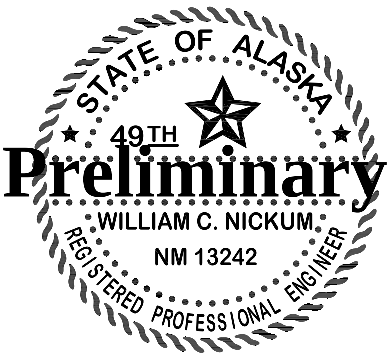

DAY BOAT ACF

Design Study Report

Prepared for: Alaska Marine Highway System • Ketchikan, AK

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Elliott Bay Design Group
Architectural & Engineering Services for the Marine Industry

PREPARED BY

Elliott Bay Design Group
5305 Shilshole Ave. NW, Ste. 100
Seattle, WA 98107

GENERAL NOTES

1. This report is not intended for submittal to any regulatory body.

REVISIONS

REV	DESCRIPTION	DATE	APPROVED
3	Preliminary issue	07/10/13	

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1 INTRODUCTION

In February of 2013 the Draft Design Concept Report for the Day Boat ACF (DCR) [1] prepared by Coastwise Engineering on behalf of the Alaska Department of Transportation and Public Facilities (ADOT&PF) was delivered to the state. This report sets down a mandate for a new ferry vessel to be built and operated by the Alaska Marine Highway System (AMHS), for use as a day boat only, meaning no overnight passengers, crew or accommodations. The goal is to build two vessels within a budget of $117 million, the amount available to the state left from the initial $120 million allocation for the original Alaska Class Ferry (ACF 350) project.

2 PURPOSE

AMHS contracted with Elliott Bay Design Group (EBDG) to prepare a Design Study Report (DSR) and associated vessel concept design, using the DCR as the starting point. The purpose of the DSR is to review and substantiate the mission requirements for the new vessel and investigate primary options for equipment and configuration of spaces.

The concept design, as intended, would represent a worked example of a design that meets the requirements of the DCR, as modified and supplemented by the DSR. The primary decisions that establish the vessel characteristics and features of the design are supported by calculations and analyses as documented below. The selection of vessel proportions and configuration are detailed in this report.

The new Day Boat ACF will be a passenger vehicle ferry owned and operated by AMHS, and will operate initially on routes in Lynn Canal. As a class design, other future Day Boat ACF vessels may operate on other established routes within Southeast Alaska and Prince William Sound.

3 GIVEN REQUIREMENTS

3.1 Day Boat Mission Requirements

The fundamental operating paradigm for this vessel is that it be a day boat. Specific work rest rules by the United States Coast Guard (USCG) require that crews not work over 12 hours in any 24-hour period. By not having room and board accommodations on the vessel, the crews will have to leave the vessel at the end of their work shift and return the following day.

The DCR [1] gives a preliminary set of mission requirements for the Day Boat ACF. The requirements presented in this section represent those original requirements with slight modifications as suggested by AMHS as the design study process has progressed.

- Payload: The vessel must carry a minimum of 53 Alaska Standard Vehicles. The vessel shall have a certificate for 300 passengers, and provide seating for as many as 300 passengers.

- Speed: The vessel shall operate at a 15.5-knot schedule speed. The vessel shall be capable of making a 16.0-knot service speed at 85 percent of the Maximum Continuous Rating (MCR) of the engines.

- Bow Configuration: The vessel shall feature bow vehicle unloading, with self-propelled mooring to hold to the terminal. The bow shall have a door which shall be able to be opened just prior to landing. The bow door shall be simple, strong, and reliable. The bow shall reduce spray generation during winter operation. The vessel shall not have forward side doors.

- Stern Configuration: The vessel must have a center stern door and at least one port side door aft. An additional starboard side door at the stern may be considered as an option.

- Maneuverability: Maneuverability is a key part of each vessel's daily operation. The vessel must be able to turn and back quickly into a dock, one or more times per day. The vessel must therefore be highly maneuverable. Excellent visibility astern from the wheelhouse is required. Three rudders or a stern thruster are options to consider for enhanced maneuverability.

- Manning: The vessel design shall safely minimize the required manning. Close attention shall be paid to the arrangements for lifesaving and vessel evacuation requirements. An un-manned engine room shall be considered. Food service accommodations shall be limited so as not to require any additional crew. Mooring operations must not increase manning requirements.

- Accommodations: Good accommodations shall be provided for passengers and crew. Passenger spaces shall be broken into multiple rooms, so that passengers have a choice of seating and activities during transit. At least three of the passenger areas shall have lights available during non-daylight hours of operation. Food service shall be provided via a minimum size food court and vending machines.

  A small separate area shall be available for crew. Crew accommodations shall provide a break room, quiet room, and lockers for gear storage.

3.2 Standard AMHS Mission Requirements

In addition to the mission requirements specific to the Day Boat ACF, AMHS has a set of standard mission requirements based on previous vessel design efforts.

- Safety: The vessel must be safe in all regional environmental conditions. Vessel survivability in a grounding event shall be at least as good as existing AMHS TAKU Class, regardless of USCG regulations.

- Reliability: Vessel operation shall exceed 99 percent sailing frequency, or as good as existing AMHS service, whichever is greater.

  Vessel construction shall use marine systems that have demonstrated five years minimum proven marine technology, capable of being serviced in Ketchikan, Alaska. Steel vessels shall be designed for approximately a 60-year life span, with one main engine replacement and two passenger accommodation area refurbishments.

- Regulatory: Vessel shall be USCG approved as meeting Subchapter H of 46 CFR [2]. The vessel shall be classed by the American Bureau of Shipping (ABS) or Det Norske Veritas (DNV)[1]. Vessel classification shall include relevant machinery and electrical certifications. Relevant Federal and State emissions (Tier 3 air emission, vessel general permit) and discharge (sewage) requirements shall be met.

- Environmental Conditions: Vessel shall be designed for operation on the coastal waters of Alaska. For this operation, the AMHS maintains standard environmental criteria that shall be used as minimum design criteria:

    - Permanent list of 15 degrees
    - Permanent trim of 5 degrees (by bow/stern)
    - Roll of 30 degrees (each side) with total rolling period of 12 seconds from horizontal
    - Pitch of 10 degrees (bow up/bow down) with total pitching period of 8 seconds
    - Ambient air temperature between minus (–) 20°F through plus (+) 85°F
    - Seawater temperature between plus (+) 28°F through plus (+) 65°F

- Seakeeping: Vessel shall be designed to provide lower (i.e. better) ship motions than found on the AMHS LECONTE Class vessels. This analysis shall be limited to bow and stern seas. The goal shall be ship motions approaching the levels found on the AMHS vessel TAKU, without greatly impacting the budget.

  The vessel shall be designed to minimize spray generation and fore end slamming. The design shall limit ice formation on vessel safety equipment, with winter spray performance that shall be significantly better than the LECONTE Class vessels.

  Assuming operation on all routes in Southeast Alaska, except ocean entrances, the vessel shall be able to survive a once in 50-year storm event.

- Vehicles: An Alaska Standard Vehicle (ASV) is defined as a 10 ft x 20 ft block. However, for the Day Boat ACF, five adjacent lanes (two eight ft wide lanes, two eight ft six inch wide lanes, plus one center 10 ft wide lane) would be an acceptable combination.

- Passengers and Other Cargo: The vessel must be able to accommodate motorcycles, bicycles, and walk-on passengers. A luggage cart and ADA van are normally carried by AMHS vessels, but how this requirement is met will be partly dependent on the terminal operations.

  The vessel shall meet applicable Americans with Disabilities Act (ADA) requirements

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[1] AMHS has experience with both ABS and DNV as vessel classification societies, however only ABS has classed AMHS steel vessels. For that reason, ABS is recommended, and by default is cited as the regulatory reference in the balance of this report. The final decision on classification society rests with AMHS.

per the Proposed Passenger Vessels Accessibility Guidelines [3] and shall be accessible to the greatest extent possible for marine vessels. A passenger elevator shall provide for access to all passenger decks.

3.3 Vessel Cost Requirements

ADOT&PF, of which AMHS is a Division, has mandated that it will deliver safe, simple and reliable vessels. Further it will deliver these vessels at the least reasonable cost. Through all stages of the project – design, procurement, and construction, including construction management – ADOT&PF will monitor the cost of the vessel and seek safe means to control them. As the design proceeds, consideration is given to capital and life cycle cost trade-offs. Capital budget and life cycle cost considerations from [1] are discussed in the following sections.

3.3.1 Capital Budget

ADOT&PF has expressed a desire that the total constructed price of two Day Boat ACF vessels not exceed $117 Million. This is derived from the capital remaining in the existing Alaska Class Ferry project funding. The total constructed price is to include the vessel contract design, the shipyard contract for vessel construction of two vessels, AMHS construction management and oversight of construction, and ADOT&PF indirect cost recovery plan (ICAP) charges. ICAP charges are applied to all ADOT&PF capital projects to recover department overhead expenditures.

The Day Boat ACF contract design package is to include the minimum necessary vessel features to meet the day boat mission and standard AMHS requirements. If desired by the AMHS, additional vessel features may be added to the contract design package as optional change orders, which may be activated if funds are available. The contract design package is the vessel design from which the shipyard will negotiate its construction price with AMHS.

Budget monitoring shall occur periodically throughout the project. The AMHS team will create a brief project status report, including a vessel construction cost estimate, at intervals no longer than three months. Vessel construction cost estimates at early stages of vessel design may be calculated using parametric cost models.

3.3.2 Life Cycle Costs

Reduced construction costs in some cases may not be in the best interest of AMHS or ADOT&PF. The Day Boat ACF is expected to have a useful life of 60 years and operational costs over the life of the vessel will outweigh greatly initial construction costs. As design decisions are made, AMHS shall task its design team to be mindful of the trade-offs between capital and life cycle costs. In some cases, options to reduce initial capital costs related to vessel construction can have detrimental impacts on the vessel operational costs. In cases where options are found to minimize vessel operational costs, but have an impact on construction costs, the design team shall advance these issues for analysis and decision.

3.3.3 Construction Manager/General Contractor (CM/GC)

The anticipated contract delivery method for the construction of the two Day Boat ACF vessels is to utilize a Construction Manager/General Contractor (CM/GC). ADOT&PF has entered into a CM/GC contract with Alaska Ship and Drydock (ASD) of Ketchikan, Alaska. The CM/GC agreement is a two-phase contracting method comprised of pre-construction professional services and construction services. ASD will assist the AMHS team during the design phase of the project. Provided a Guaranteed Maximum Price can be negotiated successfully and ADOT&PF is confident that the vessels can be constructed on schedule and within the budget, the construction contract will be awarded to ASD.

4 FERRY SYSTEM OPERATIONAL REQUIREMENTS

4.1 Proposed Routes

Not all routes within AMHS can be served efficiently by a day boat. The ideal arrangement is for the vessel to work as a shuttle between two terminals, returning to the same port or terminal at the end of every workday.

The DCR [1] identified numerous potential routes for this vessel, within three main geographic areas:

1. Lynn Canal – From Juneau (Auke Bay) north to Haines and Skagway, including intermediate and yet-to-be-developed terminal sites
2. Northern Southeast – From Juneau south to Angoon and Tenakee Springs, and east to Hoonah and Gustavus
3. Prince William Sound – including Cordova, Whittier and Valdez

4.1.1 <u>Highest Priority Routes</u>

The first priority for these new vessels will be to serve two routes:

1. Juneau to Haines and return, and
2. Haines to Skagway and return

AMHS currently serves these terminals via a three-stop route, sailing from Juneau to Haines, then to Skagway, then back to Haines, then back to Juneau. This route length, however, is too great to be served in one 12-hour day, considering all the intermediate stops. The DCR proposed solution is to have one vessel serving Juneau and Haines, with a second vessel working between Haines and Skagway. One round trip per day is the limit between Juneau and Haines, but multiple round trips are possible between Haines and Skagway.

The DCR provides proposed schedules and time statistics for each of these routes, using a schedule speed of 15.5 knots. Increasing speed by two knots on the Juneau to Haines route provides a reduction in sailing time of almost 30 minutes, however the sailing frequency does not change (one round trip in 12 hours) so there is no advantage gained from the speed increase.

The schedule times include estimates of the time needed to maneuver at the dock, moor the vessel, and unload/load vehicles and passengers. The DCR coined the acronym MLOPS to refer to the Maneuvering and Loading Operations time. For the two highest priority routes, 30 minutes is assigned for each load or unload cycle: 30 minutes for the initial load, then 60 minutes to accommodate one combined unload/load, then 30 minutes at the final unload. The total schedule time for the Juneau – Haines round trip is cited as 11 hours & 44 minutes, leaving a 16-minute margin under 12 hours.

For the Haines – Skagway route, as many as four round trips can be scheduled in a 12-hour day, with a margin of 40 minutes, using a reduced MLOPS allowance. The DCR suggested that a two round trip day might be preferred by AMHS to align in Haines the arrival of the vessel from Juneau with the vessel from Skagway once during the day.

Next on the priority list for routes are other AMHS established routes within reach of Juneau or Ketchikan. These would include service from Juneau to Angoon, Gustavus, Hoonah, and Tenakee Springs, and from Ketchikan to Metlakatla.

Service to Angoon and return is challenging due to the route length, requiring almost 11 hours of underway transit time. The DCR noted that this route will require a reduced MLOPS allowance as well. The Angoon terminal is currently unmanned, so the actual MLOPS time needed in Angoon may be longer, but the traffic is relatively light and the MLOPS time allowance is based on the vessel operating with a car deck at full capacity.

AMHS has identified the Cascade Point to Haines route as a potential route. The length for this route is about two hours and 50 minutes (labeled Berners Bay to Haines in the DCR). With a standard MLOPS allowance of two hours, one round trip can be made on this route in slightly less than seven hours. A round trip could be done with an eight-hour crew, and in high demand times two eight-hour crews could provide two daily round trips.

4.1.2 Lower Priority Routes

Pages 9 and 10 of the DCR are referred to for a listing of other potential routes for this vessel.

4.1.3 Critical Routes

A number of the potential routes were analyzed to determine which ones might be critical, i.e., routes on which proposed sailing schedules might exceed 12 hours due to operational delays. The analysis consisted of a sensitivity check to variations (delays) in mooring time, vehicle loading and unloading times, terminal operations time, and transit times. The analysis started with the MLOPS times as provided in the DCR.

With the exception of the Juneau – Angoon route, the MLOPS times for the analyzed routes exhibited a reasonable degree of insensitivity to minor delays, due either to operational challenges during mooring or loading, or weather issues that cause slower transit times and longer mooring times.

While the MLOPS times were found to be reasonable, it is important to note that these times are significantly faster than what might be considered standard within the existing AMHS fleet.

4.2 Terminal Configuration

Matching terminal configurations to the vessel configuration to reduce time in the terminal is critical to the success of the day boat operation. For the highest priority routes – those serving Haines, Juneau and Skagway – the Haines terminal is the key transfer point. Those traveling from Juneau to Skagway for example would be required to transfer at Haines. The terminal in Juneau (Auke Bay) has two mooring sites, one side berth that accommodates vessels with side port doors, and a stern berth that is normally used by the M/V FAIRWEATHER. The terminal in Skagway is a side berth terminal. Neither of these terminals is scheduled for an upgrade in the near future and existing berths will be used by the Day Boat ACF.

