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Island Home Design

The Washington State Ferries Division (Ferries) of the Washington State Department of Transportation plans to procure two Island Home type vessels for the Port Townsend-Keystone route. John Boylston, a marine architect working for Cedar River Group on the Joint Transportation Committee's 2008 vessel study, reviewed Ferries' Island Home design and has recently ridden on the Island Home in operation at Woods Hole. The consultant also made a preliminary assessment of the suitability of the Island Home for use on other Ferries' routes.

A. Background

The Island Home was designed by Elliot Bay Design Group of Seattle for the Woods Hole, Martha's Vineyard and Nantucket Steamship Company (SSA) for operation in the strong tidal currents that characterize the Atlantic Ocean waters between Cape Cod and Martha's Vineyard Island. The SSA Island Home went into service in 2007.

The Island Home, with modifications, was one of three options recommended for further review by Ferries' *Port Townsend-Keystone Route Planning Vessel Planning Study* in December 2007. The other two vessel options were a modified Steilacoom II or an unmodified Steilacoom II.¹ A Pierce County owned Steilacoom II has been operating on the Port Townsend-Keystone route since February 2008 replacing the Steel Electric class vessels that operated on the route prior to their retirement in November 2007.

The 2008 legislature appropriated funds for up to three new vessels of up to 100 car capacity to replace the Steel Electric vessels. (ESHB 2878 §309 (1)).

In March 2008 Ferries received bids for construction of a 50-car vessel based on the Steilacoom II design. Based on the bids and an assessment of the performance of the Pierce County Steilacoom II on the Port Townsend-Keystone route, the Governor in May 2008 announced the decision to build two 64-car vessels based on the Island Home design. Ferries is preparing design documents anticipating a bid for the Island Home type vessels in the fall of 2008.

B. Island Home Design Modifications

Ferries is modifying the existing Island Home design to meet the requirements of the Port Townsend-Keystone route. Key modifications are:

- **Length** – An additional 20 feet mid-body section has been added to accommodate additional sewage and fuel tank capacities. SSA is allowed to dump their sewage

¹ The *Port Townsend-Keystone Route Planning Vessel Planning Study* discusses the severe weather conditions characterized by heavy cross-seas and narrow Keystone Harbor channel that lead to the recommendation that these three options be pursued.

tanks at sea and re-fuels three times per week which are not the practices in the Washington State ferry system.

- **Bow Doors** – Given the severity of the sea conditions around Nantucket, the SSA Island Home has bow doors to protect the car deck. These doors will not be necessary on the Port Townsend-Keystone route. The doors also increase maintenance required.
- **Passenger Space Reduction/Increased Bicycle Space** – The SSA Island Home carries 1,200 passengers. The design has been modified for Port Townsend-Keystone to accommodate 650-750 passengers, with one of the mezzanine passenger areas (also called passenger saddle decks) converted to a bike holding area.
- **Vehicle Capacity** – The SSA Island Home holds 60 vehicles on the car deck and 14 on a hoistable vehicle deck. With the additional 20 feet in length, the Port Townsend-Keystone Island Home will hold 64 vehicles on the car deck. Removal of the hoistable deck will make it easier to accommodate the large trucks that regularly use the route. However, the support structures will be installed for the hoistable deck so that it could be added at a later date if desired.

C. Review of Modified Island Home Design – Summary

The consultant’s review concluded that the:

- **Modifications Are Appropriate** – The consultant believes that the modifications being made by Ferries to the SSA Island Home design are appropriate and will result in a vessel more suitable for the Port Townsend-Keystone route.
- **Island Home Near Risk Free Design** – The Island Home is the most recent ferry built in the United States. The excellent Society of Naval Architects paper “*Tradition and Innovation: The Design of the Ferry Island Home*”² by Douglas M. Wolff was part of the Society’s annual meeting papers from November of 2007. This paper chronicles the proper and exhaustive design process involved, and gives the results from sea trials and service. (No alternative design could provide such a complete basis for vessel design assessment). This paper, the existing design, and computer design aspects necessary for production, allow Ferries to build on a near risk free basis in the least time possible. It is, in the view of the consultant, incredibly fortunate that the Island Home design is a close fit to the Port Townsend-Keystone route requirements. Design changes made by Ferries have made it a more perfect fit without compromising all of the other existing engineering carried out.

D. Design Review

The consultant was asked to review a number of design features in response to concerns that have been brought to the legislature’s attention.

