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LYNN CANAL FERRY SERVICE

Vessel Comparison Report for Dayboats on Lynn Canal Routes

Prepared for: Municipality of Skagway • Skagway, AK

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REVISIONS

REV	DESCRIPTION	DATE	APPROVED
–	Initial issue	05/06/20	WCN NM 13242
A	Section 5.5 and Conclusion updated per new information[5] related to operating costs of the FVF vessels.	5/13/20	WCN NM 13242
B	Changed report title per client request. Added Appendix A per client request.	5/21/20	WCN NM 13242
C	Added Appendix B per client request.	8/12/20	WCN NM 13242

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1 PURPOSE

The Municipality of Skagway, Alaska (MOS) has retained Elliott Bay Design Group (EBDG) to provide recommendations on vessel concepts that would fit MOS's needs for ferry service between the cities of Skagway, Juneau and Haines. Historically these communities have been served by one or more Alaska Marine Highway System (AMHS) vessels. Recent reports [1] [2] commissioned by the MOS have addressed the desire to maintain and even provide a higher level of service in support of the traffic and travel patterns that have evolved over time. Also, the municipality commissioned another report [3] looking at a locally controlled ferry system or operator, should AMHS service to the Northern Lynn Canal (NLC) communities of Skagway and Haines become nonviable in the future.

AMHS service connects Skagway and Haines to Auke Bay (Juneau terminal location) via various classes of vessels, depending upon time of year and vessel availability. Typical service runs from Auke Bay north to Haines, then to Skagway, and the reverse, with alternate runs from Skagway directly to Auke Bay, and the reverse. Frequency also varies with time of year, weather and related sea conditions. Lynn Canal is a long narrow fjord where wind and seas tend to orient along its length, such that vessels are mostly operating in head or following seas.

Vessel concepts that MOS is interested in investigating at a minimum include:

- Alaska Class Ferry (ACF) – two vessels built, M/V TAZLINA delivered in 2019, is currently in operation in Lynn Canal. M/V HUBBARD has not entered service yet, currently undergoing modifications to add a forward side port door. Both AMHS vessels.
- Inter-island Ferry Authority (IFA) Ferry – two vessels built, M/V PRINCE OF WALES and M/V STIKINE. One boat in daily round-trip service between Ketchikan and Hollis, second boat on stand-by.
- Fast Vehicle Ferry (FVF) – two vessels built, M/V FAIRWEATHER and M/V CHENEGA, part of the AMHS fleet, neither boat in operation currently.

This report will address the suitability of these vessels to serve the NLC communities, taking into consideration vessel size, seakeeping, speed and resulting route opportunities, crewing requirements, fuel and maintenance costs, and capacity.

Table 1: Vessel Characteristics

	ACF	FVF	IFA
Length Overall	280'-0"	235'-5"	197'-6"
Length Waterline	257'-6"	210'-8"	175'-6"
Beam Overall	67'-0"	59'-1"	53'-0"
Design Draft	13'-6"	8'-6"	11'-0"
Displacement at Design Draft	3,010 LT	787 LT	1,195 LT
Passengers	297	250	193
Vehicle Lane Feet	1,060	680	550
Vehicle Capacity (@ 20 ft per Vehicle)	53	34	27
Vehicle Deadweight Capacity	284 LT	200 LT	119 LT
Regulatory Tonnage	3,217 GT	1,290 GT	95 GT
International Tonnage	5,304 GT	3,424 GT	2,334 GT

Figure 1: M/V PRINCE OF WALES

Figure 2: M/V TAZLINA

Figure 3: FVF FAIRWEATHER

2 PROCEDURE

Vessel comparisons will be generated by reviewing the available references within the EBDG archives and those provided by MOS. Only published sources will be used to generate tables and figures. Where informative, some anecdotal information may also be provided.

3 GIVEN AND ASSUMED PARAMETERS

The comparisons in the report will utilize existing published reports provided by MOS and those available to EBDG from their involvement with the candidate vessels and with the Alaska Marine Highway System.

No new extensive analyses will be generated, the intent is to use what is in hand or readily available from reference files or websites.

4 REGULATORY PICTURE

The three vessels selected for comparison in this analysis have several basic similarities:

1. They are passenger vehicle ferries, carrying both walk on passengers and a quantity of cars and trucks.
2. They have enclosed vehicle decks, protecting them from weather and sea spray.
3. They are day boats, meaning there are no crew sleeping accommodations on board, and thus are limited by crew work/rest requirements.

Also, each carry USCG Certificates of Inspection (COI) that delineate crew requirements, route limitations, lifesaving requirements, and passenger limits.

However, because of the different sizes, hull configurations and operating speed regimes, these vessels fall into different regulatory classifications. Each of these classifications stipulate minimum construction, operational standards, and crew requirements. The IFA vessels are regulated under the requirements of 46 CFR Subchapter K, Small Passenger Vessels carrying more than 150 passengers. The ACF vessels are regulated under the requirements of 46 CFR Subchapter H, Large Passenger Vessels, and are classed by the American Bureau of Shipping (ABS). The FVF are regulated under the requirements of the International Code of Safety for High Speed Craft (HSC 2000) and classed by DNV-GL.

