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Summary

This report describes the preliminary vessel design developed to replace the M/V *Guemes*, currently operating as a vehicle and passenger ferry between Anacortes and Guemes Island, Washington. The following drawings and reports provide a complete background and definition of this preliminary design.

- Preliminary Cost Estimate report
- General Arrangement drawing
- Lines Plan drawing
- Speed and Power report
- Weight and Stability report
- Structural Arrangement drawing
- Tonnage report
- Electrical Load Analysis
- Electrical One Line diagram
- HVAC diagram
- Firemain and Bilge diagram
- Sanitary and Potable Water diagram

- Fuel Oil Service diagram
- Insulation Schedule drawing
- Concept Design Report, Reference 1
- Vessel Capacity Study, Reference 2
- Transportation System Assessment, Reference 3

Figure 1 and Figure 2 present the preliminary replacement vessel. The vessel is a double-ended vehicle and passenger ferry, with a three-tiered deckhouse located on the starboard side of the vessel (on the West side of the route). The design accommodates four lanes of vehicles, including highway-rated trucks and emergency vehicles.

Figure 1 Port (East) side view of the replacement vessel

Figure 2 Starboard (West) side view of the replacement vessel

Through the design process, comments from the crew and ferry riders have been instrumental in transforming the original concept presented in December of 2017 to what is seen herein. Characteristics of the preliminary design are presented below in Table 1.

Table 1 Principal characteristics of replacement vessel

Parameter	Value	Parameter	Value
Length, overall	160'-0"	Vehicle capacity	28 AEQ
Length, waterline	152'-8"	Passenger capacity	150 persons
Beam, overall	53'-0"	Main deck seating	36 seats + 2 ADA
Beam, waterline	39'-0"	Bicycle storage	20 bikes
Depth, main deck at side	13'-0"	Gross registered tonnage	Less than 100
Draft, full load	7'-6"	Propulsion power	2 x 750 kW
Displacement, full load	512 LT	Propulsor type	L-drive with Nozzles

The Concept Design Report, Vessel Capacity Study, and Transportation System Assessment, References 1 through 3, describe many aspects of the design, requirements, and design basis information that still apply to the preliminary design presented herein.

The cost estimate for the ferry construction, electrical equipment installation, and terminal modifications has been updated to reflect the development level of the design. Additional information can be found in the cost estimate reports, References 6 and 7.

Deckhouse Design

Passenger Accommodations

The design segregates passengers from vehicles, with the passenger space on the starboard side of the vessel. The vessel's arrangement allows passengers to progress from one end of the vessel to the other without entering the vehicle area. The vessel accommodates 36 seated passengers within the Main Deck Passenger Lounge, with dedicated space for two wheelchairs.

The Passenger Lounge has perimeter windows that allow the entry of natural light, promote sightlines to the exterior views, and encourage a continued sense of community between walk-ons and passengers in vehicles.

A covered breezeway outboard of the main Passenger Lounge provides access for crew, passengers, bicycles, wheelbarrows, etc. to move from one end of the vessel to the other without entering the Vehicle Deck or the Passenger Lounge. The breezeway is purposefully separated from the vehicle deck to limit vehicle exhaust fumes in passenger spaces. Chain closures will enable the crew to close off the breezeway to passengers during inclement weather or for other safety concerns.

Considering the current COVID-19 pandemic and other potential airborne and contact related diseases, the vessel will be designed to minimize hazards to the public and crew to the extent practicable. A door on either end of the Main Deck Passenger Lounge will provide ample movement of air when held open. Crew-only spaces are fitted with opening windows for additional ventilation. Fresh air ventilation is provided to all passenger and crew spaces via fans and ducting, without recirculation. All interior touch surfaces will be non-porous and easy to clean, such as stainless steel, smooth laminate, powder coated metals, and vinyl sheet. A partially covered exterior passenger space at each end of the vessel offers a standing area for those not wishing to enter the Passenger Lounge.

Dedicated bicycle storage space is provided on each end of the vessel, with a total capacity of 20 bicycles. Bicycle racks made from bent pipe sections can also be used for wheelbarrow storage and passenger leaning rails when not occupied by bicycles. Additional exterior deck area provides a queuing space for embarking and disembarking passengers.

CCTV cameras will be used to monitor all passenger areas.

Crew Accommodations

The vessel is equipped to operate with a crew of three, like the *Guemes*. A Crew Day Room on the Main Deck provides a location to rest and get out of the weather. One deck locker on the Main Deck (End No. 2) provides storage space for regularly used equipment, tools, etc. A pass-through locker, accessed from within the Crew Day Room (End No. 1) provides additional storage space.

A Crew Lounge on the Upper Deck is accessed via stairs through the Crew Day Room, and is provided with a booth and table, counter, sink, under counter refrigerator, microwave, and coffee maker. A single head (toilet and sink) is provided adjacent to the Crew Lounge. The primary access to the Pilothouse is through the stairway leading from the Crew Day Room and passing by the Crew Lounge.

Only the crew has access to the exterior Upper Deck area.

Pilothouse Layout

The Pilothouse itself is located amidships and achieves a commanding view of the surrounding area, as well as unobstructed sightlines from the control consoles to the Main Deck on both ends.

Three-dimensional desktop visibility experiments were performed to investigate a single operator station vs. dual operator stations, with the former showing inadequate visibility without substantial modifications to the vessel such as reducing the Passenger Lounge capacity and length As a result, identical control consoles are installed on each end of the pilothouse. Double ended pilothouses are common on double ended ferries.

The Pilothouse is isolated from the passenger spaces and accessed by a lockable door. The space is heated with separate controls from the passenger spaces, and all windows are provided with directional blowers to eliminate fogging on the inside of the windows.

Hull Design

Vehicle Deck Layout

Four lanes of vehicles are accommodated on the vessel, with a total capacity of 28 automotive equivalents (AEQ). The entire Vehicle Deck is design to withstand tire loading from highway rated trucks and emergency vehicles, including firetrucks. Like the *Guemes*, the Main Deck plating is COR-TEN steel (see below). All escape routes and void hatches are kept clear of the Vehicle Deck. A total of 35'-8" lane width is available across four lanes of traffic, with wider lanes prioritized for commercial traffic. A total of 34'-9" exists on the *Guemes*. Note that passenger car lane width on most ferries is 8'-6", with commercial lanes between 9'-0" and 10'-0" wide.

Structure and Tonnage

The steel hull is designed in accordance with ABS Rules for Building and Classing Marine Vessels, 2020, as required by the Code of Federal Regulations (CFR; 46 CFR §177.300). The Structural Arrangement drawing shows the proposed structural midship section arrangement. The notable design elements are highlighted below.

The hull is of single-bottom construction and longitudinally framed to seek a lightweight and fair hull. Similarly, the deck is longitudinally framed to help mitigate "washboarding" of the deck due to heavy wheel loads.

Transverse web frames spaced at the maximum spacing of 48 inches on center for "ordinary frames" satisfy US Coast Guard MTN No. 01-99 (Tonnage Technical Policy). The tonnage calculation, resulting in a Gross Registered Tonnage of less than 100, is further detailed in the Tonnage report.

The main deck plating is ASTM A588 COR-TEN steel plate with thicker wear plate inserts at the ends in way of the boarding ramp. All deck stiffening (girders, transverse and longitudinal frames) is made from ASTM A572 steel (50 ksi yield stress). The main deck scantlings are governed by commercial and emergency vehicle axle loads.

The hull shell plating and internal stiffening are made from ASTM A36 (36 ksi yield stress) steel. The sponson is fitted with a thick guard plate to help resist deformation during hard impacts.

The deckhouse and bulwarks are of aluminum construction, alloy 5083 for plate and 6061-T6 for extruded shapes. Aluminum is selected to reduce the amount of compensatory ballast required, redoubling the weight savings and ultimately reducing lifetime energy costs.

The deckhouse sides and decks are longitudinally framed. The framing is supported by transverse web frames and deck transverses aligned with the hull ordinary frames. Bi-metallic strips are used around the perimeter of the deckhouse and bulwarks to enable welded connection of the aluminum to steel structure.

In addition to the aforementioned weight savings, aluminum also requires less maintenance, further reducing the annual cost of ownership. The unstiffened exposed sides of aluminum structure will be covered with vinyl film coating in lieu of painting to retain the aesthetic without the additional maintenance.

Hull Form

The hull design is a shallow-draft, double-chine monohull with one azimuthing thruster located on centerline at each end. A perspective view of the concept hull is shown in Figure 3. Skegs provide docking support for the hull and assist with directional stability. The fins, like fixed rudders at the ends of the hull, provide increased and essential directional stability for the hull, as discussed below. The vessel Lines Plan provides further hull shape details.

Figure 3 Perspective view of the vessel's hull, looking upward from below

Propulsion Arrangement

The replacement vessel has one azimuthing L-drive propulsor on each end, on centerline. The depth of the hull at centerline permits the units to be installed below deck, including the vertically oriented motor. This is preferrable to the arrangement of the *Guemes*, which has off-centerline thrusters that take up valuable Main Deck space, impart yawing forces during maneuvering, and have disadvantageous propulsive efficiency.

With a two-propulsor arrangement, ferry service is interrupted when one propulsion unit is inoperable. This necessitates a rigorous maintenance schedule to mitigate the risk of unit failure. A four-unit arrangement is more reliable due to inherent redundancy; if one unit is offline then the vessel can still maneuver and perform in a normal manner provided the weather is benign.

Knowing that a highly reliable vessel is desired, a comparison of two vs. four azimuthing thrusters was performed. The comparison investigated hull efficiency, propulsor efficiency, dock pushing power, capital cost including one spare unit, and maintenance costs.

The four-unit propulsion arrangement would be more operable due to overall redundancy in propulsors but would come with increased costs and complexity. It resulted in higher capital, operating, and maintenance costs, and also negatively impacted the vessel battery and shoreside battery costs. The four-unit system would have more parts and more structure, in addition to making the vessel more complex and difficult to build. Access to the four units would be restricted since the hull is shallower outboard due to the deadrise. Based on this evaluation, Skagit County elected to keep the two-unit configuration as shown in the preliminary design, on the basis that the significantly increased cost and complexity is not worth the tradeoff with redundancy.

Directional Stability

Double-ended ferries are known to be susceptible to dynamic course instability due to their generally low L/B ratios and high B/T ratios (Reference 4). As dynamic course instability can make maneuvering unpredictable and dangerous, it is preferable to analyze the course-keeping ability of a double-ended hull before the vessel design is finalized. A modified 25°-1° zig-zag test was performed using Computational Fluid Dynamics (CFD). Results show the preliminary hull has adequate directional stability to make course corrections. Further analysis will be performed after the hull is optimized (see Hull Optimization section below) to ensure the final hull is sufficiently stable while still providing high maneuverability.

The modified 25°-1° zig-zag test is suggested in Reference 4 as a suitable replacement for the traditional 10°-10° and 20°-20° tests, which are often not possible for these types of vessels. For the 25°-1° test, the rudder (or thruster, in this case) is turned 25° to one side and held until the vessel heading changes by 1°, at which point the rudder is turned to 25° on the other side and held until the vessel crosses its original heading and reaches 1° on the opposite side. This is repeated for several turns to assess the dynamic response of the vessel. Performance is defined in part by the “overshoot angle,” which is the difference between the heading at the time the turn is initiated (the target heading, or 1° for this test) and the actual change in heading when the vessel begins to turn.

In Reference 4, a low L/B, high B/T double-ended ferry hull similar to that of the replacement vessel was tested in a model basin. With the original hull configuration, the model was able to complete only a few turns before deviating completely from its course. Subsequently the hull was modified with additional stabilizing fins, and the model was able to carry out an unlimited number of course corrections without divergence. A summary of these results is shown in Figure 4.

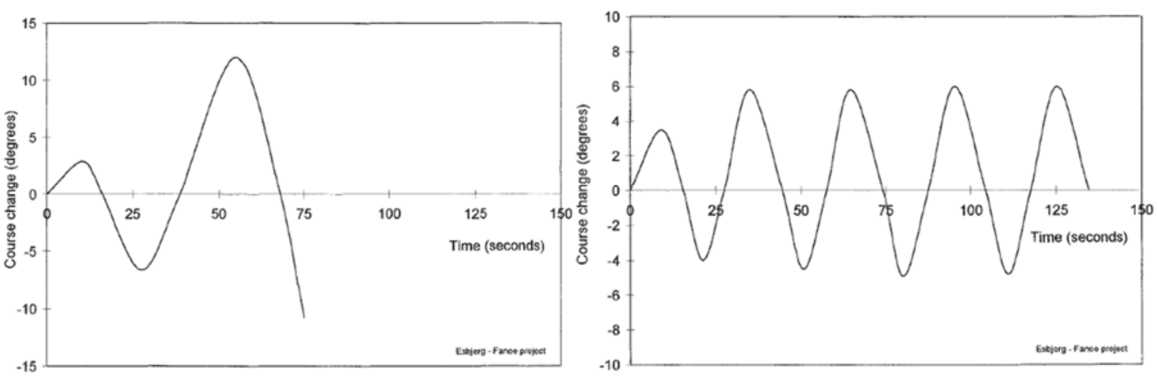


Figure 4 A failed 25°-1° model test (left), compared to a model with fins added (right) (Reference 4)

To assess the dynamic stability of the replacement vessel's double-ended hull, the CFD solver FINE/Marine was used. The forward and aft ducted azimuthing thrusters were represented by actuator disks inside simplified nozzles and controlled with a user-defined dynamic library with a zig-zag algorithm. The displacement of the vessel was set to 455 LT, which represents the most probable loading condition in the Weight and Stability report. The forward thruster was held steady with 30% of the total thrust and the aft thruster provided steering control with 70% of the thrust. Total thrust was defined as the amount needed to propel the vessel in a straight line at 11.5 knots and determined in an initialization analysis.

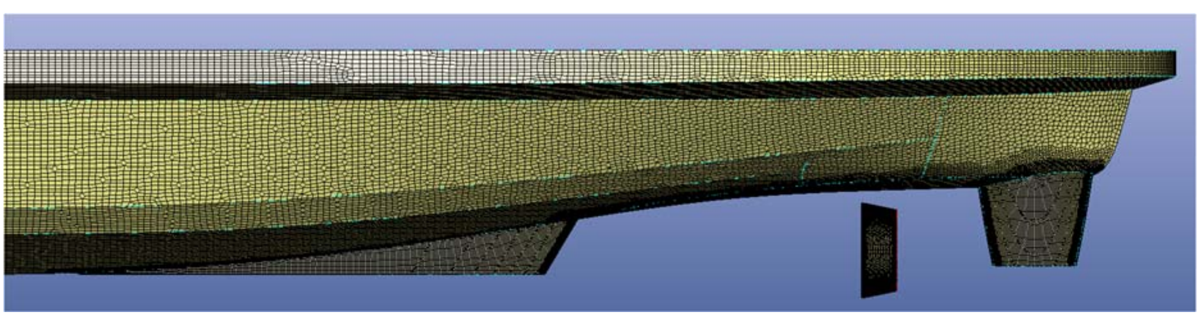


Figure 5 Vessel mesh in FINE/Marine

Results of the analysis are shown in Figure 6. Based on the evolution of the vessel yaw, the test had not reached a steady-state point of operation; however, the rate of change of the overshoot angle is clearly converging. The overshoot angle is significant at nearly 7°, slightly higher than the 5° overshoot from the successful model tests in Reference 4 (note that these tests were model scale and the maneuvering speed for the tests is not published, making direct comparisons difficult).

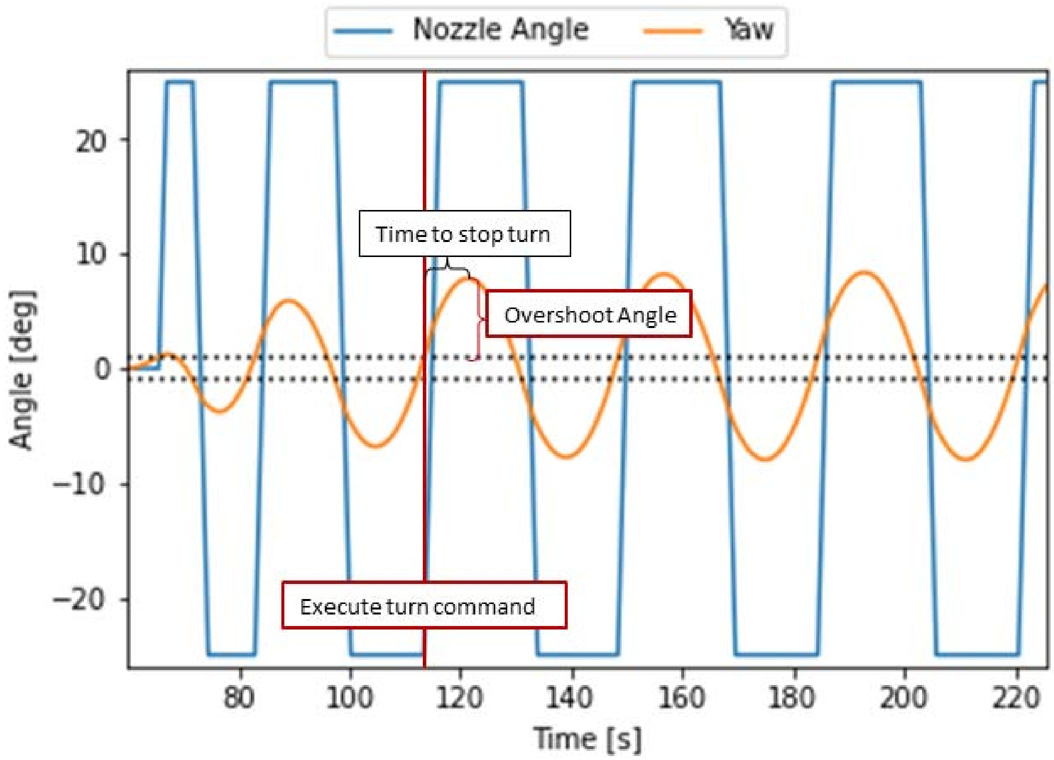


Figure 6 Vessel yaw and nozzle angle

In Figure **7**, streamlines are shown at two planes in the flow around the hull at the final time step of the simulation. At the top, the flow at the vessel baseline (aligned with the bottom of the skeg) is shown, while the bottom image shows the streamlines at a cut through the centerline of the thruster nozzle (approximately 1.5 ft above the baseline). The streamlines are shaded by velocity. There is some interaction between the forward thruster and the forward end of the skeg; however, the interaction between the aft thruster and the aft fin is much more significant. At the aft end of the vessel, the wake from the thruster clearly bends around the fin, decreasing the effective angle of the thruster. This may have implications for the dynamic stability of the vessel and will be examined further in contract design.

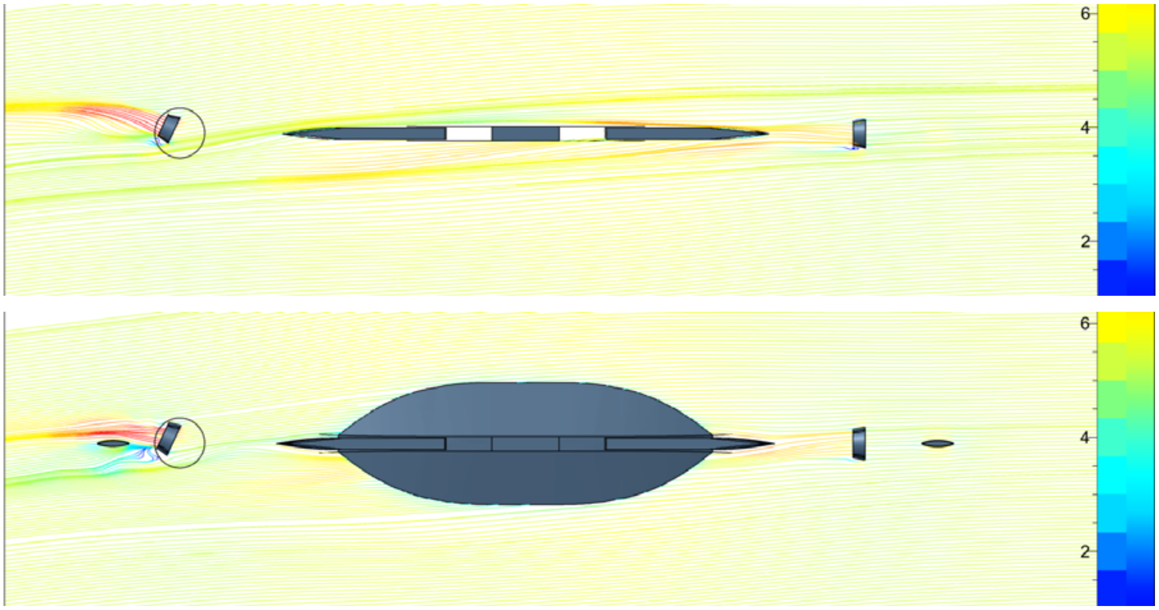


Figure 7 Streamlines shaded by velocity (m/s) at baseline (top) and nozzle center (bottom) at t=225 s

Hull Optimization

The hull shape shown in the Lines Plan will be optimized through a computer optimization program. The target of the optimization is to find a hull design with least thrust power while meeting the constraint set. The optimization is carried out in different stages using a sequence of algorithms applying small manual adaptations between phases. All design variants are analyzed using a hydrostatic and potential flow computational fluid dynamics (CFD) code. Around 20,000 designs are generated and fully analyzed in the process of balancing constraints and objectives. Typical optimizations on similar vessels have resulted in 10% or more reduction in resistance.

