Appendix B

WSF Southworth, WA Kitsap Transit POF Technical Feasibility Study

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WSF SOUTHWORTH, WA TERMINAL

Kitsap Transit Passenger-Only Ferry Technical Feasibility Study

Prepared for: KPFF Consulting Engineers • Seattle, WA

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PURPOSE

The purpose of this document is to answer key questions in support of Kitsap Transit's examination of various options for passenger-only ferry service between Southworth and downtown Seattle.

One concept would be to design and build a bow loading passenger-only ferry that could operate out of a Washington State Ferries (WSF) auto-slip. In this case the intent is to operate as a bow loading ferry at WSF's Southworth Dock, a single slip facility used for vehicle ferries, and transit to Pier 50 in Seattle where it would be used as a side-loading vessel with two loading stations at the Pier 50 float. The vessel needs to achieve about a 28-knot cruising speed and be able to unload and then load 150 passengers in seven minutes or less. The vessel would also need to have the capability of carrying 10% or more of its passenger capacity in bicycles. In other words, a bicycle rack to accommodate at least 15 bicycles would be required if the vessel was certified to carry 150 passengers.

WORK PERFORMED

In analyzing the seven questions posed, EBDG has utilized both in-house data and published information on existing passenger-only ferries that have all been built in the Puget Sound. These vessels are either currently working in Elliott Bay or in San Francisco Bay in California. Photographs and principal dimensions of these four ferries and the Southworth terminal are shown in Appendices A and B respectively. The technical details of the Southworth terminal were provided by WSF in References [1] and [2].

ANALYSIS AND RESULTS

The questions posed by KPFF, their analyses, and results are following:

QUESTION 1

Could a passenger-only ferry with bow loading configuration to fit within the WSF vehicle slip be of the traditional size of a 150-passenger-only ferry or would it need to be a bigger platform?

> ***NO, AN EXISTING TRADITIONAL SIZE 150-PASSENGER FERRY WOULD HAVE DIFFICULTY UNLESS MODIFIED BY BOW EXTENSIONS.***

The M/V SPIRIT OF KINGSTON, currently operated by King County in Puget Sound, represents a traditional size 150-passenger-only ferry with an overall length of 71.7 ft and a 2.8 length-to-breadth ratio. EBDG drew to scale the Southworth terminal and the M/V SPIRIT OF KINGSTON attempting a docking there in Figure 1.

