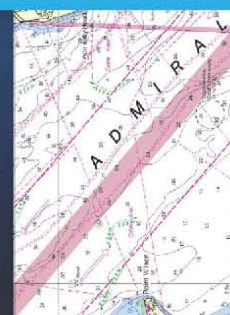
Port Townsend-Keystone Route Planning

Vessel Planning Study

REVIEW DRAFT

DECEMBER 10, 2007



WSDOT

Washington State Ferries

Washington State Department of Transportation

Washington State Ferries

Vessel Planning Study

June 3, 2008

Prepared for:
Washington State Ferries
2901 Third Avenue, Suite 500
Seattle, WA 98121
(206) 515-3400

Prepared by:
KPFF Consulting Engineers
1601 Fifth Avenue, Suite 1600
Seattle, WA 98102
(206) 622-5822
KPFF Job No. 107269.10

Washington State Department of Transportation

Washington State Ferries

Washington State Department of Transportation

Washington State Ferries

Table of Contents

Washington State Department of Transportation

Washington State Ferries

List of Figures

List of Tables

Appendices

Appendices are in the process of being formatted for clarity and will be included in the next version of this report

Washington State Department of Transportation

Washington State Ferries

Executive Summary

This report analyzes options for replacing Washington State Ferries' (WSF) Steel Electric Class vessels as part of the route planning effort mandated by the Washington State Legislature. This report is intended to serve as part of the environmental documentation that will be prepared for the route, including the terminals at Port Townsend and Keystone. In earlier planning processes, WSF determined that the only viable option if the Steel Electrics can no longer provide service on the Port Townsend-Keystone route is acquisition of new vessels.

The Port Townsend to Keystone route is critical to the communities on both ends, as demonstrated by the effects of the current disruption, which started with the suspension of vehicle ferry service on November 20, 2007. Restoring vehicle ferry service to the route as soon as possible and maintaining service continuity are the highest priorities for WSF, along with ensuring the safety of passengers and crew.

The goal of the vessel planning study was to develop new vessel options to replace the Steel Electrics on the Port Townsend-Keystone Route. The options are intended to inform the Legislature as it makes a vessel decision. All new vessel concepts must meet the following criteria as defined in a letter from the WSF Executive Director to the local communities:

- Vehicle capacity of 100 cars or less
- Capable of operating within the existing Keystone Harbor

Throughout the vessel planning study WSF worked closely with the Port Townsend and Whidbey Island communities. A "partnership group" made up of leaders from both communities met regularly to review the study assumptions and preliminary analysis and provide feedback to WSF. This partnership group also helped define additional baseline criteria that were used to guide the selection and evaluation of viable options.

The report studied replacement vessel options including the following:

- Single-ended and double-ended vessels
- Monohulls, catamarans, and other multi-hull vessels
- The use of conventional and highly maneuverable propulsion systems (eight different systems in all)
- Re-use of the existing superstructure on new hulls
- Proposals volunteered from local boat builders

Single-ended vessels were determined to be unworkable due to the narrow navigation channel at Keystone Harbor. Double-ended monohulls and double-ended catamarans were determined to be feasible for operations in the existing Keystone Harbor and were carried forward into the development of capital and operating cost estimates and a qualitative comparison of other characteristics, including maneuverability, reliability, fleet compatibility, and compatibility with existing terminal infrastructure.

In addition to options for hull form and propulsion systems, the study also conducted a qualitative assessment of the effects of vessel capacity on the local community, natural environment, and system operations. This analysis also included a preliminary assessment of the environmental process that would be triggered by each of the various alternatives being studied.

The initial efforts in the study included the assessment of ferries with nominal capacities of 60, 80 and 100 vehicles, but when vehicle service was suspended, the focus was narrowed to replacing the capacity of the existing Steel Electric class ferries (nominally 60 vehicles), in order to expedite the acquisition process.

As a result, the scope of this study was expanded to include assessment of options for new vessels that could be built on an expedited construction schedule. Options studied included the following:

- **New hulls with the existing superstructures.** The resulting vessels would comply with all current USCG regulations and have the same passenger and vehicle capacity as the Steel Electric class ferries
- **New vessels that are duplicates of recent deliveries.** These include the *Steilacoom II*, a 50 vehicle[1] ferry delivered in 2007 to Pierce County, WA, and the *Island Home*, a 72 vehicle ferry delivered in 2007 to the Woods Hole, Martha's Vineyard, and Nantucket Steamship Authority.
- **New vessels that are modified versions of recent deliveries.** Modifications required and/or recommended to the *Steilacoom II* and the *Island Home* were identified to improve their suitability for the Port Townsend – Keystone route.
- **New vessels using designs that have been completed but not built.** The Safe Passage class double-ended monohull ferry design was the only option studies in this category.

As drafts of this report were circulated for review, additional information on the condition of the Steel Electric class ferries came to light and the need to identify a fast-track strategy for the acquisition of replacement ferries became even more urgent. The recommendations below are based on the need to restore vehicle service as quickly as possible while maintaining WSF's standards for safety and reliability and do so in the most cost-effective manner.

- **If two Steel Electric class ferries are returned to service, construct two new vessels custom designed for the Port Townsend – Keystone route.** With the investment in repairs to the hulls of the Steel Electric class ferries, it is reasonable to assume they will continue to be seaworthy for at least three additional years of service. In this time, a new design could be developed, model tested, and constructed using an expedited acquisition strategy based on commercial practice.
- **If only one Steel Electric class ferry is returned to service, or if it is not practical to return any Steel Electric class ferries to service, construct two modified versions of the *Island Home*.** This would have a higher acquisition cost than a modified *Steilacoom II* with the same delivery schedule. This design can be modified to increase the vehicle capacity of the vessel if warranted by future

[1] **Throughout this report, vehicle capacities are stated based on the WSF standard vehicle, which is 6'-6" wide and 18'-0" long.**

demand. It also has a much more protected car deck, which would result in the same or fewer weather related cancellations relative to the Steel Electric class ferries. If none of the Steel Electrics are returned to service, WSF would also work with local communities to develop acceptable mitigation strategies until a new vessel can be built.

- Acquisition of one or more new ferries that are duplicate or modified versions of the Pierce County ferry *Steilacoom II* is not recommended as that design was not developed for the exposed waters encountered on the Port Townsend – Keystone route. Although it would be the least expensive option and the quickest into service, the use of this class of vessel on the route would likely lead to increased motion sickness among passengers, more weather related cancellations, and a higher risk of injury or vehicle damage resulting from vehicles shifting while crossing heavy seas. These effects are anticipated due to the *Steilacoom II*'s open car deck arrangement, relatively light displacement, and narrow beam.

At present, WSF intends to work with Pierce County to arrange for trials of the *Steilacoom II* on the Port Townsend – Keystone route as soon as practical. If the results of these trials indicated better performance than expected, the above recommendation on the use of this class vessel may be revisited.

To deliver new vessels on the schedules below, new legislation will be required to both fund the vessels and define the contracting strategy to be used. Contracting strategies are not discussed in this report.

The key attributes of the vessels discussed above are summarized in Table ES-1.

Table ES-1: Preferred Options Summary

Option	Acquisition Cost	Acquisition Schedule	Annual Cost	Daily Route Capacity
New Design	\$30-\$40 M	36-42 months	\$6.7 M[2]	900
Modified *Island Home*	\$30-\$34 M	24-30 months	\$6.7 M	900
Unmodified *Steilacoom II*	\$20 M	18-20 months[3]	\$5.6 M[4]	1,000

Note: Throughout this report, estimated acquisition schedules include 6 months to account for the time needed to select a builder and negotiate a contract.

---

[2] The annual cost and daily route capacity for a new design and a modified version of the *Island Home* are based on the current schedule.

[3] Although a representative of Nichols Brothers Boat Builders has stated that a duplicate of the Steilacoom II could be built in 12-14 months, Elliot Bay Design Group has been informed by a representative of NC Machinery, the local Caterpillar engine supplier, that the lead time on engines of the type used in the Steilacoom II would be 12-4 months for an order placed in the first quarter of 2008, which could increase the time to delivery of a new vessel.

[4] The annual cost and daily route capacity is for an unmodified version of the Steilacoom II are based on two vessels running 16 hours each during the peak season.

The relative costs and benefits of all of 14 alternatives studied are summarized at the end of the report in Table 9-1.

1. Introduction

1.1. CURRENT SITUATION

Washington State Ferries (WSF) owns four Steel Electric (SE) class vessels – Quinault, Klickitat, Illahee and Nisqually. These vessels predominantly serve the Port Townsend-Keystone and San Juan Islands inter-island routes. They are the only ferries in the system capable of operating in Keystone's narrow and shallow harbor. The vessels are 80 years old and have been slated for retirement from the ferry system for several years.

Since early 2007, maintenance issues have been emerging with the Steel Electrics. These resulted in multiple repairs, increased and more stringent inspections, and ultimately, on November 20, 2007, a decision by WSDOT Secretary Paula Hammond to pull all the Steel Electric vessels from service. This caused auto ferry service to be suspended on the Port Townsend-Keystone route.

Since that decision, WSF has initiated passenger-only service on the route, using the MV Snohomish. Extensive research into existing options for replacing Steel Electric class ferries found no viable options other than building new vessels specifically for service on this route. New vessels are required to replace the aging Steel Electrics and ensure continued passenger-vehicle service on the Port Townsend-Keystone route. This situation lent additional urgency to the vessel planning study that had been started by WSF in July, 2007.

Funding for replacement vessels for the Steel Electrics has not been identified. However, WSF has received Washington State Legislative approval for $347.6 million for building four new 144-car vessels.

1.2. BACKGROUND

The Port Townsend-Keystone route carries three percent of the system ridership (778,000 total riders and 370,000 vehicles). Traffic on the route is primarily recreational and commercial, with a very small base of regular commuters. Due to tidal and weather conditions that severely affect entrance to the Keystone Harbor, the Port Townsend-Keystone Route has the most trip cancellations in the entire ferry system.

WSF had originally proposed to replace the two 65-car Steel Electric ferries on the route with one mid-sized Issaquah class vessel (similar to the new vessels being built today.) The vessels would be interchangeable throughout the ferry system. The new vessels would not be able to operate in Keystone Harbor as it is currently configured, so WSF was considering an option of moving the terminal out of the harbor, along with other options. Community concerns with this possibility led to a legislatively-mandated study of options for keeping the terminal inside Keystone Harbor. The Keystone Harbor study was conducted in 2004 -2005. The report recommended that WSF study three vessel sizes to replace the Steel Electrics while continuing to operate within Keystone Harbor. The three vessel sizes were 65-car, 100-car, and 124-144 car vessels. Alternatives included modifying the harbor to accommodate a larger vessel and building a smaller, special vessel that could operate in the existing harbor. Community concerns began to arise regarding the environmental impacts of modifying the harbor to accommodate the largest vessel under consideration.

Subsequent to the Keystone Harbor Study, a State Environmental Policy Act (SEPA) review of terminal maintenance and expansion options at the Port Townsend end of the route surfaced significant community concerns with the 124-144 car vessel as an option for the route. These concerns revolved around traffic, community character, and service frequency.

As a result of the route communities' concerns with the alternatives being considered for the route, WSF suspended planning efforts on both sides of the route in late 2006 in order to consult with the communities and work towards finding a mutually acceptable solution for the route. In May 2007, Executive Director Mike Anderson sent a letter to the community outlining a new path forward for the route. In the letter, community concerns were acknowledged and WSF's response to these concerns resulted in new planning assumptions for the route. These included a decision to remove the 124-144 car vessels from consideration, a focus on replacement vessels that would be no larger than 100-cars, and a commitment to remain in Keystone Harbor without modifications to the harbor.

The Legislature allocated $1 million to support a combined route planning effort over the 07-09 biennium. In June 2007, WSF announced the start of a joint Port Townsend–Keystone route planning effort, which would include a vessel planning study incorporating the newly-decided vessel parameters.