Lifesaving

The deckhouse contains adult lifejackets sufficient for three crew and 150 passengers, plus an additional 50 child sized lifejackets. Lifejackets are stored within the Passenger Lounge in cabinets and below seats, and in dedicated storage boxes on the Upper Deck.

The replacement vessel is not required to have survival craft as it operates on Lakes, Bays and Sounds and within one nautical mile from shore (46 CFR 180.207). No survival craft (i.e. liferafts) will be provided.

Per 46 CFR 180.210, the replacement vessel must carry a motorized rescue boat unless the USCG determines that *(1) The vessel is sufficiently maneuverable, arranged, and equipped to allow the crew to recover a helpless person from the water; (2) Recovery of a helpless person can be observed from the operating station; and (3) The vessel does not regularly engage in operations that restrict its maneuverability.* The replacement vessel has been designed with an awareness of these requirements and it is the intention to gain approval of the vessel without the need for a rescue boat.

Machinery Spaces

The machinery spaces are laid out as shown in the General Arrangement drawing. Access to the main machinery spaces is provided though the deckhouse, using inclined stairs. All emergency egress hatches open to passenger spaces (not the Vehicle Deck). Access to the Drive Rooms is provided through quick acting watertight hatches and vertical ladders.

Bolted equipment removal plates, designed to the same structural standards as the Main Deck, are provided over the thrusters and Generator Room for major equipment removal. Securing hardware is located entirely below the Main Deck and out of the weather.

Electrical

The electric plant is a critical system for this vessel. Some significant details of the electric plant will depend on the integrated vessel-shore-charging system design, but most major characteristics can be described now. A simplified schematic of the electric plant is shown in Figure 8. A more detailed diagram and a load analysis are provided in the Electrical Power Load Analysis and Electrical One Line diagram.

Many details of the electric plant arrangement are best determined in collaboration with an electrical integrator responsible for delivering the equipment and control system. During development of the preliminary design, a formal Request for Information (RFI) process was used to seek vendor input. More information about the RFI process, including summaries of technical and commercial responses received, can be found in Appendix A thru Appendix E.

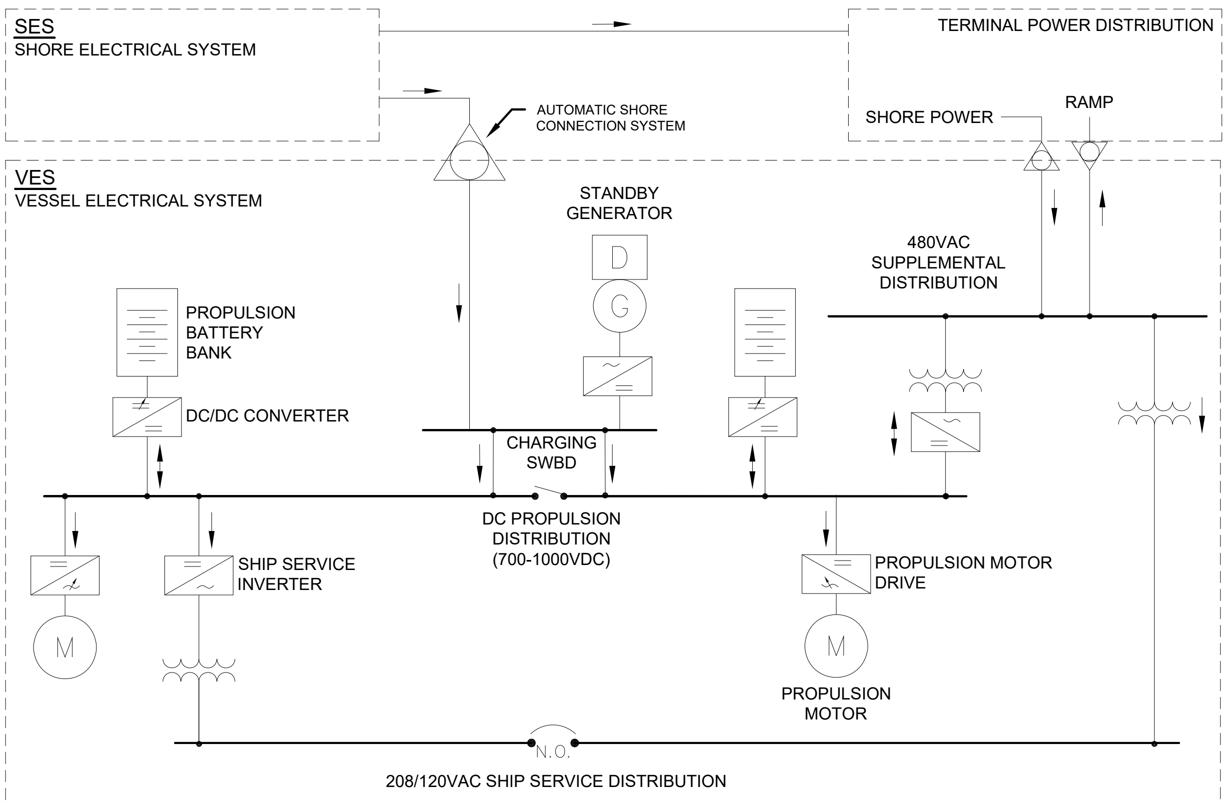


Figure 8 Overview of electric plant, simplified version of Electrical One Line diagram

Main DC Switchboards

Two main DC switchboards will be provided. Each will primarily serve to connect one of the vessel's battery banks to the associated propulsion motor via a DC-AC inverter. Secondary functions include connections to the shore charging system, ship service electrical distribution system, and auxiliary equipment used to regulate the DC bus. A separate charging switchboard may be used, as shown in Figure 8.

The switchboards require freshwater cooling to cool the main power electronics. Exact cooling requirements will depend on the chosen equipment, but a rough estimate is to provide 16 gpm at

100F. Depending on the vendor, this might be delivered to a switchboard cooling module containing a water to water heat exchanger and small cooling pumps, or the vessel's freshwater system might directly supply water to various switchboard components.

Propulsion Drives and Motors

The most significant electric plant loads are the two thrusters. The L-drive thrusters are driven by electric motors, which will be powered from the batteries via the DC bus and solid state inverters called propulsion motor drives (PMDs). Integration of these components is highly important and includes the following scope:

- Torque and speed matching between the thruster and motor
- Mechanical coupling of the fixed and rotating portions of the thruster and motor
- Controls integration between throttles and PMDs
- Controls integration between the thruster controls and power management system
- Electrical integration between the motors and PMDs
- Electrical integration between the motors, drives, and DC plant to manage voltage transients (braking)

Other key details of the thruster and motor include:

- Redundant electric steering
- Dual synchronized bridge controls
- Permanent magnet (PM) motor selected for reliability and efficiency

Several components in the propulsion system require freshwater cooling. These may include the propulsion motor, the thruster oil cooler, and a steering dynamic brake resistor.

Battery Banks

The preliminary design is based on Lithium Nickel-Manganese-Cobalt (Li-NMC), a specific type of lithium ion chemistry. Li-NMC systems offer the most mature technology suitable for this marine application, but other chemistries will be reviewed during contract design to confirm that this battery type is the best choice. The following discussion assumes Li-NMC; other chemistries could prompt some changes to size, rack layout, or other parameters.

Two independent battery banks are provided for reliability and redundancy. Each bank will be approximately 340-400 kWh, consisting of either three or four strings housed in separate racks. Three separate criteria must be evaluated to determine the required battery bank size:

- Limiting trip power: the vessel is being designed to operate on batteries alone for 95% of the predicted weather. This requires approximately 200 kwh total, 100 per bank, to provide the propulsion required for an Anacortes-Guemes Island round trip.
- Extremis maneuvering power: the battery banks will be capable of delivering the full rated power to the propulsion motors (750 kW) so that maneuvering in an emergency will be limited by the motor/thruster and not by the battery banks. This requires approximately two 265 kWh battery banks, one for each motor.
- Battery lifetime: deeper discharges limit battery lifetime. A larger battery will have a shallower depth of discharge and will last longer. This is the limiting criterion and drives the battery sizing in order to achieve a 10 year lifetime. This size will be reviewed during contract design to minimize lifecycle cost. A smaller battery bank, designed to be replaced more frequently, could feasibly save money over the long lifetime of the ferry.

Miscellaneous equipment will be provided with the battery including the Battery Management System (BMS), which handles low-level control and safety of the batteries. A BMS balances power between the individual battery modules to account for minor variations in performance, monitors temperatures, current, and other key parameters to detect problems, and interfaces with the overall Power Management System (PMS) to regulate power distribution and battery charging under normal and abnormal situations.

Charging and discharging inefficiencies in the battery generate heat, accounting for approximately 2% of the utilized power. A cooling system will be provided to remove this heat using either air or water. The choice of battery cooling depends largely on manufacturer and is discussed in more detail in Appendix A. Regardless of the primary cooling method utilized, the battery spaces will be air conditioned to cool miscellaneous electronics and prevent moisture or condensation from forming in the battery racks.

All energy storage has associated risks; batteries are no exception. The primary concern for batteries is to prevent thermal runaway and to limit the consequences if a runaway occurs. ASTM F3353 provides comprehensive safety standards for lithium ion batteries used on board ships. This standard addresses battery safety by providing defense-in-depth from the cell level up to the ship level:

- The BMS must monitor applicable battery parameters. If problems are detected, the BMS automatically disconnects the affected battery module electrically and generates alarms.
- Should the BMS fail and a thermal runaway occur, the basic physical design of the battery modules prevents propagation of fire between adjacent cells.
- Battery racks have integral exhaust ducts that prevent thermal runaway explosive gases from escaping to the battery room. Some battery vendors require a non-sparking or explosion-proof fan to safely direct gases overboard.
- A dedicated automatic fire extinguishing system is provided for each battery space should the above measures fail to prevent a battery space fire from starting.
- Finally, each battery space is isolated from adjacent passenger spaces and the Generator Room by A60 isolation, minimizing the possibility of a fire spreading to threaten the vessel.

The USCG reviews and approves several documents to ensure that the design, installation, and operation of battery systems achieves a level of safety equivalent to a diesel-powered ship. These include:

- Qualitative Failure Analysis (QFA), a design study that evaluates the effects of failures in the control, instrumentation, and alarm systems associated with the battery, propulsion, and power management systems.
- Design Verification Test Procedures (DVTP), a construction test that validates the battery system was installed correctly and validates the failure assumptions in the QFA.
- Periodic Safety Test Procedures (PSTP), a formal preventive maintenance program that periodically tests battery safety systems for proper function
- A maintenance and operations manual that provides step-by-step instructions for crew response to abnormal battery conditions such as low voltage, high temperature, or fires in the battery or adjacent spaces.

Power Management System

Overall control of the batteries, shore charging system, propulsion system, and auxiliary generator (when running) will be coordinated through a Power Management System provided by the electrical integrator. The PMS will provide control and monitoring of the electric system including the following features:

- Provide information to the Shore Electrical System (SES) prior to and during each charging evolution
- Coordinate the operation of contactors and other equipment to ensure safe connection and disconnection of the Automatic Shore Connection System (ASCS)
- Display battery and propulsion status to crew in the Pilothouse
- Remotely bring the standby generator on and off-line
- Provide control and indication at switchboard and Pilothouse consoles

Ship Service Distribution

Based on the criteria of size, cost, complexity, and availability, a grounded wye multiphase power distribution system will provide the most flexible and efficient option for the vessel. A 208/120VAC (four wire wye) has been selected. Power will be distributed from a split main bus in the Switchboard Room. Some loads will be powered directly from the switchboard. Additional 208 wye 120 VAC load centers will provide power for vital and non-vital systems, including 24VDC power supplies for loads such as navigation equipment and control systems. Three AC load centers are provided – one on each deck. Two DC load centers are provided – one on the Hold Deck and one near the Pilothouse.

Inverters are used to provide power from the batteries on the DC bus to the AC switchboards. As shown in Figure 8, transformers must be used to step down the inverter's output voltage. On one side of the electric plant, an intermediate 480V switchboard is provided. This provides for interface with regular shore power for overnight and layup conditions. This also allows the vessel to provide backup ramp power in case of a utility outage. Finally, a limited number of large loads might be powered from the 480V bus. Preliminary sizing of the inverters and transformers is included in the Electric Power Load Analysis and One Line Diagram. Sizing will be further refined during contract design.

Auxiliary Generator

An auxiliary generator, nominally 550 ekW, is provided to supplement shore charging. The generator enhances the vessel's capabilities and reliability in several important ways:

- Increased endurance in situations where the vessel operates outside the normal route. These include rendering assistance and transits to and from shipyards for maintenance.
- Robustness against a loss of utility power or component failure in the shore charging system. Without the ability to charge batteries from the utility, the vessel would be unable to operate in the absence of an alternative power source. A backup source of power on the vessel allows continued operation in these cases. See next section (Two Sources of Power) for additional information.
- Tolerance for faults in the vessel's electrical system. Various electrical component failures could compromise the ability to operate or charge the batteries. The generator mitigates these failures and allows continued operations.

Two Sources of Power

Basic considerations for safety and risk management require assurances that key equipment will not lose power. This is codified in 46 CFR §183, which requires two sources of power for key equipment. This includes propulsion and steering functions provided by the thrusters and also various equipment that receives power via the ship service 208/120 busses.

There are three sources of power on the vessel – the two battery banks and the auxiliary generator. It is anticipated that the vessel will have three basic power options for sailing:

- Both battery banks, shore charging available
- One battery bank with auxiliary generator –allows continued operation with one bank out of service
- Auxiliary generator only – if shore charging unavailable
    - A charged battery must be maintained as backup
    - Power limited operation, or supplement with battery power but spend extra dock time charging batteries using the auxiliary generator

Auxiliary Systems

HVAC

Sufficient natural ventilation will be provided so as not to require air conditioning (cooling) in the crew and passenger spaces. Doors and windows with adjustable opening areas will allow for airflow modulation through the spaces during the summer months. Windows will in general be double-pane with low-e glass to reduce solar heat gain and interior condensation.

The Pilothouse will be provided with a roof-mounted air conditioning unit to help control the heat in this largely glass-walled structure. A window defroster unit will also be provided to reduce fogging on the interior of the windows.

The HVAC diagram provides anticipated system details. Table 2 presents the criteria used for the system design, with design case seawater and ambient air temperatures presented in the top two rows.

Table 2 HVAC criteria

Criteria	***Cooling Season***	***Heating Season***
Seawater Temp	65°F	40°F
Ambient Air Temp	85°F	20°F
Pilothouse	78°F DB, 55% relative humidity	70°F
Crew & Passenger Spaces	100°F	40°F
Battery Room	72°F DB, 55% relative humidity	68°F DB, 55% relative humidity
Generator Room	113°F	40°F
Void Spaces	60 minute rate of air change	N/A
Switchboard Room	100°F	40°F
T/S and Public Toilets	4 minute rate of air change	70°F

Vents, Fills, and Level Indication

Tank vents, fill pipes, and sounding tubes will be provided where necessary and will include required containment coamings. This system will be made primarily of steel piping internally and stainless steel piping externally to reduce vessel maintenance.

Tank level indication will be provided at the bridge controls for the fuel tank, sewage tank, and potable water tank.

Firemain and Bilge

The Firemain and Bilge System drawing shows redundant electrically driven pumps and cross connections provided as necessary for each system to be backed up by the other. Suction for the pumps comes from two separate seachests. This system is comprised of steel piping.

Seawater Cooling

Vessel machinery cooling will be accomplished with freshwater circulating loops and keel coolers which are mounted on the exterior of the hull and reject heat directly into the sea. Keel cooling is discussed further in the Freshwater Cooling section below.

Deck Drains and Scuppers

Weather deck drains and scuppers will be provided where necessary and will lead directly overboard. Drains in the superstructure will be aluminum while Main Deck drains will be steel.

Freshwater Cooling

The following will be cooled by a circulating freshwater loop(s) with keel cooler(s):

- Auxiliary generator
- Switchboards
- Propulsion motors
- Chillers

Keel coolers will be mounted on the exterior of the hull and will reject heat directly to the sea. The use of channel coolers as an alternative to keel coolers will be investigated during contract design as a possible cost saving measure.

All freshwater system loops will be comprised primarily of steel piping. The systems will be provided with corrosion inhibitors and a 25% propylene glycol solution for mild freeze protection.

Battery banks may be air cooled or chill-water cooled. In either case, they are expected to be a load on the chillers, so selection of battery cooling method is not expected to significantly impact the design of the freshwater system.

Sanitary and Potable Water

Black and gray water sanitary drains are provided from the sink, toilet, and interior deck drains. All gray and black water drainage leads to the sewage holding tank, which is of plastic construction. The holding tank is of sufficient capacity for two weeks of operation.

A potable water supply system is provided on the vessel to supply hot and cold potable water to sink(s), exterior hose bibbs, and the head. Potable water is stored in a single plastic tank. A single pump and accumulator tank maintain system pressure at all times. A small on-demand electric hot water heater is provided. The potable water tank is sufficient for two weeks of operation.

CPVC piping and fittings are used for both systems. System details are outlined in the Sanitary and Potable Water System drawing.

Fuel Oil Service

The Fuel Oil Service drawing outlines the fuel oil system, which delivers fuel to the auxiliary generator engine. The system is kept as simple as possible and will be comprised primarily of stainless steel tubing.

Sufficient fuel is provided to meet the emergency response criteria discussed in the Concept Design Report.

Engine Exhaust

In an effort to reduce auxiliary generator run-time and exhaust particulate generated by the vessel, generator usage during normal operation will be limited to poor weather (less than 5% of the time annually). Typical wind speeds of greater than 10 knots during poor weather should allow exhaust gas to be easily dissipated. The generator will meet Tier 3 emissions requirements, which provides significant reduction in NOx and particulate matter (PM) compared to the older *Guemes* engines. The auxiliary generator will also operate at constant speed, thus optimizing the operating profile to limit undesired PM. Unplanned operation of the auxiliary generator will only occur during an emergency scenario or equipment failure.

A wet exhaust muffler will be provided in the Generator Room with pipe led outboard and penetrating down through the sponson. This arrangement saves valuable space within the deckhouse and is less expensive than a dry exhaust system.

Fire Suppression

A fixed fire suppression system, utilizing Novec 1230 as the fire suppression agent, will be installed in the Generator Room. The system will have audible and visual alarms and will shut down engines and ventilation louvers upon activation.

A pre-engineered fire suppression system will be installed in each Battery Space, utilizing the same Novec 1230 clean agent as the Generator Room. Battery Room systems will be automatically discharged based on ambient temperature and will have audible and visual alarms.

Manual releases of the fire suppression systems will be provided outside of the protected space.

Reliability and Availability

Achieving a high level of reliability is an important design consideration for the vessel. Electric plant designs submitted as part of the RFI process (Appendix A) highlighted a need to define criteria that clarify the vessel's minimum acceptable reliability. Given the significance of this vessel as a vital transportation link, a desirable standard would be that "no single failed component shall prevent the ferry from sailing." While suitable for many systems, it would not be practical or cost effective to meet this standard for key propulsion components such as the propulsors, propulsor motors, and propulsor motor drives. Following a failure of one of these components, the trip might be safely finished using the other propulsor and modified docking procedures. Repairs would then be necessary before resuming service. A suitable criterion considering this exception would then be:

> No single failed component shall prevent the ferry from sailing, except that failures of key propulsion train components are acceptable where redundancy for immediate shiphandling is provided by the other end.

In order to evaluate electric plant reliability, it is helpful to define more specific derived requirements that satisfy the overall vessel reliability requirement. In these requirements, consideration is given both to immediate safety following a failure and also to continuing ferry service until repairs can be made. For example, it is assumed that a single failure reducing available propulsion power below 50% would have unacceptable impacts to the ferry schedule, leading to the following requirement:

> Following isolation of a faulty battery string or DC/DC converter, at least 50% of each propulsion motor's design power shall be available via battery. This includes either unaffected battery strings connected through other converters on the affected side of the electric plant or, if a bus tie is provided, the other end's battery bank.

This assumes that in average weather conditions, it is possible and desirable to continue ferry operations without running the auxiliary generator. Figure 9 illustrates two design approaches that satisfy this requirement. The first approach minimizes the impact of a single failure by separately connecting each battery string. In the second design, the failed converter takes two battery strings out of service, but power is available from the opposite bank via the bus tie to satisfy the requirement.