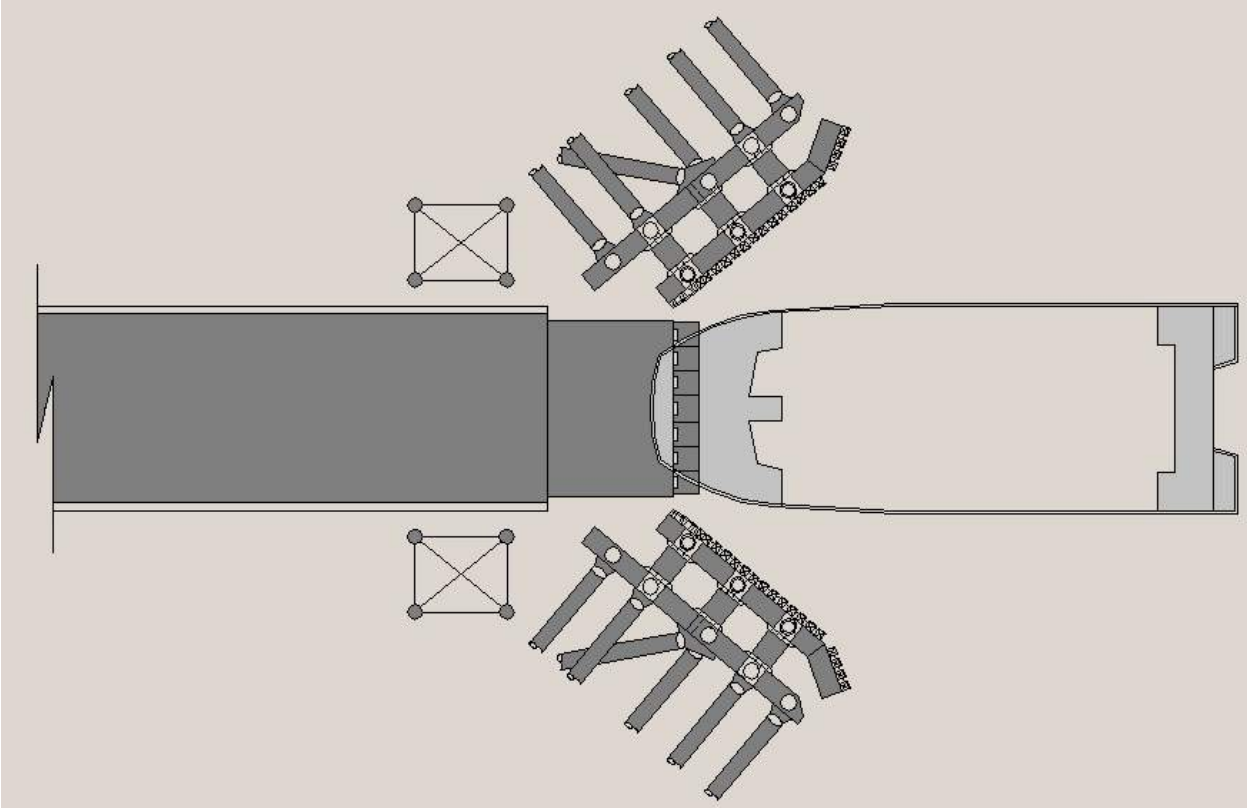

Figure 1 – The 150-passenger ferry M/V SPIRIT OF KINGSTON with a beam of 25.6 ft

As can be seen in Figure 1, the breadth of a traditional sized 150-passenger ferry is not wide enough to come into contact with the wingwalls before the apron's lip would strike the forward cabin superstructure. The distance between the port and starboard wingwall batter boards adjacent to the terminal's apron lip is approximately 24.5 ft, while the maximum breadth of the ferry is 25.6 ft. The ferry, *M/V RICH PASSAGE 1*, would have the same problems with its beam of 28.2 ft.

QUESTION 2

If it can be of the typical 150-passenger vessel size, what elements would need to be incorporated into the design to make that work, especially relevant to bow loading out of the vehicle slip.

FOR AN EXISTING 150-PASSENGER-ONLY FERRY:

CONSTRUCT A MODIFICATION TO THE VESSEL'S BOW SUCH THAT IT WOULD ADEQUATELY MAKE CONTACT WITH THE WINGWALLS.

The main deck and guard plating of an existing ferry would need to be modified with wing extensions, port and starboard, in a shape similar to that of a hammerhead shark in plan view, see Figure 2. These extensions would complicate the ferry side-docking in downtown Seattle as they would extend beyond the maximum breadth of the vessel.

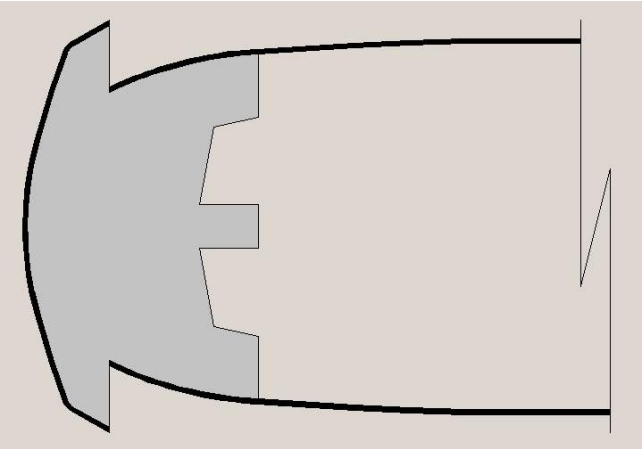

Figure 2 – 'Hammerhead' bow extension

Note that in the early 2000's, the main deck and guard plating of WSF passenger-only ferry *M/V SNOHOMISH* was lengthened out over the bow longitudinally in a modification in order to dock at WSF auto-slips, as shown in Figure 3. Compare Figure 3 to original bow configuration the photo in Figure 13. A bow extension kit was made for her sistership, the *M/V CHINOOK*, but never installed.

