Evaluating the Use of Liquefied Natural Gas in Washington State Ferries

Prepared For:

Joint Transportation Committee

Consultant Team

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The Cover Photo shows the Norwegian ferry operator Fjord1's latest ferry, the design and construction of which will be the world's largest LNG-fueled ferry, with delivery scheduled for November 30, 2011.

EXECUTIVE SUMMARY

The 2011 legislature directed the Joint Transportation Committee to investigate the use of liquefied natural gas (LNG) on existing Washington State Ferry (WSF) vessels as well as the new 144-car class vessels and report to the legislature by December 31, 2011 (ESHB 1175 204 (5)); (Chapter 367, 2011 Laws, PV).

This white paper includes recommendations on design, construction, and operation of WSF LNG vessels and the consultants' independent financial analysis. It is a companion to the study's October white paper.

ANTICIPATED LNG SCHEDULE

The schedule includes detailed design and regulatory review for the first vessels, ordering of LNG fueled engines which take approximately one year for delivery, and construction. Retrofit construction of each Issaquah class vessel is anticipated to take six (6) months.

WSF has awarded the contract for the first new 144-car vessel with a diesel engine. If a second 144-car vessel is built with a LNG fueled engine, it is anticipated to be complete in 2016.

The Super class 144-car *Hyak* will be out-of-service for 10 months from September 2013 to July 2014 for a major renovation. To maintain service the Issaquah class retrofits will begin after the *Hyak* returns to service. The Issaquah class vessels are anticipated to be retrofit at the rate of one per year starting in 2014-15, with all six (6) completed by 2020. On this schedule, the Issaquah class vessels would have between 22 and 24 years remaining on their anticipated 60-year service life following the LNG retrofits.

VESSEL DESIGN AND CONSTRUCTION

WSF has a concept design for the new 144-car LNG vessel based on the design of its new 144-car diesel vessel. They also have a concept design for the retrofit of the Issaquah class vessels. If constructed on the anticipated schedule these vessels would be the first U.S. constructed LNG fueled passenger vessels.

LNG-Fueled Vessel Safety Design Considerations

Det Norske Veritas (DNV) a Norwegian classification society has identified three main safety challenges for LNG fueled vessels: explosion risk, steel cracking if LNG is released onto ship steel, and the protection of gas fuel tanks from external fire, mechanical impact, and from the ship side and bottom in the event of a collision or grounding.

WSF's concept design has two features that are different from Norway's existing LNG fueled ferries and from the new LNG ferry being constructed in Quebec.

- *Engine room standard.* There are two (2) types of engine room design standards – intrinsically safe and emergency shutdown (ESD).[1] The WSF concept design is for an intrinsically safe engine

[1] An intrinsically safe design has an engine room with all explosion proof equipment so no ignition source is available in the event of a gas leak. In the emergency shutdown concept, the gas fueled engine is allowed to be in an area with non-explosion proof machinery but the piping is double walled and there are methane detection alarms. In the event of a leak, the affected engine is immediately shutdown.

room. Norway and the Quebec ferries engine rooms are emergency shutdown designs. The Norwegians exceed both the ESD and the inherently safe engine room requirements by placing each gas fueled engine in its own steel enclosed space such that a fire or explosion in the space will not affect any other space.

- *Storage tank location.* WSF's concept design has the storage tanks on top of the vessel. All of the Norwegian LNG ferries and the new one being built in Quebec have the storage tanks in the hull. The International Maritime Organization (IMO) is developing rules regarding the placement of the storage tanks in the hull.

LNG Fueled Vessel Regulatory Considerations

As discussed in the first *White Paper* there is regulatory uncertainty surrounding LNG fueled vessels. The International Maritime Organization (IMO) rules are under review and the United States Coast Guard (USCG) does not have applicable regulations. The deadline for the IMO to adopt regulations regarding LNG fueled vessels has been extended from 2012 to 2014, making rules regarding storage tanks and engine room designs more uncertain.

A major consideration for the Issaquah class retrofit is whether the USCG will decide that the retrofit constitutes a major conversion which would require WSF to update the vessel to meet all current regulatory requirements, which would add to the cost.

Vessel Construction Considerations

No U.S. shipyard has experience with the construction of LNG-fueled vessels, which increases the potential for problems.

It is important to test the vessel engines with the LNG that will be used in operation as the gas composition varies by source.

Consultant Design and Construction Recommendations

The consultants recommendations are intended to: ensure that European LNG fueled passenger ferry experience is used during the design and construction of WSF LNG-fueled vessels; facilitate on-going legislative decision-making; and minimize regulatory risk.

Recommendation 1: Classification

The LNG vessels should be designed to a classification society rules (which could be DNV or another classification society) and classed during construction.

Recommendation 2: Legislative Oversight

a. The classification society should provide periodic independent reports to the legislature on its findings with regard to the design and construction process.

b. WSF should follow the mandated pre-design process for the Issaquah class LNG retrofit and for the new 144-car LNG vessel.

Recommendation 3: Regulatory Determination for Issaquah class retrofit

WSF should request a ruling from USCG on whether the Issaquah class retrofits will constitute a major conversion before proceeding with more detailed design and construction.

Recommendation 4. Design

WSF should contract with an outside design firm that has previous LNG fueled passenger vessel design experience rather than design the LNG vessels in-house. As a practical matter Washington state naval architects would have to sub-contract with firms that are experienced in the design of LNG fueled systems to meet this requirement.

Recommendation 5. Construction

a. The construction bid process should require bidders to include an expert from a shipyard with LNG fueled vessel construction experience in their bid. This would require a change in the procurement process to allow WSF to qualitatively evaluate the proposed outside expertise.

b. The LNG fuel supply contract should be in place before the shipyard construction contract is let.

CONSULTANTS' CAPITAL COST ESTIMATE

The consultants have developed independent rough order of magnitude capital cost estimates for an Issaquah class retrofit and for the use of LNG as a fuel source for a new 144-car vessel. In 2011 dollars, the first Issaquah class retrofit is estimated to cost $23.6 million and the new 144-car vessel $19.5 million.

The cost estimate includes the costs for security planning, WSF internal costs, and costs for design and construction of the vessels.

The consultants reviewed the capital preservation costs and determined that no changes in preservation costs could be confidently estimated.

Security Planning

The cost estimate includes an allowance of $0.5 million for security planning for the first LNG vessel. This assumes that a process similar to that required by the USCG for the location of LNG terminal facilities would be followed. The Captain of the Port can convene an ad-hoc working group - which can include state and local governments and members of the public – to consider issues related to use the LNG as a marine fuel. The advantages of this process are that is provides inter-agency coordination, encompasses the entire WSF service area, is able to incorporate all stakeholders, and is coordinated by the USCG.

WSF Internal Costs

WSF has not yet estimated its total internal costs. The consultants have provided an allowance of $1.0 million for the new 144-car vessel and the first Issaquah class retrofit to cover costs which include engineering, terminal, operation, community relations, security and other staff involvement. The allowance also provides for staff LNG training and for other costs that may be incurred, such as community relations and other consultants.

Vessel Design and Construction Costs

The consultants' independent cost estimate is based on WSF's concept designs. The consultants retained the services of an independent cost estimator who used an industry standard system work breakdown (SWBS) structure to estimate costs. The SWBS costs include regulatory review and outside naval architecture engineering support.

The initial SWBS cost estimate was prepared for the Issaquah class retrofit. The consultants met with the shipyard that is undertaking a conversion of a similar size diesel ferry to LNG ferry for Fjord 1, Norway's most experienced LNG ferry operator. The review with STX Langstein shipyard was used to confirm the estimated shipyard manhours.