The Haines terminal is scheduled for major modification in the near future. The optimum configuration in Haines, given that the Day Boat ACF will sail round trips on routes between Juneau and Haines and between Haines and Skagway, is to have two bow mooring berth sites. This configuration will enable one vessel to serve Juneau and Haines independently of another vessel serving Haines to Skagway. Also, if schedules align, vehicles, passengers and crew could unload from one vessel and load onto the other vessel.

The challenges of matching the vessel design with the existing side and stern berth terminals are known and can be accommodated with reasonable foresight. The stern configuration must provide an adequate opening to allow the terminal ramp to land on the vessel without interfering with the vessel superstructure. The side port door location and vessel mooring sites must accommodate the existing side berth mooring arrangement.

The Haines terminal bow berth design and the vessel bow designs will have to integrate with each other. The new vessel will have both a bulbous bow and bow doors that will present design challenges for the new bow berths. The need to minimize MLOPS will dictate that the bow doors of the vessel open on approach. In turn this will require careful attention to vessel structural alignment with the terminal. The bulbous bow proposed for the vessel will present challenges with the design of the interface between the vessel and the terminal. In addition, to allow for minimal line handling and rapid turn-around, the intent is for the vessel to use its own power to hold it in the berth.

The terminal operation protocol will need to be adjusted to streamline the mooring, loading and unloading scheme, in order for the vessel to meet the day boat mandate. Vehicle and passenger tickets will need to be collected in advance of loading. Walk-on passenger loading and unloading separate from vehicle loading ramps should be considered. The terminal exit lanes and upland arrangements for discharging vehicles must be adequate to funnel traffic quickly off the vessel. Night crews will be needed to handle vessel maintenance duties and fueling. Assistance with vessel startup, loading at the beginning of the day, unloading at the end of the day and vessel shutdown should also be considered.

4.3 Mooring

Vessel mooring arrangements will be configured to match existing stern and side berth terminals. Generally this will entail stern mooring fittings located at the car deck level, and to suit the side berth terminals mooring fittings at the passenger or weather deck level on both sides.

For bow mooring at the new bow-loading terminal in Haines, the vessel will require mooring arrangements forward, accessible once the bow door assembly and ramp are open and deployed. During times of quick turnaround, only the forward portion of the vessel would be secured during loading, with force applied by the vessel propulsion system to hold the vessel in the berth. At other points when the transfer time is longer, there would be time to fully secure the vessel and not use the vessel's propulsion to assist.

Mooring times to suit the proposed schedules will need to stay below 15 minutes on the long channel routes, and below 10 minutes on the short channel routes. Mooring time includes the time needed to rotate the vessel 180 degrees for backing into the terminal. For comparison purposes, AMHS plans to collect data on the time needed to moor the AMHS vessels AURORA and LECONTE when using a stern berth, starting from the beginning of the rotation.

4.4 Loading

Loading of vehicles and passengers in a timely fashion is another key factor in meeting the mission of the day boat. Loading times are typically slower than unloading times, due to positioning of vehicles and people leaving their cars to go topsides. Unloading times are dependent upon the upland space for the departing vehicles.

4.4.1 Vehicle Loading

The vehicles will generally be loaded straight through, either on via a stern ramp and off through the bow door, or on via bow door and off via stern ramp or aft side port door.

To minimize MLOPS, passengers and drivers will need to be allowed to remain on the car deck for some time after departure and allowed access to the car deck prior to arrival. For regulatory purposes this means that the vehicle deck will need to be considered a passenger space. From the design side, this requirement will dictate (to meet regulations):

- Boundary classifications between the vehicle space and other spaces on the vessel
- Adequate space around and accessibility of the cars in the event of an emergency
- Quantity and configuration of the ventilation of the vehicle space

In addition to having drivers and passengers in the cars, the discharge area or road at the terminal must be clear of interferences, and have adequate capacity to handle the volume of cars.

Operationally, it will also be necessary to ensure that the vehicles aboard are not unaccompanied, unless special arrangements are made that will minimize the effect on schedule.

Loading and unloading times for vehicles and passengers will need to be less than 15 minutes to meet the proposed route schedules For a full load of 53 vehicles, that translates into a rate approaching four cars per minute, not counting the time needed to handle walk on passengers if they are loading on the vehicle deck.

4.4.2 Passenger Loading

With most existing AMHS terminals, passengers are loaded onto the car deck either ahead of or after vehicles are loaded. Where possible, separating passengers from vehicles during loading and unloading operations will speed up the turn-around time. The best way to accomplish this is to provide a separate ramp or loading assembly that allows passengers to enter or exit the vessel from a separate deck (e.g. the passenger deck). Alternatively, providing a protected lane on one side of the vehicle ramp and on the vessel car deck may accomplish the same thing.

The vessel will need a 36 in wide walkway for the length of the car deck to meet the requirements of [3]. This walkway will give disability access from either end of the vessel along the car deck to the access stair and elevator serving the passenger decks.

4.5 Manning Requirements

Minimum crew requirements are based on the applicable regulations, found in Section 15 of 46 CFR [2] and Volume III of the Marine Safety Manual [4], and on the Certificates of Inspection (COIs) of similar vessels. The USCG COI minimum safe manning is determined based on the crew required for normal operations while underway, and for specific operational scenarios such as abandoning ship and vessel mooring and loading.

4.5.1 Normal Vessel Operations

If the vessel admeasures over 1,600 Gross Registered Tons (GRT), the master and mates must also have first class pilot licenses. The gross tonnage for the Day Boat ACF has not been determined yet, but it may be possible to design the vessel to admeasure less than 1,600 GRT, to meet the stated DCR requirement of minimum manning cost.

The voyage length for the vessel will be less than 400 miles. Therefore, two mates are required for general operations, instead of the usual three.

For normal vessel operations the minimum crew size is estimated at seven.

4.5.2 Abandoning Ship

Abandoning ship is one of the limiting cases of the potential specific vessel operations. Crew will be required to man the vessel, direct passenger evacuation, search any passenger spaces, and deploy all necessary life rafts.

Crew members will be required to search the car deck and the two decks with passenger lounges.

One crew member will be required at the top and bottom of the Marine Evacuation System (MES) once deployed, and one rescue boat will have to be deployed with two crew members to manage and muster the life rafts.

It is estimated that a minimum crew size of nine will be needed to accomplish an abandon ship operation.

4.5.3 Mooring and Loading Operations

Mooring, unloading, loading, and undocking of the vessel are critical to the ability to regularly maintain a 12-hour operating day. As such, a crew member must be available to perform each of the tasks required during this process, without overlap or potential for disruption of any other tasks required for the operation.

On approach to and during docking at a terminal, the master and mate must be able to operate the vessel in either direction, with a full view in the direction of approach, and have the ability to communicate clearly. Crew members must perform a sweep of each of the passenger spaces to ensure that passengers are ready and waiting to disembark immediately upon arrival.

The vehicle deck doors to be used for loading and unloading must be opened just prior to docking. Each active mooring station on the vessel will require two crew members during all mooring operations. Once moored, two crew members will be required to direct traffic and passengers to ensure a timely unloading of the vessel.

It is estimated that a minimum crew of eight to nine will be needed to handle mooring and loading operations.

In summary, a vessel crew of nine persons is recommended for safe operations.

Since the vessel will not have a crew aboard beyond the 12-hour limit, a dedicated night crew will also be required to provide vessel security, cleaning and routine daily maintenance when not operating. On the Juneau – Haines route, the minimum night crew is estimated to be three people, one for security and two for vessel cleaning and maintenance. On the Haines – Skagway route, given the shorter time underway, maintenance is expected to be handled entirely by the ship's crew, thus one security person is expected to be sufficient as the night crew.

5 MAJOR DESIGN DECISIONS

This section identifies the major design decisions needed to ensure that the vessel has the necessary features required to meet the identified mission and AMHS Requirements.

5.1 Bow Loading Configuration

To facilitate straight through vehicle loading and unloading, the bow of the vessel will need to be fitted with a door or doors. Given the nature of the weather and seas in the proposed area of operation, a regulatory compliant watertight (WT) shell door assembly with inner WT door assembly is recommended. The outer door can be one piece or two, either a bow visor (knight's hood) that raises and lowers vertically, or a two door side opening arrangement. The inner door must form a closure of an extension of the vessel's collision bulkhead, and can either be a dedicated door or formed by a combination ramp/door assembly. Information on these options is provided in Appendix A.

A shore-based ramp with dedicated inner WT door is preferred, given the risk to the vessel schedule if the combination door/ramp assembly were to be damaged during deployment or mooring.

Bow doors are not uncommon on RO-RO vessels and ferries in other parts of the world, in particular northern Europe, the Baltic Sea and northern Canada. Weather and sea conditions in those parts of the world are similar to those found in the North Pacific.

The primary advantage of the side opening doors is the fact that their operation does not compromise the visibility of the vessel master during docking, unlike the bow visor style Also, the side stowing doors are generally less massive, so that the opening and closing mechanisms are smaller and require less power.

The disadvantage of the side opening doors is their location, vulnerable to impact with potential terminal features. As described above, the terminal proposed for this vessel is still under development and the vessel and terminal designs must be integrated to ensure that the bow door operation will not be compromised by the terminal, and vice versa. An additional complicating feature of the vessel design in the bow area will be the presence of a bow bulb, a recommended design feature to improve vessel resistance and fuel consumption.

The time needed to open the doors is estimated at only about 45 seconds. However, depending upon the configuration and complexity of the inner door and ramp assembly, deployment of the ramp could take another two to three minutes. While still within the MLOPS envelope for the intended routes, as the vessel design proceeds care must be taken such that the door and ramp deployment times are not impacted negatively.

5.2 Vessel Length

Vessel length plays an important role in several key factors of the vessel design. The length of the vessel directly impacts the available vehicle capacity. Length can also have a beneficial impact on speed and powering, and on seakeeping and vessel motions. However, increasing the length may impact maneuvering characteristics. Further, increasing the length will increase the overall displacement and structural weight, and thus cost.

One proposed design feature that will increase fuel efficiency without making the actual vessel longer is a bulbous bow. This forward appendage acts to shift the vessel's bow forward, changing the overall wave train, and as a result can reduce wave-making resistance. Adding a bulb may be beneficial only if a vessel is operating above a certain speed; below that point it can have a detrimental effect. For vessels of about this size operating above 14 knots a bulb is beneficial to reducing overall wave-making resistance.

If this vessel is classified by ABS, the design will have to be done in accordance with their rules for steel vessel construction. Even without formal ABS classification, the USCG will require that the vessel structural design conform to ABS rules. As it happens, there is a rule length transition at approximately 305 ft of overall length; vessels under this length have to meet one set of rules, larger vessels are required to meet another set. While many of the basic requirements are equivalent between both sets of rules, there are definite differences which, when the rules for larger vessels are invoked, will increase vessel construction costs. It is recommended the vessel length not exceed the ABS rule length limit that would force the design and construction to conform to the large vessel rule set.

5.2.1 Vehicle Capacity

The stated vehicle capacity for the new Day Boat ACF is 53 ASV's. However, testing has shown that up to five cars can be comfortably parked side by side in a 40 ft wide space. To provide space for larger trucks, the lane configuration proposed in the DCR [1] is 42 ft wide, consisting of four eight-foot wide lanes, and one 10-ft wide lane. To ensure adequate clearance for people carrying baggage, an increase of 6 in in two of the lanes is proposed, for a net car lane width of 43 ft. This lane configuration coupled with the vehicle capacity requirement establishes the layout of the car deck including the minimum length of each lane.

While different numbers of car lanes could be proposed (e.g. four or six), five lanes side by side is the most efficient means to arrange the cars in a space that matches with conventional length to beam ratios. For this vessel, 220 ft of length is used for vehicle stowage, with an additional 30 ft of deck length for end taper and access purposes. Making the vehicle stowage area wider may result in a shorter vessel, but the additional width would require a significant increase in power to meet the speed requirement. Fewer lanes may mean that the vessel could be narrower, but it will increase the overall length requirement. Each of these options has capital and life cycle cost trade-offs, as well as other design impacts above and below the car deck.

5.2.2 Speed and Power

Lengthening the vessel may provide some improvement to the hull resistance by altering the waterline length of the vessel relative to the waves the hull produces. Any gains in resistance performance would come at an increased weight and cost of the longer vessel, but could be offset if the engine power requirement was reduced enough to use smaller engines.

To test this possibility, powering estimates for two vessels of the same beam and draft but different lengths (280 ft and 305 ft LOA) were done using standard resistance prediction software, over the speed range that the vessel is intended to operate. The results indicate that a nine percent increase in length yields only a two percent decrease in power requirement at 16 knots, as shown in the table below. Therefore, the increase in length is not recommended.

Vessel Configuration	Total Power @ 16 knots
280 Ft LOA	5,094 BHP
305 Ft LOA	4,991 BHP

5.2.3 Seakeeping

The overall vessel length impacts the motions of the vessel in waves, and the effect of those motions on the passengers, crew, and vehicles. Anecdotal evidence is present within the AMHS fleet; the TUSTUMENA was originally built at 240 ft in length, but was lengthened by 56 ft only a few years after it was delivered to improve ride quality in its area of operation. Generally increasing vessel length will have a direct and positive influence on vessel motions.

Coincident with the current DSR effort, a comprehensive wind and wave analysis of Lynn Canal was developed by another consultant for the state of Alaska [5]. Using the results of the climatology analysis, comparison Motion Sickness Incidence (MSI) values were developed for a range of vessel lengths, operating in the 95th percentile worst month sea state. MSI is a measure of passenger comfort, which can be stated as "the percentage of a passenger population that may be expected to experience sea sickness when exposed to a particular motion environment for a particular duration" [5].

This analysis addressed motions in head and following seas only, as experienced by vessels transiting up or down Lynn Canal, at a speed of 15 knots. Motions in head seas exhibit the highest vertical accelerations and therefore the highest MSI percentages; motions in following seas exhibit much less severe motions. The 95th percentile worst month sea state, in the most exposed location on the route between Juneau and Haines exhibits significant wave heights of 8.5 ft (2.6 meters). These wave heights are the result of a weather event of substantial magnitude, occurring at most only a few days of the year.

Based on [5], the average MSI percentage estimated for a 280 ft vessel similar to the Day Boat ACF, in the 95th percentile worst month, is about 11 percent of the passengers. This represents an improvement over the LECONTE of about 25 percent. Lengthening the boat to 305 ft would reduce this estimated percentage to slightly below 10 percent.

A significant conclusion derived from the analysis that may not be obvious is that MSI is also dependent upon where one is located longitudinally on the vessel. Vessel motions, in particular vertical accelerations which are the primary contributor to motion sickness, are shown to be highest at the vessel ends, and less towards midships. The option of locating some passenger accommodations in the vicinity of midships provides passengers a low motion refuge spot that may be of more benefit to the passengers than just providing a longer vessel. The other motion mitigation option that is also available is to slow down, reducing the encounter frequency between ship and waves, and the resulting motions.

For reference, the difference in construction cost between the two lengths is estimated to be approximately 5 percent, or about $2.5-3 Million. Although the improvement in motion behavior is undoubtedly real, it is not large, and it comes at a significant cost. It is recommended that the design proceed with the 280 ft length vessel, and that the passenger accommodation areas be arranged to provide more space in the midships area of the vessel for passengers to gather during rough seas.