Figure 3 – M/V SNOHOMISH bow extension for auto-slip docking

Other bow modifications options would be:

- Modification of the bow railing – cutaway and setback
- Incorporating a gate into the modified bow railing
- Flattening the deck camber, if highly pronounced
- Cutback of the sloping aesthetic side fascia plating, if present
- Placement of two cleats, port and starboard, for tying off mooring lines
- Relocating the anchor, if normally stowed on or near the bow railing
- Relocation of towing bitts and clears, if present at the bow
- Relocating and/or partially eliminating some bow bicycle racks
- Wrapping a rubberized bumper around the new bow guard plate for contact with the wingwall batter boards.

Some of the above modifications can be seen on the bow of the *M/V SNOHOMISH* from her services at the Port Townsend terminal in December 2007 as shown in Figure 4.

Figure 4 – Bow modifications to an existing ferry

FOR A NEWLY DESIGNED 150-PASSENGER FERRY:

CUSTOM DESIGN THE FERRY WITH A WIDE BEAM TO FIT THE TERMINAL'S WINGWALL INNER WIDTH AND THE DIHEDRAL ANGLE OF ITS BATTER BOARDS.

Increasing the beam, by widening the wet deck between two demi hulls of a catamaran ferry, and shaping the bow curvature in plan view to more suitably meet the width and dihedral angle of the terminal's batter boards, are design elements that could be incorporated into a new construction. An excellent example of widening the width of the wet deck, and thus the overall beam, is the *M/V SHANE GOULD*, a 230-passenger ferry operating in the harbor of Sydney, Australia, and shown in Figure 5. Deck camber should be minimized for terminal's apron to thoroughly rest upon. Note that a wider beam also allows for a single deck level with a raised wheelhouse.

However, the ride quality for passengers decreases with increased beam. The demihulls of a catamaran encounter oblique waves at slightly different times inducing a combination of pitch and yaw motions. Increased beam also creates a larger wet deck (plating between demihulls) which is exposed to slamming forces in higher waves. Therefore, catamarans with wider beams are usually only put into service on rivers and harbors where the water conditions are calmer than in sounds.

Figure 5 – Australian 230-passenger ferry M/V SHANE GOULD with a wide wet deck and beam

QUESTION 3

If a bigger platform is needed, how much bigger? Would that then be more in line with the typical 200, 250, or more passenger-only boat?

THE GEOMETRY OF THE SOUTHWORTH VEHICLE SLIP REQUIRES A BIGGER PLATFORM THAN A TYPICAL TWO-DECK 150-PASSENGER FERRY. HOWEVER, IT COULD BE SATISFIED BY A WIDE-BEAMED 150-PASSENGER VESSEL, OR A FERRY ANYWHERE WITHIN THE RANGE OF 200 TO 300 PASSENGERS WITH A BEAM OF AROUND 35 FT.

The 350-passenger *M/V SNOHOMISH* successfully operated in WSF's auto-slips on the Port Townsend-Keystone route from the early 2000's until its sale to San Francisco's Golden Gate Bridge Highway and Transportation District in 2009. Therefore, it is known that a beam of 37 ft is workable at WSF auto-slips. A scaled drawing of this operation in Southworth's auto-slip is illustrated in Figure 6.