Issaquah Class Rough Order of Magnitude Cost Estimate

The consultants' estimate of $23.6 million for the first vessel is higher than WSF's estimate of $14.7 million. The difference is because the WSF estimate did not include non-shipyard costs of $2.55 million included in the consultants' estimate for naval architects, regulatory approval, WSF internal costs, ad security planning. WSF also estimated fewer shipyard man-hours and did not include shipyard sub-contractors or profit.

WSF intends to convert all six (6) Issaquah class ferries, which they estimated would cost $65 million. The consultants estimate that the cost will be $134.2 million for all six (6) Issaquah class vessels in 2011 dollars or $151.6 million in year of expenditure dollars.

New 144-Car Vessel Rough Order of Magnitude Cost Estimate

The consultants' estimate of $19.5 million is higher that the WSF estimate of the additional costs for a new 144-car LNG vessel of $10.8 million. The difference are in part attributable to the fact that the consultants had the advantage of the more detailed Issaquah class retrofit drawings that were not completed when WSF did their estimate.

The differences include the allowance the consultants provided for WSF costs and security planning of $1.5 million that was not included in the WSF estimate; contingency of $2.3 million which was not in the WSF estimate; and differences in shipyard man-hours, profit, and materials estimates.

Preservation

Preservation costs for the new 144-car vessel and for the Issaquah class vessels could potentially be lower with LNG fueled engines than with diesel fueled engines. The potential cost savings are not included in the consultants' estimate nor are they included in WSF's cost analysis. There is no basis upon which to reasonably project savings since all existing LNG-fueled vessels are 10 years old or less.

The potential savings are from reduction in engine overhauls and replacement and reduced topside painting. Topside painting could be reduced because there is no particulate matter from LNG exhaust.

CONSULTANTS' OPERATION COST ESTIMATE

Operations costs reviewed are maintenance costs, vessel staffing, classification and fuel. Washington State Patrol costs have not yet been reviewed.

Engine Maintenance

The consultants do not anticipate any changes in the cost of engine or other vessel on-going maintenance. Consultant interviews with Fjord 1 in October 2011 and interviews with Tide Sjo in Oslo indicate that maintenance costs for the LNG vessels are now the same as for their diesel vessels. Cost estimates developed by WSF for the new 144-car diesel vessel and the LNG fueled vessel show similar motor maintenance and repair costs for both versions of the vessel.

The Norwegians are finding that oil changes can be possibly extended to 30,000 service hours from the normal 8,000 service hours because the engine is so clean.

Engine Room and Deck Staffing

The Issaquah class ferries operate with three (3) staff in the engine room 24-hours a day and 11 deck staff when the vessel is in service, except for the 90-car Sealth has a deck staff of 10. The 16-year financial plan assumes that the new 144-car vessel will have the same staff requirements as the Issaquah class.

The USCG makes the determination on minimum staffing levels. Our analysis and WSF's assumes that the USCG will not require additional staffing.

It should be noted that the bunkering for LNG vessels is more complex than for diesel vessels. The LNG bunkering in Oslo used three (3) ferry staff plus the LNG truck driver all in hazardous material product suits. There is an extensive safety checklist that is followed.

Classification

Classification of operating vessels involves inspections by the classification society to determine if the vessel operation and status is in compliance with applicable rules. WSF does not maintain class on its diesel vessels nor do the Norwegian ferry operators the consultants interviewed. The Norwegian ferry operators do maintain class on their LNG fueled vessels because of the relative sophistication of the vessels and limited experience with operating them.

Recommendation 6: Operation Classification

During the first at least 10 years of the vessels operation, WSF should maintain classification services on the vessel.

Fuel

LNG fuel is significantly less expensive than diesel fuel. The consultants estimate the 2014 price per gallon for LNG at $1.25 per gallon assuming it is trucked to the area from California. WSF has estimated a 2014 price per gallon for LNG assuming a local supplier becomes available by then.

The fuel savings in year of expenditure dollars for the Issaquah class boats from the first 2015 conversion to the retirement of the last vessel in 2042 are $144.6 million under the assumed starting price of $1.25 per gallon or $181.7 million if the price starts at $0.85 million gallon.

Projected savings for the new 144-car vessel over the 60-year life of the vessel are $65.6 million if LNG price per gallon starts at $1.25/gallon or $72.6 million at $0.85 per gallon.

Contents

SECTOIN I. INTRODUCTION

The 2011 legislature directed the Joint Transportation Committee to investigate the use of liquefied natural gas (LNG) on existing Washington State Ferry (WSF) vessels as well as the new 144-car class vessels and report to the legislature by December 31, 2011 (ESHB 1175 204 (5)); (Chapter 367, 2011 Laws, PV).

The JTC report will: (1) assess WSF's work and studies on LNG use; (2) identify the full range of issues that must be addressed to successfully implement LNG use; and (3) analyze the cost, risk, timeline, and related implications of implementing LNG use for a retrofit of an existing Issaquah class vessel and for incorporating LNG into the new 144-car vessel design. The report is intended to address legislative concerns regarding the full potential cost of LNG, which is less expensive and its price less volatile than the ultra low sulfur diesel (ULSD) currently used by WSF, but may result in other significant costs.

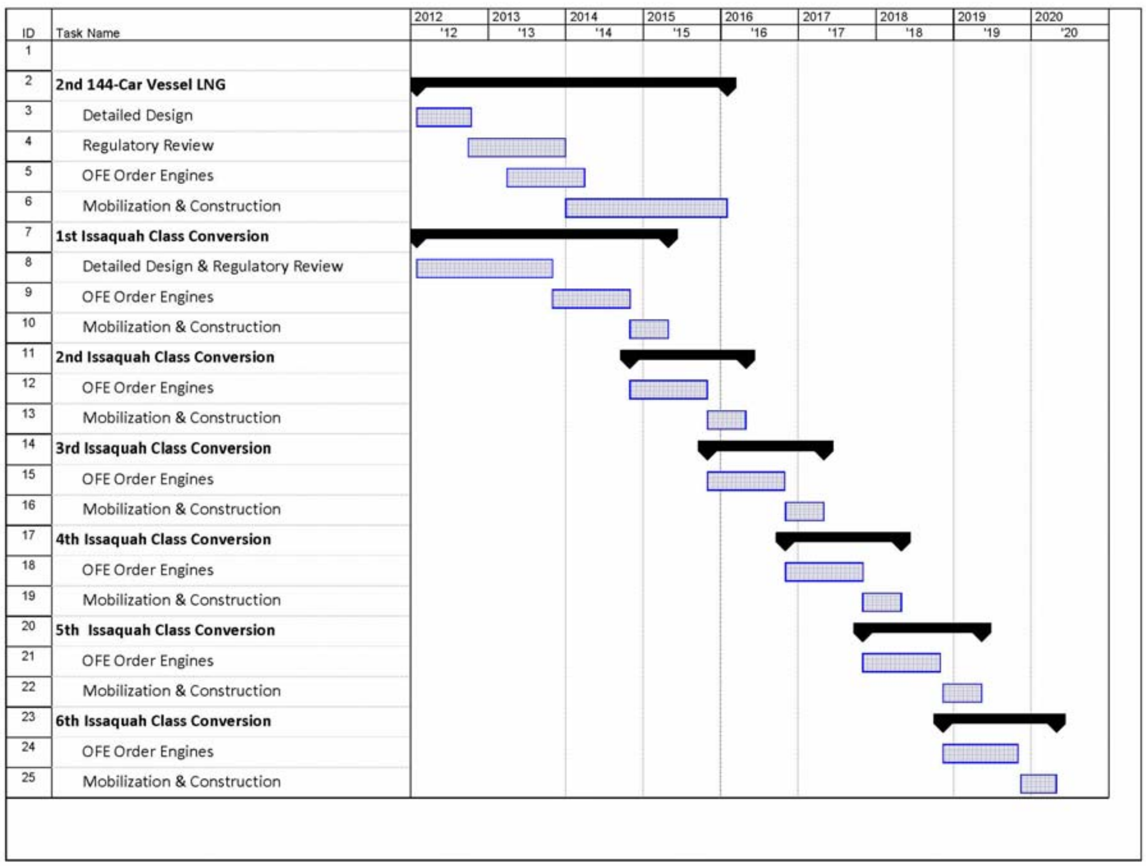
An October 19, 2011 white paper developed as part of this study includes a review of the WSF fleet, background information on the use of LNG as a marine fuel; an overview of WSF's studies on implementing LNG use; and an identification of the range of issues that will be considered in the study.

