A Report to the Maryland General Assembly

Senate Budget and Taxation Committee

and

House Appropriations Committee

regarding

Publicly Operated Ferry Service for the Chesapeake Bay Crossings (2019 JCR, p. 86)

January 2020

Maryland Department of Transportation
Maryland Transportation Authority

Contents

1 - Introduction

The Maryland Transportation Authority (MDTA) prepared this report in response to committee narrative contained in the 2019 *Joint Chairmen's Report* (JCR). The language states:

> *"**Report on Publicly-operated Ferry Service for Chesapeake Bay Crossings:** The committees wish to ensure that the Maryland Transportation Authority (MDTA) considers all alternatives for a third Chesapeake Bay crossing, given that this will represent a substantial investment in transportation infrastructure for the State. While prior reports on a ferry service have stressed that a privately-operated ferry service is of limited feasibility, these reports do not consider new developments in technology and alternative forms of management. For example, all-electric ferries have become realistic alternatives to more traditional designs for short-haul operation, having been successfully adopted both nationally and internationally. Such vessels eliminate the impact of the variable rate of fuel, resulting in a reduced cost of operation and limited environmental impact.*
>
> *The committees request a report on the feasibility of an MDTA-operated ferry service utilizing all-electric ferries as an alternative to a third bridge crossing for the Chesapeake Bay. The report should include the following:*
>
> - *the level of service required to make an appreciable impact on traffic congestion at the William Preston Lane Jr. Memorial Bridge, including the number of ferries required and the frequency of operation;*
> - *required infrastructure to support operations, including terminals necessary to support docking and loading/off-loading of ferries, as well as the development of access to these terminals;*
> - *direct and indirect services required to support the operation of a ferry service, including but not limited to vessel crew, ticketing, and security; and*
> - *operating and capital cost estimates for an all-electric ferry service alternative.*
>
> *The report should consider alternative operating schedules, including seasonal service, and the impact varying schedules would have on the estimated total cost of a ferry service and congestion relief. Further, the report should address how current MDTA services and equipment could be adapted to minimize the costs to develop a ferry service. Finally, the report should identify whether a ferry service is an alternative in the Bay Crossing Study being developed pursuant to the National Environmental Policy Act. This report should be submitted by December 31, 2019."*

2 - Previous Chesapeake Bay Ferry Service

Purpose of Inclusion

A Chesapeake Bay motor vehicle carrying ferry service has not operated since 1952. The present William Preston Lane Jr. Memorial Bridge (Bay Bridge) spans (open for service in 1952 and 1973) and associated transportation connections were constructed to replace ferry services. The history of the Chesapeake Bay ferry service is included because it helped guide initial research for this Electric Ferry Study.

History of Ferry Service

Travel by water across and along the Chesapeake Bay has a long and varied history. As the area was settled and developed, commerce flourished thanks to the Bay's natural resources and its ability to accommodate transportation of people and freight. As technology progressed, simple boats became steamships, and vessel design evolved to carry vehicles as well as passengers.

Private Ferry Service

Ferry services were initially operated by private enterprises on routes serving a variety of locations dictated primarily by demand and viability. Ferry business in the 19th century was brisk and served travelers to and from Philadelphia who preferred to cross the Bay than travel a more tiresome route through areas currently served by I-95. Historic ferry routes included: Baltimore to Tolchester, Baltimore to Love Point on Kent Island, Annapolis to Claiborne and, (starting in 1930) between Annapolis to Matapeake on Kent Island with a connecting service between Romancoke and Claiborne.[1] The Annapolis terminal was moved in 1943 to Sandy Point to facilitate expansion of the Naval Academy.

State Operated Ferry Service

Through the early years of the 20th century, increases in vehicle volume coupled with technological advances in roadway and bridge engineering led to support for a bridge structure across the Chesapeake Bay. In 1941, in anticipation of the Bay Bridge construction, the State of Maryland purchased the operations of the private Claiborne–Annapolis Ferry Company and ran it as a public service through the State Roads Commission. The Second World War thwarted attempts to design and construct a bridge and efforts were restarted in 1947 with construction beginning in January 1949. State-run ferry services ceased operations in 1952 on the same day that the Bay Bridge opened to the general public.

Vessels & Routes at Service End

In 1952, there were five ferries in operation along two routes: from Sandy Point to Matapeake and from Romancoke to Claiborne[2]. As transportation modes changed and volumes became greater, the Bay ferries began carrying both motor vehicles and passengers.