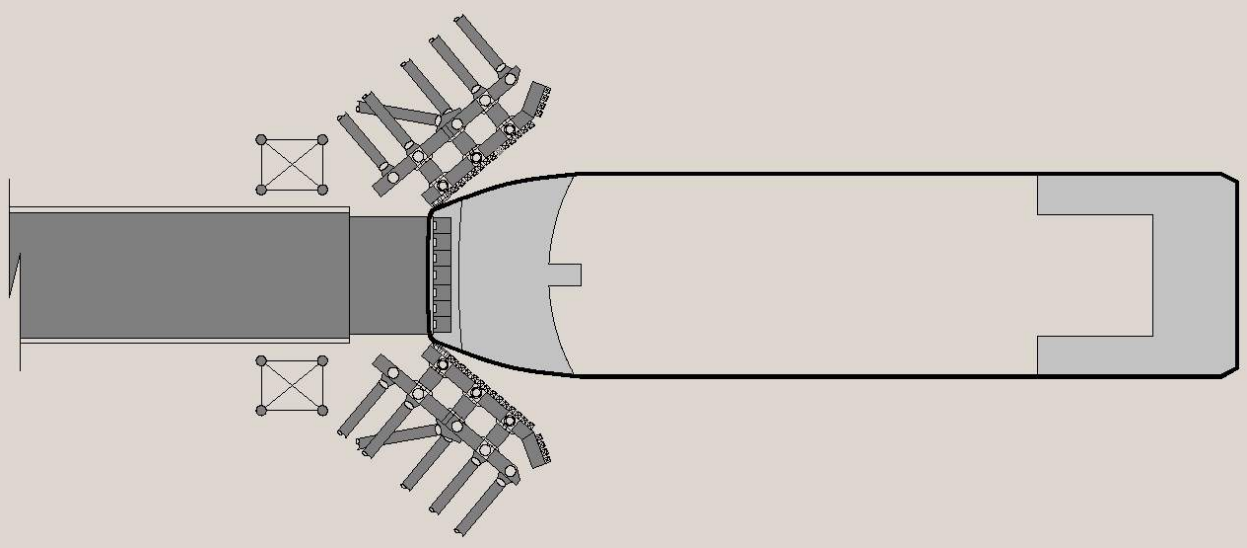

Figure 6 – The 350-passenger M/V SNOHOMISH with a beam of 37 ft

The bow extension added to the *M/V SNOHOMISH* permitted it to snugly contact the batter boards of the wingwalls. The landing of the apron however may not have been an ideal distance from the tip of the vessel's bow. A bit lesser beam would have allowed the apron to land a bit further aft on the foredeck for greater safety.

At the time of the vessel design and its sister ship, the *M/V CHINOOK*, wake wash was not especially emphasized and thus its demi hulls are of fairly typical catamaran proportions.

An example of a 200-passenger ferry is *M/V SCORPIO*, constructed on Whidbey Island and operating in San Francisco Bay for the Waterborne Emergency Transportation Authority (WETA). The design of this class of ferries, of which four have been constructed, emphasized a low degree of wake wash, and thus its demihulls are long and narrow. If it were to dock at the Southworth auto-slip, the geometry would look like the scaled drawing in Figure 7.