This white paper includes the consultants' capital and operating cost estimates for LNG conversions vessels and provides recommendations on design, construction, and operation of these vessels.

SECTION II. ANTICIPATED LNG SCHEDULE

The schedule includes detailed design and regulatory review for the first vessels, ordering of LNG fueled engines which take approximately one year for delivery, and construction. The anticipated schedule for LNG vessel construction is shown in the exhibit below.

Exhibit 1.
LNG Vessel Construction Schedule



New 144-Car Vessel

WSF has awarded the contract for the first new 144-car vessel with a diesel engine. If a second 144-car vessel is built with a LNG fueled engine, it would be complete in 2016 which is approximately one-year later than a second diesel fueled LNG would be completed.

Issaquah Class Vessels

The Issaquah class vessels are anticipated to be done at a rate of one per year following the completion of the first conversion in May 2015. The first vessel will take longer due to design requirements and regulatory review. Assuming that construction on the first Issaquah class vessel is completed in the spring of 2015, all six vessels would be completed in the spring of 2020.

Fleet Impact

The schedule as proposed should minimize disruption to the fleet. Construction of the vessels would occur during the winter off-peak period. The first Issaquah class conversion has been scheduled after the renovation of the Super class *Hyak,* which is scheduled to be out-of-service from September 2013 to July 2014.[2]

Remaining Life

WSF's vessel acquisition and deployment plan assumes that each vessel will have a 60-year life. The remaining life of the Issaquah class vessels assuming that the retrofits are done in an order in which the oldest vessel is renovated first is shown in the exhibit below. The vessels would have a remaining life of 23 to 25 years.

Exhibit 2.
Issaquah Class Vessel Life Remaining Following LNG Retrofit

Vessel	Year Built	Year LNG Conversion	Remaining Life (years)
Issaquah	1979	2015	24
Kitsap	1980	2016	24
Kittitas	1980	2017	23
Cathlamet	1981	2018	24
Chelan	1981	2019	23
Sealth	1982	2020	22

[2] The initial WSF schedule had not taken the Hyak renovation into account and called for the first Issaquah class vessel to be out-of-service from November 2012 to July 2013 which would overlap with the Hyak being out-of-service.

SECTOIN II. CONSULTANTS' CAPITAL COST ESTIMATE

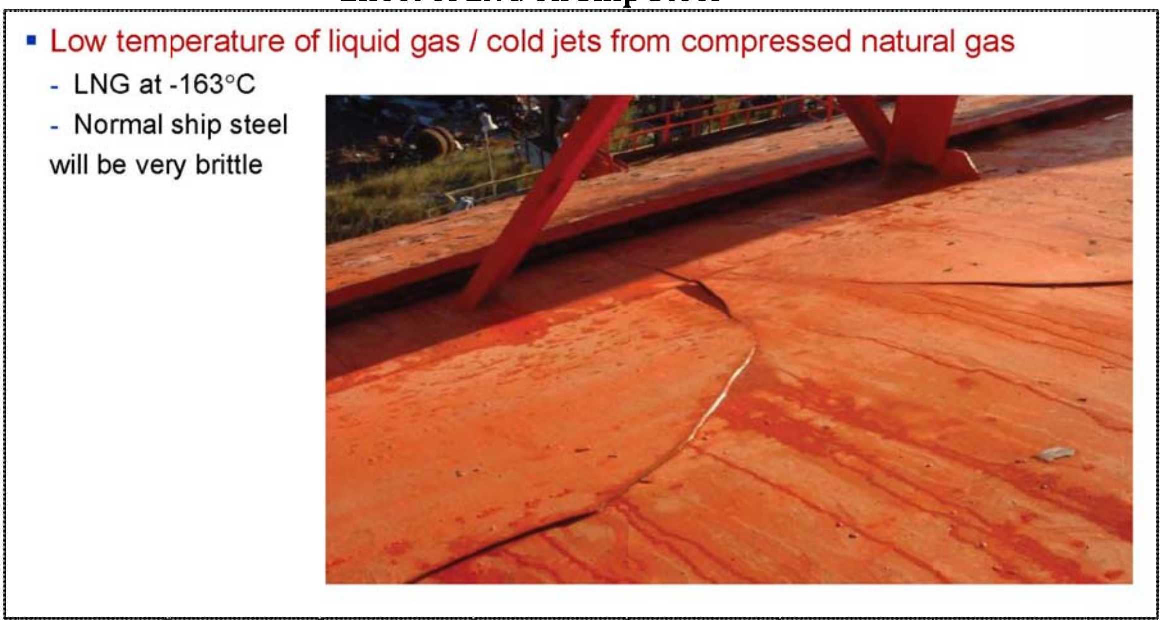
WSF has a concept design for the new 144-car LNG vessel based on the design of its new 144-car diesel vessel. They also have a concept design for the retrofit of the Issaquah class vessels. If constructed on the anticipated schedule these vessels would be the first U.S. constructed LNG fueled passenger vessels.

LNG-Fueled Vessel Safety Design Considerations

An October 2011 presentation by DNV[3] identified the main safety challenges using natural gas as marine fuel including:

- *Explosion risk.* LNG is flammable in a range of ab. 5-15 percent mixture in the air
- *Low temperature of LNG.* LNG released onto normal ship steel will make that steel very brittle, which could result in cracking of the steel.

Exhibit 3.
Effect of LNG on Ship Steel



Source: DNV

- *Gas tank large energy content.* The tank must be protected from external fire, mechanical impact, and from the ship side and bottom in the event of a collision or grounding.

WSF's concept design has two features that are different from Norway's existing LNG fueled ferries and from the new LNG ferry being constructed in Quebec.

Engine Room Standard

There are two (2) engine room design standards intrinsically safe and emergency shutdown (ESD).

[3] DNV, *Gas fuelled engine installations in ships Background, status, safety, some solutions- Interferry Barcelona- October 2011.*

- *Intrinsically safe engine room design*. In this design concept the engine room is designed with all explosion proof equipment such that no ignition source is available. In recognition of this added safety margin, the fuel line from the LNG tank to the engine is allowed to be single wall (together with some encasement in certain areas).
- *The ESD (Emergency Shut Down) engine room design.* In this concept the gas fueled engine is allowed to be in an area with non-explosion proof machinery. In recognition of the added ignition hazard the piping connecting the LNG tank to the engines must be double walled, with the air in between the walls sampled continuously for methane gas. Any methane detection sounds an alarm and, by pushing a single button in the control room, the gas engine and associated machinery is instantly deactivated. It is required with the ESD design, that there must be at least two (2) sources of propulsion power so that the deactivation of one gas fueled diesel does not render the ferry inoperable.

