously rotating through shipyard/repair projects to develop particular expertise in the area of shipyard project management within the SSA.
- Utilize contract provisions such as liquidated damages to mitigate risk associated with vessel shipyard projects.
- Include adequate budget and scheduled contingencies in all shipyard projects. Favor the use of data and external references over internal judgement when determining contingency levels.
- Implement processes that provide effective oversight of shipyard project managers at the senior management level. This oversight should include systematic review of critical project documents, such as technical specifications, project schedules, and risk analysis summaries.
- Maintain rigorous schedule control throughout shipyard projects starting with clear statements of schedule requirements to potential shipyards in pre-contracting phases, and continuing with regular updates of shipyard-developed project schedules from contract award to project completion.
- Introduce management processes that review shipyard projects after their completion and allow the SSA to learn from specific successes and failures within each project.

- Utilize vessel crews as project support personnel appropriately. Investigations into past shipyard projects suggest that crew involvement is extremely valuable when crews with the correct experience and skill sets are allocated to projects, but less so when personnel are selected based on seniority alone.
- The SSA should require that shipyards develop specific test procedures for all new and modified equipment, and allow for the SSA to review such procedures well in advance of actual testing.

4.2.5 Engineering Risk Assessment

The SSA engineering management does not adequately account for risk when making decisions affecting the operation, readiness, and maintenance of fleet vessels. The SSA also lacks management processes that organizations typically use to manage risk systematically. Such processes provide checks on decision makers such that no individual is able to expose the organization to undue risk by virtue of their position or authority.

There are several examples of situations in which the SSA's operational decisions did not appear to have adequately considered the prevailing risk.

Engineering Resources. As detailed in Section 4.2.2 Engineering Resources, the SSA does not appear to have the resources in place to support the current vessel shipyard, repair, and overhaul schedule. Although management generally acknowledged this lack of resources, their actions indicate a preference to accept the risks of inadequate resourcing rather than relaxing the schedule or adding personnel. For example, when a port engineer left the organization in 2010, management temporarily eliminated the position in order to save money. The position was not re-instated until 2016. A risk analysis of the effect of losing this position on the readiness and reliability of the vessels is unlikely to have indicated that the elimination of this position was acceptable on even a temporary basis.

Vessel Return to Service following Repair Periods. In numerous independent conversations, crew members and other personnel of the SSA expressed discomfort with the condition in which vessels are commonly allowed to return to service following a shipyard or repair period. Although no direct connection was identified between incomplete shipyard work and the vessel incidents that occurred in the spring of 2018, the extensive list of unresolved discrepancies recorded as the M/V *Martha's Vineyard* departed the shipyard does corroborate the discomfort reported by the vessel crew.

The root cause analyses performed in association with casualties suffered by the M/V *Martha's Vineyard* shorty after her return to service indicate that problems with the vessel alarm system contributed to those casualties, and points to the lack of comprehensive system testing prior to the vessel's release to service as a causal factor.

These observations suggest that the SSA has, in the face of pressure to maintain vessel operating schedules, allowed vessels to return to service before they are ready. These observations also suggest that the SSA makes such decisions not based on a systematic review of vessel readiness or considered risk analysis, but based on an individual's evaluation that the vessel is seaworthy[3].

Crew Training. Another circumstance in which the SSA was observed to underrate operational risk was related to the training of crew. As is discussed in more detail in Section 4.3.1 Crew Training, shortcomings in the SSA training processes allowed vessel crew to be placed in situations where they were required to operate equipment on which they were not sufficiently trained. The most notable training gaps resulted from new crew not receiving sufficient training

[3] Used in this context, a vessel is seaworthy if it is reasonably fit for its intended use.

when joining a vessel, and from the SSA crews not receiving training when new systems or equipment were added to existing vessels.

Ensuring that crew members have adequate training to operate the SSA vessels is made particularly difficult due to several factors that are unique to the SSA:

- Most of the SSA vessels have three separate crews assigned at any given time.
- The SSA's fleet is very diverse, with unique systems, equipment, and configurations that may require specific training or familiarization on each vessel.
- Rotation of crews between vessels is common.
- The addition of new crew members to the SSA system is also common.

The chance that the safe operation of the SSA vessels may be entrusted to crews who lack the training to properly perform their duties is clearly a risk for the SSA. Lack of training was identified as a contributing factor in three of the four root cause analyses performed on recent vessel incidents.

The fact that the SSA has no formalized vessel training or familiarization process to ensure that crews are fully trained on vessel-specific equipment and systems before they assume a watch suggests that the SSA management has not evaluated the risk associated with training gaps, or actively considered the challenges that face the organization when planning for crew training.

Investigation of Casualties. Vessels were also observed to be returned to service after casualties without adequate investigations to ensure the underlying issues causing the casualties were resolved. For example, on March 17th of 2018, the M/V *Martha's Vineyard* was returned to service only hours after two blackouts and a fire in a machinery space, without any substantive investigation into the causes or effects of the incident. As is discussed in more detail in RCA Sections 3.4 and 3.5, the SSA's failure to adequately investigate the matter allowed the vessel to be returned to service with unidentified damage to the switchboard, and operational limitations that led to another blackout. This example and others suggest that the SSA's only salient criterion for determining when a vessel is 'ready' to be returned to service is the USCG's permission to return it to service, and that no practical assessment of the risks is performed in the aftermath of such incidents.

4.2.5.1 Issues

The observed shortcomings in the way that the SSA manages risk associated with vessel operations are summarized as follows:

- The SSA does not have a safety management system (SMS) or other management processes in place to systematically manage risk and provide safety and quality backstops. In an environment where no such backstops exist, the decisions that individual managers make have the potential to expose the organization to unacceptable risk.
- The SSA managers have made critical mistakes in assessing and addressing risk, particularly in circumstances where a manager was under commercial pressure to return a vessel to service. These mistakes have contributed directly to vessel casualties, as in the case of the March 17th blackout of the M/V *Martha's Vineyard*, in which the vessel was released to service after a major casualty with unidentified latent limitations that resulted in a blackout underway.
- USCG permission to sail should be seen as a minimum assurance, not the end goal. Nobody, including the USCG, knows the SSA's operation as well as the SSA crew, maintenance personnel, and vessel management. The USCG has limited resources and is limited in its ability to assess every situation with the multitude of operations and vessels

they are tasked to inspect. The SSA is lacking clear criteria for ensuring vessels are ready to return to service after a casualty or maintenance work based on its intimate knowledge of its own vessels and operations.

4.2.5.2 Industry Standards/Best Practices

Organizations of the SSA's size and complexity typically use formalized management processes, such as job safety analyses and safety management systems, to systematically manage risk. These processes limit the degree to which any individual can incur risk through their discreet decisions by prescribing how high-risk activities are managed and implementing programs that specifically prevent circumstances that have been identified as high risk. For example, a formalized training program that requires verification that a crew member has completed vessel-specific familiarization training prior to their being assigned to a vessel systematically prevents crew members from being accidentally assigned to vessels for which they are not properly trained.

These processes provide all levels of management with clear "sail/no sail" criteria where individual judgement may understate risks, such as in the areas of vessel seaworthiness, crew training, and equipment maintenance status.

The utilization of a dedicated health, safety, quality, and environmental (HSQE) director is common for an organization of this size (see Section 4.1.6).

Adequate engineering resources are necessary to mitigate the multitudinous risks to the reliability of vessels when being newly constructed or subject to midlife refit. See Section 4.2.2 for best practices on adequate staffing of the engineering department.

4.2.5.3 Specific Solutions

The SSA should institute mechanisms that provide checks against individuals who are able to take on undue risk for the organization by virtue of their position and the SSA's organizational structure. Suggested mechanisms are:

- Risk assessment protocols that include proactive identification and consideration of operational risks.
- Implementation of a safety management system (SMS) and quality management system. Such systems, if properly implemented, would include processes and provide backstops which would effectively prevent any individual from incurring undue risk onto the organization (see further discussion of a safety management system in Section 4.1.6 Health, Safety, Quality, and Environment Policies).
- The designation of an individual or individuals within the organization who are responsible for the identification and mitigation of risk. This role should be independent of the vessel operations chain of command and insulated from commercial and operational pressures to the greatest degree possible.

The SSA should evaluate the staffing level of its engineering department (see Section 4.2.2 Engineering Resources).

The SSA's mission statement should include safe operation of the vessels and be actively and persistently communicated to all of its employees, as a step towards shifting the organizational culture towards safety above all else (see Section 4.1.1 Mission Statement).

4.3 Vessel Operations

4.3.1 Crew Training Program

An examination of the documentation provided by the SSA indicated that the route-specific "Pilotage Workbook," "Vessel Systems and Training Manual," and "Vessel Operations and Training Manual" do not address *recency* (how long ago an employee received the training) and are not tailored to address vessel-specific operating procedures.

On-site field observations and an examination of the provided documentation indicate that training is inadequately documented. While a manual system is in place to document training of new hires using an Excel spreadsheet, it was just recently implemented and is labor intensive. At any given time, it is not known who has completed what training and the recency of any relevant training. Interviews of some newer crew members revealed that they had never received any training.

Interviews with the SSA personnel indicated some specific incidents, including:

- A report of a late departure due to the engineer's lack of knowledge regarding main engine start up.
- Reports of personnel being transferred to vessels they haven't operated for long time, without adequate re-training.

4.3.1.1 Issues

The SSA's training programs have not kept pace with new vessels and new technologies. The current systems rely on regulatory requirements for training, which do not keep pace with the rate of change of technology and industry best practices. Regulatory requirements should only be considered a minimum standard.

Furthermore, no vessel in the SSA's fleet is alike, which increases training requirements and the resources to develop and implement them. Some SSA vessels are new and/or utilize new systems and technology. Distributing crew assignments to personnel who are not properly familiarized with the vessel and its equipment increases the risk of accidents.

4.3.1.2 Industry Standards/Best Practices

New industry standards have been established through the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW). These standards are heavily focused on training and development of formal training programs. Many of the larger ferry operators in the US and abroad have developed comprehensive training programs and Learning Management Systems. These systems are designed to evolve with the fleet and changes in manning requirements, equipment, and technology. They track progress by individual crew members and provide a feedback loop to promote continuous improvement.

4.3.1.3 Specific Solutions

A comprehensive training program should be developed. The following guidelines are recommended:

- Establish a company directive to address training requirements.
- Ensure operating procedures are vessel specific.
- When a new vessel is acquired or when substantial modifications are made, establish a change process that evaluates all modes of operation and maintenance. Develop vessel-specific procedures for each.

- When personnel are transferred to new assignments, provide proper familiarization with the vessel and the equipment they will be operating.
- Establish recency requirements for all training and familiarization processes.
- Establish a routine audit process that identifies training gaps and ensures procedures are implemented.
- Develop a training program which tracks training completed by each employee.

4.3.2 Watch Processes

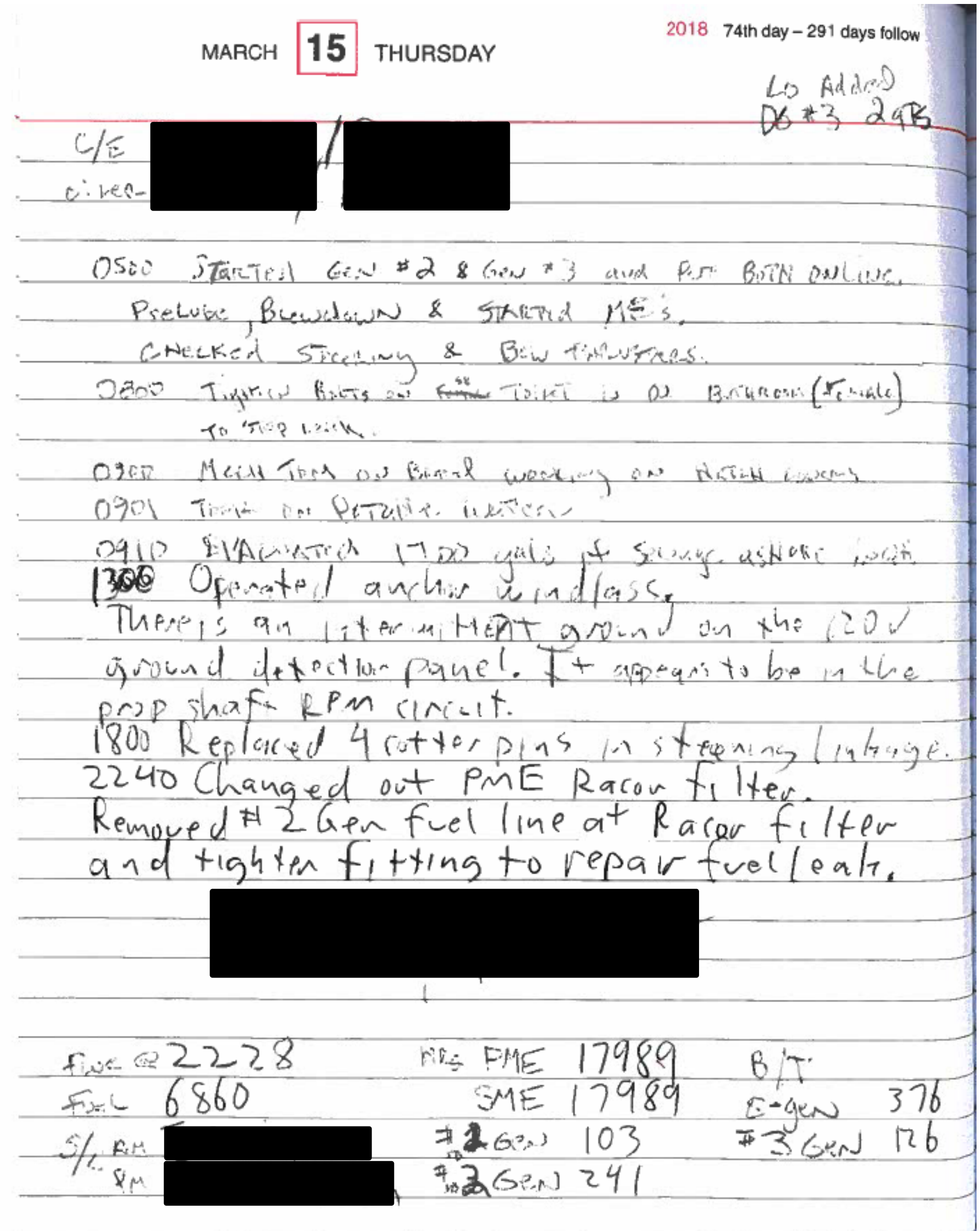
For the purposes of this evaluation, Engineering Watch Processes are defined as the policies, procedures, and practices that determine what engine room personnel do while they are standing a watch. These processes typically define details of activities such as:

- **Watch rounds.** Who makes rounds of the plant equipment, when they perform their rounds, and what particular checks are made.
- **Watch readings.** What plant process data is recorded during watch rounds, where and how it is recorded, what methods (if any) are used to identify abnormal readings.
- **Log book conventions.** What plant process data and watch operational information is recorded and how it is recorded.
- **Plant configuration conventions.** How and where information about the status of variable plant configuration information is maintained, such as '#1 pumps on', 'transferring fuel', '#2 SS air compressor OOC for maintenance', etc.
- **Watch responsibilities.** What the performance expectations and responsibilities are for each watch stander.
- **Watch turn-over conventions.** The protocols associated with watch turn-overs during vessel operations. This includes exactly when a turn-over takes place, how long the overlap between out-going and in-coming watch standers is, and what information is passed on from watch to watch.

These 'Watch Processes' essentially represent all the things that watch standers do during a watch and how they do them.

Log book conventions. None of the SSA's vessels utilize a formal log book to document engine room watch activities or operations. The official log book that is utilized is a dated notebook, in which the watch engineer records plant start-up, equipment change-over, equipment hours, fuel soundings, and various operational activities (bunkerings, maintenance, troubleshooting, etc.). A typical example of a log book page is presented as Figure 7. The type of information that is recorded is generally consistent across vessels and crews, but even cursory review identified inconsistencies and omissions in the log keeping of some vessels.

No actual plant process data is recorded in the engine room log books other than daily engine hours and fuel totals. Operational information that is typically recorded in log books is also absent, such as watch turn-over. Plant start-up is generally recorded, but plant shut-down, which is arguably just as important, is almost never recorded.



MARCH 15 THURSDAY

2018 74th day – 291 days follow

LO Added
DG #3 2 QTS

C/E [redacted]
Oiler [redacted]

0500 Started Gen #2 & Gen #3 and put both online.
Prelube, Blowdown & Started ME's.
Checked Steering & Bow Thrusters.
0800 Tightened Bolts on Toilet in BR Bathroom (Female) to stop leak.
0900 Mech Tech on Board working on Hatch covers
0901 Tech on Petrie. Watch
0910 Evacuated 1700 gals of Sewage ashore ...
1300 Operated anchor windlass.
There is an intermittent ground on the 120V ground detection panel. It appears to be in the prop shaft RPM circuit.
1800 Replaced 4 cotter pins in steering linkage.
2240 Changed out PME Racor filter.
Removed #2 Gen fuel line at Racor filter and tighten fitting to repair fuel leak.

[redacted]

Fuel @ 2228
Fuel 6860
S/L AM [redacted]
PM [redacted]

HRS PME 17989
SME 17989
#1 Gen 103
#2 Gen 241

B/T
E-Gen 376
#3 Gen 126

Figure 7 SSA engine room log book, M/V *Martha's Vineyard*, sample page (names redacted)

Watch readings. The watch engineer does not record any plant process data as part of their watch. Watch oilers do take readings during rounds, using official SSA forms, such as the one shown in Figure 8. Review of a limited number of watch round sheets suggest that the accuracy and consistency with which these round sheets are recorded varies. For example, in the hours before the May 5th casualty on M/V *Martha's Vineyard*, the critical parameter that was out of range and indicative of an impending failure, generator final fuel pressure, was not recorded on the day of the casualty, despite the fact that it had been recorded in the preceding days by all three watch oilers assigned to the vessel.

There is no evidence to suggest that the watch engineers consistently review the watch oiler log sheets. In the previous example, despite a field on the log sheet for the Chief Engineer's signature, there were no signatures on the sheets that were reviewed.

Plant configuration conventions. Most vessel propulsion plants have some configuration variability that changes on a regular basis. For example, plants with redundant auxiliary equipment may rotate from #1 pumps to #2 pumps on a weekly basis. Vessels with multiple fuel or water tanks may change from one active tank to another in accordance with operational needs or established conventions. Where operators make changes to such variable plant configurations, they are typically recorded on control room wipe boards or by similar means.

The SSA vessels utilize such configuration 'wipe boards', and vessel crew reported established conventions regarding the rotation of vessel equipment. There did not appear to be any documented policies regarding these communication tools or equipment configuration conventions. These practices all appeared consistent with what is typical of vessels similar to those operated by the SSA.

The investigation team did observe one notable issue regarding the communication of plant configurations, however. As is discussed in more detail in the M/V *Martha's Vineyard* March 17th blackout root cause analysis summary, Section 3.4, a change in the configuration of the fuel piping contributed to the vessel casualty. Although the specifics of when and under what circumstances the configuration change was made, it is clear that neither the vessel crew onboard at the time of the casualty nor the SSA engineering management were aware of the change.

Watch responsibilities. Vessel operations that utilize two-person engine room watches typically assign different roles and responsibilities to the two members of each watch. In general, such watches allow the main control room or operating platform to be manned constantly, while the two watch standers alternate making rounds of the engine space. The watch engineer (or senior watch stander) is typically responsible for the overall operation of the plant, and for ensuring that their subordinate conducts their watch properly. The watch oiler (or junior watch stander) typically will take the watch readings and report anything unusual to the senior watch stander.

Although the investigation team's observations of the SSA vessel engine room watches suggested that their engine department crews generally follow these conventions, the organization has no written policies that indicate what their expectations are for watch standers, or define the responsibilities of either watch team member.

Watch turnover conventions. Watch turnover practices at the SSA were not sufficiently observed or investigated to make any statements regarding the practices in use onboard SSA vessels.

4.3.2.1 Issue

Two of the four vessel incidents that were investigated by means of root cause analysis resulted from situations in which vessels operated for an extended period of time with latent issues that would result in a blackout if not recognized and corrected by vessel crew. In both cases, the crew failed to recognize the hidden issue, and the vessels did, indeed, black out.