Subchapter K – The USCG defines a small passenger vessel as one admeasuring under 100 gross registered tons (GRT). Note that this use of the word "ton" refers to a unit of volume, not weight. Small passenger vessels have less stringent regulations for fire safety, crew certification, electrical systems, alarm and monitoring systems, and mechanical systems. Consequently, small passenger vessels are less expensive to operate and to maintain for the same size of vessel.

Subchapter H – All of the conventional vessels of the AMHS fleet (except for the LITUYA) are regulated by the USCG as large passenger vessels. Consequently, they have higher levels of crewing than small passenger vessels plus the qualifications of the crew positions are greater. For example, a deck hand must hold merchant mariner documents which reflect a level of training in firefighting, lifesaving, and marine knowledge.

The role of a Classification Society (ABS or DNV-GL) is to provide an independent third party to set construction requirements and to perform inspections to ensure those requirements are maintained throughout the life of the vessel. USCG and Class Society regulatory requirements are in alignment but not identical. The USCG may delegate some of their inspection requirements to ABS or DNV to fulfill. Maintaining the vessel "in Class" brings extra expense that may be partially offset by a reduction in marine insurance costs.

HSC 2000 – The High-Speed Craft (HSC) code is an international body of regulations created by the International Maritime Organization (IMO). They provide a safety framework for large vessels moving at high speed while transporting passengers and possibly vehicles. The framework encompasses not only design and initial construction but operational items such as maintenance, crew qualifications, and training procedures. Generally, the maintenance and fuel costs are greater for a high-speed vessel because of the operating stresses on the hulls and machinery.

The additional crew qualifications result in higher crew costs per position compared to conventional Subchapter H vessels and restricts how crew members can be dispatched to vessels. For example, a Master that is qualified to operate the MATANUSKA in Lynn Canal cannot transfer to operate the FAIRWEATHER without additional training specific to the FAIRWEATHER. Further, this training must be "kept current", similar to certification for a pilot on a particular aircraft. This has been a constraint on AMHS that they did not fully appreciate when the fast vehicle ferries were first introduced.

5 VESSEL COMPARISONS

Several comparison factors are addressed below for each of the three vessel options.

5.1 Seakeeping

All three of the vessels in the comparison are seaworthy, designed and built to operate in the demanding climate of SE Alaska. However, the prevailing winds and seas found in Lynn Canal between Auke Bay to the south and Haines/Skagway to the north are particularly challenging, given that the canal is a long narrow fjord with few places for refuge. Heavy seas can slow the vessel down, stress machinery, equipment, and vehicle lashings, and cause discomfort and motion sickness to the passengers and crew.

The ACF vessel was designed for Lynn Canal operation, and while now in operation, no real-time data exists for the vessel regarding motion sickness and seakeeping. During the design phase the vessel hull was model tested, where the vessel was run in head and following seas equivalent to Sea State 5, and accelerations were measured at various points along the vessel's length. From that data the plot of Motion Sickness Incidence Percentage (MSI%) versus length in Figure 4 was generated.

Data from two other AMHS vessels and a parametric hull are included on the plot taken from Reference [4]. It is clear from the plot that hull length matters when it comes to motion sickness, i.e. the longer the vessel, the lower percentage of people suffer motion sickness. It also points out the benefit of providing passenger accommodation space in the middle to after portions of a vessel, where motions are less severe.

The IFA vessel operates on a route that crosses Clarence Strait, transiting west outbound from Ketchikan and east on the return trip, exposed to the prevailing north/south weather and seas. Predictions were made during the IFA vessel design to determine seakeeping behavior during heavy weather [5]. The conclusions within the IFA seakeeping report provided recommendations for inclusion of bilge keels with fixed fins to help reduce rolling motions in heavier winter wave conditions. Like the ACF, the best MSI results were found in following seas. In general, for the worst sea state in the report, the MSI for head seas is approximately 10% for 2-hour exposure. This indicates that two hours in these conditions can be expected to cause sea sickness in 10% of the passengers onboard.

Seakeeping and MSI% data for the FVF is not available for review. The M/V FAIRWEATHER has been used on the Lynn Canal routes in the past with success, except for a slamming incident in December of 2004 that damaged the hull in heavy weather. In that instance the vessel was on its scheduled run from Haines to Juneau when it was struck by what was reported as a rogue wave. Damage was limited to the forward void between the two hulls and the vessel completed its run to Juneau [6]. The vessel has operational constraints in its Certificate of Inspection [7] that provides maximum speed limits depending on significant wave height.