WSF design is an intrinsically safe engine room. In Norway all of the LNG engine rooms reviewed are designed to the ESD standard with individual ESD controls for each engine room locally and in the control room. The new LNG ferry being constructed in Quebec is also designed to an ESD standard.

The consultants reviewed WSF's concept design with Norwegian ferry operators and shipyard personnel experienced with building LNG vessels. The purpose of the interviews was to get cost information, not to seek comments on the design. However, the Norwegians noted that the WSF concept design for the Issaquah class retrofit and the new 144 vessel was unusual for an inherently safe engine room. The concept design combines single wall LNG gas piping with a non explosion proof equipment engine room. While less expensive than other potential designs, those interviewed thought the design to be risky. The Norwegians exceed both the ESD and inherently safe engine room requirements by placing each gas fueled engine alone in its own steel enclosed space such that a fire or explosion in that space will not affect any other space.

Based on the reactions of the Norwegian operators, the consultants corresponded with a German naval architecture firm that has extensive experience with LNG fueled vessels. Marine Service indicates that they prefer a system where gas is fed to the engines through double walled fuel lines and there is a valve hood room with ESD valves that cut off the fuel supply to the engines whenever there is a leakage in the primary gas fuel line. It allows you to have a conventional engine room arrangement, while sailing on gas and having conventional equipment in the engine room with not everything being explosion proof and expensive. It is in Marine Service's view more practical with conversions, as it allows the vessel to retain the old auxiliaries.

Storage Tank Location

WSF's concept design has the storage tanks on top. All of the Norwegian LNG ferries and the new one being built in Quebec have the storage tanks in the hull.

IMO is developing international rules regarding the placement of LNG storage tanks. The new code will include other gases than methane/ natural gas, also low flashpoint liquids and other machinery types like fuel cells, gas turbines etc.

According to the October 2011 DNV presentation one of the primary questions being addressed in the IMO review is whether LNG tanks can be safely located below deck and below passenger spaces if properly contained.

Topside Storage Tank

The primary reason to place the storage tank topside is because there is not enough room below deck. WSF indicates that in discussions with the USCG this is their preferred location. However, the letter from the USCG that provides the basis for regulatory review has no reference to the tank location.

The topside arrangement has some issues. When LNG is released in a cryogenic state (-259 F) the methane vapors are heavier than air and if a tank breach occurs a vapor cloud of methane can form which, depending on the amount of methane released, could be several ferry lengths. Ventilation systems could pull this vapor into the ferry engine rooms and passenger spaces, which in the presence of an ignition source at the right methane mix could result in a fire.

The topside arrangement requires that the storage tank be securely mounted and able to withstand rough seas and/or a vessel collision. The cryogenic stainless steel spillway under each tank should be designed to discharge over the side of the ferry and not to impinge on the deck.

The storage tank location requires expert design of the piping to ensure that the piping can withstand movement of the vessel superstructure in extreme conditions. One option for predicting superstructure movement is to use Finite Element Analysis (FE) to determine, with good accuracy, what movement the piping must accommodate.

Having the storage tank on top requires piping through the passenger space walls, which is not required if the storage tank is in the hull.

LNG Storage Tank – Hull

The primary advantage to having the storage tank in the hull is that there is less movement in the hull than on the superstructure and less piping through the passenger areas. DNV is developing revised rules for the placement of tanks in hulls under passenger spaces that would increase the separation of the tank from the hull.

The disadvantages of having the LNG storage tank in the hull are that any gas is released into a more confined space and if there were an explosion it could affect the passenger areas. Additionally, having the gas located below deck could allow it to dissipate upwards into the passenger area in the event of a leak.

Regulatory Considerations

As discussed in the *LNG Fuel White Paper* there is a great deal of regulatory uncertainty which results from the fact that the existing IMO rules are under review and the present lack of USCG regulations.

IMO Rules

The IGC code, the rules on how gas carriers can store, handle and use gas as a fuel, is being revised at the same time that a set of interim guidelines on the use of LNG as a fuel, known as the IGF code, in other vessels is being developed and solidified. The deadline for confirming the IGF code has been extended to 2014 from an original goal of 2012 in part to resolve contradictions between the two codes. This has increased the uncertainty about the direction of IMO rules.

USCG Regulations – Major Conversion

As discussed in the October 19 *White Paper* if the USCG decides that a proposed conversion is a major conversion then the ship owner is required to update the vessel to meet all current regulatory requirements. For a 30-year old vessel such as the Issaquah class vessels, this could add considerable cost.

The cost estimates developed by the consultants and WSF assume that retrofitting the Issaquah class vessels for LNG will not constitute a major conversion.

Vessel Construction Considerations

Shipyard Experience

No U. S. shipyards have experience with the construction of LNG-fueled passenger vessels, which will add risk to the project. When the U.S. built LNG carriers at General Dynamics, Newport News and Avondale shipyards, General Dynamics and Newport News hired foreign yards experienced in the LNG system installation to work together with US shipyard engineers and workers to accumulate all off the engineering and assembly experience they had gained. Avondale, to save money did not, and installed insulation on the LNG tanks incorrectly. When on sea trials, the insulation failed and the three ships valued at $500 million were determined by the USCG to be incapable of carrying LNG and therefore were considered to be constructive total losses, as it would cost as much to fix them as it cost to build them.

LNG Fuel Supply

Discussions with Tide Sjo and Gasnor in Norway indicate that it is important to test the vessel engines with the LNG that will be used as the gas composition varies by source. Tide Sjo's three (3) vessels were built in France and they brought LNG from Norway to test the engines during construction.

Consultant Design and Construction Recommendations

The consultants recommendations are intended to: ensure that European LNG fueled passenger ferry experience is used during the design and construction of WSF LNG-fueled vessels; facilitate on-going legislative decision-making; and minimize regulatory risk.

Recommendation 1: Classification

The LNG vessels should be designed to a classification society rules (which could be DNV or another classification society) and classed during construction.

If something is constructed to class it means that the classification society guidelines have been followed and the classification society has inspected the construction and certified it. WSF classes new construction but does not normally use a classification process on preservation projects. We recommend that these ships, whether new construction or retrofits, go through the classification process to ensure the safest possible gas fueled vessel even if this essentially duplicates the USCG review.

Recommendation 2: Legislative Oversight

a. The classification society should provide periodic independent reports to the legislature on its findings with regard to the design and construction process.

Giving the legislature direct access to the classification society will provide reassurance that safety standards are being adhered to.

b. *WSF should follow the mandated pre-design process for the Issaquah class LNG retrofit and for the new 144-car LNG vessel.*

The legislature requires that all vessel improvement projects and vessel preservation projects over $5 million include a pre-design study (ESHB 3209 adopted in the 2010 session). The pre-design study can provide the legislature with additional information prior to appropriating funds for construction of a LNG fueled vessel. The schedule does not call for construction until 2014 so there is ample time for legislative review of a pre-design report.

Recommendation 3: Regulatory Determination for Issaquah class retrofit

WSF should request a ruling from USCG on whether the Issaquah class retrofits will constitute a major conversion before proceeding with more detailed design and construction.

If the USCG decides that the retrofit is a major conversion it will add costs and may affect the out-of-service time for the conversion.

Recommendation 4. Design

WSF should contract with an outside design firm that has previous LNG fueled passenger vessel design experience rather than design the LNG vessels in-house. As a practical matter Washington state naval architects would have to sub-contract with firms that are experienced in the design of LNG fueled systems to meet this requirement.

WSF has discussed the potential for designing the LNG Issaquah class retrofit in-house. For at least the first vessel, we recommend that the work be contracted to an outside firm that has specialized expertise in LNG fueled systems design. Washington State naval architectural firms could sub-contract with firms that are experienced in the design of LNG fueled passenger vessels to meet the requirements.