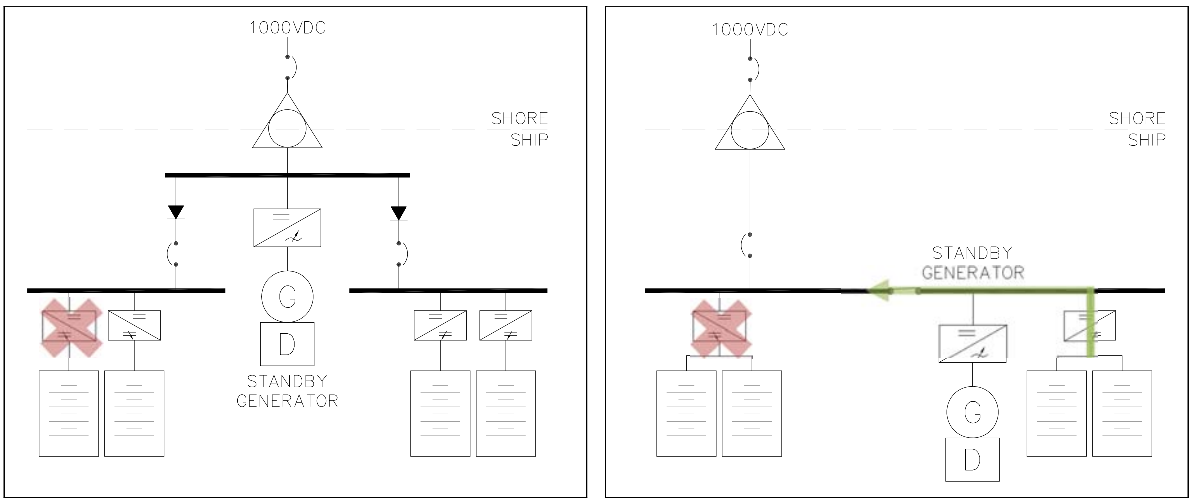


Figure 9 Two approaches that maintain 50% of each end's normal battery power following a single failure

A number of components in the shore electrical and automatic shore charging systems could fail and disable the vessel's shore charging capability. Designing these systems for single-fault tolerance would dramatically increase cost and complexity and is not practical. The vessel sailing criteria can only be satisfied by relying on power from the auxiliary generator. It is necessary, therefore, to prevent common modes of failure that can affect both sources, leading to the following requirement:

> The failure of a single component shall not prevent both the ASCS and the auxiliary generator from providing power to either DC bus.

The first design in Figure 9 fails this criteria, as the contactors between the charging bus and the main DC busses are a common failure mode for both the ASCS and the auxiliary generator. Providing dedicated connections to each bus as shown in Figure 10 allows the generator to power the DC bus affected by the failed charging contactor. Similarly, the second design in Figure 10 meets this criteria because the generator and ASCS connections are on opposite sides of the bus-tie. No single failure can disable both sources of power. Note that in these cases, ferry operations will continue, but some delay might be required to recharge batteries from the generator between trips.

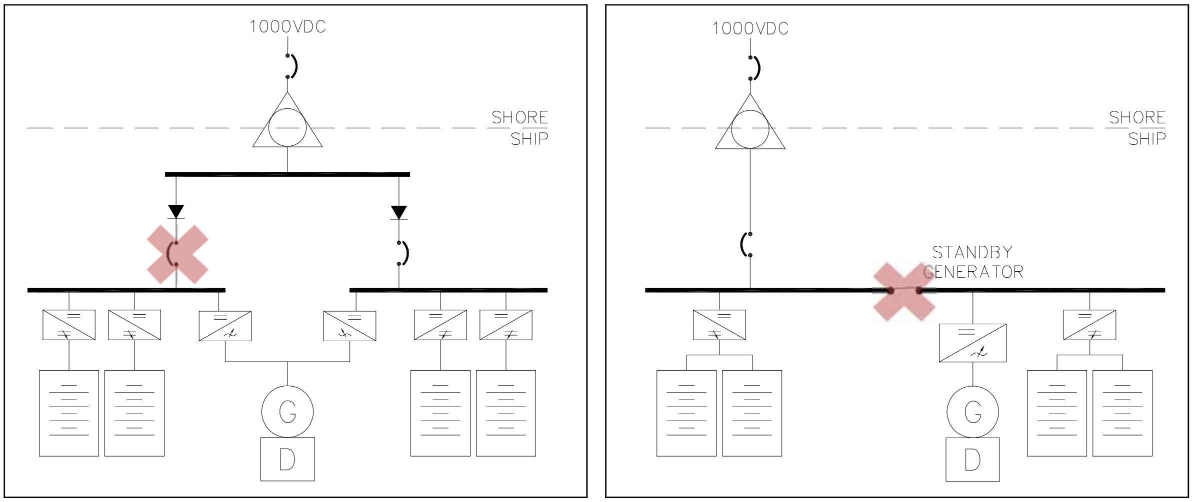


Figure 10   Two approaches that avoid ASCS/generator common mode failures

Future Work

Vendor Contracting

Through the recently completed RFI process, many qualified vendors wishing to provide the entire scope of supply, including the Shore Electrical System, Automated Shore Charging System, and the Vessel Electrical System (SES, ASCS, and VES), were identified.

Glosten believes it is in the best interest of Skagit County to award the full scope to one vendor, herein referred to as the Integrator. It will reduce Skagit County's risk significantly to have one Integrator deliver all of the electrical equipment and own all of the controls and interfaces, which is one of the most challenging aspects of an electric ferry system.

It would be preferable to select this Integrator using a best-value approach if possible. A suitable best-value approach is already outlined in RCW 39.26 but is only authorized for State agencies. A low-bid selection process could be used with strong supplemental criteria, but a low competency, higher risk vendor could inadvertently be selected. Alternatives to these approaches could include "special market positions" or "brand name bidding", outlined in RCW 39.04.280.

Skagit County desires a contract design with enough specificity to reduce cost and schedule risk in the shipyard contract. To deliver a design at this level of detail, Integrator selection would need to take place during the contract design phase. Selecting a competent Integrator would allow Glosten to:

- Complete the contract design of the vessel with confidence.
- Deliver the electrical system design for the entire project.
- Deliver the mechanical system designs supporting the batteries, motors, and onboard electrical equipment.
- Deliver the terminal design for the automated shore connection system.
- Deliver the structural design for the vessel, including foundations of major equipment.
- Obtain USCG review of critical vessel components.
- Write a specification for the construction of the vessel that is comprehensive and reduces risk to all parties.

Glosten's experience shows that providing critical engineering prior to the shipyard bid reduces overall project risk and total acquisition costs. This arrangement also enables vessel construction to proceed while the terminal and shore side electrical design is undergoing environmental review. Consultation with an environmental consultant may help better define the preferred path. Changing the Washington State law to allow counties to use the RCW 39.26 best-value bidding approach will benefit the shipyard selection process, helping to minimize project risks and ultimately providing better value to Skagit County.

Contract Design

Glosten will continue with contract design of the replacement vessel, preparing a full set of plans, specifications, and estimates. Our work will include all facets of naval architecture and marine engineering tasks to further advance the design, with the primary objective of de-risking the project. We will leave the design flexible where possible to provide options for the shipyard, while ensuring the vessel has the features and characteristics that Skagit County needs. Completing the contract design is very dependent on selecting an Integrator in the early part of contract design.

Glosten will also continue to support Skagit County through the bidding and construction phases of the contract on an as needed basis.

Project Schedule

The overall project schedule (Figure 11) shows the anticipated future contract design work, contracting, construction, and delivery of the new vessel. The project critical path is shown in red, and currently includes design, vessel contracting, and construction. Environmental permitting will also become critical path if permit approval is delayed.

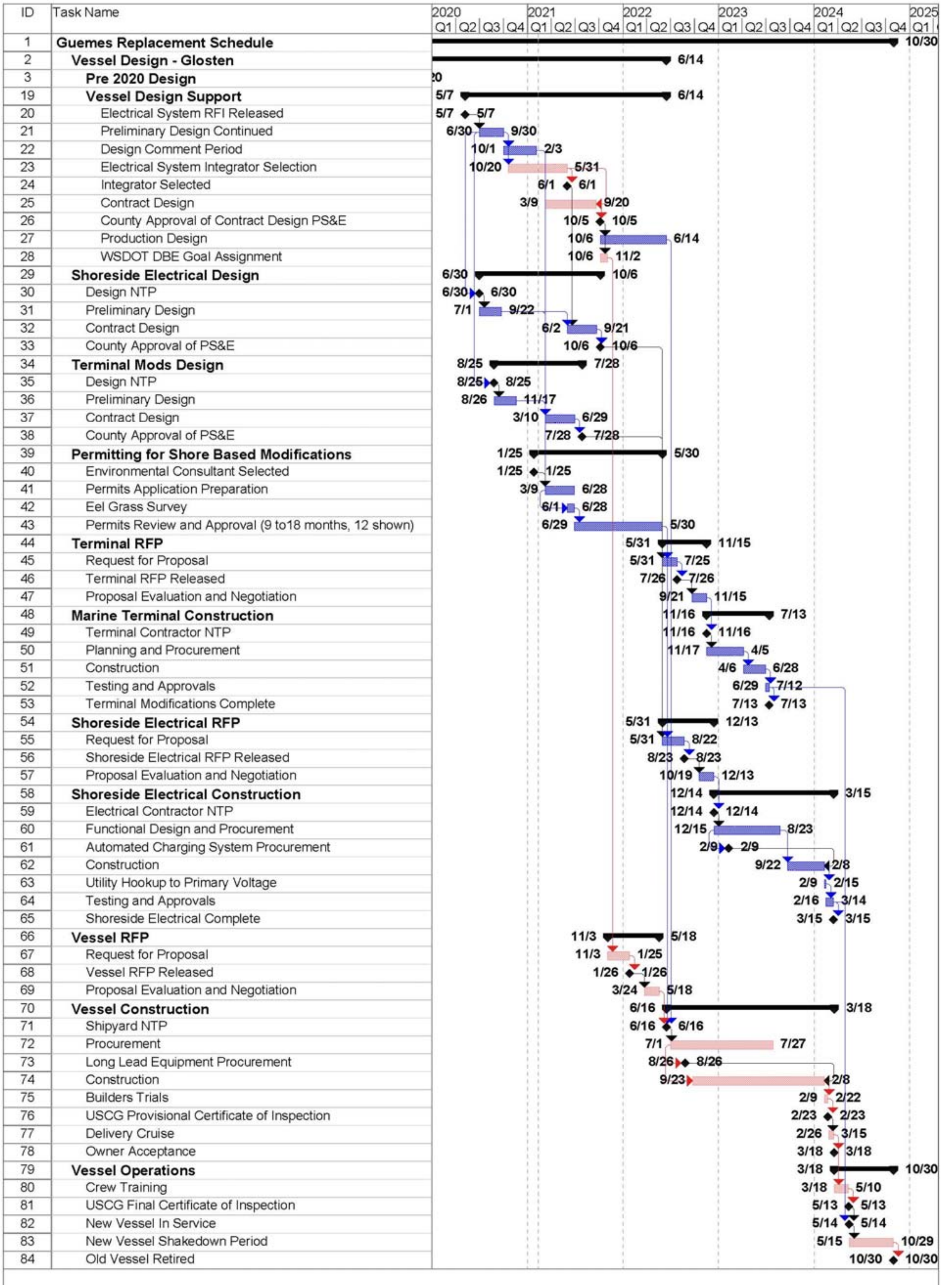


Figure 11 Overall project schedule through new vessel delivery

Appendix A Vessel Electrical System RFI

General

Skagit County and Glosten issued formal Requests for Information (RFI) to identify potential vendors and inform technical approaches and cost estimates. The complete RFI documents are included in Appendix E for reference. Four separate RFI's were published: the Vessel Electrical System (VES), Automatic Shore Connection System (ASCS), Shore Electrical System (SES), and Propulsor. 23 responses were received from a variety of electrical integrators, propulsor manufacturers, and others. Nine proposals were received from integrators that could credibly deliver an integrated VES, ASCS, and SES scope.

The RFI included a conceptual electrical arrangement but allowed for responses that proposed alternate approaches. Responses included several significant design differences. These are discussed further below. Many details were consistent across the concepts and all respondents. For example, all designs included two functionally separate sides of the electric plant, corresponding to each end of the ferry. With a few exceptions, the functionally separate sections are also physically independent switchboard sections. Most designs included a DC bus tie, and in several cases it was clear that the tie would be normally shut. In other cases, the intended operation of the bus tie was not clear. One vendor proposed a split plant with no tie capability. Cost, complexity, and reliability considerations for split plant design are discussed further in the Reliability and Availability section of the main report.

Five responses included a small charging switchboard. The size and function of this switchboard varied between designs, but it generally provided for increased redundancy and maintainability by physically separating the charging connection to the two sides of the electric plant. A space reservation for a charging switchboard has been included in the forward starboard corner of the Switchboard Room.

In the RFI concept design, the auxiliary generator was located on the 480VAC auxiliary bus. Several respondents suggested relocating this generator toward the main DC busses connecting either directly to the DC bus via a rectifier or to a 600-690VAC bus, depending on the design. This change reduces weight, simplifies operations, and is expected to break even or offer slight cost savings compared to the RFI concept. This change is adopted in the current preliminary design.

Price

Rough Order of Magnitude (ROM) prices for the VES in RFI responses ranged from $1.2 to $4 million. Scope varied widely across these responses. For example, the $1.2M offer did not include the propulsor motors where all other offers did. The range of prices is summarized in Figure 12. The mean price was approximately $2.5M.

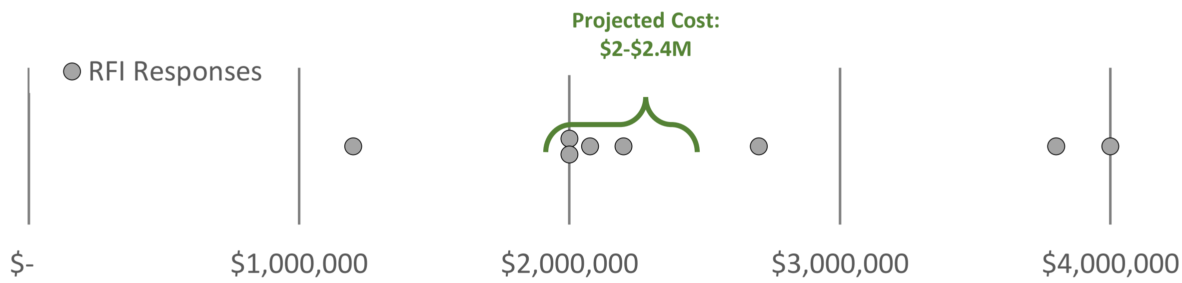


Figure 12 Summary of Pricing Data in VES RFI responsess

Batteries, DC Bus Voltage, and Convertors

With one exception, all integrators proposed one of two type-approved marine Lithium Ion battery systems, the Corvus "Orca" or the Spear "Trident" system. These systems are based on the same basic cells from LG Chem, and in many respects are functionally identical. Accommodating minor differences in battery options and control schemes is within the scope of the electrical integrator and is not a major concern. On the other hand, choosing an approach to battery cooling has notable effects on auxiliary systems, and the design of the battery connection to the electric plant can impact reliability and control system complexity.

Battery Pack Voltage

Nominal battery voltages range from 700-1000 VDC. Battery cells are connected in series to achieve the desired nominal voltage. Each string of series batteries is packaged as one physical battery rack. Multiple racks are connected in parallel to provide the necessary level of energy storage. As a result of the greater number of cells, higher voltage racks also provide slightly greater energy storage (12-15 kWh per 100V). At lower voltages, eight battery racks are required (two banks of four). At higher voltages, it is possible to achieve the required energy storage with fewer racks. Higher voltage racks are taller but would still fit in the planned space and could potentially allow reducing from eight strings to six (two banks of three). Selection of battery voltage has many impacts on the electric plant design, so this decision will be left to the electrical integrator.

Battery Limits

An important battery limitation is the C-rate. A battery with 100 Ah discharging at 100 A is discharging at 1C. Charging at 200A is charging at 2C. All evaluated batteries are capable of at least one cycle at 3C and short-term transient operation at 6C. This is important to ensure that the batteries can support the maximum power rating of the propulsion motor and thrusters during extremis maneuvers. Additionally, control and power systems associated with the battery must be designed to accommodate the range of voltages and currents associated with such transient maneuvers. Another way to assess the suitability of battery sizing for the design is to calculate the root-mean squared (RMS) C-Rate across the operating profile. The RMS rate gives insight into long term effects like battery aging and design decisions related to battery cooling, and is approximately 1.4C for typical proposed designs.

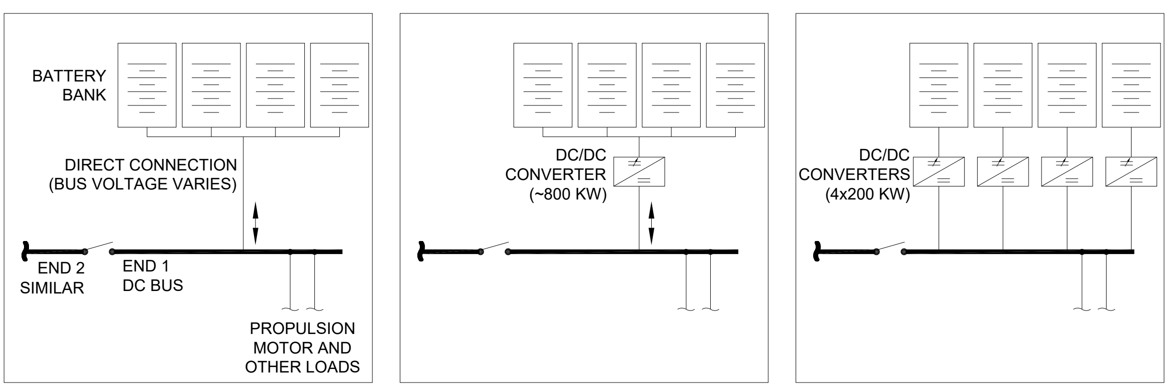
Battery Cooling

Depending on the manufacturer, battery packs are available with air cooling, water cooling, or a choice of either. For water-cooled batteries, it is important that the pack is designed to minimize the possibility of a water leak causing a short-circuit. A battery short could cause thermal runaway, hydrogen production by electrolysis, or fire. Important design features include sealed electrical connections and avoiding mechanical connections inside the battery cabinet. Maintaining batteries within acceptable temperature ranges by liquid cooling often requires chill water provided by separate seawater-cooled chillers. However, simple freshwater cooling may be possible given the low year-round water temperatures in the Guemes Channel. This option will be explored further during contract design if a water-cooled battery is selected.

Air-cooled battery racks depend on efficient cooling of the Battery Spaces, utilizing internal fans to circulate cool air from the room around the battery modules. Air cooling is simpler and requires fewer connections to auxiliary systems. All electrical spaces on the ferry will be air conditioned. This includes the Battery Spaces, even if the batteries are water cooled. Air cooled batteries will simply place a larger cooling load on the AC system, with no need to integrate separate piping, chillers, or heat exchangers. However, air cooling responds more slowly to spikes in battery temperature. Careful collaboration with the electrical designer will ensure that the air conditioning system is properly sized to manage all foreseeable battery heat loads.

Variable Battery Voltage

One notable difference between vendors is the approach towards DC/DC convertors. Battery voltage will vary approximately 100-150V depending on the state of charge. One option is to allow DC bus voltage to float on the battery. This is acceptable if all equipment on the DC bus is designed for the full range of battery voltages. Siemens and Flanders proposed this type of design. All other proposed designs maintain a nominal bus voltage by including DC/DC convertors between the batteries and bus. The convertors provide a variable amount of voltage boost that compensates for the battery state of charge. Vendors offering convertors are further distinguished by the choice of whether to individually connect each of the 6-8 battery racks with a dedicated convertor or to parallel the racks in each bank and connect the bank to the bus with a single large converter. Simplified schematics of these alternatives are given in Figure 13.



(13a) DC bus floats on battery (13b) Single converter for each battery bank (13c) Converter for each battery string

Figure 13 Options for battery connection to DC bus

The choice between these options is a tradeoff on the complexity and controllability of the battery and power management systems. For example, additional complexity in the power management system might allow simpler battery management functionality. A direct connection as shown in Figure 13a requires a battery management system that coordinates across all four battery strings.

After reviewing these tradeoffs with several equipment vendors, no clearly preferred variant was identified. Each approach has minor advantages and disadvantages and a final choice will be made after vendor selection.

Appendix B Automatic Shore Connection System RFI

Options for the shore charging system are limited by the range of motion requirements. Tidal range presents the biggest challenge, but the preference to freely yaw between East/West dolphins is also a significant requirement.

Among vendors offering the full VES/SES/ASCS scope, all but two proposed one vendor that uses a socket and autonomous crane as shown in Figure 14.

Figure 14 Charging system most commonly provided in the RFI responses. Illustrative of charging mechanism only - planned location is different.