1.3. STUDY GOAL

The goal of the vessel planning study is to assess the costs and benefits associated with viable new vessel options to replace the Steel Electrics on the Port Townsend-Keystone Route. All new vessel concepts must meet the following criteria:

- Vehicle capacity of 100 cars or less
- Capable of operating within the existing Keystone Harbor

Initially, this study was intended to look at typical hull forms and propulsion system options to provide a basis for a new vessel design if authorized. The study was not intended to develop or review specific vessel designs – that would be addressed at a future date if legislative approval to proceed with vessel design was received. However, when the Steel Electric class ferries were taken out of service, it became apparent that new vessels would be needed on a very expedited delivery schedule so the scope of the study was expanded to include the review of suitable vessel designs that had recently been delivered for service for their ability to serve the Port Townsend – Keystone route and be delivered within two years, sooner if possible.

The viable vessel options developed in this study and an analysis of the feasibility of existing designs will be presented to the Legislature in January 2008. The final Vessel Planning Study report will be included as a specialized discipline report in the environmental documentation prepared for the Port Townsend – Keystone route.

1.4. VESSEL STUDY SCOPE

The vessel study comprehensively assesses a range of potential vessels suitable for the Port Townsend-Keystone route based on a variety of parameters including: systems planning; physical and environmental constraints; operations requirements; community characteristics; terminal requirements; and short- and long-term costs.

This study looks at a range of hull forms and propulsion systems currently in service around the world and identifies those configurations that could be suitable for service on the Port Townsend – Keystone route. For each viable configuration, high-level acquisition and operating cost estimates were developed along with a discussion of the relative benefits and drawbacks associated with each option.

2. Relevant Project Technical History

2.1. PAST ESTIMATES OF FUTURE DEMAND (DRAFT LRSP)

Previous forecasts have included up to 40 percent increases in traffic by 2030, based on population and employment demographics. WSF is currently engaged in a collaborative process to re-draft the long range plan that may result in alternative forecasts or responses to increased demand other than adding capacity.

2.2. KEYSTONE HARBOR STUDY

The Keystone Harbor Study investigated the opportunities for making modifications to Keystone Harbor to accommodate a larger ferry, in particular a 130 vehicle capacity vessel, *Issaquah* class or similar. The options investigated dredging the harbor plus either extending or moving the existing jetty.

2.3. NEW VESSEL SEPA CHECKLIST AND ENVIRONMENTAL DISCIPLINE REPORTS

It is WSF policy to conduct SEPA analyses on the deployment and operation of new vessels. The most recent vessel SEPA analysis WSF conducted is for the new 144 auto ferries, which are being designed and built to replace aging vessels in the fleet. A copy of the 144 Auto Vessel SEPA Checklist is included to provide reference for the scope of studies required in the environmental analysis.

2.4. EXISTING TECHNICAL MEMORANDUMS

Technical memorandums have been produced related to both the Keystone Harbor EIS and the Port Townsend Ferry Terminal Preservation and Improvement Project. These memorandums addressed the environmental, traffic, cost, community, and other potential impacts and mitigation options for terminal improvements at the terminals on each end of the route.

3. Stakeholder Involvement

3.1. PARTNERSHIP MEETINGS

Since suspending work on both the Port Townsend and Keystone projects in October 2006 due to community and legislative concern about the proposed size and scale of new facilities, WSF and representatives from Port Townsend and Whidbey Island have been working closely together to discuss community concerns and find the best path forward for this route.

In January 2007, WSF began regular partnership meetings with representatives from Port Townsend and Whidbey Island to discuss community concerns and find the best path forward for this route. The group met in January, February, March and May of 2007. At their first meeting, the group identified the following purpose statement to guide the partnership effort: Identify issues and concerns for both sides of the route in preparation for continuing discussions between the communities and Washington State Ferries.

In their first four meetings, the partnership group discussed community concerns and worked to gain a mutual understanding of values and constraints in order to help WSF determine the best path forward. Through this process the group identified the following key issues:

1. The environmental review for both projects should be combined, not conducted independently.
2. Vessel size and frequency of service should fit the scale and character of the local communities and provide reliable service.
3. Impacts on local streets from ferry traffic need to be thoroughly analyzed and minimized.
4. The scale and size of terminals should fit the scale and character of the local communities.
5. There is community interest in testing a reservations program or other operating strategies to analyze the impacts of those strategies on ferry queuing and facility sizing.

As the Vessel Planning Study got underway, the Partnership group included the study in their discussions with WSF. The next four meetings focused on the vessel study, as well as continuing discussions with WSF about other pertinent issues.

Meeting dates and primary Vessel Planning Study topics were as follows:

- August 21, 2007: Study scope and schedule. At this meeting, WSF shared the study plan with the Partnership Group.
- September 18, 2007: Baseline requirements. At this meeting, WSF and the Partnership worked to develop baseline requirements that would be the basis for evaluating viable hull/propulsion options and their suitability for the route. See Section xx for these assumptions.

- November 16, 2007: Hull and propulsion system study findings and recommendations; initial evaluation of viable options. At this meeting, WSF presented the initial results of the hull and propulsion studies and provided the list of potential hull/propulsion options that would be screened. The Partnership group also reviewed and commented on the weighted criteria that would be used to develop a list of viable hull/propulsion options.
- December 12, 2007: Review of draft Vessel Planning Study report. At this meeting, the Partnership group received an overview of the study results, learned about new vessel options considered in the study, reviewed WSF's study recommendations, and discussed trade-offs of the recommended options.

3.2. WSF STEERING COMMITTEE

A steering committee composed of directors from each department within WSF was formed to guide the policy recommendations of the study and provide a conduit for the flow of technical information. The steering committee was comprised of senior WSF staff from the following departments:

- Vessel Engineering
- Vessel Preservation and Maintenance
- Terminal Engineering
- Planning
- Operations
- Communications

In recognition of the importance of the study effort, the WSF Executive Director served as the committee chair. In addition to the Steering Committee meetings, one-on-one meetings were conducted with each department head to better understand the issues and constraints affecting the study and to ensure the Committee members understood the role of the Committee and the importance of the study. Over the course of the study, additional meetings were held with Steering Committee members to address specific technical issues as they arose.

Washington State Department of Transportation

Washington State Ferries

4. Systems Planning

4.1. RELEVANCE WITHIN THE LONG RANGE (CAPITAL) PLAN

There is currently no funding in the WSF Long Range Capital Plan for new vessels for the Port Townsend – Keystone route. Funding has been designated for terminal improvements at both Port Townsend and Keystone. The required improvements at each terminal will be influenced by the size and performance characteristics of any new vessel on the route, so the previous budgets for terminal improvements will be revised and included in an overall capital plan for the route that included new vessels, terminal improvements, and costs associated with traffic improvement and other mitigation efforts.

4.2. ROUTE AND VESSEL CAPACITY

Port Townsend-Keystone Route Statistics for 2005

- This route carries 3 percent of system wide ridership (778,000 total riders and 370,000 vehicles).
- Traffic on this route is primarily recreational and commercial, with a very small base of regular commuters. Only 6 percent of riders use frequent user fare media, which is well below the system average of 33 percent.
- Ridership fluctuates seasonally. Three times as many people use the route in summer months than in winter.

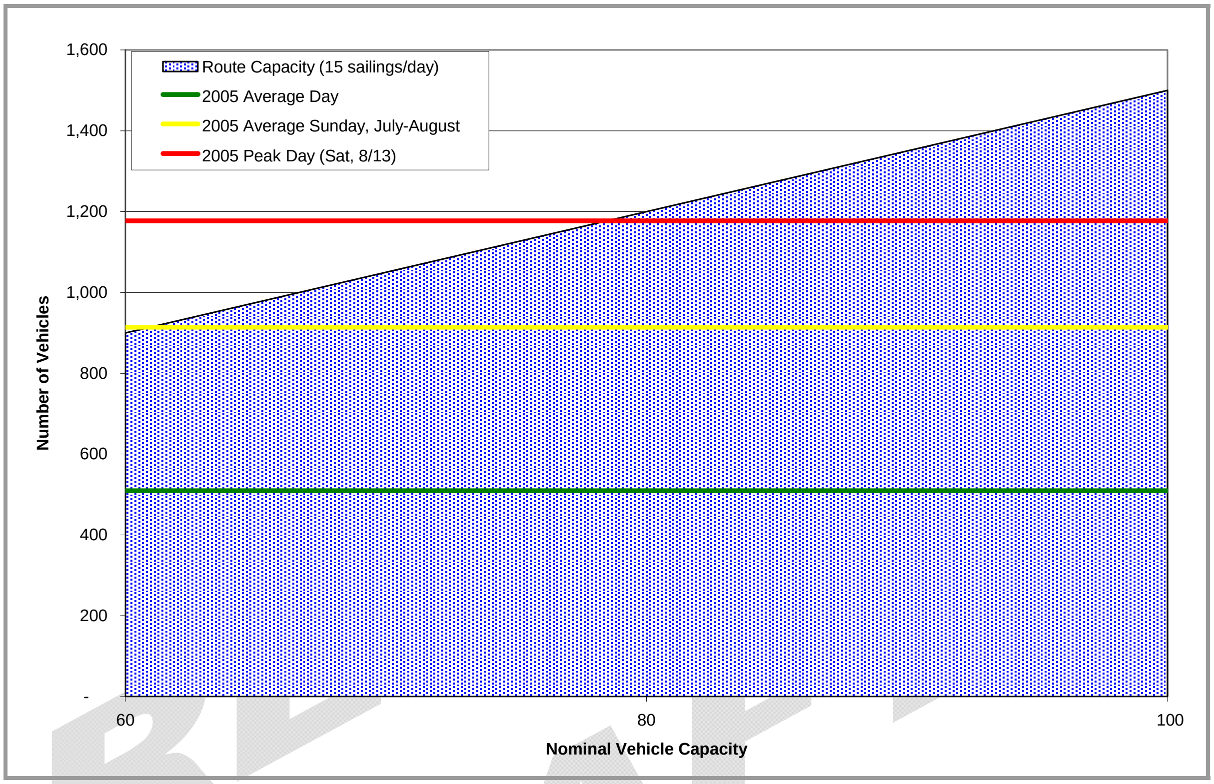


Figure 4-1, Nominal Daily Route Capacity Versus 2005 Demand

Weekday traffic patterns are heavily centered around Bremerton and Port Townsend/Jefferson County on the west side and North Whidbey Island on the east side of the route. Weekend traffic is more distributed throughout the greater Olympic Peninsula and the Whatcom County/lower British Columbia mainland.

4.3. SERVICE LEVELS AND SCHEDULES

The current summer schedule for the Port Townsend – Keystone route has a departure from Port Townsend every 45 minutes. This allows each crew working an eight hour shift to complete five round trips and provides a total of 15 departures per day on the summer two-boat schedule.

In the course of this study, it was suggested that if new vessels are built for this route, their speed be increased to all for more daily departures. To accomplish this, the service speed of the new vessel would have to be fast enough to allow each eight hour shift to make an additional round trip, resulting in 18 departures per day. The chart below illustrates the additional speed required to get an extra round trip in a single eight hour shift. As shown, large increases in service speeds will be required. Cruising at these higher speeds would consume approximately three times as much fuel as maintaining the current schedule. Based on the cost of the additional fuel required, these higher speed options were not carried forward in the hull and propulsion system studies.