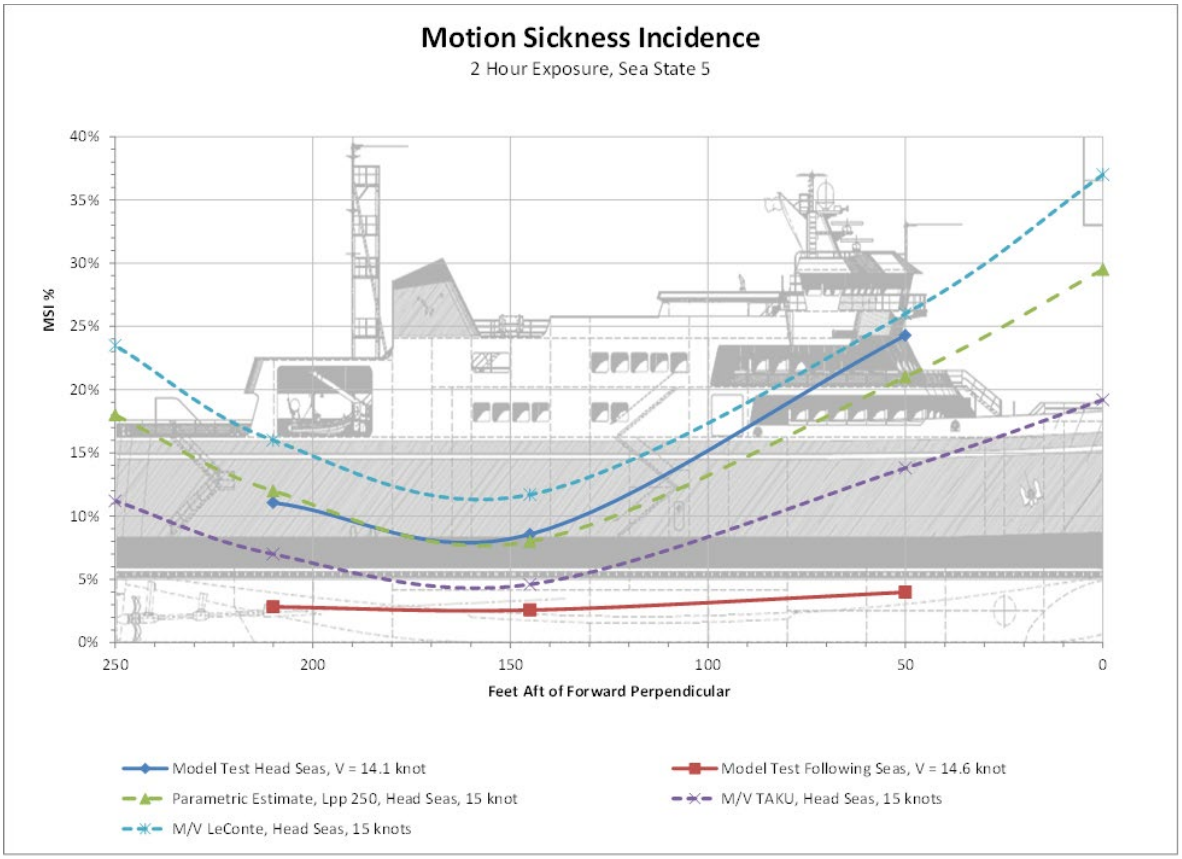

Figure 4: ACF Motion Sickness Comparison with other AMHS vessels [8]

5.2 Vessel Speed and Route

Two of the vessels in the comparison are conventional mono-hulls, the third is a catamaran designed to operate at higher speeds. Published speed data for the three vessels is given below. These speeds are representative of normal operations in milder weather, with engines operating at approximately 85% of their maximum continuous power rating (MCR).

- IFA – 14 knots
- ACF – 16.5 knots
- FVF – 32 knots

The additional power reserve is available to make up for heavy weather and other potential schedule impacts. As day boats the vessels are limited to a voyage length (time at sea) of 12 hours. A greater voyage length brings with it the requirement for a two-watch system [9], something for which none of the vessels are equipped.

In addition to speed through the water, the ability to unload and load vehicles and passengers efficiently is dependent upon the vessel's vehicle deck arrangement, location of openings, and ability to maneuver well when docking and undocking. The IFA and FVF vessels are configured similarly, with a stern door and a forward side door sized for large vehicles.

All three vessels under comparison are challenged to handle vehicle traffic between Haines and Skagway, due to the necessity of either loading vehicles stern first, unloading vehicles in reverse, or turning around within the confines of the vehicle deck, significant adding to the time in port. Recreational vehicles (RVs) are common in the summer travelling between Haines and Skagway due to the road connections available to both ports, and their added length further complicates the vehicle handing.

The ACF vessels were built with a stern door and large clamshell bow door/ramp assembly to facilitate straight through loading and unloading, plus they have another side door on the port side aft. The ACF loading door arrangement was predicated on a major renovation to the Haines Terminal that would allow two ACF vessels to moor bow in, taking or offloading vehicles to or from either Auke Bay or Haines. However, the Haines terminal modifications were never completed, so now one of the ACF vessels (M/V HUBBARD) is being retrofitted with a forward side door, and the TAZLINA is scheduled to be retrofitted as well sometime in the future. This arrangement will match the configuration of the other boats in the AMHS fleet (and the IFA vessels), plus it will provide the added advantage of relatively straight-through loading between Haines and Skagway.

The routes of interest to the MOS are given below, in order of priority.

1. Skagway/Auke Bay – 162 miles round trip
2. Skagway/Haines – 29 miles round trip
3. Haines/Auke Bay – 136 miles round trip
4. Circular Route (Auke Bay/Haines/Skagway/Auke Bay, or the reverse) – 164 miles
5. Traditional Route (Auke Bay/Haines/Skagway/Haines/Auke Bay) – 179 miles

An excerpt from Google Maps is provided in Figure 5 for perspective.