Several RFI responses included charger options that would integrate into the vehicle apron. The advantage of this approach is that the transfer span and apron provide significant range of motion for tidal compensation, reducing the requirements for the ASCS. Locating the charger at the bow of the ferry also significantly reduces the yaw motion that the ASCS must be able to compensate for. However, apron-mounted options have been ruled out and will not receive further consideration. This decision was made for several reasons:

- The existing apron hydraulics system has limited margin to accommodate extra weight
- The vessel socket would interfere with walk-on and vehicle traffic flow as there is no extra width available on the apron
- The risk associated with locating the charger/socket near passengers and vehicles is undesirable

Viable options were reviewed in detail and evaluated for compatibility with the terminal arrangements. Due to the physical and operational restrictions, only two systems were identified. Both systems can accept a variety of electrical voltages and powers, including DC and AC charging. These systems are compatible with a similar socket location on the upper deck and would utilize similar modifications to the breakwater structure to provide a fixed foundation. These similarities allow the preliminary design to progress and final selection of a charging interface to be performed at a later date.

Appendix C Shore Electrical System RFI

Compared to the VES, technical approaches to the SES varied widely, using a variety of different AC and DC voltages, physical and functional equipment arrangements, and energy storage system sizes. There is relatively limited integration between the SES and other equipment outside the integrator's scope. It is recommended to leave the architecture to vendor discretion with a few limitations:

1. It is assumed that Skagit County has few operations personnel trained in medium voltage electrical safety requirements. Utility power should be immediately stepped down from 12.5 kV to minimize the scope of equipment requiring outside assistance for maintenance.
2. The SES should not require any external support systems. If liquid cooling is used for any equipment, it should be self-contained within the scope of the SES. It is acceptable to utilize 480V circuits on the shore switchboards for SES loads.
3. SES batteries should be selected to minimize lifecycle cost (LCC) by balancing procurement cost and expected utility demand charges.

Some unique possibilities arose in discussions with vendors. These include non-marine vendors, alternate battery chemistries, minimizing LCC with smaller batteries and shorter replacement timelines, and allowing the utility to use the system as distributed energy storage. Alternatively, maximizing commonality with the vessel has some advantages for maintenance and spare parts, and might allow immediate replacement of a failed VES battery module by swapping one in from the SES.

It is recommended that the integrator be allowed to use technical discretion to minimize LCC except for advanced cooperation with the utility. Coordinating technical requirements and cost structures would cause unacceptable delays to the selection of an electrical integrator and design of the ferry.

Similar to the VES, the SES batteries could be directly connected, use one large DC/DC converter, or use a separate converter for each battery string. The tradeoffs for these options are similar to those discussed in Appendix A.

Price

ROM prices for the SES in RFI responses ranged from $900,000 to $2.3 million. As with the VES, some differences in the proposed scopes limit the usefulness directly comparing offers. The range of prices is summarized in Figure 15. The mean price was approximately $1.5M.

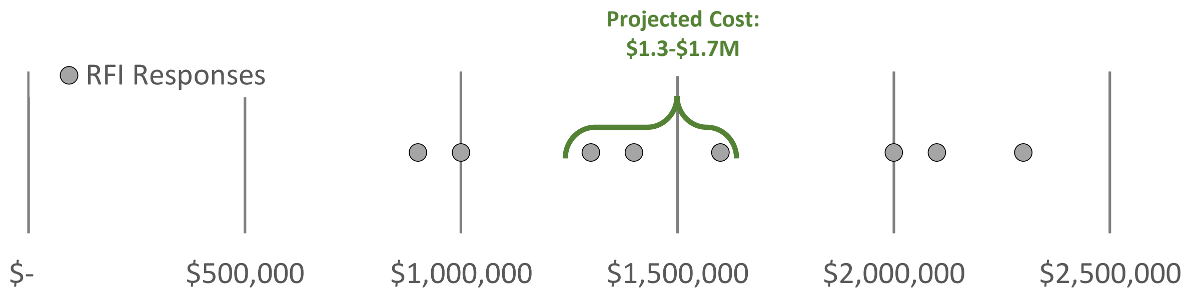


Figure 15 Summary of pricing data in SES RFI responses

Appendix D Propulsor RFI

The Propulsor RFI included sufficient detail for propulsion vendors to calculate thrust and motor power based on provided vessel resistance and hydrodynamic coefficients. Information on desired and required elements of the thrusters was also provided. The most restrictive aspect of the RFI was the maximum total height of the thruster at 14 feet. This is required to meet the navigational draft requirements while allowing the L-drive motor to maintain clearance below the main deck structure.

Seven proposals were submitted in various stages of completeness, with thruster costs ranging from $0.6M to $1.25M for the shipset (two thrusters). This cost includes the electric motor even though it is likely to be supplied under the VES. Also included are the various items requested in the RFI, such as propulsion controls for two interior consoles and one exterior console. Lead times were generally around 40 to 45 weeks. All input powers were between 700 and 750 kW.

Most of the thrusters are available as a top mounted configuration, meaning they can be extracted vertically through the main deck removal hatch. In an L-drive configuration, the electric motor stays attached to the thruster as the entire unit, including nozzle and propeller, is lifted out. If a spare unit is available, swapping out a thruster can take less than one day and can be done with the vessel afloat at the terminal (requires a mobile crane).

One vendor provided a podded propulsor with the electric motor below water and in line with the propeller. While this eliminates the right-angle gearbox, it is replaced with a planetary gearbox and an electric motor that is submerged. This unit is not suitable for removal through the main deck.

Insufficient information was provided to identify any underwater radiated noise benefits or disadvantages with specific vendors.

Given the range of options available, selection of a propulsion thruster can be performed at a later time.

Appendix E Requests for Information

REQUEST FOR INFORMATION – VESSEL ELECTRICAL SYSTEM

GUEMES ISLAND FERRY REPLACEMENT

000 GENERAL REQUIREMENTS

000.1 Objective

This Request for Information describes the requirements for the electrical system of the Guemes Island Ferry Replacement (GIFR) vessel, a 160-ft. battery electric passenger and vehicle ferry, at the ferry terminal in Anacortes, Washington. Skagit County owns and operates the Guemes Island ferry and ferry terminal. Glosten has been selected by Skagit County to design the replacement vessel and the associated charging system. We are requesting detailed technical information including a basic one-line diagram, equipment drawings, specifications, and rough order of magnitude (ROM) pricing for this equipment to progress the design of the vessel.

The GIFR vessel is expected to be the first purpose-built electric vehicle ferry in the United States. The battery electric system for this project could serve as a model for similar future ferry projects in Washington State and the surrounding region.

The information provided in response to this RFI will not be used as a basis for selection of vendor or equipment.

Responses are requested by 30 June. Please note all information does not need to be provided at one time and early information submittal is encouraged.

000.2 Reference Documents

The following are document is referenced within this RFI:

1. *GIFR Transportation System Assessment (PDF)*. Glosten, Inc., Document No. 17097-000-02, Rev. -, 14 December 2018.

The above document is for informational purposes only and should not be used for design and engineering beyond the purposes of this inquiry.

To request these documents, please email Jeff Rider at jmrider@glosten.com.

000.3 Acronyms

Acronyms used throughout this document are as follows:

ASCS	Automatic Shore Connection System
CFR	Code of Federal Regulations
GIFR	Guemes Island Ferry Replacement
HMI	Human Machine Interface
LMFB	Last make/First break
NEC	National Electrical Code, NFPA 70
PCS	Propulsion Control Systems
PMS	Power Management System
RFI	Request for Information
ROM	Rough Order of Magnitude
SES	Shoreside Electrical System
SOC	State of Charge

VES	Vessel Electrical System
WAC	Washington Administrative Code

000.4 Requested Data

The following drawings and data are requested:

- Dimensional drawings of all components.
  - Switchboards.
  - Propulsion battery banks.
  - Power conversion equipment.
- Weight estimate of all components.
- Electrical equipment description and ratings.
- One-line electrical diagram indicating scope of supply and significant features.
- Auxiliary system requirements (cooling, ventilation, etc.).
- Technical description of equipment and its operation. The description shall list all components that are in the scope of supply and proposed step by step instructions for system operation. If drawings of minor components cannot be provided at this time, a clear description with overall dimensions and weights should be provided.
- Overall electrical efficiency of all major distribution and conversion components.
- ROM cost estimate for equipment, with itemized commissioning services. Cost estimates should not include costs for shipping equipment.
- Information outlining vendor support and warrantee of equipment throughout vessel's operational life.

All documents do not need to be delivered at one time.

000.5 Project Information

The GIFR project electrical system (see Figure 1 for overview) has been broken into three portions: the Shoreside Electrical System (SES), the Automatic Shore Connection System (ASCS), and Vessel Electrical System (VES). Figure 1 is an outline of how the systems are expected to interface with each other; details of system architecture within each system may vary by vendor and technical solution.

As indicated in Figure 1, the standby generator is not within the scope of supply of the vessel electrical system vendor. Details of the AC ship service distribution panelboard are under development, Figure 1 represents preliminary design which may evolve throughout the development of the vessel.

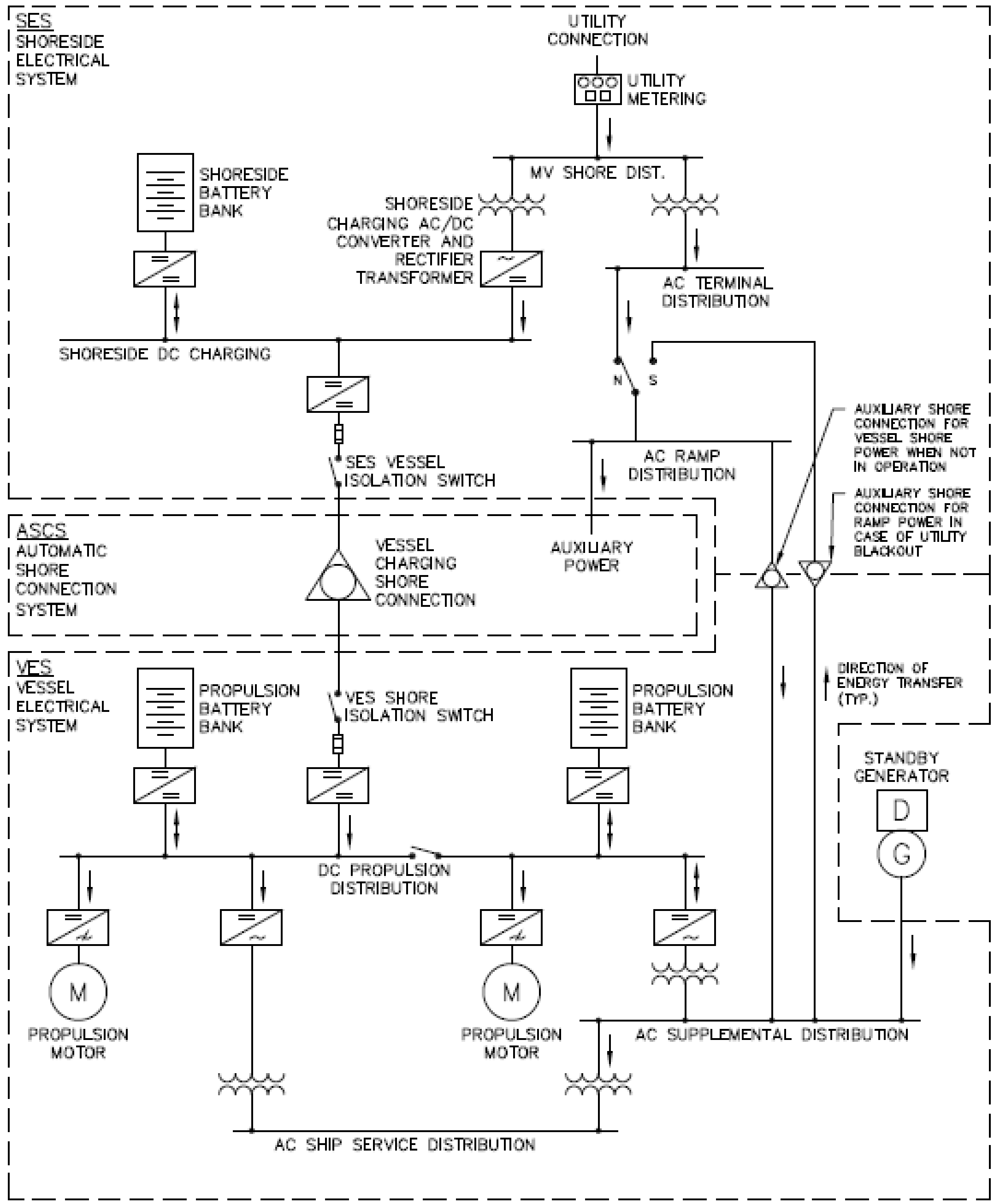


Figure 1 GIFR project electrical overview

000.5.1 Procurement and Support

Table 1 Estimated project timeline

Preliminary design complete	September 2020
Contract design complete	March 2021
Shipyard period	November 2021 to July 2023
Terminal modification period	November 2022 to April 2023
Vessel in service	September 2023

Table 1 provides an estimated timeline for major milestones for the GIFR project. Preliminary VES information from vendors is expected ahead of the completion of the preliminary design.

000.5.2 Multiple GIFR RFIs

Glosten will issue separate RFIs for the automatic shore connection system (ASCS), shoreside electrical system (SES), and propulsor units. Vendors may elect to respond to any of the RFIs on an individual basis. In cases where a cost savings may be obtained by selection of a single vendor for multiple scope items, this should be explicitly stated and costs savings broken out.

000.5.3 Vessel

Table 2 Vessel Particulars

Length, Overall	160'-0"
Beam	53'-0"
Draft	7'-6"
Car Capacity	28
Full Load Displacement	530 LT
Propulsors	(2) 700 kW L-Drive Azimuthing Propulsors
Speed, Cruise	11.5 kts

It is estimated that the vessel will operate 365 days per year, with an average of 24 round-trip crossing per operating day. Figure 2 depicts the timeline of a typical round-trip crossing, which takes 30 minutes. Note the battery sizing calculations assume some maintenance downtime resulting in 8400 round trips per year.

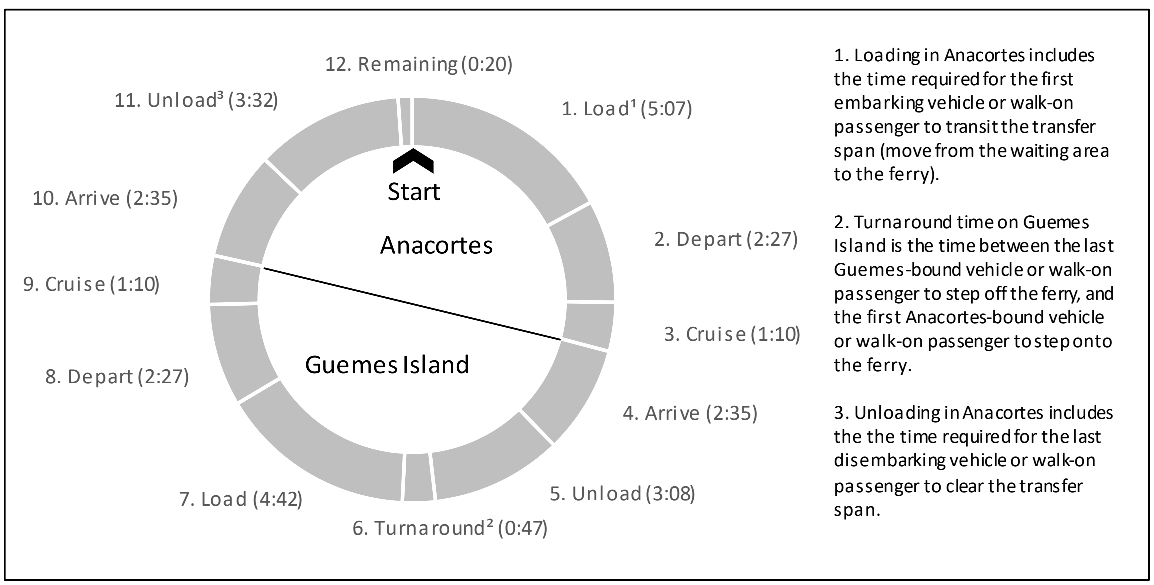


Figure 2 Typical round-trip transit

000.5.4 Terminal

The SES will be installed at the Anacortes terminal to provide high-power charging capability for the ferry. The SES will include a set of shore batteries to allow relatively constant power draw from the medium voltage utility system, with cyclic higher power discharge to the ferry.

The ASCS will be installed at the Anacortes terminal docking facility to serve the vessel. The ASCS will transfer the required electrical energy from the SES to the VES to charge the propulsion batteries and power the vessel during connection. No shore charging connection is required on the Guemes Island side.

The SES and ASCS outlined above are outside the scope of this RFI, see Section 000.5.2.

000.5.5 Regulatory

The vessel will be required to satisfy the rules for a USCG Inspected Small Passenger Vessel under US CFR Title 46, Subchapter T. This includes all aspects of the vessel electrical system which are installed on the vessel, and may also include review of the shoreside system for information. Per Title 46, the electric propulsion system is required to meet the applicable portions of Section 4-8-5/5 of the ABS Steel Vessel Rules.

The USCG has limited experience reviewing and inspecting this type of all electric vessel and the rules and requirements pertaining to a large battery installation of this type are not well defined. The integration of an ASCS of this nature on the vessel is unique in the United States and we expect both the USCG and the Washington State electrical inspectors to review this aspect of the project. Glosten is working with the regulatory bodies to define particular requirements and will provide details to vendors when available.

001 VESSEL ELECTRICAL SYSTEM (VES)

The VES shall be an all-electric system which allows the vessel to transit back and forth between the Anacortes and Guemes terminals using energy stored in propulsion batteries. The batteries will be charged during the regular loading/unloading period at the Anacortes terminal via the ASCS.

The VES must be equipped with two (2) independent propulsion battery banks. The propulsion battery banks shall serve as the two independent power sources required by the USCG, and all ship service and propulsion loads must be able to be powered from either battery bank. The main propulsion bus shall be capable of being split so that a fault on one portion of the bus does not disable ship service power and one of the two propulsion motors.

The VES must accommodate the interface to a standby generator to supplement the battery capacity in severe weather conditions and other abnormal operations (e.g. emergency evacuation or utility blackout). The standby generator is anticipated to operate less than 5% of the time the vessel is operating, but may run for extended periods of time during some runs.

Table 3 provides a summary of the major electrical power sources and loads on the vessel.

This RFI is written with the assumption that a DC propulsion bus configured in a manner similar to that shown in Figure 1 will be best suited for this project. Figure 1 is primarily intended as an outline of the scope of each electrical system; the details of the configuration may be modified to fit the capabilities of the systems offered by vendors. Vendors may propose alternate configurations. If proposing an alternate configuration, vendors should interpret the requirements of this RFI accordingly, and are encouraged to provide support in the proposal to justify the deviation from the DC bus configuration.

Table 3 Summary of major electrical power sources and loads

Equipment	Qty.	Rating (each)	Notes
DC Propulsion Dist. and ASCS Interface	1	2.0 MW 1000V DC (nom.)	See Section 001.1.3
Propulsion Battery Banks	2	800 ekW (charge) 600 ekW (discharge)	Energy storage capacity to be based on operating profile, see Section 001.1.2
Propulsion Motors/Drives	2	~750 ekW Variable speed drive	See Section 001.1.1
Ship Service Distribution	1	40 ekW 208Y/120V, 3Ø, 4W, 60 Hz	Redundant feed from propulsion battery banks See Section 001.3.1
Standby Generator	1	550 ekW 480V, 3Ø, 3W, 60 Hz	See Section 001.2.1
Ship Service Shore Connection	1	60 Amps 480V, 3Ø, 3W, 60 Hz	For use when moored and not in operation, see Section 001.2.2
Ramp Standby Connections	2	50 Amps 480V, 3Ø, 3W, 60 Hz	For ramp power in case of blackout (one each end), see Section 001.3.2

001.1 Electric Propulsion

001.1.1 Propulsion Motors and Drives

Two (2) 750 ekW variable speed motors powered by variable speed inverters will provide power for the azimuthing L-drive propulsors. The following are general motor characteristics which should be used for the purposes of this proposal:

a. Water-jacket cooled.

b. PM synchronous type.

c. V1 flange mount (vertical, shaft facing down, to interface with propulsor).

d. Continuous duty.

e. Embedded winding and temperature sensors.

f. DE & NDE bearing temperature sensors.

g. 0-100% speed control.

h. 6500 Nm torque.

i. 1100 rpm maximum (both directions).

The above characteristics are preliminary and will be confirmed as the design progresses. The motor is expected to need to be as short as possible to clear the deck above. A compact purpose-built motor for marine L-drive applications is expected to be most suitable. Geometric requirements of the motor are discussed in the propulsor RFI, see Section 000.5.2.

The propulsion drives must interface with the power management system and power limiting functions (see Sections 001.1.4 and 001.4.3).