Recommendation 5. Construction

a. *The construction bid process should require bidders to include an expert from a shipyard with LNG fueled vessel construction experience in their bid.* This would require a change in the procurement process to allow WSF to qualitatively evaluate the proposed outside expertise.

b. *The LNG fuel supply contract should be in place before the shipyard construction contract is let.* This will allow the engine to be tested with the actual LNG fuel that will be supplied.

SECTION III. CONSULTANTS' CAPITAL COST ESTIMATE

The consultants have developed independent cost estimates for an Issaquah class retrofit and for the use of LNG as a fuel source for a new 144-car vessel. In 2011 dollars, the Issaquah class retrofit is estimated to cost $24.1million and the new 144-car vessel $19.5 million.

The cost estimate includes the costs for security planning, WSF internal costs, and costs for design and construction of the vessels.

Security Planning

Operational requirements have not been discussed with the USCG, but they will have to be as part of the ultimate operation of the vessel and the issuance of the Certification of Inspection (COI) before the vessel is authorized to sail.

The cost estimate assumes that a security planning approach modeled after the planning process required of LNG terminal facilities would be followed. The process is outlined in the Navigation and Vessel Inspection Circular (NVIC) No. 01-2011 Guidance Related to Waterfront Liquefied Natural Gas Facilities.

The guidelines allow the Captain of the Port (COTP) to convene an ad-hoc working group of existing security committees - Harbor Safety Committees and Area Maritime Security Committee - and other stakeholders including state and local governments and members of the public to review waterway suitability assessments required of applicants for LNG terminals. Applicants are also encouraged but not required to develop transit management plans.

The primary advantages of this process are:

- *Inter-agency coordination*. The process provides a way to coordinate federal, state, and local public safety and fire reviews across the WSF service area.
- *Encompasses entire WSF service area.* The Puget Sound Harbor Safety Committee encompasses all the WSF routes.
- *Able to incorporate other stakeholders.* The process is designed to encompass other stakeholders include members of the public. There would be an opportunity for example to include representatives from the Ferry Advisory Committees.
- *Coordinated by the USCG*. The local COTP would be in charge of the process.

The applicant, in this case WSF, pays for any studies or other assessments that may be needed. We have made an allowance of $0.5 million in our estimate to provide for a similar, scaled-back process for LNG planning.

WSF Costs

The project costs will include a variety of WSF internal costs including:

- *Staff.* Vessel engineering staff involved in project management, design, and construction management will charge to the project as will vessel operation staff. In addition it can be anticipated that staff LNG training will be a project expense. Security, communications and community relations staff will also charge to the project as will staff involved in the procuring the LNG supply.
- *Other costs.* Community relations and other outside consultants may also be employed to support this project.

WSF has not yet estimated its internal staff costs. The consultants' cost estimate includes an estimate of $1.0 million for the first vessel assuming that design is carried out by outside consultants.

Design and Construction Cost Estimate

Cost Estimate Approach

Concept Design

The consultants' independent cost estimate is based on WSF's concept design. WSF has submitted two requests for regulatory review to the USCG: one for the new 144-car vessel and separately for the Issaquah class retrofit.

The Issaquah class retrofit request submitted to the USCG in September 2011 includes more detailed plans and engineering than were submitted with the earlier new 144-car vessel request for regulatory review. The Issaquah class retrofit drawings and accompanying calculations were used by the consultants to determine quantities and measurements used in the cost estimate for the Issaquah class retrofit. This estimate was then used to develop a corresponding estimate for the new 144-car vessel.

WSF is considering two engine options: a single fuel/LNG engine and a dual fuel (diesel and LNG) option. This cost estimate is based on the single fuel/LNG only option, which is the engine that is used in all currently operating LNG fueled ferries.

System Work Breakdown Structure (SWBS) Estimate

The consultants retained the services of a professional shipyard cost estimator who used an industry standard system work breakdown structure to estimate costs.

Quantities for the estimates were derived from WSF's drawings. Cost information came from vendor quotations. A shipyard labor rate of $70.00 per hour is used, which is based on labor rates of the Vigor shipyard contracted to construct the new 144-car vessel.

The SWBS estimates include:

- *Shipyard costs.* Shipyard costs for labor, material, and sub-contractors are included in the estimate.
- *Owner furnished equipment (OFE).* Historically WSF has owner supplied the propulsion systems to take advantage of federal grants. The SWBS estimate for the new 144-car vessel and the Issaquah class retrofit each include $7.7 million for propulsion system acquisition which will be owner furnished.
- *Regulatory review.* The estimates include the cost of regulatory review by DNV, estimated at $0.3 million in both estimates.
- *Outside engineering.* The estimates include an allowance for naval architectural services of $750,000 which would be contracted directly by WSF.

SWBS Estimate – Process

The consultants first developed the SWBS estimate for the Issaquah class retrofit using the more detailed information available from WSF's September 2011 *Request for Regulatory Review*. This estimate was refined by reviews with Vigor and with a Norwegian ferry operator and shipyard currently retrofitting a vessel that is similar in size to the Issaquah class vessels.

Vigor Review

The estimate was reviewed with the shipyard, which provided the labor rate and options for the use of internal shipyard staff and subcontractors.

Norwegian Review

Fjord 1 is converting a 20-year old diesel fueled ferry, the *Tresfjord*, to LNG. The *Tresfjord* is similar in size to an Issaquah class ferry (*Tresfjord*318 ft. in length, an Issaquah class ferry 328 ft. in length) and has similar engine size (both about 2500 HP). The primary difference between the two vessels is that the *Tresfjord* is powered with one diesel engine powering two generators and thrusters while the Issaquah class vessels have two diesel engines each powering one propeller. The *Tresfjord* had one engine compartment empty.

The retrofit, which is required by Fjord 1's contract with the Norwegian government[4], involves using the one empty engine compartment to install a 2500 HP LNG fueled engine, retaining the existing diesel engine for back-up. Both engines would be hooked through common shafting and clutches to the generators. The LNG engine will be a single fuel/LNG only engine. One LNG fuel storage tank and one LNG fueling station will be added.

The STX Langstein shipyard in Norway is doing the retrofit under contract with Fjord 1. STX Langstein has previous experience constructing LNG fuelled vessels. The *Tresfjord* is the yard's first LNG conversion project. The *Tresfjord* conversion was expected to take 6 months. The contract was awarded in January 2011 with delivery expected in June 2011. Delivery is now expected in February 2012 because of problems encountered with the originally supplied LNG valves and piping that had to be re-ordered.

The consultants sent the SWBS estimate for the Issaquah class retrofit and WSF's engineering information from the Issaquah class retrofit request for regulatory review to STX Langstein. In subsequent meetings at the shipyard, the consultants were able to obtain man-hours used by STX Langstein on the *Tresfjord*. The consultants worked with the shipyard staff to adjust the STX Langstein man-hours for the Issaquah class vessel retrofit. Adjustments were for the extra man-hours incurred on the *Tresfjord* conversion from the faulty valves and piping; differences in the storage tank location; differing lengths in LNG filling and supply to engine piping; and for differences in engine room classification.

The consultants then compared the resulting man-hour estimate with the SWBS estimate for the Issaquah class retrofit. Taking into consideration the relatively lower efficiency of North American shipyards when compared to European shipyards, the consultants' estimate of approximately 112,000 shipyard man-hours for the Issaquah class retrofit and 14,100 hours of sub-contractor labor were generally confirmed by the *Tresfjord* experience. The consultants' estimate of shipyard and sub-contractor labor is about 15 percent lower than the *Tresfjord* experience.