[1] Simmons, C. A. (2009) *Chesapeake Ferries: A Waterborne Tradition, 1636-2000*, Maryland Historical Society
[2] Simmons, C. A. (2009) *Chesapeake Ferries: A Waterborne Tradition, 1636-2000*, (pp. 82-85), Maryland Historical Society

Historical Ferry Vehicle Capacity

At the time ferry service ceased operation in 1952, ferry vessels could carry 750 passengers and 65 vehicles[3] with a sailing time of around 40 minutes between Sandy Point and Matapeake[4]. Inadequate vessel capacity resulted in delays on each shore with associated traffic congestion, creating long vehicle queues which the original span of the Bay Bridge was intended to address. Combined with the growth in the number and use of private automobiles and trucks, along with the subsequent development of high-speed freeways, travel across the Chesapeake Bay was transformed from multiple point-to-point routes, to being funneled along highways towards the Bay Bridge.

Details of Previous Ferry Service and Bay Crossing Attempts

The following text is taken verbatim from the engineering study for the original span of the Bay Bridge prepared by consulting engineers J.E. Greiner Company in 1948 and provides a thorough overview of historical ferry service and the contemporary services in operation prior to construction of the Bay Bridge.

> LEGAL HISTORY AND DEVELOPMENT Of THE CHESAPEAKE BAY CROSSING
>
> The Maryland Legislature in 1947 and the Congress of the United States in 1948 have brought to finality the essential enabling acts to bring to fruition the hope and need of the years in Maryland to span the Chesapeake Bay for motor traffic.
>
> For half a century, the endeavors of private capital as well as of the State to bridge the Bay reflect the economic need of this project and the evolution of travel from the river and bay boats and the horse and buggy to the automobile as well as the evolution of financing such projects from private capital, with its large personal profits, to State revenue bond financing, under the guidance of State Authority, with continuing State operation and control assuring adequate but reasonable tolls during the life of the bonds.
>
> With the development of the motor vehicle, even the long trip around the northern head of the Bay shortened the old comfortable but slow daily trips of the river boats between the Eastern and Western Shores, separated as they are for 130 miles by the Chesapeake Bay.
>
> The early legendary history of the State indicates that a ferry plied the Bay between Kent Island and points at or near Annapolis, and recurring stories indicate that sketchy preliminary studies were made during the latter part of the 19th century to span the Bay by bridge. The records indicate that in 1907, coincident with the development of interurban trolley lines, there was a proposal by private capital to bridge the Bay, and although the proposal was endorsed by the Merchants and Manufacturers Association of Baltimore, the project did not advance beyond a very preliminary stage. In 1918 private capital again considered the possibility of a double deck structure to carry both railroad and trolley lines across the Bay. Again in 1919, before revenue bond financing acquired

[3] New Steel Motor Ferry, Governor Harry W. Nice, (1938, July), *Pacific Marine Review, Vol. XXXV, No. 7,* 33-35
[4] McCardell, P, June 11, 2009, Chesapeake Bay Ferries, *The Baltimore Sun*

its impetus after the depression of 1929, private capital undertook preliminary studies to bridge the Bay between Miller's Island and Tolchester.

During the last forty years while the river boats have given way to motor vehicles, it may be said that Bay ferries have been used as temporary expedients until the hope of the years of a fixed bay crossing could be realized.

Private capital operated the Bay ferries, one between Baltimore and Tolchester, another between Baltimore and Love Point, and another between Annapolis and Matapeake and Claiborne. The latter was operated successively by Claiborne-Annapolis Ferry, lncorporated, and The Claiborne-Annapolis Ferry Company. Since the assets of the latter were taken over by the State Roads Commission of Maryland under Act of Legislature of 1941, the Annapolis-Matapeake ferry, later the Sandy Point-Matapeake ferry has been operated by the State, and will be abandoned when the Bay Bridge is opened for traffic.

The Chesapeake Bay Bridge Company, chartered in Maryland in 1926, received legislative authority in 1931 to construct the Miller's lsland-Tolchester Bridge, and the Legislature in 1935 provided that the authority of the Company should be null and void unless the Company should commence construction of the bridge within two years and complete its construction within five years from June 1, 1935. The Company abandoned its efforts and its charter was annulled in 1938. Governor Ritchie meanwhile in 1931 had appointed a Commission to study the problem of spanning the Bay through the revenue bond financing method. By 1935 the public demand for a Bay crossing became so great that the Legislature in 1935 created the Chesapeake Bay Authority, as a public body, with power to construct the Miller's lsland-Tolchester Bridge under the revenue bond financing method and with further power to acquire the assets and franchises of the Claiborne-Annapolis Ferry Company. The Chesapeake Bay Authority, however, was abolished by the Legislature in 1941.