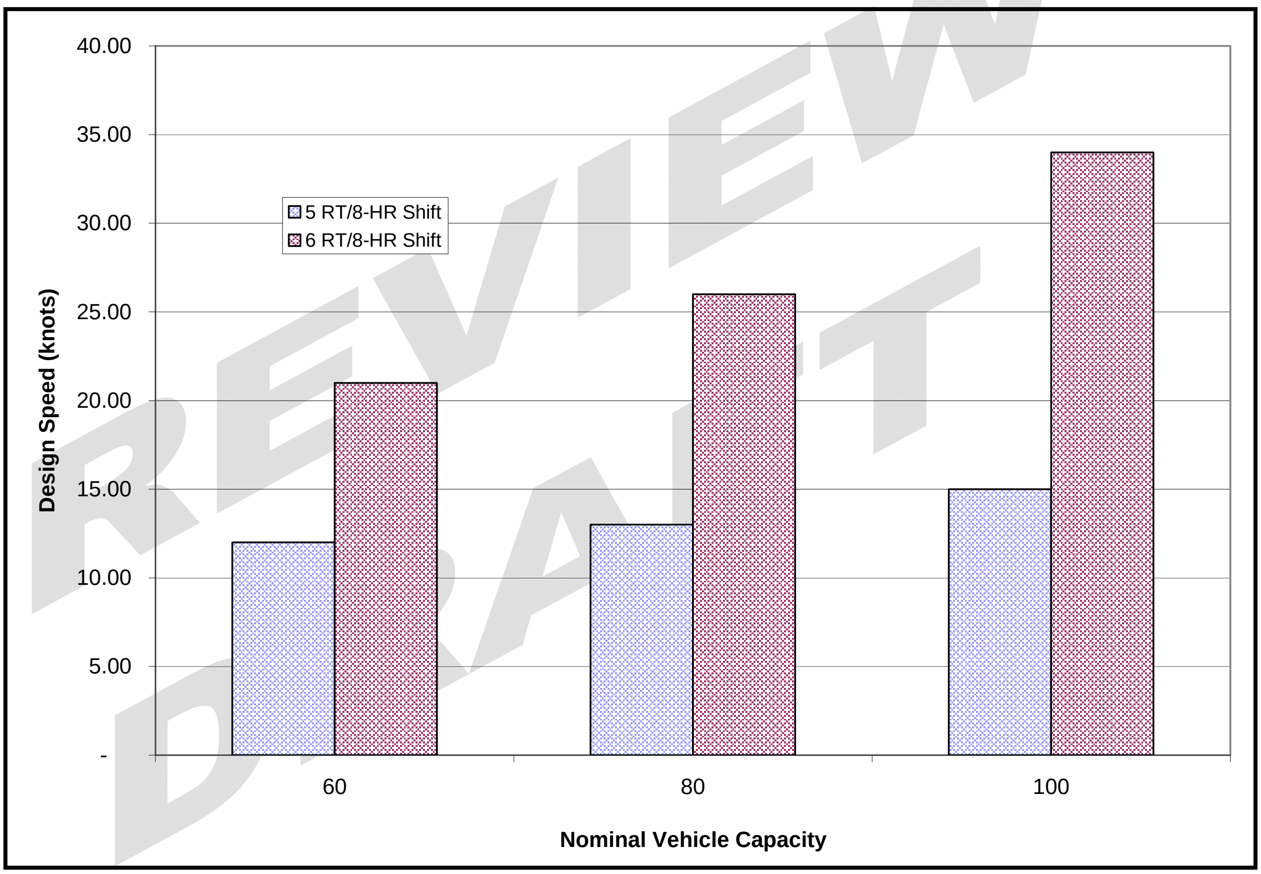


Figure 4-2, Speed Versus Service Level

5. Baseline Requirements

Recognizing the sensitivity of the communities served by the route, WSF consulted with the Partnership group to develop baseline assumptions for the Vessel Planning Study that addressed community concerns and constraints as well as WSF concerns and constraints. In addition to the two design limits defined at the initiation of the Vessel Planning Study, (no larger than 100-car ferry, and no modifications to the Keystone Harbor) the following additional requirements were developed and agreed to by WSF and the Partnership:

a. Must fit within the existing Keystone Harbor with current dredging schedule.

b. Maneuverability: must be able to safely enter Keystone Harbor with a 3.4 knot ebb current calculated off Bush Point (closest predicted current reference station).

c. Must have a propulsion system with a proven reliability record in a similar operating environment.

d. Must have the functional ability to provide at least the same number of sailings as the current schedule (one round trip every 90 minutes, departure to departure).

e. Vehicle capacity: no less than existing capacity and no more than 100 cars.

f. No less than the current Steel Electric passenger capacity (600 passengers).

g. No more weather related cancellations than current operations.

The Partnership group also expressed a wish to strive to exceed the minimum baseline assumptions wherever possible, practical and affordable.

These requirements were used as thresholds that any hull form, propulsion system, or proposed design solution must be able to meet in order to be carried forward in the study process.

6. Vessel Studies

6.1. HULL FORM STUDIES

The initial vessel studies began with an evaluation of hull forms, using the following criteria:

- Compatible with standard WSF vehicle loading facilities and can be used on other routes within WSF system: Hull forms that allow docking at WSF terminals using standard dolphin, fender, and transfer span configurations are preferred to those that would require unique marine structures that are incompatible with the rest of the WSF fleet.
- Seakeeping in heavy cross-seas (passenger comfort): The route between Port Townsend and Keystone crosses Admiralty Inlet at the eastern end of the Strait of Juan de Fuca, where strong winds are often opposed to tidal currents, created very steep seas. Even though heavy-weather routes minimize the time spent running perpendicular to the prevailing seas, there is always some exposure during turns. A vessel that minimizes motions during these periods is preferred.
- Low resistance at design speed (efficient): Fuel consumption makes up a large portion of the operating cost so hull designs that minimize the amount of power needed to maintain schedule are preferred.
- Easy to load and unload (efficient car deck layout): Hull forms that lend themselves to simple, easy to load car decks are preferred to those that require structures in the middle of the car deck, creating complex vehicle lanes and making truck loading a challenge, as is the case with the existing Steel Electric class ferries.
- Construction cost: Low cost hull forms are preferred. Low cost can be achieved through the use of simplified structure or efficiency leading to the purchase of smaller propulsion systems.
- Can fit through Ballard Locks: Shipyards on Lake Union and the Lake Washington Ship Canal can bid on ferries that can navigate the Ballard Locks, increasing competition and lowering repair and maintenance costs.
- Can be docked at two or more shipyards in the Puget Sound area: With the limited number of dry docks or other haul-out facilities available in Puget Sound, designing a new vessel with a small enough footprint that can be serviced at a variety of shipyards will be more economical in the long run.
- Designed for 60 year service life: Because WSF ferries are so unique, there is generally very little re-sale value when they have reached the end of their useful service life. To maximize its return on investment, WSF typically invests in a major overhaul/upgrade at about 30 years, with the intent of getting another 30 years of service out of the primary hull structure.

6.1.1. Single-Ended Versus Double-Ended

All of the Washington State Ferries are double-ended, which means they can operate equally in either direction. Both ends of the vessel have the same configuration so the vessel does not have to turn around to approach the terminal on either end of its route. Single-ended vessels can only operate effectively in one direction, having a distinct bow and stern, and must turn around approaching and departing one of the terminals on its route.

Both double-ended and single-ended ferries can be configured for drive-through operations, which means the cars being carried do not have to turn around onboard in order to disembark. All ferries in the WSF fleet are configured for drive-through operation. The MV Coho is a local example of a single-ended ferry that is also configured for drive-through operations.

The entrance to Keystone Harbor is very narrow, requiring a straight approach both entering and exiting. To achieve this, a single-ended vessel would have to turn around within the harbor prior to departing. The width of the navigation channel makes this a very difficult maneuver at most tides and it is impossible at low tides, when the width of the channel is only a few feet greater than the length of the ferry. See Figure 6-1 for an illustration showing the relative size of the navigation channel at low tide and the existing Steel Electric class ferries serving the route. The aerial photo below illustrates the challenges associated with trying to maneuver within Keystone Harbor.

Figure 6-1: Keystone Harbor Aerial Photo

Recommendation: Only consider double-ended vessels due to difficulty maneuvering within Keystone Harbor

6.1.2. Monohulls, Catamarans, and Multi-Hulls

Another variation in the design of modern ferries is the number of hulls. Monohulls have a single hull, catamarans have two hulls, and multi-hulls have three or more. The typical characteristics of each of these general classifications are described below.

Monohull ferries are more common than any other hull forms. All of the passenger-vehicle ferries in the WSF fleet are monohulls. A monohull double-ended ferry would likely be very similar to the vessels currently serving the route, with good fuel efficiency, wide car decks supported by sponsons, large and accessible engine rooms, and a passenger cabin above and centered on the car deck. Monohulls tend to have deeper drafts than catamarans and multi-hulls, which results in longer roll periods and a more comfortable ride in cross-seas. The deeper draft also makes monohulls more difficult to maneuver, especially those with fixed shaft propulsion systems on centerline. Monohulls also have more reserve stability, which reduces the amount of vessel movement when loading or unloading heavy vehicles. Finally, a standard WSF landing configuration could continue to be used at the Port Townsend and Keystone terminals, which increases the fleet interoperability.

Catamarans are the second most common type of ferry, although there are relatively few double-ended catamarans in service around the world. Where high-speed service is required, single-ended catamarans are frequently the preferred vessel type due to their fuel efficiency, seakeeping, and loading/unloading efficiency. However, at the lower speeds being considered in this study, the fuel efficiency of catamarans is not as good as monohulls. The maneuverability and loading/unloading efficiency of catamarans is generally better than monohulls. The roll period of catamarans tends to be shorter and less regular than that of monohulls, resulting in the potential for higher frequencies of seasickness among passengers. One design recently put into service in Norway and Turkey takes full advantage of the width of a catamaran. It allows up to four lanes to load at once onto a vehicle deck that has no obstructions as all services and systems are run up the sides of the vessel. To take full advantage of this feature, extensive modifications would be required at the terminals on both ends of the Port Townsend - Keystone route.

Multi-hull ferries, defined for the purposes of this report as having three or more hulls, are only seen in high-speed service. To achieve their hydrodynamic efficiency, multi-hulls do not have the secondary hulls at midships; rather, they are located aft of midships to avoid negative wake interactions. Since there are no other multi-hull ferries operating in the speed range under consideration and there is always substantial risk associated with a new type of hull form, multi-hull options will not be considered further in this study.

Table 6-1: Hull Form Comparison

Hull Form	Capital Cost	Fuel Efficiency	Loading Efficiency	Seakeeping	System Compatibility
Monohull	Higher	Higher	Lower	Good	Good
Catamaran	Lower	Lower	Higher	Poor	Poor

6.2. PROPULSION SYSTEM STUDIES

Propulsion systems are composed of all the machinery necessary to make a vessel move. They typically include an engine (also known as a prime mover), a propeller or other device that converts the energy created by the engine into thrust, and a drive train that carries the energy generated by the engine to the propelling device. This study investigated both fixed-shaft systems, which generate thrust only inline with the propeller shaft, and enhanced maneuverability systems which can generate thrust in any direction.

6.2.1. Propulsion System Evaluation Criteria

An initial set of evaluation criteria for the selection of propulsion systems was developed and submitted to the Steering Committee. The criteria listed below, and their relative weights, were agreed upon by the Steering Committee and reviewed by the Partnership group. The weights associated with each of these selection criteria represent the importance of each individual criterion relative to the others.

- Reliability (20 points): Reliability is defined as the ability of the vessel to maintain the published schedule. WSF has a fleetwide goal of 100 percent schedule reliability and regularly achieves over 99 percent.

  The most important element in assessing system reliability is the built-in redundancy, which eliminates the possibility of a single-point failure causing an interruption in service. Another factor in predicting the reliability of a system is its complexity; in general, simpler systems are more reliable than complex systems. Complexity is a concern for both vessel operators, who prefer user-friendly control systems, and engineers who prefer systems that are easy to learn and fix. Finally, if there is a failure of the propulsion system, the vessel can be returned to service quicker if the system can be repaired with the need for dry docking.

- Maneuverability (20 points): Maneuverability is important as it controls the number of scheduled cancellations due to tidal currents. Getting into and out of Keystone Harbor can be very challenging with the existing vessels, hence the need to schedule cancellations to avoid peak cross-currents at the harbor entrance. More maneuverable propulsion systems would require fewer cancellations and allow safer operation at all times.