Additional Costs

Two (2) costs were added to the SWBS estimate:

[4] The contract required a LNG fueled vessel on the route. Fjord 1 elected to do the retrofit to meet this requirement.

- *Shipyard profit.* The consultants were not able to get an estimate for shipyard profit from Vigor. An industry standard assumption of 7 percent was used for this estimate. The profit was applied to shipyard costs only – excluding OFE and naval architect costs.
- *Contingency.* A 15 percent contingency was applied to the estimate.

Issaquah Class Retrofit Rough Order of Magnitude (ROM) Cost Estimate

Consultants' Estimate

The Issaquah class retrofit cost estimate in 2011 dollars is summarized in the exhibit below.

Exhibit 4.
Consultants' Issaquah Class Retrofit ROM Cost Estimate (2011 $ in millions)

SWBS GROUP	Labor Hours	Labor Cost	Material	Subcontract	Total
Hull	20,548	$1.4	$0.2	$0.0	$1.7
Propulsion	5,853	$0.4	$8.1	$0.1	$8.6
Electrical	5,314	$0.4	$0.1	$0.0	$0.5
Navigation, Communication & Alarms	4,158	$0.3	$0.1	$0.1	$0.5
Auxiliary Systems	30,721	$2.2	$0.4	$0.1	$2.6
Joiner, Insulation, & Paint	8,927	$0.6	$0.2	$0.0	$0.8
Engineering, Planning, Project Management & Supervision	16,348	$1.1	$0.0	$1.1	$2.2
Production Support	20,081	$1.4	$0.5	$0.0	$1.9
Sub-total SWBS	111,950	$7.8	$9.7	$1.4	$18.9
Shipyard Profit @ 7% (exclude OFE/naval architect from profit calculation*)					$0.7
Sub-total					$19.6
Contingency @ 15%					$2.9
Sub-total					$22.6
Allowance for WSF Internal Costs					$1.0
Sub-total					$23.6
Allowance for Security Planning					$0.5
Total					**$24.1**

* OFE $7.7 million/naval architect $0.75 million excluded from profit calculation

WSF Estimate

WSF's estimate for the Issaquah class vessel retrofit was $14.8 million. This estimate was completed prior to the submittal of the request for regulatory review in September 2011. The estimate did not include: regulatory review, naval architects, shipyard profit, internal WSF costs, or an allowance for security planning. The WSF estimate included contingency of 25 percent for the shipyard costs.

Exhibit 5.
WSF ROM Cost Estimate Issaquah Class Retrofit: Shipyard, OFE, & Contingency

(2011 $ in millions)

Description	**Labor Hours**	**Labor Cost***	**Materials**	**Total**
Engineering	4,400	$0.3	$0.0	$0.3
Temporary Services	400	$0.0	$0.2	$0.2
Removable of Existing Engines	6,925	$0.5	$0.1	$0.6
Install New LNG Engines	16,295	$1.1	$8.5	$9.7
Install LNG Tanks on Sundeck	6,400	$0.4	$0.5	$0.9
Sub-total	34,420	$2.4	$9.3	$11.8
Contingency @ 25%				$2.9
Total				**$14.7**

*WSF estimate in 2012 dollars used $72.00 per hour labor rate. This table uses the 2011 $70.00 per hour rate.

Estimate Difference Consultants and WSF

The difference between the WSF estimate and the consultants of $9.4 million occurs because: 1) the WSF estimate does not include costs other than shipyard costs, OFE, and contingency; 2) WSF shipyard man-hour estimates are lower; 3) shipyard sub-contractors are not included in the WSF estimate; and 4) shipyard profit is not included in the WSF estimate.

- *Non-shipyard costs.* The consultants' estimate includes $2.55 million for naval architects ($0.75 million), regulatory approval ($0.3 million), WSF internal costs ($1.0 million), and security planning ($0.5 million) not included in the WSF estimate.
- *Shipyard man-hours.* The consultants estimate that the shipyard will use approximately 112,000 man-hours while the WSF estimate includes only approximately 34,450 man-hours with a cost difference of $5.4 million The differences include man-hours in the consultants' estimate for auxiliary systems, project management and supervision, and production support.
- *Shipyard sub-contractors*. The consultants estimate includes $0.4 million for sub-contractor support for the shipyard. One million dollars ($1.0) is included in the sub-contractor estimate for the naval architect ($0.75 million) and DNV ($0.3 million).
- *Shipyard profit*. The consultants' estimate includes an allowance of $0.7 million for shipyard profit that is not included in the WSF estimate.

Exhibit 6.
Difference Consultant and WSF Issaquah Class Retrofit ROM Estimates

($ 2011 in millions)

Cost Estimate Area	Difference Consultant Estimate & WSF Estimate
Non-shipyard costs	$2.5
Shipyard man-hours	$5.4
Shipyard sub-contractors	$0.4
Shipyard profit allowance	$0.7
Shipyard materials	$0.4
Total	**$9.4**

Issaquah Class Estimate

WSF intends to convert all six (6) Issaquah class vessels to LNG. WSF estimate for converting all of the vessels is $65 million, which assumes that the contingency is not needed and that there are economies of scale from doing more than one vessel, as are experienced when constructing more than one new vessel in a class.

The consultants' estimate is lower for the second and subsequent vessels. Costs eliminated or reduced from the first to subsequent vessels are: $1.0 million for one-time naval architect design costs, DNV costs, and production drawings which results in a cost reduction of $1.1 million in the total estimate when those costs are then deducted from the contingency estimate. The consultants' estimate for the subsequent five (5) vessels also lowers the estimate for WSF staff to $0.5 million per vessel and for security planning to $0.1 million per vessel.

The consultants' interviews with Vigor indicate that it is unlikely there will be shipyard cost efficiencies from doing more than one conversion. This is primarily because for WSF to maintain fleet capacity, each conversion must be done separately and completed before the next one can be done. With new ships being built, the shipyard gains efficiency by starting work on a vessel while another is still in the construction process.

The consultants' total cost estimate in 2011 dollars to convert all six (6) Issaquah class vessels to LNG fuel is $134.2 million.

Issaquah Class Year of Expenditure Estimate

The year of expenditure estimate is based on the schedule discussed above and on the February 2008 Implicit Price Deflator for Personal Consumption (IPD-PC) used in the 2011-13 budget. The estimate assumes that each engine is paid for separately one year before the start of construction.[5]

As shown in the exhibit below, based on these assumptions the total year of expenditure costs for the six vessels is $151.6 million.

[5] Engines will most likely be ordered in one or two orders with staggered delivery dates.

Exhibit 7.
Issaquah Full Class Retrofit YOE ROM Estimated Cost ($ millions)

Biennium	$	Issaquah Vessel Projects
2011-13	$1.0	Design, WSF staff, security planning
2013-15	$32.7	Construct vessel 1/Order engine vessel 2
2015-17	$49.3	Construct vessels 2 & 3/Order engine vessel 4
2017-19	$51.4	Construct vessel 4 & 5/ Order engine vessel 6
2019-20	$17.2	Construct vessel 6
Total	**$151.6**	

New 144-Car Vessel Estimate

Consultants' Estimate

The estimate of additional costs for the new 144-car vessel as a LNG fueled vessel is shown in the exhibit below.