The Legislature of Maryland in 1937, during the administration of Governor Nice, authorized a comprehensive State plan for the construction of bridges or tunnels and gave authority to the State Roads Commission to issue revenue bonds of the State payable solely from earnings to pay the cost of construction. This Act provided that such bonds should not constitute a debt of the State of Maryland or a pledge of the faith and credit of the State. The legality of the 1937 Act was approved by the Court of Appeals of Maryland in a test case in 1938. Under the authority of the 1937 Act the State Roads Commission initiated studies for four principal crossings by bridge or tunnel which were covered by the Report on Maryland's Primary Bridge Program to the Commission by J. E. Greiner Company, Consulting Engineers, on October 15, 1938, including a bridge over the Susquehanna River, a bridge over the Potomac River, a bridge over or tunnel under the Patapsco River in Baltimore Harbor, and a bridge over the Chesapeake Bay at the Miller's lsland-Tolchester site or in the alternative at the Sandy Point-Kent Island site. The 1937 Act also created the Bridge Supervisory Committee with power to pass upon preliminary plans of the State Roads Commission of contemplated bridges or tunnels, and to give their opinion as to whether the same were feasible, practicable and advantageous to the State. The Act of Congress, approved April 7, 1938 authorized any two or more of the four crossings to be jointly financed by a single issue of revenue bonds to be serviced by the pooling of tolls, construction to commence within three years and to be completed within five years from April 7, 1938. Two of those structures, the Susquenhanna Bridge and the Potomac Bridge, treated as a single project for financing purposes, were commenced in 1938 during the administration of Governor Nice, and were completed in 1940 during the administration of Governor O'Conor.

The State Roads Commission in 1938 had determined to construct the Chesapeake Bay Bridge at the Sandy Point-Kent Island site, as well as the Susquehanna Bridge and the Potomac Bridge, and the Trust Indenture of October I, 1938, between the State Roads Commission and the Safe Deposit & Trust Company of Baltimore, as Trustee, in providing for the issuance of revenue bonds for the Susquehanna and Potomac Bridges, contained a provision for the issuance at any time prior to July I, 1942, of additional bonds for the cost of the Chesapeake Bay Bridge, including the cost of acquiring the ferry. The War, of course, prevented the construction of the Bay Bridge as then contemplated.

Meanwhile, during Governor O'Conor's administration, the Legislature in 1941 authorized the State Roads Commission to purchase the assets of the Claiborne-Annapolis Ferry Company with power to finance the purchase by the issuance of revenue bonds serviced primarily by ferry tolls. The State took over this ferry system, and the Legislature, during the War, in 1945, in Governor O'Conor's administration, extended the facilities of the ferry system between Sandy Point and Matapeake by authorizing ferry improvement bonds for the purchase of additional ferry boats and for the expansion of the two terminal facilities of the ferry, such improvement bonds being serviced by gasoline taxes.

Finally, during the present administration of Governor Lane, the Legislature at its General Session of 1947 passed a comprehensive Act, amended at the Extraordinary Session of 1947, providing an additional or alternative method for the construction and financing of bridges, tunnels and motorways under the revenue bond financing method and authorizing the State Roads Commission, upon determining to construct a Chesapeake Bay crossing from Sandy Point to Kent Island, to finance the same by the issuance of revenue bonds and to refund outstanding bonds on existing bridges whose tolls will be pooled with those from the Chesapeake Bay crossing. The 1947 Maryland Act further provides that on or prior to the issuance of the new revenue bonds the State Roads Commission shall provide for the redemption and retirement of all of the outstanding Ferry Revenue Bonds of 1941 and all of the outstanding Ferry Improvement Bonds of 1945. It will, of course, be the function of the legal advisors of the State Roads Commission to correlate the provisions of the 1947 Maryland Act with the provisions of the Act of Congress of 1 9482 hereinafter mentioned. Under the 1947 Maryland Act, the Commission shall continue to operate the adjacent Chesapeake Bay Ferry between Sandy

Point and Matapeake during the construction of the Bridge and upon completion of the Bridge, such ferry service shall be discontinued.

The Congress of the United States, by its Act approved June 16, 1948, supplementing the Act of Congress approved April 7, 1938 111 authorizes the State Roads Commission to construct a crossing of the Chesapeake Bay, as well as a crossing of the Patapsco River at Baltimore Harbor, with authority in the State Roads Commission to pool such new tolls with tolls on the existing Susquehanna Bridge and Potomac Bridge to service the new bridge revenue bonds.