001.1.2 Propulsion Batteries

Two sets of propulsion battery banks must be configured to serve as the two electrical power sources required by USCG. The batteries should be sized to provide a 10 year operational life based on the probabilistic load profiles listed in Table 4 and 8400 round trips per year (24 runs per day, 350 operating days per year). The load profiles listed in Table 4 reflect the battery power required for each propulsion battery bank.

The standby generator is assumed to be operating in the “With Generator” and “Schedule Slip” load profiles shown in Table 4.

Each battery bank is to have the following features/capabilities:

a. Independent battery management system.

    1. Charging control.

    2. High temperature alarm and high-high temperature shutdown functions.

    3. High voltage and abnormal voltage deviation alarm and shutdown functions.

b. Battery modules equipped for isolation and mitigation of thermal runaway.

c. Meet the requirements of ASTM F3353-19, *Shipboard Use of Lithium-Ion Batteries*.

d. UL 1642 or IEC 62619 certified.

e. Temperature monitoring for each battery cell. A single sensor located between two cells may be used, but a single sensor may not monitor more than two cells.

Table 4 Cumulative probability load profiles for propulsion batteries based on weather and tidal predictions

Operation		50% Probability[1]		80% Probability[1]		95% Probability[1]				99.7% Probability[1]	
		Average Run		*Above Average*		Without Generator		With Generator		Schedule Slip	
		Time [minute]	Power[2] [kW]	Time [minute]	Power[2] [kW]	Time [minute]	Power[2] [kW]	Time [minute]	Power[2] [kW]	Time [minute]	Power[2] [kW]
Anacortes to Guemes Isl.	*Maneuver*	0.87	566.0	0.90	629.1	0.90	681.7	0.90	194.1	0.87	566.0
	Ramp Up	0.78	816.4	0.78	923.7	0.78	999.4	0.78	511.8	0.78	816.4
	Cruise	1.17	687.0	1.17	776.4	1.18	839.5	1.18	351.9	1.17	687.0
	Ramp Down	0.78	492.9	0.78	555.5	0.78	599.6	0.78	112.1	0.78	492.9
	Maneuver	1.03	566.0	1.03	629.1	1.20	681.7	1.20	194.1	1.03	566.0
	Unload/Load	9.02	134.7	9.67	229.4	10.23	408.2	10.23	-79.4	9.02	134.7
Guemes Isl. to Anacortes	*Maneuver*	0.87	566.0	0.90	629.1	0.90	681.7	0.90	194.1	0.87	566.0
	Ramp Up	0.78	816.4	0.78	923.7	0.78	999.4	0.78	511.8	0.78	816.4
	Cruise	1.17	687.0	1.17	776.4	1.18	839.5	1.18	351.9	1.17	687.0
	Ramp Down	0.78	492.9	0.78	555.5	0.78	599.6	0.78	112.1	0.78	492.9
	Maneuver	1.03	566.0	1.03	629.1	1.20	681.7	1.20	194.1	1.03	566.0
	Unload/Load	1.00	134.7	1.00	229.4	1.00	408.2	1.00	-79.4	1.00	134.7
	Unload/Load (charging)[3]	10.72	-702.7	10.00	-948.2	9.07	-1386.3	9.07	-206.5	10.72	-702.7

1. Probabilities listed indicate the annual cumulative probability that the required load profile power will not be exceeded.
2. Required power discharge from batteries reflects the quantity that would be measured at connection to DC propulsion switchboard; negative values indicate battery charge. Conversion and battery losses are not reflected in these values.
3. Charging from the ASCS during unload/load at Anacortes estimated assuming a constant charge/discharge cycle efficiency of 95%. These values should be adjusted based on specific system capabilities.

001.1.3 Shore Charging

The electric propulsion and battery systems must be capable of being powered through the ASCS while simultaneously providing power to ship service and propulsion motor loads, charging both propulsion battery banks, and in some cases also consuming power generated by the standby generator.

001.1.4 Power Management System (PMS)

The PMS will provide control and monitoring of the battery electric system through HMIs and other operator interfaces at the main switchboard and the two (2) pilothouse control stations (one facing each direction). The PMS should include the following features:

a. Automatic loadshed of non-vital ship service loads and power-limit control of propulsion motors as required to avoid prolonged overload and blackouts. Additional capability for manual control to loadshed of non-vital loads in case of lower than desired battery SOC.

b. Control, monitoring, and safety protection function interfaces with the ASCS and SES to enable automated charging and safety disconnections. See Section 001.4 for interface details.

c. Controls to remotely bring the standby generator on and off-line and set the power generation level. Operation of the standby generator will be manual only, with no automatic functions except for safety related shutdowns. See Section 001.4.4 for interface details.

d. Alarm, monitoring, and control of equipment within the scope of the electric propulsion system, similar to that required for an unattended machinery space; including equipment faults, propulsion battery health and status, breaker status, voltage, frequency, current, etc.

e. Monitoring of power consumption and battery SOC with options for real time comparison to a range of previous trip profiles, averages, and targets.

f. Monitoring and alarm of the battery SOC which provides indication of various SOC thresholds and a range of alarms activated by SOC levels outside of the nominal range.

The PMS shall include or interface with a method of logging parameters of the electric propulsion system such as propulsion power, ship service power, and SOC, along with other outside parameters which affect energy use like currents, wind, and vessel loading. Vendors are encouraged to propose logging, tracking, and analytic tools that will help reduce operation costs and energy consumption.

001.2 Supplemental Power Sources

001.2.1 Standby Generator

A 550 ekW standby diesel generator will serve as a standby power source in addition to the main battery electric system. The standby generator is expected to operate in the following instances:

a. Utility blackout at the Anacortes terminal which prevents charging of the propulsion batteries through the ASCS.
b. High propulsion loads due to severe weather, requiring supplemental power generation to maintain schedule or avoid undesirably high discharges of the propulsion batteries.
c. Transit off-site or emergency operations outside of typical operating profile.

The standby generator is planned to be a standardized skid mounted 480V, 3-phase, 3-wire, 60Hz synchronous marine genset. Figure 1 shows an acceptable configuration for integrating the standby genset in to the VES, however the vendor may propose alternate ratings and methods of interconnection which meet the project design intent (see exception below).

The vendor should provide for interfaces with the standby generator as described in Section 001.4.4.

Other than the exception described below, supply of the standby genset skid should not be included in the scope of the VES proposal; the standby genset skid is intended to be provided by the shipyard.

Exception: Vendors may propose an alternative to the 480VAC rating for the standby generator, but must include the proposed genset skid (engine, generator, etc.) in the technical proposal and as a line item in the commercial proposal. Vendors considering this alternative are encouraged to discuss further with Glosten.

001.2.2 Auxiliary Shore Power

A ship service shore power receptacle rated for 480V, 3-phase will provide power for the ship service system while the vessel is moored at the Anacortes terminal and unattended (ASCS not intended to operate while vessel is not crewed). The rating of the circuit will be 60 amps or less, to be finalized later in the design process. The receptacle will be located on the Anacortes end of the vessel and will be used for manual connection to the shore power cable.

001.3 AC Distribution

001.3.1 Ship Service Distribution

The main ship service system should distribute 208Y/120Y, 3-phase, 4-wire, 60Hz power and must have the following characteristics:

a. Separate power feed from each of the two propulsion batteries (similar to Figure 1), with interlocked breakers or power transfer switches for isolation to ensure the panel can only be energized from one source at a time. The separate power feeds shall include independent inverters and transformers to provide fully redundant means of power supply to the ship service bus.

b. Rated, at minimum, for 40kW continuous load.

001.3.2 Ramp Standby Power Receptacles

Two (2) ramp standby power receptacles, each rated for a maximum of 60 amps, 480V, 3-phase, will provide a second source of power for equipment which actuates the ramp and ASCS in case of utility blackout. Receptacles will be located on each end of the vessel and will be used for manual connection to cable plugs at each terminal.

Unlike the main ship service distribution, the ramp standby power receptacles are not vital loads and do not require redundant power sources. The system must be able to provide 60 amps continuously at one of the standby power receptacles, and have sufficient short-time overload capacity for starting a 15kW 3-phase squirrel cage motor.

001.4 Systems Interface

The VES should provide a high level of automation and integration to allow the two-person crew on the ferry to focus attention on maneuvering and vessel operation.

001.4.1 Automatic Shore Connection System (ASCS)

The following outlines the interfaces and connections expected to be required between the VES and ASCS:

a. Wireless communication between ASCS and VES to allow the vessel operator to remotely monitor the ASCS and control the ASCS connection.

b. Ground bond to hull for ASCS ground conductor(s) and ground continuity relay pilot conductor. VES to facilitate installation of ground continuity relay end device, but the ground continuity check system to be provided as part of SES.

c. The following hard-wired control circuits are envisioned but may be modified as the design progresses:

   1. The primary control and data transfer interface between the SES and VES (see below).

   2. ASCS emergency disconnect circuit. The circuit will be energized by the ASCS control power, and the ASCS will immediately disconnect if the circuit is opened. The ASCS vendor shall provide emergency pushbuttons to open the circuit at the pilothouse control stations and adjacent to the ASCS socket.

   3. SES pilot circuit, circuit made by LMFB contacts in ASCS. The circuit will be energized by the SES control power, and the SES isolation switch will not be able to close unless the circuit is closed and will open if the circuit is broken. The VES shall provide a contact in series with the circuit to coordinate operation of the isolation switches.

   4. VES pilot circuit, circuit made by LMFB contacts in the ASCS. The circuit shall be energized by the VES, and the VES shore isolation switch shall not be able to close unless the circuit is closed, and shall open if the circuit is broken. The SES and ASCS will provide contacts in series with the circuit to coordinate operation of the isolation switches.

Items (b) and (c) above are based on what is expected to be required for a galvanically connected ASCS. Induction or other galvanically isolated types of connection systems will have different interfaces, but the functions for item (c) will still be required in some manner.

001.4.2 Shoreside Electrical System (SES)

Electrical Power

The SES will provide electrical power on demand to the VES through the ASCS to charge the vessel propulsion batteries and power vessel loads while the ASCS is connected. The SES will regulate the source voltage to maintain the nominal voltage at the vessel.

The VES must coordinate fluctuations in vessel loads with charging the vessel batteries to maintain a relatively constant power transfer from the SES over a given charging cycle, and to ramp up and ramp down power transfer on either end of the charge cycle.

Control and Data Transfer

The SES and VES must have a set of control and data transfer interfaces which allow communication between the two systems. These interfaces are expected to be driven primarily by the requirements of the SES, but will include:

a. Basic connection and monitoring feedback to the SES to coordinate operation of isolation switches and charging.
b. Basic energy required and charging duration feedback in real-time to the SES during the vessel charging cycle. This is intended to allow the SES to coordinate the power flow from the shoreside batteries and the utility in an effort to allow the SES to optimize utility power demand (i.e. reduce monthly peak power demand) and the shoreside battery cycle.
c. Additional feedback to the SES including required energy and duration predictions for upcoming charge cycles, time remaining before next charge cycle, and other relevant data. This is intended to inform the shoreside battery charging rates while the ASCS is not connected as a means to further optimize each SES cycle.
d. Basic monitoring information from the SES to alert vessel operators of utility blackouts and other shoreside electrical conditions which will impact vessel operations.

The primary interface between the two systems will be over a wired or fiber-optic connection provided through the ASCS, intended to facilitate items (a) and (b) above. The details of the signal protocol used for (b) will be developed. Either analog current/voltage signals or an industrial ethernet communication over fiber-optic is expected to be used. Note that if the ASCS is of the non-conductive type (e.g. inductive charging) the primary interface will need to be over a robust and secure wireless connection.

A secondary interface between the two systems should be able to facilitate basic data transfer between the VES and SES when the ASCS is not connected (i.e. wireless) to facilitate items (c) and (d) above. The secondary interface is not intended to be used for primary control of charging equipment.

001.4.3 Propulsion Control Systems (PCS)

A basic PCS will allow for thrust and azimuth control of the two L-drives from the two pilothouse control stations. The propulsion drives shall interface with the PCS to provide the required control and feedback, and the PMS shall interface with the PCS for power limit control functions. The secondary interface is not intended to be used for primary control of charging equipment.

001.4.4 Standby Generator

The VES shall include all required interfaces to connect, control, and provide electrical protection of the standby generator, including the following:

a. Base load operation in parallel with ship service inverter capabilities. Baseload setpoint as percent power to be manually adjustable through the PMS interfaces.

b. Manual start/stop and connection capability through PMS.

c. Standard generator protection features including overcurrent, short-circuit, reverse power as well as automatic stop of generator upon high voltage or 100% battery SOC.

The standby generator skid is planned to include a local operator panel to handle the basic standard alarm and protection functions such as over-speed, high-temperature, low-pressure. These functions are expected to be outside the scope of the VES.

REQUEST FOR INFORMATION – AUTOMATIC SHORE CONNECTION SYSTEM

GUEMES ISLAND FERRY REPLACEMENT

000 GENERAL REQUIREMENTS

000.1 Objective

This Request for Information describes the requirements for an automatic shore connection system (ASCS) to charge the batteries aboard the Guemes Island Ferry Replacement (GIFR) vessel, a 160-ft. battery electric passenger and vehicle ferry, at the ferry terminal in Anacortes, Washington. Skagit County owns and operates the Guemes Island ferry and ferry terminal. Glosten has been selected by Skagit County to design the replacement vessel and the associated charging system. We are requesting detailed technical information including a description of the shore connection system, equipment drawings, specifications, and rough order of magnitude (ROM) pricing for this equipment to progress the design of the vessel and ferry terminal.

The GIFR vessel is expected to be the first purpose-built electric vehicle ferry in the United States and implementation of the automated shore connection system for the vessel is expected to be the first of its kind in the United States. The automated shore connection system selected for this project could serve as a model for future ferry projects in Washington State and the surrounding region.

The information provided in response to this RFI will not be used as a basis for selection of vendor or equipment.

Responses are requested by 30 June. Please note all information does not need to be provided at one time and early information submittal is encouraged.

000.2 Reference Documents

The following are documents referenced within this RFI:

1. *GIFR Vessel Layout (2D CAD)*, Glosten, Inc. (17097.02_GIFR Vessel Layout_ASCS RFI_2019-07-21.dwg).

2. *Anacortes Terminal As-Builts (2D CAD)*, PND Engineers, Inc. (174082-01.dwg).

3. *GIFR Transportation System Assessment (PDF)*. Glosten, Inc., Document No. 17097-000-02, Rev. -, 14 December 2018.

The above documents are for informational purposes only and should not be used for design and engineering beyond the purposes of this inquiry.

To request these documents, please email Jeff Rider at jmrider@glosten.com.

000.3 Acronyms

Acronyms used throughout this document are as follows:

ASCS	Automatic Shore Connection System
CFR	Code of Federal Regulations
FMLB	First Make/Last Break
GIFR	Guemes Island Ferry Replacement

LMFB	Last Make/First Break
NEC	National Electrical Code, NFPA 70
RFI	Request for Information
ROM	Rough Order of Magnitude
SES	Shoreside Electrical System
VES	Vessel Electrical System
WAC	Washington Administrative Code

000.4 Requested Data

The following drawings and data are requested:

- Dimensional drawings of all components.
  - Vessel and shoreside charging apparatus.
  - Control cabinets, panels, misc. equipment.
  - Proposed arrangement(s) of the charging apparatus interface between vessel and shoreside components.
- Weight estimate of all components.
- Electrical equipment description and ratings.
- One-line electrical diagram indicating scope of supply and significant features.
- Auxiliary system requirements (electrical, hydraulics, etc.).
- Description and/or schematics of interlocks and safety functions.
- Technical description of equipment and its operation. The description should list all components that are in the scope of supply and proposed step by step instructions for system operation. If drawings of minor components cannot be provided at this time, a clear description with overall dimensions and weights should be provided.
- Overall electrical efficiency of components.
- ROM cost estimate for equipment packages, with itemized commissioning services. Cost estimates should not include costs for shipping equipment.
- Information outlining vendor support and warrantee of equipment throughout vessel's operational life.

All documents do not need to be delivered at one time.

000.5 Project Information

The GIFR project electrical system (see Figure 1 for overview) has been divided into three portions: the Shoreside Electrical System (SES), the Automatic Shore Connection System (ASCS), and Vessel Electrical System (VES). Figure 1 is an outline of how the systems are expected to interface with each other; details of system architecture within each system may vary by vendor and technical solution.

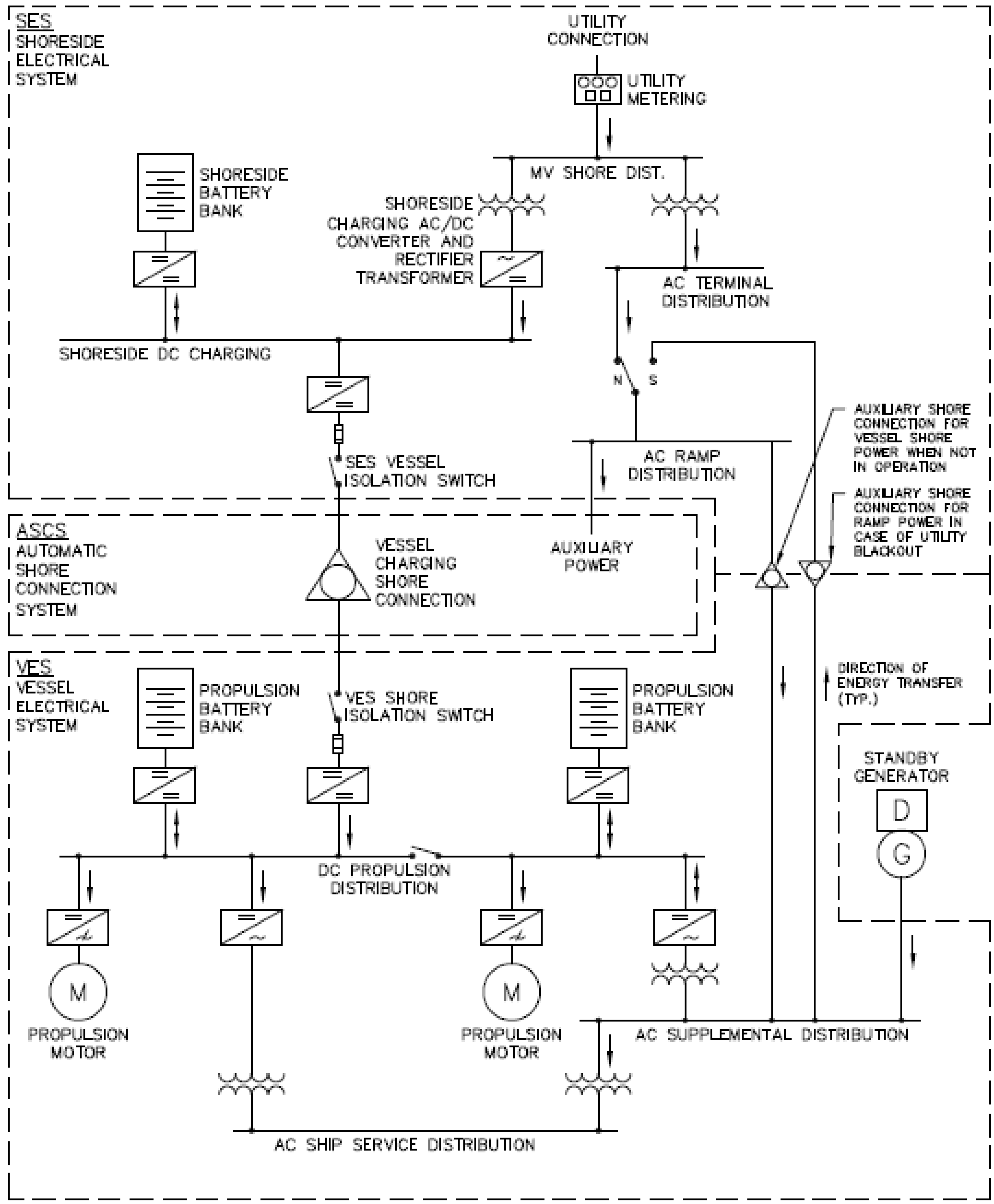


Figure 1 GIFR project electrical overview

000.5.1 Procurement and Support

Table 1 Estimated project timeline

Preliminary design complete	September 2020
Contract design complete	March 2021
Shipyard period	November 2021 to July 2023
Terminal modification period	November 2022 to April 2023
Vessel in service	September 2023

Table 1 provides an estimated timeline for major milestones for the GIFR project. Preliminary ASCS information from vendors is expected ahead of the completion of the preliminary design.

000.5.2 Multiple GIFR RFIs

Glosten will issue separate RFIs for the vessel electrical system (VES), shoreside electrical system (SES), and propulsor units. Vendors may elect to respond to any of the RFIs on an individual basis. In cases where a cost savings may be obtained by selection of a single vendor for multiple scope items, this should be explicitly stated and costs savings broken out.