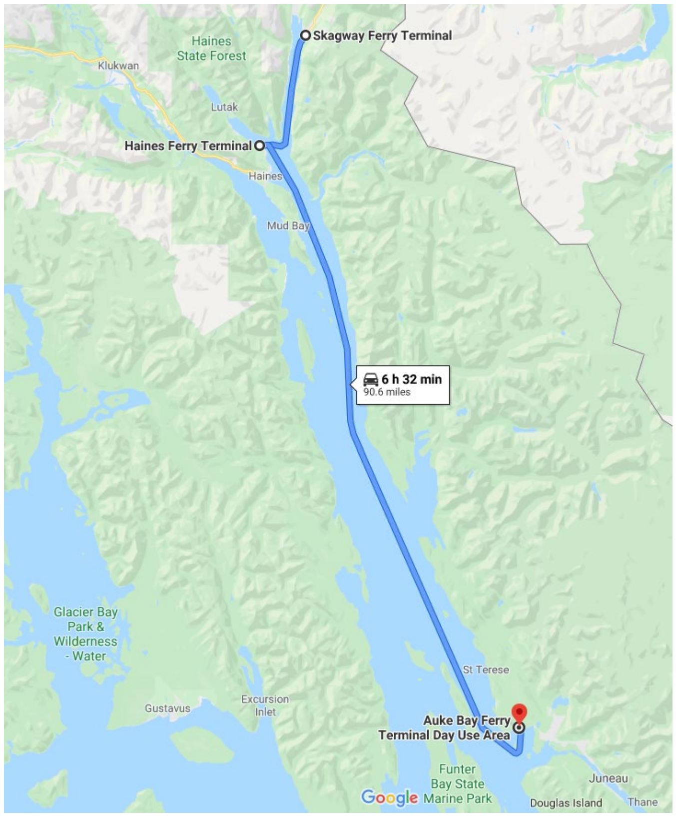

Figure 5: Lynn Canal

The ACF vessel is fast enough to service all routes identified above within a 12-hour period except for the Traditional Route, assuming an in-port time of 45 minutes. The TAZLINA is currently in service on the Circular Route, making the trip twice a week in a 12-hour underway schedule. This timing allows one hour for start-up and loading in the morning and one hour at the end of the day for unloading and shutdown to stay within the maximum allowance of 14 hours between rest breaks. To makes the leg between Skagway and Auke Bay within the scheduled time requires an average speed of 16.2 knots, making it the most challenging part of the route to stay within schedule. Over the entire day, allowing for 45 minutes at each port, mandates a speed of 15.6 knots. The frequency (sailings per week) of the Circular schedule depends upon work/rest rules and work week limitations, but it can make the trip multiple times per week. The time required in port will vary depending upon the vehicle load. A summer load with several RVs may take longer to turn around than a winter load of local traffic only.

The ACF can provide once daily round-trip service between Auke Bay and Skagway, Auke Bay and Haines, and all three via the Circular Route. It can do multiple trips per day between Haines and Skagway.

The lower speed of the IFA limits its ability to serve any route that includes both Auke Bay and Skagway. It can provide once daily round-trip service between Auke Bay and Haines, or multiple trips between Haines and Skagway. Service between Skagway and Auke Bay would require an overnight in Haines.

The higher speed of the FVF vessel brings all route options into play with at least one round trip per day. Multiple round trips per day could be provided at times on all routes except for the Traditional Route, with some frequency constraints on the longer routes needed to stay within work/rest limits.

5.3 Crewing Requirements

The issue of crewing any vessel, and particularly those that accommodate significant numbers of passengers, covers a wide range of separate but related functional requirements.

The primary concern is safe manning, which is covered by USCG regulations for minimum requirements. These minimum standards may be modified by vessel size, service region, time of year and other factors. Numbers may be defined relative to deck and engine room, but the overriding factor will be numbers of crew to facilitate fire fighting or emergency evacuation of the vessel. These numbers will, in turn, be dictated by the number of passengers, type of lifesaving equipment, and capacity of each unit. The minimum required crew composition and number is specified by the USCG and documented in the vessel's Certificate of Inspection (COI). The three vessels' COI required crewing is summarized in Table 2.

Table 2: COI Crewing Requirements

	ACF M/V TAZLINA[1] [10]	FVF M/V FAIRWEATHER[2] [7]	IFA M/V STIKINE [11]
Masters	1	1	1
Licensed Mates	2	2	1
Able Seamen	2	2	0
Ordinary Seamen	1	0	0
Deckhands	0	0	3
Chief Engineers	1	1	0
Licensed Engineers	0	1	0
Oilers	1	0	0
Wipers	0	0	0
TOTAL	**8**	**7**	**5**

Many ferry operators operate with manning that exceeds the minimum requirements of the COI to support their desired operational scheme, customer service, and collective bargaining agreements. For example, AMHS operates the M/V TAZLINA with 14 crew and the M/V FAIRWEATHER with 10 crew, while the IFA operates the M/V STIKINE with 8 crew (3 of whom are galley staff).

The decision to increase deck crew depends on operational area, length of voyage, frequency of port calls and type of mooring equipment. Engine room needs will depend partly on the size, and complexity

[1] Must include 7 certified lifeboatmen

[2] Must include 5 crew with HSC (High Speed Craft) type rating, and one GMDSS (Global Marine Distress and Safety System) operator

of the machinery outfit, degree of automation and on whether the vessel has a maintenance management system in place, and whether there is an integrated condition monitoring module.