The first such incident was the March 17th blackout of the M/V *Martha's Vineyard*, in which the fuel oil day tank dropped slowly over a period of many hours until the tank was completely empty. The other incident was also on the M/V *Martha's Vineyard*, when on May 5th the fuel pressure to the running generator dropped slowly over a period of two days until it caused the generator to shut down.

It is reasonable to expect that a well-trained engine room watch would notice a nearly empty fuel service tank or a generator being starved of fuel oil. However, to conclude that these casualties were the result of inept or incompetent crew is neither accurate nor constructive. Such a conclusion prevents the organization from using these incidents as learning experiences from which they can improve the quality and safety of their operations. Other factors that should be considered before placing blame for these incidents on vessel crew include the following:

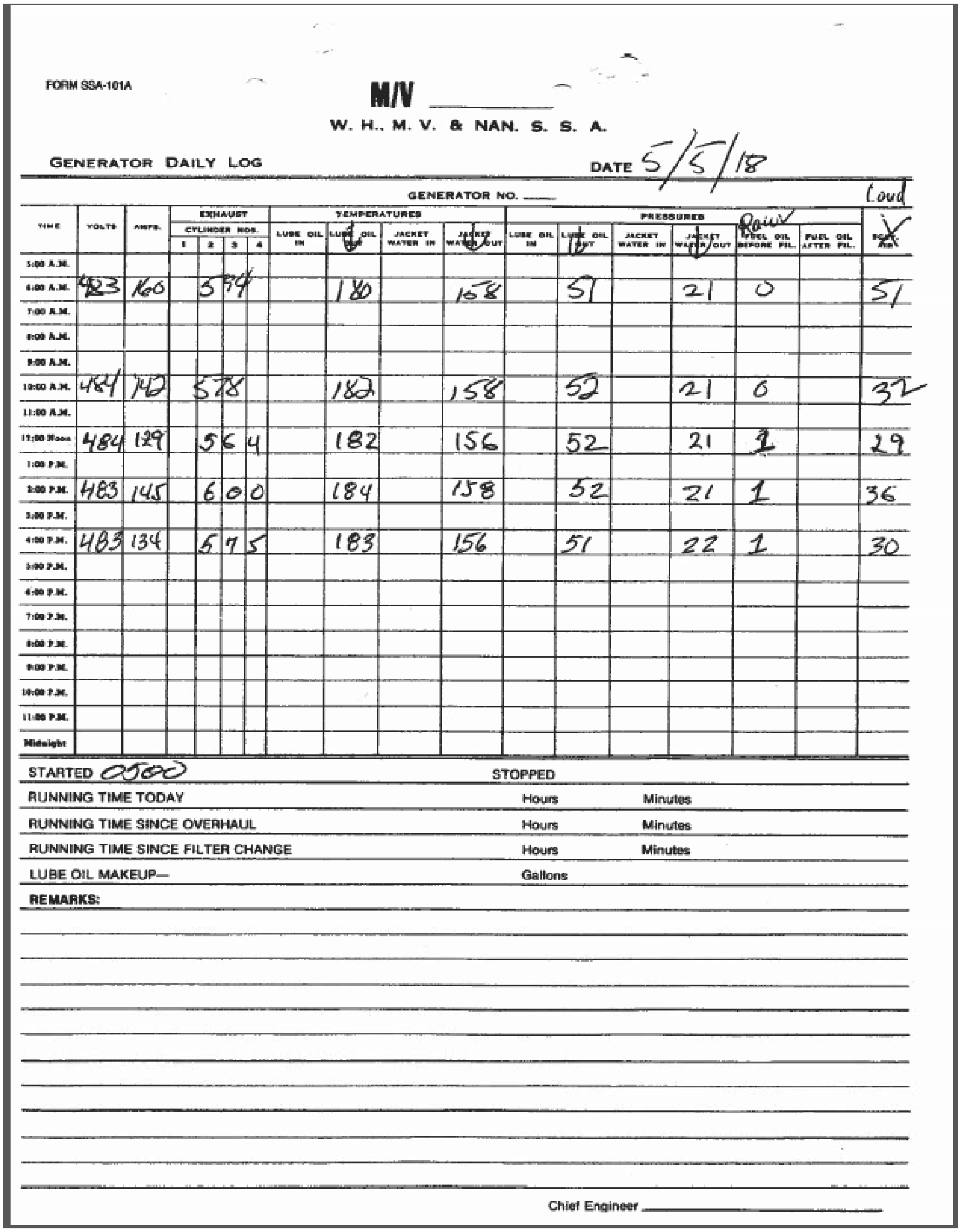
- While it is reasonable to expect that well trained crew members would be able to recognize the latent issues associated with these two vessel casualties, the SSA does

not provide vessel-specific training or familiarization (see Section 4.3.1 Crew Training Program).
- In the case of the May 5th blackout of the M/V *Martha's Vineyard*, all three crews associated with the vessel stood watch while the fuel pressure to the generator was operating below the normal range. One watch stander failing to notice an abnormal plant condition may suggest that the individual may bear some blame for the lack of recognition of a problem. If all six watch standers associated with a vessel fail to notice the abnormal plant condition, this is indicative of a systematic problem that is preventing any crew from recognizing the issue.
- The failure of the watch standers to recognize these latent issues was not the cause of either of the two blackouts, but rather missed opportunities to prevent them. In both cited examples, numerous other factors contributed to the casualties (see Section 3.5 May 5th Blackout of M/V *Martha's Vineyard*).

A more analytical evaluation of why watch standers did not notice or appreciate the abnormal conditions that portended the vessel casualties in these two situations suggests that:

- The watch standers did not observe the relevant critical parameters as part of their watch rounds.
- The watch standers did not read the relevant critical parameters correctly.
- The watch standers did not realize that the value they observed for a critical parameter was out of range.

At least one of these factors must have been true in both M/V *Martha's Vineyard* blackout casualties. This suggests that the watch practices in place at the SSA are not forcing watch standers to accurately observe and evaluate plant critical parameters.



FORM SSA-101A

M/V ______

W. H., M. V. & NAN. S. S. A.

GENERATOR DAILY LOG

DATE 5/5/18

GENERATOR NO. ____

Load

TIME	VOLTS	AMPS.	EXHAUST CYLINDER NOS. 1	2	3	4	TEMPERATURES LUBE OIL IN	LUBE OIL OUT	JACKET WATER IN	JACKET WATER OUT	PRESSURES LUBE OIL IN	LUBE OIL OUT	JACKET WATER IN	JACKET WATER OUT	FUEL OIL BEFORE FIL. (Raw)	FUEL OIL AFTER FIL.	SCAV. AIR
5:00 A.M.																	
6:00 A.M.	483	160		5	74			180		158		51		21	0		51
7:00 A.M.																	
8:00 A.M.																	
9:00 A.M.																	
10:00 A.M.	484	142		5	78			182		158		52		21	0		32
11:00 A.M.																	
12:00 Noon	484	129		5	6	4		182		156		52		21	1		29
1:00 P.M.																	
2:00 P.M.	483	145		6	0	0		184		158		52		21	1		36
3:00 P.M.																	
4:00 P.M.	483	134		5	7	5		183		156		51		22	1		30
5:00 P.M.																	
6:00 P.M.																	
7:00 P.M.																	
8:00 P.M.																	
9:00 P.M.																	
10:00 P.M.																	
11:00 P.M.																	
Midnight																	

STARTED 0500 STOPPED

RUNNING TIME TODAY Hours Minutes

RUNNING TIME SINCE OVERHAUL Hours Minutes

RUNNING TIME SINCE FILTER CHANGE Hours Minutes

LUBE OIL MAKEUP— Gallons

REMARKS:

Chief Engineer ______

Figure 8 SSA generator log sheets - sample page

4.3.2.2 Industry Standards/Best Practices

The following description of a typical two-person engine room watch is provided as a point of comparison to the watch processes in place onboard SSA vessels.

The Oiler (or junior watch-stander, referred to here as the 'Oiler') is responsible for making rounds of the machinery space, taking 'readings', and reporting anything abnormal or unusual to the Engineer (or senior watch-stander, referred to here as the 'Engineer'). The 'readings' are recorded on a watch round form that is designed by engineering management and includes all critical plant parameters. The SSA "Generator Daily Log" sheets seen in Figure 8 are a reasonable example of such a form, but only cover generator critical parameters, where watch round forms would typically include readings from all plant machinery. After making a round, the Oiler delivers the completed watch round form to the Engineer, and reports anything that was observed to be unusual.

The Engineer is responsible for making their own rounds of the machinery space, for completing the official log book for the watch, and for ensuring that the Oiler performs their duties properly. The Engineer reviews the readings recorded by the Oiler on the watch round form and points out any errant readings to the Oiler, so that they can re-check those particular parameters. It is very typical for new Oilers to require several watches to learn how to correctly take a set of readings, and the feedback that the Engineer provides them is required in order for them to complete this learning process.

At least once per four-hour watch, the Engineer records a set of readings representing the most important plant parameters logged on the Oiler watch round form into the vessel's official log book. The official log book is a large-format book that is custom designed and printed for the vessel and provides space to record the readings in tabular form. The log book pages also include spaces for each watch stander to record notable events, such as the starting or stopping of equipment, the addition of lube or fuel oil to any machinery, or any arrivals or departures. These pages also include space for each watch engineer to print and sign their name, attesting to the accuracy of everything that is recorded during their watch. An example of a typical engine room log book is shown in Figure 9 and Figure 10.

On an ocean-going vessel with a conventional watch rotation and a Chief Engineer, the official log book is presented to the Chief Engineer on a daily basis for review. Every log book page includes a signature line for the Chief Engineer, who reviews all readings recorded for the 24-hour period of operation and signs the log to attest that the readings are correct. If the Chief Engineer identifies any issues with the readings or the log book, they would discuss the issue with the appropriate watch stander prior to signing.

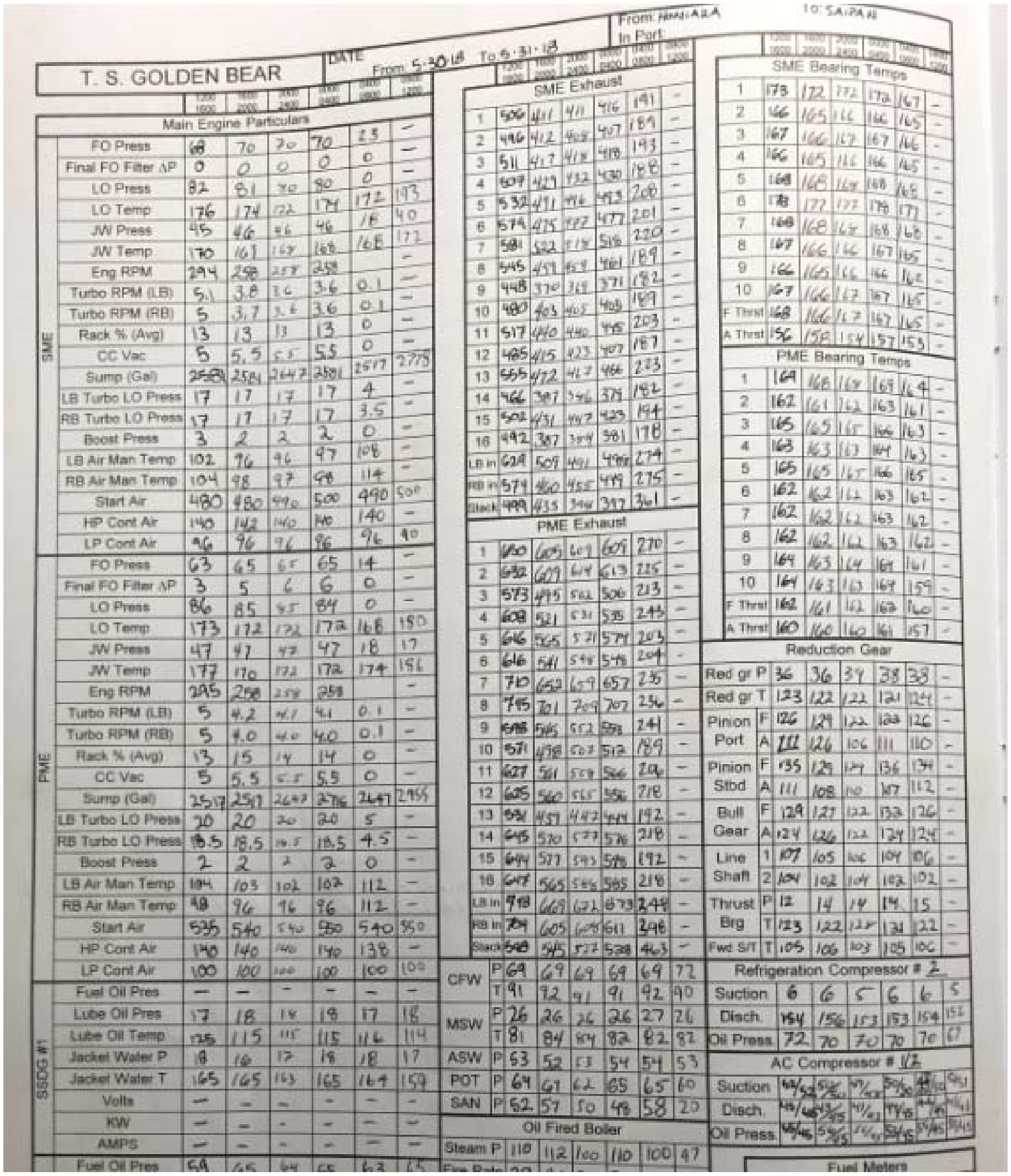


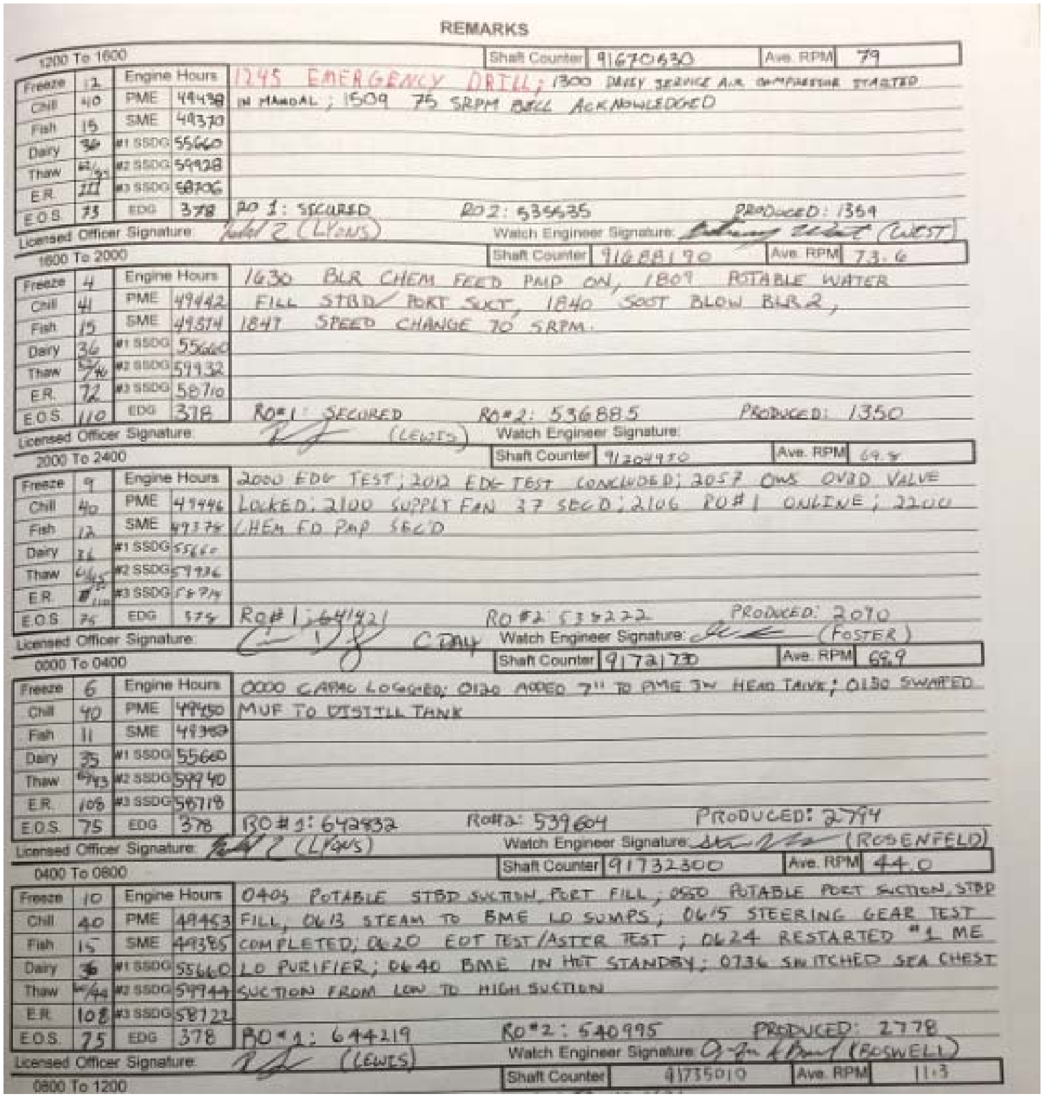
Figure 9 Excerpt of a typical engine room log book – Page 1 (courtesy California State Maritime Academy)

The above description of typical or sample watch processes is not suggested as a prescription for the SSA, but rather as an example of a well-developed watch process that forces crew members to pay attention to critical parameters, and thereby ensures that they will recognize when equipment is running outside of normal process ranges. For example:

- When the watch Engineer is forced to record plant parameters into an official log book and then sign for the accuracy of the recorded readings, they will take more care to ensure the readings are correct and properly entered into the log book.
- When the watch Engineer is motivated to record the correct readings into the official log book, they will ensure that the watch Oiler is correctly logging plant readings on their watch round forms.
- If the watch Engineer is made accountable for the performance of the watch Oiler, and in particular their accurate recording of plant parameters on the watch round sheets, they will be more inclined to ensure that their watch partner is well informed about the plant.
- The transcription of process variables in a table that logs plant variables at regular time intervals illuminates whether the variable has changed over the past several watches. This makes unusual trends very obvious to the watch stander. The repeated transcription

of these values over a period of watches has the natural effect of helping the crew members internalize the ‘normal’ values for all plant parameters.

- The logging of plant variables into an official log book and the retention of watch Oiler round sheets creates official records of plant readings and watch activities, which can be reviewed and audited by a senior watch stander or engineering supervisors. Such review provides feedback to those responsible for crew training and vessel operations regarding the performance of watch standers.



