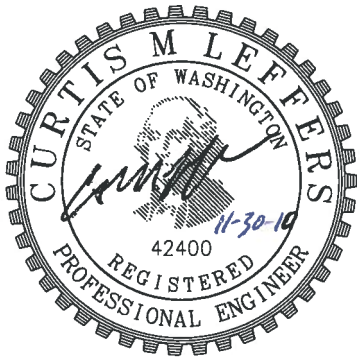

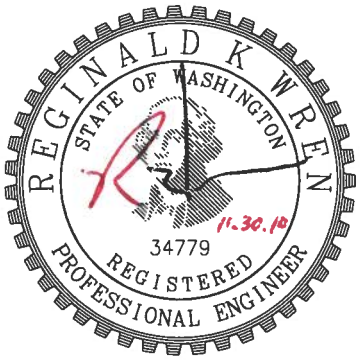

VESSEL MAINTENANCE, PRESERVATION, AND IMPROVEMENT PLAN

Prepared for: WSDOT Ferries Division • Seattle, WA

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Elliott Bay Design Group
Architectural & Engineering Services for the Marine Industry

PREPARED BY

Elliott Bay Design Group
5305 Shilshole Ave. NW, Ste. 100
Seattle, WA 98107

W. Greg Johnson NA&ME
Alion Science and Technology

REVISIONS

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EXECUTIVE SUMMARY

Elliott Bay Design Group (EBDG) and Alion Science and Technology (Alion), (herein referred to as "we"), were tasked by Washington State Ferries (WSF) to develop a Vessel Maintenance, Preservation, and Improvement Plan (VMPIP) for presentation to the transportation committees of the Legislature. The two primary goals of the VMPIP are:

- To develop recommendations to assist WSF in reducing Vessel Out-of-Service Time (VOST)
- To develop recommendations that could enhance the efficiency of WSF's Vessel Maintenance, Preservation, and Improvement (VMP&I) activities.

In order to meet WSF's goal of vessels having a 60-year service life, a well planned maintenance, preservation and improvement program is an absolute necessity. Informed, dedicated and consistent maintenance will extend the life of major systems and increase the intervals between preservation activities. From our observations and analysis, we conclude that WSF does a good and reasonably efficient job in managing the maintenance and preservation plans given the funding and personnel to execute the plan.

The development of the VMPIP was broken up into several different sections that are described below. Conclusions and recommendations relevant to each section are bulletized in their respective sections.

Background Document Summary Review

We performed a review of 11 existing reference documents associated with WSF's VMP&I activities and many of their current practices. The specific documents that we reviewed are listed in the References section at the end of this report. This section chronicles the prior recommendations from each of the reference documents that are relevant to the two fundamental VMPIP goals, and our assessment of the recommendations. We also incorporated applicable information and data from these reference documents into the VMPIP. There were a large number of recommendations from the references, which were applicable to VOST or VMP&I efficiency and are too extensive to list in the Executive Summary, but we summarized each one with our comments in the Background Document Summary Review section.

In accomplishing the review, it is clear that many previous recommendations targeted toward accomplishing the same WSF goals have already been expressed, and are still very relevant to this ongoing process.

Recommendation:

- Many of the recommendations made in the background references impact VOST or the efficiency of the VMP&I program. In our review and analysis, we concurred with many of the recommendations, and for those recommendations, we recommend that WSF develop the organizational will where required, and establish processes and/or procedures to follow-up with each one.

Personnel Interviews

In gathering information to develop the VMPIP, it was also necessary to interview key members of WSF's organization as well as individuals and organizations outside WSF, such as private shipyards (SYs) in the Puget Sound area, other public and private ferry operators. The information gathered during the interviews was valuable and we used it extensively throughout this project.

Best Practices Summary

We investigated industry best practices for VMP&I activities and evaluated those that we felt could most effectively be applied to WSF. The best practices recommendations were developed based on EBDG's and Alion's experience, practices that are common to and are proven to work effectively for other successful fleet operators, and information gathered during the personnel interviews. We identified best practices coming from Staten Island Ferry, Steam Ship Authority, Black Ball Transportation, and Foss Maritime/Foss Shipyard. We also listed the industry best practices already employed by WSF.

Recommendations:

- Find a way to incentivize both the Masters and Chief Engineers to actually minimize both VOST and missed sailings.
- Continue to adopt designs incorporating vessel system simplicity and redundancy of machinery and systems, with a focus on reduced maintenance, reliability, and safety.
- Continue to make improvements in WSF's and Eagle Harbor (EH)'s Information Technology (IT) systems. All systems currently in use (Maintenance Productivity Enhancement Tool (MPET), Preventive Maintenance (PM) at a Glance, Life Cycle Cost Model (LCCM), Statewide Inventory, Statewide Accounting System, and more) need to talk to each other.

Planning Processes Schematics

In order to understand the WSF's current VMP&I planning practices, we researched and documented organizational schematics for each of the two key planning processes:

- The EH Maintenance Lay-Up Process
- Commercial SY Availability Process

The intent of the schematics is to show the most important steps in each process. The schematics gave us an appreciation of the complexity of the information and flow of these key processes.

Schedule of Vessel Maintenance, Preservation, and Improvement Activities

This section developed a representative 16-year schedule of vessel maintenance, preservation, and improvement activities. The schedule was developed for the next eight biennia, beginning

with the upcoming 2011 – 2013 biennium. The schedule also includes a financial plan to estimate the Present Value (PV) costs associated with each VMP&I activity.

Conclusions:

- The results of the schedule and financial plan show that it will cost approximately $2.47 billion to maintain, preserve, and improve the current WSF fleet for the next eight biennia. Maintenance costs account for approximately $440 million, preservation costs account for approximately $1.01 billion, and improvement costs (including new vessels) account for $1.02 billion. The results of this analysis provide a relatively conservative estimate since it is based largely on the LCCM cost estimates and includes contingencies.

- It is important to note that accurately predicting preservation and improvement costs beyond the current and upcoming biennium is difficult. Although using the LCCM cost estimates is a good basis for budgeting, the exact work scopes for preservation items cannot be known in detail far ahead in the future. We want to stress the importance of continually updating the LCCM interval and cost estimates with updated information as preservation items are accomplished in order to continually improve forecasting ability.

Recommendations:

- WSF should continue to evolve and expand their inspection processes to allow for a better understanding of material condition on the vessels. For example, hull inspection coupled with the steel preservation program allows more detailed information to be obtained on the condition of each vessel's hull steel. This enhanced knowledge will allow for more detailed scoping of the work, which will in turn allow for more precise budgeting.

- We also recommended that as a first step, portions of the maintenance budget be developed and allocated by vessel class. This would put the WSF maintenance budgeting process more in line with common industry practice and would allow for more detailed budgeting. If WSF begins to budget and allocate maintenance funds by vessel class, WSF will need the authority to move funds easily from one class to another in order to deal with unplanned maintenance requirements.

Vessel Maintenance and Preservation Activities Analysis

The legislature required WSF to consider 13 elements within the VMPIP. We examined the 13 elements and discussed them in detail in Sections 1-13 respectively within the report. The 13 elements included:

Section 1 Methods to Reduce VOST

Section 2 Reducing VOST by Consolidating EH and SY Work

Section 3 Review and Assess the $120K Project Threshold Established for Utilization of State Work Forces

Section 1 Methods to Reduce VOST

In this VMPIP section, we have identified various methods for WSF to consider in reducing the impact of maintenance, preservation, and improvement projects on VOST. Other North American Ro-Ro ferry and commercial vessel fleet operators currently employ many of these methods, and some are currently in use by WSF. The identified VOST reduction methods are prioritized and ordered along the lines of obtaining maximum benefit (positive impact on reducing VOST), with minimized net operating costs and/or organizational change. The prioritization has considered, but has not been dominated by, potential impacts from current labor contracts, legal obligations, outside business or political agreements, or other WSF organizational/cultural policies and current practices.

Estimating an annual savings in days of VOST is relatively easy, but actually achieving the predicted savings on a consistent basis is very unlikely. The reasons for this uncertainty vary by the method. For instance:

- Managing the critical path of each shipyard contract will likely reduce the number of days to do the entire contract but without a firm scope of work, engineers cannot count on a VOST savings ahead of time.

- Expediting that is not on the critical path will not save VOST, and the critical path is different from contract to contract.

- The use of EH employees to do EH work at shipyards cannot always be counted on. EH vessel maintenance labor competes with terminal maintenance labor as the same work

force accomplishes both tasks. In addition, the location of the shipyard doing the work is unknown until award and the efficiency of the EH workforce is directly dependent on the travel distance to the shipyard.

The end result is that we endorse efforts to reduce VOST where possible and we believe that there is a reasonable probability that VOST can be reduced to some extent for each of the methods discussed in this report. However, due to the inherent uncertainties involved with marine repair projects, it may be risky to make important business decisions based on expected savings in VOST, since it may not be realized due to circumstances out of WSF's control.

Section 2 Reducing VOST by Consolidating EH and SY Work

An operational vessel maintenance strategy currently employed by WSF and the EH work force is to have select EH crews travel to various Puget Sound SYs during the vessel's planned availability, and perform work on the vessel at the commercial SY's. This section evaluated the advantages and disadvantages of this practice as well as the impact that it has on VOST. It is important to consider the benefits and limitations of this practice.

Conclusions:

- EH employees working on work scopes will not shorten the duration of a SY availability. The reality of this issue is that only by decreasing the duration of the SY project's critical path, will the SY availability be shortened. If the SY project's critical path is not shortened, then no amount of consolidated work outside of the critical path issues will result in a shortened yard period or reduced VOST.

- There are both opportunities and good business and operational reasons for consolidating (traditional) EH work scopes into and during commercial SY availabilities, there are also definite and restrictive limitations. EH employees accomplishing work scopes involving hot work, steel replacement, steel preservation, (large) piping system refurbishments, extreme heights, and all underwater hull work, inside Puget Sound commercial SYs, is unlikely to ever be allowed by the commercial sector.

- There are advantages to having EH employees working on WSF vessels inside of commercial SYs, but reducing VOST is not necessarily one of them.

Recommendations:

- Continue the practice of utilizing EH workforce inside commercial SYs, but only when it accomplishes one of the following goals:
  - Accomplishes a vital system maintenance event that is either overdue or due before the next scheduled yard or EH availability.
  - Eliminates the need for removing the vessel from service in the immediate future.
  - Reduces the critical path for an upcoming EH lay-up period.
  - Eliminates or mitigates a potential vessel scheduling problem or EH work force scheduling problem.

Section 3 Review and Assess the State Work Force's $120K Threshold for Projects

The primary goal for this section of the VMPIP was to provide a recommendation as to what the appropriate state work force dollar threshold should be in order to maximize savings on projects. For the current biennium period (effective March 15, 2010 and expiring June 30, 2011), and on a trial basis, WSF and EH have been granted authority to utilize state work force resources for public works projects up to and not to exceed $120K. The $120K limit is on a per project basis and includes both fully burdened labor and material costs.

Recommendations:

- Both WSF and EH should put into place the necessary processes and procedures that will allow data to be accurately captured and easily shared, that will allow direct comparisons of similar capital projects accomplished by EH and independent contractors.
- Do not make any changes with respect to the $120K threshold at this time. Allow more time to go by and project opportunities in this size range to present themselves to EH.
- When bidding on large capital projects, EH should plan on and budget for assigning at least a part time, maybe full time, experienced project manager to manage the project.
- EH should not bid on large capital projects that do not match up well with their core competencies and capabilities. Their first $120K project should not be in an area outside their core competencies and should not be a "strain" to accomplish.

Section 4 Comparisons Between EH and Commercial SYs

In this section of the VMPIP, we were tasked with benchmarking EH's labor efficiencies and cost structure against other public and commercial SYs. To accomplish this, we interviewed management personnel from four Puget Sound SYs currently utilized by WSF. We also interviewed management from several privately owned marine diesel engine service contractors, as well as management from three other ferry operators (public and private), and a work boat fleet operator. The ferry and workboat fleet operators interviewed also manage and operate either SYs, vessel maintenance organizations, or terminal maintenance organizations.

Conclusions:

- All other factors being equal, the EH maintenance facility's hourly rates (EH = $51.97; Puget Sound SYs = $69.95 – See Section 4 and "Final Note" 4.A), zero mark-up on materials, familiarity with the vessels and vessel systems, and 24/7/365 on-call availability provides WSF significant value relative to other Puget Sound SYs.
- EH's structure and size is similar and proportionate to other Public Ferry Operators (PFO)s examined.
- Annual average travel and penalty pay effectively reduces the labor rate differential between EH and commercial SYs by approximately $4.94/hr. (For projects involving combined and/or extensive travel and penalty pay, it is possible that VMP&I tasks performed by EH personnel could completely erase the value added differential.)

- EH's cost structure is very much in line with maintenance facilities of some other PFOs.
- EH's overhead costs as a percentage of billing rates are roughly half that of most of the SYs questioned. The primary reason for this low overhead percentage is EH's relatively high ratio of hourly to (salaried) supervisory personnel.
- Diesel engine maintenance and repair and electrical system/component maintenance and repair work scopes represent the two most critical skill sets that are in highest demand by WSF vessel crews, followed closely by the pipe fitters, and are the areas where EH personnel provides significant value to WSF. Not coincidentally, expert proficiency and resource capability in these three areas contribute heavily to the admirable, industry leading level of safe and reliable service WSF provides the citizens of Washington State (See Reference 11).

Recommendations:

- EH should fully identify, track, and manage both their employee benefits and overhead costs separately.
- WSF and EH should identify the primary causes for penalty and travel pay, and work toward reducing the causes of both.

Section 5 WSF Personnel Vessel PM Responsibilities

In this section of the VMPIP we reviewed and evaluated the both the scope and range of maintenance activities performed by vessel crews and EH personnel. We also researched recent trends indicating that vessel crews are creating more and different types of work requisitions for EH, that were typically performed by vessel crews in the past.

This section also incorporates and combines information obtained from interviews (shore side VMP&I managers and vessel crews) with reviews of typical work scopes routinely accomplished by vessel crews and EH personnel, while vessels are operating or out of service in commercial SYs.

Conclusions:

- Most WSF vessel crews are accomplishing the vast majority – almost all – of the PM type work orders that are created and managed through the fleet's PM Computerized Maintenance Management System (CMMS). At the same time, there is opportunity for some vessel crews to increase their range and level of accomplishing standard PM type work scopes during the course of daily operations.
- Accomplishing any significant amount of preservation work while underway is believed to be impractical and, in some cases, nearly impossible and dangerous.
- It is reasonable to expect that many PM and predictive maintenance inspections, some additional maintenance tasks, and some additional minor, isolated preservation/ improvement tasks could be handled by crews while vessels are underway and/or during nighttime lay-ups.

Recommendations:

- We recommend that WSF study and document the operational history of the M/V Puyallup to understand opportunities for increasing maintenance activities on other fleet vessels. (There may be other WSF vessel's with similar records, but these were not identified during the course of our efforts.)
- We recommend that WSF review and communicate to the fleet, its organizational goals with respect to on board maintenance activity.
- Continue the current shift in WSF management policy and focus, as recommended in recent LCCM studies, toward a more predictive maintenance organization. With proper training and tools, vessel crews should be able to accomplish and/or participate in non-destructive inspections via thermal imaging, ultrasonic testing, and other predictive maintenance techniques.
- WSF should renew focus and emphasis on equipment/system standardization, particularly with regard to the new vessels.

Section 6 VMP&I Task Cost Comparison Model

This section of the VMPIP allows comparison of the estimated costs of a limited set of tasks that would normally be accomplished at EH, to the estimated costs of these same tasks if accomplished by the vessel crew, either during operating hours or while tied up at night. To accomplish this comparison we reviewed the wage structures of both vessel engineering crew and EH personnel along with the travel and penalty pay aspects of the various collective bargaining agreements. We then used this information to develop a VMP&I task cost comparison model. With estimated hours, material costs, employee wages, and other input from the reader, the model provides cost comparisons between identical work scopes accomplished by vessel crew or EH personnel.

Conclusion:

- Results from the review of the variables associated with VMP&I tasks is so wide, that no general conclusion or recommendation concerning task costs on jobs performed by the two respective work forces (EH and/or Vessel Crews) can be made at this time. If anything, it appears to us that the difference between costs of most tasks performed by the two respective work forces, is negligible.
- Penalty pay, when and how it applies to specific tasks and for specific unionized employees, drive costs, and this is especially applicable to vessel crew unlicensed engineers.

Section 7 Contracting Process and Contractual Requirements

In this section we reviewed the contracting process and contractual requirements of the WSF vessel maintenance, preservation and improvement program including change order review and post availability lessons learned. We interviewed Mr. Tim McGuigan (WSF Director of Legal Services and Contracts) and Mr. Ron Wohlfrom (WSF Construction Manager). We also

reviewed and discussed WSF's graphical representation of the Schedule of Maintenance Periods and the WSF Maintenance, Preservation, and Engineering Schedule.

Conclusions:

- When one considers having eight to eleven contracts in one stage or another at any given time, it is impressive that WSF has consistently awarded vessel contracts when scheduled.
- It is exceptional that very few, if any contract awards are delayed because the (contracting) process was not executed properly.
- We believe that when the (preservation) item is inspected for the LCCM validation, it also is the best time to baseline the scope and cost estimate for the next biennium's budget and 16-year work plan.

Recommendations:

- Establish the baseline scope of work for preservation items during the LCCM validation inspection.
- We strongly recommend incorporating our condition-based maintenance suggestions.
- Incorporate auto deck and strength deck steel inspections within the purview of the hull inspection team.
- Treat inspection and painting of potable water tanks and sewage tanks a priority as a means to determine the preservation item for steel replacement.
- Institute a new electrical insulation quality inspection and analysis using polarization index readings and a third party analysis.
- Make the vibration analysis program of rotating equipment more robust and require EH or a third party vendor take the readings quarterly. (Note: EH would need additional training and equipment.)
- Make slight changes to the change order process to improve the capture of the reasons for each change, especially for contract extensions.
- Expand the requirements for the contracting lessons learned program.

Section 8 Expediting the Delivery of Shipyard Work

This section analyzed the costs and benefits of expediting delivery of commercial SY work. In order to develop this section, we sent questionnaires to SYs that routinely bid on WSF contracts, and are reasonably successful in winning vessel repair contracts with WSF. The questionnaire asked specific questions related to these shipyards seeking information on their practices in conducting work on WSF vessels.

Conclusions:

- There are noise restrictions within the Puget Sound region that restricts work after 8 p.m. and in some cases 10 p.m.

- In many cases, by choosing the contract durations they do, it appears that WSF already forces contractors to work some 10-hour days, weekend work, or second shifts to complete all required work on time. This may not be intentional but, in at least one SY's opinion, that is the case for topside painting contracts.

- Although none of the three respondents indicated there was a problem ramping up to work overtime/second shift, with new construction in the area at several yards, we believe for the near term that there will be a shortage of qualified SY workers.
- It appears that WSF already anticipates SYs need to work overtime, work on weekends, or work second shifts to accomplish routine availabilities. Therefore, to be able to count on accelerating work further for the sole purpose of trying to reduce out-of-service time does not appear to be a wise strategy, especially if the reason to reduce the out-of-service time is to justify reducing the fleet size.

Recommendations:

- We recommend WSF make no changes in their approach to expediting work in shipyard contracts.

Section 9 Comparing Planned vs. Actual SY Out-of-Service Time

In this section we looked at how well WSF plans their contract SY availabilities with respect to constructability. In other words, does the entire scope of work planned fit into the planned out-of-service time? To make this determination, we analyzed data related to drydock and dockside availabilities from March 2005 to March 2010.

Conclusions:

- WSF has increased attention in both interior and exterior hull inspections and coating preservation, which will reduce the need for steel renewal.
- Where steel renewal is required, those needs can be quantified through the hull inspection program or by drydocking inspections and then be included as a definite item in the next contract, thus reducing unplanned out-of-service time and change order costs.

Recommendations:

- As part of the availability summary of data, include the contract award start and end dates, the redelivery date, and the calculated difference.
- Any change to the contract redelivery date should be done by change order, as is the practice, but the reasons for the contract extension should be clearly explained and tied to specific contract line items. The vessel project engineers, the vessel business staff, and legal services and contracts should then review each contract extension and determine if similar extensions might be averted if changes are made to internal contract management policy, pre-contract inspections, specification language, or different approaches to recurring work requirements.

- For typical critical path items, it may be beneficial to keep track of the scope of work in some qualitative fashion vs. the time required to do the work and maintain that database. By having these metrics, engineers can better estimate the duration of contracts with those critical path items as part of the contract. Examples: topside painting and hull painting could be square feet; passenger spaces renovation could be square feet of deck, number or linear feet of seating, number of tables.

Section 10 Coordination with Required USCG Drydockings.

This section evaluated the United States Coast Guard requirements for periodic drydocking of passenger vessels applicable to the WSF fleet in addition to the eligibility requirements for in the Under Water Inspection in Lieu of Drydocking (UWILD) program. All subchapter H passenger vessels are required to be drydocked to permit underwater hull and other underwater vessel systems' inspections twice every five years (two times in every consecutive five year period of the vessel's operational life.) The UWILD program permits a vessel owner to inspect in the water instead of the drydock, at alternate intervals. Drydocking can be reduced to once every five years rather than twice in five years, but must have two diver inspections and two internal hull inspections in that 5-year period between drydockings.

Conclusions:

- Eligibility for the program for passenger vessels is detailed in 46 CFR 71.50-5. Upon successful application, vessels under 15 years old may participate, and may continue to participate after 15 years of age. Vessels over 15 years of age may apply for entry into the program and will be considered on a case-by-case basis.

Recommendations:

- Given the potentially significant cost and VOST advantages associated with having vessels enrolled in UWILD, we recommend that WSF first fully explore and assess the technical feasibility, then assess the costs vs. benefits, of enrolling some of their vessels into the UWILD program.

Section 11 Route Impacts on VMP&I Projects

This section analyzed the influences that each vessel route has on VMP&I projects. The routes that WSF vessels travel are diverse in both geographic scope and service requirements. Vessel maintenance, preservation, and to a lesser degree improvement projects are directly and indirectly influenced by certain characteristics of the various routes. In order to assess the route impacts we developed a Route Impact Analysis Matrix (RIAM).

Conclusions:

- We believe that there are characteristics of routes that have certain negative and positive effects on specific VMP&I projects. These effects also impact the general overall vessel readiness and condition.

- Results from the RIAM show that while there are differences in the impacts identified and scored for each route, the impacts tend to balance out, resulting in route impact scores that are very close to each other for most routes.

Section 12 Evaluating Ongoing Maintenance and Preservation Costs Associated with Proposed Improvement Projects

In this section we evaluated methods to analyze maintenance and preservation Life Cycle Costs (LCC) when evaluating the impacts of improvement projects. WSF vessel improvement projects can be associated with two different types of projects. The first type deals with an existing preservation item, which after a scheduled inspection, WSF decides to accomplish earlier than the interval period indicated in the LCCM. However, the other type of improvement project is when WSF proposes to replace an existing system with another system, or install a new system where none existed before. In either of the latter cases, these new systems should provide an overall benefit to the WSF system as a whole. The benefit could be in reduced tangible LCC, or intangible benefits like improved environmental compliance, improved safety, improved capability, improved reliability and/or availability, or as in recent cases, improved security.

Recommendation:

- Use a cost benefit analysis to evaluate improvement options based on the difference between the value of all intangible benefits and all tangible costs.

Section 13 Vessel Route Suitability Matrices

Most WSF vessel classes are designed to accomplish the service requirements of a single route. At the same time, most WSF's vessels are also typically designed with the understanding that they may be called upon at any time to substitute for other vessels; sometimes not of the same vessel class, or even designed or designated for the same primary route. For this section of the VMPIP, we were tasked with constructing an independent Vessel Route Suitability Matrix (VRSM) for each WSF vessel class to evaluate how well that class's capabilities match up against nine general route requirements.

PURPOSE

Elliott Bay Design Group (EBDG) and Alion Science and Technology (Alion) were tasked by Washington State Ferries (WSF) to develop a Vessel Maintenance, Preservation, and Improvement Plan (VMPIP) for presentation to the transportation committees of the legislature. The primary two goals of the VMPIP are: (1) to develop recommendations to assist WSF in reducing Vessel Out-of-Service Time (VOST), and (2) develop recommendations in enhancing efficiency of Vessel Maintenance, Preservation, and Improvement (VMP&I) activities. A schedule of VMP&I activities and costs for the next eight biennia was also developed as part of the plan. Some additional specific goals of the VMPIP are to evaluate each of the 13 elements to consider listed below:

1. Identify methods of reducing out-of-service times for VMP&I projects.
2. Analyze options to reduce VOST by consolidating Eagle Harbor (EH) and shipyard (SY) work.
3. Review and Assess the State Work Force's $120K Threshold for Capital Projects.
4. Benchmark EH's labor efficiencies and cost structure against other public and commercial SYs.
5. Evaluate WSF's personnel vessel Preventive Maintenance (PM) responsibilities.
6. Develop a model that would allow a comparison of the estimated costs of a limited set of tasks that would normally be accomplished at EH, to the estimated costs of these same tasks if accomplished by the vessel crew, either during operating hours or while tied up at night.
7. A review of the department's VMPIP contracting process and contractual requirements.
8. Evaluate the costs compared to benefits costs associated with expedited delivery for commercial SY work.
9. Analyze planned versus actual SY VOST.
10. Coordination with required USCG drydockings.
11. Evaluate route impacts in VMP&I projects.
12. Evaluate the ongoing maintenance and preservation costs associated with proposed improvement projects.
13. Construct a model for each WSF vessel class that can be used to evaluate and compare how well a particular class's capabilities, arrangements, and characteristics match up against nine general route requirements, for each of WSF's nine vessel routes.

PROCEDURE

In order to develop the VMPIP, EBDG and Alion (herein referred to as "we") had to perform a comprehensive investigation into existing reference documents associated with WSF's VMP&I activities and many of their current practices. As part of this effort, we reviewed all documents listed in the Reference section of this report, and incorporated applicable information and data from these reference documents into the VMPIP as discussed in the Document Summary Review section below.

In gathering information to develop the VMPIP, it was also necessary to interview key members of WSF's organization as well as individuals and organizations outside WSF, such as private SYs in the Puget Sound area, other public ferry operators, and private ferry operators. The information gathered during these interviews was used extensively throughout this project.

We also investigated industry best practices for VMP&I activities and evaluated those that can most effectively be applied to WSF. The best practices recommendations were developed based on EBDG's and Alion's experience, practices that are common to and are proven to work effectively for other successful fleet operators, and information gathered during the personnel interviews. We also listed the industry best practices already employed by WSF.

An important step in evaluating WSF's current practices was to develop and refine process schematics of two important processes that WSF uses to perform VMP&I activities. These two processes are: (1) an EH maintenance lay-up period for performing maintenance activities, and (2) a commercial SY availability for performing preservation, maintenance, and improvement activities. A schematic was developed for each process using information gathered in project meetings, personnel interviews, and Reference 4. The schematics include key data and information streams and key decision points of the processes, as they currently exist.

A 16-year schedule of VMP&I activities was developed for the next eight biennia, beginning with the upcoming 2011 - 2013 biennium. The schedule also includes a financial plan to estimate the Present Value (PV) costs associated with each VMP&I activity. Estimated VMP&I activity budgeting requirements are provided both by planned biennium and for the complete 16-yr period.

Each of the 13 elements to consider described in the Purpose section were specifically analyzed and reviewed, as they have significant influence on the VMPIP. All of these elements were examined and discussed in detail in Sections 1-13 of this report and include discussions on the methodology employed for each section.

List of Acronyms used in this document:

- ABS – American Bureau of Shipping
- CBA – Cost Benefit Analysis
- CFR – Code of Federal Regulations
- CMMS – Computerized Maintenance Management System
- CRG – Cedar River Group
- EBDG – Elliott Bay Design Group

- EH – Eagle Harbor
- FIRS – Financial Informational Retrieval System
- IFB – Invitation For Bid
- IT – Information Technology
- KPI – Key Performance Indicators
- LCA – Least Cost Analysis
- LCC – Life Cycle Costs
- LCCM – Life Cycle Cost Model
- MPET – Maintenance Productivity Enhancement Tool
- NVIC – Navigation and Vessel Inspection Circular
- OFM − Office of Financial Management
- PDMA – Product Development Manufactures Association
- PFO – Public Ferry Operators
- PM – Preventive Maintenance
- PV – Present Value
- RCM – Reliability Centered Maintenance
- RIAM – Route Impact Analysis Matrix
- RFP – Request for Proposal
- SCE – Staff Chief Engineer
- SIF – Staten Island Ferries
- SSA - Steam Ship Authority
- SY – Shipyard
- UWILD – Underwater Inspection in Lieu of Drydocking
- USCG – United States Coast Guard
- VMP&I – Vessel Maintenance, Preservation, and Improvement
- VMPIP – Vessel Maintenance, Preservation, and Improvement Plan
- VOST – Vessel Out-of-Service Time
- WSDOT – Washington State Department of Transportation
- WSF – Washington State Ferries

BACKGROUND DOCUMENT SUMMARY REVIEW

As stated above, the two expressed goals of this plan are: (1) to recommend how WSF can achieve efficiencies in maintaining and preserving the fleet, and (2) potentially reduce VOST. As part of this effort, we are tasked with reviewing all documents listed in the Reference section of this report, and incorporating applicable information and data from these reference documents into this final plan. In accomplishing this, it is clear that many previous recommendations targeted toward accomplishing the same WSF goals have already been expressed, and are still very relevant to this ongoing process. This section chronicles both the prior recommendations from reference documents that are relevant to the two fundamental (VMPIP) goals, and our assessment of the recommendations.