The biggest area of variation, subject to meeting mandated lifesaving needs, is in the hotel department. Size is very dependent on the quality of service aimed for in the operation. For day boat ferries, the hotel department will be driven by food service, gift shops, and other onboard amenities.

Note that, different vessels will have different crew training requirements. USCG training requirements are included as footnotes where applicable. Most notably, the HSC code has additional training requirements for the FVF. There is additional overhead cost to maintaining the required number of qualified crew members, and a slightly higher wage rate compared to traditional vessels. Additionally, there are more limited options for dispatching crew for the FVF (see Section 4 above).

The average total cost per position for the FVF versus more traditional vessels in the AMHS fleet are tabulated below. In general, FVF crew positions, which earn only slightly higher per hour rates, required more than double the total compensation of other vessels in the fleet.

Table 3: Average Crew Cost Per Position (FY15 values, excerpted from Reference [12])

Vessel Type	FVF		Dayboat	Mainliner	Ocean
Vessel Name	CHENEGA	FAIRWEATHER	AURORA	MATANUSKA	KENNICOTT
Total Compensation	$3,393,421	$3,954,739	$3,698,410	$7,502,290	$9,217,110
Positions	10	10	24	48	55
Compensation/Position	$339,342	$395,474	$154,100	$156,298	$167,584

5.4 Fuel Costs

Vessel fuel consumption and resulting costs are heavily dependent on the vessel's weight and operating speed. Fuel consumption is compared in gallons per mile, gallons per mile per passenger, and gallons per mile per vehicle to capture both weight and speed effects in Table 4 below.

Table 4: Fuel Consumption

	ACF [13] M/V TAZLINA	FVF [13] M/V FAIRWEATHER	IFA[3] [14] M/V STIKINE
Operating Speed (KT)	16.5	32	14.0
Gallons/Hour	250	600	127.2
Gallons/NM	**15.15**	**18.75**	**9.08**
PAX	290	210	195
20ft Vehicles	53	27	34
Gallons/NM/Passenger	**0.052**	**0.089**	**0.047**
Gallons/NM/Vehicle	**0.286**	**0.694**	**0.267**

[3] M/V STIKINE's fuel consumption was estimated based on installed horsepower.

The fuel consumption for the M/V STIKINE noted above was estimated based on the installed horsepower on the vessel of 3,000 BHP using a trendline generated by the AMHS fleet [13].

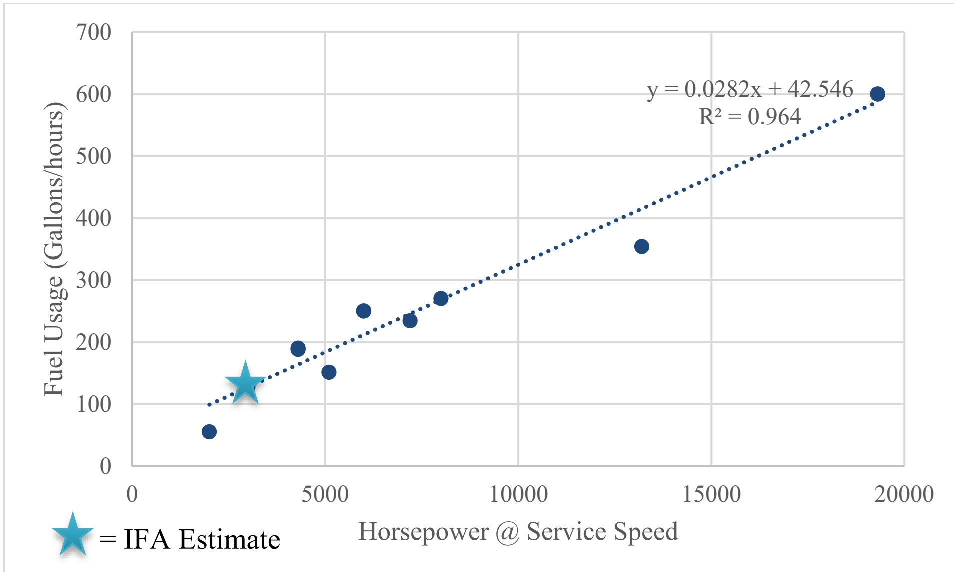

Figure 6: Fuel Usage Estimate Based on Horsepower

Email correspondences with the IFA[4] show that the propulsion engines consume 45 to 60 gallons per hour depending on engine load. This tentatively suggests that the M/V STIKINE's estimated overall fuel consumption of 127 gallons per hour is likely conservative.

5.5 Non-Fuel Operating Costs

Per mile costs for each vessel option is used as the basis for the annual non-fuel operating cost estimate presented in Table 5. Due to the age and ownership of the three vessels, data from various sources must be compiled to establish the cost estimates for each vessel.

- Per mile cost for the FVF is based on the 2012 AMHS cost information compiled and summarized in Ref. [1]. The vessel cost is the average per mile non-fuel operating cost of the FAIRWEATHER and the CHENEGA (both AMHS fast vehicle ferries). EBDG has anecdotal information[5] that **engine maintenance costs are not included in the available operating costs of the FVFs**. The engines have been under extended warranty from construction through last year. This warranty covered most, if not all, costs associated with maintaining the engines including their replacement in 2014. A more complete understanding of the source material may reveal other items to be better understood.