REMARKS

1200 To 1600 — Shaft Counter: 91670630 — Ave. RPM: 79

Freeze	12	Engine Hours		1245 EMERGENCY DRILL; 1300 DAISY SERVICE AIR COMPRESSOR STARTED
Chill	40	PME	49438	IN MANUAL; 1509 75 SRPM BELL ACKNOWLEDGED
Fish	15	SME	49370	
Dairy	36	#1 SSDG	55660	
Thaw	62/35	#2 SSDG	59928	
E.R.	111	#3 SSDG	58706	
E.O.S.	73	EDG	378	RO 1: SECURED RO 2: 535635 PRODUCED: 1359

Licensed Officer Signature: (LYONS) Watch Engineer Signature: (WEST)

1600 To 2000 — Shaft Counter: 91688190 — Ave. RPM: 73.6

Freeze	4	Engine Hours		1630 BLR CHEM FEED PMP ON, 1809 POTABLE WATER
Chill	41	PME	49442	FILL STBD/PORT SUCT, 1840 SOOT BLOW BLR 2,
Fish	15	SME	49374	1847 SPEED CHANGE TO SRPM.
Dairy	36	#1 SSDG	55660	
Thaw	5/40	#2 SSDG	59932	
E.R.	72	#3 SSDG	58710	
E.O.S.	110	EDG	378	RO#1: SECURED RO#2: 536885 PRODUCED: 1350

Licensed Officer Signature: (LEWIS) Watch Engineer Signature:

2000 To 2400 — Shaft Counter: 91204950 — Ave. RPM: 69.8

Freeze	9	Engine Hours		2000 EDG TEST; 2012 EDG TEST CONCLUDED; 2057 OWS OVBD VALVE
Chill	40	PME	49446	LOCKED; 2100 SUPPLY FAN 37 SECD; 2106 RO#1 ONLINE; 2200
Fish	12	SME	49376	CHEM FD PMP SECD
Dairy	36	#1 SSDG	55660	
Thaw	64/35	#2 SSDG	59936	
E.R.	[illegible]	#3 SSDG	58714	
E.O.S.	75	EDG	378	RO#1: 641921 RO#2: 538222 PRODUCED: 2070

Licensed Officer Signature: C DAY Watch Engineer Signature: (FOSTER)

0000 To 0400 — Shaft Counter: 91721730 — Ave. RPM: 68.9

Freeze	6	Engine Hours		0000 CAPAC LOGGED; 0130 ADDED 7" TO PME JW HEAD TANK; 0130 SWAPPED
Chill	40	PME	49450	MUF TO DISTILL TANK
Fish	11	SME	49382	
Dairy	35	#1 SSDG	55660	
Thaw	6/43	#2 SSDG	59940	
E.R.	108	#3 SSDG	58718	
E.O.S.	75	EDG	378	RO#1: 642932 RO#2: 539604 PRODUCED: 2794

Licensed Officer Signature: (LYONS) Watch Engineer Signature: (ROSENFELD)

0400 To 0800 — Shaft Counter: 91732300 — Ave. RPM: 44.0

Freeze	10	Engine Hours		0405 POTABLE STBD SUCTION, PORT FILL; 0550 POTABLE PORT SUCTION, STBD
Chill	40	PME	49453	FILL, 0613 STEAM TO BME LO SUMPS; 0615 STEERING GEAR TEST
Fish	15	SME	49385	COMPLETED; 0620 EOT TEST/ASTER TEST; 0624 RESTARTED #1 ME
Dairy	36	#1 SSDG	55660	LO PURIFIER; 0640 BME IN HOT STANDBY; 0736 SWITCHED SEA CHEST
Thaw	6/44	#2 SSDG	59944	SUCTION FROM LOW TO HIGH SUCTION
E.R.	108	#3 SSDG	58722	
E.O.S.	75	EDG	378	RO#1: 644219 RO#2: 540995 PRODUCED: 2778

Licensed Officer Signature: (LEWIS) Watch Engineer Signature: (BOSWELL)

Shaft Counter: 91735010 — Ave. RPM: 11.3

0800 To 1200

Figure 10 Excerpt of a typical engine room log book – Page 2 (courtesy California State Maritime Academy)

4.3.2.3 Specific Solutions

The SSA can decrease the chances that abnormal plant conditions, such as those associated with the M/V *Martha’s Vineyard* March 17th and May 5th blackouts, will go unrecognized in the future by instituting new watch standards and processes such as those described in this section. A solution to this is for the SSA to develop new engine room watch processes, document them as formal policies and procedures, and implement them by putting the required tools in place and training crews on how the tools are to be used. The new watch processes should incorporate the following features and characteristics:

- An individual within the SSA management is responsible for the performance of all engine room watch standers, and this ‘Watch Supervisor’ is empowered with sufficient authority and resources to develop and maintain watch policies/procedures and ensure that all crew are adequately trained. The watch supervisor is held accountable for any issues with crew performance.
- Watch Engineers are responsible for the safe operation of the vessel during their watch, for the accurate completion of the official engine room log book, and for the performance of the watch Oiler.
- There are well developed expectations about how crew members stand their watches, which are clearly communicated to all watch standers through documented policies, procedures, and standing orders.
- Watch Oilers complete watch round reading forms that have been developed by the SSA and are specific to each vessel. These watch round forms are retained onboard and reviewed by the senior watch stander and the member of the SSA management who is responsible for watch stander performance.
- Entries are made into an official log book, which has been developed by the SSA and is specific to each vessel, once per four-hour watch by the watch Engineer. The watch Engineer signs the log book on a per watch (or per shift) basis, attesting to the fact that the log book is a complete and accurate representation of the vessel’s operation.
- The watch supervisor periodically reviews Oiler watch round forms and the official engine room log books, to ensure that all readings are correct and to identify any unusual or unexpected trends in the data.

4.3.3 Watch System

Provisions for “alternative compliance” regarding work/rest periods are outlined on each vessel’s Certificate of Inspection (COI) issued by the USCG. These provisions allow the SSA crews to work for periods up to 18 hours and with little rest between watches. Although approved by the cognizant Officer in Charge of Marine Inspections (OCMI), these are among the only provisions of this type our collective team has witnessed in the domestic ferry industry.

Sailing schedules are tightly integrated with crew schedules and may require complex union negotiations to make any adjustments. For example, it is widely understood that scheduled 15-minute vessel turnarounds are insufficient resulting in (unpublished) late departures. However, these short turnarounds were established to help ensure vessel crews comply with the work/rest requirements stated in provisions for alternative compliance.

Work rules agreed to by crew members through union negotiations contractually provide for only one alternative crew schedule. It has been reported that this alternative was a compromise that remains unpopular among many crew members and is collectively referred to as “the nuclear option.”

4.3.3.1 Issue

Regardless of the route of the vessel or work rules agreed to by crewmembers individually or through collective bargaining, persons who are assigned duties as officer in charge of a watch or whose duties involve safety, pollution prevention, and security are required to be fit for duty. If credentialed officers or crew members are too fatigued to stand an alert watch, a hazardous condition has been created.

Instances regarding excessive workloads, automation system failures, management system failures, inability to safely operate and maintain the vessel, and design- or component-related issues increase the likelihood of a serious marine incident.

4.3.3.2 Industry Standards/Best Practices

A 12-hour work day is considered a reasonable work hour limit for vessels of this class. Although the 2010 amendments to the STCW Convention that include changes to the hours of rest requirements are only applicable to personnel working on board U.S. vessels subject to STCW, the typical work hour limits for vessels of this type are no more than 12 hours in a 24-hour period.

Regardless of regulatory restrictions and the interpretation of how those are applied, the international and domestic regulations clearly indicate the importance of combating fatigue in vessel crews and ensuring it does not become a contributing factor to incidents. The industry has embraced a strict adherence to the 12-hour rule primarily due to the acknowledgement and understanding that crews are frequently faced with extenuating circumstances which require their rest periods to be impacted. While the 12-hour rule ensures some flexibility regarding these circumstances, the current schedule being utilized at the SSA does not allow for any margin of error.

4.3.3.3 Specific Solutions

The SSA should develop a fatigue risk management plan to assess, inform, and continuously improve fatigue risk management. In developing a fatigue risk management plan, the SSA should carefully consider the circumstances and intent of the alternative provisions regarding work/rest periods outlined on each vessel's COI and consider the principles in establishing work hour limits for mariners. In addition, the SSA should take the following steps:

- Ensure employees and management are educated regarding safety concerns of inadequate rest.
- Utilize the model format for records of hours of work or hours of rest of seafarers developed by the IMO (Reference 9).

4.3.4 Standard Operating Procedures

There are three areas where the SSA's current procedure documentation could be improved:

Integration. On-site field observations and an examination of the provided documentation indicated that the program and procedural interfaces between the *Vessel Systems and Training Manual,* the *Vessel Operations and Safety Manual* and other operations manuals such as the *Customer Handbook*, the *Pilot Training Manual* and the *HSC Craft Operations Manual* (specific to the *Iyanough)* are not clearly defined.

There were also numerous accounts of policy updates distributed by memorandum that were not tracked and/or documented. Observations identified memos to be the primary mechanism for communicating policies and procedures. Typically, the memo was the procedure.

Obsolescence. A document review and interviews with crew members across the fleet indicated that the *Vessel Operations and Safety Manual* (est. 1997) includes procedures that are not being consistently utilized or applied. In some cases, procedures were in conflict with subsequent memos without any corrections or updates being made to acknowledge or establish precedence. The majority of crew were unaware of the manual's existence.

Risk assessment. A document review indicated that the SSA operating procedures do not include risk assessments or job hazard analyses.

4.3.4.1 Issues

Integration. There are many partially-developed management systems at work at the SSA. Users of these systems find it difficult to determine which system or manual to reference for any particular requirement, which can confuse roles and responsibilities regarding operating procedures and safety management.

Under the current system, when a new procedure is published or changes to existing procedures are adopted it is unclear how to incorporate them. Properly integrating and summarizing each management system by conveying the system's basic design concept aids employees without specialized skills in navigating program and procedural interfaces.

Memos are not integrated into a comprehensive safety system and subject the user to a data mining process that is unlikely to be followed. There is no means to help ensure that all affected users are aware of changes or additions distributed by memo. There is no means to alleviate or identify conflicts with previous policies or procedures.

Obsolescence. The SSA's *Vessel Operations and Safety Manual* (est. 1997) was crafted in an apparent attempt to meet or emulate ISM Code requirements at the time of its implementation (1998 for passenger vessels). Although the ISM Code is internationally accepted as the standard for the safe operation of ships and pollution prevention, the SSA is not using it.

Risk assessment. Safety management objectives should establish safeguards against all identified risks. Although the method of identifying risks may vary, the approach should be well organized and planned.

4.3.4.2 Industry Standards/Best Practices

As the maritime industry has adopted management systems as an effective way to establish, communicate, and verify compliance with policies and procedures, it has not been without difficulties. With the more active management of vessels comes the burden of ensuring crews are not overburdened by, confused by, or unaware of new procedures. Over the past twenty years, operators have adapted by ensuring management systems follow strict document control and communications protocols. The systems are also designed and managed to ensure proper integration of their various elements.

4.3.4.3 Specific Solutions

Integration / Obsolescence. Provide a clear demarcation of management system interfaces so personnel have no confusion regarding their roles and responsibilities regarding operating procedures and safety management.

- Designate a person responsible for ensuring all document control procedures are followed.
- Develop a list of all SSA management systems.
- Develop a process to track documentation updates, revisions, and additions to ensure accuracy and consistency. Include an explanation of document revision and distribution routines. Ensure procedural changes are rigorously tracked, organized and easily accessible by vessel personnel.
- Establish a means to explain and discuss procedural changes with vessel personnel.
- Ensure only current copies of procedures are being used. Destroy older versions.

Risk assessment. The SSA should specify a methodology adopted for performing risk assessments and show evidence they have addressed a given risk for each procedure. At a minimum each procedure should include the following:

- Activity being performed.
- Known hazards.
- Possible consequences.
- Measures to reduce or eliminate risk (risk control).

4.3.5 Emergency Response Plans

It was observed that the SSA does not have a consolidated reference containing procedures for responding to emergencies on board the vessels or at the terminals. This includes a lack of plans for management response, including coordination of repair activities, public communications, and scheduling contingencies.

Incidents and emergency situations are responded to with an informal, ad hoc approach. The SSA relies heavily on institutional knowledge of staff to direct their response (see Section 4.1.8 for a detailed discussion on SSA's over-reliance on institutional knowledge).

4.3.5.1 Issue

Ferries systems are extremely complex, and even the best organizations cannot eliminate incidents completely. Minor mechanical issues can cause delays or other inconveniences, and major incidents such as groundings, collisions, or fires can have long-term impacts on operations, pose financial and reputational risks, and threaten the safety of passengers and crew. While prevention is a key to mitigating these risks, it is also critical to have adequate plans in place to minimize their impact if they do happen.

Organizations without a clear and consolidated emergency response plan are generally ineffective at responding to situations they have not previously experienced. New hires in such organizations are at a severe disadvantage, relying solely on instinct to aid the response efforts.

4.3.5.2 Industry Standards/Best Practices

Most maritime operations develop, implement, and periodically train with an emergency response plan. This is a requirement of any operation subject to the International Safety Management (ISM) Code but is also viewed as an industry best practice by most operators.

Many operators also invest in specialized training for vessel crews and management. Most vessel officers and other crew should have formal training in firefighting, basic safety, survival at sea, and emergency medical and first aid. Passenger vessel operators should also invest in crowd and crisis management. At the management level, many operators ensure key personnel receive formalized training in emergency procedures management and the Incident Command System (ICS).

4.3.5.3 Specific Solutions

The SSA should develop an emergency response plan that provides guidelines to vessel crews on response. Plan development should include the following steps:

- Establish a list of existing emergency procedures. Identify missing or incomplete elements and publish a standard procedure for each.
- In addition to emergency response, ensure the plan provides guidelines to vessel crews on communications protocols.

- Ensure the system addresses the following items, at a minimum:
  - Fire Fighting
  - Flooding
  - Abandon Ship
  - MOB
  - Heavy weather
  - Hazardous bars
  - Medical Emergency
  - SAR (Search and Rescue)
  - Piracy / Terrorism
  - Emergency Assistance to Other Vessels
  - Loss of steering
  - Loss of propulsion
  - Emergency towing
  - Emergency anchoring
  - Grounding
  - Collision
  - Pollution
  - Icing conditions
  - Shifting Cargo (vehicles)
- Incorporate additional training on response topics specific to SSA, as well as annual tabletop exercises to include all five major functional areas of a standard ICS; Command, Operations, Planning, Logistics, and Finance/Administrations. Within these should be subcategories that focus on safety and public communications/media.

4.3.6 Sailing Schedule

Discussions with the SSA personnel and an examination of the provided documentation revealed that no contingency plan for unplanned trip cancellations exists. This results in fleet rotation challenges when the system is utilized at near-full capacity.

Sailing schedules and crew schedules are interdependent and may require complex union negotiations in order to adjust. For example, it is widely understood that scheduled 15-minute vessel turnarounds are insufficient, resulting in (unpublished) late departures. However, these short turnarounds were established to help ensure vessel crews comply with the work/rest requirements stated in provisions for alternative compliance on the vessel Certificates of Inspection (see Section 4.3.3 Watch System).

4.3.6.1 Issues

System reliability and system capacity are inversely related. When ferry system capacity is reduced (e.g. a vessel breaks down resulting in a cancelled trip) without a commensurate reduction in trips on the ferry schedule, system reliability is diminished. Alternatively, when system capacity is increased (a vessel is added) without adding trips to the ferry schedule, reliability increases; there is an increased likelihood that the ferry system will perform to fulfill its purpose and meet public expectations.

Currently, when unplanned trip cancellations occur, the likelihood that the SSA ferry system will perform to meet its purpose is very low. The SSA’s response to numerous ferry cancellations in the spring of 2018 resulted in decreased system reliability and a loss of public confidence. This strongly indicates that the ferry system is overburdened during the busy summer months.

It is important to note in this section that the term “ferry system” refers to “system” or “line” capacity when the <u>entire</u> feet is deployed. In operations vernacular it may be referred to as “rolling stock capacity” but should not be confused with seating capacity, vehicle capacity, or design capacity.

Since the likelihood of adding a standby ferry vessel is low due to the extraordinary expense, the most feasible solution is to have contingency plans in place detailing how to respond to unplanned trip cancellations. Currently there is no formal contingency plan.

4.3.6.2 Industry Standards/Best Practices

Although practices may vary among operator's fleet rotations and vessel assignments that satisfy some variety of unusual circumstances regarding unplanned trip cancellations are commonly outlined in a single document such as a contingency plan. Although the final solution for any given trip cancellation and how to manage it may vary, a contingency plan document can be used as a valuable decision-making tool.

4.3.6.3 Specific Solutions

The SSA currently utilizes an informal, case-by-case approach to dealing with trip cancellations. This approach may be successful at times but breaks down under increasingly complex conditions. No model is perfect, but memorializing the successes, failures, and lessons learned from the SSA's past experience with unplanned trip cancellation will help identify and mitigate operational and capacity risks of future cancellations.

The SSA can begin implementation of this solution by articulating in writing the goals they wish to achieve when a trip is cancelled. They can then develop a contingency plan to achieve these goals that includes same-day service adjustments. Contingency plan development should include the following tasks:

- Specify vessel assignments by outlining which vessels are assigned to each route under normal conditions.
- Identify possible solutions in the event of an unplanned cancellations for each route that includes vessel rotations and messaging the public (reduce the number sailings, lease a vessel, etc.)
- Define the constraints for each solution.
- Outline schedule recovery opportunities.
- Consider these constraints when publishing future schedules.

4.3.7 Weather Cancellations

There was some speculation by members of the SSA that one reason for the increased number of trip cancellations and delays may have been due to a reduction over time in the willingness of captains to operate the SSA's ferries in the same inclement weather conditions in which they once would have operated. This opinion was found to be held by a small minority of employees.

There was unanimous consensus among management that captains have full responsibility and authority in their determination of whether to sail, and should not be pressured into getting underway. There was nearly unanimous consensus among captains that management respected their judgment on whether or not it was safe to sail. No evidence of undue pressure on captains to sail was observed.

Three factors were observed that may affect the determination made by captains to sail in inclement weather conditions:

1. There has been a reduction in the average required minimum skill level of deckhands, due to the replacement of some Able Seamen (ABs) with Ordinary Seamen (OSs).
2. There has been a reduction in the average skill of entry-level employees due to an aging workforce and difficulty filling deckhand roles.
3. There are frequent crew rotations and deficient training, resulting in crews being, on average, less familiar with the vessels on which they operate than if they were assigned longer tenures to each vessel, and formally trained on the operation of each vessel onto which they were rotated.

The captain must decide whether or not it is safe to sail in inclement weather conditions based on many variables beyond wind speed and sea state. The decision must consider these variables along the entire route, not just the known conditions at the dock. Examples of these variables include:

- The ability of crew to operate the vessel and respond to emergencies at any time.
- The condition and state of machinery.
- Seaworthiness of the vessel.
- Number and demographics of passengers being carried.
- Type and disposition of cargo being carried.
- Density and types of vessel traffic in navigation channels.
- Vessel maneuvering and seakeeping characteristics.
- Restrictions or hazards to navigation.
- Speed of advance.
- Other environmental variables, including:
    - Visibility (due to time of day, fog, precipitation).
    - Wind direction (certain wind directions are worse than others).
    - Tidal current direction and force (particularly in relation to wind direction and force).
    - Temperature (which could affect icing of decks, visibility, consequences if there is a man overboard, etc.)

4.3.7.1 Issues

Under general maritime law, the master is ultimately responsible for the safety of the vessel's crew, passengers, and cargo. It is generally recognized that the master has the overriding authority to control the vessel, including whether or not to get underway.

The decision to sail or not, under inclement weather conditions and any other variables concerning safety, is not one that can be reliably quantified. There are too many variables, many of which are elusive and extremely dynamic in nature.

Although increased cancellations reduce vessel revenue and reliability, questioning or attempting to influence the master's decisions will only result in a further erosion of trust between vessel crew and management. Ultimately this will only increase the rate of missed sailings.

4.3.7.2 Industry Standards/Best Practices

The chain of command is critical on a ferry, because an ever-changing environment must be reacted to immediately to avoid incidents. This requires one person (the captain or master) to have the final and ultimate say on all operating decisions. Consequently, the captain is ultimately responsible for the safety of all of the occupants of the ferry and the surrounding environment. Therefore, it should be the captain's decision on whether to sail in inclement weather conditions, based on a consideration of all the factors that affect safety.

Ferry systems with well-trained crew, seaworthy ferries, and reliable equipment tend to have more reliable service in inclement weather conditions.

4.3.7.3 Specific Solutions

Management should focus on factors it can control. If the SSA can improve the skill and training of its employees, perhaps it will be able to realize a reduction in trip cancellations and delays.

To increase the probability that a captain will operate in marginal weather conditions, the SSA should focus on improving the skill of its employees and the quality of its equipment. Crew re-training should be formalized as described in Section 4.3.1.

The SSA should also reevaluate the costs and benefits of replacing ABs with OSs. Although the reduction in skill level may result in some cost savings, it could also contribute to an increase in weather cancellations, reducing revenue, or to other incidents that increase costs and reduce revenue.

Vessel reliability should also be improved by implementing a quality management system that systematically locates and resolves quality issues, continually improving the safety and reliability of the vessels. Beyond the direct effect on reducing unplanned maintenance, the vessel crews will grow more confident in the reliability of their vessels over time, which will translate into more confidence to operate in marginal weather conditions.

4.3.8 Operational Metrics

The program for collecting and interpreting performance metrics was observed to be incomplete and lacking specificity. For example, trip cancellation reports provide only three reasons for cancellation: Weather, Mechanical, or Other, without the ability to provide further details.

4.3.8.1 Issues

One issue is that the desire for users of the SSA ferries to hold the organization accountable for its operation reflects an interest in transparency and a results-oriented means of conducting business. Without accurately defining key performance metrics the level of service and performance cannot be measured and it is therefore difficult to make improvements.