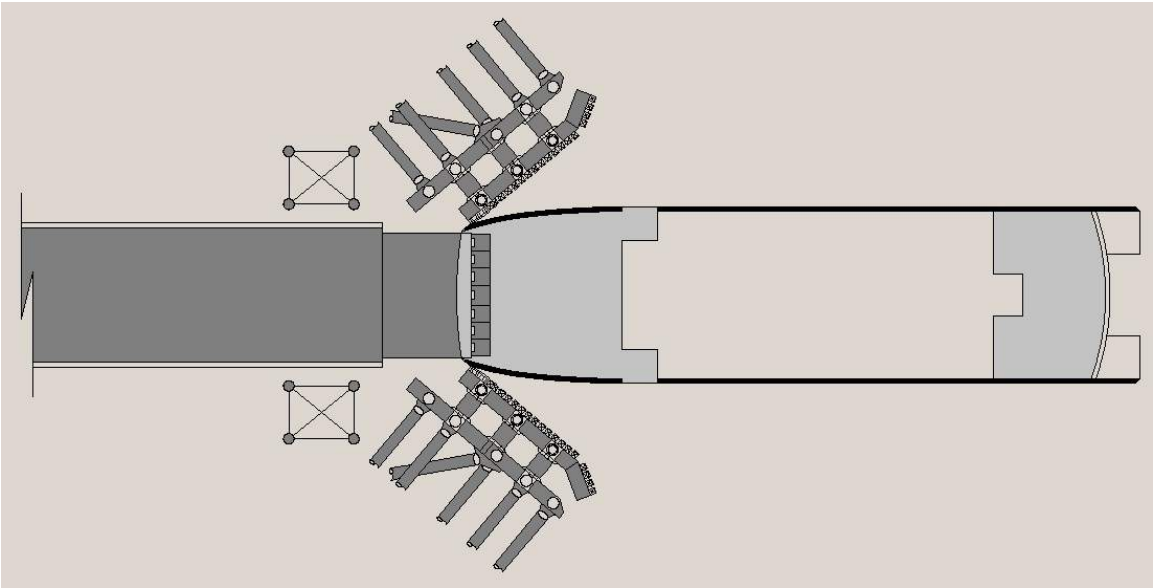

Figure 7 – The 200-passenger M/V SCORPIO with a beam of 37 ft

With an overall beam of 30.4 ft, the terminal's apron rests on the ferry's foredeck an adequate distance from the tip of the bow but the width of the apron is at the limit of the sloping aesthetic fascia plating at the sides, requiring some cutback of these.

An example of a 250-passenger ferry is *M/V SALLY FOX* operated by King County. A scaled drawing of a possible docking of this vessel at Southworth's auto-slip is illustrated in Figure 8.