Additional efforts will continue during the following phases of the design to improve the behavior of the vessel in seas. The vessel will not have forward side door openings and the resulting sponson structures prevalent on the existing AMHS fleet. These structures are prone to slamming during heavy seas, making for additional accelerations and discomfort. The vessel bow shape and flare above the waterline, as well as the bulbous bow shape below, will be carefully developed to minimize slamming forces. Seakeeping model tests are recommended for the vessel to measure actual accelerations and observe the vessel's behavior in heavy seas.

5.3 Hull Configuration and Proportions

The proposed vessel will be a single-ended ferry with a high, flared bow to suit the route characteristics. A double-ended configuration would be optimal to handle fast turn-around end vehicle loading, however, it would not be an appropriate choice for this vessel because of weather and sea conditions.

The preliminary hull concept is based on the primary overall vessel proportions, and on the requirements for the vehicle deck arrangement. A single-chine configuration is selected to simplify construction and reduce cost, with the potential tradeoff of a slight increase to overall resistance and thus life cycle cost of the vessel. The hull form shape will be optimized during the next phase of the design using numerical analysis methods and it is recommended that model tests are performed to confirm the results of the optimization.

To provide sufficient reserve buoyancy within the constraint of allowable freeboard, the vessel sheer forward at the deck will need to be raised. Regulations require that the vessel meet a two-compartment standard for subdivision and damage stability.

The displacement of the vessel at the subdivision draft must be greater than the maximum anticipated full load displacement, including Service Life Margin (SLM), to ensure the vessel will have suitable capacity throughout its anticipated life.

5.4 Survivability

At a minimum the Day Boat ACF vessel will have to be designed to remain afloat with damage to any two adjacent compartments. Double bottom protection should also be provided, generally from the forward collision bulkhead at least through the machinery spaces. Fuel, fresh water and sewage holding and storage tanks should be located above the double bottoms and clear of any shell boundaries, to minimize the risk of seawater contamination or discharge due to damage.

A number of the existing AMHS vessels have increased protection from sinking due to damage of the vessel's bottom or side shell, in the form of a wing double bottom portion that extends up the vessel side some distance above the top of the double bottom. These wing portions of the double bottom, while not extending to the car deck or even above waterline, have been high enough that in more than one instance a long, raking side impact a vessel was subjected to did not result in loss of the vessel. The double bottom portions on the existing vessels usually carry fuel, which has the added advantage of protecting the steel surfaces within the tank such that corrosion is largely prevented.

While double bottom extensions or wings are recommended to provide the increased damage protection, carrying fuel in the double bottoms is not. High quality protective coatings are available to apply to the steel, which combined with good access to the void spaces will provide an acceptable alternative to carrying fuel in the double bottom spaces.

5.5 Propulsion and Machinery Configuration

While not explicitly stated in the DCR [1], the assumed propulsion configuration for the Day Boat ACF is a twin shaft arrangement with medium speed diesel engines driving fixed or controllable pitch propellers through reduction gears. This is a tried-and-true configuration that is found on all the monohull vessels in the AMHS fleet, and the recommended propulsion scheme in an earlier trade-off analysis done in 2008 for the ACF 350 project. The recommended engine for the estimated power range for this vessel is the EMD 710 Series. Preliminary powering estimates recommend installing 3,000 brake horsepower (BHP) engines, one per side, which equates to 12 cylinder EMD engines.

It is recommended that there be only one engine room on the vessel, holding the propulsion machinery, ship's service generators, boiler and all associated auxiliary machinery. It is recommended that an Engineer's Operating Station (EOS) be provided adjacent to the engine room with direct access to the vehicle deck and to the engine room.

A bow thruster compartment is recommended forward, housing the thruster and all associated thruster drive machinery. Preliminary calculations indicate that a 600-650 HP transverse tunnel thruster will be necessary to provide sufficient control in high winds and currents. A variable frequency drive electric motor driven arrangement is recommended.

5.6 Car Deck Configuration

The vehicle lane widths, accommodating car and truck ingress and egress through the vessel ends and through an aft side door, are some of the primary design drivers for the layout of the car deck. In addition, there is the requirement for access between the hold, car deck and upper decks of the vessel, plus the need for air in and exhaust out from the machinery spaces below the car deck. The configuration depicted in the Roadmap vessel contained in the DCR has two outboard casing structures along the vessel sides, with a center portion of the car deck completely given over to vehicles from end to end.

Another option for the car deck could include a single casing structure, either on centerline or shifted off-center, with vehicles lanes on either side of the casing, similar to many of the existing AMHS vessels. However, the primary mission of this vessel is to load vehicles straight through, on at the stern and off at the bow, or vice versa. The best arrangement for this mission is to have the casings at the side, and provide a comfortable scheme of straight-line parking and lanes, with room on centerline for heavy vehicles to park without causing heel to the vessel. One casing may be adequate for passenger flow and even exhaust piping, but two casings provide the room for a pair of access stairs, separated exhaust runs, ample ventilation space, and room for a large passenger elevator. Twin side casings are recommended.

To accommodate disabled passengers a 36 in wide ADA lane is recommended along the length of the car deck, located between the car lanes and the casing that houses the passenger elevator. In way of the opposite side casing a 12 in wide curb set back is recommended.

5.6.1 Closed Aft Deck over Vehicle Space vs. Open

The DCR proposed the concept of making a portion of the deck over the vehicle space open to the weather as a means to reduce the vessel capital cost. Some of the pros and cons of this configuration, together with some estimates of the potential cost savings, are presented in Appendix B. The estimated savings amount to approximately one and one-half percent of the vessel cost.

These estimates make certain assumptions about the differences between equipment costs of the two options, in particular car door costs and the cost of ventilation. With some care and attention, by making use of as much of the open area for ventilation as possible, the difference between the two options may be even greater, i.e. the open deck version exhibiting even larger savings. On the other side of the ledger, the current recommendation is to have only one aft side door (port side only), to save cost, as the chances that an aft starboard side door would be needed is quite low.

The vehicle space will be designed such that water can be on the deck, and the after portion of the space does not need to be fully watertight. It is recommended that the forward 50 percent of the vessel length be watertight up to the weather deck, but the portion aft could be weathertight at most. The interior portion will not be considered as part of the vessel's buoyant internal volume. Thus, the only large superstructure doors that must be watertight are the bow door and the inner door (ramp). The large aft doors do not need to be watertight, which will reduce their overall capital cost plus reduce the requirement for monitoring.

The vehicle space will have to have drainage to handle deck wash down, melting snow and rainwater from vehicles, plus the water from annual testing of the deluge sprinkler system. The recommended approach is to have deck scuttles with three-way check valves. The valves would normally capture everything on deck and direct it to a collection tank. Alternatively the valves could be turned to direct all water over the side. The check valve would prevent ingress of seawater.

As discussed in Section 4.4.1 above, for regulatory purposes the vehicle space must be assumed to be accessible to passengers at all times. This ensures that the passengers can be allowed down to the vehicle deck prior to arrival to minimize unload time. There are some regulatory items that must be addressed during the design to ensure that the space can be passenger accessible, but these items are not a determining factor whether the space is open or not.

For weather protection and reduced maintenance, it is recommended that the vehicle space be completely covered, bow to stern. For cost savings, making the aft exterior car doors weathertight versus watertight is also recommended. The car deck ventilation system design should include sufficient heat to keep the vehicle space nominally above freezing, to protect equipment, people and pets during the voyage. The ventilation system is required by regulation to operate at all times, even in freezing weather.

5.7 Passenger & Crew Spaces

The DCR [1] identified a number of passenger and crew requirements to meet the day boat mission. Discussions with AMHS personnel have confirmed most of these requirements, including:

- Passenger seating for up to 300 passengers
- Forward observation lounge
- Family lounge and children's play area
- Quiet lounge
- Theater or movie lounge (could be incorporated into family lounge)
- Minimum food service, in the form of vending machines and/or a small food court
- Solarium
- Crew day room
- Crew quiet room
- Space for crew lockers

Providing two levels of passenger accommodations is recommended, and matches what is presented in the DCR. One ADA compliant passenger elevator is required to serve the car deck and both passenger decks.

To meet the requirements for Subchapter H passenger vessels, stair towers and corridors are needed to access the accommodation areas. Stair tower landing areas are also dictated by regulation. Stair widths and slopes for the passenger stairs should meet ADA requirements, which are more restrictive than USCG requirements.

5.8 Maneuverability

Because of the rigidity of the proposed daily operation schedule, efficiency in maneuvering in and out of terminals is of paramount importance. The vessel's maneuverability is directly impacted by the hull form, vessel weight and fixed appendages, as well as size and configuration of control components such as rudders, thrusters and propellers.

An initial analysis of the control components recommends the following at a minimum:

- single transverse tunnel bow thruster
- twin spade rudders in-line with the propeller shafts (benefits of an articulated high-lift rudder should be analyzed further)

The analysis also addressed the option of driving the vessel with controllable pitch propellers (CPPs) or with fixed pitch propellers (FPPs) via reversing reduction gears, however no recommendation is offered at this time. AMHS intends to gather data on the time required to maneuver a similar vessel with fixed pitch propellers, such as the AURORA or LECONTE, in and out of terminals. The goal is to determine if a vessel with fixed pitch propellers may reasonably be expected to perform docking maneuvers in the time assumed in the route planning analysis.

Further investigation of the performance and life cycle costs of CPP and FPP installations should be performed before a decision is made. The general belief is that a CPP system is both more expensive to purchase (capital cost) and more expensive to maintain, but there may be some offset in operational costs, particularly fuel costs, with a CPP system because of the ability to optimize the efficiency of the propeller with pitch adjustment.

Another aspect of rapid and efficient docking and undocking is the ease with which the crew can manage the process. It is recommended that the pilothouse be arranged to provide clear visibility in both forward and aft directions, in support of bow-in and stern-in docking. In addition to the conventional forward centerline propulsion controls, additional controls should be located at the aft end of the pilothouse or at bridge wing stations. It is recommended that AMHS consider the placement of CCTV cameras at the vessel stern to further aid in docking maneuvers. In addition to good visibility from the wheelhouse, careful consideration should be given to the location and arrangement of line handling stations.

6 CONCEPT VESSEL DESIGN

A concept vessel design is presented that meets the mission requirements set down in the DCR [1] and the recommendations identified in this report. The concept arrangement drawings, consisting of Outboard and Inboard Profiles, Deck Plans of all levels, and a concept arrangement section view, can be found in Appendix C.

6.1 Concept Arrangement

The concept vessel design has the following particulars.

Vessel Particulars	
Length, Overall	280'-0"
Length, Design Load Waterline	257'-6"
Length, Between Perpendiculars	250'-0"
Beam Over Guards	67'-0"
Beam at Waterline	61'-6"
Depth at Side	20'-0"
Draft at DLWL	12'-6"
Freeboard at Side	7'-6"
Passenger Capacity	300
Vehicle Capacity	53 ASV

The hull is divided into eleven compartments. The tanks containing consumables are structural tanks, located on centerline above the double bottom, with a tank top height of 16 ft 6 in. The trim tanks and the oily water and car deck drain tanks are deep tanks or double bottom tanks that are flush with the hull.

The engine room is sized to contain the two main engines plus the two ship's service diesel generators as well. The EOS is located in the space immediately forward of the engine room. The bow thruster compartment is located immediately aft of the collision bulkhead. All other hull spaces except the steering gear compartment are voids.

The vehicle deck features five open lanes on centerline with two casings outboard, port and starboard. There is a three ft wide ADA access path adjacent to the starboard casing, which runs the length of the vessel. The open space for vehicles has a clear width of 43 ft, equivalent to two outboard lanes at 8 ft wide, two inboard lanes at 8 ft 6 in wide, and one centerline lane at 10 ft wide. The casings contain passenger stair towers, engine room access stairs, exhaust trunks and air intake trunks. The starboard casing houses an elevator accessed from the starboard stair tower.

The passenger deck features a solarium with an open deck aft. There is a food court and dining area located forward of the solarium. The forward half of the passenger deck features washrooms, a first aid room, purser's office, a library and quiet room, and a family and children's room.

The upper deck has additional passenger spaces, including an observation lounge forward with a theater and additional washrooms amidships. Aft of the passenger space is a crew area locker room and quiet room, and exterior ladders for crew access both up to the housetop and down to the passenger deck. The emergency generator room, crew break room and security office are on the housetop. The wheelhouse is raised above the housetop by five ft over a large fan room, with bridge wing controls extended beyond the vessel side for good visibility in both directions when docking.

6.2 Lifesaving Arrangement

Lifesaving equipment for the vessel must meet USCG requirements as described in Subchapter W of Reference [2]. For this vessel the compliment and arrangement of equipment to meet the regulations and meet AMHS standard evacuation procedures includes the following:

Rescue boats – One each port and starboard

Life rafts – Capacity of 100 percent of the total persons on board (passengers and crew)

Marine Evacuation Systems (MES) – One each port and starboard, located at the passenger deck

The rescue boats are located on the passenger deck, aft of the stacks and outboard of the solarium. A covering deck is included above the rescue boats to support the boat launch and recovery hoist mechanism, and to provide weather protection for the boats.

The evacuation slides are located forward on the passenger deck, outboard of the central lobby. This location provides ample room for passengers to move from the muster station to the evacuation slides.

Each MES contains one 100-person capacity raft within its stowed enclosure that inflates upon release of the slide. Two additional 100 person life rafts (one each port and starboard) will be located above the passenger deck to provide the required lifesaving capacity.

6.3 Terminal Interface

The concept vessel design has been placed (on paper) into the existing stern berth and side berths at the terminal in Juneau (Auke Bay).

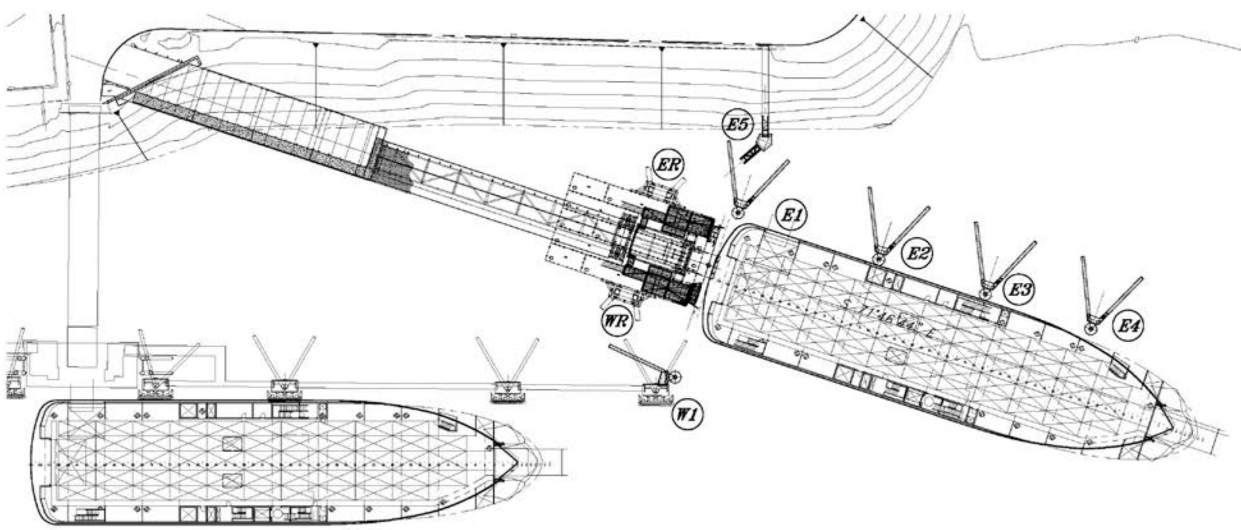

Figure 1: Juneau (Auke Bay) Terminal

Because of the vessel's width at the car deck, the terminal stern ramp lands to port of the vessel centerline. This requires that the vessel stern door and opening be wider to maintain symmetry about centerline.