Another issue is that metrics tend to over-simplify more complex attributes which can create problems if the metric is not well defined or understood . For example, the trip cancellation report lists only three reasons for a cancelled trip (weather, mechanical or other). These categories do not address the multitude of variables involved in each case, the results will be misleading and hamper the organization's ability to identify real performance issues and address them.

Another example exists regarding trip cancellations due to bad weather. The lack of qualifying factors could lead management to wonder why there have been more cancellations. Perhaps management may draw inaccurate conclusions based on this limited data. Armed with only a numerical value (without context) an implied message is that the vessel crew may have done something wrong that could result in pressure on the captain to neglect the broader goals of the organization by questioning his or her own judgement.

Dedicating time to carefully articulate the intent of each metric can help guide the process of improvement. For example, if a ferry service is measuring reliability as a metric, a simple statement excluding "force majeure" events may help distinguish its purpose.

4.3.8.2 Industry Standards/Best Practices:

All ferry systems are unique and are therefore best served by developing their own performance metrics tailored to their system.

The stakeholders tend to have the best sense of which operational performance metrics are best suited to their organization. However, some metrics are more common than others for ferry services like the SSA. Among those are reliability, on time departures and missed sailings. Safety metrics such as lost-time accidents and near-misses are also very common. For example, Washington State Ferries metrics include on-time performance, service reliability, total vessel out-of-service time and passenger satisfaction. A smaller operator, Pierce County Ferry tracks and publishes performance metrics which include total ridership, vehicles left behind and on-time/delay metrics.

4.3.8.3 Specific Solutions:

Establish operational KPIs for the fleet using the standard format in the examples provided below.

- Determine how the SSA views success on an operational basis and identify key performance indicators (KPIs) that should be used (see Section 4.1.2 Strategic Planning).
- Clearly define each metric and establish how it will be collected and reported.
- Define the desired targets.
- Hold key managers accountable to meeting these targets by requiring them to develop performance plans and incorporating the goals into performance reviews.
- At a minimum, adopt the following operational KPIs:

Metric: Reliability	
Data Source:	Ships logbook or short form
Frequency:	Per sailing (continuously from crew)
Target:	99% sailing completion

In this metric, reliability is defined as the proportion of completed trips to scheduled trips. A 99% goal for reliability should exclude ‘force majeure’ events outside of human control such as weather conditions and include planned maintenance events (yard periods) and mechanical failures. Establishing a desired reliability of 100% suggests that the operator has a reliable backup vessel plan, robust preventative maintenance programs and can effectively respond to operational needs. Trip cancellations should be recorded in the ships logbook and continuously monitored against the schedule.

Metric: On Time Departure	
Data Source:	Ships logbook
Frequency:	Per occurrence (continuously from crew)
Target:	Three minutes at 95%

Considering the duration of this route, HMS recommends vessel departures no later than 5 minutes 95% of the time (in normal operating conditions) as reported in the ship’s logbook by the vessel’s Master. Measuring on time departures provides insight to operational needs. For example, was a delay the result of a slow boarding process or a mechanical failure? Did ice on the boarding ramp delay the loading process? Delays should be continuously monitored and reported at regular intervals.

Metric: Missed Sailings	
Data Source:	Ships logbook
Frequency:	Per occurrence (continuously from crew)
Target:	0

Missed sailings metrics vary from reliability metrics in in that they measure the results of *unplanned* disruptions of service. They should be reported as a critical item using a Situation Report (SITREP) and evaluated on a case by case basis. Missed sailings are often the result of mechanical failures but may also include incidents or accumulated delays and it is critical to analyze all of the variable associated with each missed sailing.

4.3.9 Terminal Flow

Inefficiencies in the loading and offloading process were observed, especially with regards to lane use control, signage directing passengers to appropriate platforms and real time messaging to the public of arrival/departure information and updates.

The SSA terminal system appears to rely heavily on personal interaction to convey information, at which the employees were observed to be particularly adept. From standard queuing instructions to answering questions regarding delays and cancellations, the on-site terminal employees are the default method of communication.

4.3.9.1 Issue

Inefficiencies in terminal flow are detrimental to service levels and passenger wait times, especially when trip cancellations occur. This has a cascading effect on passenger satisfaction and employee morale, particularly when confused passengers randomly inquire with passing SSA employees. Communicating information in this way makes it difficult to control the message or maintain consistency.

The SSA ferries are subject to delays caused by backing vehicles, turning vehicles, pedestrian crossings, and high traffic volumes at various terminals. The proximity of terminal components and the number of vehicles and passengers each component must process is negatively impacting terminal flow.

Opportunities to message the public in real time regarding arrival and departure information updates are being missed, especially when trips are cancelled or delayed. Messaging the public about arrival and departure information, including trip delays and cancellations in real time, using different modes of communication (signs, smartphone messaging, radio announcements), would relieve congestion and ease terminal flow when unplanned trip cancellations occur.

4.3.9.2 Industry Standards/Best Practices

Much can be learned from other modes of public transportation such as bus lines, airport terminals and train stations. Peers in the marine industry utilize highly visible numbered lanes for staging vehicles and clear demarcation lines for exclusive right of ways for both passengers and vehicles. This is done for efficiency and the safety of passengers and employees. Strategically-placed monitors and digital signage providing real time updates regarding arrivals, departures and cancellations are utilized throughout the transportation industry.

4.3.9.3 Specific Solutions

Perform a passenger flow analysis addressing the following items:

- The current behavior of passenger and vehicle flow.
- A model of potential choke points.
- Lane use control.
- Vehicle and passenger right of ways.
- Traffic controls (signals / stop signs).
- Boarding and loading ramp capacities.
- Potential improvements.

Install signs, monitors and digital signage to message the public in real time.

- Install a real time sign on the roadside in the vicinity of the operations center in Falmouth reporting cancellations and delays to drivers bound for the ferry approximately six miles away.
- Install monitors with real time schedule updates and cancellation notices in highly visible locations.

Establish an advisory radio broadcast system.

- For each port apply for an AM radio broadcast station license through the FCC on allocated non-interference frequencies between 540 kHz and 1700 KHz and establish an advisory radio station providing real time schedule updates to the public. Updated messages can be recorded and broadcast as needed.

Post highway signs on approach to each terminal indicating the presence of the system and instructions regarding how to access the system. For example, "Tune your radio 550 AM for up to date ferry schedules and service adjustments."

Install highly visible numbered lanes for vehicles.

- Install highly visible numbered lanes for vehicles at each terminal.
- Install highly visible directional signage.

4.4 IT Systems

4.4.1 IT Project Planning

On site field observations and interviews with IT staff revealed a lack of planning for IT activities. Although active projects are being updated at weekly management meetings, an IT-specific strategic master plan (such as a five-year plan) or an inventory of the top five IT projects for 2018 could not be produced upon request.

Further inquiries and interviews with IT staff revealed that there is <u>no centralized means to track and prioritize known issues</u> related to the SSA's IT systems. The SSA's IT systems are mission critical and include the:

- Reservation system.
- Point of sale (pos) system.
- Website.
- Network/servers.
- Phone system.
- Email marketing system.

4.4.1.1 Issues

Without a proper plan or strategy, the SSA may have trouble keeping technology projects within scope, schedule, and budget, and other departments will not know when to expect the efficiencies required to drive the future of their respective departments (i.e. mobile app-based ticketing POS for all ferries and ports). This has a direct impact on the entire organization's ability to effectively plan, and to maintain adequate staffing and resources to accomplish goals and projects within the timeframe allowed.

All developers and contractors that are based on hourly fees need to be organized and complete projects on time with the appropriate speed and urgency. Currently, developers and contractors are allowed too much flexibility if there is no plan identifying project parameters.

The absence of a centralized means to track and prioritize known IT issues does not allow management to prioritize those items that are "urgent for the business" versus "nice to have for the public."

4.4.1.2 Industry Standards/Best Practices

Although the complexity of the any given project plan may vary, a basic work breakdown structure outlining information such as scope, schedule, and budget is a hallmark of IT best practices.

The normal industry best practice to track and prioritize IT issues is to establish an IT help desk. As problems are initially evaluated by the IT help desk, they are assigned a priority and severity level. If issues cannot be handled by the help desk, they are assigned and tracked to other staff whose specific job function it is to handle those issues. The help desk would also serve the customers for IT-related issues, such as problems with the phone APP or at a ticket terminal, wi-fi, etc. These issues would be treated much the same way as IT staff issues, either handled directly and expeditiously or assigned to someone who can better assist.

4.4.1.3 Specific Solutions

- **Establish top five priorities for 2019.** Each mission critical system should be managed through a list of "Development" items (scope, budget, timeline, and project leader).
    - Establish a "Development List" prior to the start of the fiscal year that provides stakeholders insight into the What is happening in the IT Department, When it is being deployed, How Much it costs to implement and Who will lead the project.
    - Prioritize the "Development List" to determine the SSA's top five IT priorities for 2019.
- **Draft an IT-specific strategic plan (five years).** With a focus on solutions that facilitate process improvement, establish a master plan for the department that lays out its strategic direction and operational priorities. Outline initiatives (computer replacement, server consolidation, cloud-based computing, stewardship of the reservation system) that reflect these priorities.
- **Establish an IT help desk to track and prioritize IT issues.** Each mission critical system should be managed through a centralized means to track and prioritize known IT issues that includes the following capabilities:
    - Ticket creation.
    - Routing and prioritization.
    - Notification and escalation.
    - Routine (monthly) testing procedures for each system.

4.4.2 Reservation System

Discussions and interviews with the SSA IT staff revealed that the SSA's reservation system is entirely owned, managed, and maintained by a single individual operating remotely and the report program generator (RPG) code that the system is written in is dangerously outdated. The SSA's departmental constituents do not have access to the code or know how it works, resulting in a "single point of failure" should this proprietor of the reservation software become incapacitated or otherwise unavailable.

4.4.2.1 Issue

The primary issue is that if the current owner of the reservation system's source code becomes disgruntled or deceased, or if the company becomes insolvent or is sold, the SSA could be rendered operationally ineffective if they do not have the ability to access and maintain the source code.

In the event that a contractual solution was established, it is important to note that the RPG code is a very old programing language that is dangerously outdated. This programing language is not used in any form of modern development and the likelihood of finding a coder that could develop or fix an issue in the event of an emergency is very low.

4.4.2.2 Industry Standards/Best Practices

Best practices may vary according to the organization but, under normal conditions, an appropriate standard would be to maintain some level of proprietary or contractual control over any system that is essential to the function of the organization.

Most companies have either built their reservation system so they control it or they have bought a system that they then have full access to develop. Other organizations that use licensed systems and do not grant access to the code, provide contractual obligations in regards to uptime / development and bug fixes, they also host and maintain the servers and infrastructure to ensure these deliverables.

4.4.2.3 Specific Solutions

The SSA and the reservation company have discussed possible solutions including:

- Buying the company/code, including owner, and having the owner teach and train existing employees and new employees to develop the system.
- Moving away from the existing reservation platform to a new web-based system. Reportedly, the challenge with this option has been the uniqueness of the "truck/car spatial organization" feature of the existing reservation system (i.e. how many trucks/cars can fit on a given vessel).

To choose from the identified solutions, the SSA should perform a cost/benefit analysis of the following two options:

- Purchasing the reservation code outright and hire RPG programmers that start to immediately train on and develop the source code of the existing reservation system, or
- Examine off the shelf solutions like www.carus.com and develop an RFQ for a new modern cloud-based reservation platform that is mobile-compliant, PCI-compliant, and seamlessly integrates with the online web portal. Systems like this often offer custom modules that can solve the "truck/car spatial organization" issue.

4.4.3 Website Platform Management

Although the SSA's website uses a custom CMS (content management system) not all essential personnel have access or training and it is unclear who has been designated the content manager. Under the current system, the website platform is managed by multiple teams in multiple departments. If it is "managed by everyone" then it is really "managed by no one".

For example, the marketing department updates some of the content (pictures, text), the operations department updates schedules and prices whilst the IT department/ 3rd party developer updates functionality, maintain servers and back-ups, develops integrations to other systems and maintains the “up-time”.

Interviews with representatives from iMarc, the current 3rd party web developer, revealed that the relationship between SSA and iMarc is not well defined. The website is hosted at SSA with little to no access by developer. The developer does not track the status of website problems but attends to them in an “ad hoc” fashion, only as requested by SSA.

Further interviews with staff suggest that no single person is focused on SEO (search engine optimization) or Google Analytics (tool used to determine simple traffic stats, user and usage stats, referring sources, top pages, etc. for mostly marketing knowledge). Google analytics script is installed but no dashboard or reporting or regular usage and viewing of the statistics is being done.

4.4.3.1 Issue

The issue with an incomplete content management system is that there are multiple contributors. If the rules of collaboration are not well defined the resulting digital content can easily become mis aligned with the goals of the organization and incorrect or inappropriate information can be uploaded. Ambiguity regarding the responsibilities of the web developer, the IT department and other department should be avoided.

The issue with an ill-defined/ad hoc relationship with the web developer (iMarc) is that the developer remains unaware of the changing priorities at SSA. There is no path or clearly defined deliverables which reflects poor management principles. This is an iteration of the IT project planning observation in that improper planning serves as a barrier for projects relating to the website to stay on track and under budget.

The issue with a lack of SEO utilization is that, under current conditions, competing ferry services are displayed over SSA’s. As the leading public service to Nantucket and Martha’s Vineyard the SSA should be the number one result. Compare search results for a user searching for a “Boston Bus” and a search engine will first show the MBTA (Massachusetts Bay Transit Authority). This should be the case for the SSA.

4.4.3.2 Industry Standards/Best Practices

Normally a company would designate members of the department to serve as the website’s content manager, a liaison to the web developer and/or the person responsible for Search Engine Optimization. The duties and responsibilities for each role would be clearly defined and delegated to staff.

4.4.3.3 Specific Solutions

Establish a website content manager. The IT department should clearly establish its role regarding the website. Although the IT department must coordinate marketing and operations ultimately, IT must serve as the gatekeeper to this relationship. This gatekeeper role should be clearly defined and agreed upon throughout the organization.

The content manager should manage website specific project lists and provide the tools (CMS) and ensure only designated and trained employees in marketing and other departments have access to the system (authority to upload content should be strictly enforced) and updates to the website should be approved before any changes are made.

Regular communication with iMarc. Establish bi-weekly update meetings with iMarc to stay informed of current projects and review all deliverables. Establish a monthly / quarterly project development plan with measured deliverables and responsible parties. A project manager should be responsible for all deliverables and deadlines and keeping the SSA and iMarc team members in coordination. All projects should be tracked using a project-based software to allow for transparency at anytime to the SSA employee's / council / iMarc management.

Develop an SEO (Search Engine Optimization) strategy. Establish a ".gov" domain and establish an SEO strategy that reflects the priorities of SSA ridership. SSA should maintain their presence in SEO and through their web address as a .gov as the government provided and maintained ferry system to the island and distinguish themselves from the privately held but licensed ferry providers.

Section 5 Final Recommendations and Implementation Plans

The analysis of SSA's operations identified numerous areas of potential improvement. The following section details the opportunities for improvement that were deemed to be both achievable and impactful.

Where these opportunities for improvement were deemed to be both achievable and impactful, they were included in our final recommendations, which are detailed in this section. The final recommendations aligned with four key categories:

1. Implement Process-based Management
2. Establish a Vision
3. Change Organizational Structure
4. Change Management Recruitment and Performance Evaluation

The study team felt these categories were significant, and introduce each as a concept in this section, supported by the specific recommendations that will advance them.

These final recommendations encapsulate the specific solutions the study team believes will provide the best combinations of impact and ease of implementation. Some can have a meaningful impact with minimal effort. Some will have significant impact but will require more resources to implement, while others are in between, offering moderate impact and moderate ease of implementation.

A key point which requires emphasis is that all of the following recommendations must be properly funded and assigned the necessary resources in order to be successful. Whether the SSA feels they have both the expertise and resources in-house or will need to engage external resources, all items will require proper funding and commitment from leadership.

Each recommendation is accompanied by a preliminary Implementation Plan intended to provide high-level guidance to SSA leadership by informing them of the general strategy, any prerequisite steps which must take place, and any major challenges the study team anticipates the SSA may face. Each implementation plan identifies the scope, schedule and cost estimates (not including in-house resources) based on stated assumptions. These are rough order of magnitude estimates aimed at providing relative guidance and can be influenced greatly by the implementation strategy the SSA elects to pursue for each recommendation.

The plans are defined by three distinct phases: Development, Implementation and Maintenance. Development represents the effort to design and create the system. Implementation is focused on introducing the system to employees, training and getting processes established. While development and implementation are singular tasks with a finite timeline, Maintenance represents the ongoing requirements to ensure the system in question continues to function in the desired manner.

5.1 Implement Process-based Management

The SSA can best be described as an organization that relies heavily on the experience, dedication and hard work of long-tenured employees, perhaps too heavily. It utilizes a general management approach that focuses on institutional knowledge and budget-focused direct solutions for tasks. As a result, the organization has been unable to control quality, standardize roles and responsibilities, or identify operational risks. Without implementing a process-based approach to management, SSA will continue to be unable to prevent unforeseeable factors, such as crew performance, from impacting their operations.

Process-based management is an organizational approach that views a business as a collection of processes, managed to achieve a desired result (see Section 5.2). There are three stages to process-based management:

1. Documentation of the process in order to achieve consistency and to communicate the process to all
2. Analysis of performance in order to measure the organization's progress and identify improvements in the process
3. Implementing the improvements to make the process more effective in attaining the desired output.

These stages also align with the continuous improvement cycle; Execute, Evaluate, Improve.

The majority of the solutions identified through the team's analysis (see Appendix B – RCA Solutions and Appendix C – General Observation Solutions) are addressed by one or more of the recommendations in this category. These recommendations are designed to put SSA on a path to process-based management.

5.1.1 Recommendation i. Safety Management System

It is strongly recommended that the SSA utilize the ISM Code as guidance to develop and implement an externally-audited safety management system (SMS) across the fleet.

The International Safety Management (ISM) Code is an international standard for the safe operation of ships and for pollution prevention. It provides a framework for any maritime organization to develop an effective safety management system (SMS).

The team's root cause analyses and general observations identified a general lack of documented procedures, document control and the operational consistencies that generally accompany such practices. While a fully developed and properly implemented SMS will address this issue, including a large portion of the specific solutions identified in this report, it will also contribute greatly to the mitigation of potential future fleet incidents.

5.1.1.1 Implementation Plan

The study team believes an SMS would have a very high impact, perhaps the highest of the recommendations, on SSA operations. This impact is both short-term and long-term. However, it is also one of the most difficult of the final recommendations to implement properly with a high initial investment cost and considerable challenges involved. This is not something the SSA would be in a position to take on without external guidance and considerable commitment from leadership. See Section 4.1.6 for further details.

Prerequisites	Recommendation vii. – Health, Safety, Quality and Environmental Management Recommendation iv. Mission Statement and Performance Objectives Recommendation v. Strategic Plan
Scope	Phase 1 Development: document all vessel operating procedures Phase 2 Implementation: train crews and management

	Phase 3 Maintenance: audit, continuous improvement
Schedule	Phase 1 Development: approximately one year Phase 2 Implementation: approximately six months Phase 3 Maintenance: ongoing
Cost	Phase 1 Development: $150,000 Phase 2 Implementation: $100,000 Phase 3 Maintenance: $50,000 annually[1]
Challenges	Lack of existing inhouse experience with the ISM Code. Gaining acceptance during implementation. Proper implementation.

1 - Maintenance costs are primarily for external audits on management and all vessels. This does not include the costs associated with Recommendation #HSQE.

5.1.2 Recommendation ii. Quality Management System

It is strongly recommended that the SSA develop and implement a quality management system (QMS) across the entire organization, preferably in concert with an SMS.

A quality management system (QMS) is a collection of business processes focused on consistently meeting customer requirements and enhancing their satisfaction. Similar to an SMS, it is aligned with an organization's vision. The ISO 9001 standard is a commonly utilized guide. Or, as explained in the general observations in Section 4.1.6, a QMS and SMS can be combined into one system for efficiency.

5.1.2.1 Implementation Plan[1]

Similar to the implementation of a safety management system, the SSA would benefit greatly from a QMS, particularly if developed and maintained as a combined system with the SMS. As a QMS would include more varied departments within SSA (HR, IT, Ops, Engineering) it could require a slightly greater degree of effort than an SMS, taking a little longer to develop and implement.