Reference 1: New York City Department of Transportation – Staten Island Ferry – Maintenance Audit Report - January 2006

The recommendations contained in this reference are mostly specific to the organizational structure, conditions, and operational needs of the Staten Island Ferries (SIF) system, and are, therefore, not directly transferable or applicable to WSF. While the recommendations made in this reference are specific to SIF, other aspects of their marine operations and vessel repair organizations are similar and share issues in common. Some of these shared issues are discussed below and elsewhere in the VMPIP.

Reactive vs. Preventive vs. Predictive Maintenance Organizations

At the time this audit was conducted (2006), the SIF maintenance system was just starting the process of evolving from a "reactive" to a "preventive" system. Almost 75% of their maintenance activities were being accomplished with little advanced planning, resulting in over time expenditures approaching 35% of expended maintenance labor costs. SIF has since turned this figure around, but compare this early overtime labor metric with EH's 2009 overtime expenditures, which amounted to approximately 12% (Vessels – 7.8%; Terminals − 4.5%). Based on most objective measures, WSF's vessel maintenance and preservation organization and policies are evolved from a "reactive" (SIF in 2006) to a more mature, "preventive" organization. In fact, WSF's maintenance organization is beginning to evolve again via predictive inspection procedures recommended in the Life Cycle Cost Model (LCCM) studies, and through expanded use of and maturation of the LCCM, into a "predictive" maintenance organization. Completing this evolution from a predominately "preventive" to a predominately "predictive" maintenance organization, will increase the overall efficiency of the organization and reduce VOST.

Several best practices ideas borrowed from SIF that can be applied to and utilized by WSF, are discussed briefly in the Best Practices section of the VMPIP.

Reference 2: Performance Audit Report – September, 2007

This report contains nine recommendations specifically addressing issues that affect the two primary goals of the VMPIP. (The tenth recommendation made in Reference 2 does not specifically address either of the two previously stated VMPIP goals.) We understand that many of the action items addressing most of these recommendations have been initiated and completed to varying degrees, and that there is general, but not total, agreement with the recommendations on the part of Washington State Department of Transportation (WSDOT)/WSF and Office of

Financial Management (OFM). We recommend that an internal task force (perhaps the same task force suggested in Reference 2's recommendation #9) conduct a follow-up review of WSF's progress and realized results toward developing and implementing these nine recommendations.

Reference 3: WSF Financing Study II – January 2008

This report contains four broad recommendations, two of which comprise a total of six sub-recommendations, all addressing specific issues dealing with vessel conditions, preserving and maintaining the fleet, and out-of-service time. Paraphrasing, these six recommendations from Cedar River Group (CRG) include elements of the following:

- Review SY contracts to expedite service. (shorten time in SYs).
- Conduct preservation work while underway.
- Bilge and void maintenance program.
- Visual inspection/audio gauging steel preservation program – older vessels.
- Integrated coating program.
- Standardized cabin maintenance materials.

The first two recommendations noted above are examined in detail later in this VMPIP. Numerous other broad categories of review found in this reference contain specific recommendations that are partially related to the two core goals of this plan. These areas of review include Vessel Replacements, Capital Financing, Maintenance and Repair Operating Financing. Some of these specific recommendations are also covered in great depth later into this VMPIP and are not singled out or addressed here.

We have reviewed all six issues and have addressed them later in the VMPIP. We do not believe that accomplishing entire preservation projects while underway is practical.

Reference 4: WSF LCCM Validation Study for Vital Systems – April 2008

Reference 4 constitutes a review of preservation threshold intervals (for vital systems only) within WSF's LCCM database. The goal of the review was to either validate or update the threshold intervals (for the five largest ferry classes only). Section 4.0 of Reference 4 provides both a summary of the validation/update review of WSF's LCCM intervals and lists four recommendations, three of which involve additional detailed study of specific systems and components. Section 5.0 of Reference 4 lists 11 additional recommendations principally aimed at improving the accuracy and usefulness of the LCCM database and ultimately toward improving the efficiency of WSF's VMPIP.

At this time, we understand and believe that improving the accuracy, validity, and thus the usefulness of the LCCM database, will both improve the accuracy of WSF's budgeting basis and increase the efficiency of the entire maintenance and preservation organization. Further to this point, we feel all recommendations made in Reference 4 have merit. They are all somewhat interrelated, but some are distinctly and definitely more important to the goals of this study than others. Some of the recommendations have already been acted upon, to varying degrees, by

WSF fleet operations personnel. We feel that these recommendations should be prioritized and acted upon by WSF fleet managers.

Reference 5: WSF LCC Analysis – Phase II – March, 2009

Reference 5 represents an extensive review/study of WSF's Ferry Preservation Program as it is currently managed and driven by the framework established in WSF's Fleet LCCM. Although the report is split into four logical and discrete sections, all aspects of the review and all recommendations / suggestions contained in the report are interrelated and, to a certain degree, interdependent. While there is no priority assigned to the recommendations (some are referred to in the report as suggestions), many obviously offer greater positive impact if enacted than others, and all are focused on the larger goals of improving the efficiency of processes, procedures, and management tools involved in vessel preservation. (NOTE: While this reference focuses on the vessel's LCCM, and hence preservation items, many of the recommendations/suggestions can and should be applied to vessel maintenance activities as well.) There are a large number of specific, detailed recommendations/suggestions discussed and explored in this report, all of which can be grouped around the central concept of capturing, updating, sharing, and utilizing accurate information pertaining to the condition of vessel systems. The three primary recommendations made in Reference 5 are paraphrased and briefly discussed below.

- *Modify processes, task assignments, and/or job descriptions in order to increase the quantity, quality, and utilization of vessel condition information obtained through inspections. Increase WSF's use of PM technology.*

In addition to improving the accuracy of both the fleet's maintenance and preservation budgeting processes, accomplishing this recommendation has the potential to stimulate WSF's maintenance and preservation organization to achieve new heights in efficiency, increase vessel readiness, and reduce unplanned VOST.

- *Enhance the power and capabilities of the LCCM database, and improve the accuracy, integration, and usefulness of the various data streams.*

The entire organization of people principally responsible for estimating, budgeting, planning, supervising, contracting, and accomplishing any fleet preservation and maintenance activities will benefit from improvements made to the LCCM, PM at a glance, and Maintenance Productivity Enhancement Tool (MPET) systems. However, we recognize that transformational Information Technology (IT) projects can be expensive, time consuming, and very challenging to develop and implement. The specific (IT-related) recommendations put forward by Alion in Reference 5 are relatively simple and inexpensive to implement, but software changes must be accompanied by procedural changes to be effective.

- *Don't spend any time on incorporating Least Cost Analysis (LCA),Cost Benefit Analysis (CBA), and other traditional cost analysis tools into the preservation management decision process. Instead, focus on obtaining and utilizing more and better vessel condition assessments, and use those assessments to evaluate the probabilities of failure, and then base preservation decisions on those probabilities of failure and other corporate mandates as required.*

This approach for preservation items is consistent with current industry best practices and is the recommended course of action. Although we do not recommend a CBA for preservation items, we discuss an approach to a CBA to justify improvement projects in Section 12 of the VMPIP.

Reference 6: Auto-Passenger Vessel Sizing / Timing – Final Report – April, 2009

EBDG's review of this reference (although not exhaustive) turned up several discrepancies in facts, including the following:

a. Underwater Inspection in Lieu of Drydocking (UWILD) definition and applicability to WSF fleet. (This issue is discussed in greater detail elsewhere in the VMPIP.)

b. Footnote #5, page 3: …."*Fixed costs, such as capital preservation and engine room crews, do not change by route assignment."*

c. Docking Procedures, page 6: …."*Engines operating at 60 rpm….recommendation is to reduce this to 30 rpm."*

Ø Recommendation 1: *Ferries should reduce average planned out-of-service time from seven weeks per vessel per year to six weeks. This can be achieved by (1) consolidating EH work with other SY work, (2) focusing on reducing time spent on top side painting, (3) designing vessels with aluminum superstructures and other features that reduce required maintenance, and (4) requesting the Coast Guard to allow underwater inspection in lieu of dry docking.*

The seven week per year average VOST metric for WSF vessels should be understood for what is and not used for comparative purposes inappropriately. We understand that the 7 week / per year / per vessel "average" is in fact an average derived off data across the entire fleet, and largely driven upwards by the historically very large top side painting and/or interior space refurbishment preservation projects. Because this figure is such a broad based average, we suggest first changing the philosophy behind the metric by placing these rare, long duration preservation projects into their own category. Secondly, we suggest developing a new metric to measure and track VOST due exclusively to planned, routine drydockings (2 times in 5 years) in conjunction with planned annual maintenance, preservation, and improvement projects. We feel that the first step toward reducing VOST is to better understand what is causing VOST, and this simple change in tracking methodology will help accomplish that.

We also believe there is room for improvement in VOST associated with both the planned Vessel Maintenance, Preservation, and Improvement (VMP&I) activities and those associated with the large planned preservation projects. The four general ideas expressed above broadly define Recommendation 1, and these ideas seem both reasonable and will reduce VOST to some extent. The specific approaches identified in Reference 6 in support of this recommendation (pages 43-46) are not universally applicable, and in many cases are already being employed by WSF. WSF is already currently engaged in some of these recommended activities. Some of the recommended activities are limited in scope, and some simply will not work. However, some of the specific information and ideas should be fully explored and developed and will result in a reduction of annual VOST. Other ways for reducing VOST are stated and examined elsewhere in this report.

- Recommendation 2: *The legislature should recognize that in order to reduce out-of-service time and reduce fleet size, the per vessel expenditure on maintenance and preservations may increase and, therefore, it will be necessary to provide adequate maintenance and preservation funding for each vessel in the fleet in order to minimize service disruption.*

We concur with this recommendation. Different levels of vessel operational readiness (levels of service) require different levels of funding for VMP&I projects.

- Recommendation 4: *Ferries should implement a system to use vessels that are in maintenance for emergency response.*

Related to the above recommendation, a very similar question/issue was raised by the Washington State legislature and presented to WSF for inclusion in the VMPIP. Paraphrasing from the language used by the legislature, the question reads as follows: *When a vessel is undergoing maintenance at EH, consider the benefits and limitations of having the ability of returning it to service on short notice when an operating vessel is impacted by casualty.*

The central operational question being addressed here is this: *Can WSF change how vessels are scheduled into, and managed while in, the EH facility in such a way that would allow them to provide a comparable level of service with fewer overall vessels, or otherwise increase their efficient use of the vessels they have?*

We do not believe this is a practical recommendation. Implementing such a system, while possible, is easier said than done. It is not at all clear or proven that the benefits of doing so will serve the best interests of WSF, or the citizens of Washington with regard specifically to EH lay-up availabilities. Advanced work scope planning, along with "real time" project execution and managing, will be both challenged and potentially negatively impacted by such a system. Overall fleet scheduling, for both EH lay-up and commercial SY availabilities, will be impacted and become more complicated and intertwined. Certainly, such a system can be made to work, more so for certain organizations in some specific situations than for others; however, it is generally not considered good operational practice or an efficient use of resources. Theoretically, at least, the single largest benefit of implementing such a system might be to allow a smaller number of vessels to cover a broader range of territory, or range of customer service requirements. Comparing another benefit of the opposing ideas (emergency availability scheduling and planning vs. stand-by vessels) with respect to service disruption time, does not favor the emergency scheduling/planning option.

A significant, possible fatal, limitation to the emergency scheduling/planning idea is that the replacement vessel (the one being pulled out of the EH facility) must have similar capabilities and characteristics as the vessel impacted by the causality (being removed from service). With any diverse fleet of vessels or customer requirements, this limitation could, at least, impact the replacement vessel's level of service, or may prove to be simply impossible. (See also Section 11 - Route Impact Analysis Matrix (RIAM) of the VMPIP for more explanation of this issue.)

Two other negative impacts that could result from implementation of the emergency scheduling/planning idea, is increased maintenance costs and generally worse vessel condition on average across the fleet. An argument (for) that could be presented involves the true potential

impact to the current system. In other words, how often over the course of an average year would the staged vessel be called on to "spring into action?" The reality is that the scheduling, planning, and project management impacts to the vessels entering SY or the EH facility for maintenance, will take their toll.

Several different strategies and organizational changes would likely need to be employed to make such a system work for WSF. These strategies would include things like always scheduling multiple vessels of overlapping operational capabilities into EH at one time, in effect staging them, so that there would always be an acceptable substitute vessel in EH lay-up. The work scope on this acceptable substitute vessel would need to be limited and planned, chopped up into discrete short duration tasks, to allow rapid deployment in the case of a fleet operational failure. Implementing such a system would definitely require a higher level of advanced project planning and production supervision for all vessels entering EH, and would also likely increase the overall vessel's scheduled maintenance availability. As some WSF fleet vessels cannot be substituted for others on their normal scheduled runs (see also the RIAM later in this study), this type system cannot be considered a viable option for WSF until all potential contingencies and impacts have been identified and understood. (The belief among WSF port engineers is that there are not enough "spare vessels", especially in the summer months, to make this a viable recommendation.)

Reference 7: WSF Long Range Finances – Final Report, May 2009

This reference is a continuation of the study initiated under Reference 3 and consists of a review of the broad spectrum of issues involving WSF's long-term capital financing strategies, with respect to revenue and expenditures. Reference 7 is primarily focused on WSF's capital financing expenditure issues and contains hundreds of recommendations and/or alternative courses of action. The following recommendations have been selected for review based on their specific relevance to two stated goals of the VMPIP.

- Recommendation 17: *Ferries should consider ways to reduce out-of-service time associated with EH Repair and Maintenance Facility vessel work, including the potential for double shifts.*

We believe due to geographic, environmental, and socio-political reasons, the potential for double shifts and/or expanded operational hours at the EH facility appears very limited. There are three basic ways the EH facility and personnel can be used to reduce VOST:

1. Continue their 24/7/365 availability to the fleet to handle emergency repairs.
2. Manage and focus all EH facility lay-ups and resources on reducing the critical paths associated with every VMP&I project, whether these are conducted at EH or an outside facility. (There is more on this subject later in the VMPIP.)
3. Related to (2) above, utilize the EH organization to enhance the predictive maintenance capabilities (vessel inspections, predictive maintenance inspections of machinery and systems, added feedback loops into the LCCM and MPET).

(Paraphrasing and combining Recommendations 18 and 19) *These recommendations talk about the frequency of (major) preservation efforts involving top side painting and passenger space*

renovations, and the strategy of arbitrarily and inherently raising funding levels (30%) for these planned events, to allow for expedited work scopes in order to reduce project related VOST.

We believe WSF should consider a comprehensive review of the LCCM preservation approach and intervals for top side paint systems, WSF paint specifications, and the availability of new and different marine coating systems. There is more on this subject in Section 1 of the VMPIP.

Generally, other recommendations were made in Reference 7 pertaining to the goals of increasing efficiencies of specific vessels, efficiencies in the MP&I of the fleet, and/or otherwise reducing out-of-service time. Many of these recommendations are not cited or commented on here in this section of the report since, later in this document, they are reviewed and incorporated into the VMPIP.

Reference 8: WSDOT/WSF Final Long Range Plan – June, 2009

Unlike most of the other references for this report, WSDOT/WSF's 2009 Final Long Range Plan does not contain specific recommendations for implementation. It is more a compilation of detailed financial and operational data, strategies, ideas, and action items that are to be implemented by WSF going forward into the next decades. We have no comments with regard to this plan.

Reference 9: WSDOT/WSF Division Construction Program W, Definitions – August 2009

As with Reference 8 above, this document does not contain recommendations from previous studies applicable to the specific goals of achieving efficiencies in fleet maintenance and preservation or reduction of VOST. We have no comments with respect to this document.

Reference 10: Vessel Life Cycle Cost Model Update 2010 – July 2010 Final Report

In the Executive Summary of this report, there are a total of nine distinct recommendations, the bulk of which deal with changes in current planning, contracting, and project management practices and procedures employed by WSF for vessel preservation projects. If these ideas were developed and implemented, it would help reduce VOST and/or otherwise have a positive impact on estimating, budgeting, and managing preservation projects at commercial SYs. While this list is not all inclusive nor is it detailed in its implementation planning, it does provide a framework of ideas for starting down a path toward better cost control and management of preservation projects.

Reference 11: WSF Expert Panel (PVA) Report - September, 2010

There are 36 specific recommendations contained in Reference 11, however most of these do not address the two specific goals of the VMPIP (improving efficiency of the VMP&I organization and/or reducing VOST). The list of recommendations from Reference 11 that do specifically address these two goals, and our corresponding comments, are listed below.

- Recommendation 3: *The Panel recommends WSF modify its capital projects design and management structure to be more in line with industry norm.*

Being a government entity, WSF is limited in the ability to match private sector budget and management organizational structures. At the same time, there are potential opportunities for

moving closer toward these structures and best practices. We feel WSF and the citizens of Washington State would be well served if these opportunities were explored and implemented as applicable. We also recommend that these same types of (potential) opportunities for organizational change and best practices implementation be considered and extended to include WSF's VMP&I projects organizations.

- Recommendation 12: *The Panel recommends that WSF run a test project to contract dry-docking for one vessel class such as the Issaquah Class*. (This recommendation refers to the idea of developing "master" specifications and RFPs for classes of vessels, and/or largely similar work scopes on identical or very similar vessels. All qualified Puget Sound SYs would be solicited to participate and bid on the master "class specific" contracts. It is believed that through this process, some of the efficiencies and economies of scale that could be achieved by the SYs would be passed on to WSF. It is also believed that these same efficiencies have the potential to reduce VOST and benefit WSF scheduling.

We concur with this recommendation.

- Recommendation 13: *The Panel recommends that WSF not adopt the CRG suggestion that WSF require, as part of their SY contracts, that a vessel in intermediate maintenance at a commercial SY be available within 24 hours in order to provide back-up service.*

We concur with this recommendation and propose that it be extended to vessels engaged at EH for lay-up maintenance as well.

- Recommendation 16*: The Panel recommends that WSF explore different approaches to in-house maintenance.*

A couple of examples to different approaches to in-house maintenance discussed in Reference 11 include the following:

- (Second) Eastside Vessel Maintenance Facility (that will allow 2 or 3 shifts to coincide with 24/7/365 vessel operations).
- Vessel Maintenance crews riding the vessels to perform maintenance at night.

We concur with the general nature of this recommendation, meaning that all reasonable and available options for (a) improving the efficiencies of WSF's VMP&I operations, and (b) for reducing VOST should be explored. WSF currently has the ability, and on occasion has utilized the practice, of using "Tiger Teams" to conduct critical maintenance and repairs to vessels when they are tied up at night. WSF also stages mobile shops at the Seattle Terminal effectively utilizing the equivalent of an Eastside Maintenance Facility.

It is unclear what goals Recommendation 16 is intended to achieve. Other sections of the VMPIP, to a limited degree, address the cost benefit issues associated with vessel crews (and EH personnel) accomplishing work at night on tied up vessels. Please refer to the VMPIP's Section 5 for more information on this issue.

Ø Recommendation 17: *The Panel recommends additional EH Maintenance Facility supervisory staff that is part of management and not part of the labor force.*

We concur with this recommendation and suggest an additional 2-3 mid-level project managers in order to have an effective manager to worker ratio.

Ø Recommendation 18: *The Panel recommends that WSF continue to transition to a zero-based budget.*

Although this was not a specific area of review for the VMPIP, we generally concur with this recommendation. To make this work for WSF, there needs to be a casualty line item and authority within WSF to reallocate maintenance funds when unexpected events occur.

Ø Recommendation 23: *The Panel recommends that WSF continue to seek new technologies that are more energy efficient and to refine operating procedures.*

We concur and specifically recommend that new coatings technologies be considered to be used on a test case basis. The purpose of this will be to extend the time intervals between large paint preservation projects.

Ø Recommendation 25: *The Panel recommends that WSF continue to seek ways to reduce out-of-service time through increased maintenance while the vessel is underway and through the strategies identified in Reference 7.* (NOTE: The aforementioned "Reference 7" is listed as "Reference 6" in the VMPIP.)

We concur with this recommendation in general; however, there are limitations to the amount of additional maintenance that can be accomplished while the vessel is underway, beyond what is already being accomplished. We concur with the general feeling among many WSF vessel and port engineers, that for most WSF vessels, additional maintenance while the vessel is underway and/or during overnight lay-up periods, will not entirely eliminate the need for occasional and necessary VOST. Furthermore, the benefits of this minimal amount of additional underway PM must be considered in terms of how it affects the vessel's true operational readiness, and/or the critical path work scopes of a vessel removed from service for scheduled and required maintenance or preservation work. See the "Maintenance and Preservation Activities Analysis" sections for more details.

Ø Recommendation 29: *The Panel recommends a pilot program where only the Chief Engineer's position is staffed 24 hours per day.*

We do not concur with this recommendation, in part because it is contrary to best practices utilized by several fleet operators interviewed for this report. If enacted, it will impact how much maintenance can get done, the type of maintenance that is possible with only one person aboard (at night), and the ability for the vessel to take fuel on during night tie-up. It might be reasonable to try it as a test program for a very small and select group of vessels, but only if it is structured and designed in such a way as to offer a fair and definitive comparison of expectations and results. The vessels are currently staffed in a manner that is conducive to maximizing the quantity and quality of vessel PM. Generally, WSF's Staff Chief Engineers (SCE) and Port

Engineers believe this level of manning is required to achieve the fleet's overall current state of vessel maintenance, readiness, and service levels.

- Recommendation 30: *The Panel recommends that WSF study the types of work performed by vessel crews while the vessel is in a SY and then determine the cost/benefit of this practice.*

This recommendation is specifically addressed in Section 5.

PERSONNEL INTERVIEWS

WSF Personnel

In gathering information to develop the VMPIP, it was necessary to interview key members of WSF's organization. The information gathered during these interviews was used extensively throughout this project. Examples of questions asked of Vessel Maintenance, Preservation, and Engineering personnel and of Staff Chief Engineers are shown in Appendix A.

The lists below represent those WSF personnel specifically contacted for this project.

Vessel Maintenance, Preservation, and Engineering Personnel:

Paul Brodeur: Director of Vessel Maintenance, Preservation, and Engineering
Tim Browning: Senior Port Engineer Vessel Preservation
Mike LaCroix: (Former) Senior Port Engineer Fleet Maintenance
Ron Wohlfrom: Vessel Construction Manager
Scott Mullen: Port Engineer, Fleet Maintenance
Vern Day: EH Senior Port Engineer
R.J. Kelly: EH Port Engineer
Nancy Adams: EH Administration

Staff Chief Engineers:

Mark Nitchman: Staff Chief Engineer, M/V Puyallup
Robin Zahler: Staff Chief Engineer, M/V Kitittas

Finance and Administration:

Tim McGuigan: Legal Services and Contracts Director
Matt Hanbey: Operating Program Manager
John Bernard: Capital Program Manager
Dave Burns: Transportation Planning Specialist 4
Lucy Fullerton: Transportation Planning Specialist 5

Non-WSF Personnel

In gathering information to develop the VMPIP, it was necessary to interview and obtain information from commercial shipyards (SYs), other government sponsored and private ferry operators, other commercial fleet operators, and fleet operators who also own and manage their own commercial/fleet SY and/or fleet vessel maintenance organization. The information gathered during these interviews is largely confidential and proprietary. We have utilized the information extensively as it was received, but we have not disclosed the specific sources of the information. Examples of questions asked of these entities are shown in Appendix A.

There was a considerable amount of information gathered during the interviews with both WSF and non-WSF personnel, far too much to replicate in the VMPIP. Two poignant, relevant points made by industry knowledgeable, non-WSF personnel, who are very familiar with doing business with WSF are listed below.

Marine Diesel Engine Service Company Owner:

WSF has their own machine shop, highly trained and experienced diesel mechanics, a spare parts inventory, comparable travel issues (with respect to outside contractors) and intimate familiarity with the vessels and engines. These represent huge advantages for WSF. The Best – Optimum scenario is to combine the advantages WSF already has, with repair contracts representing actual labor expended – and manage that process. This arrangement provides the most efficient solution achievable.

Puget Sound Shipyard Estimating Manager:

Unfortunately there are not too many WSF projects that we are able to participate in and of those few, there is significant competition we must underbid. This tends to create a change order driven contract. If WSF endeavors to find better value and shorter out of service duration they may want to look at "Best Value" contract award criteria utilizing a defined point system with the following elements: 1)Past Performance and References; 2)Facilities; 3)Timeline; 4)Financial. Some government entities have adopted this process after experiencing the worst that lowest price can offer…..You already know the low bid fallacy….I doubt, that you, as a matter of course, automatically award your roofing project to the lowest bidder. References, time line, resources weigh nearly equal to price. I know they do with me. I realize that a couple of these elements are established with the annual WSF pre-qualification process, but still believe this type of award criteria would benefit all the residents of Washington and go a long ways towards creating a partnership with local shipyards and WSF. Along with that type of contract award criteria, and equally important, WSF needs to produce a comprehensive work specification that accurately describes all work. Currently, they can't do that. When contractors ask the tough questions in order to accurately define the scope, WSF dodges with "refer to the specification" all too often. Case in point: WSF Spec States: "Crop and renew 100 SF of 15.32# plate on the car deck. Include all interferences." Shipyard question/request: "For bidding purposes, please identify areas where plate will be cropped and renewed. Will there be 25 each 2' X 2' inserts or 1 each 10' X 10' insert? Please identify if these area include voids or machinery spaces below." WSF answer: "Bid in accordance with the specification". This creates more than one problem for the bidder and for WSF: If they can't accurately identify the work scope how can they establish performance period. We see this all the time, too little time to perform the work, unless it is repeat work scope in same class vessel. This leaves the contractor to scheme his bid strategy and plan for change orders.

BEST PRACTICES SUMMARY

This section presents industry best practices that can most effectively be applied to WSF. The best practices recommendations are developed based on EBDG's and Alion's experience, practices that are common to and/or are proven to work effectively for other successful fleet operators, and information gathered during the personnel interviews. Where applicable, industry best practices already employed by WSF are noted and discussed.

Staten Island Ferry (SIF):

- Master dry-docking contracts: Contracts specific to six (6) large ferryboats, and differentiates these from contracts specific to two (2) small ferryboats. Each contract has an initial term of five years with two one year options and addresses all items normally associated with routine regulatory dry-dockings, maintenance and repair, and any emergencies which might arise during the term of the contracts. Benefits include the following:

    (a) Estimated costs associated with routine regulatory dry-dockings are more accurate for budget planning;

    (b) Staff resources are better utilized because the continual preparation and bidding of dry-docking contracts has been reduced to twice in five years versus an ongoing annual requirement;

    (c) Scheduling of dry-dockings is more predictable and , therefore, regulatory compliance is improved;

    (d) Economies of scale and a better tracking of repair items and related costs should result. Approximate time to implement: Two to three years from inception until contract award.

Steam Ship Authority (SSA):

- Financial reports to measure performance on a monthly basis. This includes the monitoring of actual receipts and disbursements, both on a cash and an accrual basis, compared to budget projections and the prior year's actual results. A monthly business report is also prepared summarizing: (1) monthly and year-to-date traffic statistics vs. the previous year; (2) monthly and year-to-date net income (loss) from operations vs. budget projections; (3) a brief narrative of the reasons for any major budget variances; (4) monthly and year-to-date cash balances for the various funds (operating and special purpose funds) vs. budget estimates; (5) projected allocation of the annual revenues , cost of service and net operating income by routes to make sure each route's revenues cover their respective cost of service; and, (6) market share data on the number of passengers carried monthly and year-to-date vs. our competitors.