  Although the baseline requirement for vessels considered in this study was to operate with no additional scheduled cancellations, several members of the Partnership and Steering Committee expressed concern that acquiring new vessels that do not perform any better than the Steel Electric class ferries would not be a good use of taxpayer funding.

- Fuel efficiency (20 points): Fuel costs are the single largest element of the vessel's operating cost directly affected by the choice of propulsion system. The more efficient systems will burn less fuel over time, which could offset a higher acquisition cost over time. Fuel efficiency is not weighted as high as maintenance costs because significant differences in efficiencies between systems are not anticipated.

- Maintenance costs (20 points): Maintenance costs include both maintenance performed by the vessel's engineering crew and that performed in the Eagle Harbor maintenance yard or another shipyard. Maintenance costs reflect costs for regular maintenance between overhauls, predicted service life, consumable, replacement parts, and all other costs related to keeping the machinery in operation. Maintenance costs were weighted highly as they can be very significant and are a highly visible annual budget item.

- Fleet compatibility (10 points): Because deck and engine room crew members can change vessel assignments, the training costs of a system that is similar to existing systems in the fleet will be lower than those of specialized or unusual systems. In addition, there is a reduced likelihood of error when using or maintaining systems with which the crew is familiar. This is an important consideration in the selection of a propulsion system but it is secondary relative to reliability, maneuverability, and operating costs.

- Acquisition costs (5 points): Acquisition cost was not weighted heavily because it is a one-time cost whereas all of the other costs will continue to be incurred over the life of the vessel. When acquisition costs are amortized across the lifespan of the propulsion system, these costs are small relative to those of fuel and maintenance.

- Risk of grounding damage (5 points): The susceptibility of the system to grounding damage was weighted lowest because the likelihood of grounding is inversely proportional to the maneuverability of the system.

All of the propulsion systems being considered are assumed to use a diesel engine as the prime mover. There are currently no commercially available non-diesel prime movers in the power range being considered. The diesel-electric systems could more readily be converted from a diesel prime mover to an alternate energy source, such as a fuel cell, as only the diesel engine and generator would have to be replaced. The electric drive motor and all downstream components would remain the same.

6.2.2. Propulsion System Evaluation

Eight potential propulsion systems were considered. These included both fixed-shaft systems with high-efficiency rudders and directional thrust systems, which do not require rudders for maneuvering. The eight systems considered were:

1. Diesel-Mechanical Fixed-pitch Propeller
2. Diesel-Mechanical Controllable-pitch Propeller[5]
3. Diesel-Electric Fixed Pitch Propeller
4. Diesel-Mechanical Contra-rotating Propellers
5. Diesel-Electric Azimuthing Geared Drive
6. Diesel-Electric Azimuthing Podded Drive
7. Diesel-Mechanical Vertical Axis Propulsor
8. Diesel-Mechanical Fixed Shaft Propeller with Contra-rotating Electric Azimuthing Geared Drive

A summary of these systems is provided in Table 6-4 Illustrations of the systems studied are shown in Figure 6- through Figure 6-.

[5] This is the type of propulsion system selected for the new WSF 144 vehicle class ferries

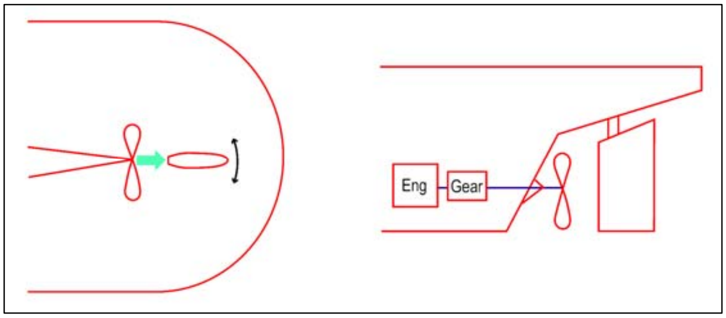


Figure 6-2: Option 1 – Diesel-Mechanical Fixed Pitch Propeller

Diesel-Mechanical Fixed Pitch Propeller

Pros

- Lease expensive
- Simple
- Easy to maintain

Cons

- Slow response time

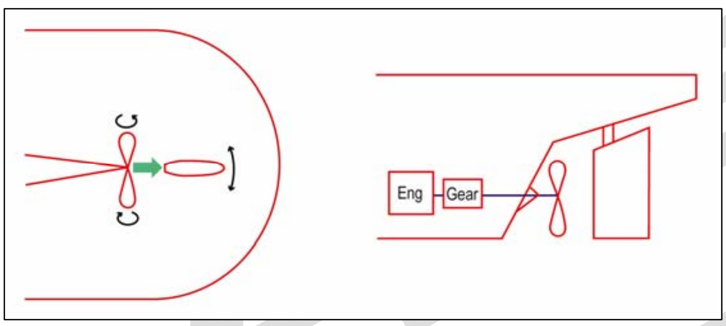


Figure 6-3: Option 2 – Diesel-Mechanical Controllable Pitch Propeller

Diesel-Mechanical Controllable Pitch Propeller

Pros

- Common system in WSF fleet
- Most maneuverable fixed-shaft system with quickest response time
- Easy to maintain

Cons

- Least redundant fixed-shaft system

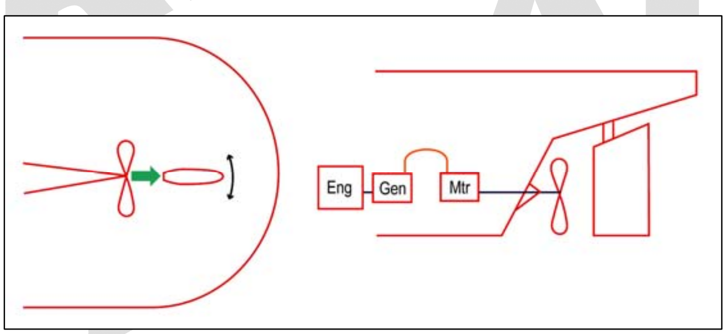


Figure 6-4: Option 3 – Diesel-Electric Fixed Pitch Propeller

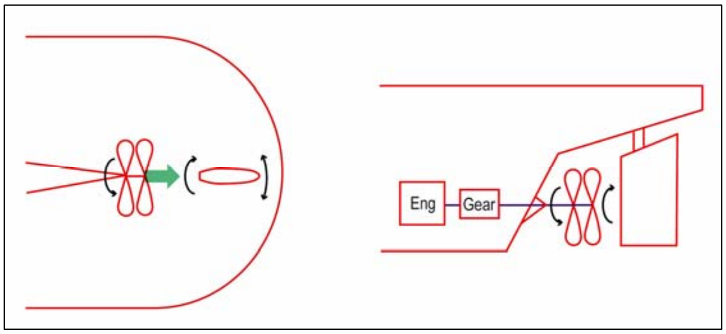
Diesel-Electric Fixed Pitch Propeller

Pros

- Common system in WSF fleet
- Most reliable system
- Most redundant system

Cons

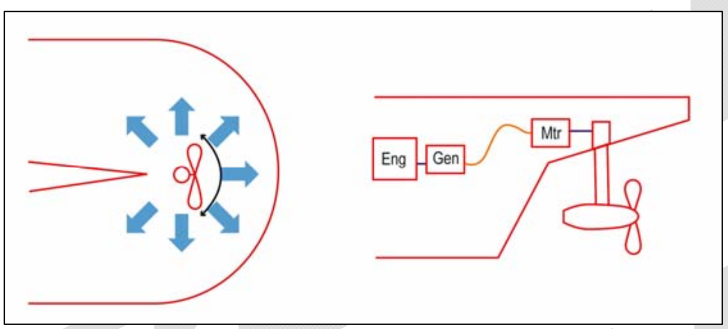
- More complex
- Highest acquisition cost fixed-shaft system



Diesel-Mechanical Contra-rotating Propeller

Pros	Cons
■ Theoretically highly efficient	■ No proven systems in similar operating environment

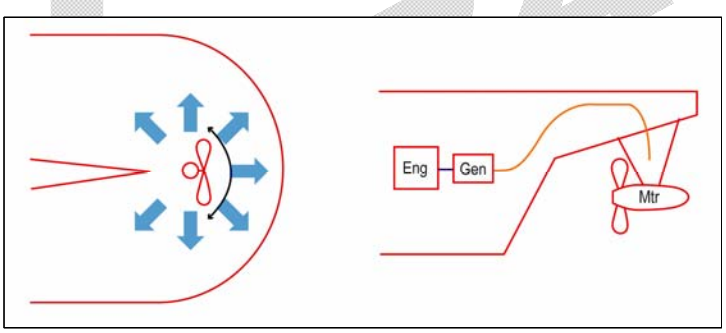
Figure 6-5: Option 4 – Diesel-Mechanical Contra-rotating Propellers



Diesel-Electric Azimuthing Geared Drive

Pros	Cons
■ Can deliver full thrust in any direction	■ Moderate response time
■ Can be replaced without need for drydocking	■ Less efficient than fixed shaft systems
■ More redundant than vertical axis system	■ Subject to grounding damage
	■ Most expensive system

Figure 6-6: Option 5 – Diesel-Electric Azimuthing Geared Drive



Diesel-Electric Azimuthing Podded Drive

Pros	Cons
■ Theoretically highly efficient	■ No proven systems in similar operating environment

Figure 6-7: Option 6 – Diesel-Electric Podded Azimuthing Drive

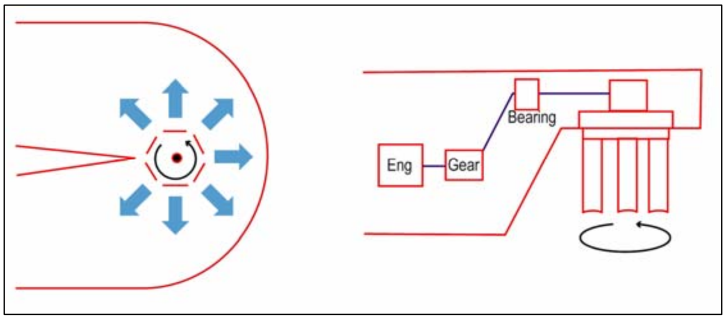


Figure 6-8: Option 7 – Diesel-Mechanical Vertical Axis Propulsor

Diesel-Mechanical Vertical Axis Propulsor

Pros

- Can deliver full thrust in any direction
- Fast response time
- Better braking allows slower cruising speed
- Second lowest acquisition cost
- Lowest estimated fuel cost

Cons

- New system for WSF
- Extensive training required for both operators and engineers

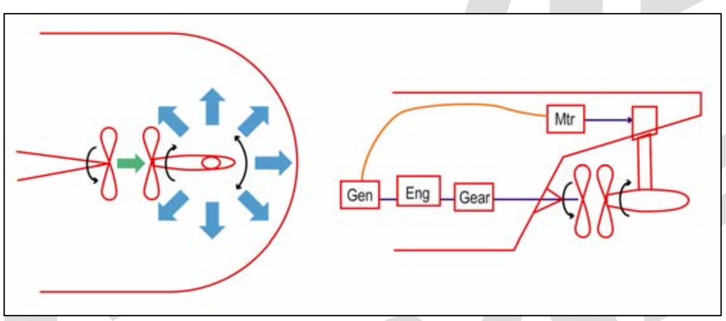


Figure 6-9: Option 8 – Diesel-Mechanical Fixed Shaft Propeller with Contra-rotating Electric Azimuthing Geared Drive

Diesel-Mechanical Fixed Pitch Propeller with Contra-rotating Electric Azimuthing Geared Drive

Pros

- Theoretically very efficient

Cons

- No proven systems in similar operating environment

Of these eight systems reviewed, very limited information was available on Option 4 (fixed-shaft contra-rotating propellers), Option 6 (azimuthing drives with podded motors), and Option 8 (diesel-mechanical fixed-shaft drives with contra-rotating azimuthing drives). Based on this lack of information and the baseline requirement that any potential propulsion system have a proven record of reliability in a similar operating environment, these systems were dropped from further consideration.