[4] Email thread "IFA Stikine COI", April 27,2020, Walter Marsh, Chief Engineer
[5] Conversation, Robert Ekse (EBDG) and an AMHS source, 5/12/20

- IFA per mile costs are based on cost and route information in Ref. [15]. IFA vessels are assumed to make 360 round trips annually, 72 miles per round trip. Miles traveled and expenses are assumed to be divided equally between the two vessels.
- ACF costs are based on the annual mileage and cost estimates summarized in Ref. [1] for the day boat/ACF vessel option. Per mile costs are based on the average costs for both routes considered by Ref. [1]. In addition, the vessel has a crew of 14 rather than the nine assumed by Ref. [2], and therefore the total annual cost is increased by the annual salary of the five added positions based on the day boat crew cost in Table 3.

Costs are inflated to 2020 dollars using an assumed 3% annual inflation rate. For each vessel, annual costs are based on an assumed annual mileage total of 50,000 miles.

Table 5: Non-Fuel Operating Costs

	ACF	IFA	FVF
Per Mile Cost	$267	$143	$177
Estimated Annual Cost (2020 USD)	$13,350,000	$7,150,000	$8,850,000

The data pool from which the FVF cost was extrapolated represents a single year of operation only. This is too small of a sample to reliably extrapolate future operating costs. As noted previously it is EBDG's understanding that none of the engine maintenance costs are included in the 2012 data. The FVF has a propulsion plant of 19,310 installed horsepower versus 6,000 for the ACF. The FVF also has four propulsion engines and waterjets, versus two propulsion engines with CP propellers on the ACF. Maintenance costs will be related to the size and complexity of the propulsion machinery. In the case of waterjets, they will tend to have a lower annual maintenance cost until a required overhaul where they are largely rebuilt. Extrapolating annual operating costs from a single year's data can miss periodic costs such as this. FVF manning costs are also considerably higher than other AMHS vessels as noted in Section 5.3. Operation under the HSC Code means that onboarding new crew members will have significant expenses not seen in the operation of the ACF or IFA vessels.

5.6 Car / RV Carrying Capacity

The capacity of the three classes of vessels are compared in two ways: vehicle lane length and maximum weight of vehicles. Cars and RVs tend to be limited more by vehicle lane length than by allowable loading. The allowable loading will tend to limit the number of heavy commercial trucks which may be carried. Note that the vehicle capacity descriptions provided below are approximate, and more fully detailed descriptions are available in the source material. The IFA information is sourced from contract documents pre-construction. Final stability documents may allow for heavier loading.

The different vessel capacities may result in some under-capacity in the summer months, or in over-capacity in the winter months. The McDowell Group has provided in-depth analyses [2] [1] of the route traffic volumes.

Table 6: Vessel Capacity Comparison

	ACF	IFA	FVF
Vehicle Lane Length (feet)	1,060[6]	550[7]	680[8]
Maximum Weight of Vehicles (LT)	284[9]	119[10]	200[11]
Vehicle Capacity Description[12]	53 ASVs OR 26 cars & 6x large trucks[9]	27 ASVs OR 21 cars & 2x40 ft trailers w/ trucks[10]	34 ASVs OR 30 cars & 2x small trailers[11]

6 CONCLUSIONS

All three of the vessel types compared in this report are capable and seaworthy, able to operate in Lynn Canal in all seasons. The shorter length of the IFA vessel means that motion sickness incidence is expected to be greater on the IFA vessel than on the ACF vessel. Data is not available to provide ride quality information on the FVF vessel. It is worth noting that the FVF vessel will be exposed to heavy seas for at most one-half the time of the ACF or IFA vessel. The FVF is restricted to not more than 27 knots in wave heights exceeding 8.2 ft (Sea State 5). According to model test results [8] in Sea State 5 head seas the ACF will be slowed by a couple of knots.

Due to speed limitations, the IFA vessel cannot provide round-trip service between Auke Bay and Skagway in the same day. It can serve the Auke Bay/Haines route in one day and serve the Skagway /Haines route on a different day. The ACF can serve all routes except for the Traditional Route, and the FVF can serve all routes with time to spare, due to its significantly higher speed.

The different crew requirements for the three vessels reflect the differences in size and capacity, installed HP and resultant speed, and the different regulatory envelopes that each vessel type operates within. The requirements for the FVF are the most restrictive, in that there is specialized training required to operate a vessel under the HSC Code, and that training must include multiple crews to ensure regular service. The requirements for the IFA vessels are the least restrictive, due to their smaller size and that they are regulated as a small passenger vessel. Certification to work as crew for a Subchapter K small passenger vessel is easier to obtain than that required to operate a Subchapter H

[6] Taken from Ref. [2] and measured from Ref. [19]. Note that Ref. [16] lists the lane length as 850 feet.
[7] As measured from Ref. [22].
[8] As measured from Ref. [20]. Note that Ref. [16] lists the lane length as 620 feet.
[9] Taken from Ref. [17].
[10] Taken from Contract stability document, Ref. [18]. In-service data may vary.
[11] Taken from Ref. [21].
[12] Alaska Standard Vehicles (ASV) measure 20 feet in length with a weight of 6,000 pounds.

vessel such as the ACF vessel. This provides a larger and relatively less costly pool of people to draw from.