- SSA also prepares and distributes weekly payroll reports comparing the total number of hours and wages paid, by cost center, vs. budget projections and the related information for the corresponding period from the previous year. Benefits of SSA's best practice:

a. The continuous monitoring of the SSA's performance through the use of various monthly reports allows corrective action to be taken immediately to help avoid operating losses, to the extent possible, and a potential deficit assessment against the port communities.

BlackBall Transportation:

- Vessel is typically manned 24/7/365 by both engineering and deck crews of at least two persons each. These crew members do not stand watches during operating hours, and are onboard solely to maintain the vessel. The maintenance crew is supervised by engineering and deck officers that serve watches during normal operating hours (12 to 18 hours/day).

- Financial incentives are available for both deck and engine room officers to actually minimize both VOST and missed sailings.

Foss Maritime / Foss Shipyard:

- (On board their fleet of tug boats.:) A large percentage of deck and engine room "routine maintenance work" is accomplished by the operating crews outside of the shipyard. The crews are responsible for keeping the vessels well maintained and running to the full extent of their capabilities.

- There is significant and regular – sometimes hourly - communication between the vessel crews, dispatch, and shore side port engineers / port captains responsible for those vessels. It is the port captains / engineers responsibility to know the condition of the vessel at all times, to properly plan and arrange maintenance and preservation activities, and to keep both the purchasing and the shipyard groups informed as required.

- Weekly planning meetings are held, whereby vessel operations port captains & engineers, shipyard management, engineering, and production staff, and purchasing staff / warehouse personnel attend to discuss current, intermediate, and long term maintenance and preservation issues and projects.

- SY utilizes a fully integrated manufacturing environment Job Cost Reporting software package. Time sheets, payroll, billing, inventory, work requisitions, change orders, job cost reports, and more are all available inside a single software program.

WSF Best Practices:

- Tracking and acting upon operational Key Performance Indicators (KPI). The EH facility has begun tracking various metrics, and should expand on these in order to increase their efficiency. Some of the KPI's currently being monitored by WSF include the following:

    - Filter setting in MPET provide managers the ability to track and monitor the status of "Open" work requisitions vs. "Closed" work requisitions.

- Financial Informational Retrieval System (FIRS) accounting data is collected and reviewed to determine budget status for both labor and non-labor. Adjustments in manpower levels and material acquisitions are considered when a negative trend is detected.

- Work Order distribution is not categorized in MPET and would take a monumental effort to go back to get a history.

- Project schedule and budget is tracked for capital work only.

Work Orders waiting parts are not tracked (by EH) at this time. (See Appendix A "shipyard questions" for a partial list of more important KPIs. Additional KPIs are found in Reference 1, and various manufacturing business textbooks.)

- WSF and the EH maintenance planners currently do a better than average job at sequentially scheduling class vessels for EH maintenance activities, even though this idea does not appear to play a primary role in development of the fleet maintenance schedule. This practice can lead to efficiencies resulting from both economies of scale and learning curves from similar vessels/similar projects, and should be systematically incorporated into maintenance scheduling and planning. EH maintenance activities are currently (by design) scheduled to coincide with (both before and after) planned SY availabilities and /or USCG annual inspections. These latter practices offer great advantages toward general vessel condition, readiness, production efficiency while the vessel is in the shipyard, and regulatory compliance levels, but must be carefully managed to minimize excessive out of service time and/or non-essential expenditures.

- WSF monitors monthly fuel consumption reports by vessel, number of missed trips, vehicle reservation statistics, call center activity, number of reservations made via the company website vs. by telephone or in person.

- A Quality Assurance/Quality Control program has been implemented for critical maintenance items. Currently the program includes eighteen established check sheets to detail the process of work to be performed. Each procedure also establishes a customer acknowledgement that the job was performed in the correct manner and meets his/her satisfaction.

- A customer survey form has been created to gage the success or failure of the work that is being performed. A customer satisfaction survey is presented to each vessel Staff Chief Engineer by EH at the conclusion of their lay-up or lay-up season and to the terminal agents at the end of each summer maintenance season.

- Development and use of LCCM to manage preservation work items

- Use of a hull inspection team to develop detailed information on condition of hull steel

- Use of condition based maintenance (although limited) such as vibration analysis, lube oil analysis, thermography, meggering, and Product Development Manufactures Association (PDMA) motor testing.

- Use of a PM program to reduce the amount of emergent work
- Use of a maintenance management tool (MPET) to allow for work request scheduling, procurement, and inventory management
- Environmental management including implementation of the Vessel General Permits and EH storm water management as required by regulation.
- Partnership and permit work with local waste water treatment plants for documenting sewage discharges, which allows the use of oily water separator systems more effectively.
- Voluntary early adoption of Ultra Low Sulfur Fuel.
- Experimental use of biodiesel fuels followed by routine use of a 5% blend on several vessels where the product is readily available.
- WSF's partnership with the Puget Sound Clean Air Agency to work on cleaner diesel emissions, which resulted in securing substantial federal grant funding.
- Long Lead / Vital System Spare Parts Inventory.
- Standardized Propulsion and Auxiliary Equipment Machinery: WSF has standardized vessel machinery w/respect to manufactures for both makes of main engines (EMD and GE), and ships service generators (Detroit Diesel series 60).

PLANNING PROCESSES SCHEMATICS

The purpose of this section is to graphically represent two important processes that WSF uses to perform vessel maintenance, preservation, and improvement activities. These two processes are (1) an EH maintenance lay-up period for performing maintenance activities and (2) a commercial SY availability for performing preservation, maintenance, and improvement activities. A schematic was developed for each process using information gathered in project meetings, personnel interviews, and Reference 4. The schematics are shown in Appendix B and the processes are described in more detail below. It is important to note that the intent of the schematics is to show the most important steps in the processes and not to show every detail.

EH Maintenance Lay-up Process

The EH maintenance lay-up process schematic shows the major steps involved in planning and executing a vessel lay-up period. This process is relatively straight forward since it primarily involves maintenance activities, which are typically shorter in duration and lower in cost compared to preservation and improvement projects (Reference 8). The purpose of a maintenance activity is to maintain the usefulness of an asset rather than changing or significantly improving it. Maintenance activities are planned by the vessel's Staff Chief Engineer, the Port Engineer, and the EH General Forman. The work is accomplished by EH personnel along with the vessel engine crews and typically do not involve the services of a naval architect, project engineer, or a commercial SY. These availabilities may involve the service of the Vessel Engineering Department when drawings need to be produced to support the work.

An important management tool in planning a lay-up period is MPET. This software is used to integrate maintenance activities for the vessels, terminals, and the EH maintenance facility. One of the primary functions of MPET is to manage work items. Another function of MPET is to manage vessel PM items through a module called PM At-a-Glance. This module identifies and tracks PM items relevant to each vessel in the fleet. Each vessel's SCE is responsible for managing the work items in this program. PM items that must be accomplished during vessel lay-up are turned into work requisitions in MPET for accomplishment at EH. Other functions of MPET include tracking of spare parts and consumables, ordering of spares and consumable inventory, and interacting with other WSF databases (Reference 4).

As shown in the schematic, the SCE inputs work items into MPET where the items are reviewed by a Port Engineer. The Port Engineer evaluates the work requisitions by priority, cost, and schedule and develops a work list. The work list is then evaluated by the EH General Foreman, and then refined during a pre lay-up meeting. This meeting produces an updated priority work list that EH uses to plan the work. The items in the work list are then accomplished during the lay-up period and the vessel is delivered back into service. Annual USCG inspections are typically conducted the last two days of the EH lay-up periods.

Commercial SY Availability Preservation and Improvement Process

The commercial SY availability preservation, maintenance, and improvement process schematic shows the major steps involved in planning, budgeting, and executing a contract for a commercial availability. Preservation and improvement activities are make up the majority of work accomplished in a commercial SY periods, however, it is important to note that some maintenance activities are accomplished during commercial SY drydocking periods such as

propeller repair, hull paint touch up, and stern tube seal replacement. This is a complex process compared to an EH maintenance lay-up period. This is largely due to the fact that preservation and improvement activities are capital projects and must be funded accordingly. Preservation and improvement activities are typically longer in duration and higher in cost compared to maintenance activities. The purpose of a preservation project is to extend to the life of existing vessel and terminal assets by replacing existing systems of the asset that have reached the end of their life cycles. The purpose of improvement projects is to change or improve the characteristics of an existing asset to meet new program requirements or to create new assets. This can include the construction or lease of new assets. Preservation and improvement projects usually require the services of naval architects and engineers (Reference 8).

An important management tool in budgeting and planning preservation activities is the LCCM. The LCCM is a database that is used as the basis for estimating future terminal and vessel preservation needs and developing the budget request for terminal and vessel preservation funding. It contains information on preservation inventory items for each vessel such as replacement intervals, the year the item was last renewed, and estimated costs for renewal. The LCCM is used in conjunction with condition assessments to verify the need for work on vessel systems that are due for replacement or renovation (Reference 3).

As shown in the schematics, there are two main phases for a preservation and improvement availability (1) planning and budgeting and (2) execution.

Planning and Budgeting

This phase shows the process that WSF must go through to obtain capital funding for the upcoming biennium. This is accomplished by submission of a 16-year plan and budget for preservation and improvement activities of the fleet and terminals. In order for funding for the upcoming biennium to be obtained, the plan and budget must be ultimately be approved by the WSF Capital Committee, WSDOT, OFM, the Governor, and Legislature.

Another important process in the planning and budgeting phase is the work order process. The work order process is separate from the submission and approval of the 16-year plan and budget. The work order process functions as a cost collection center and identifies the funding sources for an activity. Work orders are submitted by the Senior Port Engineer for Preservation to the Vessel Business Staff, who initially enter the request into the Oracle Work Order tracking system. The WSF Program Development and Management Office screens the request for the appropriate funding sources, gives their approval, and forwards to the WSDOT Assistant Secretary Marine Division for approval. Once approved, WSDOT Accounting services enter the work order into the WSDOT TRAINS and CAPS financial systems, and a contract number is assigned. Once a contract number has been assigned, an Invitation For Bid (IFB) can be solicited for an upcoming vessel availability and charges can be made to the work order.

Execution

The execution of the commercial availability process begins with the SCE and Preservation Project Engineer validating the material condition of LCCM items and reviewing condition reports to compile a list of preservation items to be worked on during the availability. A Preservation Project Engineer and the Senior Port Engineer for Preservation reviews, budgets,

scopes the work items and incorporates them into the schedule for the current and upcoming biennium and sixteen year plan. The schedule consists of a detailed plan for the EH and commercial SY availabilities in the current and upcoming biennia for all of the vessels in the fleet. When funding has been established, the work items are discussed in a kick-off meeting. After the kick-off meeting, the Preservation Project Engineer develops a scope of work, which the Vessel Construction Project Engineer uses to create specifications. When a contract number has been received from the planning and budgeting process, the specifications are turned into a contract along with an IFB. The winning SY then accomplishes the contract during the commercial SY availability, and the vessel is delivered back into service after the vessel acceptance process.

SCHEDULE OF VESSEL MAINTENANCE, PRESERVATION, AND IMPROVEMENT ACTIVITIES

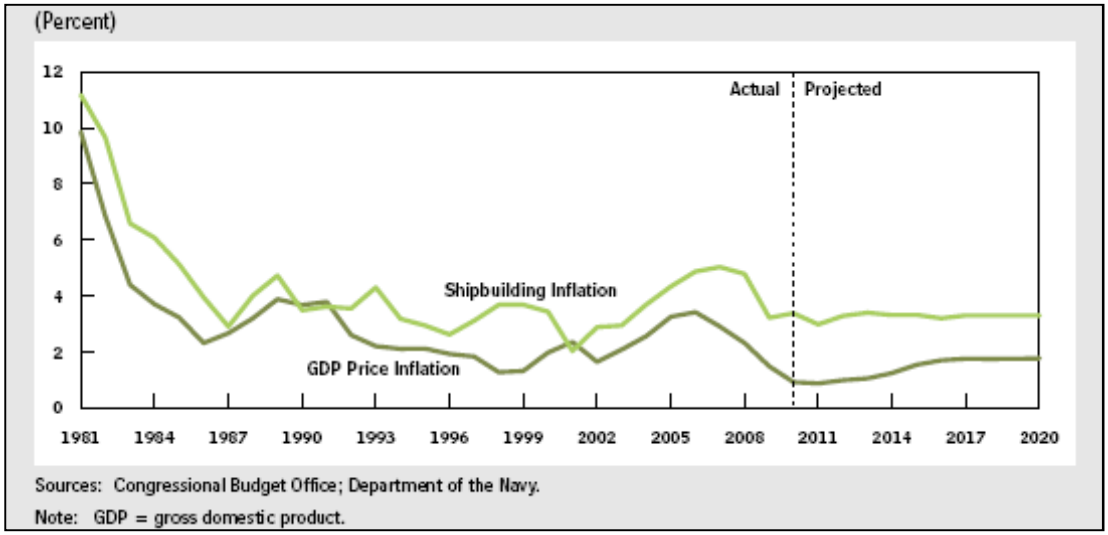
The purpose of this section is to develop a representative 16-year schedule of vessel maintenance, preservation, and improvement activities. The schedule was developed for the next eight biennia, beginning with the upcoming 2011 – 2013 biennium. The schedule also includes a financial plan to estimate the PV costs associated with each VMP&I activity.

The 16-year schedule was developed based on common elements of the current WSF 16-year plan, the Long Range Plan (Reference 8), and the Vessel LCCM Update (Reference 10). The Long Range Plan was used to determine when new vessels are constructed and put into service and when old vessels are retired and removed from service. The Vessel LCCM Update and WSF's current 16-year plan were used as a basis for scheduling preservation and improvement activities for all of the vessels in the fleet. Preservation and improvement activities and their associated PV costs are itemized for each vessel in each biennium. WSF's current estimated vessel preservation and improvement PV costs are included for comparison. The costs for each preservation and improvement activity are also subtotaled for each of eight biennia in the 16-year period for each vessel. Maintenance costs are not allocated per vessel and are therefore included as a lump sum for all vessels per biennium. The maintenance costs included in this plan are only the X4 and X7 subprogram costs such as those for engine lay-up labor and materials, EH maintenance labor and non-labor, vessel maintenance contracts, and vessel maintenance labor and non-labor. The maintenance costs used in the schedule are based on the WSF budget submitted to the OFM for the 2011 – 2013 biennium. A summary of the 16-year schedule costs is shown in the table below. The detailed schedule is shown in Appendix B. All costs shown in the table below and in the detailed schedule in Appendix B have been adjusted for inflation and are shown in Net Present Value (NPV) for 2011 dollars.

All of the costs in the 16-year plan have been adjusted for inflation, which is an important factor to consider when establishing long term budgets since it greatly affects the overall costs. For the purposes of this analysis, inflation represents the growth in the costs of labor and materials that the shipbuilding industry has experienced. Although it is difficult to predict what inflation will be in the future, it is well understood that shipbuilding inflation has typically been higher than Gross Domestic Product (GDP) inflation for the last 30 years as shown in the figure below[1]. For the purposes of this analysis, inflation was assumed to be a constant 3.2% annually.

[1] Referenced from: An Analysis of the Navy's Fiscal Year 2011 Shipbuilding Plan, Congressional Budget Office, May 2010.

Annual Rates of Shipbuilding Inflation and GDP Price Inflation



Maintenance Costs

As stated above, maintenance costs were determined from WSF's 2011 – 2013 budget submitted to OFM. Maintenance costs were adjusted for inflation but a contingency was not applied since the work scopes of maintenance activities are well understood.

Preservation Costs

Preservation costs were determined using the updated LCCM cost estimates for each preservation item on each vessel and were adjusted for inflation. It is important to note that WSF's 16-year plan was already in development when the Vessel LCCM Update was released, therefore there are differences in the costs of preservation items between the 16-year plan presented in this study and WSF's 16-year plan. A five percent contingency was applied to each preservation item scheduled for the upcoming 2011 – 2013 biennium. A 10 percent contingency was applied to each preservation item scheduled for the 2013 – 2027 biennia. This is due to the fact that the work scopes of the preservation items in the upcoming biennium are better understood than those further out in time.

The cost factors found in the Vessel LCCM Update largely represent the historical costs for performing the work for each preservation item. It is important to note that the cost of a preservation item is contingent upon its work scope. Some preservation items such as the renewal of rescue boats, radars, radios, and boilers have relatively consistent work scopes. Other preservation items such as hull steel replacement and sewage tank steel renewal are more challenging to estimate in the upcoming biennia since the scope of work can vary significantly. Other examples of preservation items that have variable work scopes are the renewal of hull paint and piping systems.

Improvement Costs

The majority of the improvement costs in the 16-year schedule are construction costs for new ferries. The improvement costs include the construction of vessels two and three of the 64 auto

ferry class, the M/V Salish and M/V Kennewick respectively. The M/V Salish is set for delivery towards the end of the 2009 – 2011 biennium. This analysis assumes that a portion of the contract costs for the Salish will be paid out in the beginning of the 2011 – 2013 biennium. The M/V Kennewick is scheduled for delivery in the middle of the 2011 – 2013 biennium so the entire contract cost of the vessel was included in the upcoming biennium.

According to the Long Range Plan, five vessels will be retired in the three biennia from 2025 – 2031. The vessels scheduled for retirement are the Evergreen State class vessels M/V Tillikum and M/V Klahowya, and the Super class vessels M/V Elwha, M/V Kaleetan, and M/V Yakima. In order to provide replacement vessels, five new 144 auto ferries will need to be constructed. One new vessel is scheduled for delivery in 2027, three are scheduled for delivery in 2028, and the fifth vessel is scheduled for delivery in 2029. Since the 16-year schedule only covers up to the 2027 biennium, the improvement costs include the full estimated contract cost for two 144 auto ferries, and a partial contract price for the third ferry. The remaining contract costs are assumed to be funded in the 2027 – 2029 biennium.

The construction cost estimate for each 144 auto ferry was determined by multiplying the price per pound of light ship weight paid for construction of the M/V Chetzemoka ($18.42/lb) by the estimated light ship weight of a 144 auto ferry (3499.8 long tons)[2]. The construction cost estimate was then adjusted for inflation and multiplied by a contingency of 10 percent.

Conclusions

The results of the 16-year schedule and financial plan show that it will cost approximately $2.47 billion to maintain, preserve, and improve the current WSF fleet for the next eight biennia. A summary of the 16-year schedule costs is shown in the table below. Maintenance costs account for approximately $440 million, preservation costs account for approximately $1.01 billion, and improvement costs account for $1.02 billion. The results of this analysis provide a relatively conservative estimate since it is based on the updated LCCM cost estimates and includes contingencies. In comparison, WSF's 16-year plan estimates that vessel preservation will cost approximately $680 million and vessel improvements will cost approximately $1.1 billion over the next eight biennia. The differences in preservation and improvement costs between WSF's 16-year plan and the 16-year plan presented in this study can largely be accounted for by the differences in the costs basis of LCCM items, contingency factors, inflation factor, and the estimated capital costs of new vessel construction.

It is important to note that accurately predicting preservation and improvement costs beyond the current and upcoming biennium is difficult. Although using the LCCM cost estimates is a good basis for budgeting, the exact work scopes for preservation items cannot be known in detail far ahead in the future. We want to stress the importance of continually updating the LCCM interval and cost estimates with updated information as preservation items are accomplished in order to continually improve forecasting ability. See Section 7 for additional recommendations regarding the determination of work scopes on preservation items.

[2] Referenced from: New 144 Auto Ferry Weight Estimate, 9000-660-100-03, Rev. -, EBDG, February 28, 2006.

Additionally, WSF should continue to evolve and expand their inspection processes to allow for a better understanding of material condition on the vessels. For example, hull inspection coupled with the steel preservation program allows more detailed information to be obtained on the condition of each vessel's hull steel. This enhanced knowledge will allow for more detailed scoping of the work, which will in turn allow for more precise budgeting.

We also recommended that as a first step, portions of the maintenance budget be developed and allocated by vessel class. This would put the WSF maintenance budgeting process more in line with common industry practice and would allow for more detailed budgeting. If WSF begins to budget and allocate maintenance funds by vessel class, WSF will need the authority to move funds easily from one class to another in order to deal with unplanned maintenance requirements.

Summary of PV Costs for 16-Year Schedule of VMP&I Activities

		Biennium End								
Vessel	**Activity**	**2013**	**2015**	**2017**	**2019**	**2021**	**2023**	**2025**	**2027**	**Vessel Subtotal**
All Vessels	Maintenance	$43,558,000	$46,390,315	$49,406,799	$52,619,427	$56,040,953	$59,684,959	$63,565,914	$67,699,224	$438,965,592
Salish	Preservation	$0	$0	$0	$376,652	$4,704,309	$4,615,685	$15,610,098	$5,779,669	$31,086,412
	Improvement	$10,639,125	$169,000	$311,056	$193,000	$206,000	$221,000	$236,000	$236,000	$12,211,181
Kennewick	Preservation	$0	$0	$0	$0	$401,144	$5,010,202	$4,915,815	$16,625,129	$26,952,289
	Improvement	$70,927,500	$0	$180,000	$537,568	$206,000	$221,000	$236,000	$536,000	$72,844,068
Chetzemoka	Preservation	$0	$0	$353,656	$4,417,092	$4,333,879	$14,657,039	$5,481,848	$2,394,936	$31,638,449
	Improvement	$650,000	$169,000	$180,000	$193,000	$206,000	$221,000	$236,000	$236,000	$2,091,000
Cathlamet	Preservation	$4,954,017	$3,593,952	$1,878,020	$5,265,054	$3,488,131	$21,798,270	$15,259,588	$997,793	$57,234,826
	Improvement	$263,000	$266,818	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,652,818
Chelan	Preservation	$897,964	$7,700,952	$9,435,051	$359,457	$4,815,677	$23,323,527	$9,841,615	$29,634	$56,403,877
	Improvement	$263,000	$266,818	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,652,818
Elwha	Preservation	$10,877,364	$7,582,101	$6,604,878	$9,355,160	$16,698,715	$2,117,089	$5,373,874	$114,848	$58,724,031
	Improvement	$1,063,000	$282,000	$301,000	$322,000	$344,000	$368,000	$0	$0	$2,680,000
Evergreen State	Preservation	Retired								$0
	Improvement	Retired								$0
Hiyu	Preservation	$0	Retired							$0
	Improvement	$100,000	Retired							$100,000
Hyak	Preservation	$6,996,568	$6,600,819	$16,753,118	$3,075,141	$2,327,645	$11,162,098	$408,502	$188,182	$47,512,073
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
Issaquah	Preservation	$2,553,834	$5,817,344	$4,189,449	$4,554,932	$5,869,958	$9,345,883	$8,612,547	$935,082	$41,879,030
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
Kaleetan	Preservation	$4,860,215	$3,878,164	$20,124,950	$10,898,054	$2,313,100	$7,053,855	$10,769,497	$437,788	$60,335,623
	Improvement	$4,103,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$6,508,000
Kitsap	Preservation	$2,692,447	$6,011,444	$19,640,619	$729,227	$4,028,941	$14,868,007	$2,210,556	$28,086	$50,209,327
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
Kittitas	Preservation	$444,225	$3,856,622	$5,488,757	$2,536,567	$19,262,312	$8,707,379	$7,286,617	$1,853,638	$49,436,118
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
Klahowya	Preservation	$5,505,425	$11,095,113	$2,077,069	$3,637,247	$2,868,326	$859,463	$7,045,115	$127,458	$33,215,217
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
144-Auto Passenger Ferry #1	Preservation	$0	$0	$0	$773,766	$3,937,269	$1,574,513	$6,770,329	$1,799,760	$14,855,637
	Improvement	$151,725,000	$0	$0	$221,000	$236,000	$254,000	$300,000	$300,000	$153,036,000
144-Auto Passenger Ferry #2	Preservation	$0	$0	$0	$0	$824,079	$4,193,286	$1,832,685	$10,851,563	$17,701,614
	Improvement	$151,725,000	$0	$0	$0	$221,000	$236,000	$254,000	$300,000	$152,736,000
144-Auto Passenger Ferry #3	Improvement	$0	$0	$0	$0	$0	$0	$0	$229,104,750	$229,104,750
144-Auto Passenger Ferry #4	Improvement	$0	$0	$0	$0	$0	$0	$0	$229,104,750	$229,104,750
144-Auto Passenger Ferry #5	Improvement	$0	$0	$0	$0	$0	$0	$0	$114,552,375	$114,552,375
Puyallup	Preservation	$1,114,431	$2,768,300	$8,915,462	$34,167,753	$1,210,334	$373,708	$4,134,144	$5,897,957	$58,582,089
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
Rhododendron	Preservation	Retired								$0
	Improvement	Retired								$0
Sealth	Preservation	$1,678,927	$2,136,263	$6,849,626	$7,556,910	$3,577,432	$7,985,282	$24,509,540	$335,445	$54,629,426
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
Spokane	Preservation	$717,266	$11,931,551	$10,591,779	$4,183,032	$3,635,112	$7,664,538	$13,129,112	$2,156,541	$54,008,931
	Improvement	$263,000	$282,000	$301,000	$7,354,167	$344,000	$368,000	$394,000	$394,000	$9,700,167
Tacoma	Preservation	$1,824,298	$9,949,322	$4,328,066	$17,602,009	$1,224,427	$21,162,284	$5,368,203	$5,128,768	$66,587,377
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
Tillikum	Preservation	$2,468,553	$7,847,627	$4,354,440	$4,246,343	$171,828	$201,301	$3,401,599	$746,538	$23,438,230
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
Walla Walla	Preservation	$5,957,770	$8,502,196	$1,420,717	$13,005,091	$4,434,856	$1,774,794	$11,844,682	$670,571	$47,610,677
	Improvement	$263,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$2,668,000
Wenatchee	Preservation	$14,628,412	$10,641,797	$536,643	$14,127,213	$356,061	$5,540,441	$22,497,969	$7,259,454	$75,587,990
	Improvement	$263,000	$282,000	$0	$322,000	$344,000	$368,000	$394,000	$394,000	$2,367,000
Yakima	Preservation	$135,311	$4,605,885	$19,408,796	$7,365,362	$11,183,390	$3,773,090	$4,648,894	$188,182	$51,308,909
	Improvement	$4,103,000	$282,000	$301,000	$322,000	$344,000	$368,000	$394,000	$394,000	$6,508,000
Biennium Subtotal	Preservation	$68,307,028	$114,519,454	$142,951,098	$148,232,063	$101,666,926	$177,761,733	$190,952,829	$64,547,023	$1,008,938,155
Biennium Subtotal	Improvement	$398,717,625	$5,101,636	$5,487,056	$13,650,735	$6,923,000	$7,409,000	$7,566,000	$580,673,875	$1,025,528,927
Grand Total		$510,582,653	$166,011,405	$197,844,953	$214,502,225	$164,630,879	$244,855,693	$262,084,744	$712,920,122	$2,473,432,674

MAINTENANCE AND PRESERVATION ACTIVITIES ANALYSES

In WSF's Request for Proposal (RFP) dated 5/3/10, 13 plan "elements to consider" were identified as items requiring additional specific review, as they have significant influence on WSF's VMPIP. All of these elements are examined and discussed in detail in Sections 1−13 of this report.

Section 1 Methods to Reduce VOST

VOST is a necessary requirement for all marine vessels. For most fleets, the reasons which drive VOST are equally well understood and generally universal across multiple vessel types. As with commercial marine markets, VOST (for WSF) equates to lost revenue, potentially reduced customer service, and (usually) added expense. Fortunately, VOST can be managed and minimized within the limits established by the risks and limitations inherent to all mechanical/electrical/structural system and organizational enterprises.

In this VMPIP section, we have identified various methods for WSF to consider to reduce the impact of maintenance, preservation, and improvement projects on VOST. Other North American Ro-Ro ferry and commercial vessel fleet operators currently employ many of these methods, and some are currently in use by WSF on a limited basis. The list below is prioritized and ordered along the lines of obtaining maximum benefit (positive impact on reducing VOST) with minimized net operating costs and/or organizational change. The prioritization has considered, but has not been dominated by, potential impacts from current labor contracts, legal obligations, outside business or political agreements, or other WSF organizational/cultural policies and current practices.

1. Organize, plan and manage all maintenance periods around the critical paths, and/or vital system/inspections. Maintenance periods include SY availabilities, as well as the planned EH lay-up periods. Accomplishing work items outside the critical path – while important and usually necessary – does little to nothing in reducing VOST. This will require a change in perspective among WSF vessel engineers, Project Engineers, Fleet Port Engineers and other vessel work scope planners, such as the EH Planner and Vessel General Foreman. WSF VMP&I project specifications will also need to be written with awareness of the critical paths in mind, and SYs will need to be held accountable for effectively managing WSF projects' critical paths. Specific aspects of critical path planning and issues are discussed in more detail in other sections of this report. EH already incorporates this approach to a limited degree into their project planning activities.