The side berth terminal in Skagway is similar to the side berth in the Auke Bay terminal.

The current plan is for the Haines terminal to be upgraded with berths that support bow in mooring. The design of the terminal upgrades and vessel bow structure will need to be accomplished in an integrated fashion to ensure that the bow shape and mooring arrangement fits with the terminal arrangement.

6.4 Weight Estimate

A preliminary weight estimate for the vessel has been developed using parametric and comparative methodologies, based on the most recent weight estimate for the ACF 350.

The structural weight, which comprises the majority of the overall vessel weight, is determined by breaking the hull and each of the various superstructure decks into individual sections. The weights for each section are calculated based on the ratios of the approximate enclosed volumes. The center of gravity for each superstructure deck is located at the center of the space.

The machinery and electrical sections are scaled from the ACF 350 weight estimate by the ratios of the installed power, propulsion or electrical, as applicable. A linear scaling is not used, as many of the components of the various systems would remain similarly sized for either configuration. The outfit weight is scaled relative to the total internal volume of the vessel.

Weight margins are added to the estimate for each Ship Work Breakdown System (SWBS) section following the recommendations of Reference [6], based on the level of design detail. The margins amount to:

- Eight percent for the structure (relatively well defined)
- 12 percent for propulsion (engine weights known)
- 15 percent for the remaining sections (electrical and electronics, auxiliary machinery and outfit).

The design margins will be reduced as the calculations are refined through the design process.

For this stage of design, all potential vertical center of gravity (VCG) increases are handled by a flat one foot of VCG margin added to the light ship weight. As the design is refined, the light ship VCG will become more settled, and the lifetime VCG increase will be handled by raising the VCG of the service life margin, but for now this methodology is conservative.

A service life margin is included in loading condition calculations to account for weight and CG changes over the life of the vessel. The subdivision displacement is normally set at or slightly greater than the sum of the full load weight and the service life margin. Based on historical weight growth data for the existing AMHS fleet, a service life margin of 15 percent of the vessel's light ship weight is recommended.

The preliminary estimated light ship weight and service life margin for the vessel are as follows. The light ship weight is the total weight of the vessel without any passengers, vehicles, stores, water, fuel, or any other non-permanent weights. Weights are given in long tons (LT) of 2,240 lbs.

Item	Weight (LT)	LCG (Ft aft Fr 0)	VCG (Ft above BL)
Light Ship Weight	2,050	128.72	27.62
Service Life Margin	307.4	128.72	27.62

6.5 Speed and Powering

Preliminary speed and power estimates have been developed for the vessel using NavCad 2012 software [7]. The Holtrop 1984 method [8] [9] is the most appropriate bare hull resistance prediction for this type of hull form. NavCad uses statistical regression to fit the vessel, based on its characteristics, into the matrix of performance data for the chosen method. The contribution of wind, wave, and appendage data to resistance is included in the total resistance calculation.

Based on the resistance estimate, NavCad is then used to perform propulsion calculations to determine propeller pitch and blade area, and the gearbox reduction ratio. The propeller sizing is based on an assumed propeller diameter of 8 feet 6 inches, and twin propulsion engines each rated to deliver 3,000 HP at 900-RPM, maximum continuous rating (MCR). The B-Series [10] [11] regression is used for the propeller calculations, a propeller series that is widely used for commercial vessels.

To determine the required BHP at a given speed, the overall propulsive coefficient (OPC) is calculated based on typical shafting efficiencies and on the propeller's estimated performance. The NavCad calculations are performed using a fixed pitch propeller (FPP) approach, with the propeller pitch sized for the design speed of the vessel. The end result is a speed vs. power plot for the vessel, which demonstrates the estimated performance of the vessel relative to engine power.

The design goal for the vessel is to provide a service speed of 16 knots at 85 percent MCR. As can be seen in Figure 2 below, the 280 ft long vessel with 3,000 HP engines just meets this design goal. While this prediction estimate is conservative, it is recommended that the vessel's hull form undergo numerical analysis in the next design cycle to search for improvements in the resistance and propulsion efficiency. Finally, the hull form should also be model tested to confirm the predicted resistance in both still water and expected heavy seas.

Speed (knots)	Total Power (BHP)	
	280 ft LOA	305 ft LOA
10.0	955	991
12.0	1645	1697
13.0	2161	2218
14.0	2829	2879
14.5	3260	3281
15.0	3783	3757
15.5	4402	4325
16.0	5094	4991
16.5	5822	5733
17.0	6551	6514

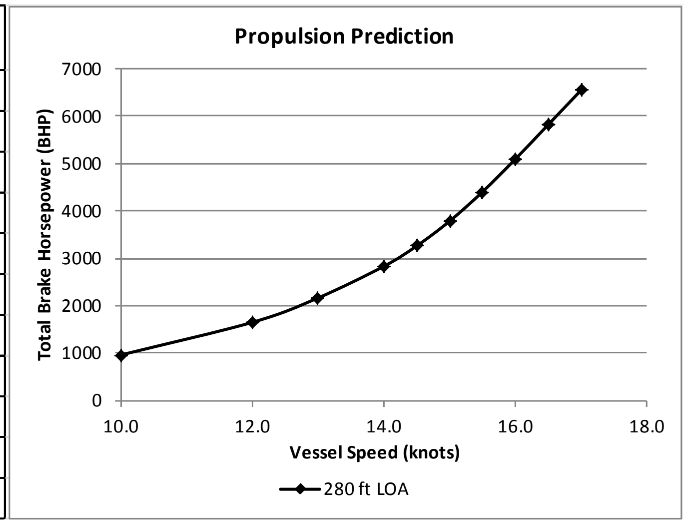

Figure 2: Speed and Powering Prediction

6.6 Capacities and Endurance

The Tank Capacities and Vessel Endurance memorandum, Reference [12], summarizes the development of the required Day Boat ACF's tank sizes. The memo addresses fuel, lube oil, fresh water, sewage, waste oil, and oily water tanks. Additional input from AMHS has been received, based on historical data from their fleet, and preliminary tank sizes established.

The tank capacities are calculated based upon known and assumed operations and consumptions for the proposed vessel. While the calculations are based upon early design assumptions, they provide useful guidance of the required space and weight allocations commensurate to the preliminary level of design. The calculations and recommended tank sizes will be updated and refined as the design progresses. The proposed tank list is contained in the table below:

Tank Name	Capacity in Gallons
Potable Water	24,000
Sewage Holding	24,000
Fuel Oil Day (P/S)	5,700 each
Fuel Oil Storage No. 1	21,000
Fuel Oil Storage No. 2	17,000
Oily Water, Car Deck Collection	6,500
Forward Trim	12, 900
Aft Trim	9,600

Other small miscellaneous tanks will be added as necessary, including reduction gear oil, hydraulic oil, and shaft seal lubricant.

6.7 Subdivision and Stability

The Day Boat ACF will be a USCG Subchapter H vessel subject to the applicable intact stability requirements of Subchapter S in Title 46 of the Code of Federal Regulations [2]. Preliminary calculations have been performed using General HydroStatics software version 13.50 and Excel to evaluate the vessel for all applicable intact stability criteria.

The assessment is performed using a maximum keel to vertical center of gravity (VCG) versus displacement method. For a range of displacements and trims, the maximum allowable VCG which meets each criterion is calculated. The displacements range from below light ship to the subdivision draft, and trims range from one-half degree forward to one degree aft. Loading condition calculations are then run for a range of vessel loads, and the results checked for compliance against the CG versus displacement data. Current fixed loads include:

Light ship Weight	2,050 LT	Concept design estimate
Service Life Margin:	307.5 LT	15 percent of light ship
Passengers & Crew:	26 LT	300 passengers @ 185 lbs each 9 crew plus effects @ 325 total lbs each
Maximum Vehicle Weight:	292 LT	6 Large Trucks @ 80,000 lbs each 29 cars @ 6,000 lbs each
Stores & Outfit Allowance:	40 LT	Estimated
Weather Ice:	44 LT	For winter operation between 42° and 66.5° North latitude

Floodable length calculations are performed for the vessel at the 13.5 ft subdivision draft, and for a VCG of 27.5 ft above baseline. A two-compartment standard of subdivision is met throughout the vessel.

The vessel as currently envisioned meets all applicable intact stability requirements for passenger vessels operating in exposed waters.

6.8 Electrical System

The ship's electrical plant will be designed and constructed to supply vessel vital and auxiliary loads under normal and emergency conditions. Two ship service generators are envisioned for the system, with a single ship's service switchboard, split in to two sections per ABS Under 90 Meter Rules.

The switchgear architecture has not yet been determined. It will be developed based on the required quantity of circuits, power rating, load shedding requirements, and remote shut down requirements. At that time, the determination whether or not to use parallel generator operation will also be made.

The requirements for the final emergency source of power will be satisfied by an emergency generator set and emergency switchboard, similar to the other AMHS monohulls inspected under

Subchapter H. The emergency generator will supply the required loads, and per AMHS request, also loads required to operate one propulsion drive train.

Uninterruptible Power Supplies (UPS) will be used to supply vital navigation, control, and communication hardware, as well as emergency lighting. These will guard against fluctuations and brief failures in the ship's service electrical supply.

As the vessel will connect to shore power at the end of each day, the shore power connection and transfer system will have to be safe, simple and robust due to the frequent usage.

6.9 Construction Cost Estimate

As described in the DCR [1], parametric models are used to develop a range of construction cost estimates when few details are known about a design. The model presented in the DCR is based on volume and estimated block coefficients for hull structure or outfit densities of spaces for passenger and crew spaces at the car deck and above. Special consideration is given for equipment such as propulsion machinery, electrical equipment and the proposed bow door. This approach coupled with a database of recently constructed vessels yielded a parametrically derived range of construction cost estimates between $44.3M and $54.1M for the DCR Roadmap Day Boat ACF. The mid-point of this range is $49.2M. The high and low values represent a variance from the mid-point of plus or minus ten percent.

In a manner similar to that described above, EBDG has developed weight-based parametric models for deriving construction cost estimates. These models use data from a library of previously constructed passenger auto ferries of similar size and weight with known construction contract prices. As the development of the design study has proceeded, weight estimates have been developed using parametric and comparative data for each of the major SWBS groups as described in Section 6.4. In this current state of design development these models are appropriate for use in deriving a range of construction cost estimates for the Day Boat ACF. A basic assumption included in the cost estimating process is that the vessel will be constructed in a US shipyard (required by the Jones Act) using a competitive bid process, with AMHS taking delivery in the Pacific Northwest.

From the weight-based parametric estimating models, a range of values between $46.3M and $53.9M has been derived, with a mid-point value of approximately $50.1M. The high and low values represent a variance from the mid-point of plus or minus seven and one-half percent. This reduction in variance is expected as design development progresses. As recommended in the DCR and as required by the CM/CG process, construction cost estimates shall be developed on a regular basis as the design proceeds. This regularity will help to establish the cost trend of the design process.

ADOT&PF desires to build two Day Boat ACF vessels within the remaining funds allocated to the ACF project. Multiple vessel contracts can provide some cost advantages by allocating design costs, including costs for detail design and lofting spread over both vessels. Further, it is reasonable to expect that the shipyard costs for follow-on vessels in the contract will be less due to production process improvements that might be realized.

In calculating total vessel program costs, the DCR suggested a cost differential of approximately ten percent between the first vessel and the second vessel was realistic. A differential of this magnitude represents a significant learning curve, or realization of production process improvements, between the first and second vessel. Corroborating or establishing a realistic cost differential between vessels in a multiple vessel contract is very difficult, given that most multiple vessel contracts provide one contract price for all vessels.

What is known about shipyard construction practices in multiple ship construction contracts is that the learning curve between the first and second vessel is typically flat. Gains are typically most significant between the second and fourth vessels, after which the curve flattens out again. For a two-vessel contract some learning may occur between vessels. Cost savings due to learning will be limited to labor reductions. It is likely that these savings will be offset by process improvement implementation costs, as well as escalation of labor and commodity costs throughout the contract period. Material may be ordered for both vessels at one time to provide a hedge against inflation; however these savings may be offset by storage costs.

Savings between the first and second vessel are typically found in non-recurring costs. Non-recurring costs are usually included in shipyard overhead and not directly related to the construction of the vessel. These costs will include:

- Detail design and production engineering
- Design review and approvals by regulatory agencies
- Subcontractor engineering costs for joinery, HVAC, control systems, etc.
- Shipyard developed shop drawings and jigs and fixtures

Non-recurring cost categories typically represent four to six percent of the total vessel construction contract price in a competitive vessel acquisition environment. As it turns out, ten to 20 percent of these non-recurring costs will, in fact, be incurred on the second vessel due mostly to learning from the first vessel. As a result, a realistic cost savings of three to five percent of the total vessel construction cost may be assumed between the first and second vessels.

To determine the overall program costs, an estimated cost reduction of four percent between the first and second vessel is included in the summary below. The first vessel cost is the mid-point in the range of estimated construction costs for one vessel. State program costs other than design are percentage based, applied as noted, and the percentages match those used in the DCR.

	DCR	**Current**	
Contract Design (PS&E)	$3.2M	$3.0M	AMHS estimate
Construction Cost Estimate			
First Vessel	$49.2M	$50.1M	Midpoint of estimated range
Second Vessel	$44.3M	$48.1M	(96 percent of 1st vessel)
Subtotal	$93.5M	$98.2M	
Construction Engineering	$5.6M	$5.9M	(6 percent of both vessels)
ICAP	$4.9M	$5.1M	(4.79 percent of all above)
Total Project Cost	**$107.2M**	**$112.2M**	

Based on the current estimate, the project is within budget with contingent funds of $4.8M. The main growth in the cost estimate (compared to the DCR) is due to a reduced estimated savings for a two-vessel contract, fully covering the car deck, and increasing the beam to accommodate wider vehicle lanes and a larger elevator. Remaining unknowns that could affect cost during design development include the propulsion system type (controllable pitch versus fixed pitch propeller) and the level of outfit and amenities for passenger and crew spaces.

6.10 Annual Operating Costs

The primary components of a vessel's operating costs are:

- Manning
- Fuel
- Maintenance

Calculations of manning and fuel costs over a calendar year have been developed for a two vessel fleet serving the proposed northern Lynn Canal routes. The service profile used for developing these costs assumes that each vessel will be in service up to 12 hours per day, allowing for one round trip on the Juneau – Haines route and two round trips on the Haines – Skagway route. Operational profiles for summer and winter and an allowance for an annual four-week overhaul period for each vessel have been provided by AMHS.