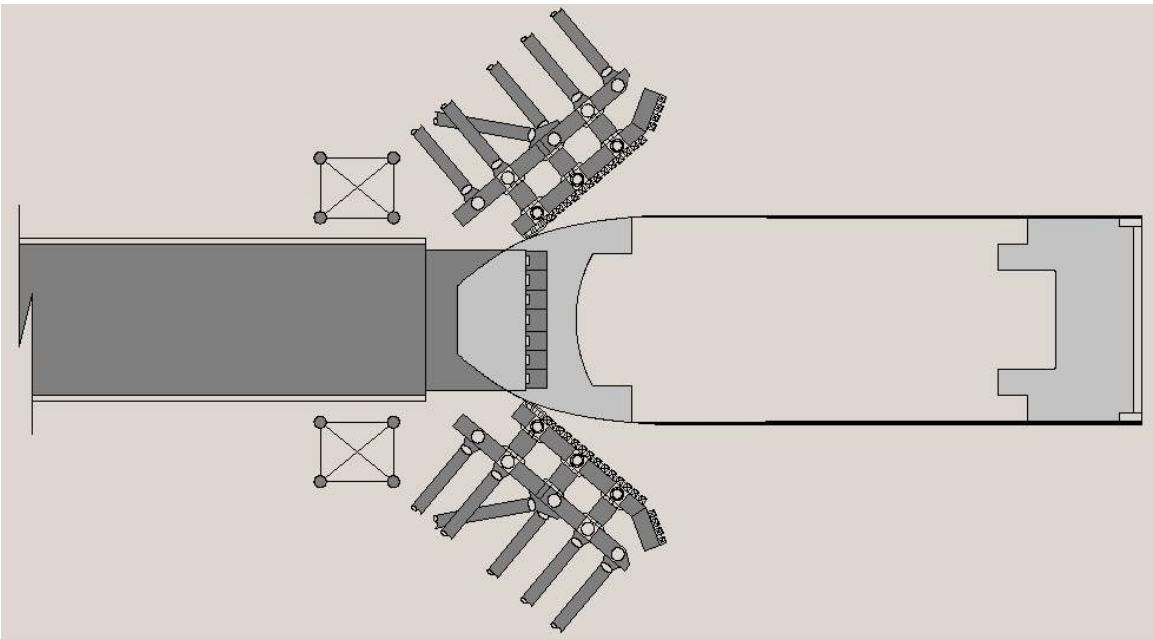

Figure 8 – The 250-passenger M/V SALLY FOX with a beam of 33 ft

As noted in Figure 8, the *M/V SALLY FOX*, and its sister ship, the *M/V DOC MAYNARD* with an overall beam of 33 ft, would snugly contact the wingwall batter boards, however the apron would land quite far aft on the foredeck. This two-deck class of ferry was not designed

especially for low wake wash (not having to traverse Rich Passage), and the demi hulls are somewhat beamy to provide the displacement for a maximum capacity of up to 278 passengers and 3 crewmembers plus a significant amount of fuel.

From Figure 7 and Figure 8, it can be deduced that the optimal beam for a two-deck passenger-only ferry is 35 ft and the capacity should be in the range of 200 to 250 passengers. This amount of beam would ensure good contact with the wingwall batter boards

A custom designed single deck 150-passenger ferry would also require a beam of 35 ft.

In all instances the weight of the apron on the foredeck results in a small amount of forward trim of the vessel. Generally, this trim will not be noticeable. The movement of passengers to the forward end of the vessel during docking will have a larger impact on vessel trim. This can be addressed either through vessel design or operational procedures to limit the movement of people during docking.

The continued population growth in the Puget Sound region will drive increased ridership on its passenger-only ferries, especially with commuters. This same growth phenomenon is present in San Francisco and is best illustrated by the two-deck *M/V Scorpio* class of dimensionally identical ferries shown in Figure 9.

Figure 9 – Three of the four ferries of the M/V Scorpio class

The first two ferries of this class were built around 2009 with a capacity of 150 passengers. Two years later in 2011 however, the final two ferries of the class were built for 200 passengers. Now in 2015, the first two ferries of the class are being renovated to now carry 225 passengers instead of the original 150. It is predicted that in the future, a similar upgrade will be made to the final two vessels of this class.

Thus, the focus of new designs these days seems to be in passenger capacities well above 150, especially where sensitivity to wake wash is not of a critical concern (as it is in Rich Passage).

Note that in all four of the above vessel and auto-slip examples, the wingwalls and dolphins of the slip do not provide surfaces for the ferry to rest against and resist winds, especially from

abeam. For passenger-only ferries, keeping a slight ahead-thrust while at the dock will keep the bow against the inner batter boards of the wingwalls. The two mooring ropes on the foredeck further secure the vessel. To mitigate strong winds, in lieu of support by the wingwalls and dolphins, the demihulls can be fitted with transom mounted electric thrusters to prevent the stern from slewing.

QUESTION 4

In this type of vessel, what are the pros and cons of two engines versus four engines?

A ferry is normally designed for a specific route's distance and the desired schedule headways determine its design service speed. The efficiency of propulsors (propellers versus waterjets) greatly dictates whether two or four engines are employed. Propellers have the best efficiencies up to about 29 knots. Speeds in that regime are considered conventional for passenger-only ferries and two engines driving propellers are sufficient. If route distances and schedule headways demand high speeds (30 knots and higher), then waterjets are more efficient as propulsors. Two or four engines coupled to two or four waterjets at the transom are typical arrangements. The propulsive arrangement is dependent on the total power needed to overcome the ferry's total resistance through the water, waves, and wind to achieve its desired service speed. The relationship between speed and power is a cubic function, meaning that each one-knot increase in speed requires a tremendous increase in power, especially if the vessel is not fully planing.