2. Expand upon the M/V Puyallup's operational history of limiting EH annual availabilities. Fully explore and document what the M/V Puyallup is doing onboard to allow the vessel to move to biennial EH lay-ups, and spread her vessel crew maintenance policies and practices to other vessels as possible. It is understood and accepted that not every WSF vessel will be able to eliminate the annual EH Maintenance Facility lay-up periods. This is due to a complex variety of reasons, not the least of which is the general age of the fleet coupled to the fact that M/V Puyallup represents the youngest vessel class in the fleet (Jumbo Mark II). Also, the mechanical/electrical redundancy of the Jumbo Mark II class of vessels provides significant operational flexibility to her crews and WSF.

Nevertheless, every new vessel entering the WSF fleet has the potential, at least during the first 20 (+) years or so of operational history, to minimize VOST spent at EH Maintenance Facility. There are many operational lessons to be learned from the M/V Puyallup and spread to other WSF vessels and vessel classes.

3. Adopt as a matter of policy, (future) vessel designs centered on reliability, redundancy, environmental friendliness, and reduced maintenance and preservation costs. At a minimum, this will include the following:

    a. Increased mechanical/electrical system redundancy. (This is one of the keys to the M/V Puyallup's (Jumbo Mark II's) ability to minimize VOST.)

    b. Aluminum superstructures and specially designed "wet areas."[3]

    c. Advanced coating systems (above and below water).

    d. Staggered/Staged Painting and Preservation Schedules (re-paint the entire vessel over the course of time, as opposed to re-painting the entire vessel during one or two SY availabilities).

    e. Superior grade floor and wall coverings. (customized for longevity).

4. Aggressively review and revise where deemed appropriate, both the intervals for major exterior topside and interior passenger space refurbishments. (In conjunction with this method, initiate operational and procedural changes to obtain current, accurate information with regard to vessel conditions in real time. This might require adjusting existing or establishing new job requirements for vessel crews, Fleet Port Engineers, Preservation Project Engineers, and the new Life Cycle Cost Analyst position, that includes vessel inspections and maintaining the LCCM database. (See also related recommendations found in Ref. 5)

Detailed technical comments and notes related to how this (exterior topside preservation activity) method might be employed by WSF are outlined below:

Topside Painting (Preservation)

Topside painting is split into two distinct parts: (1) Passenger spaces exterior and curtain plates (including and above the exterior waterline) is accomplished on dry dock for environmental reasons and (2) the interior car deck sides, the car deck itself, and all internal spaces can be accomplished dockside.

The period of performance is one of the longest of all preservation items.

[3] This recommendation applies strictly to *future* vessel design. In file number 10048.02 Rev A, "Cost Benefit Analysis for Aluminum Superstructure", The Glosten Associates concluded that changing the superstructure from steel to aluminum for the *existing* 144 auto ferry design is not cost effective.

The current LCCM interval for topside painting is seven years. This presents a problem in that the exterior is tied to drydock availabilities and, therefore, the cycle will be: yr 2, yr 5, yr 7, yr 10, yr 12, yr 15, so the interval will have to be seven then eight, then seven then eight and so on.

Coatings engineers and industry experts have been consulted and, in combination with our own knowledge and experience on the subject, advise the following:

- For decades now, military, ferries, offshore and inland workboat, commercial fishing, and other marine market segments have attacked freeboard and superstructure running rust on a routine basis and with the onboard deck crew. Over the last decade, in certain market segments, a move has been made to contract out the painting, but still the work is done in bits and pieces; rarely is the entire top side taken down to bare metal. That practice in itself is prone to risk. It is frequent that the new paint system is applied poorly and fails, becoming worse than before the "new paint job."
- It is common that the paint system fails in the same areas repeatedly and if the rust can be inhibited, it will be prevented from spreading and making the job bigger.
- In areas where the coating system is failing, only select areas of rust are taken down to bare metal and the paint system built back up. There can be a minor difference in shade of the patch vs. the larger area, but in time, it should blend in.

Current WSF practice is to let the paint system go for seven to eight years, and live with rust and discoloration for most of the seven to eight years. WSF has tried to spot paint the curtain plate and exterior passenger spaces, but had to use maintenance budgets to support this activity, which competes with limited funds needed for other priority maintenance issues. We suggest considering splitting the top side paint job into several steps. Here is how a typical WSF vessel preservation project might look under this plan: (Not applicable to UWILD boats.)

- The entire preservation project spans a 15- year period instead of seven.
- Drydock 1 (yr 2) Clean and Spot blast and paint exterior.
- Dockside (yr 3 or 4) Clean and Spot blast and paint interior car deck.
- Drydock 2 (yr 5) Clean and Spot blast and paint exterior.
- Drydock 3 (yr 7) Clean and Spot blast and paint exterior.
- Dockside (yr 8 or 9) Clean and Spot blast and paint interior car deck.
- Drydock 4 (yr 10) Clean and Spot blast and paint exterior.
- Drydock 5 (yr 12) Clean and Spot Blast and paint exterior.
- Dockside (yr 13 or 14) Blast and paint all interior.
- Drydock 6 (yr 15) Blast entire exterior and paint.

The idea is that you extend the complete job out from 7 years–to 15 years– and use "Clean and Spot" painting procedures to gain the extra life and improve the appearance. This idea and schedule does not take into consideration the advantages that might be available through advanced coating systems.

We have not accomplished the analysis, but it seems logical that there would be an associated savings of VOST assuming the spot work could easily be accomplished within the current three to four week average drydock. We recommend WSF doing a pilot project on a new or newly painted vessel, and we would expect that one complete job would be required approximately every 15 years.

5. Routinely review and evaluate extended availability periods and unanticipated SY change orders that are beyond acceptable thresholds to determine the causes. Change specifications or procedures to reduce the probability of similar occurrences.

6. Increase EH staff and onboard vessel crews' involvements and responsibilities for accomplishing VMP&I efforts while underway, or alternatively during scheduled "daily down-periods". These daily down periods are where the majority of small VMP&I tasks and other small projects, two hours or less, would occur. In addition to making the time in-between scheduled runs, these efforts require good advanced planning and coordination between vessel crews, port engineers, port captains, vessel business staff and vendors. The net result is a reduction in out-of-service time with no noticeable increase in project costs and with minimal reduction in service levels. Black Ball, Pierce County, AMHS and other ferry operators have built these one to two hour down periods into their daily schedules.

7. Expand WSF's participation in the United States Coast Guard (USCG) Under Water Inspection in Lieu of Drydocking (UWILD) program to include the Jumbo Mark II Class. (Discussed in detail in Section 10 of this report.)

8. Expand utilization of "Tiger Team" concept. "Tiger Teams" are comprised of a select, usually small group of EH employees, who are well trained and equipped to make emergency or critical system repairs. We see no apparent reason why this concept could not be expanded to include specific planned projects or repairs across the class or fleet while the ship(s) are tied up, as long as the project could be done during the two to six hours at night while the ship is tied up at their overnight pier. The project/repair/inspection may also be conducive to being broken into two to six hour increments and accomplished over a period of days as well. By carefully planning and incorporating these "preventive" type maintenance or capital repairs into the EH production and vessel schedules where and as appropriate, WSF takes another step away from "reactive" fleet maintenance. This will incrementally reduce the out-of-service time across the fleet, and will increase fleet reliability and readiness.

9. There is a shortage of skilled, qualified marine repair personnel in the Puget Sound region. Occasionally for specific projects and on a short-term basis, it may benefit EH to be able to "scale –up" their workforce. One method of accomplishing this would be for EH to plan, budget, and implement at the start of every fiscal year, an "On-Call" contract

with multiple yards, to provide and deploy short term labor to the EH facility in times of critical need. This would allow EH to procure additional skilled unionized labor within one to two days, as opposed to the two to three weeks it currently takes. (Note: This may require changes to existing bargaining agreements.)

10. For emergency underwater inspections and repairs, consider utilization of pre-qualified, in-situ vessel repair companies such as Global Diving and Salvage Inc. or HYDREX® as an alternative to drydocking. To gain the most benefit from this approach, contractual issues should be resolved in advance of the necessary repairs, along with identification of applicable repair categories and tasks specific to each vessel class. Examples of inspections and repairs that fall into this category include all forms of underwater surveys and inspections, hull cleaning, CPP blade and seal repairs and replacements, fixed propeller repairs, rudder repairs (all types), stern tube seal repairs or replacements, hull steel repairs, and more.

Section 2 Reducing VOST by Consolidating EH and SY Work

One vessel maintenance strategy employed by WSF and the EH work force, is to have select EH crews travel to various Puget Sound SYs during the vessel's planned availability, and perform work alongside the commercial SY's employees. It is important to consider the benefits and limitations of this practice.

2.A Reducing VOST via Managing Critical Paths

The main premise of this issue, as defined in the heading above, needs to be clarified especially with regard to the idea that somehow EH employees working alongside SY employees will decrease the SY availability duration, and, therefore, reduce VOST. EH employees working on work scopes will not shorten the duration of a SY availability. The reality of this issue is that only by decreasing the duration of the SY project's critical path, will the SY availability be shortened. If the SY project's critical path is not shortened, then no amount of consolidated work outside of the critical path issues will result in a shortened yard period or reduced VOST. (See also Sections 7 and 8 for more on the issue of critical paths.)

The noted deviations to this are explained as follows. If EH personnel or vessel crew accomplish work that would either (a) prevent, or significantly delay with no added time penalty, the vessel from having to visit EH, or (b) if the work being accomplished during the SY availability will eliminate, shorten, or correspondingly change the EH lay-up period critical path, then VOST will be reduced. This is an important reality to acknowledge, focus on, and incorporate into WSF's maintenance planning and philosophy: Only by shortening the critical path of ongoing or future maintenance, preservation and/or improvement work scopes will VOST be reduced. The other deviation to the importance of the critical path concept discussed above, of having EH personnel working inside commercial SYs, is of course related to EH personnel accomplishing preventive and predictive maintenance activities that are either due, or need to be accomplished. Deferring these events beyond their due dates incurs an operational risk that may result in increased VOST. In other words, even if these VMP&I activities are not on a critical path, if they are due during the SY availability period, they should be accomplished.

Beyond the critical path issues discussed above and elsewhere in the VMPIP, work scopes that offer the most significant opportunities for efficiency, reduced costs, and reductions in VOST, include the following:

- Main and Auxiliary Engine Overhauls and Repairs.
- DC Motor Commutator Inspections/Repairs.
- Electrical Systems Inspections and Repairs.
- Other Vital System maintenance events that are either due or will be due before the next scheduled SY period.
- Preparations for USCG Annual Inspections.

Other benefits and good reasons exist for having EH personnel or vessel crew accomplish vital and/or critical path maintenance and preservation work scopes. At a minimum, these reasons include the following:

- Familiarity with the vessels and systems. In house retention and sharing of vessel technical information reduces the cost and lost productivity associated with training and educating SY personnel and their vendors, and all this should translate into higher production efficiency with specific tasks.
- Potential for reduced VMP&I costs (on many types of projects) due to both efficiencies and lower hourly rates for skilled personnel.
- Enhanced Operational Flexibility for WSF. (WSF has more direct control over the timing and extent of work scopes.)
- Potential for "pre-packaged/pre-staged tool and parts kits", a hallmark of efficiently planned maintenance operations. (EH currently incorporates this practice into their operations.)

Potential negatives associated with this same practice are as follows:

- Increased requirements for direct WSF supervision of vessel crews and/or EH personnel.
- Higher maintenance costs, particularly for non-vital system work items (in effect "low priority make-work items" that allows for balancing work loads of EH personnel) and/or tasks that are outside the core competencies or efficient capabilities "comfort zones" of EH personnel.
- Vessel crews may delay performing PM items, knowing that the vessels are scheduled for upcoming SY availabilities.

2.B Barriers to Utilizing WSF Personnel inside Commercial SYs

SY imposed barriers to consolidating work traditionally accomplished exclusively at EH, with EH personnel and/or ship's crews while the vessels are in commercial SYs, are well defined and understood by all parties. This practice is literally as old as the marine industry itself and is generally accepted almost everywhere, but on a very limited basis. Of the Puget Sound SYs surveyed, 100% expressed some degree of "reluctant dissatisfaction" with the concept, yet almost all (seven out of eight) acknowledged that they do allow some degree and types of work to be performed either by the vessel crew or, in this case, EH personnel.

There are numerous, hard and fixed limitations on the degree of cooperation and types of work scopes that can be expected from SYs in this regard. We believe that environmental, economic, security, liability, insurance, and other hard constraints will continue to drive limitations on this issue, even beyond where they are now. SYs are in business to sell skilled and semi-skilled labor, and every labor hour they agree to give up, represents a likely reduction in profit. At present, all issues have reasonable work around solutions, but all must be discussed, negotiated, and terms understood, accepted and communicated up front between the parties. Contractual binding agreements, well-defined responsibilities, good and continuous communications, and good production planning and supervision are all keys to mitigating all the barriers associated with this practice.

A listing and brief description of some of the most significant barriers to this practice is as follows:

- Production Planning: Safe and efficient production planning is critical to the success of commercial SYs. The introduction of outside work crews directly into the heart of a SY's normal operations, adds complexity to this already difficult and key operational necessity. (In all instances, there is language in WSF's contracts with commercial SYs that allow work by vessel crews and/or EH personnel on a "not to interfere basis".) More and better-advanced job planning, supervision, and execution is typically required to mitigate this barrier. The addition of this owner requirement has the potential to increase a project's overall cost and extend the schedule.

- Hot Work, Scaffolding Work, Work from Man Lifts, and Painting: In addition to impacts on the production schedule, the liability and risks associated with these general work scopes are almost universally not acceptable by commercial SYs. Except for a very limited amount of isolated painting, not a single SY surveyed indicated they would ever allow any of these work scopes to be accomplished by vessel crews or other outside contractors, such as EH personnel, on a routine basis. **NOTE**: All of the SYs surveyed routinely allow specialized contractor and vendors to accomplish these types of work scopes. When they do, the vendors come in as fully insured and bonded subcontractors to the SYs themselves. All legal issues are resolved in advance under the SY's broader contracts and legal department procedures, and all this work carries monetary mark-ups that are passed on to the vessel owners as negotiated in advance.

- Union/Non-Union Personnel: A complete discussion of union issues and their impacts to WSF operations is beyond the scope of this report, and fortunately, this is mostly a non-issue with the various Puget Sound SYs and their management teams. Nevertheless, this remains an issue that must be addressed and managed by both parties prior to and during the performance period.

- Security Access: Access to all SY and pier side facilities is now restricted by federal laws and is being increasingly enforced. This issue presents the SY with multiple layers of added costs and causes for concern, such as perimeter fences and limited access points, access badges, security personal to monitor entering and leaving personnel, and more.

- Safety: SYs are noisy, dirty, dangerous places. There are sparks flying, vehicles moving, cranes and other equipment moving heavy weights both on the ground and overhead; slippery walkways, chemicals, deadly environments (tanks), tripping hazards, etc. in effect, a risk manager's nightmare.

- Work Warranty: Like production planning, this issue can impact or be impacted by other ongoing work scopes. To help mitigate this issue, it is necessary to define in advance of work being accomplished, where each party's responsibility and work guarantees begin and end.

- EH Personnel Local Travel: Depending upon the distances involved, there are either minor or significant potentials for added costs and lost productivity associated with travel to/from the SY to perform the work.

2.C Options for Mitigating Barriers Between EH Staff and SYs

Options for mitigating the barriers, noted previously, include the following:

- **Specialized, Limited, Well-Defined Project Work Scopes**: As noted above, there is a select group of specialized tasks and work scopes that WSF personnel are better trained and equipped to handle than commercial SY personnel. These works scopes can be easily communicated to, and will usually be accepted by, commercial SYs. Provided these work scopes do not impinge on the safety, liability, insurance, and warranty barriers discussed previously, they can usually be successfully dealt with. (As stated previously, WSF's SY contracts typically contain language pertaining to work accomplished by vessel crews / EH personnel, on a "not to interfere basis". This contract feature partially mitigates some of these barriers, but it also significantly limits the extent of work that WSF or EH crews can engage in while the vessels are in commercial SYs.

- **Negotiation Strength via Large "Master" (Class Specific) Contracting:** If WSF were allowed to award comprehensive, master contracts for large blocks of work, let's say defined predominately by identical types of work or by vessel classes, this could provide WSF with a strong position to better negotiate the mitigation of many (but not all) of the aforementioned barriers. For specific work scopes such as drydocking and underwater hull work, this master contract approach might also allow for a division of work (between the SY and WSF maintenance crews) that is less restrictive on WSF than the current "not to interfere basis" contracts.

- **Terminal/Pier Side Contracts:** Many Puget Sound SYs have pier and/or terminal space available for owners to work on their vessels. These spaces are typically on the edge of the SYs, still accessible by mobile cranes and other SY services, but just outside the SY boundaries. Special negotiated contracts with these owners allow the SYs significant relief from many of the traditional barriers associated with this practice. This risk doesn't go away, it transfers to the vessel owners. An added benefit to vessel owners is that all standard SY services and capabilities are readily available, including crane services, machine shop services, and additional SY personnel literally available within minutes, should they be needed.

- **Split Work Scopes:** On a "not to interfere basis", this practice is already in use by WSF.

In summary, while there are both opportunities and good business and operational reasons for consolidating (traditional) EH work scopes into and during commercial SY availabilities, there are also definite and restrictive limitations. Accomplishing work scopes involving hot work, steel replacement, steel preservation, (large) piping system refurbishments, extreme heights, and all underwater hull work, inside Puget Sound commercial SYs, is unlikely to ever be allowed. At the same time, it is very cost efficient, as explained in greater detail in subsequent sections of the VMPIP, for WSF to utilize their own skilled employees for specific and select work scopes while vessels are undergoing work at commercial SYs. This practice has the potential to reduce VOST when planned and managed properly, and in accordance with shortening or otherwise changing the critical paths associated with VMP&I projects.

Conclusions:

Section 2.A

- There are advantages to having EH employees working on WSF vessels inside of commercial STs, but reducing VOST is not necessarily one of them.
- EH employees working on work scopes will not shorten the duration of a SY availability. The reality of this issue is that only by decreasing the duration of the SY project's critical path, will the SY availability be shortened. If the SY project's critical path is not shortened, then no amount of consolidated work outside of the critical path issues will result in a shortened yard period or reduced VOST.

Sections 2.B & 2.C

- There are strict fixed limits on the extent that WSF personnel will ever be allowed to work on WSF vessel's while inside commercial SYs.

Recommendations:

- Continue the practice of utilizing EH workforce inside commercial SYs, but only when it accomplishes one of the following goals:
  - Accomplishes a vital system maintenance event that is either overdue or due before the next scheduled yard or EH availability.
  - Eliminates the need for removing the vessel from service in the immediate future.
  - Reduces the critical path for an upcoming EH lay-Up period.
  - Eliminates or mitigates a potential vessel scheduling problem or EH work force scheduling problem.

Section 3 Review and Assess the $120K Project Threshold Established for Utilization of State Work Forces

The current threshold of $120,000 is on a per project basis and includes both fully burdened labor and material costs. (For purposes of this analysis, the term "material costs" includes all machinery, parts, equipment, or other materials rented, purchased, and/or supplied by WSF.) NOTE: Although the $120k threshold (upper limit) authorized by the legislature for utilization of state work forces on public works projects applies to all types of public works projects, the review and assessments accomplished by EBDG on this task for the VMPIP reference Capital Projects only.

3.A Compare Similar Projects Accomplished by EH vs. Independent Contractors

The original work scope for this section of the VMPIP required that we…. "*Identify and contact appropriate WSF managers, vessel preservation staff, and/or WSF bookkeepers who will be able to (a) identify projects that contain similar elements, and (b) provide or otherwise "tease out" data from past projects that will allow a reasonable comparison of state forces versus out-sourcing."* Parts of this task overlaps with the research and efforts accomplished in Section 4 of the VMPIP. As discussed in Section 4, specific project data was not available that would allow for direct head-head comparisons of performance between EH and independent contractors. At the same time, we obtained and reviewed considerable job cost information and data from both EH's and WSF's project and budgeting records. Below, we have made assessments on the $120K threshold amount based on our review of this data and our collective industry expertise. Please see Section 4 of the VMPIP for further analysis of this issue.

3.B Allocation of EH Project Costs

The original work scope for this section of the VMPIP required that we …." *Look at the basic costs for labor, overhead, and materials between EH projects and commercial projects to understand how project costs at EH are allocated."*

As with Section 3.A above, this issue is reviewed and discussed in detail in Section 4 of the VMPIP.

3.C Assessment of Current $120K State Work Force Threshold for Public Works Projects

For the current biennium period (effective March 15, 2010 and expiring June 30, 2011), and on a trial basis, WSF and EH have been granted authority to utilize state work force resources for public works projects up to and not to exceed $120K. The previous threshold was $60K and had been in effect since July 1, 2005, at which time the old threshold ($50K) was abandoned. In the schedule of VMP&I activities section of the VMPIP, we document the annual shipbuilding rates of inflation since 1981, and projected out to the year 2020. Quoting from that section…"*Although it is difficult to predict what inflation will be in the future, it is well understood that shipbuilding inflation has typically been higher than GDP inflation for the last 30 years."*

In FY 2000, the average commercial SY straight time labor rate for Puget Sound SYs was $53/hr. Today, that same average labor rate is $69.95/ hr. In some specific instances, the cost of

marine materials, equipment, and systems has increased over these same years at an even higher rate than the *average* inflation indices noted above. It is not at all uncommon for commercial SY projects, for vessel's equivalent in size to the average WSF vessel, to incur daily expenditures between $10k and $15k, for labor alone. (For extensive, intensive, and well-planned projects, the daily labor expenditure can and does go up to $25k - $30k. for comparable sized vessels) At current labor rates, a $15k daily expenditure equates to two daily shifts with approximately 12 SY employees working each shift, plus miscellaneous materials and SY services. Common commercial industry practice is to only incur maintenance or capital project induced VOST when absolutely necessary, driven by regulation, because of emergency or market demands. In all instances, the goal for both the SY and the vessel owner is to work as quickly and efficiently as possible, so that the vessel can be returned to service as soon as possible. Doing this requires considerable planning, and typically, considerable daily expenditures.

Given that the $120k threshold was just put into place four months ago, it is not surprising that EH has yet to accomplish any single capital project that approaches the $120K threshold. Information obtained through interviews with EH management indicates that 12-15 people would be a comfortable and manageable upper limit of labor to apply to a single project at any given time. The 15-person guideline applied to a single project at any given time translates roughly to $5.3K/day in billable labor, or $26.5K/week. This does not include travel, penalty, or OT pay, nor does it include materials.

For large public work projects involving new (or completely rebuilt) machinery and equipment, material costs typically represent a higher percentage of overall project costs than they do for traditional maintenance projects. For these type projects (involving new engines, generators, switchboards, rescue boats, davits, radars, etc.) material costs often approach 40%-50% or more of overall project costs. Given that EH labor costs could reach $26.5K/week for a single project, and given that equipment and material costs for large capital projects can reach an equivalent magnitude, the current $120K threshold level seems reachable and reasonable. At the same time, a review of recent EH capital projects (Appendix E) shows that the capital projects EH have been involved with are all well below the old $60K threshold.

Given that EH does not have a drydock and thus are not equipped to handle large exterior shell or underwater preservation projects, the crafts that would most likely be involved in vessel projects in excess of $100K are machinists, electricians, and pipe fitters, or some combination of the three. Our recommendations with regard to the new trial $120K threshold are as follows:

- Do not make any changes with respect to the $120K threshold at this time. Allow more time to go by and opportunities to present themselves to EH.
- When bidding on large public works projects, EH should plan on and budget for assigning at least a part time, maybe full time, experienced project manager to manage the project.
- EH should not bid on large projects that do not match up well with their core competencies and capabilities. Their first $120K project should not be in an area outside their core competencies and should not be a "strain" to accomplish.

3.D Limits on EH's Ability to Reduce VOST

Without EH, WSF would not be able to provide the level of service it does to the citizens of Washington State. Without EH, VMP&I costs for the WSF fleet would be higher than they currently are. Without EH, WSF's VOST would likely increase, possibly beyond an acceptable level, which would either require a reduction in service level or additional vessels. Given all this, WSF would survive and operate without EH, but it would definitely be a different organization. As much benefit as EH obviously provides to WSF, EH has some well understood, inherent limits to its capabilities and these limitations translate into limits on its ability to (a) hold down VMP&I costs, and (b) reduce VOST. These well understood, fixed limits include the following:

- No drydock.
- (Extremely) limited topside painting capabilities.
- Limited availability of skilled marine repair tradesmen (Puget Sound Region).
- No full service machine shop. (No propulsion shafting component capabilities.)
- No Crane Services beyond a medium sized boom truck.
- Neighborhood politics, noise, and other environmental restrictions that significantly limit EH's available operating hours.
- Little to no ability to affect durations of commercial SY availabilities.
- WSF's policy for no VMP&I work in public view during vessel in service operating hours.

At the same time, EH's current and potential abilities to positively impact (reduce) VOST has been extensively documented throughout the VMPIP (see Reference Summary Review – Reference 7, Recommendations 17 & 18 and other reference summaries; Sections, 1, 2, 8, 9, and others).

Recommendations:

Section 3.A

- WSF and EH put into place the necessary processes and procedures that will allow data to be accurately captured and easily shared, that will allow direct comparisons of similar capital projects accomplished by EH and independent contractors.

Section 3.C

- Do not make any changes with respect to the $120K threshold at this time. Allow more time to go by and project opportunities in this size range to present themselves to EH.
- When bidding on large capital projects, EH should plan on and budget for assigning at least a part time, maybe full time, experienced project manager to manage the project.

- EH should not bid on large capital projects that do not match up well with their core competencies and capabilities. Their first $120K project should not be in an area outside their core competencies and should not be a "strain" to accomplish.

Section 4 Comparisons Between EH and Commercial SYs

In this section of the VMPIP, we were tasked with benchmarking EH's labor efficiencies and cost structure against other public and commercial SYs. To accomplish this, we interviewed management personnel from four Puget Sound SYs currently utilized by WSF. We also interviewed management from several privately owned marine diesel engine service contractors, as well as management from three other ferry operators (public and private), and a work boat fleet operator. The ferry and workboat fleet operators interviewed also manage and operate either SYs, vessel maintenance organizations, or terminal maintenance organizations. Note that the information received from the participating companies is sensitive and proprietary. We have used their information in the VMPIP, but have maintained the confidentiality of the companies at their request. Four other Puget Sound SYs were solicited, but declined to participate in this effort.

4.A Cost Structure Comparisons - Commercial SYs vs. EH

Table 4.A.1 below provides a detailed breakdown of labor rates and material mark-ups for various Puget Sound SYs, compared to the fully burdened labor rates of EH.

Table 4.A.1 – Ship Yard Labor Rate Comparison

Puget Sound Shipyards	Straight Time	Over Time	Dbl Time	Material Mark-Up	Date of Data	References & Comments
Eagle Harbor Maintenance Facility 2010	**$51.97**	**$69.22**	**NA**	**NA**	**2010**	**(*See Final Note below.)**
Puget Sound Shipyards (2009 average) ***Commercial Rates***	**$69.95**	**$100.55**	**$123.45**	**20%**	**2009**	**(*See Final Note below.)**
Ship Yard No. 1	$69.00	$103.50	$138.00	15%	Jan-09	Plus $2.00/Hr for Consumables
						(Nuts, bolts, rags, tape, etc.)
Ship Yard No. 2	$64.00	$96.00	$128.00	15%	Jan-09	
Ship Yard No. 3				20%		
Inside Machinists	$73.50	$104.00	$113.50		"	Shafting fabrications, pump parts,
Outside "	$71.00	$101.50	$111.00		"	Diesel engine repair and other items
All Other Crafts	$69.00	$99.50	$109.00		"	
Ship Yard No. 4	$72.00	$96.00	$128.00	20%	"	Double time after 8 Hrs of OT
Ship Yard No. 5				15%	"	
First Shift	$65.00	$89.00	$103.50		"	
Second Shift	$67.00	$92.00	$105.50		"	
Ship Yard No. 6				33%	"	
Inside Mach, Caulkers, Electricians	$77.00	$116.00	$154.00		"	
All Other Crafts	$72.00	$108.00	$144.00		"	

In 2009 dollars, a typical average breakdown of Puget Sound SY's straight time hourly billing rates consists of the following:

- Employee Wages - $25.18/hr. → 36%.
- Employee Benefits (health insurance, vacation pay, holiday pay) - $9.23/hr. → 14%.
- Additional Overhead "Burden" (rent, utilities, insurance, permits, administrative and non-billable employee salaries and benefits, M&R of the facility and its equipment) - $27.98/hr. → 40%.
- Profit - $7.0/hr. → 10%.