Operation is assumed to be seven days per week during a 20-week summer season and four days per week during a 28-week winter season. AMHS anticipates that the vessels will operate on the northern Lynn Canal routes just six days per week in summer and three days per week in winter. During the additional day of operation each season, it is likely that the Juneau-based vessel will service additional northern Southeast Alaskan routes. For the remaining four weeks of the year, the vessels are assumed to be taken out of service for annual maintenance.

Annual maintenance costs for a single vessel have also been estimated. This is presented as an average of the estimated maintenance costs for a single vessel over 30 years, or one-half of the projected service life of the vessel. The maintenance costs are assumed to be incurred during the annual four week overhaul period described above. Consequently, daily maintenance costs and the costs of consumables and spares are not included.

6.10.1 Annual Manning Cost Estimate

Schedule	Duration	JNU-HNS	HNS-SGY	Manning Cost
Summer	20 weeks at 7 days	$1,410,000	$1,200,000	$2,600,000
Winter	28 weeks at 4 days	$1,320,000	$1,150,000	$2,470,000
Overhaul	4 weeks at 7 days	$110,000	$110,000	$220,000
	Est. Annual Manning Cost	**$2,840,000**	**$2,450,000**	**$5,290,000**

The manning costs presented in the table above have been estimated by AMHS based on the operational profile for the Northern Lynn Canal routes.

6.10.2 Annual Fuel Consumption Cost Estimate

Annual fuel consumption has been calculated based on the operating profiles described above. To calculate the fuel consumption on these routes, the operating speeds and times were derived from the route descriptions found in the DCR [1]. When the vessels are assumed to be in service, fuel consumption for main engines, generators and boilers has been estimated for both scheduled operation and while tied up overnight. During the four week overhaul period the boilers are assumed to be operating 24 hours each day. The estimated annual fuel consumption is shown below.

Schedule	Duration	JNU-HNS	HNS-SGY	Consumption
Summer	20 weeks at 7 days	372,000	178,000	550,000
Winter	28 weeks at 4 days	334,000	179,000	513,000
Overhaul	4 weeks at 7 days	5,000	5,000	10,000
Est. Annual Fuel Consumption (gal)		**711,000**	**362,000**	**1,073,000**
Notes:	1. The Overhaul fuel consumption considers only the boiler for 24 hours/day			
	2. Overnight fuel consumptions assume shore power, so no generator			

A fuel price of $3.17 per gallon of ultra-low sulfur diesel (ULSD) fuel as of July 1, 2013 has been provided by AMHS. In current dollars, at this price, annual operating fuel costs for the two vessels will be approximately $3,400,000. At present no special consideration has been given to using waste heat from the main engines. If a waste heat system is found to be viable, boiler fuel consumption can be reduced as well.

Fuel prices have varied significantly over the past several years. Economic events, refinery capacities and changing perceptions of oil reserve quantities and locations among other global and local factors impact oil and fuel pricing over time. While fuel pricing and inflation are difficult to predict, fuel price inflation has been historically at rates ahead of general inflation, reaffirming the importance of developing a fuel-efficient vessel design.

6.10.3 Annual Maintenance Costs

The Day Boat ACF is to be designed for a useful life of approximately 60 years. To make a vessel last this long, major overhauls will be done at specific intervals during the life of the vessel. For the Day Boat ACF, the DCR suggests that major vessel passenger space refurbishments should be planned in year 20 and year 40. In year 30, a vessel repowering should be done. While these actions are required to maintain the life of the vessel over this planned service life, these overhauls are significant enough that they are often considered to be capital expenditures and use funding from sources other than annual maintenance budgets.

Annual maintenance costs are a significant portion of annual operating costs, however and must be considered. The current life cycle maintenance cost estimate was developed for a 30-year period taking into account typical maintenance practices of AMHS, as well as other assumptions related to maintenance of the propulsion system, passenger and crew spaces, auxiliary systems and lifesaving equipment. As described above, AMHS typically removes vessels from service annually for approximately four weeks for regulatory inspections, and minor maintenance. Twice every five years, the vessels are put into dry dock for hull inspection, cleaning and painting. Propulsion systems and generators, as well as other rotating machinery require periodic preventative maintenance, typically based on hours of operation. Often this type of equipment will undergo different levels of maintenance at different intervals. Painting of the vessel, ADA re-certifications, control systems upgrades, and crew and passenger space repairs are considered as well.

Over a 30-year span these costs have been estimated to be about $20M in today's dollars, or about $670,000 per vessel per year. This estimate includes a budgetary contingency to cover uncertainties beyond the scope of this estimate such as parts costs and availability, exchange rate fluctuations, service technician costs, among other external influences that will affect actual costs. Historically, unlike fuel costs, the rate of inflation of vessel maintenance cost components has been generally aligned with that of general inflation.

As a basis for comparison as the vessel design is matured, this initial estimate of annual maintenance costs has been developed based on the concept vessel design presented herein. As the vessel design is developed, it will be beneficial to be vigilant of ideas to reduce maintenance costs. Ideas deemed by the design team to be of benefit, but not conforming to common practices will be brought to the attention of AMHS for consideration.

6.10.4 Summary - Annual Operating Costs

The estimated total annual cost to operate two Day Boat ACF vessels on the routes as described in this section amounts to:

Annual Cost	JNU-HNS	HNS-SGY	Total
Manning	$2.84M	$2.45M	$5.29M
Fuel	$2.25M	$1.15M	$3.40M
Maintenance	$0.67M	$0.67M	$1.34M
Total:	**$5.76M**	**$4.27M**	**$10.03M**

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[3] United States Access Board, "Proposed Passenger Vessels Accessibility Guidelines," 2013.

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[6] Naval Sea Combat Systems Engineering Station, "Margin Management and Procedures for U.S. Navy Small Craft," Norfolk, VA, May, 1988.

[7] HydroComp, "NavCad 2012," 2012.

[8] J. a. M. G. Holtrop, "A Statistical Re-Analysis of Resistance and Propulsion Data," International Shipbuilding Progress, Vol. 31, No. 363, November, 1984.

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[10] M. a. O. P. v. Oosterveld, "Further Computer-Analyzed Data of the Wageningen B-Screw Series," International Shipbuilding Progress, Vol. 22, No. 251, July, 1975.

[11] D. a. H. E. Blount, "Sizing Segmental Section Commercially Available Propellers for Small Craft," SNAME Propeller Symposium, 1981.

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Appendix A

Bow Loading Door - Configuration Options

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MEMORANDUM

Vessel: Day Boat ACF
Engineer: Will Nickum, P.E.
Reference: 13001-04M
Date: March 22, 2013

STATE OF ALASKA
49TH
PRELIMINARY
WILLIAM C. NICKUM
NM 13242
REGISTERED PROFESSIONAL ENGINEER

Subject: Bow Loading Door – Configuration Options

Introduction:

The Design Concept Report (DCR) for the Day Boat ACF (Coastwise Corporation, 2013) presents the primary mission requirements for a new vessel to provide day boat ferry service to portions of Lynn Canal and northern SE Alaska. To reduce turn-around time and meet the 12 hour operational time limit drive-through loading and unloading is necessary. To that end, a bow vehicle loading door will be required. This memo addresses the pros and cons of a few of the configurations available for this opening.

Options:

For reference, appended to the end of this document is an excerpt titled "Bow Access" from literature distributed by MacGregor (now a subsidiary of Cargo Tech), a prominent supplier of cargo access equipment for ships. The primary bow access door options are discussed, and drawings and photos of the various types are provided. Most bow access arrangements include a ramp, often articulated or folding that stows behind the primary shell opening, with a second watertight closure fitted to the collision bulkhead as required by regulations. The inner door can be formed by the ramp structure if designed to act in that way.

Basically, there are three main styles:

1. One piece bow visor or "knight's hood" door that is hinged at the top and folds up to stow above the opening.

2. Two piece side swing, parallel stowing. The two doors open to the side, staying below the line of the upper deck. The hinging mechanism is arranged so that when fully open, the doors are stowed parallel to the ship side just aft of the opening.

3. Two piece side swing, wing type. These doors open out to the side, with the hinge at the aft edge, similar to a conventional hinged door.

All doors styles are fitted with heavy gaskets and seals to provide a fully watertight closure. Power to open and close the doors and ramps is almost exclusively provided by hydraulics.

Pros and Cons:

The bow visor provides the simplest arrangement, with only one hinging surface and one (large) door. While no cost data is available, it is assumed that this type of door is less expensive than the other styles. AMHS has experience with this type of arrangement, as it is fitted on the M/V BARTLETT, a former AMHS vessel. The door stows completely above the vehicle loading and unloading pathway. Operationally, the door opening procedure can take some time, so it isn't unusual to begin the opening process while the vessel is on its final approach to the terminal. The drawback is that when the visor is open it forms a considerable visual hindrance to the vessel captain when looking forward. Another drawback is that the vessel mooring and anchor handling arrangements at the bow have to be positioned well aft of the stem, which may not be optimum.

Both of the two-piece side swing door styles, while perhaps more complicated due to the presence of two closure assemblies, have the advantage of not interfering with the vessel captain's view of the mooring operation. However, because the doors protrude out from the ship's side, they can interfere with the terminal structure. The wing type doors present the most interference, and due to their large clearance envelope would probably not be opened until the vessel is fully moored.

The parallel stowing side swing doors are designed so that the clearance required in way of the bow opening is much reduced. Even so, the doors in their open position still protrude some distance for the ship side, and could interfere with the terminal structure, depending upon the terminal configuration. Because of the large tidal ranges in the areas of operation, vertical pile structures at the terminal interface may extend well above the top of the bow doors, or perhaps be out of view below the edge of the deck. It makes sense to arrange the terminal structures (if possible) to stand clear of the bow door assemblies, and conversely to ensure that the bow door assemblies do not protrude excessively from the vessel when opened.

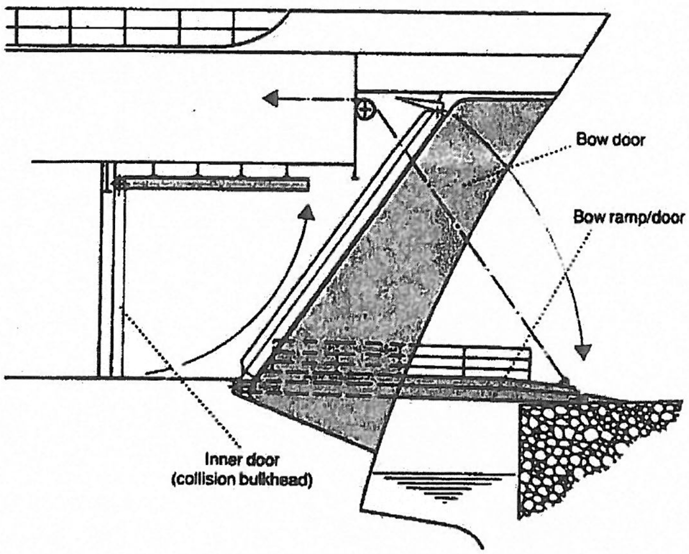
The DCR notes that the first priority routes, serving Juneau – Haines and Haines – Skagway, are configured so that bow loading and unloading will always take place in Haines, due to the mix of existing and new terminals. To meet this arrangement two new bow loading terminals will need to be built in Haines. This provides the opportunity to configure BOTH the vessel and the terminal with a complementary arrangement that works for the terminal and the vessel.

Recommendation:

The configuration recommended uses parallel stowing side swing doors. Provided the terminal configuration is compatible, the risk of damage is reduced because the doors don't protrude very far from the ship's side, and they don't extend above the weather deck at the bow so they won't block the captain's view of the landing. To keep the unloading and loading times within acceptable limits for schedule and day boat operation the doors will likely need to be opened in advance of final mooring, and with full closure occurring as the vessel is backing out of the terminal. This recommendation may be revised once confirmed operating times, door configurations and cost data is obtained from a viable cargo door vendor.

Bow Access

The principal elements . . .



About one third of all ships on unrestricted service which have a roll-on, roll-off capability, incorporate access by the bow as well as by the stern. Most of these are car/passenger ferries which, for quick turnaround, need the 'drive through' facility thus made possible; but bow access is also invaluable on some other, less numerous, ship types such as train ferries, naval support ships (e.g. LST's, dock hold ships) and heavy lift vessels.

Bow access requires, by regulation, the highest degree of integrity.

As shown in the simplified bow drawing (left), some ships may have three successive barriers to water ingress, though in most designs two watertight closures will be deemed adequate. In the latter case, the bow ramp, in its stowed position, is utilised to double as the *inner door and thus seals the aperture in the collision bulkhead.

*An exception to the 'inner door rule' is made in the case of landing craft and very small ferries operating in sheltered waters which have an open vehicle deck; here, the deck is accessed directly by a prow door/ramp.

Below: "Head-on" view of bow access onto a 15,000grt 2,000 passenger/car ferry showing the parallel-stow type 'outer' door and the 6m wide ramp; not visible is the 'inner' door in the collision bulkhead.

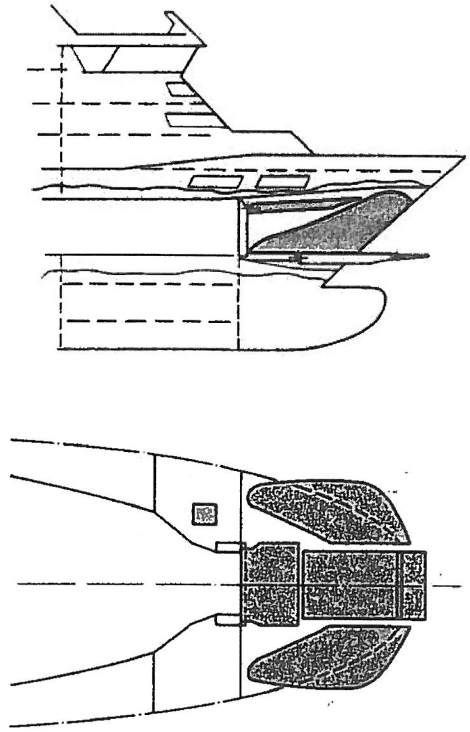
. . . in action on a 'Baltic' Ferry

Usually, forward access ramps are constructed in two or three sections which fold into stowage well behind an outer closure. Here, careful design is necessary since the available stowage space – which may have to accommodate a two- or three-piece folded ramp – is often restricted.

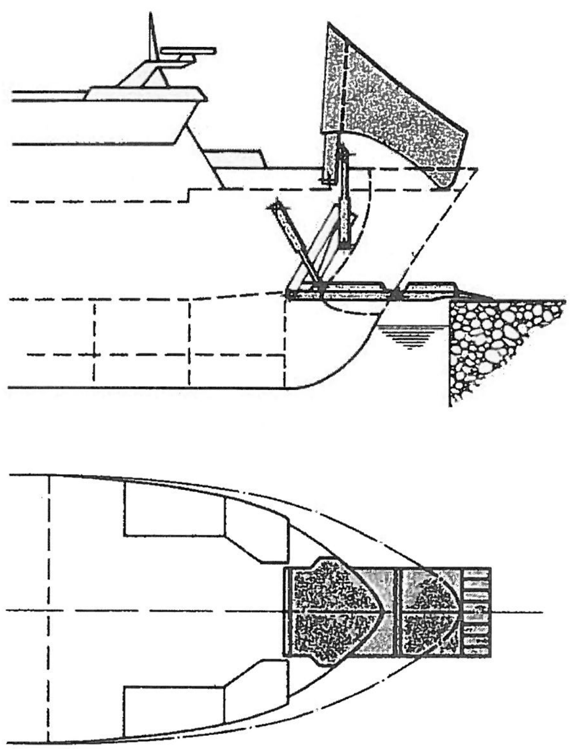
Depending mainly on vessel size, the outer closure may be a visor or alternatively a side pivoting, twin-leaf door. For the small to medium sized ferry, operating comparatively shortsea, the upward hinging, one-piece visor is probably the type most frequently specified – though size is not always the arbiter, for sheltered-water offshore and inter-island routes are often serviced by small, shuttle-type ferries having an open vehicle deck, which makes the use of a visor impracticable and the door type closure almost obligatory.