Prerequisites	Recommendation vii. – Health, Safety, Quality and Environmental Management Recommendation iv. Mission Statement and Performance Objectives Recommendation v. Strategic Plan
Scope	Phase 1 Development: document all product delivery processes. Phase 2 Implementation: train employees and management. Phase 3 Maintenance: audit, continuous improvement.
Schedule	Phase 1 Development: approximately one year. Phase 2 Implementation: approximately six months.

	Phase 3 Maintenance: ongoing.
Cost	Phase 1 Development: $175,000. Phase 2 Implementation: $150,000. Phase 3 Maintenance: $25,000 annually[2].
Challenges	Lack of existing inhouse experience with ISO programs. Gaining acceptance during implementation. Proper implementation.

1 – For estimating purposes, the Implementation Plan is based on the assumption QMS would be developed as a stand-alone project and not in conjunction with an SMS. It is expected that a combined development and implementation would realize some cost savings.

2 – Maintenance costs are primarily for external audits on management and all operations. This does not include the costs associated with Recommendation #HSQE.

5.1.3 Recommendation iii. Learning Management System

It is strongly recommended that the SSA source a Learning Management System (LMS) and implement it first with vessel crews. Based on successes and lessons learned it can then be expanded to other departments.

A Learning Management System (LMS) is a software-based training and learning program that provides administration, documentation, tracking, reporting and delivery all in one system. Ideally, an LMS is web-based and provides employees unlimited access to training modules anywhere they have the right hardware; desktop computer, laptop, tablet or even a smartphone, with an internet connection. Training can be conducted in groups or individually via online content such as videos, prepared documents or externally linked reading materials. Tests can be administered online with results reported immediately upon completion.

The SSA has developed a considerable amount of training material over the years but none of it is formally catalogued; it is administered by individual departments and rarely tracked or reported. Developing either an SMS or QMS will also provide a large amount of training material. By placing this valuable information in an LMS the SSA will be able to identify training and learning gaps by utilizing real-time analytical data and reporting.

5.1.3.1 Implementation Plan[1]

Sourcing the right LMS will require a considerable vetting effort. The development will also be considerable. It will include system design, content development and possibly equipment upgrades. Similar to the other process-based recommendations, the challenges of implementing an LMS are high but so is the reward.

Prerequisites	Recommendation iv. Mission Statement and Performance Objectives Recommendation v. Strategic Plan
Scope	Phase 1 Development: develop training matrix and content. Phase 2 Implementation: train managers on administration. Phase 3 Maintenance: audit, continuous improvement.

Schedule	Phase 1 Development: approximately one year. Phase 2 Implementation: approximately six months to a year (seasonal). Phase 3 Maintenance: ongoing.
Cost	Phase 1 Development: $100,000[2]. Phase 2 Implementation: $75,000. Phase 3 Maintenance: $40,000[3].
Challenges	Lack of existing inhouse experience with LMS. Potential IT / equipment barriers. Proper implementation.

1 – These estimates are assuming the LMS program would be administered by HR, in support of each department.

2 – Does not include any possible equipment upgrades.

3 – Based on an average of 500 employees annually.

5.2 Establish a Vision

Vision represents an aspirational purpose that the organization would like to achieve in the long run. The combination of a mission statement, performance objectives and a strategic plan should direct an organization on how they are going to achieve their vision. A vision is crucial to any organization utilizing process-based management as it represents the desired result.

It is leadership's responsibility to the organization to clearly identify and communicate the vision. The following recommendations are intended to aid SSA's leadership in the development of a vision for the organization and provide the necessary components to achieve it.

5.2.1 Recommendation iv. Mission Statement and Performance Objectives

It is strongly recommended that the SSA leadership adopt a mission statement and supporting performance objectives, communicate them to the employees and the general public, and identify the necessary metrics to measure progress against the performance objectives.

A key element to the development of a vision, a mission statement identifies the fundamental purpose of the organization. This is intended to be an enduring statement that remains unchanged over time. The mission statement provides a guide for decision-making and unites the employees in aiming for a common target or direction.

From time to time it is necessary to measure the progress the organization is making toward that target. By setting performance objectives, similar to milestones along the way, and measuring performance against those objectives the organization as a whole is able to measure their progress and determine whether adjustments need to be made.

5.2.1.1 Implementation Plan

Arguably one of the easiest recommendations of the group to implement, a mission statement and performance objectives will have positive impacts almost immediately and, more importantly, will provide valuable guidance to several of the other recommendations in this section. This is a process which the SSA's leadership can engage almost immediately and complete in a short period of time with the only expense being for some guidance if deemed necessary and advertisement.

Prerequisites	None.
Scope	Phase 1 Development: develop a Mission Statement, Performance Objectives and Metrics. Phase 2 Implementation: Communicate to employees and public, implement metrics and track. Phase 3 Maintenance: Annual reviews against performance objectives.
Schedule	Phase 1 Development: approximately two months. Phase 2 Implementation: approximately two months. Phase 3 Maintenance: ongoing.
Cost	Phase 1 Development: \$10,000. Phase 2 Implementation: \$15,000. Phase 3 Maintenance: \$0.
Challenges	None anticipated.

5.2.2 Recommendation v. Strategic Plan

It is strongly recommended that the SSA immediately begin a strategic planning process to include all aspects of the organization.

A strategic plan answers how the organization is going to navigate what is ahead in order to attain the mission (long term) and performance objectives (short term). Strategic planning provides a framework for making long-term decisions, aligns goals across an organization, and helps to ensure the long-term availability of the resources critical to organizational success. Each of these have been problem areas for SSA.

Strategic planning is not currently a part of the SSA culture. If we use Covey's Urgent Important Matrix (Reference 12) to illustrate (Figure 11), Covey identifies four quadrants within which organizations or individuals operate based on two qualifying factors, Urgency and Importance:

1. Crises – URGENT and IMPORTANT
2. Goals and Planning – NON-URGENT and IMPORTANT
3. Interruptions – URGENT and NOT IMPORTANT
4. Distractions – NON-URGENT and NOT IMPORTANT

Ideally, organizations want to spend the majority of their time in quadrant 2 setting goals and planning their path to attaining them while maintaining and enhancing their capability to operate more effectively in quadrant 1 when emergencies arise. Currently, the SSA operates primarily in quadrant 1, rarely spending any time in quadrant 2 identifying goals and planning.

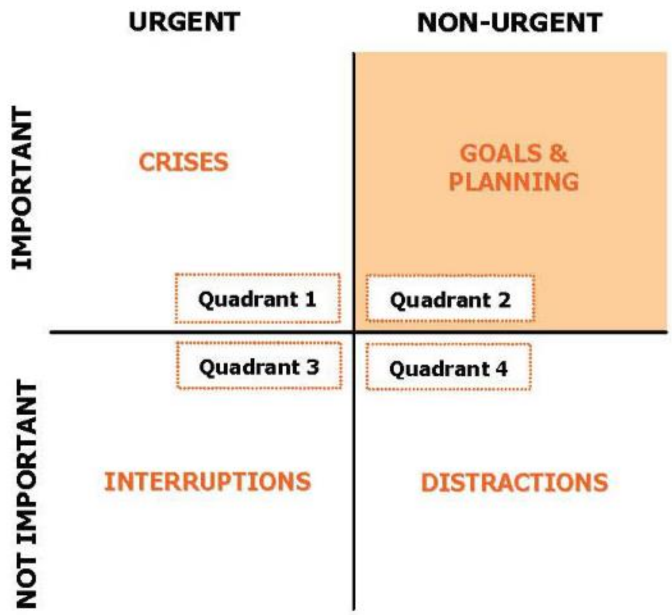


Figure 11 The Covey Urgent Important Matrix

Strategic planning is crucial to any organization that can quickly find itself buried in constant firefighting mode (quadrant 1) and never able to make any forward progress. It begins with developing a strategic plan for the organization, to include all departments and functions, but quickly infiltrates the culture and encourages all departments and then individuals to focus more on setting goals and planning to meet them.

In reality, planning is never static. Circumstances change, and the plan must be adjusted and updated. The maintenance of a strategic plan is ongoing, year after year.

The Association for Strategic Planning (ASP), a U.S.-based, non-profit professional association provides excellent guidance and resources. See Section 4.1.2 Strategic Planning for further details.

5.2.2.1 Implementation Plan

Moving from reactive to strategic management styles can be challenging, but becomes easier as it becomes an integral part of the corporate culture. It is recommended that the SSA seek external guidance in the initial strategic planning effort in order to learn the process, maintain momentum and keep the workload for inhouse resources manageable. Even with external resources, the strategic planning process requires constant involvement from the organization's leadership.

Prerequisites	Recommendation iv. Mission Statement and Performance Objectives
Scope	Phase 1 Development: develop a 10-year+ strategic plan. Phase 2 Implementation: ensure all departments are aware of plan elements that relate to or affect them and actively enact them. Phase 3 Maintenance: perform annual reviews and make adjustments.
Schedule	Phase 1 Development: approximately six months. Phase 2 Implementation: approximately two to four months.

	Phase 3 Maintenance: ongoing.
Cost	Phase 1 Development: $100,000. Phase 2 Implementation: $25,000. Phase 3 Maintenance: $0.
Challenges	Experience and resources to develop a strategic plan. Proper implementation.

5.3 Change Organizational Structure

The SSA is currently structured in a fairly flat, functional (segregated into departments by function) organizational structure. While a functional structure is standard and effective for a maritime operation, some functions of departments and associated reporting lines are not clearly defined. It is surmised that the relatively flat nature of the organizational structure is a product of financial consideration over time. A flat structure is typically more efficient in many ways, in contrast with a more hierarchical structure, but it places additional strain on the senior executive(s) and, unless properly staffed, can result in losses which outweigh the financial efficiencies realized.

Combined with alignment issues, the study team also identified a lack of key resources. This was particularly the case in Engineering and Maintenance.

5.3.1 Recommendation vi. Engineering Resources

It is strongly recommended that the SSA consider adding key positions in the engineering department and realign some conflicting responsibilities. See Figure 12, where positions highlighted in red indicate added positions.

With a fleet of ten highly diverse vessels, geographically separated between Woods Hole, Hyannis and Fairhaven, operating on a very demanding schedule, it is not realistic to expect a single Port Engineer and single Assistant Port Engineer to provide all of the oversight and support functions that are needed. It is recommended that the SSA hire an additional Port Engineer and Assistant Port Engineer, dividing the fleet between the two teams.

In addition to providing round-the-clock support to the vessels while they are in operation, planning and coordinating routine maintenance and repairs, and supervising vessel engineering personnel (see additional recommendations on this job function below), the Port Engineer is also responsible for the planning and management of major repairs and vessel overhauls. While this is an extensive workload for the resources allocated, operations support and overhaul planning and management are in constant conflict. For this reason, it is recommended that the position of Project Engineer be added to take on all responsibilities regarding the planning and management of major repairs, vessel overhauls and capital projects. While Port Engineers will provide valuable support and advice to the Project Engineer, their focus will remain on daily fleet operations. Likewise, the Project Engineer will not be involved in operations and therefore not be distracted from the demands of planning and managing projects. The Project Engineer should have a strong background in formal project management. One of their first tasks should be to develop a project management program and associated training for all project teams to follow.

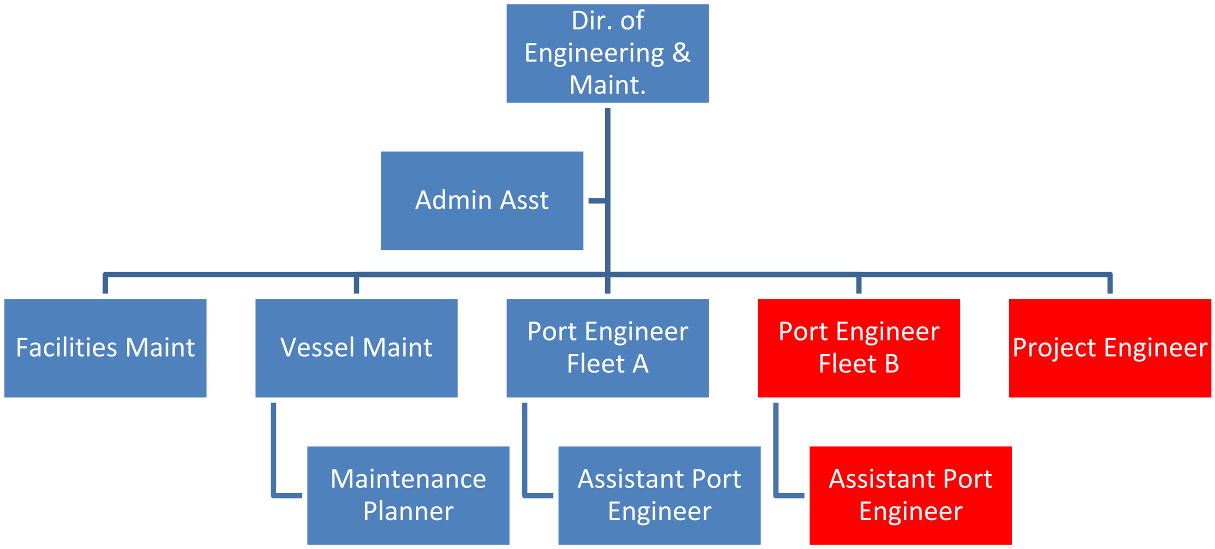


Figure 12 Proposed engineering and maintenance management structure

See Section 4.2.2 for further details.

5.3.1.1 Implementation Plan

While the study team has to acknowledge the considerable investment which this recommendation represents, it feels it is highly warranted. The expectations of the engineering department are daunting, and the resources provided are far below what could reasonably be expected to perform them and succeed. The Engineering department demonstrated a genuine desire and initiative to become more process-based but, of all departments, finds themselves perpetually in quadrant 1 (crises) when, as far as individual departments go, they benefit the most from planning.

The greatest implementation challenge will be developing a reorganization plan which effectively reallocates roles and responsibilities and provides enough guidance as everyone learns their place and new ways of doing things.

Prerequisites	Recommendation ix. Recruit Externally
Scope	Phase 1 Development: develop reorganization plan, job descriptions. Phase 2 Implementation: advertise positions, recruit and hire. Phase 3 Maintenance: monitor progress, make adjustments.
Schedule	Phase 1 Development: approximately one month. Phase 2 Implementation: approximately two to four months. Phase 3 Maintenance: ongoing monitoring and adjustments.
Cost	Phase 1 Development: $0. Phase 2 Implementation: $20,000. Phase 3 Maintenance: $452,200 annually[1].
Challenges	Identification of qualified candidates who have experience and will embrace process-based management approach.

1 – assuming a 33% burden rate

5.3.2 Recommendation vii. Health, Safety, Quality and Environmental Management

It strongly recommended that the SSA recruit and hire a Director of Health, Safety, Quality and Environmental Protection to oversee the development of process-based continuous improvement programs (SMS and QMS) as detailed in this report, manage their ongoing implementation and fulfill the duties of the Designated Person.

The development, implementation and maintenance of the aforementioned process-based management systems will not be possible without a key manager with relevant experience being added to the organization. This position must have the authority to enforce the management systems and be outside the direct operational chain of command in order to avoid being conflicted with competing business interests.

See Appendix D to identify this position (highlighted in green) within a recommended organizational chart for the SSA.

See Section 4.1.6 for further details.

5.3.2.1 Implementation Plan

Two of the most impactful recommendations (SMS and QMS) contained within this section will require the addition of an HSQE position in order to achieve success. The implementation of this recommendation will prove more challenging than would be expected for most position creations. As a highly specialized area requiring experience with the development and management of effective systems, particular familiarity with the ISM Code and ISO in general, and the ability to effect change upon an organization, the pool of qualified candidates is small.

Prerequisites	None
Scope	Phase 1 Development: develop job description.

	Phase 2 Implementation: advertise position, recruit and hire. Phase 3 Maintenance: monitor progress, make adjustments.
Schedule	Phase 1 Development: approximately one month. Phase 2 Implementation: approximately two to six months. Phase 3 Maintenance: ongoing.
Cost	Phase 1 Development: $0. Phase 2 Implementation: $10,000. Phase 3 Maintenance: $169,000 annually[1].
Challenges	Identification of qualified candidates with experience in a highly-specialized field.

1 – assuming a 33% burden rate

5.3.3 Recommendation viii. Vessel Operations

It is strongly recommended that the SSA consider a realignment of the chain of command and roles and responsibilities among operations and engineering personnel, add a Chief Operating Officer (COO) and a Director of Marine Operations, and delete the Assistant Port Captain position. See Figure 14 with proposed positions highlighted in red.

Two conditions were observed at the SSA which directly lead to this recommendation.

First, there are communication issues, conflicts of interest and a general confusion of authority between the Vessel Operations and Engineering departments. This condition is created primarily by the fact that Chief Engineers on the vessels report directly to the Port Engineers and not to the vessel Master (Captain). The Engineering Department is currently considered a line function at the SSA with levels of authority not typically seen in maritime operations (see Figure 13). This frequently creates a conflict with the Vessel Operations department, typically the primary line function. Having personnel report to more than one chain of command creates short-circuits in communication and authority.

Realigning the two departments where Vessel Operations remains the only line function and designating the Engineering department as a staff function to provide support to others, will firmly establish the vessel chain of command.

Second, there is a lack of maritime operating experience at the executive/director level and the organization’s prime function’s (vessel operations) interests and priorities are not properly represented in the decision-making process. Currently, the SSA is organized as indicated in Figure 13 (the competing chains of command are highlighted in orange). This organization places considerable burden on the Operations Manager while simultaneously marginalizing vessel operations’ decision-making participation.

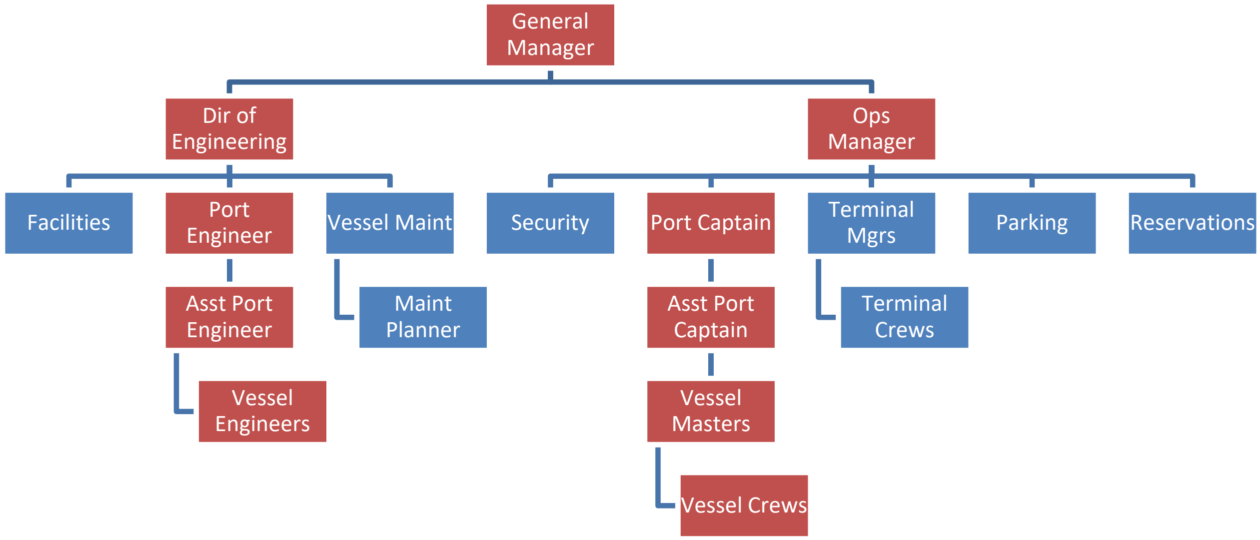


Figure 13 Current Vessel Operations and Engineering, competing chains of command

Adding a Chief Operating Officer and a Director of Marine Operations will be necessary to both realign departments and ensure that the primary function of the SSA is properly and cohesively represented in decision-making. This proposed reorganization (see Figure 14) will also support and aid the change to process-based management while alleviating some of the burden on the General Manager by the current flat structure.