All of this totals up to 100% of the straight time billing rates, which is approximately $69.95/hr.

In 2010 dollars, EH's straight time rate charged to WSF consists of the following: (*See final note below.)

- Employee Wages - $26.55 → 51%.
- Employee Benefits $17.70 → 34%.
- EH Overhead - $7.72 → 15%.

Table 4.A.2 below provides direct comparisons of SY cost structures, based on a percentage of billable straight time rates.

Table 4.A.2 SY Cost Structures as a % Function of Billing Rates

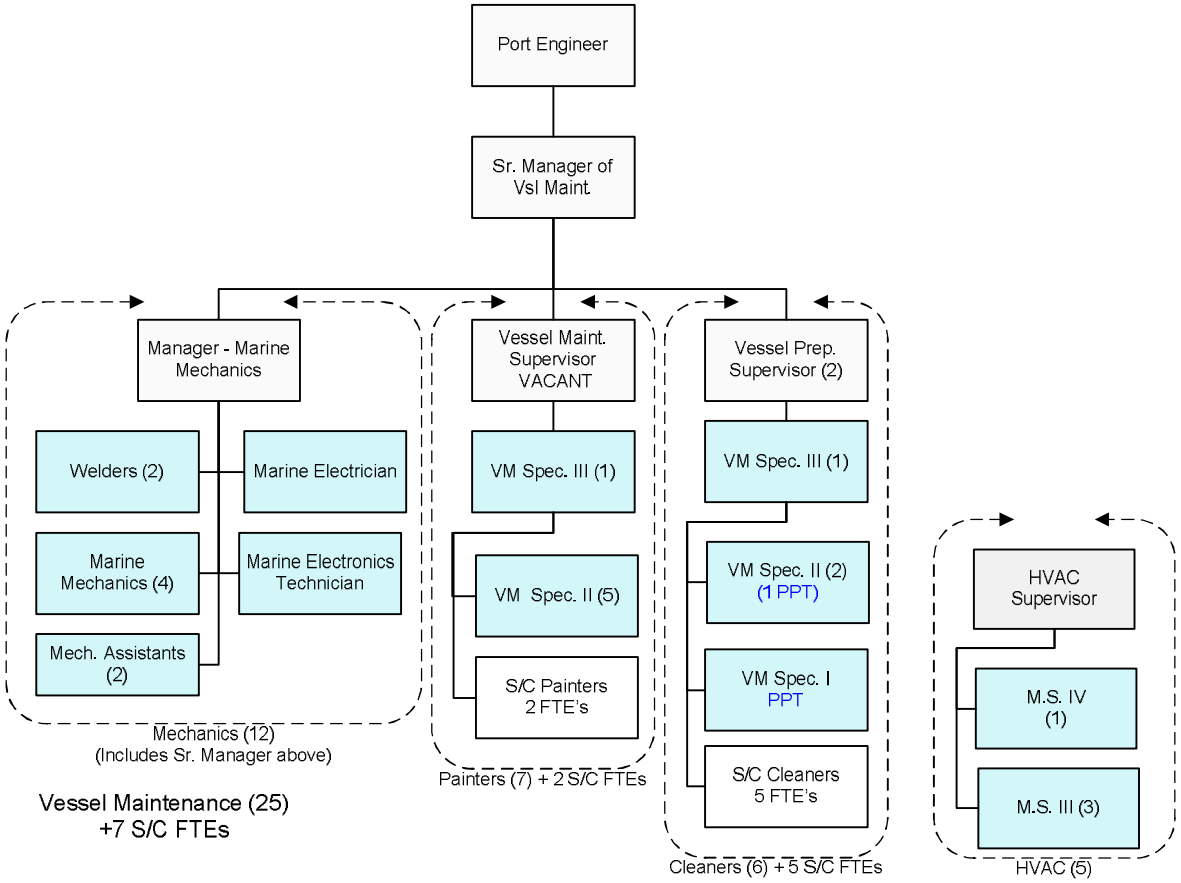
SY Cost Categories	Hourly Employee's Wages	Hourly Employee's Benefits	Overhead; (+) misc. materials, parts, inventory, tools, & consumables	Profit
SY / Maint. Org.				
Eagle Harbor	51%	34%	15%	Not Applicable
Puget Sound Ship Yard A	50%	8%	38%	4%
Puget Sound Ship Yard B	48%	15%	29%	8%
Public Ferry Operator No. 1's Maintenance Organization	57%	31.5%	13.5%	Not Applicable
Puget Sound SY Average	36%	14%	40%	10%

Section 4.A Final Note: EH's fully burdened hourly rates are calculated based information provided by both EH management and WSF's budget office personnel. (Some of this information is found in Appendix E.) EH's cost structure data is based on 2010 figures, while the commercial SY data is from 2009. EBDG believes that 2010-2011 commercial SY billing rates for Puget Sound Shipyards has increased approximately 6.5% above the reported 2009 levels. While we are confident that this increase has occurred, we could not confirm or quantify this prior to final release of the VMPIP. The analysis and comparisons of sections 4.A and 4.C are conservative, in that they compare 2010 EH hourly cost structures with 2009 commercial Puget Sound SY hourly cost structures.

4.B Organizational Structure Comparison – EH vs. PFOs No. 1 and No. 2

For comparative purposes, we have provided a chart (4.B.1) depicting the organizational structure of the maintenance workforce for Public Ferry Operator (PFO) No.1. This operator's fleet consists of five vessels (slightly larger) in size to WSF's Evergreen State class vessels. It should be noted that the vessels in this fleet are generally newer than WSF's boats, and the routes tend to be longer in duration and thus fewer in number compared to WSF levels of service. The maintenance organization for this ferry operator and the fleet itself is about 20% the size of EH.

Chart 4.B.1 Vessel Maintenance Organizational Chart



A staff comprised of 25 vessel maintenance personnel, and five HVAC employees performs maintenance functions for this fleet. The 25 vessel maintenance personnel report to a single Port Engineer and are comprised of three units: 1) mechanical, 2) maintenance, painters, and 3) cleaners. (The five HVAC personnel report to a separate manager and a separate division from the primary vessel maintenance group.) This HVAC unit also provides HVAC services to shore side equipment, and the cleaning unit also cleans shore side facilities and terminals. Various unions represent all non-supervisory marine maintenance personnel including the Marine Engineers Beneficial Association, who also represents their marine crews. The International Union of Operating Engineers, who also represents their food and retail staff and the rest of the terminal maintenance staff, represents the painters, cleaners, and HVAC personnel

who are non-supervisory. The marine crews augment cleaning, painting and mechanical support to some extent.

Annual budgets for each craft (labor and operating expenses) are as follows (this does not include capital costs):

Craft	2010 Annual Operating Budget
Marine Mechanical	$1,500,000
Painting	$600,000
Janitorial	$420,000
HVAC	$320,000
Total	$2,840,000

The budgets listed above support annual maintenance to a fleet of five, subchapter H, ropax vessels with nominal capacities of 100 passenger vehicles and 800 passengers each. Berthing facilities include two working slips at each terminal, and four maintenance slips (total). No drydocks are owned or operated by this organization. The vessels are typically drydocked at SYs located less than ten nautical miles of their home terminals.

PFO No. 2 has an almost identical pier side maintenance organizational structure to PFO No.1. The largest difference between the two lies in the nature of the work scopes accomplished. PFO No. 1's fleet is considerably smaller (roughly 50%) than PFO No. 2s, and is engaged more in both reactive and PM activities. PFO No. 2's maintenance workforce is comprised of approximately 25 trades people assigned to do primarily "reactive" maintenance. (NOTE: PFO No. 2 is actively engaged in building up their vessel maintenance work force, and shifting their primary workloads from reactive to PM.)

The basic make-up of both these PFOs' work forces largely parallels each other, and there are similarities with EH as well. For example, all three PFOs work forces have considerable capabilities in the vital system areas of diesel engine machinists, electricians/electronics technicians, and pipefitting. All three PFOs' fleets are also well supported in the areas of cleaning, painting, and general maintenance. Please refer to Appendix E for a high-level organizational chart of EH.

4.C Comparison of Primary Performance Benchmarks - EH vs. Contractors

The goal for this section of the VMPIP was to evaluate and compare the primary performance benchmarks, project costs and VOST horizons, between events utilizing EH staff and/or facilities

compared to outside contractors. Unfortunately, no data could be found that would provide a direct head-to-head comparison of actual past identical events being performed by both EH and commercial SYs or contractors. At the same time, based on our knowledge of EH, commercial SY and independent contractor billing rates, coupled with our marine repair industry experience and expertise, we are able to provide assessments in this area.

As shown in Table 4.A.1 above, EH's fully burdened labor rates provide it with cost advantages over commercial yards when biding and accomplishing WSF work. This assessment does not take into account the added efficiency afforded by EH's familiarity and "local knowledge" of the WSF fleet and their systems. Vessel and equipment familiarity efficiencies aside, one hour of commercial SY labor is roughly equivalent to 1.33 hours of EH labor (in EH). Therefore, for every eight hours of SY straight time labor, the equivalent straight time labor at EH is 10.6 hours. (See the section 4.A **Final Note** above, and impacts of penalty and travel pay below.)

This labor cost advantage is even greater when comparing vital systems maintenance and repair work between EH machinists and electricians, and independent commercial service companies. The data in Table 4.C.1 below compares 2010 commercial rates for three separate marine diesel engine service companies, with 2010 EH machinists' rates. (The rates below do not include added travel and per diem rates, which typically apply to outside contractors. The general rule of thumb for independent companies is that jobs are estimated and bid at "cost + 20%," for travel, per diem, lodging, and other expenses.)

Table 4.C.1 Comparative Marine Diesel Service Machinists Rates

	ST $/hr.	**OT$/hr.**
Marine Diesel Service Companies / Entities		
Eagle Harbor Machinists	$51.97	$69.22
Kirby Marine	$103	$155
Hatton Marine (non-OEM certified on EMD engines)	$89	$133
Valley Power Systems (OEM certified on EMD engines)	$110	$130

It is easily seen from the chart, that EH's machinist hourly rates are less than half those of independent contractors. Typical 40K hour overhauls of 5,000 HP main engines (WSF Issaquah Class) average 450 (+) man-hours per engine, which translates to an average savings of approximately $50K (+) per vessel/per 40K hour overhaul.

Penalty pay (including "dirty pay") negatively affects the positive labor hour differential metric for EH. For FY 2010, penalty pay for EH's hourly employees totaled approximately $100K. (Commercial SYs queried about "penalty pay" confirm this to be so insignificant a value that it is not tracked or measured, and is only rarely passed on to their clients.) The additional cost of

$100K effectively raised EH's fully burdened 2010 straight time rate by $0.49/hour. ($100k/202,391 man-hours = $0.49/man-hour)

Travel pay has an even more noticeable impact on the productive efficiency of the EH work force. In FY 2010, travel pay for EH personnel amounted to roughly $900K, and similar to penalty pay, raised EH's effective straight time billing rate approximately $4.45/hour. ($900k/202,391 man-hours = $4.45/man-hour)

NOTE: This travel pay assessment is based on the fact that every hour spent by an EH employee traveling to a vessel, is an hour not spent working on the vessel. While it is true that commercial SY's employee's out into the field to perform services on vessels, this is a relatively rare occurrence, and an insignificant part of their total revenue stream.

The cost returns and labor/materials breakdowns for several representative EH jobs are listed in Appendix E.

Comparing VOST horizons as impacted by the use of EH vs. outside contractor work forces is highly dependent upon the individual maintenance event situation. All Puget Sound SYs are faced with similar skilled labor limitations and constraints. EH's size establishes them as a "second tier" SY. The majority of Puget Sound SYs are also "tier 2" yards. The only commercial, tier 1 SY in Puget Sound is Todd Pacific Shipyard, and even they are constrained at times by the availability of skilled tradesmen. EH's other environmental constraints on productivity are discussed in detail in Section 3 and, in numerous sections throughout the VMPIP, and we have addressed the overriding issue of work scope critical paths as it relates to and affects VOST. VOST and project/task costs are usually inversely proportional to each other, but this is not to say that you can reduce VOST in all instances simply by spending more money. Our conclusion with regard to this issue is that there are many projects, times, and situations when the use of the EH work force will result in a reduction of VOST, when compared to using a contractor's work force. There are also projects and situations that will yield the opposite results. Through our interviews with EH management, we learned that EH places an internal upper limit of approximately 12-15 employees engaged in any one single task on any single project. Critical paths aside, projects or tasks that would require more than this number of employees to be engaged in a single task, should probably be conducted by contractors that are qualified and capable of meeting the level of effort required.

4.D Emergency Return to Service of a Vessel Undergoing an EH Lay-Up

This issue has been extensively reviewed and discussed earlier in the VMPIP. (See Background Document Summary Review, Reference 6: Auto-Passenger Vessel Sizing / Timing – Final Report – April 2009, Recommendation #4.)

Conclusions:

Section 4.A

- All other factors being equal, the EH maintenance facility's hourly rates (EH = $51.97; Puget Sound SYs = $69.95 – See Section 4 and "Final Note" 4.A), zero mark-up on

materials, familiarity with the vessels and vessel systems, and 24/7/365 on-call availability provides WSF significant value relative to other Puget Sound SYs.

- Ø EH's cost structure is very much in line with the PFO No. 1.
- Ø EH's overhead costs as a percentage of billing rates are roughly half that of most of the SYs questioned. The primary reason for this low overhead percentage is EH's relatively high ratio of hourly to (salaried) supervisory personnel.

Section 4.B

- Ø EH's structure and size is similar and proportionate to other PFO's examined.

Section 4.C

- Ø Annual average travel and penalty pay effectively reduces the labor rate differential between EH and commercial SYs by approximately $4.94/hr. (For projects involving combined and/or extensive travel and penalty pay, it is possible that VMP&I tasks performed by EH personnel could completely erase the value added differential.)
- Ø Diesel engine maintenance and repair and electrical system/component maintenance and repair work scopes represent the two most critical skill sets that are in highest demand by WSF vessel crews, followed closely by the pipe fitters, and are the areas where EH personnel provides significant value to WSF. Not coincidentally, expert proficiency and resource capability in these three areas contribute heavily to the admirable, industry leading level of safe and reliable service WSF provides the citizens of Washington State (See Reference 11).

Recommendations:

Section 4.A

- Ø EH should fully identify, track, and manage both their employee benefits and overhead costs separately.
- Ø WSF and EH should identify the primary causes for penalty and travel pay, and work toward reducing the causes of both.

Section 5 WSF Personnel Vessel PM Responsibilities

One of our tasks in developing the VMPIP was to review and understand both the scope and range of maintenance activities performed by vessel crews and EH personnel. We were also tasked with researching recent trends indicating that vessel crews are creating more and different types of work requisitions for EH, than was typically performed by crews in the past.

This section of the VMPIP incorporates and combines information obtained from interviews (shore side VMP&I managers and vessel crews) with reviews of typical work scopes routinely accomplished by vessel crews and EH personnel, while vessels are operating or tied up and/or out-of-service and inside commercial SYs. Analyses of this information were used to arrive at several conclusions and recommendations concerning vessel crews and PM activities.

5.A WSF Crew Vessel PM Responsibilities

WSF crews, both deck and engineering, are the first line of vessel and system maintenance for the fleet. In addition to other vessel operational duties, the crews provide daily cleaning, minor mechanical and electrical maintenance and repair to systems and equipment, as necessary, for the continuing operation and safety of the vessel, passengers, and other crew members. Vessel crews also accomplish both periodic manufacturer required lubrications and inspections, as possible, of vessel systems, equipment, machinery, and structure. Due to the vessels' near continuous operating schedules, with most vessels operating between 18 and 22 hours per day, VMP&I activities, especially the required preservation and improvement activities, are severely restricted by available time. There are potential safety (passengers and crew), liability, and collective bargaining issues (such as penalty pay, dirty pay, over time, union jurisdiction and separate safety issues, etc.) associated with many traditional VMP&I activities. Standard WSF management policy is to not allow vessel maintenance activities in areas that are visible to the public.

The almost universal consensus from the interviews is that most of the vessel crews are accomplishing the vast majority – almost all – of the PM type work orders that are created and managed through the fleet's CMMS. (See Appendix F for examples of PM work orders generated through MPET & PM At-a-Glance.) Furthermore, accomplishing any significant amount of preservation work while underway is believed to be impractical and, in some cases, nearly impossible and dangerous. We generally concur with these assessments. Vessel PM reports and schedules show there are a significant number of daily and other regularly scheduled PM type work orders generated and accomplished by the crews, and only a very small percentage of these are eventually passed on to and handled by EH personnel. The ones that are handled by EH, for the most part, either require specialized expertise, special tools, systems to be shut down, or more time to accomplish than is available during the course of daily operations.

This reality and the potential for some vessel crews to handle almost all PM activities by themselves, is exemplified through the mostly biennial EH lay-up schedule currently utilized by M/V Puyallup. Through a pilot test program initiated within WSF, the M/V Puyallup has significantly reduced the need for and duration of annual lay-ups at EH, and has its sights set on biennial EH lay-up periods exclusively. The M/V Puyallup and her sister vessels benefit indirectly in this respect from their redundant propulsion machinery and flexible machinery arrangements, but clearly the M/V Puyallup's crews (with limited assistance from traveling EH

personnel) are accomplishing all PM work orders either while the vessel is operating and/or during its nighttime lay-up period.

At the same time, we believe that not all PM type work orders that could be accomplished by all the vessels' crews, during the normal course of daily operations, are being accomplished. Current standard operating procedure is for certain members of WSF vessel engine room crew, in some cases an entire engine room crew complement, to travel with the vessels to all EH and commercial SY availabilities, and accomplish a list of work scope items during the VOST. We reviewed several recent examples of combined crew/EH VOST work scope task lists and based on these examples, our professional opinions, and direct firsthand experience, note the following:

- Roughly 25% to 30% of the crews' shipyard work scope tasks could have been, at least in theory anyway, accomplished during daily operations, between sailings, or at night while the vessels were shut down for maintenance.
- A notable percentage of the vessels' crews work scope tasks, while in commercial shipyards or at EH, involved diesel mechanics, electricians, and/or pipe fitters. A slightly smaller, but still significant, percentage of the work scope tasks involved EH assistance to the crews with equipment and system inspections, and/or preparing for USCG annual inspections.
- Roughly 50% to 65% of the vessels' shipyard work scope tasks involved assists from EH diesel mechanics and electricians.

5.B Vessel/Class Differences in Crew Responsibilities With Respect to Vessel PM Activities

One goal of this effort was to try to identify patterns pertaining to the type and magnitude of maintenance work scopes between vessels of the same class, and/or between classes of vessels. Very few specific or detailed facts pertaining to this issue emerged from the interviews; However, while no vessels or personnel were singled out, the interviews did confirm the general knowledge that certain crews do accomplish a broader range and level of PM items than other crews. With the loss of the Steel Electric Class and the passenger only ferries, EH has seven fewer vessels to maintain, and some crews have capitalized on the increased availability and expertise of the EH work force to take on more of the maintenance activities historically handled by vessel crews. In part this can certainly be attributed to different skill sets and experience among crews; the nuances of different vessel schedules and hours of operations; differences in vessel ages and base conditions; and differences in crew management. Likely, there are organizational, cultural, management, and personnel issues that contribute to this issue of disparity between the range and level of maintenance activities performed by different vessel crews.

Given that the first line for vessel maintenance is the crews themselves (including the vessel Chief Engineers and Captains), the second line of vessel maintenance responsibility must certainly lie concurrently with (a) management of the WSF Vessel Engineers and Captains, (b) Vessel Staff Chiefs and Staff Masters, and (c) WSF Fleet Maintenance Port Engineers. Common marine industry practice and organizational structure among commercial fleet operators, government and private run ferry operations as well as other commercial fleet operators, holds both the vessel crews and their immediate supervisors, typically defined as Port Captains and

Port Engineers, accountable for the day-to-day maintenance of the vessels. Once PM type tasks, which are not an immediate critical need and can be deferred, are budgeted and passed on to EH or commercial SYs in the form of specifications or work requests, these tasks tend to be deferred until the vessel is removed from service and the work scopes are accomplished.

We recommend that WSF review and consider its organizational goals with respect to this issue, and, if necessary, conduct a more in-depth study to determine specific differences in the level of on board maintenance activity between vessels and classes of vessels. This research might encompass information found in engineering and deck logs, cross-referenced against the detailed vessel PM work requests passed on to port engineers and EH, along with the crew work lists scheduled to be accomplished at commercial SYs.

Based on our experience with other fleet owners that also operate some level of formal "in-house" ship repair service organization, whether it's a small division of pier side employees or a full blown SY, these types of organizational issues are common. Balancing budgets, revenues, VMP&I activities and the operational readiness needs of the fleet with the work backlogs and activity levels of the organization's ship repair service organization, is a challenging, dynamic process. This is especially so in light of Washington State's generally declining ship repair service industry.

5.C Opportunities/Limitations for Expanding VMP&I Activities for Vessel Crews

Provided the limitations discussed both in Section 5.A above and again below are able to be mitigated, opportunities for expanding VMP&I activities on board vessels during normal operating hours and/or during overnight tie up periods, could begin with following the leadership provided by the crews of the M/V Puyallup. The next place to look for specific work scopes might be found by identifying all the VMP&I tasks currently accomplished by EH personnel, while the vessels are on their various runs. This could be followed up by identification and assessment of all tasks accomplished by EH while the vessels are tied up for the night. A partial listing of the tasks currently accomplished by EH personnel while the vessel is underway, includes the following:

- **Comm/Nav/Security:**
  - PA System
  - Interior Communications
  - Security Cameras
  - Electronic Locks (security)
- **Major Mech/Elect:**
  - Lighting Fixtures – Interior and Exterior

Other tasks that could be accomplished with mitigation of the noted limitations, includes the following:

- Minor and isolated steel preservation (prep and painting).
- Fire hose cabinet renewals/replacements.
- Safety and emergency signage replacements.

- Hose replacements: Hoses and small diameter tubing section replacements can be pre-measured, pre-fabricated, and delivered to the vessel for installation during the course of daily operations.
- Minor carpentry and general housekeeping items (tool boards and mirror replacements for example).
- Minor plumbing mods (engineer sink installations, piping insulation, etc.).

We believe a very beneficial and significant opportunity for expanding VMP&I activity by the crew lies in increased and enhanced vessel PM inspections in support of the LCCM and the Vessel Hull Inspection Program.)

With proper training, tools, and leadership from WSF management, we see no other reasons why vessel crews could not accomplish these inspections and the subsequent updates to the vessels' LCCM and related vessel condition reports.

The major limitations for expanding VMP&I activities on board vessels during normal operating periods have been reviewed and identified in Section 5.A. above. In Section 6, we provide representative cost comparisons between several VMP&I activities, when the work is accomplished by vessel crew or EH personnel. (**NOTE:** The Section 6 analysis shows that depending upon the situation, utilization of crew for expanded VMP&I activity can result in either additional or reduced costs.)

In addition to those previously noted, other limitations to expanding VMP&I activities for vessel crews, include the following:

- **Crew Skills and Training:** EH personnel are experienced, trained, and skilled ship repair personnel. They do this work day in and day out. Some PM tasks do not require this level of experience and expertise, but others cannot be accomplished without it. Additional training will be required for specific select crew members.
- **Tools and Instruments:** Same basic issue as with crew skills and training. Some jobs require specialized tools and instruments, while others do not. However, expanded PM requirements for vessel crews will likely require additional tools and instruments to be carried aboard all the vessels.

NOTE: Additional training and tools will increase the overall costs of the maintenance budget.

5.D Opportunities/Limitations for Vessel, Class, and Fleet Maintenance Standards

The term maintenance standards can apply to several different aspects of any PM program or organization. At the highest level, there must be performance standards and expectations that apply to the maintenance organization itself and to all its employees. Based on all that we have learned through development of the VMPIP, as well as the exemplary reliability and on time schedule departure performance of the WSF fleet, it is clear to us that WSF has established definite organizational maintenance performance standards; and the maintenance organization as a whole understands and achieves these standards and expectations. Going forward, it is important to the long-term efficiency of the WSF maintenance organization that all WSF maintenance standards accurately and completely reflect WSF's "organizational goals and

focus." In other words, having standards simply for the sake of having standards is not enough, and of extremely limited benefit. Standards that represent and support the core goals and focus of WSDOT and the WSF system are worth developing, implementing, and maintaining.

At the next level down, standardization of equipment, machinery, and systems across classes of vessels, and where possible across the entire fleet, also offers distinct advantages and opportunities for maximizing efficiency and reducing VOST. The benefits of equipment standardization on any maintenance organization include, but are not limited to, the following:

- Maximizes productivity efficiency of repair personnel when working on the same or the same manufacturer's equipment and system.
- Lowers training and tool costs.
- Minimizes vital system and/or long lead item parts inventories.
- Reduces work scope errors and improves the quality of the maintenance performed.
- All of the above contributes to lower maintenance system costs and reduced VOST.

There are also economies of scale with respect to equipment costs that can be realized through this type of fleet system/equipment standardization program. While we did not research the degree to which WSF incorporates this type of equipment and system standardization into the fleet, we believe WSF management is well aware of and actively engaged in exploring these types of class and fleet standardization opportunities. (See the "WSF Best Practices" section of the VMPIP.) This is a dynamic and ongoing process as equipment, systems, and their manufacturers change over time, and there are limits to WSF's abilities to standardize on vessel systems. The WSF fleet is somewhat diverse in its make-up and composition, utilizing different propulsion and other systems equipment manufacturers across different classes of vessels. There is a degree of equipment and system standardization that could probably be expanded upon, and any additional standardization would provide some level of expected benefits. The introduction of new vessels into the fleet offers a great opportunity for expanding WSF's equipment standardization program, and renewed emphasis should be placed on this program.

At another level, standardized maintenance and repair procedures for accomplishing equipment/system specific, periodically repetitive and/or manufacturer's recommended work scopes, definitely provides significant benefits to maintenance organizations. The development and use of written preventive maintenance procedures and checklists introduces repeatability and uniformity to the maintenance process. In plain terms, a written procedure printed on a work order given to a trades person ensures that no step is overlooked, and that the documentation of any required data collection point is provided for.

As far as we could determine, the entire WSF maintenance organization makes extensive use of manufacturer' standard PM procedures and guidelines for inspections and equipment maintenance. At a certain level, the use of formalized computer maintenance software to manage and schedule PM events is indicative of organizations utilizing standardized maintenance procedures. Generally speaking, if there are differences in the reliability of identical equipment/systems, or differences in the quality of the respective maintenance efforts/events across the organization and/or between identical systems, this might indicate an

opportunity where standardized maintenance and repair standards could be beneficial. It may also simply indicate that the personnel performing those PM procedures have different levels of skill and experience. Based on our research and information obtained through personnel interviews, we uncovered several written standardized specifications, procedures, and maintenance checklists used by vessel crew and EH personnel. The consensus of WSF maintenance personnel is that there are enough written maintenance procedures in place right now, but that as new equipment and systems are brought online, more will need to be added. We generally concur with this assessment. It should be understood that standardized maintenance/repair specifications and procedures are not static, they do change over time with improvements in new technologies and processes, and they need to be maintained and updated. We also believe that the maintenance organization itself should be tasked with the responsibility to determine when new written procedures are needed, and with development, utilization, and management of these procedures.

Conclusions:

Section 5.A

- Most WSF vessel crews are accomplishing the vast majority – almost all – of the PM type work orders that are created and managed through the fleet's CMMS. At the same time, there is opportunity for some vessel crews to increase their range and level of accomplishing standard PM type work scopes during the course of daily operations.
- Accomplishing any significant amount of preservation work while underway is believed to be impractical and, in some cases, nearly impossible and dangerous.

Section 5.C

- It is reasonable to expect that many PM and predictive maintenance inspections, some additional maintenance tasks, and some additional minor, isolated preservation/ improvement tasks could be handled by crews while vessels are underway and/or during nighttime lay-ups.

Recommendations:

Section 5.A

- We recommend that WSF study and document the operational history of the M/V Puyallup to understand opportunities for increasing maintenance activities on other fleet vessels. (There may be other WSF vessel's with similar records, but these were not identified during the course of our efforts.)

Section 5.B

- We recommend that WSF review and communicate to the fleet, its organizational goals with respect to on board maintenance activity.

Section 5.C

- Continue the current shift in WSF management policy and focus, as recommended in recent LCCM studies, toward a more predictive maintenance organization. With proper training and tools, vessel crews should be able to accomplish and/or participate in non-destructive inspections via thermal imaging, ultrasonic testing, and other predictive maintenance techniques.