Most larger ferries – especially those which, at the bow, have more than one deck above the vehicle deck – favour the bow door rather than the visor though this is by no means immutable. Such factors as weight or even customer preference may influence the ultimate choice and, not infrequently, the type of available port facilities may be the principal deciding factor. For example, space considerations at the actual berth or link span may rule out the wing type of door, permitting only the operation of a visor.

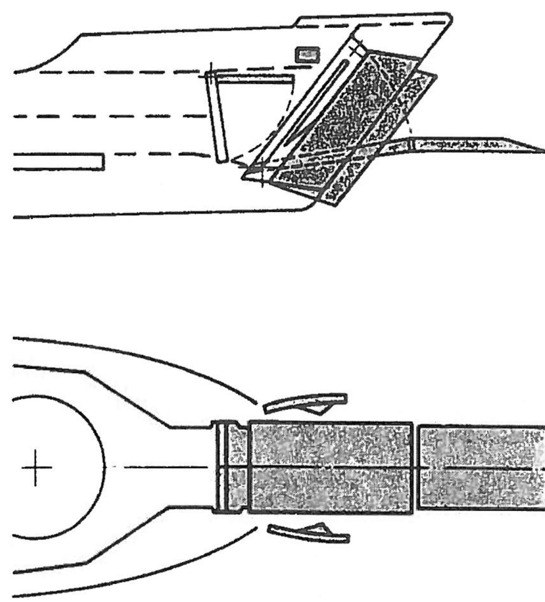
For certain car/passenger ferries operating e.g. inter-island in areas of minimum or even primitive, port facilities, and also for naval LST's, bow access is quite fundamental to RoRo operations since it facilitates the essential 'beaching' i.e. the discharge of vehicle cargo direct on to a beach.



Right: Layout of the forward access equipment on a large (36,000grt) car/passenger ferry of advanced design. The bow door, forming part of the steeply faired vessel foreship, is of the side swing, parallel stowing type (as indicated in plan view), the operation of which is interlocked with that of the two-section, 16.3m long x 6.0m wide, bow ramp. This latter stows in an inverted 'L' formation, its inner panel positioned vertically, to double as a door which closes watertight an aperture in the collision bulkhead.

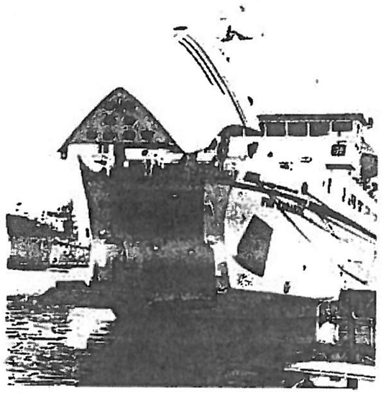


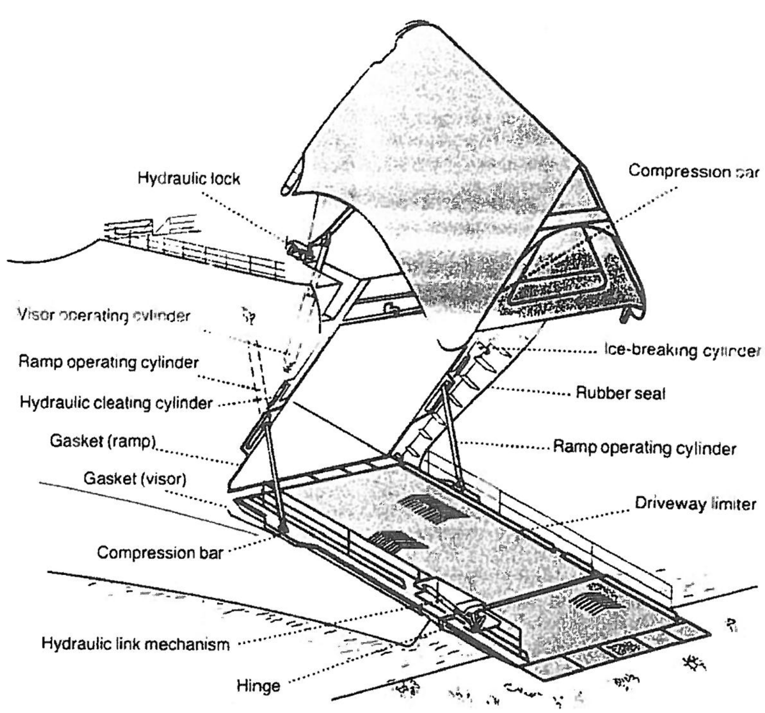
Above: The visor is a one-piece, perfectly matched portion of the ship's bow, hinged at forecastle (i.e. weatherdeck) level. The one shown above – on an 1,800grt car/passenger ferry, operating in the Adriatic – swings open to provide clearance for vehicles traversing the two-section 8.9m long x 4.2m wide bow ramp; this latter, when folded into stowage, doubles as a watertight door, being forced against a compression seal by hydraulically operated cleats.



Above: The design of forward access equipment for naval vessels as, for example, that on the 116m long x 4,400 tonne LST (landing ship) shown here obviously incorporates features fitting it for the special conditions of military service. Among these is (a) the clam type outer closure, the wing door of which has retractable lower corners to facilitate 'beaching'; (b) the ramp, 18.5m long x 4.1m wide, designed to discharge cargo onto a sloping beach and become a watertight door when folded for stowage – and (c) the fact that amphibious craft can be discharged, loaded and transferred from one LST to another (i.e. bow to bow or bow to stern). The equipment outfit at the bow is completed by a top hinged watertight door in the collision bulkhead.

Visors





Above: The photo of an upward hinging, one-piece visor shown here, translates to reality the simpler one shown by line drawing on page 8 bottom, LH.
Right: Illustrating the principal parts of bow access by visor; though a separate inner door (not shown) is provided by regulation, the visor itself – with its gasketed, closely matched joint edges – also provides an efficient barrier to water entry.

Visor design usually results from a collaboration between MacGregor-Navire and the shipyard – and its supply is also a divided responsibility, with the yard supplying the structure itself and MacGregor-Navire being responsible for the actuating mechanism, i.e. the hydraulic and mechanical parts and components. This is a convenient arrangement since the visor is normally first built as part of the foreship and then cut in one piece and refitted as a visor. A watertight fit can then be guaranteed.

For this reason also, the one-piece structure is by far the most common and the hydraulic cylinder the most frequently specified power source. However, where warranted, other designs can be supplied; occasional departures from standard, for example, are, the *two*-piece visor; and, actuation by means other than hydraulic cylinder.

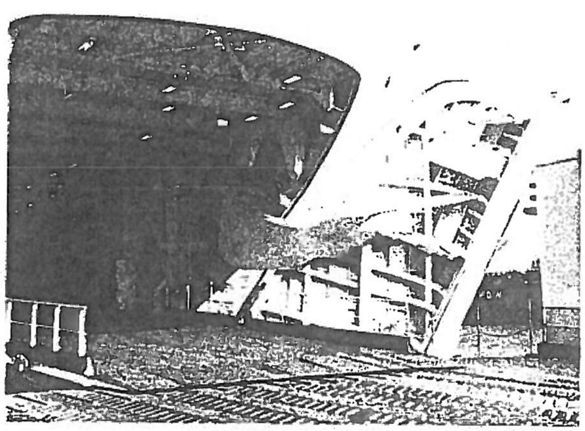
Locking of the visor into the open position and cleating tightly when closed is (as shown in the drawing above) invariably performed hydraulically – though manual operation for smaller structures can be arranged.

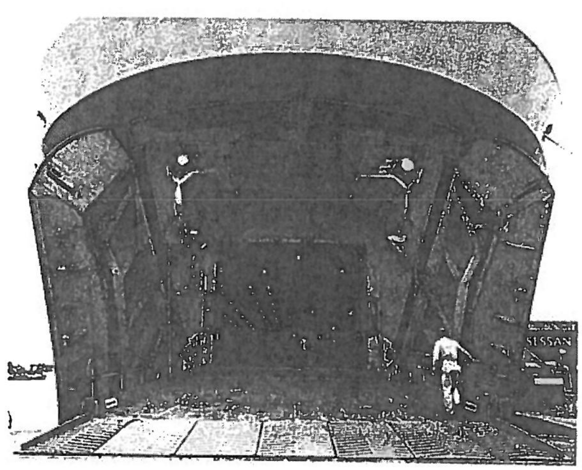
Doors – side hinged or wing type

The other type of external bow closure commonly fitted is the twin-leaf shell door – of which there are two main designs; one is the straightforward wing type, while the other is the parallel stowing type – the wings of which are so hinged that when opened they stow compactly around the ship contours at each side of the bow stem. Photographic examples of both types are shown below and on page 10.

Due to the widely differing contours of ships' bows, doors are, of necessity, almost always individually designed. Great care is necessary to ensure that when being opened or closed they do not foul the shell or the stowed ramp.

This applies almost equally to bow visors – as does the fact that both visors and bow doors are heavily stiffened internally. For, by regulation, both types must be constructed with strength sufficient to withstand the loads assumed to be acting on the surrounding structure or the unpierced shell. And in regard to watertightness, external closures supplied by MacGregor-Navire employ gaskets that give maximum first-line protection against water ingressing and approaching the inner, secondary closure.





Above: The massively proportioned wing type bow door shown here, opens onto the cavernous interior, at main deck level, of a 'Baltic'-type car/passenger ferry of contemporary design.

Above right: This twin wing type bow door fitted to a Baltic ferry has an unusual hinging arrangement made necessary by the steep fairing and curvature of the vessel's prow. For watertight closure this door – as with all bow doors of whatever design – is operated, secured and sealed hydraulically.

Appendix B

Open vs. Closed Car Deck Garage Space

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MEMORANDUM

Vessel: Day Boat ACF
Engineer: Will Nickum, P.E.
Reference: 13001-03M
Date: March 22, 2013

STATE OF ALASKA
49TH
PRELIMINARY
WILLIAM C. NICKUM
NM 13242
REGISTERED PROFESSIONAL ENGINEER

Subject: Open vs Closed Car Deck Garage Space

Introduction:

The Design Concept Report (DCR) for the Day Boat ACF (Coastwise Corporation, 2013) presents the primary mission requirements for a new vessel to provide day boat ferry service to portions of Lynn Canal and northern SE Alaska. In the discussion of capital cost requirements, a partially open aft "roof" over the garage space on the vessel is proposed as potentially reducing capital costs. Included with this recommendation is a requirement that the vessel design team investigate this option. The Roadmap Vessel Design presented in the DCR depicts this partially open aft roof concept.

Background:

With the notable exception of the LITUYA, all other AMHS vessels have enclosed garage spaces. The LITUYA has an entirely open car deck, positioned aft of the primary raised superstructure, with bulwarks and machinery casings along the sides and stern enclosing the open deck, much like an off-shore supply vessel. It operates on a relatively short route, and does not have bow access.

The standard configuration for the rest of the AMHS fleet consists of a fully enclosed garage space formed by the hull bulkhead deck (main or car deck) on the bottom, a superstructure deck (usually a passenger deck) forming the top of the garage, enclosed in the forward portion by a continuation of the side shell plating and structure, and at the sides and ends by curtain plating. The enclosures have primary vehicle access doors at the stern and forward starboard quarter at a minimum. Most of the vessels have a port forward quarter access door as well, although seldom used. These doors are built to a watertight door standard, with heavy scantlings and hydraulic or air powered dogs for sealing. The spaces are entirely covered with a deluge (manual) sprinkler system, and deck drainage is handled via deck scuttles with check valves. The deck above and portions of the curtain plating in way of life saving equipment are protected with fire insulation per regulatory requirements. The garage space ventilation system requires a large volume of air and a fairly high rate of air change to minimize the risk of accumulating combustible vapors.

Points for Comparison:

In comparing an open or partially open garage space with an enclosed space several items can be identified as cost components. Some of the larger ones are:

1. Watertight versus non-watertight access doors

   The Day Boat ACF will require a bow access door, side doors near the stern and a center stern door. A fully enclosed garage space will require that all of these closures are watertight. Additionally, the bow access door, due to its critical location, must be fitted with a watertight inner door that is an effective extension of the collision bulkhead. This inner door can be formed by a hinged ramp assembly that opens once the outer shell door (doors) is (are) opened. A portion of the language from ABS rules (ABS, 2012) is as follows:

   "*Where bow doors of the visor or side opening type are fitted leading to complete or long forward enclosed superstructure…, bow doors and inner doors are to meet the requirements of this section.*"

   A partially enclosed garage space (as depicted in the DCR) may still be required to have a watertight inner door in addition to the external shell door(s) at the bow, but possibly not. A formal ruling has not been obtained from the regulators.

   However, given the vessel's intended route in Northern Lynn Canal, with the potential for significant head seas on a regular basis, including the WT inner door is recommended. It is very likely that a ramp assembly would be included with the door, especially if provided by a company like MacGregor, an international provider of ship cargo handling equipment such as bow doors and ramps. Making the inner door/ramp assembly watertight is standard procedure for many of these assemblies, so is it expected that there would be only a minor cost savings if the inner door were not watertight.

   Doors or gates near the stern into a partially enclosed garage need not be fully watertight, although it would be prudent to provide some level of protection from wind driven spray and seas in the event of large following seas. Their opening size will be the same as for an enclosed garage, if the side bulwarks extend up to the level of the passenger deck. There would be considerable savings in installation and material costs if these doors were not required to be fully watertight. A very rough estimate of cost savings for these three doors is between $50,000 and $75,000 per door, or $150,000 to $225,000 total.

2. Control systems and monitoring requirements for a fully enclosed garage space

   If a bow door(s) and inner door are installed, a monitoring system for the bow door in accordance with ABS rules must be installed. The side and stern doors would not require monitoring if the space is not fully enclosed. Say $30,000 in cost reduction.

3. Deck drains with scuppers and check valves versus freeing ports

   There are several sources of potential water on the car deck, including sea water from flooding or intrusion through openings, rain, snow and ice melt from vehicles parked on the deck, wash down by the crew during deck cleaning, and sprinkler discharge water, either from testing the system or an actual event. If the garage space is fully enclosed, the only source of sea water is due to an event such as collision or damage. Current AMHS vessels that have fully enclosed garage spaces are fitted with regularly spaced deck drains along both sides of the space that extend down through the hull and out the side, with normally open stop check valves allowing water to flow overboard but not allow sea water in. These drains will clear the deck of water irrespective of the source.