A Southworth-to-Seattle run is of a short-to-medium length route at a proposed 30 minutes, and thus a conventional speed of 28 knots with two engines driving propellers would be sufficient.

A Kingston-to-Seattle run is of a medium-to-long length route, and thus a high speed of 35 knots with four engines driving four waterjets propellers would probably be necessary to provide reasonable commute times for passengers. Economics of the run, however, when fuel costs are factored in may point to a more conventional speed and a two engine arrangement.

The Bremerton-to-Seattle route is a highly specialized case due to the wake wash requirements through Rich Passage, which have been extensively researched. Here, using the foil-assisted M/V RICH PASSAGE 1 as an example, a high speed of 37 knots is most optimal for reducing the wake wash energy. Out in Puget Sound a speed of 32 knots provides optimal fuel efficiency while still maintaining a 35 minute crossing.

The cons of four engine designs are numerous, including the following:

- Increased capital costs
- Increased fuel costs
- Increased maintenance costs
- Increased emissions
- Increased costs of mitigating emissions
- Increased vessel displacement
- Cramped engine rooms making access for maintenance more problematic

The pros of four engine designs are few, and include primarily the following:

- The ability to attain higher design service speeds
- The ability to lower wake wash energy at high speed by incorporating a foil assist

- Redundancy in that the ferry can still operate on two or three engines if there is a malfunction

QUESTION 5

In this type of vessel, what are the pros and cons of a single deck versus two decks?

The vast majority of the world's passenger-only catamaran ferries have two decks, as a single deck arrangement would necessitate having a much wider beam for the same total passenger capacity.

A wider beam single deck ferry would be more problematic in highly congested boat traffic areas, such as at side loading ferry terminals, with its wider beam requiring a greater turning radius.

Loading and exiting times are not normally a factor in the decision process but are similar between the two arrangements.

Single deck ferries are often employed where a route has a very low air clearance under some obstruction such as a highway or railroad bridge.

Passengers enjoy the views from the upper decks of two deck ferries and this space is usually quieter than the main deck as it is further from the machinery spaces. However, the main deck typically has more seats, restrooms, and possibly a food service counter.

Persons with disabilities in mobility such as wheelchairs, do not have access to the upper deck of two deck ferries as elevators are not normally installed on these relatively small and weight sensitive vessels. However, wheelchair tie-downs are provided on the main deck for the safety of such passengers.

Stability is not an issue in the decision process between single and two deck arrangements. All catamarans have more than adequate transverse stability due to the spacing of their demi hulls as opposed to monohulls. In fact, the U.S.C.G. does not require a stability test on a catamaran for this very reason – only a deadweight survey.

QUESTION 6

How much more will it cost to construct this vessel as compared to a similar size vessel that only operates out of passenger only floats?

For newly designed ferries, there would be virtually no cost difference for incorporating features which would allow docking at standard WSF auto-slips. Designers would take into account the geometry of the auto-slip from the very start of the design process resulting in a negligible cost differential between a conventional design and an auto-slip capable design.

Washington State Ferries has cost data on the modifications that were made to the *M/V SNOHOMISH*, which may be used for scaling and comparison purposes. Unfortunately, due to the move of the WSF offices at the time this document was being written, that cost data was not available to EBDG.

QUESTION 7

What are the next steps and recommendations needed after this technical document is finalized to provide adequate information for the decision makers to determine whether to move forward or not?

With the finalization of this document, EBDG believes that the decision makers have the majority of information to move forward. The successful operation of the *M/V SNOHOMISH* in various WSF auto-slips a decade ago proved the feasibility of passenger-only ferry service, utilizing embarkation and disembarkation over the bow of the vessel, to the terminal's apron and transfer span.

This document has shown that modern ferries will best fit the auto-slip at Southworth if designed with a beam of around 35 ft. Ferries with this breadth typically accommodate passenger capacities from 200 to 300.