Section 5.D

- WSF should renew focus and emphasis on equipment/system standardization, particularly with regard to the new vessels.

Section 6 VMP&I Task Cost Comparison Model

This section of the VMPIP allows comparison of the estimated costs of a limited set of tasks that would normally be accomplished at EH, to the estimated costs of these same tasks if accomplished by the vessel crew, either during operating hours or while tied up at night. To accomplish this comparison we reviewed the wage structures of both vessel engine room crew and EH personnel, along with the travel & penalty pay aspects of the various collective bargaining agreements, and with this and other information developed a VMP&I task cost comparison model. With estimated hours, material costs, employee wages, and other input from the reader, the model provides cost comparisons between identical work scopes accomplished by vessel crew or EH personnel. The model is found in Appendix G.

As discussed in Section 5 above, there are limitations to both the types and levels of VMP&I activities that can be accomplished while the vessel is underway, and this is especially true for preservation and improvement projects. Preservation / improvement project size, requirements for machinery, equipment, and/or system shutdowns, operational disruptions (noise, dirt, no service in the case of mechanical systems), vessel area isolations (from passengers), and other job requirements typically mandate that preservation and improvement tasks are accomplished while the vessel is either tied up (after service hours) or in maintenance availability. The limited set of preservation and improvement tasks listed in the model are ones that could be accomplished while the vessel is underway or tied up overnight.

Also discussed in Section 5 were other "obstacles" (such as crew training, experience, specialized tools and instruments, etc.) which limit the practicality of vessel crews performing various VMP&I activities.

6.A Wages, Travel Pay, and Penalty Pay

As borne out by the WSF employee wage and rate charts found in Appendix G, and from information obtained through interviews with EH management, EH crafts personnel generally earn lower wages than do the vessel engine crews. This comparison of wages earned applies to very different job requirements and responsibilities, but we believe roughly equivalent marine repair skill sets and knowledge as it relates to maintaining and preserving vessel systems. This wage differential becomes significant as the comparison moves up the vessel engine crew classifications, starting with Assistant Engineers. At the lowest paid vessel engine crew levels (Unlicensed Engineers), the wages between the two groups are roughly equal, with slightly lower wages (and fully burdened hourly rates) for the vessel crew personnel. At the lowest licensed vessel engineer level, the wage differential is roughly 33% higher for vessel crews ($8/hr.), and at the Chief Engineers level, the differential is roughly 55% higher ($14/hr.). Another wage related job cost factor to consider when comparing work scopes accomplished by these two respective work forces, is the Over Time (OT) rate differential. The fully burdened OT rate for vessel engine crew personnel at the Assistant Engineer level is higher than that charged by EH, and the differential becomes quite significant at the upper vessel engine crew levels.

Travel pay is not strictly applicable to the central premise of the task cost comparisons discussed in this section, but it is included as an optional input for the VMP&I cost comparison model. (The model may be expanded and used to compare VMP&I task costs between vessel crew while the vessel is underway or tied up for the evening, relative to having EH personnel travel from EH

to the vessel in order to accomplish those same tasks.) Note that while the vessel crews are paid a special and "reduced" (fully burdened) rate (when applicable) while traveling to/from their work, the reduced rate is higher than the EH travel rate (also fully burdened) for crew rankings of Chief Engineer and above, and lower (than the EH travel rate) for crew rankings below Chief Engineer.

Penalty pay adds considerable complexity to the calculus for comparing job costs associated with the two respective work forces. This is due primarily to the fact that there are multiple unions representing the vessel engineers (licensed and unlicensed) and EH crafts personnel. The respective unions' contracts have different "penalty pay definitions, triggers, and/or related conditions" (such as minimum or guaranteed amounts of penalty or dirty pay for specific tasks, and the power tool use premium paid to the EH shore gang). Based on the interviews we conducted and our research into the specifics of penalty pay, our understanding is that penalty pay is more broadly applied (paid out) to unlicensed vessel engineers, than to licensed engineers. For both work forces and in many circumstances, the wages earned for every hour of penalty pay is equivalent to two times the employee's base wage amount.

Conclusions:

- Results from the review of the variables associated with VMP&I tasks is so wide, that no general conclusion or recommendation concerning task costs on jobs performed by the two respective work forces (EH and/or Vessel Crews) can be made at this time. If anything, it appears to us that the difference between costs of most tasks performed by the two respective work forces, is negligible.

- Penalty pay, when and how it applies to specific tasks and for specific unionized employees, drive costs, and this is especially applicable to vessel crew unlicensed engineers.

Section 7 Contracting Process and Contractual Requirements

In this section, we reviewed the contracting process and contractual requirements of the WSF vessel maintenance, preservation and improvement program. We interviewed Mr. Tim McGuigan (WSF Director of Legal Services and Contracts) on September 28, 2010, and Mr. Ron Wohlfrom (WSF Construction Manager) on October 11, 2010. We also reviewed and discussed WSF's graphical representation of the Schedule of Maintenance Periods and the WSF Maintenance, Preservation and Engineering Schedule (See Appendix H).

7.A Comparison of WSF Contract Procedures and Standard Commercial Procedures

In our interview with Mr. McGuigan, we discussed the comparison of WSF contract procedures and standard commercial procedures. By state law, vessel repair contracts are normally firm fixed-price type contracts and the award is based on low price from a qualified and responsive bidder. There is a provision in the Washington State RCW that allows for Best Value type contracts on a case-by-case basis and approved by the Washington State Secretary of Transportation. WSF normally only makes the request for a best Value contract for new construction contracts and major equipment procurements, as opposed to routine maintenance and preservation contracts. In the request, a case must be made for that specific contract why cost alone is not a wise choice for award. The request must also contain the evaluation criteria and weighting factors. Commercial owners have more latitude in how they can structure their solicitations and award criteria, and generally are able to establish long-term relationships with SYs that have served them well in the past. Government contract rules mandate full and open competition within the state, in almost all cases.

7.B Review Bidder's Comments With Respect to Contract Requirements

In our interview, Mr. McGuigan mentioned a state requirement for SYs to have a state approved apprenticeship program, in order to compete for state contracts with values exceeding $2 million. Puget Sound union SYs are in compliance with this requirement. There is one non-union SY that has an apprentice program, but has not had its program approved. Unfortunately for WSF, this yard is one of only two SYs in the region that can drydock the larger WSF vessels. Therefore, WSF is in a non-competitive bidding process for those drydock availabilities. There were no other bidder's comments shared with us.

7.C State Laws That Impact Cost and Schedules

We sent out a questionnaire to the SYs that do most of the SY work for WSF, and in one of those returned we received the following comments:

> ***Unfortunately, there are not too many WSF projects that we are able to participate in and of those few, there is significant competition we must underbid. This tends to create a change order driven contract. If WSF endeavors to find better value and shorter out-of-service duration they may want to look at "Best Value" contract award criteria utilizing a defined point system with the following elements: 1) Past Performance and References, 2)Facilities, 3)Timeline, 4) Financial. Some government entities have adopted this process after experiencing the worst that lowest price can offer. You already know the low bid fallacy; I doubt that you, as a matter of course, automatically award your roofing project to the lowest bidder. References, timeline, resources weigh nearly equal to price. I know they do with me. I realize that a couple of these elements are established with the annual WSF pre-qualification process, but still believe this type***

of award criteria would benefit all the residents of Washington and go a long ways towards creating a partnership with local shipyards and WSF. Along with that type of contract award criteria, and equally important, WSF needs to produce a comprehensive work specification that accurately describes all work. Currently, they can't do that. When contractors ask the tough questions in order to accurately define the scope, WSF dodges with "refer to the specification" all too often. Case in point: WSF Spec States: "Crop and renew 100 SF of 15.32# plate on the car deck. Include all interferences." Shipyard question/request: "For bidding purposes, please identify areas where plate will be cropped and renewed. Will there be 25 each 2' X 2' inserts or 1 each 10' X 10' insert? Please identify if these area include voids or machinery spaces below." WSF answer: "Bid in accordance with the specification." This creates more than one problem for the bidder and for WSF. If they can't accurately identify the work scope, how can they establish performance period. We see this all the time, too little time to perform the work unless it is repeat work scope in same class vessel. This leaves the contractor to scheme his bid strategy and plan for change orders.

The following are the summary bullets from this input that relate to state laws or WSF practices that affect cost:

- Best value contracts may reduce out-of-service time, but at a cost upfront.
- WSF structures their contracts such that contractors are forced to use overtime and/or second shifts to complete the work on time, but due to low price awards, contractors have to count on change orders and extensions to make a profit. See Section 8 discussion on expediting work.

Additionally, in our interview with Mr. McGuigan, he did say that the state's contract security requirements did impact SY's cash flow. Routine maintenance contracts require 100% contract security with 55% associated with performance risk, and 45% for payment risk. The yards pay for either a bond or an alternate form of security such as a letter of credit, and absorb the costs in overhead. There has been a recent expert panel suggestion to look at multi-ship contracts. The contract security issue will be a factor in that process, especially with SYs with limited cash flow.

7.D Review and Analyze WSF's Template for the Contracting Process

7.D.1 The Process

The 16-Year Plan and Schedule of Maintenance Periods: The first effort in the process is to develop each biennium, a 16-year work plan. This plan is developed by the Senior Port Engineer Vessel Preservation along with the Vessel Business Staff, and submitted to the state for approval. As part of this report, we developed an independent detailed 16-year schedule of VMP&I activities starting with fiscal year 2011-2013. The first biennium of the 16-year plan is critically developed to represent the work requirements and cost estimates. This part of the plan is the basis for the biennium budget approved for funding by the State Legislature. The two-year work plan is also based on WSF's estimate of the number of commercial availabilities and EH lay-ups, and each could include Coast Guard inspections and required drydockings. This Schedule of Maintenance Periods is depicted graphically (See Appendix H) and physically maintained by a set of magnet boards in the 5th floor Port Engineers board room. This schedule is developed based on required Coast Guard drydocking requirements and inspections, critical maintenance requirements, and validated preservation items due per the vessel LCCM database. In addition,

consideration is given to ensure enough vessels are available to provide the planned service for various times of the year, which translates at a maximum of having one Jumbo MKII or Jumbo ferry out-of-service year round. The entire contracting process for each maintenance availability period is keyed on the WSF desired start date depicted by the schedule of maintenance periods.

Typical durations for drydockings are 2-6 weeks, depending on the scope of work required. Work typically scheduled for drydocking availabilities are:

- Hull Steel Replacement
- Hull Paint
- Rudder Inspection and Repair
- Controllable Pitch Propeller Hub Inspection and Repair
- Fixed Pitch Propeller Inspections and Repair
- Bilge Paint
- Curtain Plate and Superstructure Paint
- Sea Valve Inspection and Repair

Typical durations for dockside contracts are 8-14 weeks, depending on the scope of work. Work typically scheduled for dockside availabilities are:

- Topside Painting
- Interior Preservation and Rehabs
- Piping Replacement
- Propulsion Systems Replacement
- Navigation, Communication and Lifesaving Systems Replacement
- Major Mechanical/Electrical systems Replacement
- Auto Deck Steel Replacement

WSF Maintenance, Preservation and Engineering Schedule: Over the years, WSF has fine-tuned a fairly standard sequence of events that leads to the award and the execution of contracted maintenance periods. The process takes approximately 8 months, but varies depending upon the overall complexity, estimated cost, scope of the work, and the amount of lead time for needed materials. There are typically five blocks of time leading up to award and then the contract execution period of performance as indicated on the WSF Maintenance, Preservation and Engineering Schedule (See Appendix H). This schedule includes the schedule of planned events for every commercial vessel repair contract in the next 24 months. Per the attachment, the following events and durations are typical.

1 Day	**Kick-off Meeting:** Meeting of internal stakeholders to discuss the work items to be included an agreement on the scope.
30-90 Days	**Specs and Plans:** Engineering design efforts and drawings developed or modified.
14 Days	**Specs:** Project engineer receives drawings and writes specifications. The work order and engineer's estimates are completed.
30 Days	**Review:** Technical specifications, drawings, and cost estimates are reviewed by internal stakeholders and finalized by the project engineer.

45- 90 days **Legal and Contracts:** 21-30 days to prepare IFB, 14-30 days to advertise, 2 days to award.** Depending on the complexity of the contract, the WSF cost estimate of the contract, and if federal funding is involved, IFB preparations could be more than 30 days.

5-30 days **Planning:** SY planning and materials procurement prior to WSF ship arrival and start of work.

** Note that Todd Pacific Shipyards is the only contractor in Puget Sound that has a drydock large enough to dock the Jumbo MKII and Jumbo ferries. Therefore, WSF awards all Jumbo Mark II and Jumbo Class drydock contracts sole source to Todd. The contracting process is the same until the award. If the Todd bid price is within 10% of WSF's estimate, the contract may be awarded. If the Todd bid price is more than 10% over the WSF estimate, WSF may negotiate cost, scope and schedule with Todd, usually taking about 1-2 extra days to award.

In the upcoming 2011-2012 FY, WSF has scheduled ten drydock contracts ranging from two to four weeks each, and two dockside contracts of nine and ten weeks. (See Appendix H for Representative Vessel Drydock and Dockside Maintenance Schedules.) All but the 10-week dockside are conducted in the mid-September to mid-May timeframes. Since the typical maintenance acquisition planning period is 8 months, the September-November 2011 period becomes the busiest time frame for vessel contracts when eight contracts will be in the pre-award stage, and three will be awarded and in process. This is important to recognize because when one considers the time frames to complete the specification development and contracting events for one contract, the duration of each task may seem excessive. However, when one considers having eight to eleven contracts in one stage or another at any given time, it is impressive that the awards are made when scheduled.

From the Schedule of Availability Periods, and gauging the type and magnitude of work scheduled by the 16-year work plan, the Construction Manager and Senior Preservation Port Engineer will estimate the time needed for each specification and contracting event in the contract development process. This task becomes challenging for availabilities scheduled in the summer and fall of a new biennium, because the kick-off meeting for those availabilities must take place prior to the legislation appropriating the funds to do that work. Because of this, the work considered at those specific kickoff meetings is based on the state approved 16-year plan, with the expectation that the funds will be available through the legislative process in the coming weeks. The funds must be appropriated in order for WSF to submit the work order for state approval. Every so often, depending on the appropriation law, adjustments to one or more of those availabilities may be needed.

Once vessel drydock and dockside maintenance schedules have been developed, WSF monitors these plans and the status of ongoing work to ensure:

- The contract development process in on track for an on-time award.
- The ships in maintenance periods are progressing as planned to ensure they will be returned to service when planned.
- In addition, WSF looks into the future primarily to ensure SYs will be available to accommodate the availability plans, and that the contract development process for future planned contracts is scheduled and started on time.

It is exceptional that very few, if any, contract awards are delayed because the process was not executed properly. We, therefore, do not have any suggestions to improve this process. Our only suggestion relates to improving the details in the specifications. Alion, in their 2009 and 2010 LCCM Updates (References 5 and 10 respectively), recommended using the inspection to validate the need for preservation items as a means to estimate and better define the scope of work to be done in the next biennium. Typically, the scope of work is not critically evaluated until the kick-off meeting. Admittedly, if WSF estimates the scope and cost during the validation inspection as we are recommending, the condition may change by the time of the availability kick-off meeting. However, we believe that when the item is inspected for the LCCM validation, it is the best time to baseline the scope and cost estimate for the next biennium's budget and 16-year work plan.

7.D.2 Predictive or Condition Based Maintenance

We investigated whether WSF could employ condition-based maintenance in an effort to decrease the amount of unknowns that typically crop up during commercial shipyard availabilities. These unknowns typically cause contract changes, and sometimes cause extensions to the shipyard periods or even add unplanned, emergency shipyard periods, each of which drive up maintenance or preservation costs. This very issue was addressed at length in Reference 5 and we agree with Alion's recommendations in Reference 5, which are summarized below and organized by preservation or maintenance category. In each case in the summary below, there will be a relatively small increase in cost over current maintenance and inspection practices, and that cost will depend on the extent that WSF chooses to incorporate the recommendation. But the return on investment will be realized in an overall reduction in fleet life cycle maintenance costs due to accomplishing more maintenance and preservation in a planned vs. unplanned or emergency manner. Thus, WSF should expect a reduction in change order costs, a reduction in shipyard contract period extensions, a reduction in emergency repairs and, in some cases, an increase in preservation item intervals.

Steel Replacement: We recommend auto deck and strength deck steel replacement be evaluated by the hull inspection team, since replacement criteria is similar to hull steel. The following is a quote from Reference 5, page 19.

> "If auto deck and strength deck steel replacement is needed, the scoping and estimating should be done for the budget submission. Since the evaluation criteria is very similar to the inspection practice of the hull inspection team, the auto deck and strength deck could be included in the scope of the hull inspection team. A better scope and cost estimate could be made for the biennial budget submission."

Potable Water Tanks Painting: Even though a non-vital preservation item with a 10-year interval, we recommend WSF consider it a vital monitoring tool to predict steel replacement needs at 20 yrs. WSF may even consider the potable water tanks be emptied and inspected at 5-year intervals, with painting on 10-year intervals. The following is a quote from Reference 5, page 20.

> "The current inspection process is one of inspect and repair as necessary and, therefore, for budget considerations, sufficient funding needs to be in place to account for potential change orders. To provide a better estimate for each biennium budget without change orders, we suggest WSF inspect and spot paint every ten years in drydock. (NOTE: WSF extended the intervals for painting to ten years vs. five and steel repair at 30 vs. ten.) If the system looks good, plan to re-inspect and spot repair the paint system at year 20. If at year 20 the paint system is intact and steel looks good, then plan another recoating in year 30 instead of recoating and doing steel repair. Continue this process until recoating and or steel replacement appears to be needed for the next drydocking. This inspection approach will also provide sufficient information to identify the scope of needed structural steel replacement for the next biennium; however, if the coating system is kept intact, structural deterioration should be minimized over the lifetime of the vessel. Inspecting the exterior of the tanks could easily be included in the hull inspection program, and the same team could inspect the tanks during drydock."

Sewage Tanks Painting: Similar to potable water tank painting, we recommend WSF consider sewage tank cleaning and painting as a vital monitoring tool and every five years each tank be cleaned and spot painted and during the process predict steel replacement needs at 20 years. The following is a quote from Reference 5, page 20.

> "Schedule the 5-year inspection and count on cleaning and inspecting the tank and spot coating only. At the 5-year drydocking, WSF evaluates the coating system and if spot coating is sufficient and the remainder of the system is intact, WSF may consider planning on another spot coat in another five years. Continue this process until it is apparent that recoating is appropriate and then schedule it for the next drydock. This inspection approach will also provide sufficient information to identify the scope of needed structural steel replacement; however, if the coating system is kept intact, structural deterioration should be minimized over the lifetime of the vessel. Inspecting the exterior of the tanks could easily be included in the hull inspection program."

Propulsion Motors, Generators, Alternators: Institute new insulation quality inspections via polarization index readings and third party analysis. The following two paragraphs are a quote from Reference 5, page 23. We rephrased two sentences in the section and they are enclosed in parentheses.

> "WSF Inspection Practice: This (motors, generators, and alternators) is a vital system. WSF currently takes meg-ohm (megger) readings on generators and propulsion motors on an annual basis. [The meg-ohm test is a fundamental test done by industry and is a cost effective way to determine if there is the insulation quality is sufficient, and gives the owner a magnitude of the insulation condition.] The most recent readings are recorded on the monthly condition reports by the Staff Chief Engineer. The test is typically done by an electrician from EH. [If trended, at best the annual readings can give the owner an indication of whether the insulation quality is deteriorating or not, but the readings are not accurate

enough to give an early indication of remaining life if that is the goal.] The expected life of the propulsion system is 30 years.

Other Industry Best Practices: Using a polarization index procedure for measuring insulation quality of electrical power system components is a very accurate indicator of the system degradation, if the owner performs specific insulation quality tests and trends the data with statistical tools designed for electrical systems. The degradation is not easily detected with the typical megger reading procedure with one go-no go test point, but with polarization index readings even small changes can be detected when two or more test points are trended and with statistical software tools. These tests are best done with the system not in operation. The test currents are put into the system at both the armature and field coils of a DC machine or the stator and rotor of an AC machine. The readings are taken at one and ten minutes and responses collected with reasonable quality testing equipment. It is important to take the temperature of the windings and humidity in the space. The periodicity can be as infrequent as once a year after an initial two points, six months apart. Typically, the test equipment is brought to the site as opposed to being imbedded in the system. The tests can be conducted with trained WSF personnel or by contracted experts. The data is capable of being electronically transferred to either a contractor, or WSF activity to be added to the database and then trended and evaluated. If the insulation quality is stable, all is well. If the trending shows degradation in the insulation quality, the evaluation should provide information to detect and correct the problem before casualties occur. The trending can be very helpful to predict PM needs. However, for long-term preservation decisions, WSF will be able to detect whether the generator or motor will need replacing in time to procure this long lead item and have it ready to install during the replacement biennium or decide to extend the interval period. This practice is being used by the Alaska Marine Highway System, USCGC HEALY and many electrical power plants around the country. One of the industry leaders in marine and land-based electrical power plant condition based maintenance, and owner of one of the most advanced and capable statistical software tools is the Cadick Corp, corporate offices located in Garland, TX, local marine contact: Michael G. Turner, phone: 206-300-7522, web site: www.cadickcorp.com."

Another Inspection for Propulsion Motors, Generators, and Alternators is a Narrowband Vibration Analysis Inspection: Currently WSF utilizes vibration analysis as an inspection tool to help diagnose problems on a case-by-case basis. This does provide value, but if expanded could become a key predictive tool. We recommend that every piece of equipment with rotating components be included in a rigorous vibration analysis program. Crew members, EH, or third party engineers would take manual vibration signatures once a quarter via hand held computers while the vessel is underway. We suggest EH or third party engineers do the monitoring because the readings will be done by the same engineers each time, and much less equipment will be required saving the cost of hardware procurement as well as a annual calibration costs. With EH taking the vibration reading on two vessels per week, they will capture the entire fleet in one quarter. These vibration signatures are stored electronically and trended over time to help predict impending failures. This program is not a one-time vibration reading to assess and

validate suspected problems, but the program requires a specific set of readings on a routine quarterly basis. Those signatures are trended and assessed either by proprietary software, and/or by third party vibration experts.

For further narrowband vibration analysis information, contact Balancing Services, Seattle POC, Brian Meed, phone: 206-763-1260, or their Engineering Consultant Mark Libby in Kingston, WA, phone: 360-881-0513 email: mark@libbymca.com

The following are paraphrased from Reference 5. Motors, generators and reduction gears from page 24, and miscellaneous equipment from page 27.

> Main Motors, Generators, Reduction Gears: Another source of main motor and generator repair are the rotor shaft bearings and fan bearings. Although the replacement of bearings may not be considered a motor or generator LCCM item, it certainly could be a major maintenance item in terms of taking the ferry out of operation, and in terms of cost. Most industrial applications utilize narrowband vibration analysis as a means to predict impending bearing failure and correct those potential failures in a planned manner rather that in an emergency.
>
> Many owners take vibration readings in key places on the motor housing. Each location has a vibration button fixed on the housing by a suitable adhesive, which allows a vibration sensor to be temporarily attached to the button for the measurements. Vibration measurements are made when a machine is operating at a normal speed and load. Best in class programs use a mechanical attachment of the sensor to the button for the best frequency response and make tri-axial measurements in the x-y-z plane to fully describe the machines motion. The measurements are made with a handheld instrument that makes and stores a digitized dynamic recording for about 20 to 50 seconds, depending on the machines rotation rate and configuration. The data in the handheld recorder can be downloaded onto analysis software, and then can be processed and analyzed including comparisons with prior vibration profiles. Skilled engineers can interpret the patterns and changes in the spectral vibration signature and provide timely assessments of degrading conditions, which would lead to maintenance or repair decisions.
>
> Major HVAC Fans, AC Units, Sewage Pumps, Fire Pumps, Bilge Pumps, Lube Oil Transfer Pumps, Fuel Pumps: Most of these items are not individual LCCM items, but subcomponents of the piping systems or HVAC systems. However, industry is moving from a time-based inspection process to a vibration inspection, which properly taken and trended will provide a reasonable accurate condition of the machine and, in most cases, allow extended use before maintenance is required. The pump casings rarely need replacing, but WSF may want to consider implementing a vibration analysis program to extend bearing, seal, and impeller renewals. Many owners take vibration readings in key places on pump or motor housings. Each location has a vibration button fixed on the housing by a suitable adhesive, which allows a vibration sensor to be temporarily attached to the button for the measurements. Vibration measurements are made when a machine is

operating at a normal speed and load. Best in class programs use a mechanical attachment of the sensor to the button for the best frequency response and make tri-axial measurements in the x-y-z plane to fully describe the machines motion. The measurements are made with a handheld instrument that makes and stores a digitized dynamic recording for about 20 to 50 seconds, depending on the machines rotation rate and configuration. The data in the handheld recorder can be downloaded onto analysis software, and then can be processed and analyzed including comparisons with prior vibration profiles. Skilled engineers can interpret the changes in the profiles, which would lead to maintenance or repair decisions pertaining to alignment, or renewal of bearings, impellers or seals.

Curtain Plate and Superstructure Painting: This recommendation for a tool to assist in inspecting topside painting needs is an expansion of a recommendation in Reference 5. We recommend taking pictures of existing WSF vessels with various stages of rust, representing a new paint job, and conditions that are acceptable, mediocre, time to repaint in two years, or is unacceptable. WSF could use these pictures as a baseline tool to assess the condition of the vessel topside paint systems in a more objective manner.

7.E Change Order Review and Post Availability Lessons Learned

We evaluated vessel availability contract change orders to see where improvements could be made in reducing costs or contract extensions.

Change orders have historically impacted cost. If an owner could identify the scope of the change as a definite item, the cost always will be less than if the owner paid for the same scope as a change order. In their 2009 LCCM Update Report, Alion recommended WSF conduct a post contract review of change orders to evaluate whether or not a similar change could be avoided in the future by:

- Changing pre-contract inspection practices to identify the scope more accurately.
- Changing recurring work specifications or drawings to more accurately represent the condition of the vessel allowing contractors to more accurately estimate the cost and schedule.

Although all change orders impact cost, they may or may not impact out-of-service time. Change orders do impact out-of-service time if one or more changes are on the critical path and directly result in a contract extension; however, many are not on the critical path and do not result in contract time extensions. In their 2010 LCCM Update Report, Alion recommended that WSF require all contract extensions requested by the SY to be documented by a contract change, and tied to the specific change to the requirements of a specific line item or a combination of line items. We further recommend that WSF include an analysis of these contract extensions and determine whether they could be avoided in the future by better inspection methods, or changes to the technical specifications or drawings.

During the same time frame of Alion's report generation, WSF implemented a lessons learned program in February 2010. The process is documented and a representative report is provided in Appendix H. In reviewing the lessons learned process, we find that the program leaves it up to

the individual project engineer to determine if a "lesson has been learned" and left up to the individual's initiative to submit the documentation. The process and the requirements for the lessons learned program should be worded such that specific goals for data collection will be met. In Section A of the program description, it does not specifically identify what constitutes a potential lesson learned, and it does not specifically direct the submittal of a lesson learned for specific cases. It just says that a lesson learned may come from a variety of sources, change orders and condition found reports being two. If made a requirement, we see this process could be used to evaluate all change orders including contract extensions and determine ways to avoid similar circumstances in future contracts

We recommend at least the following as potential lessons learned and require they be submitted and by whom:

- Submit all changes that resulted in contract extensions as a potential lesson learned. The goal to determine whether by modifying the pre contract inspection process or modifying the contract or specification language or drawings will preclude similar increases to out-of-service time in the future.
- Submit all changes to preservation items as a potential lesson learned. The goal is to better define the standard scope of work for that particular preservation item. Should the scope be bigger or smaller, or better defined?

To make this analysis easier, we recommend WSF require the originator of the change order to explain on the change order form the specific reason that change was required. Currently, boxes are available to categorize the change, but the specific reason for the change is left undocumented.

As it relates specifically to preservation items, we agree with Alion's 2010 LCCM Update Report (Reference 10) recommending that the preservation project engineers and vessel engineering business group make an evaluation as to whether the estimated scope of work for each preservation item was accurate. The next step would be to capture the total cost of each preservation item, including all change order costs, WSF procured long lead-time materials and pre-availability design and engineering costs. This evaluation will assist in updating the LCCM cost factors and validate or improve inspection methods. From this perspective, WSF may consider making the initial evaluation of the lessons learned program a two-person team consisting of the Senior Preservation Port Engineer and Preservation Project Engineer, and possibly even including the Staff Chief Engineer.