000.5.3 Vessel

Table 2 Vessel particulars

Length, Overall	160'-0"
Beam	53'-0"
Draft	7'-6"
Car Capacity	28
Full Load Displacement	530 LT
Propulsors	(2) 700 kW L-Drive Azimuthing Propulsors
Speed, Cruise at Full Load	11.5 kts

It is estimated that the vessel will operate 365 days per year, with an average of 24 round-trip crossings per operating day. Figure 2 depicts the timeline of a typical roundtrip crossing, which takes 30 minutes.

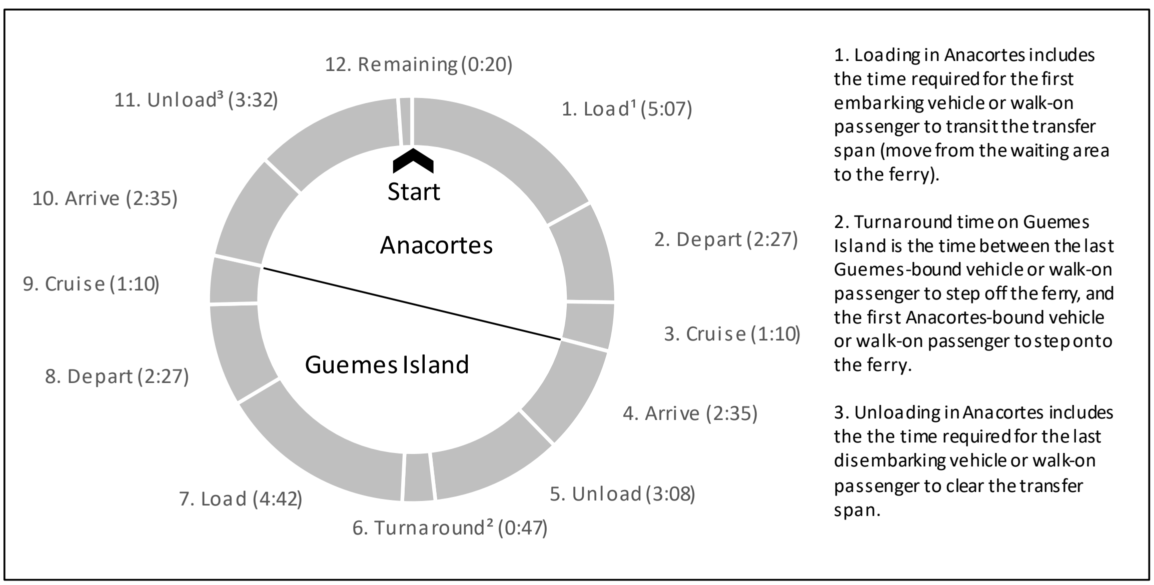


Figure 2 Typical round-trip transit

The vessel electrical system (VES) will consist of a common DC bus with two independent propulsion battery banks, which serve as the primary sources of power. Power for the propulsion motors will be taken directly from the DC bus and converted to 600-690VAC, 3-phase. Other consumers can be powered by 480VAC or 208Y-120VAC, 3-phase, 60 Hz. A 550 ekW onboard standby diesel generator will provide supplementary power for propulsion, ship loads, and battery charging during abnormal operations (e.g. bad weather, transit offsite).

The VES outlined above is outside the scope of this RFI, see Section 000.5.2.

000.5.4 Terminal

The ASCS will be installed at the Anacortes terminal (see Figure 3) to serve the GIFR vessel. No shore charging connection is possible on the Guemes Island side.

SES

The shoreside terminal facilities on the Anacortes side will be modified to provide electrical power to the new vessel. The following will be included in the scope of the shoreside electrical system (SES) modifications:

- Electrical house for SES equipment.
- New primary distribution voltage point of delivery from utility with associated metering equipment.
- New 690V step-down transformer from utility primary distribution voltage (12.5kV).
- Shore batteries with sufficient capacity to eliminate spikes in utility power demand while charging.
- Battery management and control system.
- Shore connection circuit protection and disconnects.

The SES outlined above is outside the scope of this RFI, see Section 000.5.2.

The voltage of the shoreside batteries and shore connection supply are planned for 1000VDC.

Existing Terminal

480VAC, 3-phase, 60 Hz power is currently supplied to machinery at the ramp apron and lifting tower. This is the preferred power source for auxiliary equipment required for the ASCS. One other voltage can be provided at the terminal, if necessary, for the ASCS. The additional voltage must be either 120V 1-phase, 240V 1-phase, 120V 3-phase, or 208V 3-phase.

The shoreside vehicle loading infrastructure is depicted in Figure 3, and consists of a fixed approach span, movable transfer span and apron ramp, and the lifting tower and headframe. The transfer span is hinged at the approach span and the other end is supported at the lifting tower with a cable system that allows the height of vessel end of the span to be adjusted to match the tides. The apron ramp is supported by the transfer span and is raised and lowered by a hydraulic system. When the ferry arrives at the terminal, a deckhand on the vessel lowers the apron ramp to the ferry car deck using a control pendant attached to the end of the apron ramp, as seen in Figure 4. The apron ramp will extend full width between the wingwalls, the full width is required to allow simultaneous vehicle and passenger loading/unloading.

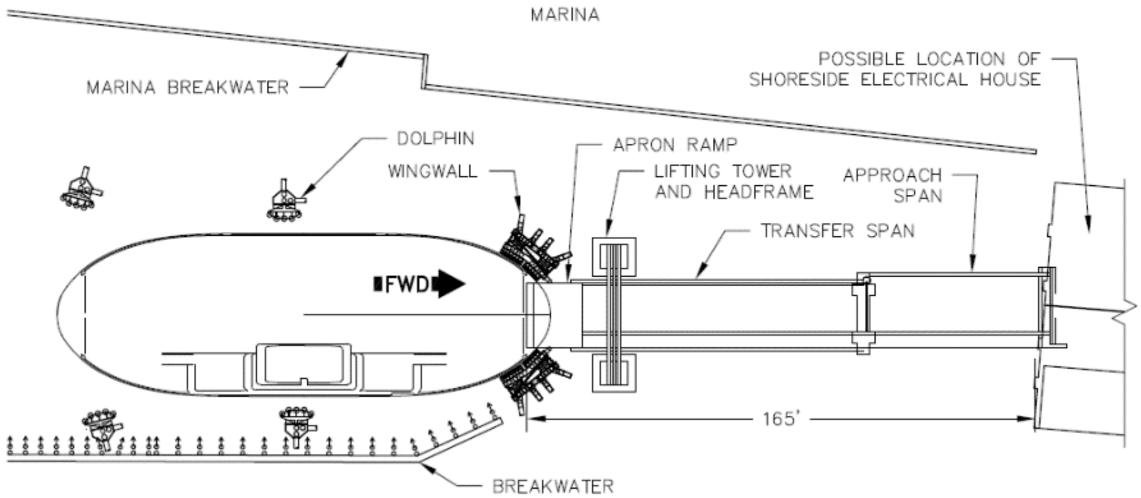


Figure 3 Anacortes terminal

Figure 4 Apron ramp operation on existing vessel

000.5.5 Regulatory

The modifications to the existing ferry terminal in Anacortes will be required to satisfy the requirements of WAC-246B Electrical Safety Standards, Administration and Installation, and the NEC. The scope of these rules will apply to all installations not on the vessel.

The vessel will be required to satisfy the rules for a USCG Inspected Small Passenger Vessel under US CFR Title 46, Subchapter T. This includes all aspects of the automatic shore connection system which are installed on the vessel, and may also include review of the shoreside system for information.

The integration of an ASCS of this nature on the vessel is unique in the United States and we expect both the USCG and the Washington State electrical inspectors to review this aspect of the project. Glosten is working with the regulatory bodies to define particular requirements and will provide details to vendors when available.

001 AUTOMATIC SHORE CONNECTION SYSTEM

001.1 Power Transfer and Connection Requirements

Table 3 Connection requirements

Energy Transfer	280 kWh (1008 MJ)
Power Transfer*	2.0 MW
Ramp up/down duration*	30 seconds (each)
Connect/disconnect duration*	30 seconds (each)
Available duration for connection	10 minutes

*Estimated values, may be adjusted by vendor based on proposed ASCS capabilities

Table 3 lists the required energy transfer through the ASCS and the available connection duration. In Table 3, power transfer is estimated from assumed ramp rates and connection speed. Total time available for connection, ramp-up, charging, ramp-down, and disconnection is 10 minutes. Estimated power transfer rate may be adjusted by the vendor based on ASCS connection speed.

The ASCS must be capable of completing a full connection, charge, disconnect cycle with minimal supervision from the crew. Operation of the ASCS will be primarily monitored from the pilothouse. The pilothouse should be equipped with controls for one-touch commands for connection and disconnection, emergency stop/disconnect, and other manual operations. In addition to these controls, it would be preferable to have a fully automated system which allows for fully automated connection and disconnection. All other aspects of the charging cycle should be automated through interfaces between the SES, ASCS, and VES.

001.2 Range of Motion Requirements

The expected range of motions for the vessel while the ASCS is active are listed in Table 4. This information is preliminary and will be confirmed or revised by Glosten during contract design.

The ASCS must be able to follow the vessel through all combinations of dynamic ranges without interrupting power transfer to the vessel or damage to equipment. No margin factor has been applied to the dynamic ranges listed in Table 4, systems with capability to exceed the listed ranges will be considered beneficial.

In general, the motions listed in Table 4 can be assumed to be from a point at the center of buoyancy of the ferry which is on centerline, amidships, and approximately 5' above baseline. Due to the interaction of the bow of the vessel with the wing walls, both yaw and sway are referenced from a point 20' aft of the bow (60' forward of amidships). The bow refers to the Anacortes end of the vessel, as shown in Figure 3. Given that the connection point location has not been established, linear movements at a particular location will need to be estimated based on the reference points.

The range of motion listed in Table 4 does not account for the range required for the ASCS to deploy from a standby position out of the way of the ferry. See Section 001.3 regarding positions and clearances around the vessel while docking.

Table 4 Preliminary range of vessel motion

	Dynamic Range of Motion (minimum)	Reference Location	Additional Details	Notes
Pitch	± 1.5°	Center of buoyancy		
Roll	± 4°	Center of buoyancy		
Yaw	± 1°	20' aft of bow	See Allowable Yaw, Section 001.2.2	Rotation about bow (Anacortes) end
Heave	± 12"	Center of buoyancy	See Tidal Compensation, Section 001.2.1	Does not include tidal range
Surge	± 4"	Center of buoyancy		
Sway	± 4"	20' aft of bow	See Allowable Yaw, Section 001.2.2	The apparent sway near amidships is larger due to yaw

001.2.1 Tidal Compensation

The shoreside portion of the ASCS will be installed on a fixed foundation supported by steel piles. The ASCS should be able to connect with the vessel over the 15.5' tidal range at the terminal while allowing for the dynamic motion in Table 4. Proposed ASCS which provide for a slightly smaller tidal range may be put forward, but the limitation to vessel operations will be taken into consideration when the ASCS information is assessed.

Other options for foundations which do not require tidal compensation integral to the ASCS, such as floating platforms or installations fixed to the apron ramp, may be considered, but are not preferred. Where the cost, weight, or complexity of an ASCS is significantly increased by following the tidal range, vendors may provide additional information for an ASCS without tidal compensation for installation on an alternate foundation.

001.2.2 Allowable Yaw

The range of allowable yaw depends on how the vessel operates. A full range of yaw between the two midships dolphins (see Figure 5) is desired because it will allow the operator full flexibility to rest against either dolphin (dictated by tidal current or wind direction), allow the vessel to be centered between dolphins (preferred for loading long or oversized vehicles), and allow the vessel to be bow moored during breaks between ferry transits. Proposed ASCS with smaller yaw ranges than that shown in Figure 5 may be put forward, but the limitation to vessel operations should be clearly provided. Figure 6 illustrates the minimum range of yaw that an ASCS must allow due to deflection of the dolphin fender panels.

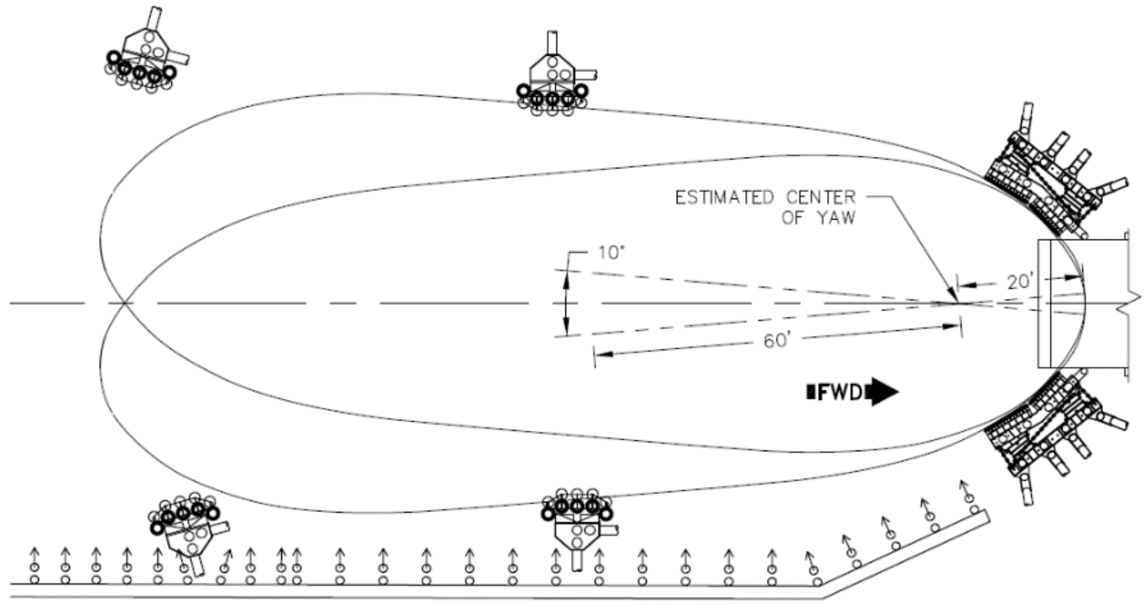


Figure 5 Desired yaw range

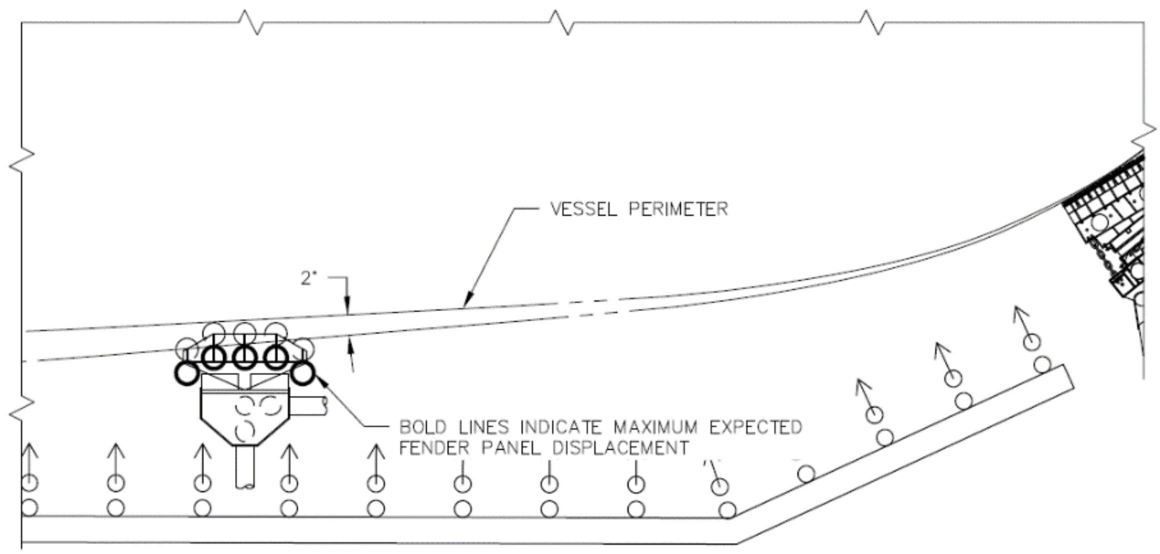


Figure 6 Minimum required yaw range

001.3 Equipment Location and Configuration

Glosten will determine the best location and configuration for each ASCS based on the discussions with vendors and the information provided. Vendors are encouraged to work closely with Glosten to help determine the optimum location and configuration for their system.

The following factors should be considered when contemplating locations and configurations:

- Visibility from the pilothouse.
- Effect on passenger walkways and seating, and vehicle loading/unloading.
- Risk of vessel collisions with shoreside shore connection equipment and foundation.

Effect of connection apparatus on vessel appearance; notably, connection apparatus which have minimal impact of the profile outline of the vessel is preferred.

Based on initial review of ASCS options available and the vessel layout, Glosten has developed several possible locations which would be suitable for the shore charging system; these hatched locations are shown in Figure 7.

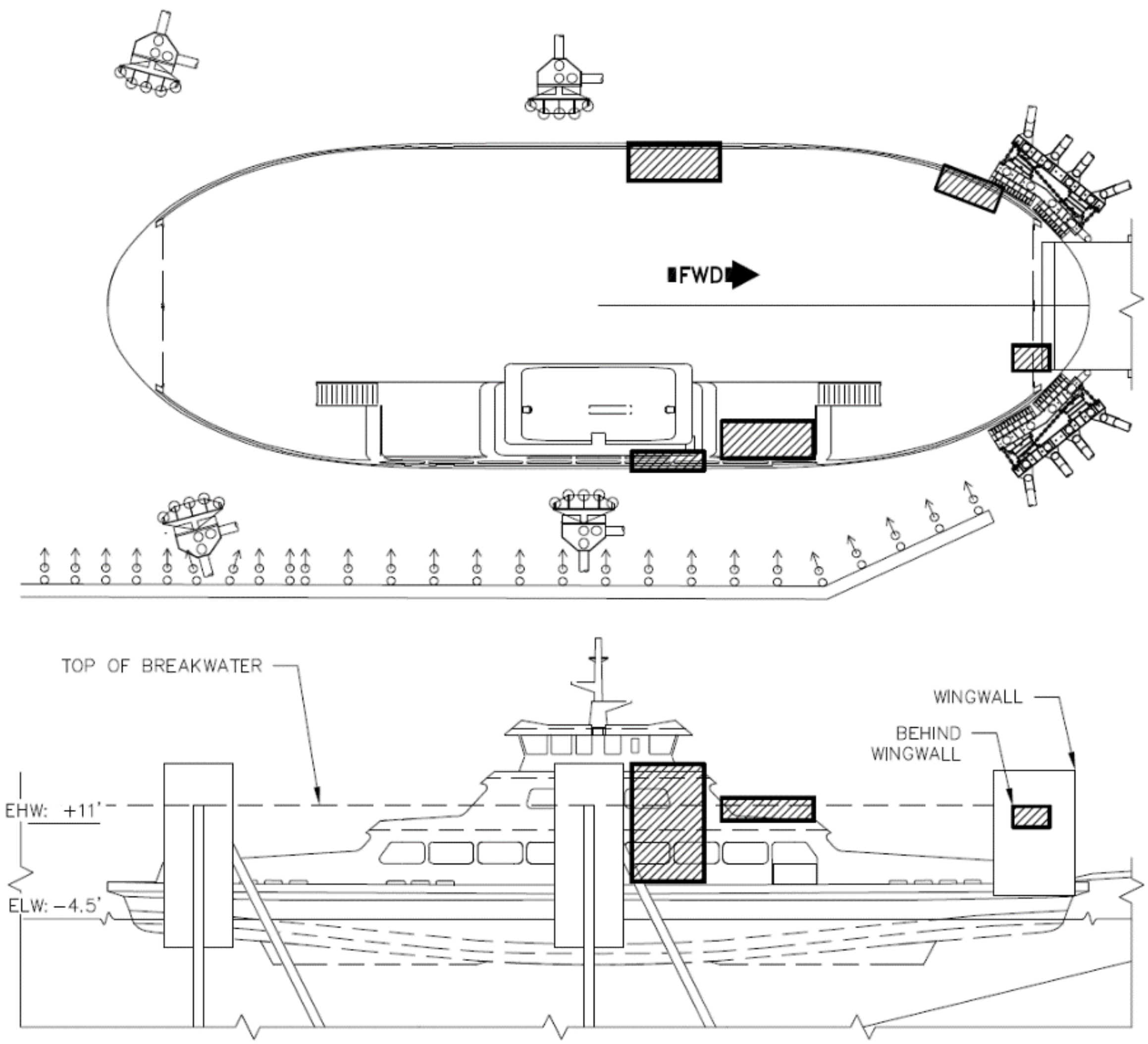


Figure 7 Vessel layout and possible locations for vessel portion of ASCS indicated by hatching

001.4 Safety Provisions

The size and arrangement of the GIFR vessel requires the charging connection on the vessel to be located adjacent to crew, passenger, and/or vehicle areas. Any shore connection system must be able to provide a very high level of protection for passengers and crew and minimize the risk of physical damage to the vessel and shore connection equipment.