² A copy of this article can be found at [www.sname.org /sections/pacific_northwest /images /R07302%20SNAME%20ISLAND%20HOME%20presentation.pdf](http://www.sname.org/sections/pacific_northwest/images/R07302%20SNAME%20ISLAND%20HOME%20presentation.pdf)

- **Propulsion System** - The Island Home has two main engines (one at each end) with fixed-pitch propeller, high-lift rudder and two directional control pump-jet thrusters (one at each end).
 - **System Design** - In designing the Island Home, SSA and Elliot Bay Marine initially selected a propulsion system that had three DC generators rather than two main engines but found that the vessel was too heavy with the three generator system. The consultant believes that the Island Home propulsion system as designed (with two main engines) is a good choice for the vessel and for the Port Townsend-Keystone route. The selected propulsion requires less horse power to achieve contract speed than the heavier three generator system, is less complex, and costs approximately half as much to purchase and install.
 - **Fuel Efficiency** - There have been concerns expressed that the relative narrow design of the Island Home coupled with the fact that the propulsion system is not interconnected (i.e. the two engines operate separately) will result in a less fuel efficient vessel. The length to beam (L/B) ratio of a vessel determines the relative efficiency of any hull form. The basic requirement for minimal propulsive power is to have the largest L/B ratio possible, consistent with stability and other design requirements. Most large Washington State ferries have an L/B ratio of 5, and as vessels get smaller, the ratio is compromised by stability and other factors and results in ratios less than 5. As an example, the larger Evergreen State class has an L/B ratio of 4.1, the Steel Electrics had an L/B of approximately 3.4 and the SSA Island Home has a ratio of 3.7, somewhat better than the identically sized Steel Electrics. Ferries addition of a 20 feet to the Island Home's length results in an L/B of 4.03. The lengthened Island Home would be the most efficient hull form among Ferries' smaller vessels.

The Island Home's propulsion system is not interconnected which makes it less fuel efficient than it would be with an inter-connected propulsion system. The consultant estimates the reduced fuel efficiency to be approximately 10 gallons per day. The consultant estimates that it would add one year to the design and construction of the Island Home to make the propulsion system inter-connected, which would not meet Ferries goal for restoring service to the Port Townsend-Keystone route. For the most expedited delivery, the slightly less optimum propulsion system is recommended.
 - **Stopping Ability** - Concern has been raised about whether having engines that are not inter-connected will mean that the Island Home lacks sufficient stopping power for the short and narrow Keystone Harbor. The consultant believes that as full power can be applied to both engines /propellers, the backing power is no less with the independent system than it would be with an interconnected system. The consultant has ridden the Island Home into Woods Hole and reports a stopping distance of one ship length in 45 seconds from 5 knots of speed. This is more than consistent with the requirements of Keystone.

- **Sooting, Stack Fire** - Concern has been expressed that the over powering of the Island Home engines will result in excessive sooting with the potential of a stack fire. The consultant does not believe that this will be a problem. While the Island Home might be considered over powered for the Port Townsend-Keystone route, extra power is a positive aspect, not a negative one. The selected engines will run just fine at projected reduced power.
- **Propeller Shaft, Propeller and Rudder** - Concern has been expressed about whether these elements of the ship will be subject to excessive damage in the event of grounding. The consultant notes that ferries on the Port Townsend-Keystone route are more subject to grounding than on any other route served by Washington State Ferries. The narrow channel at Keystone suggests that the ferry be as narrow as possible with the best steering characteristics possible to minimize grounding. These are both inherent characteristics in the Island Home design. The Island Home's propeller /shaft/ rudder assembly would suffer no more damage in a Keystone grounding than would any other centerline mounted propulsion system involving a conventional propeller /shaft and rudder, because the very substantial rudder system protects the propeller from damage.³ All other auto-passenger ferries in the Washington State ferry system employ a similar propeller /shaft/ rudder assembly arrangement and some have greater skeg area, which could be interpreted to provide greater grounding protection. However, a great deal of skeg area makes a ferry slower to respond to rudder commands. It is the consultant's opinion that the open skeg of the Island Home design offers no less grounding protection while affording much greater steering control necessary for the Port Townsend-Keystone route.

The carbon fiber shaft in the SSA Island Home design has been replaced with a conventional steel shaft in Ferries design, as SSA's operational experience has shown the carbon fiber shaft to be unnecessary. This should alleviate concerns that have been expressed about maintenance of the carbon fiber shaft.