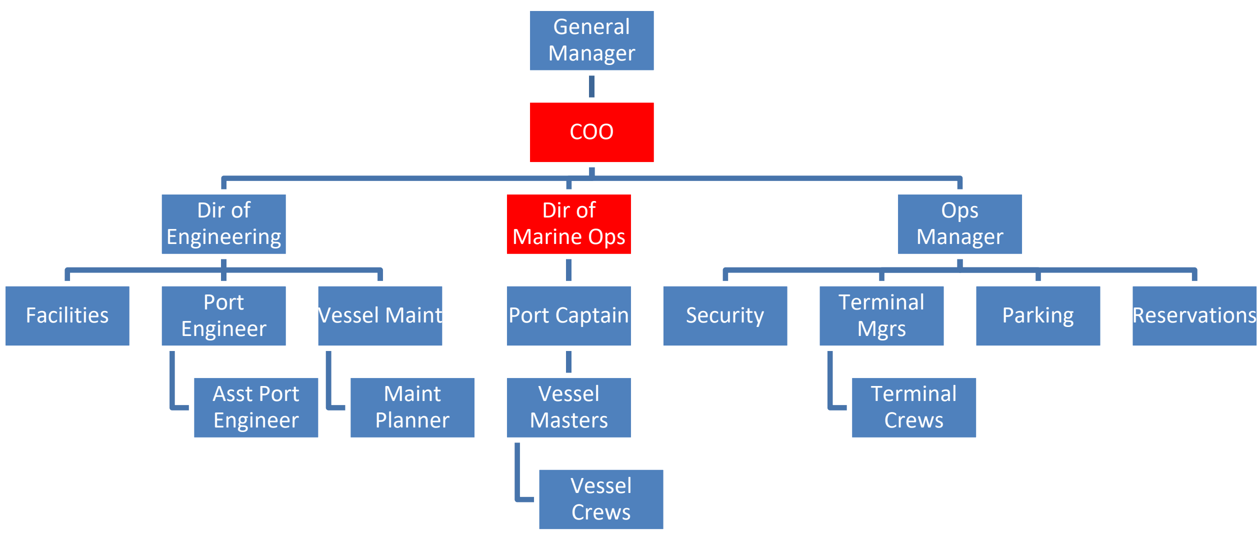


Figure 14 Proposed reorganization

Incorporating all of the organizational recommendations contained in this section, the SSA would retain a functional organization that is less flat. See Appendix D for the current and final proposed management structures.

5.3.3.1 Implementation Plan

Implementation of these changes will undoubtedly be a challenge. Between realigning roles, responsibilities and lines of communication and identifying the best qualified candidates for the roles proposed, it will require a carefully thought out plan of action and crystal-clear definition. But the benefits, in the opinion of the study team, are worth the effort and cost.

Prerequisites	None
Scope	Phase 1 Development: develop realignment plan, job descriptions. Phase 2 Implementation: advertise positions, recruit and hire. Phase 3 Maintenance: monitor progress, make adjustments.
Schedule	Phase 1 Development: approximately two months. Phase 2 Implementation: approximately two to six months. Phase 3 Maintenance: ongoing.
Cost	Phase 1 Development: $10,000. Phase 2 Implementation: $20,000. Phase 3 Maintenance: $228,760 annually[1].
Challenges	Identification of qualified candidates with experience in process-based management. Adjustment to shifting roles and responsibility, lines of communication.

1 – assuming a 33% burden rate

5.4 Change Management Recruitment and Performance Evaluation

The SSA emphasizes promoting from within and with several significant retirements and departures of senior staff in just the past few years, the effects of this policy are becoming evident.

Promoting from within is an admirable objective for any organization, but difficult to achieve success if not under the right circumstances. There are obvious advantages; motivation for the work force to easily visualize a career path, retained institutional knowledge, and maintaining cultural integrity are among them. But, while it promotes succession, its highly ineffective if the organization is not practicing succession planning. Unless certain requirements are met, the advantages are quickly outweighed by the disadvantages.

If the organization does not utilize process-based management and succession planning, roles are not well-defined, and the candidate is forced to learn on the job or create their own process. The organization is also at risk of becoming isolated in their thinking and ways of doing things without external influence. Much of this is currently apparent at the SSA.

For those new employees who do join the organization from the outside, they appear to run into barriers and resistance to change. They, or their ideas, are not readily accepted to be a part of the core group.

Of equal importance, SSA leadership and management must be held accountable for the performance of the organization. SSA does not currently have an adequate system for measuring the performance of its managers, which has resulted in a lack of accountability for their performance and the performance of their departments.

5.4.1 Recommendation ix. External Recruitment

It is strongly recommended that the SSA carefully weigh the advantages and disadvantages to promoting from within and increase efforts to recruit from outside the organization.

If process-based management is embraced, then the policy of promoting from within gains value. But as the organization shifts to process-based strategies, external hires with experience in similar systems will aid the transition. Regardless, the many advantages to recruiting externally, particularly from the maritime and passenger vessel industry, should not be discounted or overlooked.

5.4.1.1 Implementation Plan

In competition with Recommendation iv. Mission Statement and Performance Objectives, this recommendation may be the easiest to implement. Requiring no additional funding, a short timeline and very little in the way of policy change, the only potential barrier is internal resistance.

Prerequisites	None.
Scope	Phase 1 Development: develop policy change. Phase 2 Implementation: actively recruit using industry resources. Phase 3 Maintenance: continue and refine process.
Schedule	Phase 1 Development: approximately one week. Phase 2 Implementation: approximately one week. Phase 3 Maintenance: ongoing.
Cost	Phase 1 Development: \$0. Phase 2 Implementation: \$0. Phase 3 Maintenance: \$0.
Challenges	Internal resistance.

5.4.2 Recommendation x. Management Performance Metrics / Accountability

It is strongly recommended that the SSA develop performance metrics for key managers (based on the performance objectives developed under Recommendation iv. Mission Statement and Performance Objectives) and hold them accountable for progress achieved against them.

It is critical for any high-performance organization to be able to accurately and efficiently measure its own performance, so that bad practices can be identified and remediated, and good practices can be reinforced. The individuals responsible for leading and managing the organization must be evaluated based on the same performance metrics, to ensure their goals are aligned with the organization's.

This is critical for two reasons. First, without adequate measurement and accountability, employees might have other priorities that cause them to make decisions that are not in the best interest of the organization. SSA is particularly susceptible to this problem. Its hero culture rewards the appearance of heroics over strong, steady performance (see Section Y.Y.Y.). Its reliance on institutional knowledge disincentivizes knowledge sharing. Its culture of loyalty protects underperformers and holds high performers back from advancement. Instituting an objective system of performance measurement and accountability combats all of these problems, while promoting a system of continuous improvement.

Secondly, an effective system of accountability allows for efficient information discovery between critical constituents of the organization. If a manager is held accountable for a performance metric, they will be incentivized to find ways to encourage their direct reports to help their department meet those metrics. If they find that they cannot meet the metrics with the resources they are provided, then they will be incentivized to communicate those resource needs to other organizational stakeholders who can provide them. This system of knowledge transfer is especially critical to large and highly dynamic organizations like SSA.

5.4.2.1 Performance Metrics Tied to the Strategic Plan

Performance metrics should be guided by a strategic plan (developing a Strategic Plan is another of our Final Recommendations; see Section 5.2.2.). Although the basic goals of an organization may be understood (e.g. safely transport passengers between the islands and the mainland), compromises between competing objectives will always be required (e.g. cost versus level of service). As is detailed in Section 4.3.8, these compromises can only be effectively navigated if there is a plan in place to guide management through them. Without a strategic plan, two departments may have competing objectives and work against each other, rather than working towards the same goal. One of the key functions of SSA leaders and managers is to make these hard decisions. A board-approved strategic plan should be used as a guide.

The Board should be held accountable for the strategic plan, and management should be held accountable for meeting the goals of the strategic plan. To invoke this accountability, managers should be evaluated on objective performance metrics and goals that are directly tied to the objectives of the strategic plan.

5.4.2.2 SMART Goals

Goals are only useful if their completion is likely to correspond to organizational success. SSA management annual review goals were observed to be ineffective in this regard, due to a lack of clarity and measurability.

The study team recommends that SSA changes how it writes its goals to dramatically improve their effectiveness. A recommended framework for designing performance metrics that are practical and effective is the SMART goals framework. The SMART acronym is the product of the following criteria:

- **S**pecific – Goals should be unambiguous and target specific areas. There should be no room for ambiguity about whether or not a goal has been achieved.
- **M**easurable – You cannot manage what you cannot measure, so goals must be measurable.
- **A**chievable – Stretch goals are good, but goals must be realistic and within the resource constraints of the organization, otherwise they are will be righteously ignored.
- **R**elevant – Goals must be aligned with the overall goals of the organization. Otherwise, they are counter-productive.
- **T**ime-bound – Without a discreet time frame for when the goal must be achieved, the goal could be delayed into perpetuity, rendering it meaningless.

Accountability must start at the top. The annual performance evaluation of the general manager for the period ending in July 2018 was examined (Reference 3), and found to illustrate the lack of measurable performance metrics against which top SSA managers are evaluated. Utilizing the SMART goals framework, it is clear that even at the very top of the organization, the objectives on which management are evaluated do little to ensure accountability.

For example, here is Goal Number 5 from the performance evaluation:

Overseeing the timely completion of the mid-life refurbishment of the M/V Martha's Vineyard and her redeployment into regular line service.

The following observations are made:

- **S**pecific – The definitions of "overseeing" and "completion" are both highly ambiguous. What does overseeing mean? Does completion mean that the vessel has departed the shipyard? Or that every item on its mid-life refurbishment specification was accomplished to a high degree of quality?
- **M**easurable – Because of the ambiguity of this goal, it is difficult or impossible to objectively measure.
- **A**chievable – No direct issue; however, this goal was too easily achievable due to its lack of specificity, measurability, and time-boundedness.
- **R**elevant – Because of its ambiguity, the success of the goal also does not necessarily translate to success for the organization. If the vessel is redeployed into service on time but is rife with quality issues, the goal could be considered accomplished despite the poor outcome.
- **T**ime-bound – The word "timely" is ambiguous.

In hindsight, although one could argue that Goal Number 5 was met, the mid-life refurbishment of M/V *Martha's Vineyard* was a failure in many ways. The project was over-budget and behind schedule. The vessel was rushed back into service, with extensive incomplete work, including issues that led to equipment failures and unplanned downtime.

SMART goals help to prevent this ambiguity. A re-written Goal Number 5, utilizing the SMART framework, might look something like this:

Goal as written:	*Overseeing the timely completion of the mid-life refurbishment of the M/V Martha's Vineyard and her redeployment into regular line service.*
Revised goal:	*Complete the mid-life refurbishment of M/V Martha's Vineyard within the constraints of a pre-specified project plan, including within budget, within SSA's quality standards, and without disruption to planned service.*

The criteria are improved in the following regards:

- **S**pecific – Rather than being responsible for "overseeing" the project, the General Manager should be directly responsible for the actual completion of this project, due to its importance. The GM may also assign this responsibility to direct reports who are more directly involved with the project, but because the GM is responsible for hiring and managing those managers, the GM should also be held directly accountable.
  Specific budget, quality, and time requirements are added to remove ambiguity from whether the goal has been achieved.

- **<u>M</u>**easurable – The amount over or under budget can be measured. Assuming SSA has effective quality standards, these can be measured. Disruption to planned line service is a clear, binary measurement (there either is or is not disruption to planned service).
- **<u>A</u>**chievable – The goal is achievable.
- **<u>R</u>**elevant – Accomplishing this goal will result in a positive outcome for the organization.
- **<u>T</u>**ime-bound – This goal allows for the timeline to be set in advance, while holding the manager accountable for meeting the timeline that they set.

5.4.2.3 Implementation Plan

Prerequisites	Recommendation v. Strategic Plan
Scope	Phase 1 Development: Performance metric workshop to develop management performance metrics that are directly tied to SSA's Strategic Plan. Can be add-on to Strategic Plan development process. Utilize the SMART framework (or similar) for all future management performance goals. Phase 2 Implementation: Incorporate into annual reviews. Phase 3 Maintenance: During the annual review process, metrics should be reviewed to make sure they are incentivizing the right behavior (rewarding positive outcomes and penalizing underperformance). The responsibility of writing annual goals for each manager should be shared by that manager and their superior (they should both sign off on the goals the manager will be measured against for the following year).
Schedule	Phase 1 Development: Approximately 1-2 days for workshop. Performance metrics require Strategic Plan, although SMART goals can be developed immediately. Phase 2 Implementation: Performance metrics and SMART goals can be implemented immediately, at each annual review, although training the framework to managers will require 1-2 hours per manager. Phase 3 Maintenance: ongoing.
Cost	Phase 1 Development: $0 (or outsource to consultant for ~$20k). Phase 2 Implementation: $0 (or outsource to consultant for ~$20k). Phase 3 Maintenance: $0.
Challenges	Internal resistance to accountability.

5.5 Final Summary of Recommendations

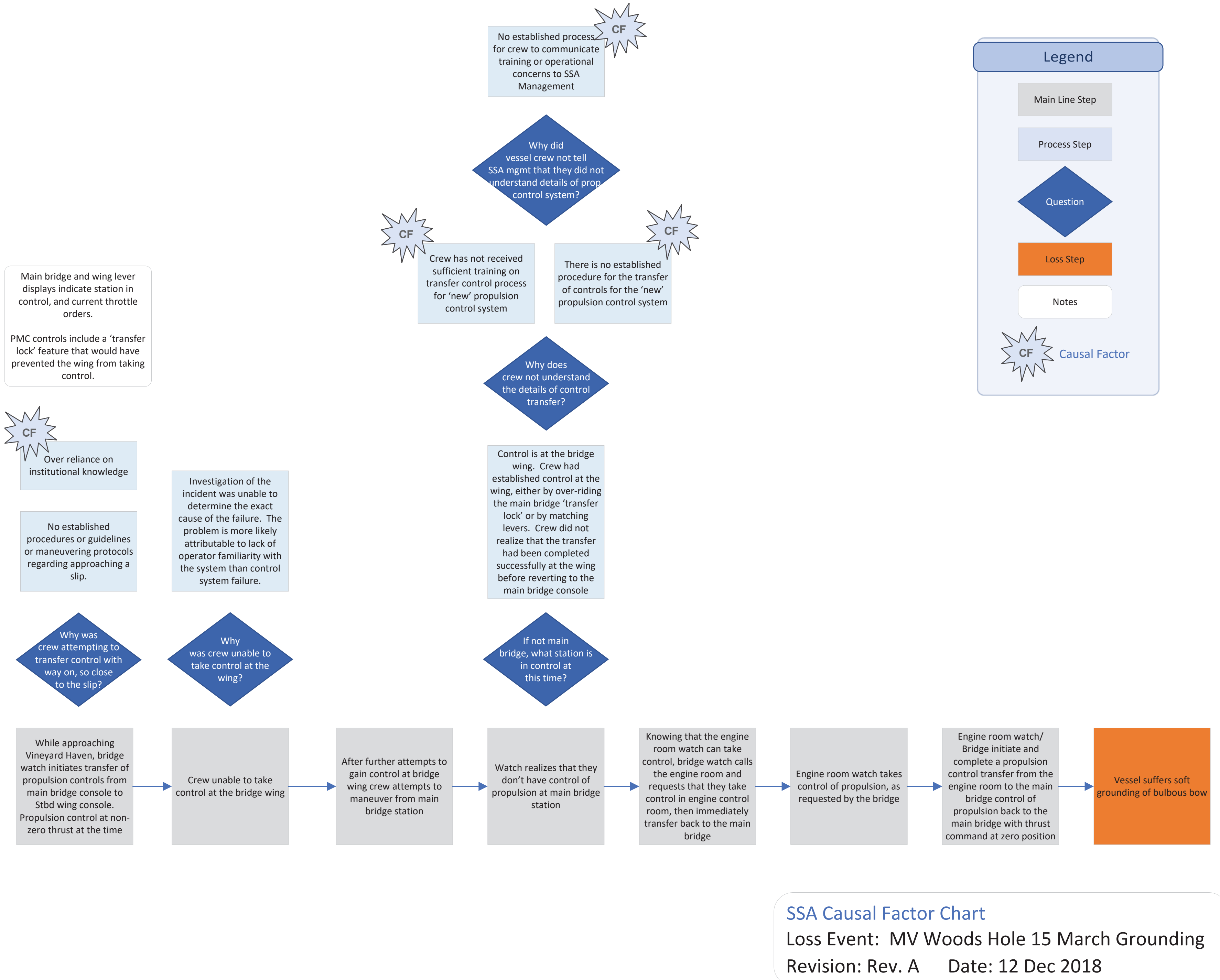
The study team does not consider the casualties of 2018 that led to this investigation an anomaly but, rather, the beginning of a trend that is bound to repeat itself if systemic changes are not made. The operating and regulatory environments along with customer expectations and demand have changed dramatically in the past twenty years and the SSA has not adapted to these changes.

In summary, this report presents ten recommendations requiring considerable effort and commitment. Given the estimates provided, development and implementation of all ten recommendations would require an initial investment of approximately $1m, not taking into account the cost of internal efforts. The cost to maintain these improvements are an additional $1m every year, in addition to the current operating budget. However, this investment is inexpensive insurance against the type of incidents that plagued the SSA during 2018 and will result in a net cost reduction in the long-term.

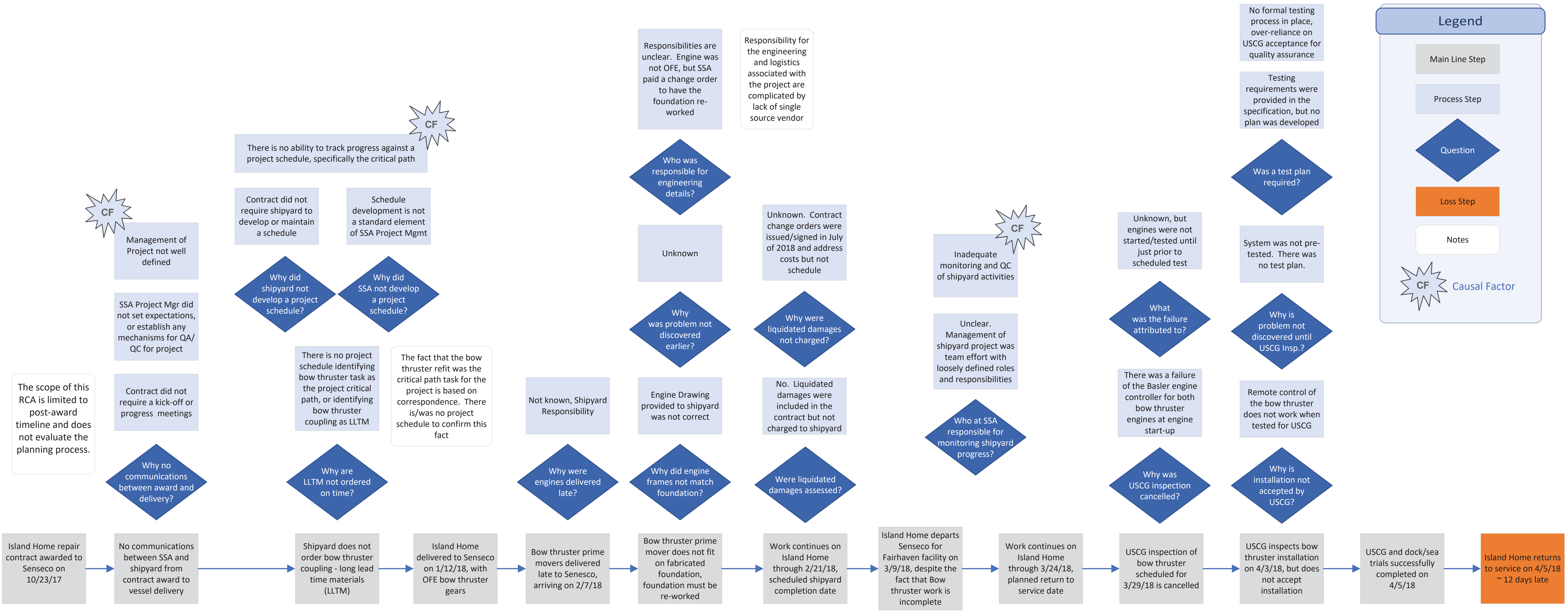
The environment which the SSA operates in has changed drastically over the past twenty years, but the SSA has not adapted to that changing environment. Based on the culmination of this comprehensive review, the study team does not view what occurred in 2018 as an anomaly, but rather the new norm, which will repeat itself in various manifestations if changes are not made. Progress under these circumstances will require strong leadership, significant change and adept management of that change.