Exhibit 8.
New 144-Car Vessel LNG ROM Cost Estimate (2011 $ in millions)

SWBS Group	Labor Hours	Labor Cost	Material	Sub-Contract	Total
Hull	13,957	$1.0	$0.2	$0.0	$1.2
Propulsion	492	$0.0	$8.1	$0.0	$8.1
Electrical	660	$0.0	$0.1	$0.0	$0.1
Navigation, Communication & Alarms	2,614	$0.2	$0.1	$0.1	$0.4
Auxiliary Systems	19,203	$1.3	$0.3	$0.1	$1.7
Joiner, Insulation, & Paint	5,960	$0.4	$0.1	$0.0	$0.5
Engineering, Planning, Project Management & Supervision	8,412	$0.6	$0.0	$1.1	$1.7
Production Support	15,815	$1.1	$0.3	$0.0	$1.4
Sub-total	67,114	$4.7	$9.2	$1.3	$15.2
Shipyard Profit 7%					$0.5
Sub-total					$15.7
Contingency @ 15%					$2.3
Sub-total					$18.0
Allowance for WSF					$1.0
Sub-total					$19.0
Allowance for Security Planning					$0.5
Total					**$19.5**

WSF Estimate

The Glosten Associates developed a cost estimate for the new 144-car vessel LNG conversion of $10.8 million.

Exhibit 9.
WSF New 144-Car Ferry LNG Estimate

(2011 $ in millions)

	Labor Hours	Labor Cost*	Material	Sub-Contract	Total
Vendor Supply (OFE)					
Main Engine & Gas System			$7.5		$7.5
Shipyard Supply					
Shipping from Norway (Engine)			$0.2		$0.2
Shipping from China (LNG Tanks)			$0.3		$0.3
Main Engine & Gas System	11,810	$0.8	$0.2		$1.0
Main Engine Installation			$0.1		$0.1
Gas Controls/Commissioning/Testing	500	$0.0	$0.2		$0.2
Regulatory				$0.8	$0.8
Design				$0.8	$0.8
Total	**12,310**	**$0.9**	**$8.4**	**$1.6**	**$10.8**

*Glosten used $65 per hour in their estimate. The estimate is adjusted to $70 per hour in this table.

Estimate Difference Consultants and WSF

The difference between the WSF estimate and the consultants is $8.7million. Part of the difference is attributable to the fact that the consultants had the Issaquah class design drawings on which to base the estimate which provided a more solid basis for estimating material quantities. Other differences are: 1) the WSF estimate does not include WSF's internal costs or security planning costs; 2) the WSF estimate does not include contingency; 3) WSF shipyard man-hour estimates are lower; and 4) shipyard profit is not included in the WSF estimate.

- *WSF costs and security planning.* The consultants' estimate includes an allowance of $1.5 million for WSF internal costs and security planning.
- *Contingency.* The consultants' estimate includes a $2.3 million contingency which is not included in the WSF estimate.
- *Shipyard man-hours.* The consultants estimate that the shipyard will use approximately 67,100 man-hours while the WSF estimate includes only approximately 12,300 man-hours with a cost difference of $3.8 million. The differences include man-hours in the consultants' estimate for project management and supervision and production support and auxiliary systems.
- *Shipyard profit*. The consultants' estimate includes an allowance of $0.5 million for shipyard profit that is not included in the WSF estimate.
- *Shipyard materials.* The consultants' estimate has $0.6 million more than the WSF for materials other than the propulsion system.

Exhibit 10.
Difference Consultant and WSF New 144-Car Vessel Estimate

($ 2011 in millions)

Cost Estimate Area	Difference Consultant Estimate & WSF Estimate
WSF costs	$1.0
Security planning	$0.5
Contingency	$2.3
Shipyard man-hours	$3.8
Shipyard profit	$0.5
Shipyard materials	$0.6
Total	**$8.7**

Consultants ROM Estimate in Year of Expenditure Dollars

A new 144-car LNG fueled vessel would start construction in the 2013-15 biennium. The additional cost for a LNG fueled new -144 car vessel in YOE dollars is $20.7 million assuming construction costs in the 2013-15 biennium.

Preservation Costs

Preservation costs for the new 144-car vessel and for the Issaquah class vessels could potentially be lower with LNG fueled engines than with diesel fueled engines. The potential cost savings are not included in the consultants' estimate nor are they included in WSF's cost analysis. There is no basis upon which to reasonably project savings since all existing LNG-fueled vessels are 10 years old or less.

Potential Preservation Savings

WSF uses a life cycle cost model (LCCM) to plan vessel preservation. The model divides vessel systems in vital systems – which are those systems considered vital for the ship being able to sail – and non vital system. The LCCM for existing vessels was updated in 2010.[6]

Discussions with the Norwegians indicate savings potential in the propulsion system (i.e. motor and associated piping), and top-side painting.

Propulsion System

WSF Planning

The WSF vessel LCCM assumes that diesel motors, with the exception of the Issaquah class vessels, are replaced every thirty (30) years. The Issaquah class motors have been maintained on a different on-going basis and are not planned for replacement in the LCCM. Motors and other aspects of the propulsion system are considered vital systems in the WSF LCCM.

LNG Impact

[6]Washington State Department of Transportation, *Vessel Maintenance, Preservation, and Improvement Plan, Vessel Life Cycle Cost Model Update*, 2010.

Norway's experience is that the LNG motors are much cleaner. It is possible that the LNG motors will have a longer life than 30 years.

LNG is also less corrosive than diesel which means that the LNG piping and tanks will not corrode to the same extent as diesel piping and tanks.

Topside Painting

WSF Planning

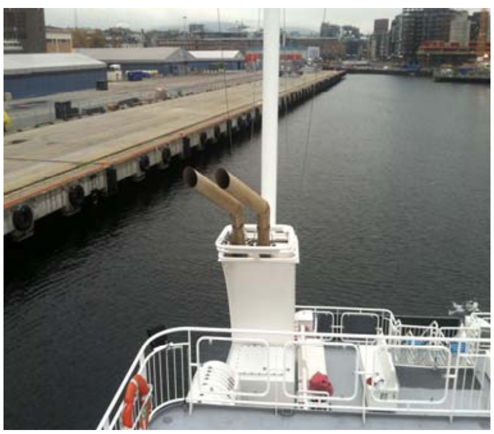
Topside painting is scheduled in the WSF vessel LCCM to be done every seven (7) years. Given budget and fleet scheduling constraints, topside painting is in actuality done somewhere between every seven (7) and ten (10) years. Topside painting is considered a non-vital system in the vessel LCCM.

Each topside painting takes the vessel out-of-service for approximately 90 days. The work must be done in relatively dry weather – meaning that it cannot be accomplished during the non-peak winter months. The cost in 2011 dollars is between $2.5 - $3.5 million per topside painting depending on the size of the vessel and the condition of the paint.

LNG Impact

LNG is a cleaner burning fuel with zero particulate emissions. This reduces the accumulated grit on a vessel which could reduce the frequency of topside painting. The photos show the difference in accumulated grime on the same Norwegian ferry's diesel and LNG exhaust pipes.

LNG Fueled Exhaust Pipe



Same Vessel - Diesel Fueled Exhaust Pipe

SECTION IV. CONSULTANTS' OPERATION COST ESTIMATE

Operations costs reviewed are maintenance costs, vessel staffing, classification, and fuel. Washington State Patrol costs have not yet been reviewed.

Maintenance Costs

Projections for maintenance cost of a new 144-car diesel vessel are based on the maintenance costs for the Issaquah class vessels. Annual maintenance costs, excluding engine room labor, are: $0.3 million for engine room non-labor supplies; $0.3 million for shipyard and other contract maintenance; and $0.1 for Eagle Harbor work.

Motor Repair/Overhaul

Fjord 1 reported in 2010 that their costs for routine LNG vessel motor maintenance for the *Glutra,* their first LNG fueled passenger vessel, had been 20 percent higher than for a similar-sized diesel vessel. Fjord 1 also report that maintenance costs of its five (5) sister ships in operation since 2007 have been 10 percent higher. Consultant interviews with Fjord 1 in October 2011 and interviews with Tide Sjo in Oslo indicate that maintenance costs for the LNG vessels are now the same as for their diesel vessels.