Conclusions:

- When one considers having eight to eleven contracts in one stage or another at any given time, it is impressive that WSF has consistently awarded vessel contracts when scheduled.
- It is exceptional that very few, if any contract awards are delayed because the (contracting) process was not executed properly.

- We believe that when the (preservation) item is inspected for the LCCM validation, it also is the best time to baseline the scope and cost estimate for the next biennium's budget and 16-year work plan.

Recommendations:

Section 7.D.1

- Establish the baseline scope of work for preservation items during the LCCM validation inspection.

Section 7.D.2

- Strongly recommend incorporating the condition-based maintenance suggestions.
- Incorporate auto deck and strength deck steel inspections within the purview of the hull inspection team.
- Treat inspection and painting of potable water tanks and sewage tanks a priority as a means to determine the preservation item for steel replacement.
- Institute a new electrical insulation quality inspection and analysis using polarization index readings and a third party analysis.
- Make the vibration analysis program of rotating equipment more robust and require EH or a third party vendor take the readings quarterly. (EH would need additional training and equipment.)

Section 7.E

- Make slight changes to the change order process to improve the capture of the reasons for each change, especially for contract extensions.
- Expand the requirements for the contracting lessons learned program.

Section 8 Expediting the Delivery of Shipyard Work

This section analyzed expediting delivery of commercial SY work. The question seems to assume that under normal circumstances, SYs do not expedite work; however work a normal 8-hour shift and, if WSF chose to authorize overtime or second shifts, they could shorten the SY availability periods and thus save out-of-service time. This was one of CRG's suggestions to decrease out-of-service days.

8.A Constraints to Expediting Work

Our method of gathering information was to send questionnaires to SYs that routinely bid on WSF contracts, and are reasonably successful in winning vessel repair contracts with WSF. The following questions were sent to these shipyards seeking information on their practices in conducting work on WSF vessels. Unfortunately, only three replied yet their responses were revealing and they were added below each question.

Introductory Premise: A past consultative study has suggested that one means by which WSF might be able to reduce vessel out-of-service time is to expedite work at commercial SYs, when and where appropriate. The recommendation calls for SYs to work more than one 8-hour shift per day as a norm.

Question 1: If requested to do so by the customer, are there any environmental restrictions (e.g. noise or light pollution restrictions), SY property/facility use permits or other arrangement restrictions, production efficiencies, labor agreements, or other considerations that constrain you from expediting work using two hours overtime for a 10-hour day, using a second shift, or working weekends?

If yes, please be specific for each example.

Respondent 1: At 10 p.m. the noise restriction gets tougher under City of Seattle ordinance; items such as 40,000 psi water blasting would have to terminate.

Respondent 2: We are able to work unencumbered for daily multiple shifts seven days a week. Saturday and Sunday work have overtime cost implications, but that can be overcome with a provision of our labor agreement allowing four 10's with the last three days being work as three 12's; all at straight time. At our facility, consideration of our neighbors dictates prudence in scheduling high noise activities after 9 p.m. or before 7 a.m. This would usually apply only to needle gun and deck scaling accomplished along side, or North Pier at the extreme east end of the yard.

Respondent 3: We are not restricted to implementing any of the proposed options. We use two 8-hour shifts (days and swing) as standard procedure for all WSF projects.

Question 2:

a) Based on your typical workforce, historical ability to ramp up, or ability to obtain adequate subcontractor support, is there any skill set that presents a constraint in your expediting work, stepping up to either:

i. two, 8-hour shifts?
ii. two hours overtime for a single 10-hour shift?
iii. initiating a second (10-hour) shift?
iv. working weekends?

All Respondents: No Restrictions

(b) If yes, which skill sets present constraints and please be specific in your explanations why, and which expediting options apply.

All Respondents: N/A

(c) Please also identify the normal/typical time (measured in days we presume) from the initial phone call to the hiring hall, until the new employee is on site at your facility working.

Skill Sets:

- Management or Foreman level
- Metal/Steel Fabricators
- Mechanical/Machinists
- Pipe Fitters
- Machine Shop (inside or outside)
- Electricians
- Electronics Technicians
- Painters/ Blasters
- Crane Operators other skills or services

Respondents 1 and 2: 24-hours (management personnel are not available from union hall, but can be identified within the organizations when needed).

Respondent 3: Two or three day turn-around from placing the manning request to the worker being onsite. This applies to all crafts.

We have sufficient management and supervision on all projects to insure the project has proper supervision to include growth work and or new work.

Management or foreman can be relocated from other in-house projects temporarily to assist if required.

Question 3: 100% topside painting is one of the WSF SY work items that take the longest time to complete. (Specifically, the curtain plate and superstructure in drydock, and the interior car deck areas in dockside or drydock.)

(a) When you normally bid these work items, do you assume a normal 8-hour workday? If no, please explain why not.

Respondent 1: Can add swing shift or overtime if required.

Respondent 2: We usually bid this type of item on a multi-shift basis. Seldom do we bid this type of work on a single 8-hour shift unless the availability allows for the time duration. WSF awards on a best price basis only, so careful consideration must be made to price impact when bidding fixed-price work.

Respondent 3: No, these are usually bid working two 10-hour shifts (days and swing) a minimum of six days a week.

(b) If yes, is either of these work items conducive to 10-hour workdays, conducive to second shifts, or overtime on weekends?

Respondent 1: All

Respondent 2: Cover-up and sandblasting work is more conducive to long shifts or second shift work than the actual painting. WSF restricts painting to daytime hours, whereas prep work is not restricted usually. Painting is also dew point sensitive and in the fall, winter, and early spring painting at times, other than during daylight hours, might not be possible.

Respondent 3: We already use double shifts as a norm.

(c) If yes, which would be the most efficient (a) in terms of reducing VOST for the WSF fleet? and (b) in terms of cost to WSF?

Respondent 1: All

Respondent 2: The best time of year to paint is during the summer, which conflicts with WSF busiest time. Multi-shift work for cover-up and prep work followed by day shift painting probably yields the shortest duration/best value matrix.

Respondent 3: We already use double shifts as a norm.

Question 4: Based on your company's technical expertise and experience with painting ships in the Pacific Northwest, are you aware of any onerous or unusually strict requirements (that might drive costs and/or schedule) contained in WSF's standard technical paint specifications? In other words, is there anything in the typical paint work scope for a WSF vessel, which specifically drives either the cost and/or the amount of time the vessel is out-of-service , that could be eliminated and still result in a perfectly satisfactory job? (For example, WSF's "Marine Coating Specifications" Revision 1/07 stipulates (page 3, line #26.) "Painting and Inspections shall be scheduled for daylight hours only." To your knowledge and based on your experience:

(a) Is this restriction in current practice and strictly followed?

Respondent 1: No.

Respondent 2: Yes! Further, WSF inspectors may not be readily available to resolve checkpoints outside of normal day shift hours.

Respondent 3: Yes, it is a current practice, but is managed very proficiently by the WSF inspectors.

(b) Is it necessary? If yes, please explain why.

Respondent 1: No

Respondent 2: No, not all of the year. Late spring and summer months can evidence temperatures and humidities that are in accordance with the paint manufactures specifications, at times other than just daylight hours.

Respondent 3: It should be changed to read "at the discretion" of the WSF inspector. This restriction has a purpose and is a good tool when managed properly. Todd's experience is that the WSF inspectors as required by circumstances and the past practices of the SY have enforced it fairly.

8.B Analysis of the Questionnaire Responses

Question 1: There are noise restrictions in Seattle and most of the Puget Sound region that limit work after certain times in the night. We are aware of restrictions as early as 8 p.m. in the evening. This restriction would restrict the second shift from doing certain tasks such as grinding and using pressurized air driven tools, making 10-hour shifts (two hours overtime) or working Saturday a more efficient option than second shifts.

Question 2: From these respondents, there does not appear to be any restriction from a personnel standpoint from ramping up to support overtime or a second shift. However, we have heard instances where this has been a problem with certain skill sets in the Puget Sound ship repair industry.

Question 3: One of the routine work items that takes the longest time to complete is topside painting. Question three explored ways to reduce the time variables with this work item. The answers from Respondent one did not appear to be responsive, but answers from Respondents two and three were revealing. They indicated that rarely did they bid straight time for topside painting because the WSF availability duration is typically too short to get all the work done without multi-shifts and overtime. However, since WSF awards repair contracts on price only, they have to be careful on pricing.

Question 4: Were there any WSF requirements that seemed to drive up cost or time? As for restrictions in the specifications, WSF may want to consider allowing painting on the second shift if temperatures and humidity requirements are met.

8.C Other Comments Regarding Accelerating Work as Routine in Order to Reduce Out-of-Service Time

8.C.1 Expediting Work vs. Critical Path

At the beginning of every contract, there is one work item or a set of interrelated work items that are on the critical path in order to complete the entire contract on time. What that means is that there is very little room for delay in completing any of the subtasks, along the time line for the

critical path items, and still be able to deliver the ship on time. It is the item or items on the critical path that may benefit from acceleration. In the case of topside painting, one contractor indicated that most of the WSF vessel contract durations in essence require them to use 10-hour shifts, second shift work, or weekend work in order to finish on time. However, accelerating an item that is not on the critical path will not improve the potential for completing the entire availability on time.

8.C.2 Expediting Work on a Fixed-Price Contract

Routine WSF SY availabilities are always firm fixed-price contracts with the low responsive bidder winning. The exception is with Todd Pacific Shipyards on the Jumbo MKII and Jumbo drydock contracts. This will be addressed later. With firm fixed-price contracts, it does not appear prudent for WSF to tell the contractor how to manage their work; otherwise, WSF takes responsibility for delays. Therefore, it may not be in WSF's best interest to advertise a contract and require the SY to expend overtime or second shift work on specific items, and to include that costing in their price. As an alternative, WSF could deliberately shorten the period of performance and anticipate bidders will recognize that they have to work overtime/second shift to complete the work on time. In at least one contractor's opinion, WSF already does this, knowingly or not, for contracts that include topside painting. From discussions with WSF project engineers, and a review of WSF contracts in general, it appears that WSF does pack the planned work into relatively small durations and expect that the contractors will have to employ some overtime and second shift work. However, they do not require it.

In the case of the Jumbo MKII and Jumbo drydock contracts, Todd Pacific Shipyards is the only qualified Puget Sound yard with a drydock large enough to drydock the Jumbo's. There is a state statute {RCW 47.56.030 (1) (e) (ii)} that allows WSF to sole source drydock contracts when there is only one known bidder for a class or classes of vessels. Such contracts may be for a single vessel drydocking or multiple vessel drydockings for a period not to exceed two years. For the Jumbo Mark II and Jumbo class contracts, Todd responds to a sole source Invitation for Bids (IFB) with pricing. If the price quote is within 10% of the WSF engineer's estimate, the award may be made. If the price quote is outside the 10% range, WSF may negotiate with Todd on price, scope, and sometimes duration. There are times where the duration may be increased, but we found no evidence that the duration was ever reduced

For emergency repairs, the typical work scope is only one item. Contracting rules usually allow WSF the ability to negotiate and accelerate the work and, in fact, has been done in the past.

8.C.3 Inefficiency of Second Shift Work

In WSF's 2010 Vessel LCCM Update Report Phase II Section 3, WSF made some comments relative to accelerating work especially related to second shift work. We agree with WSF's comments.

Second shift work is approximately 20% less efficient. This is a result of:

- Ø Disruption caused by one shift leaving off and the next shift picking up the same work. (A need to review work status, material status, tool status etc.)

- Improper or misunderstood communications between shifts. (Whether written or verbal explanations of status, problems, sequencing etc.)
- Loss of efficiency due to unnecessary rework of previous shift's work (e.g. one welder or pipe fitter not accepting the fit up of the pipe of the previous shift).
- Lost time required by overlapping supervision and key worker turnovers (e.g. on complex structural tasks, supervisors of the two shifts may spend as much as an hour together to acquire a mutual understanding of the sequencing).
- EBDG's comment: This communication is difficult when the second shift arrives in the afternoon, but it is worse when the first shift comes back in the morning and the second shift is not on site. In this situation any communication, if at all, is written.

8.C.4 Expediting Work vs. Contractor's Unplanned Delays

If WSF could devise a contractual method to pay for acceleration of vessel repair contracts from the outset, they could squeeze the duration of availabilities to the minimum, and eventually there would be no float. In other words, WSF would remove the ability of the SY to accelerate or expedite work on his own nickel in order to account for unplanned or unexpected delays.

Conclusions:

- There are noise restrictions within the Puget Sound region that restricts work after 8 p.m. and in some cases 10 p.m.
- In many cases, by choosing the contract durations they do, it appears that WSF already forces contractors to work some 10-hour days, weekend work, or second shifts to complete all required work on time. This may not be intentional but, in at least one SY's opinion, that is the case for topside painting contracts.
- Although none of the three SY respondents indicated there was a problem ramping up to work overtime/second shift, with new construction in the area at several yards, we believe for the near term that there will be a shortage of qualified SY workers.
- It appears that WSF already anticipates SYs need to work overtime, work on weekends, or work second shifts to accomplish routine availabilities. Therefore, to be able to count on accelerating work further for the sole purpose of trying to reduce out-of-service time does not appear to be a wise strategy, especially if the reason to reduce the out-of-service time is to justify reducing the fleet size.

Recommendations:

- We recommend WSF make no changes in their approach to expediting work in shipyard contracts.

Section 9 Comparing Planned vs. Actual SY Out-of-Service Time

In this section we looked at how well WSF plans their contract SY availabilities with respect to constructability. In other words, does the entire scope of work planned fit into the planned out-of-service time?

In the July 2010 LCCM Update Report Section 3, Alion addressed constructability and out-of-service time as related to drydock and dockside availabilities. In that study, they analyzed the last three years of data March 2007 to March 2010. We used the same approach to analyzing availability information and added two more years starting with 2005. The following was the introduction to the section for the 2009 study and is applicable here.

> Planned out-of-service time for maintenance versus actual out-of-service time can be significant. There is always a question of how much work can get done in a fixed period of time, and it is not always an easy question to answer. Some metrics that generally shed some light on the subject are: dollars/week expended, planned vs. actual periods of performance, dollars spent and extensions granted based on engineering contract changes to both contract work and new work, and weather related delays. We set out to see what data was available from past scheduled commercial availabilities in order to see if there were any trends or correlation. Prior to looking for and gathering available data, vessel preservation engineers indicated that a general rule of thumb in terms of cost/week was about $1 million/month or approximately $250 thousand/week. We looked at cost and schedule growth for the scheduled availabilities over the last three years, between March 2007 and March 2010. With that information, we hoped to ascertain whether projected workload for each vessel within the preservation plan could be accomplished in the projected time frames, and can the metrics show that WSF uses the available out-of-service time wisely.
>
> In reviewing the availability data from the vessel business staff, the following data was readily available:
>
> - Contract Start Date
> - Contract Completion Date
> - Actual Completion Date
> - Contract Award Cost
> - Contract Final Cost
> - Contract change order forms, but with little information other than a line item to charge and a cost for that change. The contract extensions did not contain enough detail to determine the cause.

For this study, starting with the work done by Alion in July 2010, we increased the sample size of the availabilities to five years by including calendar years 2006 and 2005. While collecting the data for the additional two years, we found areas where WSF's data, relative to out-of-service time, was not being captured in a consistent manner. Therefore, we worked with WSF and reassessed the data for March 2007 through March of 2010 and updated a few data elements for a few of the availabilities. Appendix I contains two tables of data similar in format to the Alion

2010 LCCM Update Report. One table contains the drydock contract data and the second table the dockside contract data.

We collected information necessary to calculate several key metrics relating to planned out- of-service time and to the cost of work. The data displayed in the appendices includes the planned start date (ship delivery date to the yard per the contract) and end date (contract redelivery date) and then the actual end date or ship redelivery date. These three dates are found in several documents, but in no one document are all three found.

- The Senior Preservation Port Engineer maintains an historical Vessel Maintenance Lay-up Schedule and captures actual start and end dates of all out-of-service times, including commercial SY, EH and annual inspections.
- Each contract solicitation with amendments contains the contractual start and end dates.
- The Vessel Project Engineer's contract files and their electronic database contain the start date and actual redelivery date.

Looking at the tables contained in Appendix I:

The planned contract duration (the heading "Contract Days") equals the difference between the planned start and end dates per the solicitation. The end date is included in the calculation.

In the tables there are dates in red font. The red font actual start and end dates came from the Vessel Maintenance and Lay-Up Schedule and conflicted with either the contract solicitation, or the project engineer's contract files, or both. In those cases, we explained the conflict with a note to the far right. The original contract end dates in red font also represent dates where the contract documentation was inconsistent, and the actual dates were found in the contract files.

The actual out-of-service time (the heading "Actual Days") equals the difference between the actual start and end dates.

The difference between the planned and actual out-of-service times (the heading "Delta Days") equals the contract extension in days. The color code for Delta Days is as follows:

- Green represents 2 days extension or less (on time usually a Friday).
- Tan represents 3-7 days extension.
- Violet represents 8-13 days extension.
- Blue represents 14 days extension or more.

The number of contract weeks (the heading "Weeks") is calculated by the actual number of days divided by seven days per week.

The award cost and final costs were found in the contract summary files.

The difference between the Award Cost and the Final Cost equals the cost for contract changes and the ratio of the two equals the percentage of contract growth (% Change in the tables). We highlighted the percent change if over 100% in purple, and % Change between 30% and 100% in

yellow. There did not appear to be a direct relationship between the percent change and the number of days extension.

Finally, taking the final cost divided by the number of weeks of work equals the average cost per week.

9.A Drydock Contract Data

There were 45 Scheduled Drydock Availabilities

DD Data	
Average Period	37.9 Days
Average Extension	4.3 Days
Average % Growth	27.82 %
Average $/Wk	$213,140

There were 45 scheduled drydock contracts in the last five years. We did not count emergency drydock or dockside contracts. In the drydock availabilities, it is interesting to note that the average contract extension was 4.3 days, which is exceptional given the level of uncertainty of the actual condition of the ship prior to taking her out of the water. Almost all scheduled contracts are planned to have the ship redelivered to WSF on a Friday. It is remarkable that out of the 45 drydock contracts, 28 were redelivered on the Friday as planned, two on Saturday, and one on Sunday; in other words, 31 (69%) of the contracts were completed prior to Monday, the next business day. In nine other contracts, the ship was redelivered within three to eight days.

Otherwise, there were five contracts that skewed the on-time delivery data, and were caused by either unusual amounts of hull steel or passenger/promenade deck steel replacement. The contracts with hull steel replacements took place prior to WSF instituting their hull steel inspection program, and so unexpected hull steel replacement should not happen in the future. The expectation is that the requirement for hull steel replacement will be known by inspection prior to the budget development and SY contract planning processes.

The other preservation item that caused significant contract extensions involved passenger deck steel. These occurred on vessels where the deck steel was not primed prior to installing underlayment, which contains salt. When water interacted with the underlayment, that condition was detrimental to the steel. As deck coverings are renewed, WSF ensures that the steel is primed as part of the repair specification. In addition, entry decks from the weather are now being covered with special floor coverings and renewed more frequently under maintenance funding.

These changes in the inspection and maintenance procedures will likely reduce the probability of major unplanned steel repairs in the hull and passenger decks in the future.

During interviews, the project engineers recollected the fact that unplanned extra steel replacement was the reason for the largest contract extensions.

We found that the contract data did not clearly identify the reasons for contract extensions. There were change requests to extend the contract period, but the reasons for the extension were not clear. We recommend that the reasons for all contract extensions be clearly identified by the work item, or items that trigger the extension request, and clearly explain the reasons why. Based on an analysis of this data, WSF will be able to assess whether a change in inspection procedures or change in specification language can reduce the probability of a similar extension occurrence.

The average cost per week for drydock availabilities was $213,140 a week. Using a factor of 4.3 weeks/month, the average cost was about $916,502 a month, under the $1 million a month rule of thumb WSF used to manage content of their drydock availabilities. The average percent of cost growth (28%) seemed high, but the documentation showed that most of the cost growth was due to work on the underwater body, hull steel, or within items where work requirements were hidden. These items included tank coating preservation, steel work, and other preservation work in passenger, galley, or wet spaces after the deck underlayment was removed.

The project engineers and we did not have time during the generation of this report to ascertain the reasons for contract extensions of 14 days or less. We suggest that there may be value in WSF reviewing those contracts on their own.

The cost growth for hull steel and interior hull preservation should be moving towards zero as the Hull Inspection/Steel Preservation Program improves the identification of steel preservation needs, and then preserving those areas by coating preparation and painting. In addition, WSF inspects the exterior hull during scheduled drydockings with close attention paid to areas where hull coatings have failed. WSF has increased attention in both interior and exterior hull inspections and coating preservation, which will reduce the need for steel renewal. Where steel renewal is required, those needs can be quantified through the hull inspection program or by drydocking inspections and then be included as a definite item in the next contract, thus reducing unplanned out-of-service time and change order costs.

It is always difficult for owners to predict the need to repair rudders, shafts, sea chests and other underwater body work, until the ship is out of the water. However, WSF does take bearing clearances in each drydock, which does provide some indication of impending repair need. WSF mitigates out-of-service time when these systems need repair by having spares in their warehouse. The spare is installed in place of the worn part, and the used component is remanufactured or repaired and returned to the warehouse for future emergent use.

From an analysis of changes in a representative sample of drydock contracts extended from three to eight days, these underwater body repairs had the highest cost growth. Although not clearly identified in the documentation, the extensions for these availabilities, three-eight days in length, could have been tied to these items. We recommend WSF project engineers review these contract extensions to determine if there actually is a pattern and a means to mitigate the extensions.

9.B Dockside Contract Data

There were 19 Scheduled Dockside Availabilities

DS Data	
Average Period	70.6 Days
Average Extension	3.9 Days
Average % Growth	17.25 %
Average $/WK	$167,747

For the 19-dockside contracts, the average extension was 3.9 days. Eleven availabilities (58%) were completed on time, and six others were extended seven days or less. Only two contracts were extended more than seven days, one 10 days and the longest extension was 28 days due to required changes and testing of new main diesel engines and controls. This 28-day extension was not clearly documented in the availability files, but the project engineer for that availability remembered clearly the details of that extension. As mentioned in the Alion July 2010 LCCM Update Report, the documentation was not clear on the reasons for the other seven extensions.

It was not surprising that the cost per week was lower for the dockside availabilities as opposed to drydock availabilities, because the cost of the drydock did not come into play. The average cost growth at 17% for the dockside availabilities was less than the drydock cost growth, because WSF is more able to define the work in the specifications.

Topside painting in the auto deck areas is the most time consuming and those contracts where painting was an item, the contracts were in the neighborhood of 80 to 100 days. For the contract extensions of three to seven days, five of the six were in contracts with topside painting in the auto decks. The sixth one was for security installations. Two of the topside auto deck paint jobs were completed on time. Unfortunately, the contract files did not clearly cite a reason for the extensions.

The data shows that for drydock availabilities, if the estimated cost of work is around $215,000 a week, the work can be accomplished within that period of performance chosen. For dockside periods, that number would be around $170,000.

Conclusions:

- WSF has increased attention in both interior and exterior hull inspections and coating preservation, which will reduce the need for steel renewal.
- Where steel renewal is required, those needs can be quantified through the hull inspection program or by drydocking inspections and then be included as a definite item in the next contract, thus reducing unplanned out-of-service time and change order costs.

Recommendations:

- As part of the availability summary of data, include the contract award start and end dates, the redelivery date, and the calculated difference.
- Any change to the contract redelivery date should be done by change order, as is the practice, but the reason for the contract extension should be clearly explained and tied to specific contract line items. The vessel project engineers, the vessel business staff, and Legal Services and Contracts should then review each contract extension and determine if similar extensions might be averted if changes are made to internal contract management policy, pre-contract inspections, specification language, or different approaches to recurring work requirements.
- For typical critical path items, it may be beneficial to keep track of the scope of work in some qualitative fashion vs. the time required to do the work and maintain that database. By having these metrics, engineers can better estimate the duration of contracts with those critical path items as part of the contract. Examples: topside painting and hull painting could be square feet; passenger spaces renovation could be square feet of deck, number or linear feet of seating, number of tables.

Section 10 Coordination with Required USCG Drydockings.

United States Coast Guard (USCG) requirements for periodic drydocking of passenger vessels (applicable to the WSF fleet) are found in 46 Code of Federal Regulations (CFR), subchapter H. All subchapter H passenger vessels are required to be drydocked (to permit underwater hull and other underwater vessel systems' inspections) twice every five years (two times in every consecutive five year period of the vessel's operational life.) The Under Water Inspection in Lieu of Drydocking (UWILD) program permits a vessel owner to inspect in the water instead of the drydock, at alternate intervals. Descriptions of the inspection are presented in the USCG's Navigation and Vessel Inspection Circular (NVIC) 1-89 and in the American Bureau of Shiping (ABS) for the Class Notation (UWILD), April 2007. Drydocking can be reduced to once every five years rather than twice in five years, but must have two diver inspections and two internal hull inspections in that 5-year period between drydocking. Vessels on international voyages will require inspection that is more frequent.

Eligibility for the program for passenger vessels is detailed in 46 CFR 71.50-5. Upon successful application, vessels under 15 years old may participate, and may continue to participate after 15 years of age. Vessels over 15 years of age may apply for entry into the program and will be considered on a case-by-case basis.

Steel vessels less than 15 years old with a corrosion protection system are eligible, and may participate past 15 years of age if a consistent inspection regime has been maintained, and the hull has not deteriorated. It is important to note that enrolling vessels that are older than 15 years may not be cost effective or even possible depending on the condition of the hull steel.

Vessels over 15 years of age may be allowed to participate if certain conditions are met. Some of these conditions include:

- Steel or aluminum construction.
- Fitted with an effective hull corrosion protection system.
- Full audio gauging of the hull at the last drydocking, showing the vessel free of appreciable deterioration.

The amount of appreciable deterioration is not detailed in the CFRs, but ABS's standards require structural replacement if the steel thickness is less than 75% of the calculated (ABS rules-based) required thickness (25% wastage). The depth and spread of corrosion would be a consideration in the application for UWILD program entry. With case-by-case review, mitigating factors such as a thorough existing inspection regime, records of past gauging and repairs, and ease of access for internal inspections would be considered in the evaluation.

The UWILD inspections do require some special markings and minor vessel modifications (e.g. external frame markings, removable buoyant seachest screens, ability to remove sea valves while the vessel is in the water), but allow much more flexibility in the timing and location of required hull inspection compared to traditional drydockings.

Currently, only the M/V Elwha (new in 1967 - rebuilt in 1991), M/V Chelan (new in 1981 - rebuilt in 2005), and M/V Chetzemoka (new vessel launched in 2010) are enrolled in UWILD. There may be opportunities for the Jumbo Mark II's (new in '97, '98 and '99), M/V Yakama and

M/V Kaleetan (both new in 1967, and rebuilt in 2000 and 1999, respectively), and M/V Walla Walla (rebuilt in 2005) are not enrolled in UWILD. All the new 64 and 144-car auto ferries coming on line in the next few years, and all vessels after that, are planned to be enrolled in UWILD. Enrolling vessels and removing vessels from participation in the UWILD program requires customized PM and USCG required inspections, and adjustments to the respective vessel's LCCM schedules.

Conclusions:

- There could be unrecognized opportunities for reducing VOST through the UWILD program for select WSF vessels.

Recommendations:

- Given the potentially significant cost and VOST advantages associated with having vessels enrolled in UWILD, we recommend that WSF first fully explore and assess the technical feasibility, then assess the costs vs. benefits, of enrolling all the above-mentioned vessels into the UWILD program.