In new construction, to meet current EPA regulations, all water on the deck (except in an emergency) must be retained on the vessel for discharge to a shore side facility. Thus, the deck drains will be connected to an internal drainage collection system, and have the provision to discharge over the side in the event of emergency. This type of deck drain system will be required regardless of whether the garage space is enclosed partially or fully. No cost reduction available.

4. Extent of the deck structure above

   The Roadmap Vessel depicts a partially open portion of the Boat Deck aft. The deck area left open equals approximately 3,200 square feet. Cost to purchase and install this quantity of superstructure plating, using the ACF design cost and weight estimates for reference, amounts to approximately $400,000.

5. Extent of the structural fire protection insulation

   The garage space is a high-risk space, and the boundaries that surround the space often need to be fitted with structural fire protection (SFP) insulation. In this case, using the Roadmap Vessel drawing within the DCR for reference, the area of deck or roof above the garage space has only open deck above, not another passenger space or confined area. As such, there would be no structural fire protection insulation installed in the aft portion of the Boat Deck over the garage space. The deck would need to meet A-0 requirements between an occupied passenger space and an open deck, requiring only uninsulated steel plate. No cost reduction anticipated.

6. Extent of the deluge sprinkler system.

   A manual deluge sprinkler system is required by regulation to serve the enclosed portion of the garage space. The extent would mirror the extent of the deck structure above the garage space. Using the Roadmap Vessel concept design for reference, the sprinkler system could be reduced in size by 25 to30% of that required to serve the entire garage space. Cost savings are estimated between $50, 000 and $65,000.

7. Extent of the ventilation system.

   By similar logic, the ventilation system can also be down-sized from that required to serve a fully enclosed garage space. Since the ventilation system is more complex, providing a rough reduction metric based on reduced footprint or reduced volume will be less reliable. Using a 30% reduction factor, the cost savings are estimated between $115,000 and $125,000.

Cost savings for the seven items listed above amount to between $750,000 and $850,000, or between 1.5 and 2% of the cost of a $50M vessel. There will be some life cycle cost savings as well, with less complex vehicle doors and less equipment and structure to maintain.

On the other side of the ledger, the question can be asked, what are the benefits to enclosing the garage space, and do these benefits offset the increased cost?

The primary reason to enclose the garage space is for protection from the elements. Since the intent currently is to enclose at least the forward 50 to 75% of the garage space, the space is well protected from wind, waves, and salt spray when the vessel encounters head or bow quartering seas. The space is less protected when operating in stern quartering or following seas, but the full-height bulwarks at the stern will reduce or eliminate 95% of the effects from wind, waves and salt spray. Even reduced height bulwarks aft will provide substantial protection, given the added advantage that, when underway, the vessel will usually be moving with the wind and sea motion, thereby reducing their effects. When the vessel is backing down it may be into the wind, but the speed is slow so the effects will be minimal.

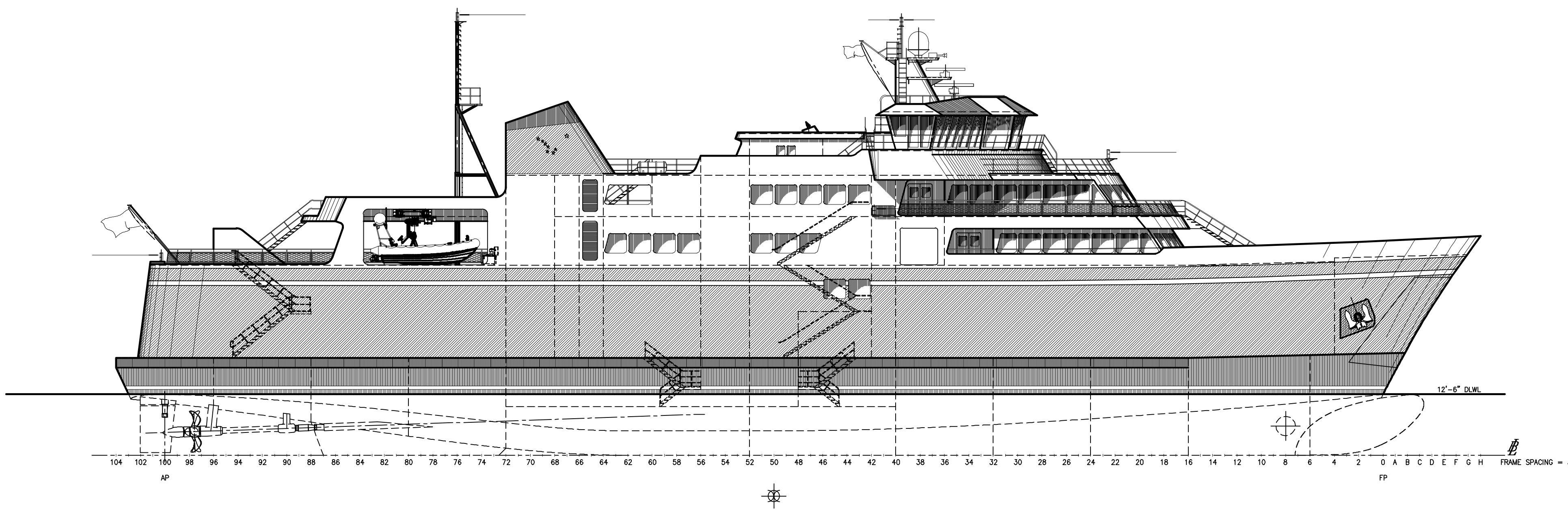
The main shortcomings of the partially open deck or roof are lack of protection from precipitation and lack of temperature control. Even if the garage space is unheated, if enclosed the ambient temperature in the space will remain much warmer than if some portion of the overhead is open to the weather. Vehicles driving aboard in winter weather often carry snow and ice both on the top and clinging to the undercarriage, which typically melts off and drains away on vessels with an enclosed garage space. If the temperature in the space remains below freezing, the accumulated snow and ice might provide challenges to the passengers and crew in terms of loading and unloading, which could impact safety and turn-around time. One possible mitigating step could be to install deck strip heaters to reduce or eliminate the build-up of ice and snow on the car deck. An operational approach could be to ensure that all vehicles are parked under cover in times of extreme weather, which may be realistic given the likelihood of reduced traffic volumes on days with extreme weather.

The question has been raised as to whether passengers can remain on the car deck or in their cars when the garage space is enclosed. The USCG regulations governing means of egress and structural fire protection provide options for how an enclosed garage space is arranged depending upon whether passengers are allowed in the space while underway or not. The decision will make almost no difference in the vessel cost. It is recommended, however, to arrange any enclosed portion of the vehicle deck to allow passenger access.

For much of the operating year, the partially open deck over the garage space will have essentially no effect on operations. It is only in extreme weather situations where a completely enclosed garage space will be missed.

Appendix C

Concept Design Profiles and Deck Arrangements



OUTBOARD PROFILE

REVISION HISTORY

REV	ZONE	DESCRIPTION	DWN	DATE	APVD

GENERAL NOTES

1. ALL MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH 46 CFR SUBCHAPTER H REGULATIONS, ABS RULES FOR STEEL VESSELS.

PLAN INDEX

SHEET NO.	CONTENT
1	OUTBOARD PROFILE
2	INBOARD PROFILE AND HOLD ARRANGEMENT PLAN
3	CAR DECK AND PASSENGER DECK ARRANGEMENT PLANS
4	UPPER, SUN AND HOUSETOP/BRIDGE DECK ARRANGEMENT PLANS
5	SECTION LOOKING AFT, APPROX. FRAME 54

PRINCIPAL DIMENSIONS

LENGTH OVERALL:	280'-0"
LENGTH DESIGN LOAD WATERLINE:	257'-6"
LENGTH BETWEEN PERPENDICULARS:	250'-0"
BEAM OVER GUARDS:	67'-0"
FREEBOARD AT SIDE:	7'-6"
DEPTH AT SIDE:	20'-0"
DRAFT AT DLWL:	12'-6"
PASSENGER CAPACITY:	300
VEHICLE CAPACITY:	53 ASV

REFERENCES

HALF SIZE PRINT ON 11" x 17" PAPER

PRELIMINARY

Elliott Bay Design Group
Seattle • New Orleans

CLIENT: ALASKA MARINE HIGHWAY SYSTEM
Ketchikan, Alaska

PROJECT: DAY BOAT ACF – AMHS 73073

TITLE: PROFILES AND DECK ARRANGEMENTS

SIZE	DWG NO.	REV
D	13001–001–101–1	5

EBDG DWG NO. 13001–001–101–1P5

SCALE 1/16"=1'–0" | FILE NAME 13001–001–101–1P5 | SHEET 1 OF 5

DWN REMc | MOD | CKD | APVD | APVD DATE

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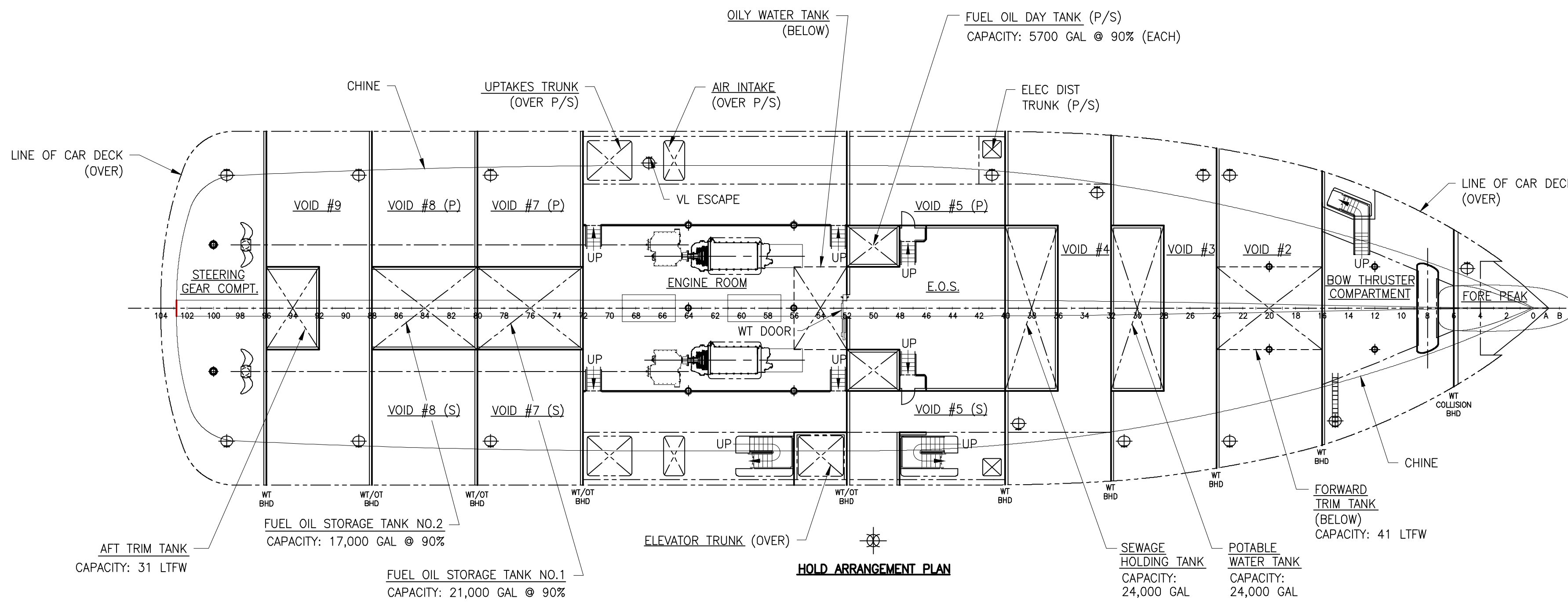
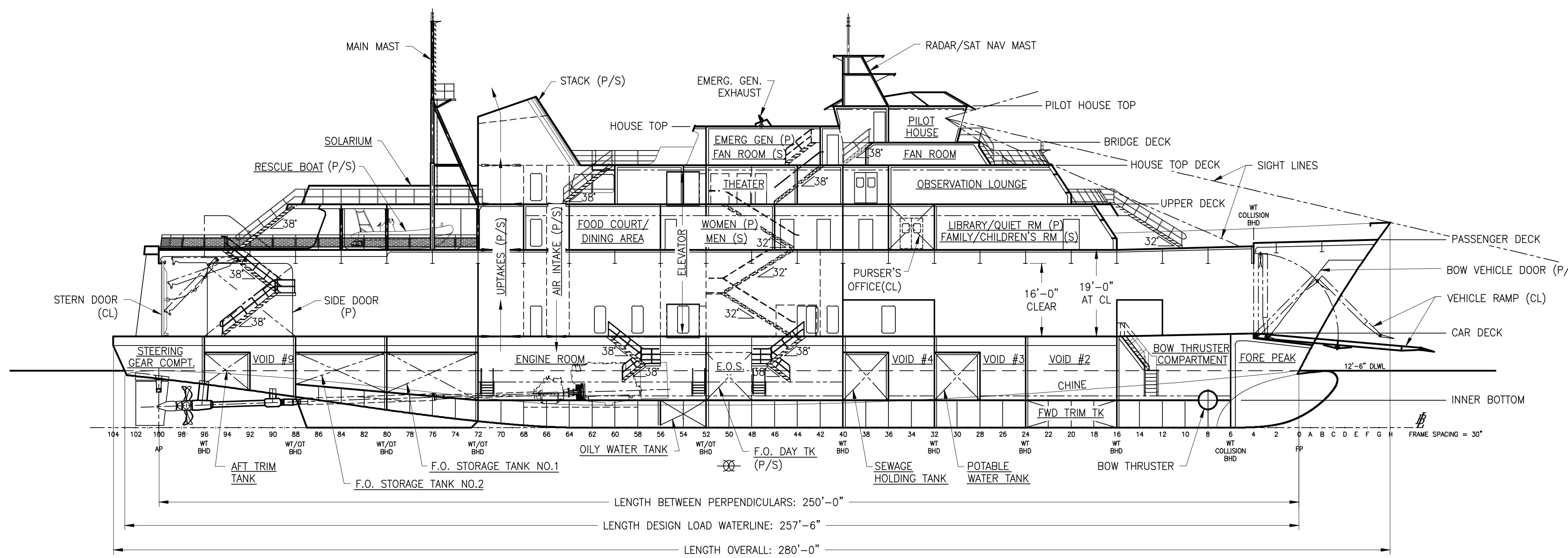