The ACF vessel manning estimate of a minimum of nine crew noted in Reference [1] reflects the stated intent to operate a true day boat with one watch. The current COI for the as-built ACF TAZLINA notes that the vessel carries up to 14 crew total, which indicates that either the estimate was in error, or that vessel operations requires more people than was anticipated at the time of the estimate, or the AMHS collective bargaining process added billets. AMHS operates all their vessels under a collective bargaining agreement with the Inland Boatman's Union (IBU)and the International Organization of Masters, Mates and Pilots (MM&P). Negotiations around the manning of these new vessels most likely contributed to the final COI numbers.

Vessel fuel costs noted in the comparison directly reflect the difference in vessel size and installed HP. The IFA vessel is the most fuel efficient, and slowest vessel, the FVF the least fuel efficient, but fastest vessel. The ACF and IFA vessels compare quite favorably on a per vehicle or per passenger basis.

A realistic comparison of non-fuel costs (a significant portion of which are crew costs) has been a more challenging task, given the limited time frame and need to restrict the investigation to published analyses. The results are inconclusive on the per-mile non-fuel operating costs for the three vessels. Given the higher per-person crew costs of the FVF vessel and the relative size of the propulsion plants, one would assume the non-fuel costs of the FVF to be higher than stated in Table 5 of this report.

The results use the estimated ACF costs based on a report from 2013, with nothing available yet from actual vessel operations due to the TAZLINA's short operational history. The FVF values come from Reference [1], the results of an analysis of one year (FY 2012) of data obtained from AMHS and do not include any significant engine maintenance costs. Data from later years is available from AMHS, but the data is in a form that considerable reduction would be required to provide useful comparison tables such as are found in [1]. This level of research and analysis is outside the scope of this project. An in-depth analysis of the operating costs of the FVF vessels over a minimum period of five years is recommended if MOS is considering utilizing an FVF vessel in Lynn Canal. This would also require developing an understanding of what all costs are not included in Ref. [1], and developing estimates to compensate.

The ACF vessel provides the largest vehicle capacity of the three vessels, both in terms of lane length and in terms of maximum weight of vehicles. Once the forward side doors are installed on the ACF vessels, they will be more versatile in terms of loading and unloading all manner of vehicles on any of the routes, but especially on the Skagway/Haines route. This will also reduce in-port time.

No other vessels, either existing or in concept were considered in this brief comparison study. Nevertheless, in preparing this report the idea of a vessel that approached the length, speed, and capacity of the ACF vessel but required a crew more in line with the IFA vessel was discussed. The IFA vessel operates under the requirements of Subchapter K, which applies to vessels that admeasure less than 100 gross tons (nominally a measure of internal volume). It is possible to design a vessel that is longer than the IFA vessel, perhaps approaching the size of the ACF, and still admeasures less than 100 gross tons. There are many arrangement and structural related compromises that would have to be considered were such a vessel to be built, especially with respect to room for machinery in the hull. But the manning requirements would be less stringent. Perhaps not in actual numbers of crew, but the licensing requirements of the master and deck hands are less stringent, and a chief engineer is not required on vessels under 100 GT. The cost savings of such an arrangement could be significant for an independent municipal port authority. The impact on vessel construction cost would be relatively minor. The longer vessel would provide both improved speed and seakeeping. Even so, it would be worth considering the inclusion of crew accommodations on a new vessel. Even operating with a single watch, crew accommodations could enable the vessel to stage out of different ports thereby increasing flexibility.

In a separate study EBDG has also considered the potential for an all-electric shuttle ferry operating between Haines and Skagway during the busy summer months. A high-level specification sheet for this vessel was developed and is included here as Appendix A, along with pertinent correspondence providing context. Also included as Appendix B is a high-level specification sheet for a diesel-powered version of the same small shuttle ferry.

7 REFERENCES

[1] McDowell Group, "North Lynn Canal Ferry Service Analysis," June 2014.

[2] McDowell Group, "Lynn Canal Ferry Service Revenue Analysis," July 2016.

[3] McDowell Group, "Lynn Canal Ferry Service: Exploring a Locally Controlled System," 10/31/19.

[4] The Glosten Associates, "Seakeeping and Motion Sickness Incidence," File 11163.03, Rev P3, June 21, 2013.

[5] EBDG, "IFA Coastal Passenger Ferry Seakeeping Analysis," 99107-4-1423, Rev A, 3/14/2000.

[6] SitNews, "Fairweather Damaged by Rogue Wave in Lynn Canal," 18 December 2004. [Online]. Available: http://www.sitnews.us/1204news/121804/121804_fairweather.html. [Accessed 6 May 2020].

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Appendix A

Electric Ferry Specification Sheet

Jan Wrentmore

From:	Jan Wrentmore
Sent:	Thursday, May 14, 2020 5:03 PM
To:	'Brad Ryan'
Cc:	'Andrew Cremata'; Deach Deach (e.deach@skagway.org); Mike Korsmo; Dennis Bousson; Stan Selmer (Primary)
Subject:	Electric Car Ferry
Attachments:	20034-01M - 120' Vehicle Ferry Spec Sheet.pdf

Dear Manager Ryan,

I am submitting for your consideration the attached spec sheet for an all-electric car ferry that could be deployed as a shuttle ferry between Haines and Skagway. This high level design concept was developed by the Elliott Bay Design Group as part of an innovative project for renewably-powered marine transportation that takes advantage of our region's abundant hydroelectric resources. Additionally, the vessel could be built in the Sitka boat yard, providing local boat building and maintenance jobs.