The remaining five systems were assessed using the weighted criteria described in Section 6.2.1 and ranked based on their composite score. The results of this analysis are shown in the table below.

See Appendix __ for a copy of the complete report.

Table 6-2: Propulsion System Comparison

System	Capital Cost	Annual Fuel Cost	Annual Maint. Cost	Maneuverability	Proven Reliability	Dry Docking Required for Repair	Fleet Compatibility	Grounding Damage Resistance	Overall Score
1. Mech. Drive, Fixed Pitch Propellers	$4.9M	$1.36M	$304K	LOWEST	YES	YES	HIGH	High	2.78
2. Mech. Drive, Controllable Pitch Propellers	$5.9M	$1.36M	$302K	MEDIUM	YES	YES	HIGH	Medium	2.93
3. Elect. Drive, Fixed Pitch Propellers	$7.6M	$1.51M	$143K	LOW	YES	YES	HIGH	High	3.18
4. Mech. Drive, Fixed Pitch Contra-Rotating Propellers	*N/A*	*N/A*	N/A	*N/A*	NO	*N/A*	*N/A*	*N/A*	*N/A*
5. Elect./Mech. Azimuthing Drive	$10.0M	$1.54M	$167K	HIGH	YES	NO	LOW	Low	2.99
6. Mech. Drive, Vertical Axis Propulsor	$5.4M	$1.29M	$270K	HIGHEST	YES	YES	LOW	Medium	3.70
7. Elect. Podded Azimuthing Drive	*N/A*	*N/A*	*N/A*	*N/A*	NO	*N/A*	*N/A*	*N/A*	*N/A*
8. Mech. Drive, Controllable Pitch with Elect./Mech. Contra-Rotating Azimuthing Drive	*N/A*	*N/A*	*N/A*	*N/A*	NO	*N/A*	*N/A*	*N/A*	*N/A*

6.3. OPERATIONAL AND SAFETY REQUIREMENTS

All of the viable options will be developed in consideration of the operational, safety, and regulatory requirements identified through interviews with WSF staff. Operational requirements include car deck load/unloading efficiency, passenger deck access, disabled passenger access, and maintenance access. Safety requirements include line-off-sight from the pilothouse, emergency power generation, and rescue boat access. Regulatory requirements address all other life safety and environmental protection issues.

For the purposes of this study, the requirements of 46 CFR Subchapter H are assumed to apply. The applicable subchapter is determined by the number of passengers carried and the gross tonnage of the vessel, which is an obtuse measure of the amount of cargo that could potentially be carried by the vessel. All of the other passenger-vehicle ferries in the WSF fleet are subject to the Subchapter H requirements and the new vessel is unlikely to be an exception.

For a ferry with a nominal capacity of 60 vehicles, it may be possible to meet the requirements of 46 CFR Subchapter K, which covers vessels of less than 100 Gross Registered Tons (GRT) carrying not more than 150 passengers. A vessel designed to Subchapter K could be as much as $10 million less than one with the same capacity designed to Subchapter H. Some of the differences are in emergency generator requirements, structural fire protection, and crewing. Ferries with a nominal vehicle capacity of 80 to 100 can not practically be designed to admeasure[6] less than 100 GRT and therefore are not eligible for Subchapter K.

6.4. ONBOARD AMENITIES

Any new vessel will be equipped with some onboard amenities, ranging from vending machines, video games, and newspaper boxes to a full galley or coffee shop. The potential revenue that can be generated by these amenities has to be considered in light of the associated additional weight and corresponding increase in fuel consumption. Onboard amenities can also enhance the customer experience and training can be provided to vendors that would allow them to assist in case of an emergency.

All of the viable options are capable of accommodating the same variety of onboard amenities. Although onboard amenities are not considered further in this study, they should be determined early in the design phase.

---

[6] **Admeasurement is the process of calculating the GRT of a vessel. GRT is a measure of volume, not weight, and is calculated using a set of complex and detailed rules.**

6.5. VOLUNTEERED PROPOSALS

Prior to the vessel study, WSF had been made aware of other vessel concepts and volunteer proposals. The Partnership group urged WSF to consider these in the vessel study. These volunteer proposals are addressed briefly below. Additional detail on these concepts and proposals is provided in the appendices.

6.5.1. Martinac Safe Passage class

The Safe Passage class ferries proposed by J. M. Martinac Shipbuilding are comparable to the double-ended monohulls described above with diesel-electric azimuthing geared drives. As initially proposed, these vessels would have a capacity of 130 vehicles but they could be modified to accommodate only 100 vehicles by eliminating the upper vehicle decks on the outboard sides. There are a number of technical issues in the design which could be resolved through discussions with WSF Operations and Vessel Preservation and Maintenance staff. These issues include the overall width of the vessel, the width of some of the vehicle lanes, and the arrangement of the vehicle deck. A detailed analysis of the Martinac Safe Passage design is provided in Appendix __. This design is too wide and has too deep of a draft to fit into the existing Keystone Harbor and therefore it is not included in the final recommendations.

6.5.2. Nichols Brothers Boat Builders – Incat/Crowther catamaran concept

Concept design studies for two double-ended catamarans were provided by Incat/Crowther Design through Nichols Brothers Boat Builders. These designs would require substantial modifications to the existing berthing and vehicle loading facilities at both Port Townsend and Keystone. In addition, there are a number of design elements that would need to be addressed to bring the concepts into compliance with USCG and WSF standards. A detailed analysis of this design is provided in Appendix __. This designs would required new design berthing structures and loading systems, which would likely trigger a substantial environmental process and therefore it is not included in the final recommendations.

6.5.3. Nichols Brothers Boat Builders – Sea Transport Systems catamaran concept

A set of general arrangement plans for a 60 vehicle, single-ended, drive-through catamaran were provided by Nichols Brothers Boat Builders. The subject vessel was designed and built by Sea Transport Systems and is similar to a number of other vessels by the same designer that are currently in service in Australia, Europe, and the Caribbean. The primary drawback of the proposed vessel is that it is single-ended, which is impractical for service to Keystone Harbor for reasons described above, therefore it is not included in the final recommendations.

6.6. OTHER CONCEPTS VOLUNTEERED

6.6.1. Re-use of Existing Superstructure

When the maintenance issues with the Steel Electrics became more problematic, and it became more obvious that selection, design and build time for replacement vessels was of greater urgency, a proposal to "re-hull" the existing Steel Electric ferries was suggested to WSF.

This concept for reducing the cost of new vessels and expediting delivery was to re-use the existing Steel Electric class superstructures and append them to new hulls. The hulls could be constructed at any of a number of yards and the superstructure installed utilizing the Synchrolift® available at Dakota Creek Industries in Anacortes. Some of the issues identified in this proposal that would require additional review include:

- Current superstructure does not meet current USCG requirements for stair width, stair slope, Americans with Disabilities Act accessibility in restrooms, MES locations, and wiring. Compliance with current regulations would require structural and systems modifications to the existing superstructures.
- The Steel Electrics, which do not meet modern USCG standards, but are USCG certificated under a "grandfathered" exception, would lose their grandfathered status with the new hull.
- Current superstructure limits vehicle height.
- Current superstructure reduces loading/unloading efficiency.
- If the two casings are replaced with a single casing on centerline, all of the transverse passenger deck beams would have to be replaced as their support will be very different.
- While this concept could reduce acquisition costs, it also has the potential to increase costs due to unknowns associated with lead paint, asbestos, and the condition of old steel hidden behind insulation.
- The delivery schedule for vessels using the existing superstructures is no faster than that of entirely new vessels.

This proposal was the subject of a meeting with local shipyards on November 26, 2007, and the general consensus from that meeting was that for the cost of the project, WSF would be better served by constructing a new vessel. The risks associated with modifying the existing structure would be substantially higher than building a whole new ferry.

The proposal received also recommended the use of a design-build strategy to expedite delivery of the vessels. Discussion and evaluation of acquisition strategies is outside the scope of this study.

6.7. EXPEDITED DELIVERY OPTIONS USING EXISTING DESIGNS FOR RECENTLY DELIVERED VESSELS

When the Steel Electrics were taken out of service, the parameters of the vessel study were adjusted. Time required to design and build a new vessel became a much more urgent driver, and options that did not meet all the baseline assumptions and were outside the original scope of the study were considered. As a result, WSF expanded their study to include the designs of two vessels recently delivered to other ferry operators. The advantage of this is that new vessel design time could be substantially reduced, if not eliminated entirely, and, if any of these options proved viable for the route, delivery time could be shortened to as little as 18 to 30 months.

As noted previously, the estimated delivery times throughout this report include six months for selecting a builder and negotiating a contract.

6.7.1. Existing *Steilacoom II* Design

The *Steilacoom II* is a double-ended ferry that was delivered to Pierce County, Washington, in 2007 for service between Steilacoom, Anderson Island, and Ketron Island. The principle characteristics of the *Steilacoom II* are:

- Vehicle Capacity: 50 vehicles[7]
- Passenger Capacity: 299 with a crew of 4 or 325 with a crew of 5
- Length Overall: 216'-0"
- Beam (molded): 68'-0"
- Service Speed: 11.4 knots
- Builder: Nichols Brothers Boat Builders, Freeland, Washington

A duplicate of the *Steilacoom II* could operate on the Port Townsend to Keystone route in compliance with USCG regulations with the addition of Marine Evacuation Slides and no other changes. Such a vessel would cost approximately $20 million[8] and could be delivered in 18 to 20 months[9].

---

7 The published capacity of 54 cars is based on a standard vehicle length of 17 feet. In determining the capacity of its ferries, WSF uses a standard vehicle length of 18 feet, which accounts for the difference in rated capacity.

8 At a meeting with state legislators, and WSDOT, WSF, and legislative staff, a representative of Nichols Brothers Boat Builders stated that a duplicate of the Steilacoom II could be built for less than $20 M. If this option is chosen, the negotiated cost may be lower.

9 Although a representative of Nichols Brothers Boat Builders has stated that a duplicate of the Steilacoom II could be built in 12-14 months, Elliot Bay Design Group has been informed by a representative of NC Machinery, the local Caterpillar engine supplier, that the lead time on engines of the type used in the Steilacoom II would be 12-4 months for an order placed in the first quarter of 2008, which could increase the time to delivery of a new vessel.

Because the existing design of the *Steilacoom II* only has a vehicle capacity of 50, to meet current service levels two vessels would be needed in the shoulder seasons on the current summer schedule and during the peak season the second vessel would have to run two 8-hour shifts.

The service speed of the *Steilacoom II* is also slightly less than that of the Steel Electric class ferries. While a duplicate vessel could likely operate successfully at the current service speed of 12 knots, it would be difficult to make-up any time lost due to delays in loading and unloading. On busy days, this could make it difficult to maintain the schedule over the course of a day.

The *Steilacoom II* was designed for service in southern Puget Sound, where conditions are generally not as severe as those encountered on Admiralty Inlet between Port Townsend and Keystone. As a result, it was designed with less protection from heavy spray and green water than the Steel Electric class ferries. Therefore, with a duplicate of the *Steilacoom II* on the route, there would likely be more weather related cancellations to ensure passenger safety. As a smaller vessel, it would also likely have larger motions in a seaway than currently experienced.

The *Steilacoom II* is operated by a contractor hired by Pierce County and maintenance is performed by a different contractor under a separate contract. In normal operation, while the *Steilacoom II* is in service, a very similar ferry also owned by Pierce County, the *Christine Anderson*, is undergoing routine maintenance and every two weeks or so, the vessels are switched. This operation is reflected in the design as there are no crew quarters onboard and the engine room is unmanned. While this sort of operation has a lower annual cost than WSF, it is only possible with a second vessel with the same capacity. If a duplicate of the *Steilacoom II* were to be used, substantial negotiations would be required under the collective bargaining agreements in place between WSF and the maritime unions.

6.7.2. Modified *Steilacoom II* Design

A new design based on the *Steilacoom II* and modified to address most of the issues raised in the preceding section could be delivered within two and a half years and at a lower cost than an all-new design. The issues of capacity and crewing could be addressed by stretching the vessel by approximately 36 feet and adding a deck of crew quarters between the passenger deck and the wheelhouse.