- **Weight** – Various concerns have been expressed about the weight of the Island Home and whether it will work well for the heavy truck use on the route.
 - **Freeboard⁴** - Concern has been expressed about whether the Island Home has sufficient freeboard to prevent water coming over the bow in the rough waters on the Port Townsend-Keystone route. (Water coming over the bow onto the car deck has been a problem with the Steilacoom II boat.) In the consultant's opinion, the addition of the 20 foot midbody to the Island

³ Systems that would be more susceptible to grounding damage would include centerline mounted Z drives, Voith Schneider drives and other azimuthing drives as they have no rudder system and thus no protecting structure. Even worse would be azimuthing type drives mounted off centerline as they would contact the bottom before the hull and could not withstand the force.

⁴ Freeboard is the distance between the water and the deck.

Home design will improve freeboard such that it will be greater than that of the Steel Electrics.

- **Buoyancy**⁵ - Concern has been expressed about the overall weight of the Island home and whether it has sufficient buoyancy to meet the needs of the heavy truck traffic on the Port Townsend-Keystone route. The consultant notes that one of the problems with any new design is that the actual weight of the completed ferry often exceeds the estimated weight during design. As the Island Home design has been built, the weight of the existing Island Home is precisely known. Adding a midbody, with the existing structural weight known, provides minimal risk in weight variation.⁶ The Island Home design is closely related to the loadings of trucks on the Port Townsend-Keystone route and has been specifically designed for the single lane loading / unloading operation employed in the Port Townsend-Keystone route.
- **Stability** – Concern has been expressed about whether the Island Home has adequate weight distribution to provide a stable vessel for the Port Townsend-Keystone route. The consultant finds that the arrangement of the lanes on the Island Home (i.e. truck lane in the center) takes into account weight variation from heavy loads in the vehicle arrangement. The vessel is no less stable than any other and rides well because it is not too wide (and stiff) as is the case with the presently used Steilacoom II ferry.
- **Aluminum Superstructure (i.e. Auto Deck and Above) Construction** – Concern has been expressed about the aluminum construction of the Island Home superstructure which is placed on a steel hull. The consultant notes that while there used to be problems with combining steel and aluminum structures, technology has alleviated them. Aluminum/steel structures are common on commercial and naval vessels. The mass of aluminum might mean more vibration in the aluminum structure. However, the Island Home design report includes measured vibration data that is quite acceptable.
- **Other Concerns**
 - **Wheelhouse** – The wheelhouse on the Island Home is wider than on other Ferries vessels. The consultant believes that the full width wheelhouse will improve docking field vision for Keystone.
 - **Overhead Clearance** – The overhead clearance on the Island Home is 16 feet, which is greater than the Steel Electrics which had overhead clearances ranging from 12’ 7” to 13’ 9”.

⁵ Buoyancy allows the ship to float on the water.

⁶ Concern has also been expressed about the future weight of the Island Home as it ages and acquires weight from increased requirements for spare parts, paint accumulation and etc. With the added 20 foot midbody section the consultant believes that the Ferries’ Island Home will have sufficient buoyancy to handle this added weight.

D. Island Home – Other Routes

Ferries has operated with 6 smaller vessels in the system:

Vessel Class	# cars	Retirement Date/Year Built	Routes Affected
4 Steel Electrics	59	Now Retired	Port Townsend-Keystone San Juan Inter-island
1 Rhododendron	48	Built 1948	Pt. Defiance-Tahlequah
1 Hiyu	34	Built 1967	De-crewed/Inactive*

* The Hiyu has been in active service since the retirement of the Steel Electric vessels.

The Island Home is an option to replace the system capacity from the Steel Electrics and the Rhododendron. At 60 years, the Rhododendron is in urgent need of replacement. Considerations include:

- The Island Home is narrower at 64 feet than is required for other routes. If the vessel were wider (i.e. as wide as the Steel Electrics which were 74 feet) it could carry 6 more vehicles.
- The Island Home is more fuel efficient as a result of its lower L/B ratio than a wider vessel would be.
- Building 4 Island Homes would allow for a complete replacement of the smaller vessel capacity in the system – providing service for Pt. Defiance-Tahlequah, Port Townsend-Keystone, and the San Juans Inter-island route.
- Building 4 Island Homes would also allow for an interchangeable small vessel fleet that could be moved between routes without a change in service characteristics. While 5 Island Homes would allow for an extra stand-by vessel for the small vessel fleet, it is not necessary if the Hiyu remains a stand-by vessel.

The JTC vessel study will examine in more detail the potential for the Island Homes.