The 120-foot monohull vessel will have capacity for 100 passengers and 15 vehicles and will utilize a lithium-ion battery bank charged by renewably-sourced shore power in the Skagway Harbor. Based on a summer schedule of two to three roundtrips per day we estimate the vessel will meet 85% of the demand on the Skagway/Haines route, highly popular with independent travelers, RV traffic and visitors from the Yukon. (McDowell Group's *Lynn Canal Ferry Service Revenue Analysis* July 2016.)

This vessel concept was originally developed as part of a grant proposal for charging an electric car ferry in Burro Creek. Subsequent analysis, however, showed that a submarine cable connecting Burro Creek power to the Skagway harbor would be more cost effective and a better utilization of Burro Creek's hydroelectric potential.

I am sending you this vessel concept in the hopes that it can be included as an addendum in the North Lynn Canal vessel selection report prepared by Elliott Bay Design Group for the Municipality of Skagway. The Skagway/Haines route is an essential link in the popular Golden Circle Tour connecting our communities with the Yukon and points beyond. Visitor industry insiders anticipate a significant upsurge in independent travelers post Covid-19. This project would position Haines and Skagway to best serve this market in the coming years and help insulate our community from uncertainties associated with future Alaska Marine Highway System viability and service levels.

Thank you,

Jan Wrentmore

Jan Wrentmore, Owner
Burro Creek Holdings, LLC

Elliott Bay Design Group
Architectural & Engineering Services for the Marine Industry
www.ebdg.com

15-Vehicle Electric Ferry

VESSEL DESCRIPTION

This 120' monohull vessel is intended to provide vehicle and passenger transportation between Skagway and Haines. The vessel is intended to be all-electric. The vessel will utilize a lithium-ion battery bank charged by shore power. The estimated contract design cost is $400 -$500 thousand, with construction cost approximately $7-$8 million, not including any shoreside infrastructure changes for charging.

PRINCIPLE DIMENSIONS

Length (O.A.):	120'-0"
Beam (Max):	40'-0"
Draft (DWL):	7'-0"
Depth:	13'-0"
Lightship:	345 LT
Hull Type:	Monohull, drive-through deck arrangement

PERFORMANCE CHARACTERISTICS

Design Speed:	10 kt
Certification:	USCG Subchapter T
Route:	Skagway to Haines
Route Length:	14.5 miles
Design Sea Conditions:	Approximately 25 kts and 6 ft seas
Passenger Capacity:	100
Vehicle Capacity:	15 (Alaska Standard Vehicle – 20ft)
CO2 Savings:	1.1 mt/trip

PROPULSION MACHINERY

Propulsion Motors:	(2) 700 kW, Permanent Magnet
Battery Bank Capacity:	2.7 MWh
Battery Bank Weight:	35 LT
Battery Chemistry:	NMC
Expected Battery Life:	7.5 yr (approx. 2,700 cycles)
Propellers:	(2) 4-bladed, fixed pitch
Rudders:	(2) Balanced

SHORE POWER REQUIREMENTS

Shore Power Available:	2 MW
Approx. Charge Time:	1 hr
Round Trip Energy:	1770 kWh

NOTES

- All charging performed at Skagway between round trips
- The hull and superstructure to be of welded steel construction utilizing a longitudinally stiffened deck
- CO_2 savings based on a comparison to the efficiency of a representative diesel mechanical system and assuming all shore power for the electric version comes from renewable sources.

Appendix B

Diesel Ferry Specification Sheet

Elliott Bay Design Group
Architectural & Engineering Services for the Marine Industry
www.ebdg.com

15-Vehicle Ferry

VESSEL DESCRIPTION

This 120' monohull vessel is intended to provide vehicle and passenger transportation between Skagway and Haines. The estimated contract design cost is $300 -$400 thousand, with construction cost approximately $6-$7 million.

PRINCIPLE DIMENSIONS

Length (O.A.):	120'-0"
Beam (Max):	40'-0"
Draft (DWL):	7'-0"
Depth:	13'-0"
Lightship:	345 LT
Hull Type:	Monohull, drive-through deck arrangement

PERFORMANCE CHARACTERISTICS

Design Speed:	10 kt
Certification:	USCG Subchapter T
Route:	Skagway to Haines
Route Length:	14.5 miles
Design Sea Conditions:	Approximately 25 kts and 6 ft seas
Passenger Capacity:	100
Vehicle Capacity:	15 (Alaska Standard Vehicle – 20ft)

PROPULSION MACHINERY

Propulsion Engines:	(2) 800 hp Caterpillar C18 ACERT Tier 3
Generator:	(2) Northern Lights 99kW
Propellers:	(2) 4-bladed, fixed pitch
Rudders:	(2) Balanced

NOTES

- The hull is to be of welded steel construction utilizing a longitudinally stiffened deck with aluminum bulwarks and superstructure
- Fuel capacity for two weeks of operation