Section 11 Route Impacts on VMP&I Projects

The routes that WSF vessels travel are diverse in both geographic scope and service requirements. Vessel maintenance, preservation, and to a lesser degree improvement projects are directly and indirectly influenced by certain characteristics of the various routes. Influences on the VMP&I projects associated with the individual characteristics/requirements of the routes include, but are not limited to, the following:

- **Total engine operating hours and fuel burned.** In conjunction with manufacturer's maintenance and inspection schedules and requirements, are the primary drivers for the timing of engine overhaul and maintenance events.
- **Engine load factors.** An example of how this influences engine maintenance can be found in the premature and regular replacement of turbo chargers on vessels regularly assigned to the south sound routes. These routes are so short, coupled to the size of the engines and route specific speed restrictions, that the diesel engines on this route do not routinely achieve design operating temperatures or loads. This is actually harmful to marine diesel engines, and contributes to "coking up" and pre-mature failure rates of the associated engines' turbochargers.
- **One way trip durations.** Affects ability and availability of on board engine crew to efficiently address routine maintenance items.
- **Total (daily) in service times.** Affects ability of on board engine crew to efficiently address routine maintenance items, and increases general wear and tear on vessels operated for longer periods of time across the board.
- **Quantity of passengers and autos.** The throughput of both passengers and automobiles has a direct impact on the general wear and tear of certain vessel systems, such as flooring, doors, galley and restroom facilities, car deck paint and general cleanliness, seats and more.
- **Percentage of walk on to drive on passengers.** Uniquely affects wear and tear on joinery, seats, doors, floor coverings, galley equipment, plumbing systems, HVAC systems, etc.
- **Exposure to weather extremes**. Most WSF vessel routes are considered inland or protected waters routes; however, some of these protected waters routes are more exposed to weather extremes than others, and this exposure influences the break-down of coatings systems and preservation requirements.
- **SOLAS requirements. (**SOLAS requirements drive many aspects of the vessels such as stability metrics, double bottom requirements, arrangements, redundancy of machinery, and additional safety and navigation equipment; the latter issues of which have to be inspected and maintained.)
- **Route Proximity to EH VMP&I Project Assistance.** It is difficult to quantify the effect that this route impact has on VMP&I projects, but we believe there must be an impact. The idea behind the impact has to do with the proximity of the route and overnight vessel berths, with EH. It is more costly and time consuming for EH personnel to visit and service the vessels farther away from EH and we believe there must be an

impact associated with this reality. For purposes of this analysis, we have assumed that the impact is increasingly negative with increasing distance between EH and the route.

The Route Impact Analysis Matrix (RIAM) results and conclusions are summarized below:

Conclusions:

- We believe that there are characteristics of routes that have certain negative and positive effects on specific VMP&I projects. These effects also impact the general overall vessel readiness and condition. Some of these effects are:
  - The high number of walk on passengers on the Seattle – Bainbridge and Seattle – Bremerton routes.
  - Increased engine maintenance on short routes with low engine loading such as Fauntleroy / Vashon / Southworth.
  - The long vessel operating hours of the Seattle – Bainbridge, Seattle – Bremerton, and Edmonds – Kingston routes.
- Results from the RIAM show that while there are differences in the impacts identified and scored for each route, the impacts tend to balance out, resulting in route impact scores that are very close to each other for most routes.

Section 12 Evaluating Ongoing Maintenance and Preservation Costs Associated with Proposed Improvement Projects

12.A LCC Elements

WSF vessel improvement projects can be associated with two different types of projects. The first type deals with an existing preservation item, which after a scheduled inspection, WSF decides to accomplish earlier than the interval period indicated in the LCCM. However, the other type of improvement project is when WSF proposes to replace an existing system with another system, or install a new system where none existed before. In either of the later cases, these new systems should provide an overall benefit to the WSF system as a whole. The benefit could be in reduced tangible LCCs, or intangible benefits like improved environmental compliance, improved safety, improved capability, improved reliability and/or availability, or for emergent regulatory changes such as the recent requirement to install various security systems.

There are volumes written on various methods of conducting a cost benefit analysis, but for the purposes of this report, we will assume the improvement project will indeed provide an acceptable level or increase of intangible benefits over the existing system, and can be quantified. So the improvement option will be evaluated on differences between the value of all the intangible benefits of the option, and all the tangible costs of that option.

Typical categories and sub-categories of tangible costs of major system acquisitions are:

- Pre-Installation Costs
  - Requirements Analysis
  - Engineering Services for Specification and Design Development
  - Computer Hardware and Software Development and Design
  - Installation Specification Development
  - Long Lead Materials
  - Contract Solicitation, Review and Award Support
- Installation Costs
  - Materials (other than long lead materials)
  - Installation Labor
- Acquisition Integrated Logistics Costs
  - Maintenance Planning
  - Supply Support : Planning and Initial Spare and Repair Parts
  - Support and Test Equipment Procurement
  - Required Manpower and Personnel Planning
  - Training and Training Support: Planning and Initial Training
  - Technical Data and Publications: Technical Manuals and Drawings
  - Computer Resource: Sustainment Plans
  - Facilities Requirements and Building
  - Packaging, Handling, Storage and Transportation
- Sustainment Support Costs
  - Manpower and Personnel
  - Maintenance and Preservation, including obsolescence replacements, for Hull, Mechanical, Electrical, and Electronics systems, and computer hardware and software systems

- Emergent Long Lead Spares
- Spare and Repair Parts
- Energy
- Training

Ø Disposal Costs

This list is applicable for any acquisition, from the most major to the smallest. If the improvement is a replacement for an existing system, some of these elements will not be applicable to the existing system but may be applicable to the improvement. Depending on the size and complexity of the improvement, some parts of the list would not be applicable for the improvement option either, or the cost may not change from the old to the new for individual vessel system replacements.

12.A.1 LCC Elements with Example

Appendix K is a spreadsheet that provides an example for a LCC analysis model for a current improvement project to install a new radar prior to the interval for the radar preservation item. The costs in the spreadsheet are aligned with the acquisition cost elements listed in Section 12.A. In addition, there are two columns of cost. The first column is the labor cost for WSF engineering staff or its sub-consultants to develop the acquisition plans. Overhead positions are not counted. The second represents the costs that would be associated with SYs or vendor suppliers. Where we believe cost estimates need to be developed, we have indicated those cells by a "yes" and highlighted that cell in "rose."

The LCC for the existing system needs to be calculated using the existing LCCM cost factors and historical costs for sustainment for the remaining life of the ship. For the improved system's LCC, the analyst would estimate acquisition costs for the initial system. Then add to that the LCC using a new estimated cost factor estimate, possibly a new interval if the system is more reliable, and the new sustainment costs, all over the remaining life of the ship.

Hopefully, by installing the new improved system there would be a reduction in LCC to overcome the acquisition costs. The reduction in LCC most likely would come from a reduction in sustainment costs and improved reliability over the existing system. This is all theoretical in a sense as related to radars, because if you waited until the interval of the existing system and looked for a replacement system, you very well could find one that does the same job or better, and is more reliable and the sustainment costs are less as well. However, if WSF wanted justification for replacing it early, this is a good model.

12.B The Maintenance and Preservation Cost Element

One of the LCC elements that have the most impact on LCC, is the element for maintenance and preservation. The concept of maintenance, especially PM, is quite simple. An owner has invested in a system or equipment consisting of components that will wear out or deteriorate over time and will need cleaning, recoating, replacement or adjustment. In accomplishing this maintenance, the equipment's ability to operate within the required ranges of performance will be restored, and its life span will be extended.

The concept for preservation is that when, through maintenance, the owner can no longer restore the system or equipment to within the required design range or condition, that system or equipment will need to be replaced by a new system that can meet the same requirements as the original.

12.B.1 Maintenance Planning and LCC Estimate

In order to develop a maintenance plan for the ship, a maintenance planner takes into account all the potential failures in each critical system or equipment and through analysis chooses the most cost effective maintenance strategy to mitigate or eliminate the failure, which will restore the system or equipment to it operational range of capability. A common and accepted method of doing this analysis is called Reliability Centered Maintenance (RCM), which will be summarized later in this section. The combination of these maintenance activities for each system, or equipment is typically called the maintenance plan for that system or equipment. A Washington State ferry is made up of many systems, and combining the maintenance plan for each of the systems generates the maintenance plan for the entire ship.

There are generally two ways to generate a maintenance plan for a system. One is to depend on the equipment or system provider to deliver a maintenance program as part of the procurement. The other is for the owner, or in this case, WSF to develop or have some third party develop a maintenance program.

For WSF to depend on the equipment or system provider to deliver the maintenance plan is a reasonable and cost effective option, particularly if the vendor and the equipment has a documented history of operation in the application of ships similar to WSF's ferries and their operational profile. It may also be a required option if the vendor offers a warranty, which is based in part on the owner following the system provider's required maintenance plan.

If the system vendor does not have a recommended maintenance plan, WSF may either require the vendor to develop one or WSF may do the work in-house or subcontract the work to a third party either in whole or as part of a WSF working group.

Based on this vendor supplied plan, WSF will:

- Estimate the type and number of maintenance events over the life cycle of the system.
- Identify who will actually perform each maintenance event. This is sometimes called the level of repair analysis and the task is assigned to either the:
    - Vessel crew
    - EH
    - Authorized commercial equipment maintainer (Vendor)
    - SY
- Estimate a cost for labor and materials to execute each maintenance action over the life cycle of the system.
- Identify WSF system spares, stored either on board vessels or in WSF control. Preference is given to procure needed spare and repair parts from the system provider or other original equipment distributor. However, if the time delay to procure and receive

specific parts or components is unacceptable, WSF may want to stock those parts in-house. This concept is really part of the supply support plan, but it is a cost associated with maintenance.

12.B.2 Preservation Planning

When maintenance can no longer restore the system to within its acceptable range or condition, the system is renewed. The system is normally defined or bounded, and acceptable ranges and condition determined. Life cycle intervals are estimated based on historical data and or industry standards, and estimated cost factors are established based on the scope of work estimated to renew the system. For WSF, these data elements are maintained in the LCCM for the vital and non-vital systems for ferries. The data is updated at least every three years. If an improvement project is being considered, the preservation costs must be estimated as part of the overall life cycle cost of the improved system.

12.C RCM Summary

Within the last 20 years, an accepted method of developing a maintenance plan is to use a methodology called RCM. It is normally used for analyzing the maintenance portion as opposed to the preservation portion of the Maintenance and Preservation cost element. This methodology is very simple in concept, but can be quite involved when dealing with complex and/or new technology without a reasonable amount of operational history. In essence, the methodology consists of the following processes:

- Identify the critical or costly systems.
- Identify failure modes for each of these systems – i.e. ways the system can fail.
- Evaluate the most cost effective way to mitigate or eliminate the failure:
    - Redesign the system to eliminate or mitigate the potential for the failure.
    - Monitor the condition of the system and perform PM when required (condition-based maintenance).
    - Perform a PM task based on time of system operation.
    - Run to failure and then renew.

This approach to identifying required maintenance, if strictly adhered to, forces the owner to conduct maintenance only for the purpose of preventing a failure of a critical system or component. It is not uncommon that maintenance is performed on a system without it being associated with a failure and that effort really is a waste of manpower and dollars. It also can have a detrimental impact by introducing potential failures by taking the system apart and not putting the system back together properly, and all for a purpose that is not providing value in the first place.

Identify Failure Modes: This task can be difficult especially with complex systems or new technology. However, there is a disciplined approach called failure mode and effects and criticality analysis. By way of this analysis, failures are identified, as well as the effect of the failure on the system. Again, for systems like diesel engines that have been in production and operation for a number of years, the failure modes are well known and maintenance tasks have already been identified by the providers of the system, which may be acceptable to WSF.

However, if the system does not have a proven maintenance plan, identifying the failure modes is the starting point.

The next task is to evaluate options that can mitigate or eliminate the various modes of failures.

Design the Failures Out: The better, more reliable systems have had design modifications made to reduce the occurrence of these failures. These modifications are mostly in the area of engineering more reliable parts and components, or using materials or manufacturing processes that improve reliability.

Condition-Based Maintenance: If the failures cannot be designed out, a common option is to monitor the condition of the system and conduct maintenance only when the variables monitored indicate the system is operating outside its operating parameters, and/or is not producing the required output. This could consist of monitoring pressures, temperatures, vibration, energy consumption, material deterioration, among others. Some form of PM is done to restore the system to within normal operating range or condition. A simple application of condition monitoring is to measure the pressure drop across a fuel or oil filter. When the discharge pressure, as compared to the inlet pressure, is below an acceptable amount, the filter(s) should be changed.

Time-Based Maintenance: Scheduling maintenance based on time or cycles is a long-standing approach to maintenance planning. Most automobile manufacturers recommend maintenance actions based on miles of operation, or months of service. However, this approach is only cost effective if the intervals are based on sound historical data, and suppliers and operators are confident that the intervals are appropriate. If a maintenance activity is done after so many hours of operation, and the inspection of the system indicates that the system looks good and was still operating within normal ranges, the maintenance may have been unnecessary. In this situation, you run the risk of introducing failures when mistakes are made during reassembly and the maintenance was not even needed. Some maintenance planners use a combination of time-based and condition-based maintenance. The maintenance is scheduled by time, but the owner requires condition-based indicators to validate the maintenance need.

Lastly there is an option to run the system or component to failure. This does not mean catastrophic failure, but failure to perform the designed output. A good example might be a small fan, motor, or valve. Often it is more cost effective to buy new than to repair.

For each failure mode, the maintenance planner chooses the most cost effective option from those above to mitigate or eliminate the failure.

There are several good reference books on RCM. One recommended resource is *"Reliability Centered Maintenance: Gateway to World Class Maintenance"* by Anthony M. Smith, 1993.

Recommendation:

- Use a cost benefit analysis to evaluate improvement options based on the difference between the value of all intangible benefits and all tangible costs.

Section 13 Vessel Route Suitability Matrices

Most WSF vessel classes are designed to accomplish the service requirements of a single route. At the same time, most WSF's vessels are also typically designed with the understanding that they may be called upon at any time to substitute for other vessels; sometimes not of the same vessel class, or even designed or designated for the same primary route. For this section of the VMPIP, we were tasked with constructing an independent Vessel Route Suitability Matrix for each WSF vessel class. In each of the nine Vessel Route Suitability Matrices, a particular vessel class was scored on how well that class's capabilities match up against nine general route requirements. These route requirements are common across all nine WSF routes. Based on the assigned scores, a total vessel route suitability score was tabulated. This total vessel route suitability score is unique for each WSF vessel class and WSF route. Please refer to Appendix L for detailed and summary information associated with the Vessel Route Suitability Matrices and vessel route suitability scores.

CONCLUSIONS AND RECOMMENDATIONS

This section of the VMPIP chronicles both the conclusions and recommendations we have reached and developed through the course of this effort. This section does not contain our comments or recommendations identified in the **Background Document Summary Review** section of the VMPIP, as these are indexed to specific previous consultant studies. The order of conclusions and recommendations presented below is reflective of the order in which they are identified in the body of the VMPIP.

Conclusions:

General

- EH maintenance facility and its employees provide cost effective, value added vessel maintenance, repair, and capital improvement services to WSF.

- WSF's VMP&I organization and policies are continuing to evolving from a "reactive" to a more "preventive" organization. This is aided by procedures recommended in the LCCM studies and the use and maturation of the LCCM, into initiating Predictive Maintenance practices

Schedule of Vessel Maintenance, Preservation, and Improvement Activities

- The results of the schedule and financial plan show that it will cost approximately $2.47 billion to maintain, preserve, and improve the current WSF fleet for the next eight biennia. Maintenance costs account for approximately $440 million, preservation costs account for approximately $1.01 billion, and improvement costs (including new vessels) account for $1.02 billion. The results of this analysis provide a relatively conservative estimate since it is based largely on the LCCM cost estimates and includes contingencies.

- It is important to note that accurately predicting preservation and improvement costs beyond the current and upcoming biennium is difficult. Although using the LCCM cost estimates is a good basis for budgeting, the exact work scopes for preservation items cannot be known in detail far ahead in the future. We want to stress the importance of continually updating the LCCM interval and cost estimates with updated information as preservation items are accomplished in order to continually improve forecasting ability.

Section 2

- EH employees working on work scopes will not shorten the duration of a SY availability. The reality of this issue is that only by decreasing the duration of the SY project's critical path, will the SY availability be shortened. If the SY project's critical path is not shortened, then no amount of consolidated work outside of the critical path issues will result in a shortened yard period or reduced VOST.

- There are both opportunities and good business and operational reasons for consolidating (traditional) EH work scopes into and during commercial SY availabilities, there are also definite and restrictive limitations. Accomplishing work scopes involving hot work, steel

replacement, steel preservation, (large) piping system refurbishments, extreme heights, and all underwater hull work, inside Puget Sound commercial SYs, is unlikely to ever be allowed.

- There are advantages to having EH employees working on WF vessels inside of commercial SYs, but reducing VOST is not necessarily one of them.

Section 3 – NA

Section 4

- All other factors being equal, the EH maintenance facility's hourly rates (EH = $51.97; Puget Sound SYs = $69.95 – See Section 4 and "Final Note" 4.A), zero mark-up on materials, familiarity with the vessels and vessel systems, and 24/7/365 on-call availability provides WSF significant value relative to other Puget Sound SYs.
- Annual average travel and penalty pay effectively reduces the labor rate differential between EH and commercial SYs by approximately $4.94/hr. (For projects involving combined and/or extensive travel and penalty pay, it is possible that VMP&I tasks performed by EH personnel could completely erase the value added differential.)
- EH's cost structure is very much in line with the public ferry operator (PFO) No. 1.
- EH's overhead costs as a percentage of billing rates are roughly half that of most of the SYs questioned. The primary reason for this low overhead percentage is EH's relatively high ratio of hourly to (salaried) supervisory personnel.
- EH's structure and size is similar and proportionate to other PFO's examined.
- Diesel engine maintenance and repair and electrical system/component maintenance and repair work scopes represent the two most critical skill sets that are in highest demand by WSF vessel crews, followed closely by the pipe fitters, and are the areas where EH personnel provides significant value to WSF. Not coincidentally, expert proficiency and resource capability in these three areas contribute heavily to the admirable, industry leading level of safe and reliable service WSF provides the citizens of Washington State (See Reference 11).

Section 5

- Most WSF vessel crews are accomplishing the vast majority – almost all – of the PM type work orders that are created and managed through the fleet's CMMS. At the same time, there is opportunity for some vessel crews to increase their range and level of accomplishing standard PM type work scopes during the course of daily operations.
- Accomplishing any significant amount of preservation work while underway is believed to be impractical and, in some cases, nearly impossible and dangerous.
- It is reasonable to expect that many PM and predictive maintenance inspections, some additional maintenance tasks, and some additional minor, isolated preservation/

improvement tasks could be handled by crews while vessels are underway and/or during nighttime lay-ups.

Section 6

- Results from the review of the variables associated with VMP&I tasks is so wide, that no general conclusion or recommendation concerning task costs on jobs performed by the two respective work forces (EH and/or Vessel Crews) can be made at this time. If anything, it appears to us that the difference between costs of most tasks performed by the two respective work forces, is negligible.

- Penalty pay, when and how it applies to specific tasks and for specific unionized employees, drive costs, and this is especially applicable to vessel crew unlicensed engineers.

Section 7

- When one considers having eight to eleven contracts in one stage or another at any given time, it is impressive that WSF has consistently awarded vessel contracts when scheduled.

- It is exceptional that very few, if any contract awards are delayed because the (contracting) process was not executed properly.
- We believe that when the (preservation) item is inspected for the LCCM validation, it also is the best time to baseline the scope and cost estimate for the next biennium's budget and 16-year work plan.

Section 8

- There are noise restrictions within the Puget Sound region that restricts work after 8 p.m. and in some cases 10 p.m.
- In many cases, by choosing the contract durations they do, it appears that WSF already forces contractors to work some 10-hour days, weekend work, or second shifts to complete all required work on time. This may not be intentional but, in at least one SY's opinion, that is the case for topside painting contracts.
- Although none of the three respondents indicated there was a problem ramping up to work overtime/second shift, with new construction in the area at several yards, we believe for the near term that there will be a shortage of qualified SY workers.
- It appears that WSF already anticipates SYs need to work overtime, work on weekends, or work second shifts to accomplish routine availabilities. Therefore, to be able to count on accelerating work further for the sole purpose of trying to reduce out-of-service time does not appear to be a wise strategy, especially if the reason to reduce the out-of-service time is to justify reducing the fleet size.

Section 9

- WSF has increased attention in both interior and exterior hull inspections and coating preservation, which will reduce the need for steel renewal. Where steel renewal is required, those needs can be quantified through the hull inspection program or by drydocking inspections and then be included as a definite item in the next contract, thus reducing unplanned out-of-service time and change order costs.
- Where steel renewal is required, those needs can be quantified through the hull inspection program or by drydocking inspections and then be included as a definite item in the next contract, thus reducing unplanned out-of-service time and change order costs.

Section 10

- There could be unrecognized opportunities for reducing VOST through the UWILD program for select WSF vessels.

Section 11

- We believe that there are characteristics of routes that have certain negative and positive effects on specific VMP&I projects. These effects also impact the general overall vessel readiness and condition.
- Results from the RIAM show that while there are differences in the impacts identified and scored for each route, the impacts tend to balance out, resulting in route impact scores that are very close to each other for most routes.

Section 12 - NA

Section 13 - NA

Recommendations:

General

- (On a trial basis) Incorporate advanced coating systems and application processes below both above and below the waterline – along with heavier scantlings - in wet and other known problem areas on board the vessels.
- Concurrently, we recommend a continuation of the current shift in management policy and focus, as recommended in recent LCCM studies, toward a more predictive maintenance organization. With proper training and tools, vessel crews should be able to accomplish and/or participate in non-destructive inspections via thermal imaging, vibration analyses, ultrasonic testing, and other predictive maintenance techniques.

Background Document Summary Review

- Many of the recommendations made in the background references impact VOST or the efficiency of the VMP&I program. In our review and analysis, we concurred with many

of the recommendations, and for those recommendations, we recommend that WSF establish a process / procedure / organizational will to follow-up with each one.

Schedule of Vessel Maintenance, Preservation, and Improvement Activities

- WSF should continue to evolve and expand their inspection processes to allow for a better understanding of material condition on the vessels. For example, hull inspection coupled with the steel preservation program allows more detailed information to be obtained on the condition of each vessel's hull steel. This enhanced knowledge will allow for more detailed scoping of the work, which will in turn allow for more precise budgeting.
- As a first step, portions of the maintenance budget be developed and allocated by vessel class. This would put the WSF maintenance budgeting process more in line with common industry practice and would allow for more detailed budgeting.

Best Practices / Interviews

- Find a way to incentivize both the Master and Chief Engineers to actually minimize both VOST and missed sailings.
- Continue to adopt designs incorporating vessel system simplicity and redundancy of machinery and systems, with a focus on reduced maintenance, reliability, and safety.
- Continue to make improvements in WSF's and Eagle Harbor (EH)'s Information Technology (IT) systems. All systems currently in use (Maintenance Productivity Enhancement Tool (MPET), Preventive Maintenance (PM) at a Glance, Life Cycle Cost Model (LCCM), Statewide Inventory, Statewide Accounting System, and more) need to talk to each other.

Section 1

- Organize, plan and manage all VMP&I projects around the critical paths, and/or vital system/inspections. Only by reducing the durations of critical path items – splitting the tasks up into discrete bits, or eliminating the items altogether through preventive/predicative maintenance practices – can out of service time be reduced to any meaningful degree.
- Expand upon the M/V Puyallup's operational history of limiting or eliminating EH annual availabilities. We recommend that WSF study and document the operational history of the M/V Puyallup to understand opportunities for increasing maintenance activities on other fleet vessels. (There may be other WSF vessel's with similar records, but these were not identified during the course of our efforts.)
- Routinely review and evaluate extended availability periods and unanticipated SY change orders that are beyond acceptable thresholds to determine the causes. Change specifications or procedures to reduce the probability of similar occurrences.
- Increase EH staff and onboard vessel crews' involvements and responsibilities for accomplishing VMP&I efforts while underway, or alternatively during scheduled down-periods. These daily down periods are where the majority of small VMP&I tasks and

other small projects, two hours or less, would occur. In addition to making the time in-between scheduled runs, these efforts require good advanced planning and coordination between consulting engineers, vessel crews, shore side vessel engineers, vessel business staff and vendors. The net result is a reduction in out-of-service time with no noticeable increase in project costs and with minimal reduction in service levels. Black Ball, Pierce County, AMHS and other ferry operators have built these down periods into their daily schedules.

- Expand WSF's participation in the USCG UWILD program to include the Jumbo Mark II Class. (See section 10)
- Expand utilization of "Tiger Team" concept. "Tiger Teams" are comprised of a select, usually small group of EH employees, who are well trained and equipped to make emergency type repairs. We see no apparent reason why this concept could not be expanded to include specific planned projects or repairs across the class or fleet while the ship(s) are tied up, as long as the project could be done during the four to six hours at night while the ship is tied up at their overnight pier. The project/repair/inspection may also be conducive to being broken into four to six hour increments and done over a period of days as well. By carefully planning and incorporating these "preventive" type maintenance or capital repairs into the EH production and vessel schedules where and as appropriate, WSF takes another step away from "reactive" fleet maintenance. This will incrementally reduce the out-of-service time across the fleet, and will increase fleet reliability and readiness.
- Plan, budget, and implement at the start of every fiscal year, an "On-Call" contract with multiple yards to provide and deploy short term labor to the EH facility in times of critical need. This would allow EH to procure additional skilled unionized labor within one to two days, as opposed to the two to three weeks it currently takes.
- For emergency underwater repairs, consider utilization of pre-qualified, in-situ vessel repair companies such as HYDREX® as an alternative to drydocking. To gain the most benefit from this approach, contractual issues should be resolved in advance of the necessary repairs, along with identification of applicable repair categories and tasks specific to each vessel class.

Section 2

- Continue the practice of utilizing EH workforce inside commercial SYs, but only when it accomplishes one of the following goals:
  - Accomplishes a vital system maintenance event that is either overdue or due before the next scheduled yard or EH availability.
  - Eliminates the need for removing the vessel from service in the immediate future.
  - Reduces the critical path for an upcoming EH lay-up period.
  - Eliminates or mitigates a potential vessel scheduling problem or EH work force scheduling problem.

Section 3

- WSF and EH put into place the necessary processes and procedures that will allow data to be accurately captured and easily shared, that will allow direct comparisons of similar capital projects accomplished by EH and independent contractors.
- Do not make any changes with respect to the $120K threshold at this time. Allow more time to go by and project opportunities in this size range to present themselves to EH.
- When bidding on large capital projects, EH should plan on and budget for assigning at least a part time, maybe full time, experienced project manager to manage the project.
- EH should not bid on large capital projects that do not match up well with their core competencies and capabilities. Their first $120K project should not be in an area outside their core competencies and should not be a "strain" to accomplish.

Section 4

- EH should fully identify, track, and manage both their employee benefits and overhead costs separately.
- WSF and EH should identify the primary causes for penalty and travel pay, and work toward reducing the causes of both.

Section 5

- We recommend that WSF study and document the operational history of the M/V Puyallup to understand opportunities for increasing maintenance activities on other fleet vessels. (There may be other WSF vessel's with similar records, but these were not identified during the course of our efforts.)
- We recommend that WSF review and communicate to the fleet, its organizational goals with respect to on board maintenance activity.
- Continue the current shift in WSF management policy and focus, as recommended in recent LCCM studies, toward a more predictive maintenance organization. With proper training and tools, vessel crews should be able to accomplish and/or participate in non-destructive inspections via thermal imaging, ultrasonic testing, and other predictive maintenance techniques.
- WSF should renew focus and emphasis on equipment/system standardization, particularly with regard to the new vessels.

Section 6 – NA

Section 7

- Establish the baseline scope of work for preservation items during the LCCM validation inspection.
- Strongly recommend incorporating the condition-based maintenance suggestions.

- Incorporate auto deck and strength deck steel inspections within the purview of the hull inspection team.
- Treat inspection and painting of potable water tanks and sewage tanks a priority as a means to determine the preservation item for steel replacement.
- Institute a new electrical insulation quality inspection and analysis using polarization index readings and a third party analysis.
- Make the vibration analysis program of rotating equipment more robust and require EH or a third party vendor take the readings quarterly.
- Make slight changes to change the order process to improve the capture of the reasons for each change, especially for contract extensions.
- Expand the requirements for the contracting lessons learned program.

Section 8

- We recommend WSF make no changes in their approach to expediting work in shipyard contracts.

Section 9

- As part of the availability summary of data, include the contract award start and end dates, the redelivery date, and the calculated difference.
- Any change to the contract redelivery date should be done by change order, as is the practice, but the reasons for the contract extension should be clearly explained and tied to specific contract line items. The vessel project engineers, the vessel business staff, and legal services and contracts should then review each contract extension and determine if similar extensions might be averted if changes are made to internal contract management policy, pre-contract inspections, specification language, or different approaches to recurring work requirements.
- For typical critical path items, it may be beneficial to keep track of the scope of work in some qualitative fashion vs. the time required to do the work and maintain that database. By having these metrics, engineers can better estimate the duration of contracts with those critical path items as part of the contract. Examples: topside painting and hull painting could be square feet; passenger spaces renovation could be square feet of deck, number or linear feet of seating, number of tables.

Section 10

- WSF should assess the costs vs. benefits of enrolling more vessels into the UWILD program.

Section 11 – NA

Section 12

- Use a cost benefit analysis to evaluate improvement options based on the difference between the value of all intangible benefits and all tangible costs.

Section 13 – NA

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