Vendors should include details of the safety provisions and protections that are either integral to the system or should be provided by others as part of the overall vessel and terminal installations. This should include prevention or mitigation of risks associated with planned and unplanned events, including:

- Unplanned or unexpected actuation of automatically controlled ASCS equipment.
- Electrical faults.
- Failure of electrical disconnects, ground connections, or safety controls and monitoring.
- Interference of passengers, water spray, or other foreign objects into normal deployment and charging.
- Vessel motions outside the allowable range that could cause physical damage to the charging connection.
- Unplanned disconnection due to extreme vessel motion or vessel departure.

001.5 System Integration

The ASCS will be integrated with the VES and SES to provide the required power for charging the vessel batteries and shore connection circuit protection. Control of the power transmission rate will be through the VES and SES and should be considered outside the scope of the ASCS, unless necessary for operation of the ASCS.

The ASCS should provide for transmission between the SES and VES of electrical power at a nominal 1000VDC, vital safety and control functions over hard-wired 24VDC control circuits, and data communication over wired industrial ethernet. Alternative types of transmission methods may be considered and should be discussed with Glosten.

Vendors should provide emergency pushbuttons to open the circuit at the pilothouse control stations and adjacent to the ASCS socket. The installation of this equipment on the vessel will be performed by others.

Vendors should include information related to the integration of electrical, control, and safety features of the ASCS with the vessel and shoreside electrical systems. The following is a basic outline of the minimum level of interfaces expected for a typical galvanically connected ASCS. Vendors should provide a details list of interfaces specific for their system:

- FMLB ground conductor(s) and ground continuity check safety system for tripping vessel and shoreside disconnect switches.
- LMFB permissive circuit conductors for vessel and shoreside disconnect switches.
- Emergency stop and disconnect operable by crew at the pilothouse, connection point, and shoreside.
- Hardwired and/or serial/ethernet connections to both the VES and SES for control and monitoring.
- Wireless communication connection for remote monitoring and fault indication of the ASCS on the vessel while in transit.

REQUEST FOR INFORMATION – SHORESIDE ELECTRICAL SYSTEM

GUEMES ISLAND FERRY REPLACEMENT

000 GENERAL REQUIREMENTS

000.1 Objective

This Request for Information describes the requirements for the shoreside electrical system required to support the Guemes Island Ferry Replacement (GIFR) vessel, a 160-ft. battery electric passenger and vehicle ferry, at the ferry terminal in Anacortes, Washington. Skagit County owns and operates the Guemes Island ferry and ferry terminal. Glosten has been selected by Skagit County to design the replacement vessel and the associated charging system. We are requesting detailed technical information including a basic one-line diagram, equipment drawings, specifications, and rough order of magnitude (ROM) pricing for this equipment to progress the design of the terminal modifications.

The GIFR vessel is expected to be the first purpose-built electric vehicle ferry in the United States and implementation of the automated shore charging system for the vessel is expected to be the first of its kind in the United States. The shore charging system selected for this project could serve as a model for future ferry projects in Washington State and the surrounding region.

The information provided in response to this RFI will not be used as a basis for selection of vendor or equipment.

Responses are requested by 30 June. Please note all information does not need to be provided at one time and early information submittal is encouraged.

000.2 Reference Documents

The following are documents referenced within this RFI:

1. *GIFR Transportation System Assessment (PDF)*. Glosten, Inc., Document No. 17097-000-02, Rev. -, 14 December 2018.

2. *Schedule 26 Large Demand Service* (PDF). Puget Sound Energy. Issued March 30, 2018.

The above documents are for informational purposes only and should not be used for design and engineering beyond the purposes of this inquiry.

To request these documents, please email Jeff Rider at jmrider@glosten.com.

000.3 Acronyms

Acronyms used throughout this document are as follows:

ASCS	Automatic Shore Connection System
CFR	Code of Federal Regulations
GIFR	Guemes Island Ferry Replacement
LMFB	Last make/First break
NEC	National Electrical Code, NFPA 70
NESC	National Electrical Safety Code, IEEE C2
NRTL	Nationally Recognized Testing Laboratory

PMS	Power Management System
PSE	Puget Sound Energy (electrical utility)
RFI	Request for Information
ROM	Rough Order of Magnitude
SES	Shoreside Electrical System
VES	Vessel Electrical System
WAC	Washington Administrative Code

000.4 Requested Data

The following drawings and data are requested:

- Dimensional drawings of all components.
  - Switchboards.
  - Electric house.
  - Battery bank.
  - Transformers.
  - Control equipment.
- Weight estimate of all components.
- Electrical equipment description and ratings.
- Outline of proposed standards and listings (NRTL) to be used for compliance with NEC and NESC for system design and major equipment including batteries, battery management system, and power conversion equipment.
- One-line electrical diagram indicating scope of supply and significant features.
- Auxiliary system requirements (cooling, ventilation, etc.).
- Technical description of equipment and its operation. The description should list all components that are in the scope of supply and proposed step by step instructions for system operation. If drawings of minor components cannot be provided at this time, a clear description with overall dimensions and weights should be provided.
- Electrical efficiency of all major distribution and conversion components.
- ROM cost estimate for equipment, with itemized commissioning services. Cost estimates should not include costs for shipping equipment.
- Information outlining vendor support and warrantee of equipment throughout vessel's operational life.

All documents do not need to be delivered at one time.

000.5 Project Information

The GIFR project electrical system (see Figure 1 for overview) has been divided into three portions: the Shoreside Electrical System (SES), the Automatic Shore Connection System (ASCS), and Vessel Electrical System (VES). Figure 1 is an outline of how the systems are expected to interface with each other; details of system architecture within each system may vary by vendor and technical solution.

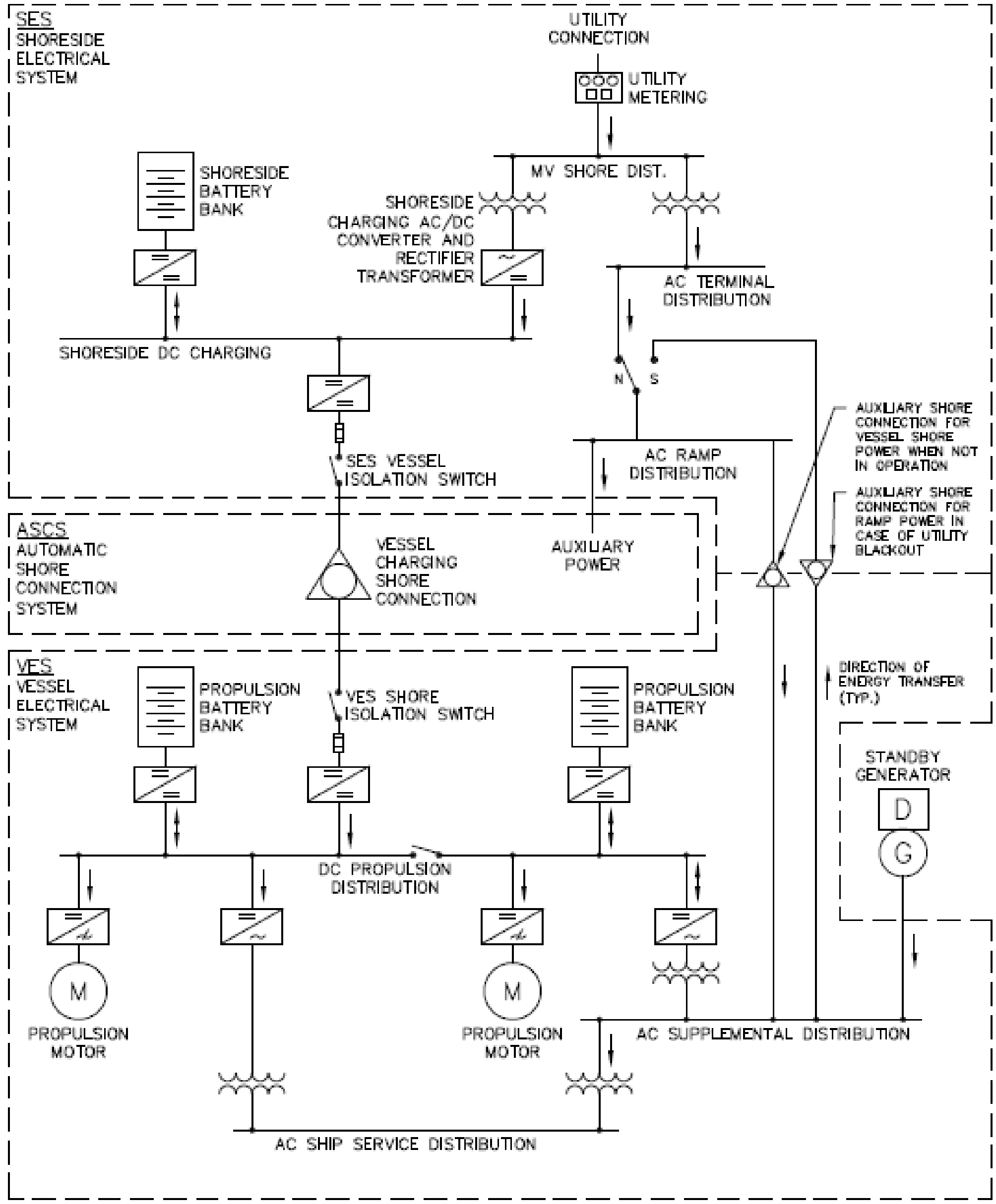


Figure 1 GIFR project electrical overview

000.5.1 Procurement and Support

Table 1 Estimated project timeline

Preliminary design complete	September 2020
Contract design complete	March 2021
Shipyard period	November 2021 to July 2023
Terminal modification period	November 2022 to April 2023
Vessel in service	September 2023

Table 1 provides an estimated timeline for major milestones for the GIFR project. Preliminary SES information from vendors is expected ahead of the completion of the preliminary design.

000.5.2 Multiple GIFR RFIs

Glosten will issue separate RFIs for the automatic shore connection system (ASCS), vessel electrical system (VES), and propulsor units. Vendors may elect to respond to any of the RFIs on an individual basis. In cases where a cost savings may be obtained by selection of a single vendor for multiple scope items, this should be explicitly stated and costs savings broken out.

000.5.3 Vessel

Table 2 Vessel particulars

Length, Overall	160'-0"
Beam	53'-0"
Draft	7'-6"
Car Capacity	28
Full Load Displacement	530 LT
Propulsors	(2) 700 kW L-Drive Azimuthing Propulsors
Speed, Cruise at Full Load	11.5 kts

It is estimated that the vessel will operate 365 days per year, with an average of 24 round-trip crossings per operating day. Figure 2 depicts the timeline of a typical round-trip crossing, which takes 30 minutes. Note the battery sizing calculations assume some maintenance downtime resulting in 8400 round trips per year.

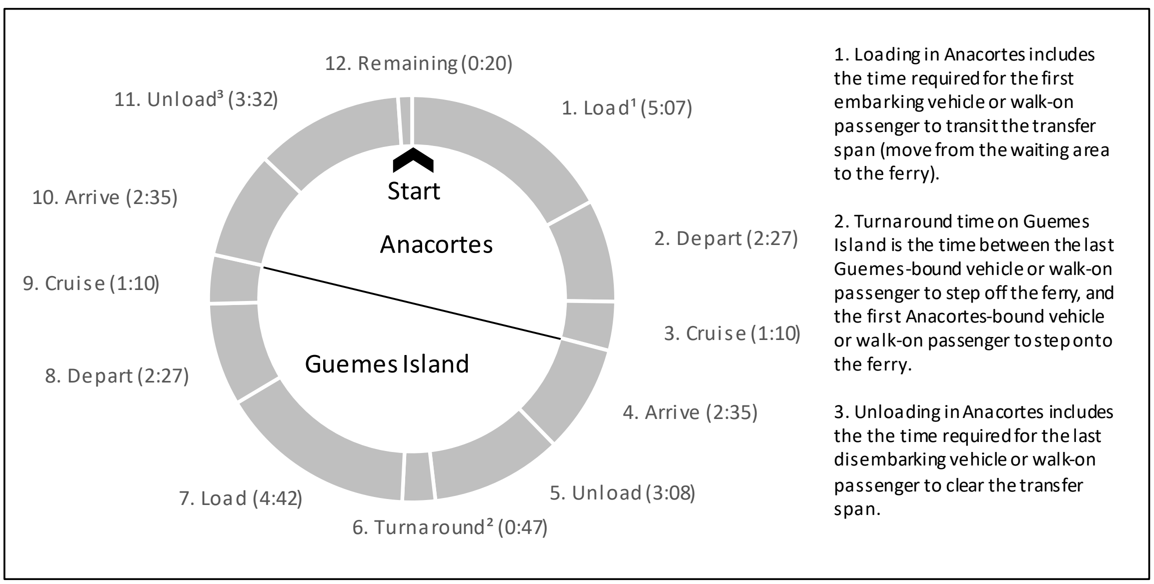


Figure 2 Typical round-trip transit

The vessel electrical system (VES) will consist of a common DC bus with two independent propulsion battery banks, which serve as the primary sources of power. Power for the propulsion motors will be taken directly from the DC bus and converted to 600-690VAC, 3-phase. Other consumers can be powered by 480VAC or 208Y-120VAC, 3 phase, 60 Hz. A 550 ekW onboard standby diesel generator will provide supplementary power for propulsion, ship loads, and battery charging during abnormal operations (e.g. bad weather, transit offsite).

The VES outlined above is outside the scope of this RFI, see Section 000.5.2.

000.5.4 Terminal

The SES will be installed at the Anacortes terminal to serve the GIFR vessel. No significant modifications will be made to the existing Guemes Island terminal electrical system.

ASCS

The ASCS will be installed at the Anacortes terminal docking facility to serve the GIFR vessel. The ASCS will transfer the required electrical energy from the SES to the VES to charge the propulsion batteries and power the vessel during connection. No shore charging connection is required on the Guemes Island side.

The ASCS outlined above is outside the scope of this RFI, see Section 000.5.2.

Existing Terminal Electrical Distribution

The existing electrical infrastructure at the Anacortes terminal consists of the following:

a. 480VAC, 3 phase, 60 Hz power supplied to machinery at the ramp apron and lifting tower and shore connection for the existing vessel.

b. Additional 120VAC, 1-phase, 60 Hz supplied to the terminal building for various small loads.

These existing loads at the terminal will be modified and integrated with the new SES, but are not a major focus of this RFI.

000.5.5 Regulatory

The modifications to the existing ferry terminal in Anacortes will be required to satisfy the requirements of WAC-246B Electrical Safety Standards, Administration and Installation, the NEC, and NESC. See the requested information regarding proposed standards and listings in Section 000.4.

The vessel will be required to satisfy the rules for a USCG Inspected Small Passenger Vessel under US CFR Title 46, Subchapter T. This includes all aspects of the shore connection system which are installed on the vessel, and may also include review of the shoreside system for information.

The integration of an ASCS of this nature on the vessel is unique in the United States and we expect both the USCG and the Washington State electrical inspectors to review this aspect of the project. Glosten is working with the regulatory bodies to define particular requirements and will provide details to vendors when available.

001 SHORESIDE ELECTRICAL SYSTEM (SES)

The SES includes the infrastructure required to bring utility power to the VES, through the ASCS. This includes a shoreside battery bank to provide energy storage to accommodate high charging power without incurring high utility demand (peak) costs. Figure 1 shows the scope of supply for the SES. The SES shall be installed at the Anacortes ferry terminal.

The SES will regulate the source voltage to maintain the nominal voltage at the vessel. Cables and wireways are to be provided by the vendor from the utility connection to the ASCS. Additional details and requirements will be developed as the design progresses.

Table 3 provides a summary of the major electrical power sources and loads on the vessel.

This RFI is written with the assumption that an SES configured in a manner similar to that shown in Figure 1 will be best suited for this project. Figure 1 is primarily intended as an outline of the scope of each electrical system; the details of the configuration may be modified to fit the capabilities of the systems offered by vendors. Vendors may propose alternate configurations to the SES. If proposing an alternate configuration, vendors should interpret the requirements of this RFI accordingly, and are encouraged to provide support in the proposal to justify the deviation from the described configuration.

Table 3 Summary of major electrical power source and loads

Equipment	Qty.	Rating (each)	Notes
ASCS Interface	1	2.0 MW 1000V DC (nom.)	See Section 001.2
Shore Battery Banks	1	600 ekW (charge) 1300 ekW (discharge)	Energy storage capacity to be based on operating profile, see Section 001.2.2
Rectifier Transformer and AC/DC Converter	1	600 ekW	See Section 001.2
AC Ramp Distribution	1	~30 ekW 480V, 3Ø, 3W, 60 Hz	See Section 001.4
AC Terminal Distribution	1	Loads to be determined Various voltages, 60 Hz	For use when moored and not in operation, see Section 001.4

001.1 Electrical House

The SES must be installed in an electrical house or other purpose-built structure located as shown in Figure 3. The electrical house and related infrastructure should be included in the scope of the SES vendor. The electrical house should include the utility metering, medium-voltage distribution switchgear, the shoreside DC charging system, shoreside battery bank, low-voltage AC terminal distribution, and the related transformers and converters.

The electrical house should be complete with all necessary safety and monitoring equipment for the electrical distribution system and battery installation.

Building foundation and other civil and structural modifications required to facilitate the electrical house are expected to be provided by others, through a separate contract with Skagit County.

The estimated area for the electrical house including all access, inspection areas, and clearances is 20' x 40'.

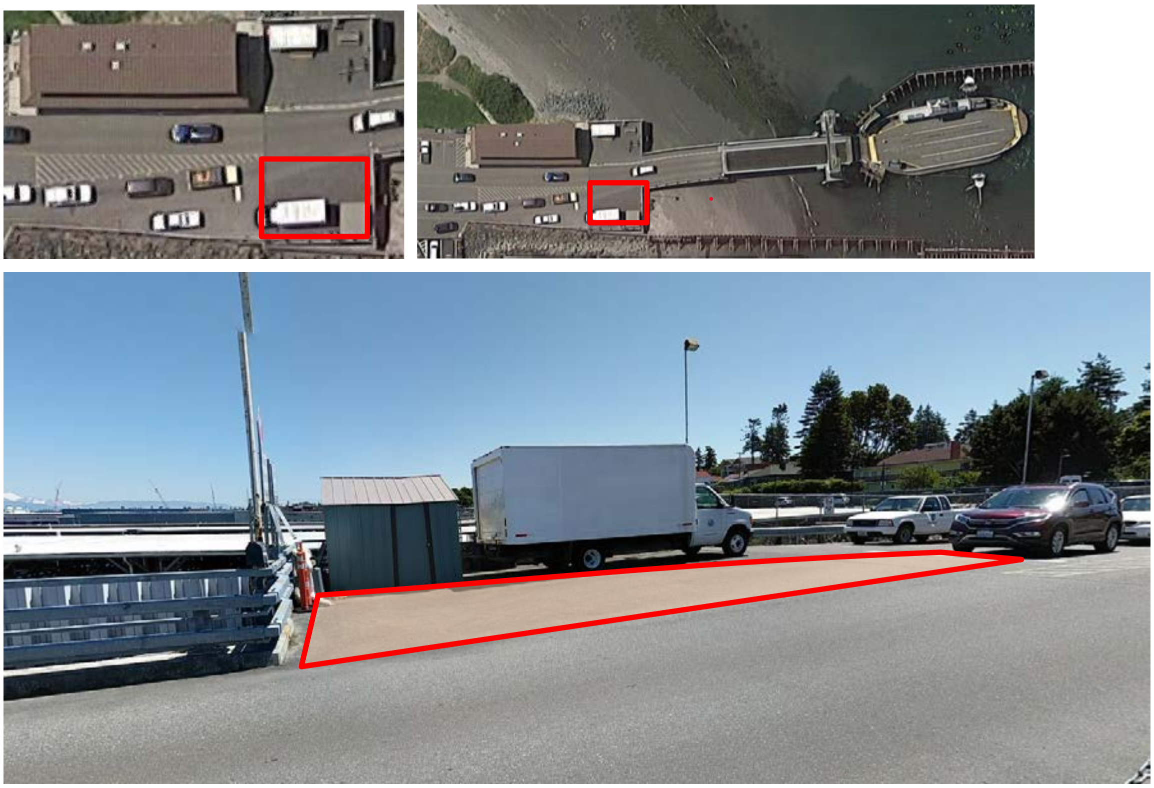


Figure 3 Proposed location for SES electrical house and utility connection infrastructure

001.2 Shoreside DC Charging

Shoreside DC charging is provided to reduce power demand charges from the utility. DC charging will be provided through an AC/DC converter and rectifier transformer. Connection to the ASCS will be through a DC/DC converter and SES isolation switch.

The AC/DC converter and rectifier should be designed to provide the required power quality at the point of common coupling, to be developed later. Redundant AC/DC converter and rectifier transformers shall be provided.

The interface between the SES and the ASCS and VES is discussed in Section 001.5.