The Chesapeake Bay Bridge, covered by this Report, was approved by the Chief of Engineers on June 29, 1948, and by the Assistant Secretary of the Army on June 30, 1948.

Thus after years of investigation and planning, the way is cleared with all necessary legislation and permits to proceed with the construction of the Chesapeake Bay Bridge, and to bring to realization the need and hope of the years.

Fate of Vessels and Facilities of Previous Ferry Service

The five ferry vessels remaining in operation when the original bridge span opened in 1952 were sold. Two continued in operation with Washington State Ferries until their retirement: the Gov. Harry W. Nice [Olympic] in 1999 and the Gov. Herbert R. O'Connor [Rhododendron] in 2012.

Of the existing terminal facilities, all continue to be used today in some form. The Matapeake[5] and Romancoke[6] terminals feature reconstructed docks with public access. The terminal at Claiborne[7] retains the dolphins (a mooring point) of the original ferry service but does not feature any other ferry terminal facilities although public access is permitted. The former terminal at Sandy Point is currently used by MDTA as a dock facility for Bay Bridge maintenance. While remnants of the original ferry dolphins are present, they have been rendered useless as changes to the dock facilities have been made to accommodate the boats and barges that MDTA uses. Public access is not available at this location.

Travel Demand and Expansion of the Bay Bridge

Traffic volumes on the original bridge span doubled in the first ten years[8] and by 1964, studies were underway to consider ways of alleviating congestion. These studies resulted in construction of a second, three-lane parallel span that opened in 1973.

Previous Studies

Interest in ferry service across the Bay continued in the intervening years with numerous studies covering a variety of potential forms of service being undertaken. These studies were reviewed

[5] Matapeake Fishing Pier and Ramp, Facilities, Queen Anne's County, https://www.qac.org/Facilities/Facility/Details/Matapeake-Fishing-Pier-and-Ramp-127
[6] Romancoke pier, Facilities, Queen Anne's County, https://www.qac.org/Facilities/Facility/Details/Romancoke-Pier-128
[7] Water Point Access, Public landings, Talbot County Parks and Recreation, https://www.talbotparks.org/index.php/facility-rental/public-landings
[8] Tier 1 NEPA Purpose and Need Document, Bay Crossing Study

as part of this study but are not included as they were not initiated for, or tasked with, alleviating congestion on the existing Bay Bridge. As a result, their conclusions and findings are not applicable to this study. At present, there is no regularly operated ferry service between the Eastern and Western Shores of the Chesapeake Bay in Maryland.

3 - Electric Ferry Technology and Services

History & Definition

The concept of electric propulsion of watercraft has a history stretching back at least 100 years. Advances within the past 20 years have focused primarily on hybrid systems using either internal or external electric motors turning the propellers using power generated by a traditional fossil fuel engine or turbine. All-electric propulsion technology has emerged as improvements in battery capacity and lifespan have become mainstream and comparable in cost to traditional energy options. All-electric vessels utilize electric motors powering propellers with on-board batteries supplying electrical power while under way. These batteries are charged using a land-based station while the vessel is docked.

Current Vessel Design & Technology

All-electric propulsion is being investigated in numerous locations around the world with concentrated development occurring in Europe. As part of this review, at least five ferry services (detailed below) were identified that currently use all-electric vessels of varying types, size and capabilities. These five services were identified based on their all-electric technology, vessel capacity, route capacity, customer type (commuter/recreational), and form of ownership (public/private). Each service is comparable in one of these aspects to a Chesapeake Bay ferry service and provide the necessary data to inform the analysis of such a service.

Landside charging stations for all-electric vessels are necessary to transfer electrical energy from the electrical grid to the vessel. Such stations can either contain a direct connection to the grid, the same amount of battery storage as the vessel to minimize demands on the grid, or a combination of both battery reserve and direct connection[9]. The choice of charging station is dependent on many factors but primarily is determined based on vessel service turnaround periods (typically 20 minutes or less). These charging stations consist of two parts: the charging connection located at the dock, and the storage/transformer location which is contained in a separate building nearby. Charging stations are located based on operating conditions and the onboard battery capacity. Some routes require a station at each terminal while others require a single terminal that charges the vessel only once per round-trip.