Appendix A Causal Factor Charts and Root Cause Map

MV Woods Hole: 15 March Grounding - Causal Factor Chart



MV Island Home Delayed Return to Service: Causal Factor Chart

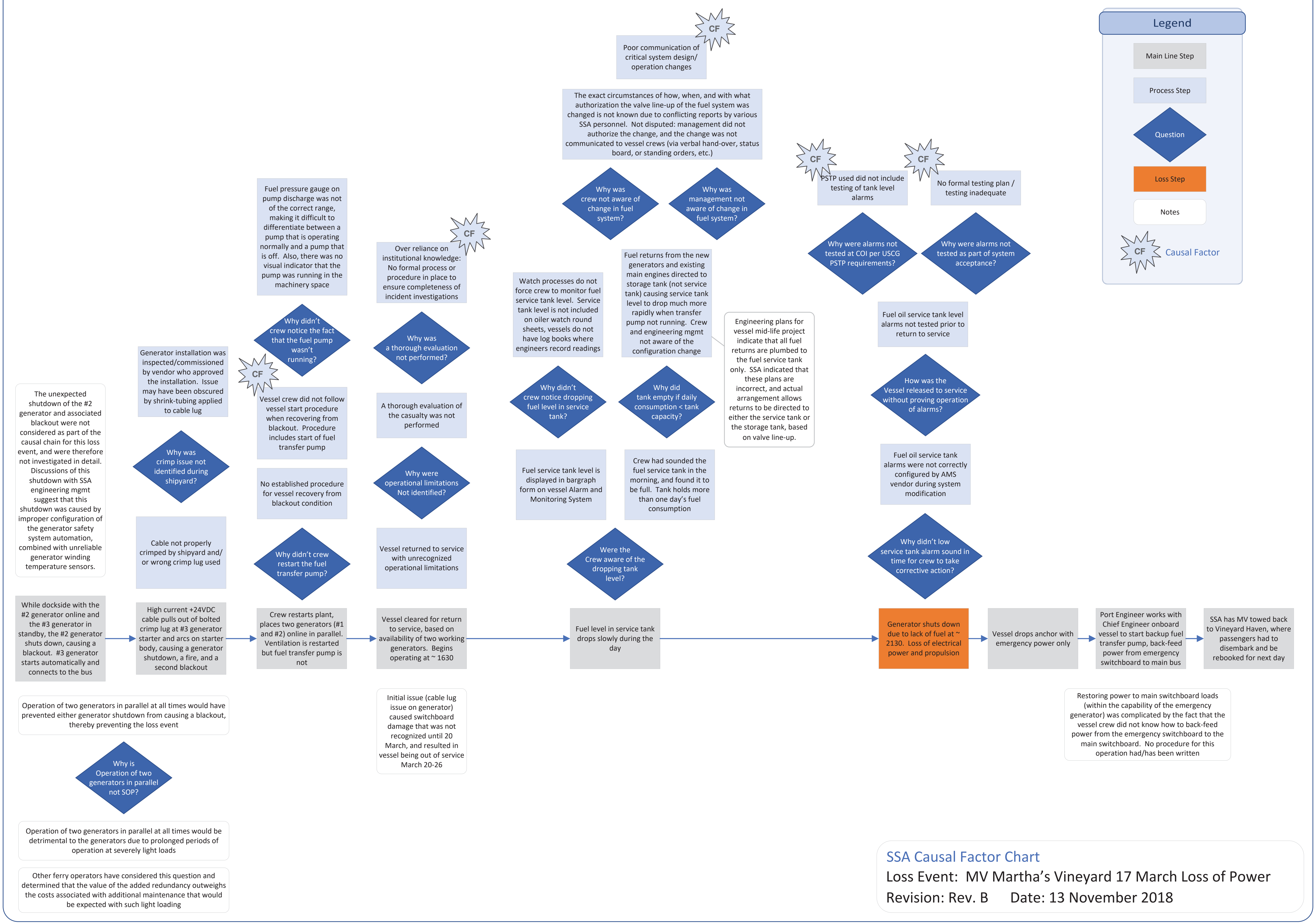


SSA Causal Factor Chart - DRAFT

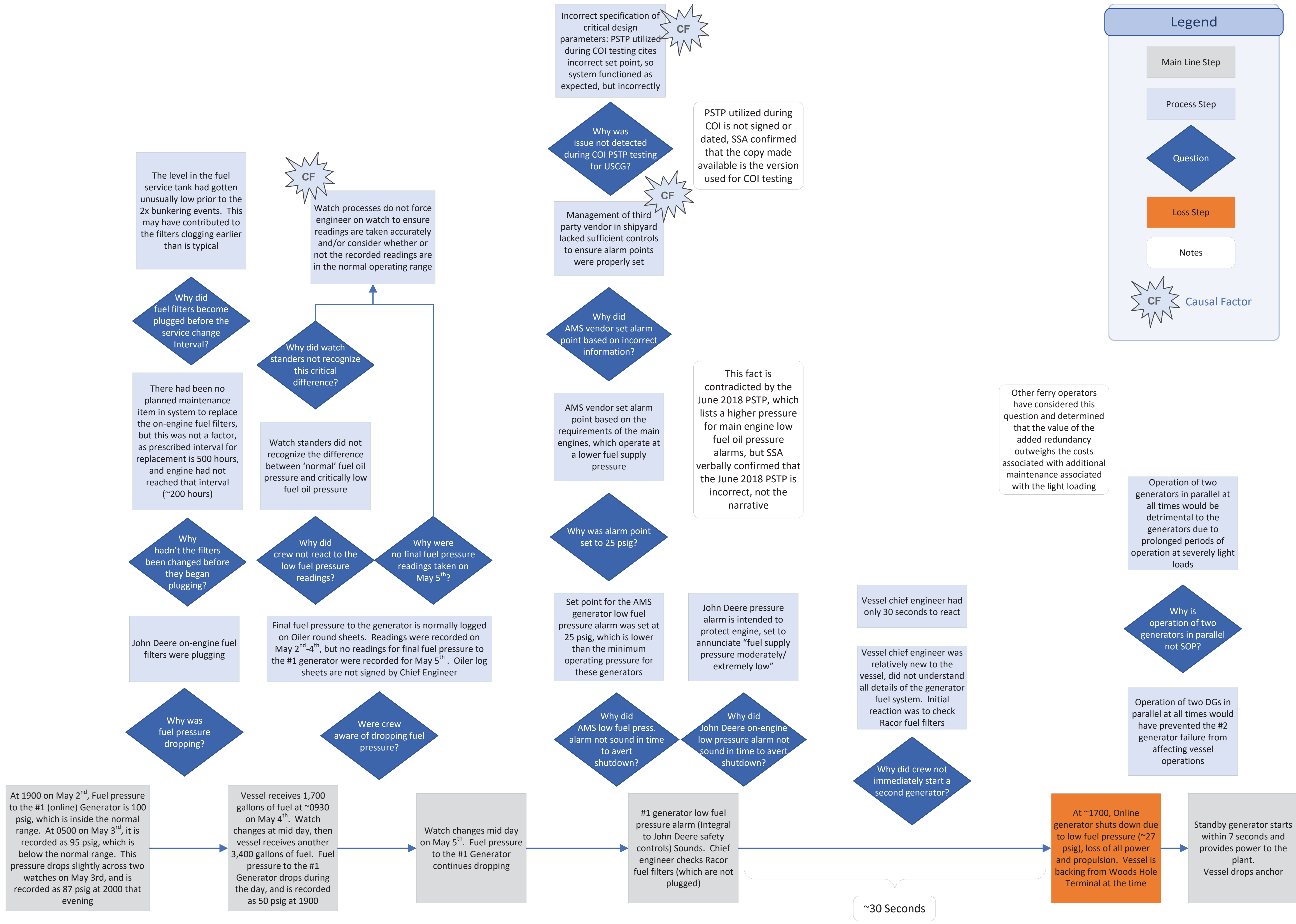
Loss Event: MV Island Home Delayed Return to Service

Revision: Rev. - Date: 29 November 2018

MV Martha's Vineyard 17 March Loss of Power: Causal Factor Chart



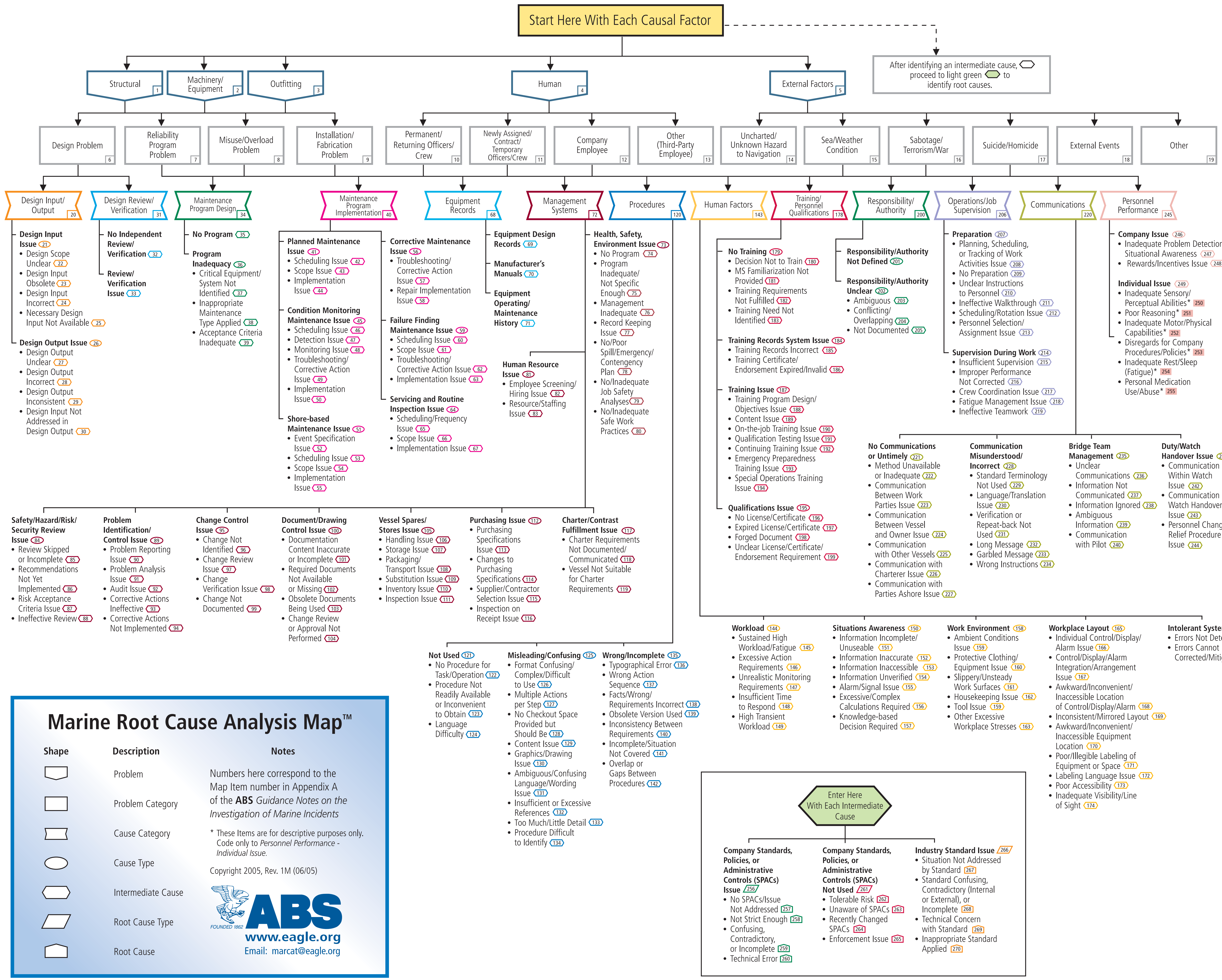
MV Martha’s Vineyard 5 May Loss of Power: Causal Factor Chart



SSA Causal Factor Chart

Loss Event: MV Martha’s Vineyard 5 May Loss of Power

Revision: Rev. B Date: 13 November 2018



Start Here With Each Causal Factor
After identifying an intermediate cause, proceed to light green to identify root causes.
Structural 1
Machinery/ Equipment 2
Outfitting 3
Human 4
External Factors 5
Design Problem 6
Reliability Program Problem 7
Misuse/Overload Problem 8
Installation/ Fabrication Problem 9
Permanent/ Returning Officers/ Crew 10
Newly Assigned/ Contract/ Temporary Officers/Crew 11
Company Employee 12
Other (Third-Party Employee) 13
Uncharted/ Unknown Hazard to Navigation 14
Sea/Weather Condition 15
Sabotage/ Terrorism/War 16
Suicide/Homicide 17
External Events 18
Other 19
Design Input/ Output 20
Design Review/ Verification 31
Maintenance Program Design 34
Maintenance Program Implementation 40
Equipment Records 68
Management Systems 72
Procedures 120
Human Factors 143
Training/ Personnel Qualifications 178
Responsibility/ Authority 200
Operations/Job Supervision 206
Communications 220
Personnel Performance 245
Design Input Issue 21
• Design Scope Unclear 22
• Design Input Obsolete 23
• Design Input Incorrect 24
• Necessary Design Input Not Available 25
Design Output Issue 26
• Design Output Unclear 27
• Design Output Incorrect 28
• Design Output Inconsistent 29
• Design Input Not Addressed in Design Output 30
No Independent Review/ Verification 32
Review/ Verification Issue 33
No Program 35
Program Inadequacy 36
• Critical Equipment/ System Not Identified 37
• Inappropriate Maintenance Type Applied 38
• Acceptance Criteria Inadequate 39
Planned Maintenance Issue 41
• Scheduling Issue 42
• Scope Issue 43
• Implementation Issue 44
Condition Monitoring Maintenance Issue 45
• Scheduling Issue 46
• Detection Issue 47
• Monitoring Issue 48
• Troubleshooting/ Corrective Action Issue 49
• Implementation Issue 50
Shore-based Maintenance Issue 51
• Event Specification Issue 52
• Scheduling Issue 53
• Scope Issue 54
• Implementation Issue 55
Corrective Maintenance Issue 56
• Troubleshooting/ Corrective Action Issue 57
• Repair Implementation Issue 58
Failure Finding Maintenance Issue 59
• Scheduling Issue 60
• Scope Issue 61
• Troubleshooting/ Corrective Action Issue 62
• Implementation Issue 63
Servicing and Routine Inspection Issue 64
• Scheduling/Frequency Issue 65
• Scope Issue 66
• Implementation Issue 67
Equipment Design Records 69
Manufacturer's Manuals 70
Equipment Operating/ Maintenance History 71
Human Resource Issue 81
• Employee Screening/ Hiring Issue 82
• Resource/Staffing Issue 83
Health, Safety, Environment Issue 73
• No Program 74
• Program Inadequate/ Not Specific Enough 75
• Management Inadequate 76
• Record Keeping Issue 77
• No/Poor Spill/Emergency/ Contengency Plan 78
• No/Inadequate Job Safety Analyses 79
• No/Inadequate Safe Work Practices 80
Safety/Hazard/Risk/ Security Review Issue 84
• Review Skipped or Incomplete 85
• Recommendations Not Yet Implemented 86
• Risk Acceptance Criteria Issue 87
• Ineffective Review 88
Problem Identification/ Control Issue 89
• Problem Reporting Issue 90
• Problem Analysis Issue 91
• Audit Issue 92
• Corrective Actions Ineffective 93
• Corrective Actions Not Implemented 94
Change Control Issue 95
• Change Not Identified 96
• Change Review Issue 97
• Change Verification Issue 98
• Change Not Documented 99
Document/Drawing Control Issue 100
• Documentation Content Inaccurate or Incomplete 101
• Required Documents Not Available or Missing 102
• Obsolete Documents Being Used 103
• Change Review or Approval Not Performed 104
Vessel Spares/ Stores Issue 105
• Handling Issue 106
• Storage Issue 107
• Packaging/ Transport Issue 108
• Substitution Issue 109
• Inventory Issue 110
• Inspection Issue 111
Purchasing Issue 112
• Purchasing Specifications Issue 113
• Changes to Purchasing Specifications 114
• Supplier/Contractor Selection Issue 115
• Inspection on Receipt Issue 116
Charter/Contrast Fulfillment Issue 117
• Charter Requirements Not Documented/ Communicated 118
• Vessel Not Suitable for Charter Requirements 119
Not Used 121
• No Procedure for Task/Operation 122
• Procedure Not Readily Available or Inconvenient to Obtain 123
• Language Difficulty 124
Misleading/Confusing 125
• Format Confusing/ Complex/Difficult to Use 126
• Multiple Actions per Step 127
• No Checkout Space Provided but Should Be 128
• Content Issue 129
• Graphics/Drawing Issue 130
• Ambiguous/Confusing Language/Wording Issue 131
• Insufficient or Excessive References 132
• Too Much/Little Detail 133
• Procedure Difficult to Identify 134
Wrong/Incomplete 135
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Notes
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Problem Category
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Numbers here correspond to the Map Item number in Appendix A of the ABS Guidance Notes on the Investigation of Marine Incidents
* These Items are for descriptive purposes only. Code only to Personnel Performance - Individual Issue.
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Appendix B Root Cause Analysis Solutions

RCAs	Intermediate Solutions	Recommendation
i. Woods Hole Grounding		
Causal Factor #1:	Over-reliance on institutional knowledge	
a.	Perform a risk assessment for approaching and departing each terminal that identifies potential risks and provides a means to mitigate each identified risk.	**SMS**
b.	Provide tools such as decision trees, job risk assessments and flow charts to aid decision making. Use unusual events as a learning and training tool. Train personnel to use the information they are provided.	**SMS**
c.	Analyze the training needs for deck officers and establish training criteria and curriculum based on those needs.	**SMS, LMS**
Causal Factor #2:	Insufficient training on new equipment	
a.	Identify the hazards of the process and tasks associated with approaching a dock or pier under normal operations, non-routine operations and emergency operations.	**SMS**
Causal Factor #3:	No established procedure	
a.	Develop a procedure for transfer control**.** Ensure all modes of operation and maintenance procedures are addressed.	**SMS**
Causal Factor #4:	No process to communicate a potential problem	
a.	Establish a simple means by which vessel personnel can provide suggestions and feedback to shore management. Develop event reporting guidelines and train vessel crews on the types of events that should be reported.	**SMS**
ii. Island Home Delays		
Causal Factor #1:	Management of project not fully defined	
a.	Develop a Project Plan for the proper and full definition of any major repair project. Ensure that all parties participate in a kick-off meeting to review the plan and confirm its definition.	**QMS**
b.	In developing a project plan, clearly define all responsibilities and authority. Communicate to all parties in order to confirm and address any conflicts.	**QMS**
Causal Factor #2:	Inability to accurately track progress against a project schedule, specifically the critical path	
a.	Develop a policy to require that all projects over certain thresholds have a project schedule which identifies the critical path, the schedule is monitored and updated regularly.	**QMS**
Causal Factor #3:	Ongoing monitoring (Quality Control) of shipyard's activities was inadequate	
a.	Develop a policy or procedure identifying required levels of project monitoring, based on specific thresholds.	**QMS**
b.	Develop a policy identifying necessary qualifications required of project team and provide adequate training where identified.	**QMS**
iii. March 17th Blackout		
Causal Factor #1:	The fuel pump was not restarted when restarting the vessel plant.	
a.	The vessel should have a checklist for normal operation after startup.	**SMS**
b.	The crew should be trained to run through a checklist to ensure normal operation of the vessel after any start or restart of the vessel's plant.	**SMS, LMS**
Causal Factor #2:	A formal evaluation of the casualty was not performed.	
a.	A standard operation procedure for conducting thorough incident investigations should be developed, to ensure all systems are operating normally, identify remedial actions, and immediately begin data collection that may be helpful in identifying any persistent, hidden issues.	**SMS, HSQE**
Causal Factor #3:	Changes to the vessel configuration were not adequately conveyed to management and circulated with crew.	
a.	Modify watch processes and communication tools to ensure that all plant configuration changes are documented in a way that is useful to vessel crews. For example, include 'fuel returns to storage tank' on a wipe board, along with information like '#1 pumps online/#2 pumps standby'.	**SMS**
b.	Management must have active control of how the vessel plants are operated. Develop policies that explain what plant configuration changes are allowed at the discretion of the crew, what configuration changes are not allowed, and how all such changes are communicated and documented.	**SMS, QMS**
Causal Factor #4:	The Periodic Safety Test Procedure did not include tests it should have.	
a.	The PSTP should be revised to include all tests required per USCG rules. If SSA does not possess sufficient engineering capability to ensure completeness and accuracy of the test document, external engineering resources should be used.	**SMS**
Causal Factor #5:	There was inadequate testing of the vessel prior to returning the vessel to service.	