HOLD ARRANGEMENT PLAN



INBOARD PROFILE

PRELIMINARY

HALF SIZE PRINT ON 11" x 17" PAPER

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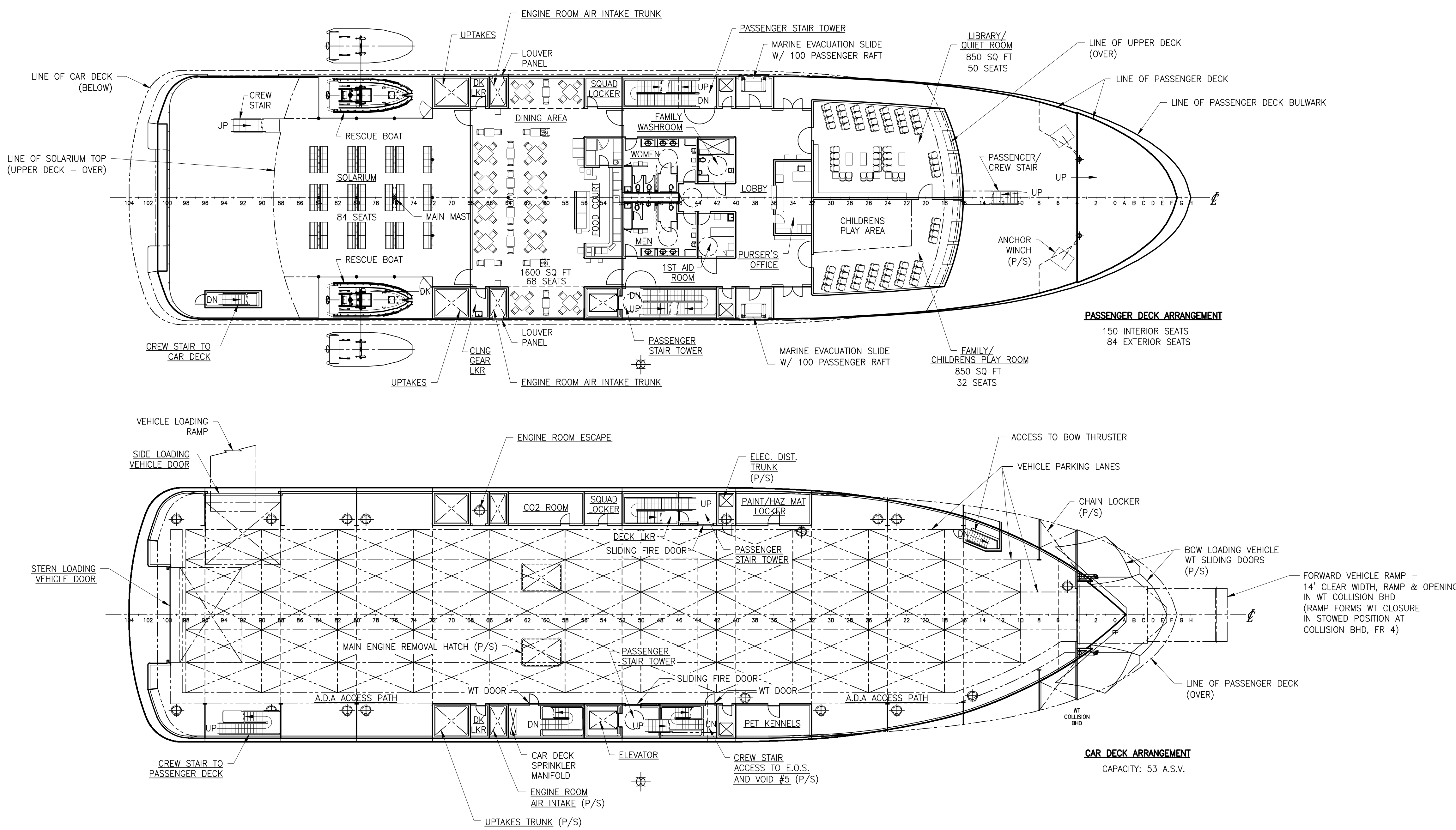

PRELIMINARY

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SCALE 1/16"=1'–0"	FILE NAME 13001–001–101–1P5	SHEET 3 OF 5

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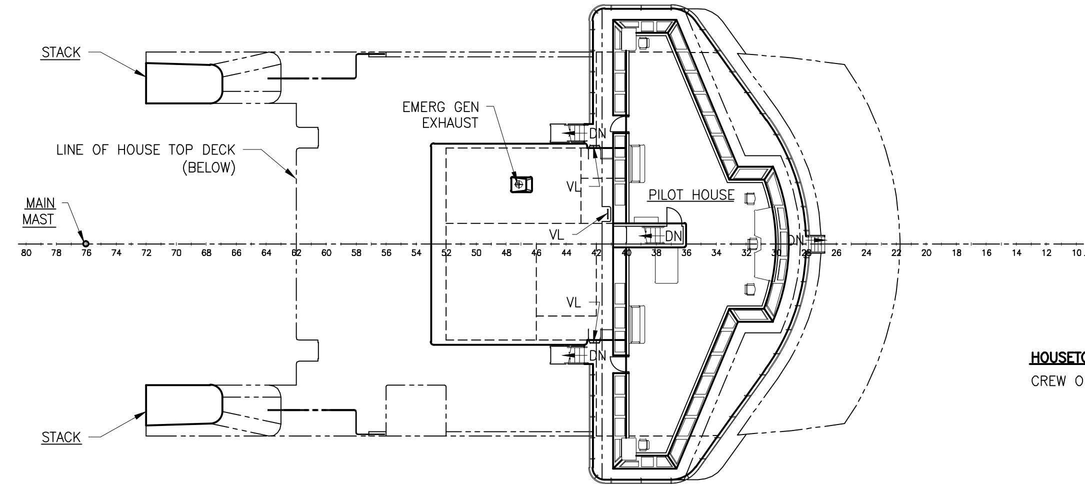
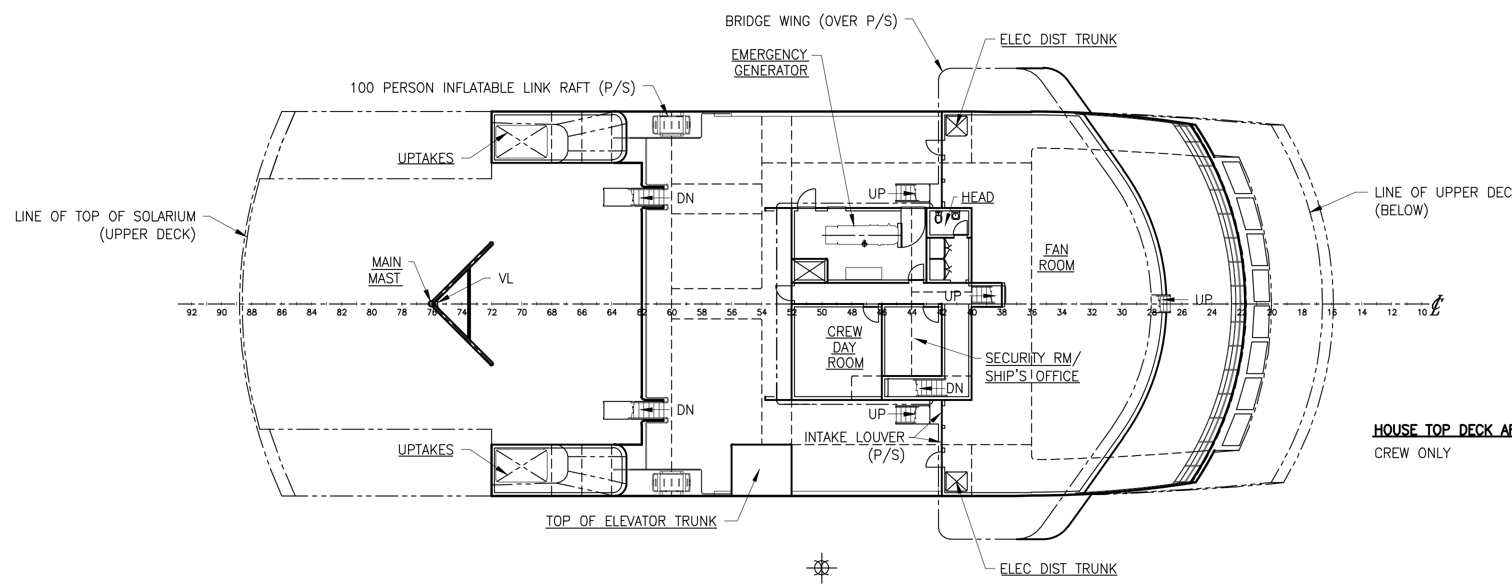
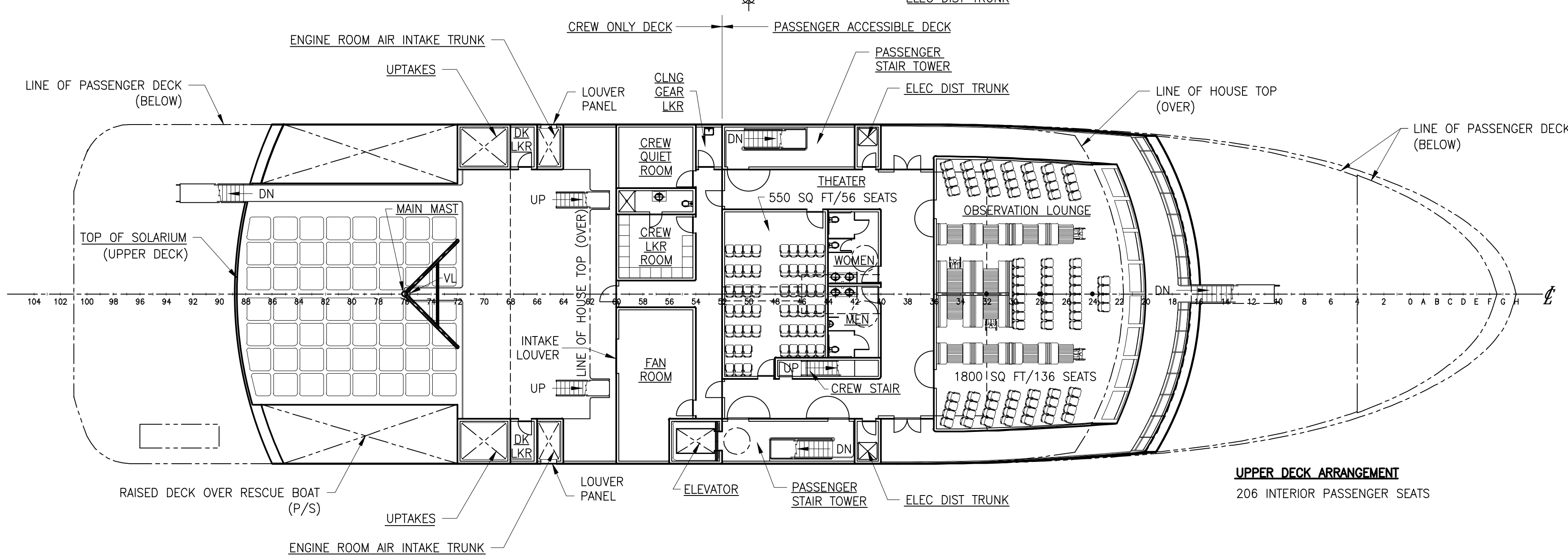


HOUSETOP AND BRIDGE DECK ARRANGEMENT
CREW ONLY



HOUSE TOP DECK ARRANGEMENT
CREW ONLY



UPPER DECK ARRANGEMENT
206 INTERIOR PASSENGER SEATS

PRELIMINARY

HALF SIZE PRINT ON 11" x 17" PAPER

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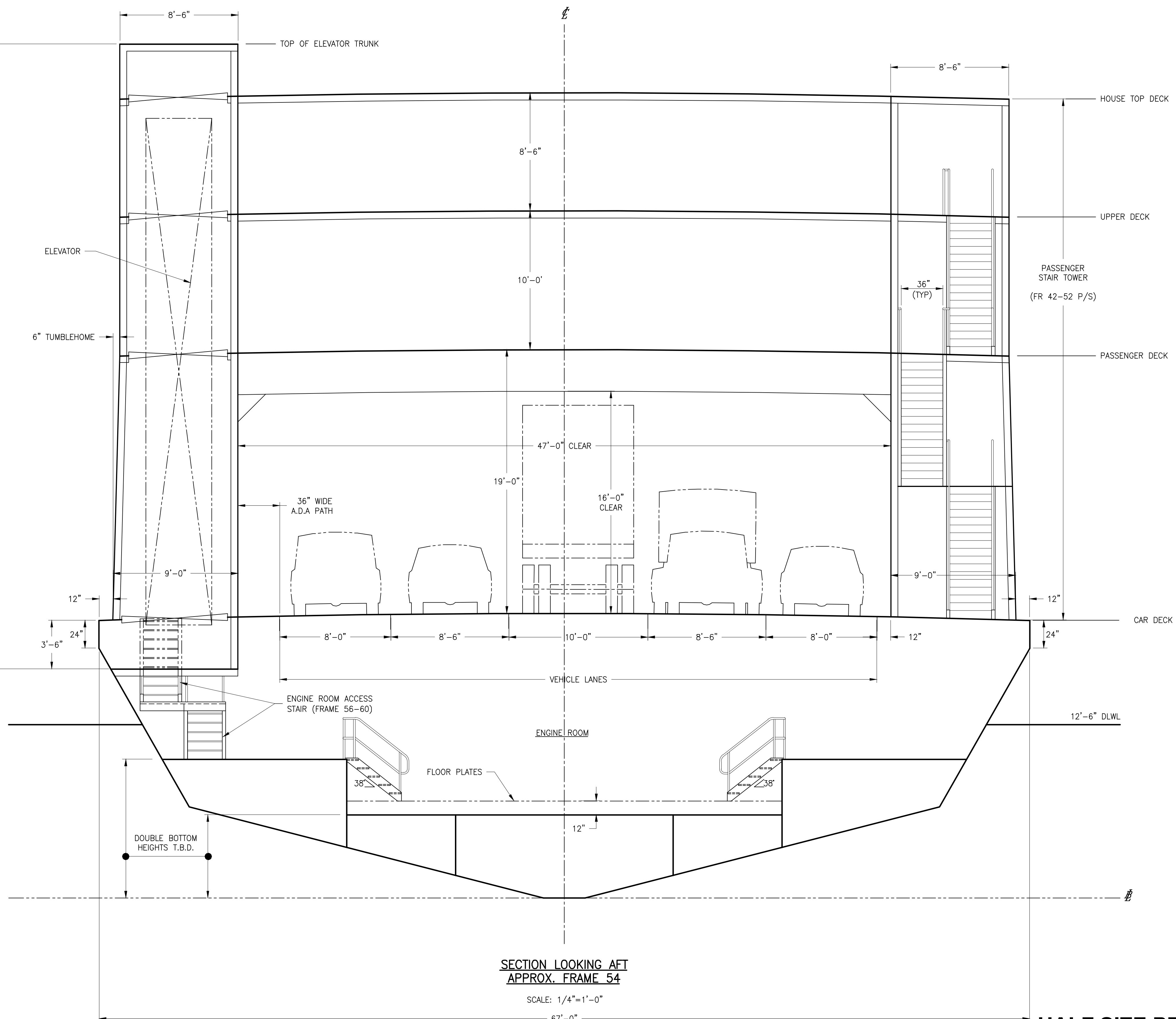
EBDG DWG NO.	13001-001-101-1P5	
SCALE 1/16"=1'-0"	FILE NAME 13001-001-101-1P5	SHEET 4 OF 5



NOTE:
ALL DECKS HAVE CAMBER

SECTION LOOKING AFT
APPROX. FRAME 54

SCALE: 1/4"=1'-0"

HALF SIZE PRINT ON 11" x 17" PAPER

SIZE D	DWG NO. 13001-001-101-1		REV 5
EBDG DWG NO. 13001-001-101-1P5			
SCALE AS NOTED	FILE NAME 13001-001-101-1P5	SHEET 5 OF 5	

PRELIMINARY
STATE OF ALASKA
49TH
WILLIAM C. NICKUM
ME 13242
REGISTERED PROFESSIONAL ENGINEER

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