001.2.1 Power Management System

A power management system (PMS) must be provided as part of the shoreside DC charging system. The purpose of the PMS is to coordinate vessel charging and charge/discharge of the shoreside batteries with power demand from the utility, to optimize the operating cost of the new GIFR. The primary function will be to reduce the peak monthly power demand from the utility, with a secondary function to optimize the cycling of the shoreside batteries to maximize battery life.

The power management system should be a non-proprietary system that allows adjustment over the life of the vessel to meet a changing energy market. A qualified person shall be capable of future modifications to the system.

A desired function, though not required, is the ability for the PMS to respond to intermittent AC terminal loads with the goal to reduce peak power draw from the utility. These terminal loads include the ramp machinery and possibly future electric car chargers.

001.2.2 Shoreside Batteries

The batteries should be sized to provide a 10-year operational life based on the probabilistic load profiles listed in Table 4 and 8400 round trips per year (24 runs per day, 350 operating days per year). The times listed in Table 4 for vessel charging are based on the expected time available for charging during unloading and loading of passengers and vehicles at the Anacortes terminal. The time listed for the operating duration of the shoreside AC/DC converter is typically the total round-trip time for the vessel, which is scheduled for 30 minutes.

The shoreside battery installation should be complete with a battery management system, and other required safety equipment.

Table 4 Cumulative probability load profiles for shoreside batteries based on weather and tidal predictions

Operation	50% Probability[1]		80% Probability[1]		95% Probability[1]				99.7% Probability[1]	
	Average Run		*Above Average*		Without Generator		With Generator		Schedule Slip	
	Time [minute]	Power [kW]	Time [minute]	Power [kW]	Time [minute]	Power [kW]	Time [minute]	Power [kW]	Time [minute]	Power [kW]
Vessel Charging [2]	10.72	863.2	10.0	1214.0	9.07	1850.0	9.07	131.0	9.75	945.1
Shoreside AC/DC Converter [3]	30.0	318.6	30.0	418.6	30.0	579.3	30.0	41.0	31.4	303.8

1. Probabilities listed indicate the annual cumulative probability that the required load profile power will not be exceeded.
2. Required vessel charging power reflects the estimated quantity that would be measured in the feed to the ASCS at the exit from the electrical house (i.e. downstream of any switching, protection, or converters related to the shoreside DC charging system).
3. Estimated DC power required from the shoreside AC/DC converter assuming a constant charge/discharge cycle efficiency of 95%. These values should be adjusted based on specific system capabilities. Note that resulting utility power demand will be higher due to efficiency losses through the rectifier transformer or AC/DC converter, which are not included in the above numbers.

001.3 Utility Connection

Puget Sound Energy is the electrical power utility which serves the Anacortes ferry terminal. Existing utility primary distribution to the terminal is through four-wire, medium voltage (12.47kV), effectively grounded, overhead lines.

Based on initial discussions, the existing utility distribution system is expected to be suitable for expansion to support power demand of the SES, but Glosten will be working with PSE to assess the scope of any needed upgrades.

The new utility connection service is expected to be under PSE Schedule 26 (see reference 2) for large demand general service (>350kW) at primary voltage. The SES must include all equipment required by PSE beyond the Point of Delivery, including provisions for metering installation, switches, cut-outs, and other items related utility service at the primary voltage. These items should be installed as part of the electrical house and provisions should be made for access as required by PSE.

The rates for 2019 are summarized in Table 5. Due to the variability in vessel energy consumption, the peak total demand charge is anticipated to make up 40-50% of the monthly cost for electrical utility service.

Under Schedule 26, Skagit County will reduce the monthly cost for electrical utility service by 3.8% with service at the primary voltage. Due to this factor, a proposed SES intended for connection at secondary voltage (600V and below) will not be considered unless the vendor can provide strong justification otherwise.

Table 5 Summary of PSE Schedule 26 for primary service (May 2019)

Basic Charge	$343.66	per month
Total Demand Charge		
October-March	$11.89	per kW
April-September	$7.92	per kW
Total Energy Charge	$0.05669	per kWh
Total Reactive Power Charge	$0.00126	per kVARh

001.4 AC Terminal Distribution

Low voltage 480 V, 3-phase terminal distribution shall be provided for the vehicle loading ramp, miscellaneous terminal loads, and possibly electric car charging. Variable loads include ramp operation and potential car charging.

Power consumption of the various AC terminal distribution loads should be coordinated with the charging system through the PMS. This information should be included in optimization of the SES charging cycle. See Section 001.2.1.

001.5 System Integration

The SES should provide a high level of automation and integration to simplify the operation for the two-person crew on the ferry to allow them to focus attention on maneuvering and vessel operation.

001.5.1 Automatic Shore Connection System (ASCS)

The following outlines the interfaces and connections expected to be required between the SES and ASCS to facilitate the necessary operations.

a. A wired communication shall be provided between ASCS and SES. The details and level of ASCS/SES integration will depend on the systems used. See Section 001.5.2 for communication details.

b. SES to provide ground continuity relay with the ASCS disconnection switch opened on a continuity fail. VES to facilitate installation of ground continuity relay end device, but the ground continuity check system to be provided as part of SES.

c. The following hard-wired control circuits are envisioned but may be modified as the design progresses:

   1. The primary control and data transfer interface between the SES and VES (see below).

   2. ASCS emergency disconnect circuit. The circuit will be energized by the ASCS control power, and the ASCS will immediately disconnect if the circuit is opened. The ASCS vendor shall provide emergency pushbuttons to open the circuit at the pilothouse control stations and adjacent to the ASCS socket.

   3. SES pilot circuit, circuit made by LMFB contacts in ASCS. The circuit will be energized by the SES control power, and the SES isolation switch will not be able to close unless the circuit is closed and will open if the circuit is broken. The VES shall provide a contact in series with the circuit to coordinate operation of the isolation switches.

   4. VES pilot circuit, circuit made by LMFB contacts in the ASCS. The circuit shall be energized by the VES, and the VES shore isolation switch shall not be able to close unless the circuit is closed and shall open if the circuit is broken. The SES and ASCS will provide contacts in series with the circuit to coordinate operation of the isolation switches.

Items (b) and (c) above are based on what is expected to be required for a galvanically connected ASCS. Induction or other galvanically isolated types of connection systems will have different interfaces, but the functions for item (c) will still be required in some manner.

001.5.2 Vessel Electrical System (VES)

Electrical Power

The SES will provide electrical power on demand to the VES through the ASCS to charge the vessel batteries and power vessel loads while the ASCS is connected. The SES will regulate the source voltage to maintain the nominal voltage at the vessel.

The SES must maintain a relatively constant power transfer to the VES based on input requirements from the VES.

Control and Data Transfer

The SES and VES must have a set of control and data transfer interfaces which allow communication between the two systems. These interfaces are expected to be driven primarily by the requirements of the SES, but will include:

a. Basic connection and monitoring feedback from the VES to coordinate operation of isolation switches and charging.
b. Basic energy required and charging duration feedback in real-time from the VES during the vessel charging cycle. This is intended to allow the SES to coordinate the power flow from the shoreside batteries and the utility in an effort to allow the SES to optimize utility power demand (i.e. reduce monthly peak power demand) and the shoreside battery cycle.
c. Additional feedback from the VES including required energy and duration predictions for upcoming charge cycles, time remaining before next charge cycle, and other relevant data. This is intended to inform the shoreside battery charging rates while the ASCS is not connected as a means to further optimize each SES cycle.
d. Basic monitoring information to the VES to alert vessel operators of utility blackouts and other shoreside electrical conditions which will impact vessel operations or require attention from maintenance personnel.

The primary interface between the two systems will be over a wired or fiber-optic connection provided through the ASCS, intended to facilitate items (a) and (b) above. The details of the signal protocol used for (b) will be developed. Either analog current/voltage signals or an industrial ethernet communication over fiber-optic is expected to be used. Note that if the ASCS is of the non-conductive type (e.g. inductive charging) the primary interface will need to be over a robust and secure wireless connection.

A secondary interface between the two systems should be able facilitate basic data transfer between the VES and SES when the ASCS is not connected (i.e. wireless) to facilitate items (c) and (d) above. The secondary interface is not intended to be used for primary control of charging equipment.

REQUEST FOR INFORMATION – PROPULSION DRIVES

GUEMES ISLAND FERRY REPLACEMENT

000 GENERAL REQUIREMENTS

000.1 Objective

This Request for Information describes the requirements for two approximately 700-kW azimuthing thruster units to be installed aboard the Guemes Island Ferry Replacement (GIFR) vessel, a 160-ft double ended car ferry. One thruster will be installed on each end, both on the centerline of the vessel. We are requesting information including drawings, 3D models, specifications, and rough order of magnitude (ROM) pricing for this equipment to progress the design of the vessel.

The information provided will not be used as a basis for selection of a vendor or equipment for the vessel propulsors.

Responses are requested by 30 June. Please note all information does not need to be provided at one time and early information submittal is encouraged.

000.2 Acronyms

Acronyms used throughout this document are as follows:

ASCS	Automatic Shore Connection System
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
GIFR	Guemes Island Ferry Replacement
RFI	Request for Information
ROM	Rough Order of Magnitude
SES	Shoreside Electrical System
VES	Vessel Electrical System
URN	Underwater Radiated Noise

000.3 Requested Data

The following drawings and data are requested:

- Dimensional drawings of all components, including 3D models if available.
  - Thrusters, including maintenance envelopes and installation details.
  - Control cabinets, panels, misc. equipment.
  - Thruster control heads and panels.
- Weight estimate of all components.
- Electrical equipment description, ratings, and drawings.
- Auxiliary system requirements (air cooling, water cooling, hydraulics, lube oil, etc.)
- Technical description of equipment and its operation. The description shall list all components that are to be delivered. If drawings of minor components cannot be

provided at this time, a clear description with overall dimensions and weights shall be provided.

- Overall electrical and mechanical efficiency of units.
- Open water propeller characteristics, incorporating nozzles.
- Motor power and torque curves as a function of motor speed.
- ROM cost estimate for equipment, with itemized commissioning services. Cost estimates should not include costs for shipping equipment.
- Information outlining vendor support and warrantee of equipment throughout vessel's operational life.

All information does not need to be delivered at one time.

000.4 Project Information

000.4.1 Procurement and Support

Table 1 Estimated project timeline

Preliminary design complete	September 2020
Contract design complete	March 2021
Shipyard period	November 2021 to July 2023
Terminal modification period	November 2022 to April 2023
Vessel in service	September 2023

Table 1 provides an estimated timeline for major milestones for the GIFR project. Preliminary propulsion drive information from vendors is expected ahead of the completion of the preliminary design.

000.4.2 Multiple GIFR RFIs

Glosten will issue separate RFIs for the automatic shoreside connection system (ASCS), vessel electrical system (VES), and shoreside electrical system (SES). Vendors may elect to respond to any of the RFIs on an individual basis. In cases where a cost savings may be obtained by selection of a single vendor for multiple scope items, this should be explicitly stated and costs savings broken out.

000.4.3 Vessel

The double ended ferry will have one thruster mounted on each end. It is assumed two 700 kW L-drive propulsion units will be installed, one on each end. The propulsors will provide an estimated 70/30 thrust split (pushing/pulling) under typical transit operations. Full power simultaneously to each thruster will be required when docking in severe weather.

Table 2 Vessel particulars

Length, Overall	160'-0"
Beam	53'-0"

Draft, Design	7'-6"
Car Capacity	28
Displacement, Design	530 LT
Speed, Cruise at Full Load	11.5 knots
Hull Material	Steel
Ice Capability	None
Main Deck Height at Centerline	13'-5"
Hull Height at Thruster	5'-6"
Main Deck Structure Above Thruster Well	5'-0"

It is estimated that the vessel will operate 365 days per year, with an average of 24 round-trip crossing per operating day. Figure 1 depicts the timeline of a typical roundtrip crossing, which takes 30 minutes.

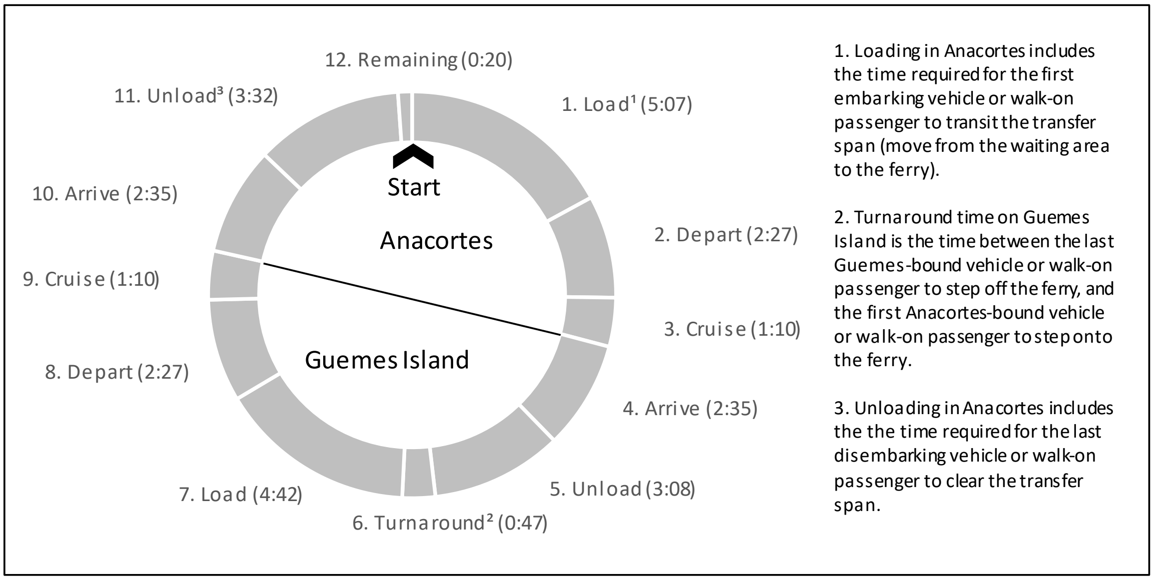


Figure 1 Typical round-trip transit

The vessel electrical system (VES) will consist of a common DC bus with two independent propulsion battery banks, which serve as the primary sources of power. Power for the propulsion motors will be taken directly from the DC bus and converted to 600-690VAC, 3-phase. Other consumers can be powered by 480VAC or 208Y-120VAC, 3 phase, 60 Hz. A 550 ekW onboard standby diesel generator will provide supplementary power for propulsion, ship loads, and battery charging during abnormal operations (e.g. bad weather, transit offsite).

The VES outlined above is outside the scope of this RFI, see Section 000.4.2.

000.4.4 Regulatory

The vessel will be required to satisfy the rules for a USCG Inspected Small Passenger Vessel under US CFR Title 46, Subchapter T.

001 AZIMUTHING THRUSTERS

001.1 Underwater Radiated Noise

Underwater radiated noise (URN) is a growing concern and vendors are encouraged to propose “quiet” propeller and gear designs or other means to help reduce URN of the thrusters.

001.2 Propeller Wake and Thrust Deduction

The Wake Fraction and Thrust Deduction for a standard case were determined through CFD analysis. The values were then estimated for a transverse (thrusting sideways) case. These values are reported below.

Wake fraction (w)

- Standard
  - Aft: -0.046
  - Fwd: 0.055
- Transverse
  - Aft/Fwd: 0.030

Thrust deduction (t)

- Standard
  - Aft: 0.033
  - Fwd: 0.125
- Transverse
  - Aft/Fwd: 0.030

001.3 Vessel Resistance

Figure 2 below provides calculated resistance curves at three (3) different operating conditions of the vessel. The operating speed is 11.5 knots in transit and 4.5 knots when maneuvering under side current. The vendor is expected to calculate required power and torque numbers to size the recommended thruster and motor. Sizing shall incorporate a 15% additional power margin for the transit case, and a 5% power margin when maneuvering under side current.

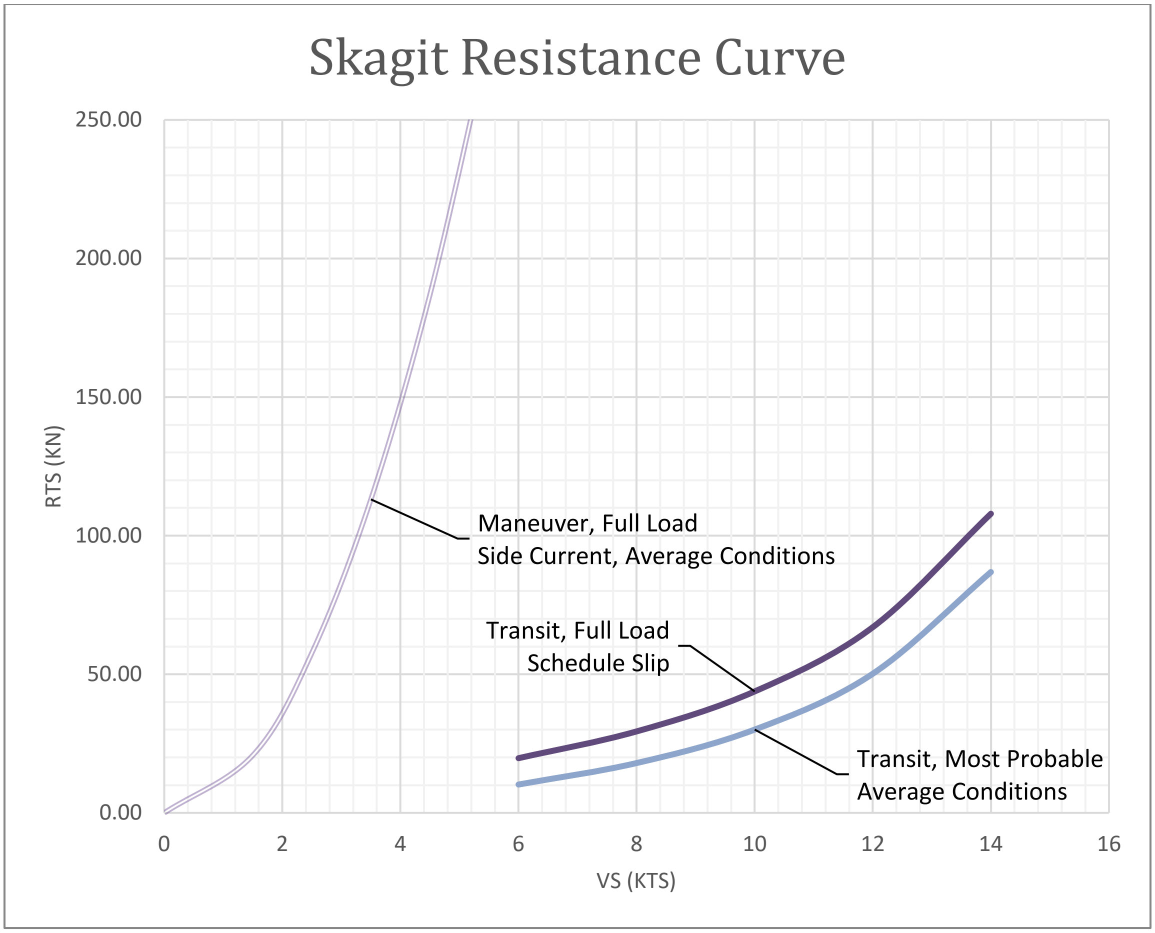


Figure 2 Resistance curves at various operating points

Table 3 is provided as an example input power estimate, with no margins added. In this example, input power represents power delivered by the motor. This value includes an estimated 3% loss for mechanical inefficiencies. It is anticipated the vendor will provide refined estimates based on their specific equipment characteristics. The limiting design case appears to be maneuvering in 4.5 knots of side current during average weather conditions. It is expected the thruster sizing will be driven by this condition, and as stated above, a 5% power margin is required in this condition.

Table 3 Input power estimates for GIFR at various operating points

Description	Environmental Condition	Speed	Input Power (aft)	Input Power (fwd)
Transit, Most Probable	Average conditions	11.5 knots	370 kW	170 kW
Transit, Full Load	Schedule slip[1]	11.5 knots	490 kW	220 kW
Maneuver, Full Load	Side current, average conditions	4.5 knots	630 kW	630 kW

1. Schedule slip begins to happen at 20 knots of wind and 3 knots of current. This is the maximum expected thruster output for transit across the channel.

001.4 Thruster Requirements

Two azimuthing thrusters shall be provided, each meeting the following requirements:

- Well mounted for extraction through the main deck while the vessel is floating.
- L-drive configuration preferred.
- Permanent magnet motors are preferred due to an increased efficiency and overhead clearance limitation when in L-drive configuration.
- Must maintain a 5% power margin during 4.5 knots of side current. The motor power and torque shall be determined by the vendor based on the efficiency of the unit proposed and the vessel resistance points provided.
- High efficiency nozzles are preferred to increase the overall performance and efficiency of the thruster.
- It is acceptable for the propeller and nozzle to extend below baseline by 1'-6" as the vessel draft is limited to 9'-0".
- The total height of the propulsion unit, including motor and nozzle, shall be no greater than 14'.

002 CONTROL STATIONS

The double-ended ferry will be equipped with two primary control stations, one on either end of the pilothouse. A third control station, mounted on the exterior deck, is required for person-overboard operations.