The issue of service speed would become more critical as a larger ferry may not be able to maintain the service speed with the existing engines. Larger engines would require a re-design of the foundations and the rest of the drive train, increasing both acquisition cost and schedule.

Even with the modifications described above, the car deck would still be exposed and a larger number of weather related cancellations could be expected. While increasing the height and possibly the extent of the curtain plate is possible, this would required additional design effort, further reducing the cost and delivery schedule benefits of re-using an existing design.

6.7.3. Existing *Island Home* Design

The *Island Home* is a double-ended ferry that was delivered to the Woods Hole, Martha's Vineyard, and Nantucket Steamship Authority in 2007 for service between Woods Hole and both Martha's Vineyard and Nantucket off the coast of Massachusetts. The principle characteristics of the *Island Home* are:

- Vehicle Capacity: 74 total vehicles (60 vehicles[10] on the car deck, 14 on hoistable vehicle decks)
- Passenger Capacity: 1,200 with a crew of 10[11]
- Length Overall: 254'-9"
- Beam (molded): 64'
- Service Speed: 16 knots
- Builder: VT Halter Marine Group, Pascagoula, MS

A duplicate of the *Island Home* could operate on the Port Townsend to Keystone route in compliance with USCG regulations without any changes to design. Such a vessel would cost approximately $34[12] million and could be delivered in 16 to 18 months plus time to select builder and negotiate a contract.

6.7.4. Modified *Island Home* Design

The *Island Home* includes several features which would be unnecessary for service between Port Townsend and Keystone, including:

- Weathertight bow doors protecting the car deck
- Mezzanine passenger decks (similar location to the upper vehicle decks on the WSF Issaquah 130, Super, Jumbo, and Jumbo Mk II ferries)
- Weathertight doors enclosing the car deck
- High-capacity heating, ventilation, and cooling (HVAC) systems for the passenger and crew cabins
- Bow thrusters at both ends

Additional features recommended to be added to increase safety and meet WSF operating standards include:

---

[10] The published capacity of 54 cars is based on a standard vehicle length of 17 feet. In determining the capacity of its ferries, WSF uses a standard vehicle length of 18 feet, which accounts for the difference in rated capacity.
[11] Although the USCG Certificate of Inspection for the *Island Home* requires a crew of 10, she operates with a crew of 13 as a result of the collective bargaining agreements between the Steamship Authority and the maritime unions.
[12] The estimated cost of the *Island Home* is based on her original contract value plus escalation factors for inflation, material costs, and higher labor costs in the Puget Sound region.

- Replacing the fixed-pitch propellers with controllable pitch propellers to reduce stopping time and distance
- Modifying the Texas Deck arrangement to increase the number of crew cabins and reduce the size of the HVAC machinery spaces

Incorporating all of the above modifications may reduce the acquisition cost and schedule, but they would also require some additional design. A modified vessel is estimated to cost between $30 and $34 million, and could be delivered in 18 to 20 months plus time to select a builder and negotiate a contract.

6.8. OPTIONS CONSIDERED VIABLE FOR FURTHER STUDY

Based on the hull form and propulsion system studies, three viable combinations of hull form and propulsion system were carried forward as follows:

- Double-ended monohull with fixed-shaft propulsion system
- Double-ended monohull with directional thrust propulsion system
- Double-ended catamaran with fixed-shaft propulsion system

For each combination, nominal capacities of 60, 80, and 100 vehicles were investigated.

In addition to the selection of viable options for design of new vessels that meet all the baseline requirements, the concepts that emerged as a result of the Steel Electric maintenance issues were also carried forward. These concepts are: re-use of the existing Steel Electric class superstructures on new hulls; an unmodified version of the *Steilacoom II*, a modified version of the *Steilacoom II*, and a modified version of the *Island Home*.

7. Viable Options Evaluation

This stage of the study involved collecting and evaluating specific data for the three viable new vessel hull/propulsion options as well as for the re-hulling of the existing Steel Electrics, and the modified and unmodified designs of the *Steilacoom II* and *Island Home*. The areas evaluated included construction cost and schedule, design cost and schedule, operating cost, maintenance costs, and schedule reliability.

7.1. ACQUISITION COST

7.1.1. Construction Cost

The cost of recent deliveries of comparable vessels was used as primary input in developing construction cost estimates for the viable options. The vessels for which constructions costs were available were the following:

- *Steilacoom II*, 50 car capacity — $20 million (2007 price)
- *MV Island Home*, 74 car capacity — $34 million (2007 estimate)
- WSF 130 car capacity monohull — $65 million (2005 estimate)
- *MV Stavanger*, 100 car capacity catamaran — $30 million (2007 estimate)

The estimates for the unmodified and modified versions of the *Steilacoom II* and *Island Home* are based on the original contract values and were updated to reflect inflation, increased material costs, and differences in labor costs between the Gulf Coast shipyards (where the *Island Home* was built) and Puget Sound area shipyards.

Figure 7-1: MV *ISLAND HOME*, 74 car double-ended monohull ferry

7.1.2. Design Cost and Schedule

For a vessel that is all new, including the hull form, design typically costs 15 to 20 percent of the contract value and takes approximately one year. Included in the schedule are: definition of performance requirements; trade-off studies; preliminary design; model tests for resistance, propulsion, seakeeping, and maneuvering; and contract design. If an existing hull form is used, this schedule can be significantly reduced as the model tests and hull structural design do not need to be revisited.

For new vessels on the Port Townsend – Keystone route, the findings of this vessel planning study can be used to eliminate or reduce the time necessary for the definition of performance requirements and trade-off studies. From the start of preliminary design through development of a contract design, the schedule could be six to nine months for an all-new design.

7.1.3. Training Cost

Based on discussions with Vessel Operations, the cost to train the deck crews on a non-standard propulsion system were estimated to be approximately $350,000. A similar cost was assumed for the additional training required by the engineering and maintenance crews. Non-standard propulsion systems are defined as those that can produce full thrust in any direction.

Figure 7-2: MV *STEILACOOM II*, 50 car double-ended monohull ferry

Figure 7-3: MV STAVANGER, 100 car double-ended catamaran ferry

7.2. ACQUISITION SCHEDULE

7.2.1. Modified Existing Designs

The re-use of existing designs, with or without any modifications, can expedite the delivery schedule by limiting the number of decision points in the design process and eliminating the need for model testing. Additional time can be saved if the shipyard that built the original vessel also builds any new vessels from the same design since the time to produce construction drawings and other production-related materials can be reduced or eliminated. The amount of time saved will vary with the extent and type of modifications to the design.

Re-use of the designs proposed for this study with the recommended modifications would proceed roughly as follows:

- Contract design preparation: 2 to 4 months
- Production drawing preparation: 2 to 4 months
- Construction: 12 to 16 months
- Total time for design and construction: 16 to 24 months

In addition to the design and construction time, additional time will be required to select a builder and negotiate a construction contract. The time to complete this process can vary greatly. In the delivery schedules in this report, six months was the assumed duration for this process.

7.2.2. New Design

For an all-new design, the acquisition schedule will be approximately one year longer than using an existing design. The acquisition schedule would proceed roughly as follows:

- Requirements definition and trade-off studies: 2 to 4 months
- Preliminary design: 2 to 4 months
- Model testing: 1 to 2 months
- Contract design: 4 to 6 months
- Production drawing preparation: 3 to 6 months
- Construction: 12 to 14 months
- Total time for design and construction: 24 to 36 months

In addition to the design and construction time, additional time will be required to select a builder and negotiate a construction contract. The time to complete this process can vary greatly. In the delivery schedules in this report, six months was the assumed duration for this process.

7.3. OPERATING COST

7.3.1. Operating Schedules

For the purposes of developing comparative annual operating costs, the current schedule was used with 15 round trips per day from Mother's Day weekend to the Columbus Day weekend and 10 round trips per day the rest of the year. Five round trips were assumed for each eight-hour shift. On this schedule vessel No. 1 operates two 8-hour shifts, 365 days per year for a total of 5,840 hours and vessel No. 2 operates one 8-hour shift, 150 days per year for a total of 1,232 hours.

7.3.2. Labor Costs

Labor rates for the current collective bargaining agreement were used. Deck crews were assumed to work 8-hour shifts as described above for the vessel and engine room crews were assumed to work two 12 hours shifts per day, 365 days per year for each vessel in service.

A modified version of the *Island Home* and new design 60 vehicle ferry would most likely operate with the same size and composition crew since would both carry the same number of passengers.. In developing labor cost estimates, the crew composition was based on a review of the muster lists for the Steel Electric, Evergreen State, and Issaquah 100 class ferries, resulting in an assumed crew of 10 composed of the following positions:

- Deck Crew
  - Master
  - Chief Mate
  - Quartermaster
  - Able-bodied Seamen (two)
  - Ordinary Seamen (two)
- Engine Room Crew
  - Chief Engineer
  - Oiler (two)

For a duplicate of the *Steilacoom II*, a crew of eight was assumed since it only has a passenger capacity of 325. The assumed composition was as follows:

- Deck Crew
  - Master
  - Chief Mate
  - Quartermaster
  - Able-bodied Seamen (two)
  - Ordinary Seaman
- Engine Room Crew
  - Cheif Engineer
  - Oiler

Because the Steilacoom II does not include crew accommodations, hotel rooms will have to be provided to some of the crew members as required by the existing collective bargaining agreements. For this study, three hotel rooms per night, 365 days per year, were assumed for the crew of Boat #1 and three hotel rooms per night, 150 days per year, were assumed for the crew of Boat #2.

The assumed crew is larger than that carried by the *Steilacoom II* because additional life safety equipment is required by the USCG for the Port Townsend – Keystone route and more crew members are needed to operate it and manage passengers in an emergency. It is also larger than the crew of the existing Steel Electric ferries because of the additional life safety equipment require to comply with current USCG requirements that the Steel Electrics aren't required to meet as a result of their grandfathered status.

The crew composition for new vessels will be the result of negotiations with both the USCG and the maritime unions.

7.3.3. Fuel Cost

For a modified version of the *Island Home* and a new design 60 vehicle ferry, fuel consumption was estimated based on the results of the resistance and propulsion model tests at a speed of 12 knots.

For an unmodified version of the Steilacoom II, model tests were not conducted and fuel consumption was estimated based on the assumption that a service speed of 12 knots can be maintained at 75% of the installed power.

7.3.4. Other Operating Costs

Other operating costs, which are less than 10% of the total annual cost, were estimated based on historic cost data for the WSF fleet.

7.4. MAINTENANCE

The largest maintenance costs are those associated with the USCG dry dockings of the vessel, which are required twice within every five year period. During these dry dockings, the following maintenance activities can take place:

- Bottom cleaning
- Full or partial bottom painting
- Full or partial topside painting
- Shaft removal, inspection, and maintenance
- Sea Valve inspection, maintenance, and repair
- Propeller and rudder inspection and repair
- Stern tube seal inspection and repair

Recent costs for each of these tasks for the Steel Electric, Evergreen State, and Issaquah class ferries was collected and used to develop estimates of the relative costs for new 60, 80, and 100 vehicle capacity ferries.

Designing new vessels to allow them to pass through the Ballard Locks increases the number of shipyards that can bid on doing repairs, which helps to control repair costs. Because the maximum vehicle capacity for this study was 100, developing a design that fits through the Ballard Locks should be possible for all options.

Other maintenance costs include engine and drive train maintenance, engine rebuilding, and maintenance and repair of auxiliary systems.

7.5. SCHEDULE RELIABILITY

Any new vessel should provide service that is at least as reliable as the Steel Electric class ferries. Reliability is affected by three factors:

- Ability to maneuver through high-velocity cross-currents
- Ability to operate in heavy weather

- Ability to maintain the published schedule with delays in loading and/or unloading

To develop a quantitative comparison of each of these factors, physical or computer model tests would be required, both of which are outside the scope of the current tasks. The attributes of the designs and propulsion systems do allow for the qualitative comparison that follows.