RCAs		Intermediate Solutions	Recommendation
	a.	SSA personnel or contractors acting as the owner's representative during shipyard or repair periods must be sufficiently involved with all vessel modifications to critical systems and equipment to monitor the quality of the work. Formalized test and inspection plans should be utilized to ensure all inspections and tests are thorough, and to provide a record of all inspections/tests.	**QMS**

iv. May 5th Blackout

Causal Factor #1:		Watch processes do not force engineer on watch to ensure readings are within normal operating ranges.	
	a.	Change watch stander logging requirements to highlight critical plant parameters, and define their normal ranges, such that process deviations critical to operations are more readily identified.	**SMS**
Causal Factor #2:		Management of third party vendor in shipyard lacked sufficient controls to ensure alarm points were properly set.	
	a.	SSA personnel acting as an owner's representative during shipyard or repair periods must be sufficiently involved with all vessel modifications to critical systems and equipment to monitor quality of work. When critical systems are modified, such as the installation of new generators, technical details like alarm setpoints should be reviewed and documented in technical specifications or commissioning check lists. SSA should require shipyards performing work on their vessels to submit detailed specifications to SSA for all work (including work done by subcontractors and equipment vendors), which SSA should review in detail.	**SMS, QMS**
		SSA should also require shipyards to submit detailed test procedures for proving functionality of all new or modified equipment, to be reviewed in detail and approved by SSA, and then carried out with an SSA representative witnessing the tests.	**QMS**
Causal Factor #3:		Incorrect specification of critical design parameters, which resulted in an ineffective Periodic Safety Test Procedure (PSTP).	
	a.	SSA engineering management should ensure the accuracy of critical documents like vessel periodic safety test procedures by establishing quality processes specific to those documents. Quality processes should designate 'owners' responsible for such critical documents and provide for independent technical review when these documents are created or modified. Where SSA does not possess sufficient technical resources to perform this review, external contractors shall be utilized.	**QMS**

v. Website Slowdown

Causal Factor #1:		Adequate load testing was not performed.	
	a.	Perform adequate load testing on the system prior to the next major event.	**QMS**
	b.	Determine an adequate frequency of load testing, identify major events and determine an adequate scope of testing.	**QMS**
Causal Factor #2:		Secondary and mirrored cloud-based website not utilized.	
	a.	The system design should be reviewed in order to determine the feasibility of attaining redundancy in the system.	**QMS**

vi. Trip Alert Emails Blocked

Causal Factor #1:		System not adequately designed.	
	a.	The system design should be reviewed in order to determine a more reliable email distribution server and domain.	**QMS**
Causal Factor #2:		Outside vendor not utilized to analyze internal email list.	
	a.	Develop a procedure for establishing the testing requirements of the Trip Alert email system.	**QMS**

vii. Connectivity Issues Due to Storm

Causal Factor #1:		System design allowed for a single-point-of-failure.	
	a.	The system design should be reviewed in order to determine a more reliable internet source in event of natural disasters or other interruptions of service.	**QMS**

RCAs	Root Cause Solutions	Recommendation
i. Woods Hole Grounding		
Causal Factor #1:	Over-reliance on institutional knowledge	
RC Solution	Solicit comments and recommendations from operations and maintenance personnel regarding the proper function and operation of the transfer control system and resolve each comment. Utilize all available information and knowledge to establish vessel specific instructions regarding how to properly transfer control. Incorporate these instructions into a vessel specific training and familiarization program that addresses recency.	**SMS**
	Provide adequate staffing with the necessary knowledge and experience.	**SMS**
	Improve the level of detail in all training material. Provide vessel specific familiarization procedures that includes physical demonstration if competencies.	**LMS**
Causal Factor #2:	Insufficient training on new equipment	
RC Solution	Compile a list of vessel specific procedures and compare them to the existing list. Define and document any missing procedures and communicate them to fleet.	**SMS**
Causal Factor #3:	No established procedure	
RC Solution	Establish a system of document control that clearly indexes the current library of procedures. OEM manuals do not replace vessel specific procedures.	**SMS, HSQE**
Causal Factor #4:	No process to communicate a potential problem	
RC Solution	Develop an enhanced reporting process to ensure risk recognition, share recognized hazards and gather data.	**SMS, HSQE**
ii. Island Home Delays		
Causal Factor #1:	Management of project not fully defined	
RC Solution	Develop a Project Plan template to be used for all projects meeting or exceeding certain thresholds, such as capital value or complexity. Establish a policy requiring a project plan and basic levels of documentation and communications commensurate with the specific project.	**QMS, ENGINEERING RESOURCES**
	Clearly define the roles and responsibilities of every team member involved in an overhaul project. Identify authority levels and decision-making protocols. Communicate these with all parties involved, including contractors and subcontractors.	**QMS, ENGINEERING RESOURCES**
Causal Factor #2:	Inability to accurately track progress against a project schedule, specifically the critical path	
RC Solution	Develop a policy requiring a project schedule with specific requirements (i.e. critical path identified) be developed for all projects exceeding certain thresholds. Ensure that the project schedule is updated on a predetermined frequency, changes or delays are communicated to the project team and adjustments are made when necessary.	**QMS, ENGINEERING RESOURCES**
Causal Factor #3:	Ongoing monitoring (Quality Control) of shipyard's activities was inadequate	
RC Solution	Develop a policy and supporting procedures which identify project monitoring requirements. Ensure that proper resources and personnel are provided to accomplish the necessary level of monitoring.	**QMS, ENGINEERING RESOURCES**
	SSA should develop a policy and supporting training to ensure all project team personnel are trained in project management disciplines and meet the proper qualifications for individual responsibilities as assigned. Designated project managers should receive formal project management training.	**LMS**
iii. March 17th Blackout		
Causal Factor #1:	The fuel pump was not restarted when restarting the vessel plant.	
RC Solution	Develop a comprehensive set of vessel policies/checklists to provide crew with direction on how to perform routine operations and respond to all likely casualty scenarios associated with each vessel.	**SMS**
	Make these policies/checklists available to all vessel crew in a place where they can access them while on watch.	**SMS**
	Train the vessel crew to utilize the procedures. Educate experienced crew, who may not feel the need to utilize such prescriptive procedures, on the impact that procedures, used as checklists, can have on error avoidance.	**LMS**
Causal Factor #2:	A formal evaluation of the casualty was not performed.	
RC Solution	Develop a formal and documented process that is automatically invoked when any vessel experiences a deviation from normal operations that impacted, or could have impacted, vessel critical systems. The process output should examine and document the following:	**SMS, HSQE**
	Investigation of the cause of the incident (or near miss) and recommendations for follow-up actions or policy/procedural changes to prevent reoccurrences (i.e. inspect other similar equipment in the fleet).	**SMS, HSQE**

RCAs	Root Cause Solutions	Recommendation
	Investigation of the effects of the incident, to ensure all possible consequences have been identified and corrected (i.e. identify damage which occurred as a result of the incident, which may not be evident during recovery from the incident).	SMS
	Recognizing the limitations of situational awareness in the aftermath of an incident, develop checklists to ensure vessel is restored to full normal operating condition before authorization to return to service is issued (e.g. restart fuel transfer pump).	SMS
Causal Factor #3:	Changes to the vessel configuration were not adequately conveyed to management and circulated with crew.	
RC Solution	SSA should implement engineering management processes that: For all aspects of vessel plant configuration that may change during the vessel's service, provide a means of communicating current configuration to all watch-standers (such as a wipe board or magnetic status board). Train crews to always 'hand-over' configuration changes at watch turn over.	SMS, LMS
	SSA should implement engineering management processes that: Develop a set of standard operating procedures for each vessel that prescribes how vessel equipment is operated, deferring to manufacturer's guidelines and other references where appropriate. This document would include details such as system line-up, equipment rotation conventions, etc. Make these standard operating procedures available to all vessel crew in a place where they can access them while on watch. Train vessel crews on the details of the SOPs and the fact that deviations from the policies require explicit permission from engineering management. Ensure, as part of the training, that the SOPs are understood. Check back with vessel crews to ensure they are operating the vessels in accordance with the SOPs.	SMS, LMS
Causal Factor #4:	The Periodic Safety Test Procedure did not include tests it should have.	
RC Solution	SSA should implement engineering management processes that: Identifies critical record plans and documents like PSTPs Forces individuals within the organization to consider how these documents may be impacted by system modifications during maintenance, repair, upgrade activities, and ensure that impacted documents are updated to reflect changes Requires review of updated documents by individuals other than those responsible for the update efforts, who have the technical ability to confirm accuracy and completeness of the changes. Where SSA lacks the expertise and/or bandwidth required to maintain this process, external resources should be applied.	SMS, QMS
Causal Factor #5:	There was inadequate testing of the vessel prior to returning the vessel to service.	
RC Solution	For all vital equipment/systems that are installed or modified during a shipyard or repair period, SSA should develop a detailed inspection and test plan. This test plan should be completed in conjunction with vendor and/or shipyard sign-off of the task and regulatory testing of the equipment/systems. Inspection and test plans may be developed by the shipyard or vendors, but such plans should be reviewed and approved by SSA prior to any inspections or testing. Where SSA lacks the technical expertise to develop or approve inspection/test plans, external contractors should be utilized.	SMS

iv. May 5th Blackout

RCAs	Root Cause Solutions	Recommendation
Causal Factor #1:	Watch processes do not force engineer on watch to ensure readings are within normal operating ranges.	
RC Solution	Develop and implement policies and procedures related to engine room watch standers that collectively: Make the chief engineer on watch responsible for the safe operation of the vessel during their watch and prescribe the tasks that they must perform during their watch. Make the watch oiler responsible to the watch chief engineer for reporting any deviations from 'normal operations' observed in the plant, prescribe the tasks that they must perform during their watch. Designate an engineering manager as being responsible for the performance of engine department watch standers and empower that individual to control the training and assignment of individuals to watches. Implements vessel-specific logging processes that identify the critical parameters that watch standers must monitor and defines the normal and abnormal ranges of each.	SMS

RCAs	Root Cause Solutions	Recommendation
Causal Factor #2:	Management of third party vendor in shipyard lacked sufficient controls to ensure alarm points were properly set.	
RC Solution	For all vital equipment / systems that are installed or modified during a shipyard or repair period, SSA should develop a detailed inspection / test plan. These test plans should be completed in conjunction with vendor/shipyard sign-off of the task and regulatory testing of the equipment/systems. Inspection/Test plans may be developed by the shipyard or vendors, but such plans should be reviewed prior to any inspections/testing. Where SSA lacks the technical expertise to develop or approve inspection/test plans, external contractors should be utilized.	**QMS**
Causal Factor #3:	Incorrect specification of critical design parameters, which resulted in an ineffective Periodic Safety Test Procedure (PSTP).	
RC Solution	Implement specific engineering quality processes that identify and manage policies, procedures, and documents associated with quality backstops like the annual automation tests associated with the USCG-required Periodic Safety Test Procedures. These quality backstops are more critical to the safe operation of vessels than most other repair activities associated with annual shipyard and repair periods and require extra diligence and independent review to ensure accuracy. Additional resources and/or external contractor assistance should be employed to support the additional effort associated.	**SMS**

v. Website Slowdown

Causal Factor #1:	Adequate load testing was not performed.	
RC Solution	Develop a procedure to ensure that adequate load testing is performed on the reservation system. Confirm a schedule and severity of tests.	**QMS**
Causal Factor #2:	Secondary and mirrored cloud-based website not utilized.	
RC Solution	The design process should be administered to ensure mission critical systems meet established standards, such as redundancy. Quality control should be introduced to ensure established standards are met.	**QMS**

vi. Trip Alert Emails Blocked

Causal Factor #1:	System not adequately designed.	
RC Solution	The design process should be administered to ensure mission critical systems meet established standards, such as reliability. Quality control should be introduced to ensure established standards are met.	**QMS**
Causal Factor #2:	Outside vendor not utilized to analyze internal email list.	
RC Solution	Develop a procedure to ensure that adequate testing is performed on the Trip Alert email system.	**QMS**

vii. Connectivity Issues Due to Storm

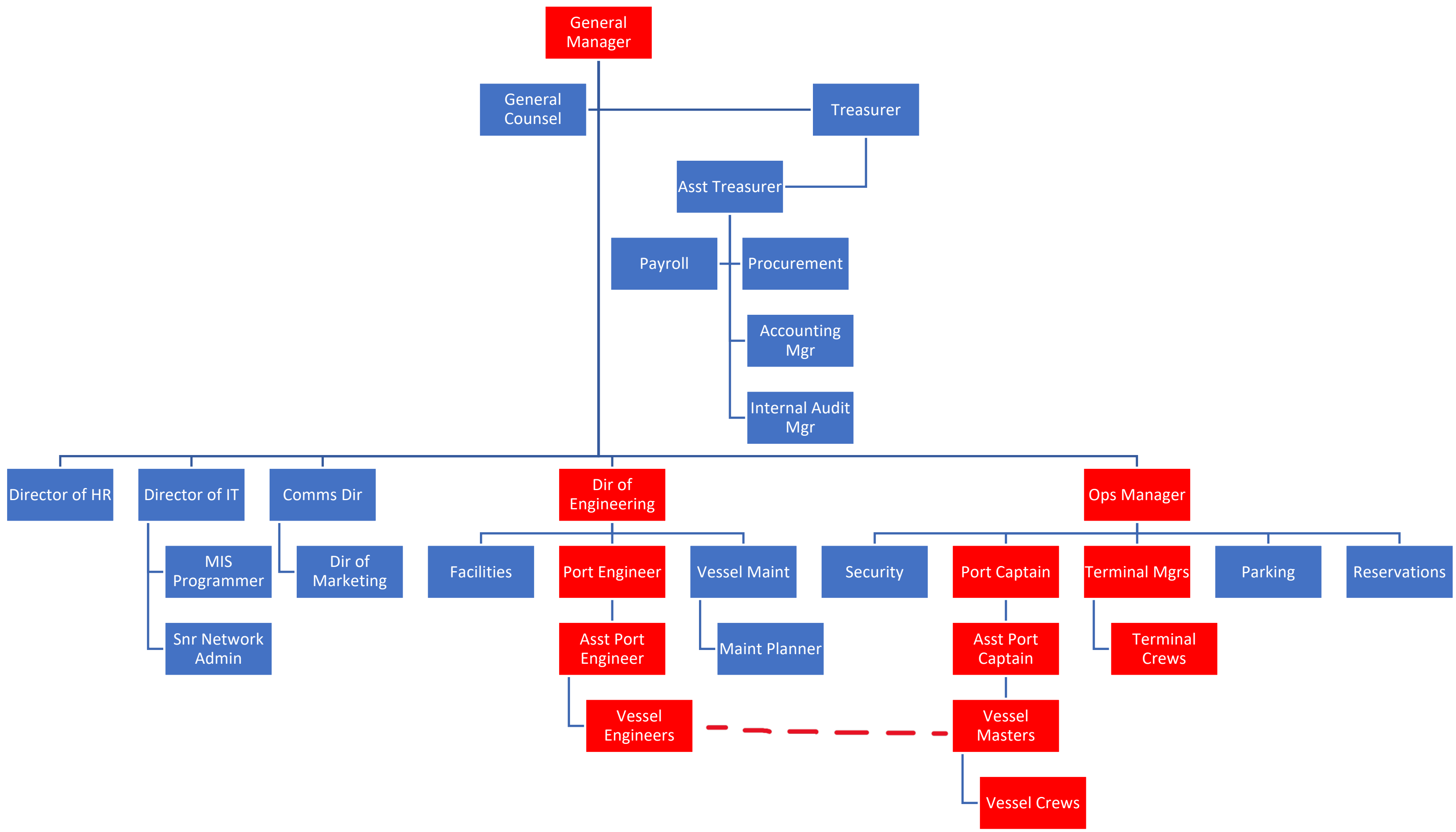
Causal Factor #1:	System design allowed for a single-point-of-failure.	
RC Solution	The design process should be administered to ensure mission critical systems meet established standards, such as redundancy. Quality control should be introduced to ensure established standards are met.	**QMS**

Appendix C General Observation Solutions

GENERAL OBSERVATIONS	SPECIFIC SOLUTIONS	Recommendation
Management Structure		
i. Mission Statement	Develop and communicate a Mission Statement	MISSION STATEMENT
	Develop performance objectives	MISSION STATEMENT
ii. Strategic Planning	Develop a strategic plan	STRATEGIC PLAN
	Implement management performance metrics	STRATEGIC PLAN, ACCOUNTABILITY
iii. Ops Structure	Reinforce the chain of command on board the vessels	
	Designate the engineering department as a staff function	VESSEL OPS
	Increase maritime operations experience at the director or executive level	
iv. Staffing	Conduct a management structure audit	QMS
	Invest in management systems	SMS, QMS, LMS
v. Allocation of HR	Perform a management structure audit	QMS
vi. HSQE	Develop and implement an ISM-Code compliant Safety Management System	SMS, HSQE
vii Hero Culture	Change to a process-based culture	SMS, QMS, LMS
viii. Institutional Knowledge	Document work processes	SMS, QMS, LMS
	Engage in succession planning	ENGINEERING RESOURCES, VESSEL OPS, RECRUITING, QMS
ix. Tenure	Recruit from outside to gain industry perspective	RECRUITING
	Tie management performance to organizational performance	ACCOUNTABILITY
Fleet Maintenance		
i. Policies and Procedures	Develop a set of company policies and procedures in a management system framework	SMS
ii. Engineering Resources	Increase number of Port Engineers	ENGINEERING RESOURCES
	Add a Project Engineer to oversee planning and project management of overhauls	
	Segregate engineering operations support and fleet preservation functions	
iii. EAMS	Commit to proper implementation of new EAM/CMMS	SMS, ENGINEERING RESOURCES
iv. Project Planning	Develop project planning and management processes	QMS, ENGINEERING RESOURCES
v. Risk Assessment	Risk assessment protocols	SMS
	Implement a Safety Management System	SMS, HSQE
	Designate a Risk Manager	SMS, HSQE
Vessel Operations		
i. Crew Training	Develop a comprehensive training program	LMS
ii. ER Watch Processes	Develop new engine room watch processes	SMS
iii. Triple Watch	Develop a Fatigue Risk Management Plan	SMS
iv. SOPs	Establish SOPs within a management system framework	SMS
	Adopt a risk assessment process	SMS
v. Emergency Response	Develop an Emergency Response Plan	SMS
vi. Sailing Schedules	Develop a contingency plan for trip cancellations	QMS
vii. Weather cancelations	Improve crew recency training	SMS, LMS
	Evaluate the practice of replacing Able Bodied Seamen with Ordinary Seamen	SMS, LMS
	Improve vessel reliabilty by implementing a quality management system	QMS
viii. Operational Metrics	Establish operational KPMs for the fleet	QMS, MISSION
ix. Terminal Flow	Perform a passenger flow analysis	QMS
	Install signs, monitors, digital signage	QMS
	Advisory radio broadcast system	QMS
	Numbered lanes	QMS, SMS
IT Systems		
i. Project Planning	Establish top 5 priorities for 2019	STRATEGIC PLAN
	Draft an IT-specific strategic plan	STRATEGIC PLAN
	Establish an IT help desk to track and prioritize IT issues	QMS
ii. Reservation System	Perform a cost/benefit analysis on reservation system options	STRATEGIC PLAN
iii. Website Platform Mgmt	Establish a website content manager	QMS
	Establish regular communication with vendor iMarc	QMS
	Develop an SEO strategy	STRATEGIC PLAN, QMS

Appendix D Organizational Charts

CURRENT SSA FUNCTIONAL MANAGEMENT STRUCTURE



PROPOSED SSA MANAGEMENT STRUCTURE

Summary of Changes:

1. Added HSQE function independent of chain of command
2. Removed Engineering from direct chain of command, shifted from line function to staff
3. Added Port Engineer and Assistant Port Engineer (Fleet B)
4. Added Project Engineer
5. Added Chief Operating Officer
6. Added Director of Marine Ops
7. Shifted Port Captain and Vessels under Director of Marine Ops
8. Removed Assistant Port Captain