This document has further shown that a conventional speed, utilizing two engines and two propellers, is appropriate for the distance to downtown Seattle. In this service such a machinery arrangement will be more economical than a four engine arrangement.

Finally, this document has shown the relative impracticality of continuing to focus on 150-passenger catamarans operating out of Southworth, or other standard WSF auto-slips, either by means of modifying an existing one, or designing a new beamier one at around 35 ft in breadth.

Recommended next steps are the following:

1. Issue an RFP for a concept design of a conventional speed catamaran to confirm these findings
2. Evaluate route options to determine whether conventional speed or a high speed service provides the most value to a passenger-only network.
3. Once a vessel concept and procurement method have been chosen, issue an RFP for a contract design to build a vessel for this service
4. Issue a RFP to shipyards for construction of the vessel

REFERENCES

[1] Washington State Ferries, "Southworth Ferry Terminal Wingwall Replacement," Seattle, WA, 5/11/2000.

[2] Washington State Ferries, "Apron," STD Drawing 3-A-100, Seattle, WA, 5/1/2001.

Appendix A

Vessel Data

Figure 10 – 150-passenger ferry M/V SPIRIT OF KINGSTON

Length Overall..... 71.7 Ft.
Beam Overall ..... 25.6 Ft.
Crew..... 3

Power..... 4 x 740 HP
Propulsors..... 4 x Waterjets
Speed..... 25 – 42 knots

Figure 11 – 200-passenger ferry M/V TAURUS

Length Overall..... 118 Ft.
Beam Overall ..... 30.4 Ft.
Crew..... 4

Power..... 2 x 740 HP
Propulsors..... 2 x Propellers
Speed..... 28 knots

Figure 12 – 250-passenger ferry M/V DOC MAYNARD

Length Overall..... 105 Ft.
Beam Overall ..... 33 Ft.
Crew..... 3

Power..... 2 x 1,800 HP
Propulsors..... 2 x Propellers
Speed..... 28 knots

Figure 13 – 350-passenger ferry ex-M/V SNOHOMISH, presently M/V NAPA

Length Overall..... 143 Ft.
Beam Overall ..... 37.7 Ft.
Crew..... 4

Power..... 4 x 1,777 HP
Propulsors..... 4 x Waterjets
Speed..... 34 knots

Appendix B

Terminal Data

Figure 14 – Aerial view of the WSF ferry terminal at Southworth, WA

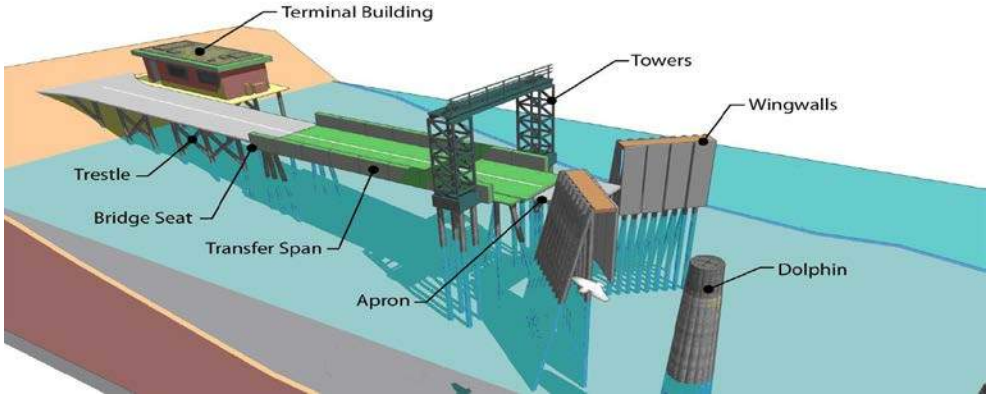

Figure 15 – The structural composition of a WSF auto-slip

Figure 16 – Separation distance of the wingwall batter boards (apron width: 21.5 ft.)