7.5.1. Maneuverability (Ability to Operate Through High Velocity Currents)

Double-ended monohulls are relatively maneuverable in general when compared to single-ended vessels as they can generate lateral and braking thrust at both ends of the vessel. For all of the new designs considered, a high-performance rudder is assumed to be included, which further enhances the maneuverability of vessels with conventional propulsion systems. With modern rudders and conventional propulsion systems, any of the new vessel options should be at least as maneuverable as the Steel Electric class ferries. However, until masters in the fleet get substantial experience, it is unlikely that the number of tidal current related cancellations will be reduced.

With one of the enhanced maneuverability propulsion systems, full thrust can be provided in any direction, increasing maneuverability significantly. The response time of azimuthing thrusters in braking maneuvers, however, is not particularly fast as they must rotate 180 degrees before full reverse thrust can be applied. If thrust is applied continuously through the rotation, unanticipated movements can be caused. This issue is eliminated with a vertical-axis propulsor, which can alter the direction of thrust very quickly by simply changing the angle of the propulsor blades. With either of the enhanced maneuverability systems included in this study, it is likely service could safely be provided through higher velocity tidal currents. How much higher can only be determined once the vessels are in operation and new guidelines developed.

7.5.2. Heavy Weather Operations

All of the viable options can operate safely in all but the most extreme weather conditions that occur on the Port Townsend – Keystone route. However, passenger comfort, the likelihood of seasickness, and the potential for damage to vehicles will vary.

The smallest and lightest of the viable options, the Steilacoom II, would likely have the greatest motions in heavy seas and the low bulwarks provide only limited protection to vehicles and passengers on the car deck. As a result, there would likely be more weather-related cancellations on the route with this class of vessel. A modified version of the *Steilacoom II* with a greater vehicle capacity would likely have smaller motions, but with the limited protection provided on the car deck approximately the same number of sailings would be cancelled as with the unmodified version

The *Island Home* was designed for open ocean operations off the Massachusetts coast and has a fully enclosed car deck. As designed, there would likely be very few weather related cancellations with this class of ferry on the route. Even without bow doors, the opening between curtain plates is just big enough for two lanes of traffic and the curtain plates extend all the way to the passenger deck up to that opening, providing very good protection for the car deck. The relatively large size of the vessel would also likely result in smaller motions. This combination of size and protection would likely allow sailings through heavier conditions than current practice.

As discussed earlier, the motions of catamarans are typically less regular than those of comparable sized monohulls. How much this would affect heavy weather cancellations can only be determined by extensive model testing or actual service.

7.5.3. Schedule Maintenance

All ferries experience delays in loading or unloading vehicles on occasion. To maintain the published schedule, it is recommended that ferries have sufficient speed reserves to make up time with faster crossings. This capability should be built into any new design vessel and is built into the design of the *Island Home*, which has a service speed of 16 knots. The unmodified *Steilacoom II* has a service speed of 11.4 knots and a trials speed of 13.1 knots. This performance would be sufficient to maintain the existing schedule but the engines may have to be run at nearly 100 percent capacity to maintain schedule, an operating mode which is generally not recommended by the engine manufacturer. The modified version of the *Steilacoom II* may have even greater difficulty maintaining schedule as it would have less speed reserve without larger engines.

8. Viable Options – Other Evaluation Criteria

Additional evaluation criteria were applied to the three viable new vessel hull/propulsion options as well as to the Steel Electric re-hull option and the modified and unmodified designs of the Steilacoom II and the Island Home. These criteria include environmental concerns, terminal modification needs, and system planning.

8.1. ROUTE ENVIRONMENTAL PROCESS

8.1.1. Process Overview

This vessel study is intended to serve as a specialized report within the context of the environmental documentation that WSF will prepare for the Port Townsend – Keystone route. It is anticipated that the effects addressed in the environmental process will generally follow the SEPA checklist

The relative impact of the viable new vessel hull/propulsion options and the other concepts carried forward in each of these categories is discussed below. Where possible, a quantitative comparison is provided. Where quantitative data is not available, the likely impacts are identified and discussed for consideration as the project moves forward.

8.1.2. Process Variability

The environmental process would be minimized if vessels that are functionally identical to the Steel Electric class are selected. Any larger vessels will have an impact on traffic as discussed in the Determination of Significance issued by WSF in June 2007 for the Port Townsend – Keystone Terminal Improvement Project. A catamaran would have additional impacts related to the need for new berthing and loading/unloading facilities. The additional process required for the design of these new facilities could add a year or more to the environmental process and the initiation of service with the new vessels.

8.1.3. Green House Gas assessment in SEPA

The environmental process will need to anticipate changes in SEPA that would likely require an assessment of greenhouse gas impacts (construction, operational and secondary, i.e., traffic related) from proposed projects. For the vessels, the assessment may be limited to operational and secondary impacts. Further guidance on this topic is expected to be provided after the conclusion of the 2008 legislative session.

8.2. COMMUNITY AND BUILT ENVIRONMENT

8.2.1. Traffic

Based on prior studies of the effect on local traffic of current and potential future ferry service, it was determined that the impact of vessels discharging up to 100 vehicles could be mitigated through improvements to the local roadways. This mitigation could include modifications and synchronization of traffic signals, installation of additional traffic signals, and/or re-channelization of existing roadways. The traffic impacts of vessels with a capacity of greater than 100 could not be mitigated, which is the primary reason they are no longer being considered for this route.

Conceptual mitigation plans were developed as part of the prior studies. The actual mitigation plan for any vessel with more capacity than the vessels currently serving the route will be developed in close cooperation with local jurisdictions after the vessel capacity decision has been made.

8.2.2. Level of Service

The WSF Draft Long Range Strategic Plan re-stated the current WSF policy on level of service (LOS) from a one-boat wait to a 90 minute wait, which was intended to better reflect the current customer experience. Replacement vessels with nominally the same capacity as the Steel Electric class ferries will result in the same level of service and users could experience greater delays and a lower level of service as demand grows. However, it is important to note that WSF is currently reviewing and potentially recalibrating its service level standards and the Draft Long Range Plan will be updated accordingly when that work is completed. Therefore, service level standards may change in the future.

Vessels with nominal capacities of 80 and 100 vehicles would improve the current level of service when they begin running and will meet the current level of service (LOS) goal of 90 minutes or less for some time into the future.

Travel demand management systems could improve the LOS by distributing demand over a larger portion of the day or allowing just-in-time arrival at the terminal. However, the study of demand management options is outside the scope of this study.

Table 8-1: Community and Built Environment Criteria

Vessel Capacity	Traffic Mitigation	Level of Service
Steel Electrics		■ No change
<60 vehicles	None	■ Longer waits on busy days ■ Route capacity maintained by adding additional service hours
60 vehicles	None	■ No change
80 vehicles	Some mitigation required	■ Shorter waits on busy days ■ Route capacity increased by 300 cars per day
100 vehicles	More mitigation required than for 80 vehicle vessels	■ Shorter waits on busy days ■ Route capacity increased by 600 cars per day

8.3. NATURAL ENVIRONMENT

8.3.1. Wake Wash

The Port Townsend – Keystone route generally traverses open water where wake wash is not a concern except in immediate vicinity of the terminals, where ferry wakes can have a significant effect on small boat traffic.

The 60 vehicle capacity options should generate no more wake than the Steel Electric class ferries currently serving the route. The 80- and 100-vehicle capacity options may generate somewhat more wake as they will have greater displacement and will travel at slightly higher speeds. The need for the larger vessels to travel at higher speeds can be somewhat mitigated through the use of cycloidal propulsion systems, as discussed in Section 6.2.

If a larger vessel or one with a highly maneuverable propulsion system is selected, additional study will be conducted on the wake wash of the selected vessel to assess the need for mitigation and potential mitigation options, if necessary.

8.3.2. Propeller Scour

Both the Port Townsend and Keystone terminals are in relatively shallow water where propeller wash from arriving and departing ferries has an effect on bottom sediments and marine life. For the conventional propulsion systems considered, the effect of propeller wash will be essentially the same as that of the vessels currently serving the route. Because the enhanced maneuverability propulsion systems investigated are capable of directing full thrust in any direction, vessels using these systems may cause additional scour over a wider swath.

Similar to wake wash, if a larger vessel or one with a highly maneuverable propulsion system is selected, additional study will be conducted on the propeller scour of the selected vessel to assess the need for mitigation and potential mitigation options, if necessary.

8.3.3. Air Quality

Any vessel ultimately built for service on this route will be required to comply with recent emissions regulations that do not apply to the vessels currently on the route. As a result of the significant reductions in engine emissions required, any new vessel will produce fewer emissions of normally regulated pollutants such as nitrous oxides, sulfur oxides, carbon monoxide, and particulate matter. The larger vessels will generate more carbon dioxide, a greenhouse gas, as a result of increased fuel consumption related to greater displacement and higher cruise speeds.

8.4. TERMINAL MODIFICATIONS

None of the monohull options studies would require substantial modifications to the dolphins, fenders, or transfer spans at either terminal. The catamaran options would require new designs but the net additional cost is not likely to be large as most of these structures are due to be rebuilt in the near to intermediate future. However, a totally new design for the marine structures is likely to trigger a higher level of environmental review than replacement structure that is essentially the same design as the existing structures.

Table 8-2: Summary of Required Terminal Modifications

Concept Description	Terminal Modifications Required
Steel Electrics	No change
Re-use existing superstructure ■ 60 car monohull ■ Conventional propulsion	No change[1]
Duplicate *Steilacoom II* ■ 50 car monohull ■ Conventional propulsion	Minor adjustments to the wingwall configuration may be necessary
Modified *Steilacoom II* ■ 60 car monohull ■ Conventional propulsion	Minor adjustments to the wingwall configuration may be necessary
Duplicate *Island Home* ■ 74 car monohull ■ Conventional propulsion	Minor adjustments to the wingwall configuration may be necessary
Modified *Island Home* ■ 60 car monohull ■ Conventional propulsion	Minor adjustments to the wingwall configuration may be necessary
■ New design 60 car monohull ■ Conventional propulsion	No change
■ New design 80 car monohull ■ Conventional propulsion	Minor localized structural mods may be required to accommodate the heavier vessel
■ New design 100 car monohull ■ Conventional propulsion	Minor localized structural mods may be required to accommodate the heavier vessel

Continued on next page

Table 8-2: Summary of Required Terminal Modifications (Continued)

Concept Description	Terminal Modifications Required
■ New design 60 car monohull ■ Enhanced maneuverability[2]	No change
■ New design 80 car monohull ■ Enhanced maneuverability	Minor localized structural mods may be required to accommodate the heavier vessel
■ New design 100 car monohull ■ Enhanced maneuverability	Minor localized structural mods may be required to accommodate the heavier vessel
■ New design 60 car catamaran ■ Conventional propulsion	New berthing and loading/unloading facilities required
■ New design 80 car catamaran ■ Conventional propulsion	New berthing and loading/unloading facilities required[3]
■ New design 100 car catamaran ■ Conventional propulsion	New berthing and loading/unloading facilities required

1. May 2005 Port Townsend Preliminary Design Report estimated the required rebuild of the existing berthing structures at $35 million. Listed costs are in addition to this required cost.
2. Enhanced maneuvering propulsion system is diesel-mechanical vertical axis propulsors (Voith-Schneider Drive).
3. Modification cost to accommodate catamaran estimated at 20 percent more than required rebuild.

8.4.1. Double-Ended Monohulls

Of the viable options identified in Section 6, the 60 vehicle capacity double-ended monohull option could be served by the existing terminals at Port Townsend and Keystone without any modifications. The 80 vehicle capacity double-ended monohull may require minor localized structural modifications to accommodate the heavier vessel. In addition to localized modifications similar to those required for an the 80 vehicle capacity double-ended monohull, the 100 vehicle capacity option would require the installation of three additional outer dolphins at the Port Townsend terminal.