Cost estimates developed by The Glosten Associates for the new 144-car diesel vessel and the LNG fueled vessel show similar motor maintenance and repair costs for both versions of the vessel at $0.1 million per year in 2011 dollars assuming a center section overhaul every 30,000 hours, an intermediate overhaul every 60,000 hours, and a major overhaul every 120,000 hours for both types of engines.

The Norwegians are finding that oil changes can be possibly extended to 30,000 service hours from the normal 8,000 service hours because the engine is so clean.

Engine Room and Deck Staffing

The Issaquah class ferries operate with three (3) staff in the engine room 24-hours a day and 11 deck staff when the vessel is in service. The 90-car Sealth has a deck staff of 10 rather than 11. The 16-year financial plan assumes that the new 144-car vessel will have the same staff requirements as the Issaquah class.

The USCG makes the determination on minimum staffing levels. This analysis assumes that there are no changes in staffing requirements with LNG fueled vessels.

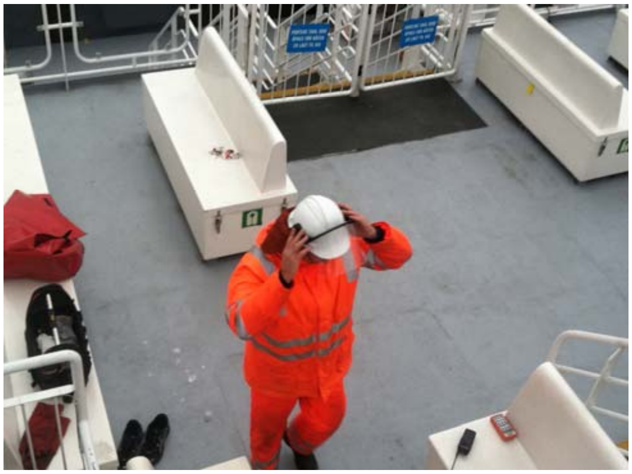
Bunkering

Refueling or bunkering of LNG is a more complex operation than diesel fueling.

LNG Bunkering

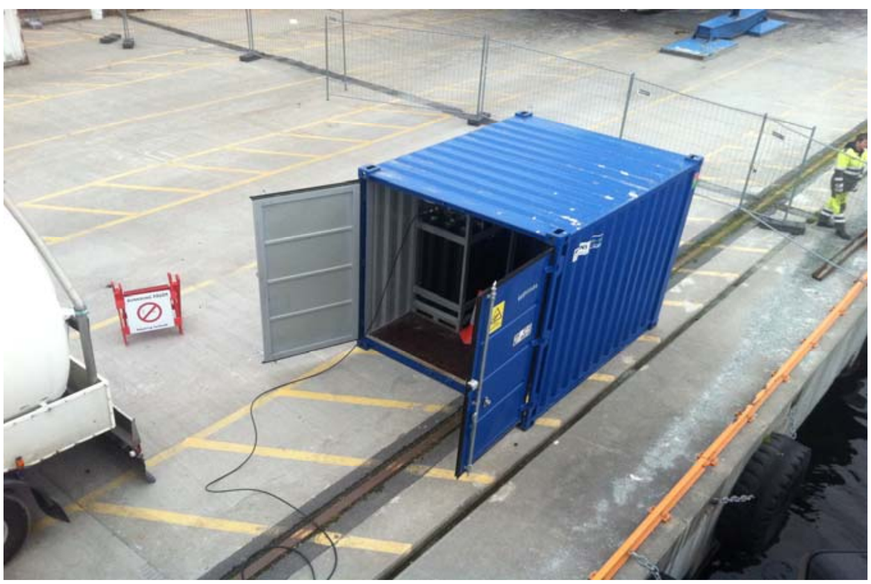
The consultants observed the fueling of vessels in Norway, including in Oslo for the Tide Sjo passenger only ferries.

Fueling takes place with an adjustable hose that is attached to the fueling truck. The line is cleared with nitrogen before and after the fuelings on each vessel to ensure that LNG does not leak into the atmosphere. The driver and both deckhands monitoring the fueling, who are stationed at the above deck bunkering station, all wear hazardous materials protective suits. The Chief Engineer monitors the process from the deck and the fueling can be halted by any of the three, who are in radio contact, if necessary. Upon completion of the fueling, the driver, crew at the bunkering station, and Chief Engineer go through an extensive safety checklist as the nitrogen is venting the line and the hose is disconnected.



Bunkering station crew

Vessel being fueled



Nitrogen tanks located at terminal

Truck driver and Chief Engineer verifying amount delivered

Diesel Fueling

The consultants also viewed a fueling by truck of one of the existing Issaquah class vessels on the Seattle-Bremerton route. Two trucks drove onto the ferry on the Seattle side and fueling took place at the end of the last sailing of the day. The Chief Engineer and engine room crew go through a short safety meeting before fueling to ensure all their communication devices are ready. They then lay out boom and devices on deck to stop any diesel fuel leaks from going overboard. The driver verifies the amount to be delivered, in this case 16,900 gallons, and the engine room staff plots how they will split the load between the fuel tanks to ensure proper ballast. During fueling the two truck drivers pumped the fuel overseen by the Assistant Chief Engineer while the oiler measured the height of fuel in the tanks as they fueled with a tape measure. No hazardous material gear is required other than gloves. The process is less automated than LNG fueling, which requires the pressure to be constantly monitored and the fill level of the tanks is measured by computer.

Measuring diesel tank aboard WSF

Measurement system for LNG – Fjord1

Issaquah class fueling station

LNG bunkering station – Tide Sjo

Classification

Classification of operating vessels involves inspections by the classification society to determine if the vessel operation and status is in compliance with applicable rules. WSF does not maintain class on its diesel vessels nor do the Norwegian ferry operators the consultants interviewed. The Norwegian ferry operators do maintain class on their LNG fueled vessels because of the relative sophistication of the vessels and limited experience with operating them.

Recommendation 6: Operation Classification.

During the first at least 10 years of the vessels operation, WSF should maintain classification services on the vessel.

LNG Fuel

LNG fuel is significantly less expensive than diesel fuel. The consultants estimate of fuel savings is based on the LNG price estimate in the October *White Paper* and the Washington State Transportation Revenue Council's September diesel fuel price forecast. The October White Paper was based on the June forecast. The September forecast is for lower diesel fuel prices in the future than was forecast in June.

The consultants estimate the 2014 price per gallon for LNG at $1.25 per gallon assuming it is trucked to the area from California. WSF has estimated a 2014 price per gallon for LNG assuming a local supplier becomes available by then.

The fuel savings for the Issaquah class boats from the first 2015 conversion to the retirement of the last vessel in 2042 are $144.6 million under the assumed starting price of $1.25 per gallon or $181.7 million if the price starts at $0.85 million gallon.

Exhibit 11.
Issaquah Class Fuel Savings Range 2015-2042

(YOE dollars)

Starting Price	2015	2020	2025	2030	2035	2040	2042	Total Savings
$1.25/gallon	-$0.8	-$5.5	-$5.3	-$5.8	-$6.6	-$6.3	-$1.3	-$144.6
$0.85/gallon	-$1.1	-$7.8	-$7.3	-$7.4	-$7.6	-$6.5	-$1.2	-$181.7

Projected savings for the new 144-car vessel assuming service on the Anacortes-San Juans route over the 60-year life the vessel are $65.6 million if LNG price per gallon starts at $1.25/gallon or $72.6 million at $0.85 per gallon.