8.4.2. Double-Ended Catamarans

To use the potential efficiency of double-ended catamarans, new berthing structures and vessel/dock interface systems would be required. Given the opportunity presented by the catamaran configuration, up to four lanes of vehicles could be loaded at once. This has the potential to substantially reduce the time required to unload and load a ferry, allowing the same departure frequency with lower cruising speeds.

The changes to berthing structures and the vessel/dock interface required to accommodate a catamaran may be substantial enough to trigger requirements for a more rigorous environmental review process. A "Determination of Significance" (DS) has been issued for modifications to the Port Townsend terminal associated with the possible expansion of the existing structure as required to accommodate the larger vessels previously under consideration. A catamaran ferry would require substantial different structures that would likely add to the project cost and schedule due to the additional time required to get the necessary permits.

8.5. SYSTEM PLANNING

Replacement vessels with the same capacity as the existing Steel Electric class will be marginally adequate to meet demand as soon as they are put in service. They will not be able to meet any increased demand.

If route capacity is not increased through the use of larger vessels, demand will have to be managed through reservations or other approaches to prevent unacceptable degradation in level of service.

Depending on the rate of growth of demand, 80 and 100 vehicle capacity vessels will be able to meet demand when placed in service and will be able to satisfy increased demand for some time.

Table 8-3: System Planning Criteria

Concept Description	Serve Other Routes	Route Capacity
Steel Electrics	No change	No Change
Re-use existing superstructure ■ 60 car monohull ■ Conventional propulsion	Yes	None
Duplicate *Steilacoom II* ■ 50 car monohull ■ Conventional propulsion	Yes	Plus 100 cars per day[13]
Modified *Steilacoom II* ■ 60 car monohull ■ Conventional propulsion	Yes	No change
Duplicate *Island Home* ■ 74 car monohull ■ Conventional propulsion	Yes	Plus 210 cars per day
Modified *Island Home* ■ 60 car monohull ■ Conventional propulsion	Yes	No change
■ New design 60 car monohull ■ Conventional propulsion	Yes	No change
■ New design 80 car monohull ■ Conventional propulsion	Yes	Plus 300 cars per day
■ New design 100 car monohull ■ Conventional propulsion	Yes	Plus 600 cars per day
■ New design 60 car monohull ■ Enhanced maneuverability[1]	Yes	No change
■ New design 80 car monohull ■ Enhanced maneuverability	Yes	Plus 300 cars per day
■ New design 100 car monohull ■ Enhanced maneuverability	Yes	Plus 600 cars per day
■ New design 60 car catamaran ■ Conventional propulsion	No	No change
■ New design 80 car catamaran ■ Conventional propulsion	No	Plus 300 cars per day
■ New design 100 car catamaran ■ Conventional propulsion	No	Plus 600 cars per day

[13] Route capacity for the duplicate Steilacoom II is based on two vessels running 16 hours per day during the peak season. The route capacity for all other options is based on one vessel running 16 hours and one running 8 hours during the peak seasons.

9. Conclusions and Recommendations

A total of 14 viable options were investigated for replacing the Steel Electric class ferries on the Port Townsend – Keystone route. These option included nine generic hull/propulsion system combination concepts, re-use of the existing superstructures on new hulls, and four concepts based on recently delivered ferries. All of the options are double-ended to allow service within the confines of Keystone Harbor. Each of these concepts could work but each one also presents a unique set of challenges. A summary of all of the viable options is provided in Table 8.1. It should be noted that not all of these options meet all the baseline assumptions agreed to with the Partnership group.

Because all of the Steel Electric class ferries were taken out of service during the course of this study, delivery schedule became one of the most important factors in selecting a preferred option. As a result, additional emphasis was placed on evaluation of concepts that minimize design and construction time.

As drafts of this report were circulated for review, additional information on the condition of the Steel Electric class ferries came to light and the need to identify a fast-track strategy for the acquisition of replacement ferries became even more urgent. The recommendations below are based on the need to restore vehicle service as quickly as possible while maintaining WSF's standards for safety and reliability and do so in the most cost-effective manner.

- **If two Steel Electric class ferries are returned to service, construct two new vessels custom designed for the Port Townsend – Keystone route.** With the investment in repairs to the hulls of the Steel Electric class ferries, it is reasonable to assume they will continue to be seaworthy for at least three additional years of service. In this time, a new design could be developed, model tested, and constructed using an expedited acquisition strategy based on commercial practice.
- **If only one Steel Electric class ferry is returned to service, or if it is not practical to return any Steel Electric class ferries to service, construct two modified versions of the *Island Home*.** This would have a higher acquisition cost than a modified *Steilacoom II* with the same delivery schedule. This design can be modified to increase the vehicle capacity of the vessel if warranted by future demand. It also has a much more protected car deck, which would result in the same or fewer weather related cancellations relative to the Steel Electric class ferries. If none of the Steel Electrics are returned to service, WSF would also work with local communities to develop acceptable mitigation strategies until a new vessel can be built.
- **Acquisition of one or more new ferries that are duplicate or modified versions of the Pierce County ferry *Steilacoom II* is not recommended as that design was not developed for the exposed waters encountered on the Port Townsend – Keystone route.** Although it would be the least expensive option and the quickest into service, the use of this class of vessel on the route would likely lead to increased motion sickness among passengers, more weather related cancellations, and a

higher risk of injury or vehicle damage resulting from vehicles shifting while crossing heavy seas. These effects are anticipated due to the *Steilacoom II*'s open car deck arrangement, relatively light displacement, and narrow beam.

At present, WSF intends to work with Pierce County to arrange for trials of the *Steilacoom II* on the Port Townsend – Keystone route as soon as practical. If the results of these trials indicated better performance than expected, the above recommendation on the use of this class vessel may be revisited.

To deliver new vessels on the schedules below, new legislation will be required to both fund the vessels and define the contracting strategy to be used. Contracting strategies are not discussed in this report.

The relative costs and benefits of all of 14 alternatives studied are summarized in Table 9-1.

Table 9-1: Summary of Options Studied

Descriptions	Vehicle Capacity[1]	Estimated Acquisition Cost[2]	Estimated Annual Cost[3]	Estimated Delivery Schedule	Daily Route Capacity[4]	Benefits	Challenges
Existing Steel Electric class ferries	***60-car***		***$5.4 M***		***900***		
New hull, re-used superstructure ■ Monohull ■ Conventional propulsion[5]	60-car	$35-$40 M	$6.7 M	28-30 months	900	■ Hull could be designed to allow future installation of 2nd car deck ■ No traffic mitigation required ■ Simplest environmental process	■ High construction risk ■ Limited growth capacity ■ Low fleet utility
Duplicate *Steilacoom II* ■ Monohull ■ Conventional propulsion	50-car	$20 M	$5.6 M	18-20 months	1,000	■ Earliest delivery ■ Lowest cost	■ More weather related cancellations due to more exposed car deck ■ No onboard crew cabins; overnight quarters required ashore ■ Limited ability to get back on schedule after loading/unloading delays ■ Least initial capacity and future growth capacity ■ Low fleet utility
Modified *Steilacoom II* ■ Monohull ■ Conventional propulsion	60-car	$24-$26 M	$6.5 M	22-30 months	900	■ Early delivery ■ Compatible with rest of WSF fleet	■ More weather related cancellations due to more exposed car deck ■ Limited ability to get back on schedule after loading/unloading delays ■ May need larger engines to maintain service speed
Duplicate *Island Home* ■ Monohull ■ Conventional propulsion	74-car	$34-$36 M	$7.7 M	20-22 months	1,110	■ Early delivery ■ Increased daily route capacity ■ Additional capacity provides good fleet utility ■ Can accommodate engines used in new 144 class[5] ■ Efficient car deck arrangement	■ Requires larger crew ■ Higher maintenance costs for unnecessary systems (doors, thrusters, HVAC) ■ Design owned by the Steamship Authority
Modified *Island Home* ■ Monohull ■ Conventional propulsion	60-car	$30-$34 M	$6.7 M	22-30 months	900	■ Early delivery ■ Fewer weather related cancellations due to increased protection of car deck ■ Less expensive than all-new design ■ Can accommodate engines used in new 144 class ■ Efficient car deck arrangement ■ Can increase route capacity with additional vehicle capacity	■ Design owned by the Steamship Authority ■ Limited fleet utility without additional vehicle capacity
■ New design monohull ■ Conventional propulsion	60-car	$35-$40 M	$6.7 M	30-42 months	900	■ Hull could be designed to allow future installation of 2nd car deck ■ No traffic mitigation required ■ Simplest environmental process	■ Limited growth capacity ■ Low fleet utility ■
■ New design monohull ■ Conventional propulsion	80-car	$45-$50 M	$6.9 M	30-42 months	1,200	■ Limited growth capacity ■ Limited fleet utility ■ Moderate fleet utility	■ Limited growth capacity ■ Limited fleet utility ■ Moderate fleet utility

Table 9-1: Summary of Options Studied

Descriptions	Vehicle Capacity[1]	Estimated Acquisition Cost[2]	Estimated Annual Cost[3]	Estimated Delivery Schedule	Daily Route Capacity[4]	Benefits	Challenges
Existing Steel Electric class ferries	***60-car***		***$5.4 M***		***900***		
■ New design monohull ■ Conventional propulsion	100-car	$55-$60 M	$7.1 M	30-42 months	1,500	■ Maximum growth capacity ■ Maximum fleet utility	■
■ New design monohull ■ Enhanced maneuverability[6]	60-car	$35-$40 M	$6.7 M	30-42 months	900	■ Fewer tide-related cancellations ■ No traffic mitigation required	■ No growth capacity ■ Additional training for operators and engineers ■ Low fleet utility
■ New design monohull ■ Enhanced maneuverability	80-car	$45-$50 M	$6.9 M	30-42 months	1,200	■ Fewer tide-related cancellations ■ Moderate fleet utility	■ Additional training for operators and engineers ■ Limited growth capacity
■ New design monohull ■ Enhanced maneuverability	100-car	$55-$60 M	$7.1 M	30-42 months	1,500	■ Fewer tide-related cancellations ■ Maximum growth capacity ■ Good fleet utility	■ Additional training for operators and engineers
■ New design catamaran ■ Conventional propulsion	60-car	$25-$30 M	$7.0 M	30-42 months	900	■ Lowest acquisition cost ■ More efficient loading and unloading ■ No traffic mitigation required ■ Fewer tide-related cancellations	■ No fleet utility ■ All new berthing structures required ■ Higher operating cost ■ Additional training for operators and engineers
■ New design catamaran ■ Conventional propulsion	80-car	$30-$35 M	$7.2 M	30-42 months	1,200	■ More efficient loading and unloading ■ Fewer tide-related cancellations	■ No fleet utility ■ All new berthing structures required ■ Higher operating cost ■ Additional training for operators and engineers
■ New design catamaran ■ Conventional propulsion	100-car	$35-$40 M	$7.4 M	30-42 months	1,500	■ More efficient loading and unloading ■ Fewer tide-related cancellations	■ No fleet utility ■ All new berthing structures required ■ Highest operating cost ■ Additional training for operators and engineers

1. Vehicle capacity is based on the WSF standard vehicle, 6'-6" x 18'-0".
2. Additional costs to modify Port Townsend and Keystone berthing structures to accommodate higher capacity vessels or catamarans are not included.
3. Annual cost includes fuel, labor, maintenance, and consumable supplies. For the *Steilacoom II*, it also includes the cost of hotel rooms since onboard crew quarters would not be provided.
4. Daily route capacity is based on the current summer schedule, with the exception of the duplicate *Steilacoom II*, which is based on two vessels each running two 8-hour shifts per day
5. Conventional propulsion system is a diesel-mechanical drive with a controllable pitch propellers
6. Although the *Island Home* design could accommodate the same engines as WSF's new 144 class ferries, it is incompatible with the rest of the propulsion system, ie reductions gears, shafts, and propellers.
7. Enhanced maneuverability propulsion system is a diesel-mechanical drive with a vertical axis propulsor (Voith-Schneider Drive)