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[9] Washington State Ferries Medium Voltage Shore Power Feasibility Study, Washington State Ferries, https://www.wsdot.wa.gov/NR/rdonlyres/6C78A08B-19A1-4919-B6E6-E9EF83E6376D/123057/HybridChargingFeasibilityStudy.pdf

All-electric Ferry Vessels and Services

European Union E-Ferry Project (EV Ellen)

The latest in all-electric propulsion is represented by the EF Ellen (Ellen), a ferry publicly funded by the European Union as a study case for all-electric vessel technology[10]. The Ellen is a single-ended roll-on, roll-off (Ro-Ro) design[11], with a capacity of 31 cars and up to 198 passengers. The single-ended Ro-Ro design only permits vehicle loading from one side. The vessel features 4 megawatts (MW) of onboard battery reserves (currently the largest in the world) which permits a total range of 26 nautical miles (NM) (2x13 NM trips) at a top speed of 14 knots using up to 1.5 MW of power. As part of the European Union's E-Ferry project which began in June 2015, the EF Ellen launched in early 2019 and began regular service in August 2019 between Søby, on the island of Ærø, and Fynshav, on the island of Als in Denmark; a distance of 10.7 NM with no alternative bridge connection. Operational performance information is not yet available.

The E-ferry project's goals[12] as stated on the project website are:

> E-ferry is a new project supported by the European initiative H2020 involving the design, building and demonstration of a fully electric powered 'green' ferry which can sail without polluting and CO2 emissions. It promotes energy efficient, zero GHG [greenhouse gas] emission and air pollution, and free waterborne transportation for island communities, coastal zones and inland waterways in Europe and beyond.
>
> The overall objective of E-ferry is to apply an extremely energy efficient design concept and demonstrate a 100% electric, emission free, medium sized ferry for passengers and cars, trucks and cargo in full-scale operation on longer distances than previously seen (> 5 NM) for electric drive train ferries, i.e. the medium range connections Soeby-Fynshav (10.7 Nm) and Soeby-Faaborg (9.6 NM) in the Danish part of the Baltic Sea connecting the island of Aeroe (Ærø) to the mainland.
>
> The E-ferry project, goes beyond current limitations of similar efforts targeting medium range connections and is likely to be the ferry with the largest battery pack ever installed in a vessel.

Other Current & Near-Future Implementations

The Ampere (Norway)

The Ampere ferry in Norway began operations in 2015[13] and conveys 120 cars and 300 passengers over a 3.5 NM journey. The fare for a passenger car is 113 Norwegian Krone (approximately $13)[14]. No alternative mode of transportation besides the ferry is available.

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[10] E-ferry, http://e-ferryproject.eu/
[11] A type of vessel designed specifically to transport wheeled vehicles which drive on and off the vessel under their own power.
[12] E-ferry, http://e-ferryproject.eu/
[13] All-electric ferry cuts emission by 95% and costs by 80%, brings in 53 additional orders, Electrek, https://electrek.co/2018/02/03/all-electric-ferry-cuts-emission-cost/
[14] Ferry Rates, Kringdom, https://www.kringom.no/ferries.343892.en.html

Amherst Island Ferry (Canada)
The Ameherst Island ferry in Canada, currently under construction[15], will convey 40 cars and 300 passengers when it enters service in 2020 on a route of 2 NM in length. Existing fares for a passenger car are CA$9 (approximately $7). No alternative mode of transportation besides the ferry is available.

Stena Jutlandica Conversion
Scandinavian company Stena Line has announced that their existing vessel, Stena Jutlandica, operating between Gothenburg and Frederikshavn, Sweden, will be converted to all-electric propulsion as part of an ongoing three phase mid-life upgrade plan, which will ultimately see 50 MW of onboard battery capacity and a total range of 50 NM when complete[16]. Fares are dependent on time and date of travel but start at €41 (approximately $46) for a passenger car and driver[17]. The road-based alternative is almost eight times the length of the ferry route.

Gee's Bend (Alabama)
The Gee's Bend river ferry in Alabama[18] carries 15 vehicles and 132 passengers over a 1.4 NM route at a speed of 8 knots. As of late 2019, this was the only all-electric ferry service in operation within the United States. The fare for a passenger car is $3 plus $1 for each adult traveler[19]. The road-based alternative is 40 miles in length.

Hybrid Electric Ferry Vessels and Services

Scandlines
This hybrid diesel-electric ferry service operates between Germany, Denmark, and Sweden. Their vessels use battery power when maneuvering before and after docking, and traditional diesel engines to generate electrical power while underway[20]. Scandlines is moving towards all-electric vessels for its next generation fleet.[21] A schedule for implementation has not yet been announced.

ForSea
This partially all-electric ferry service operates across the Öresund between Denmark and Sweden. The vessels Tycho Brahe and Aurora carry 240 cars and 1,250 passengers and operate

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[15] Ontario Building Fully Electric Ferry for Amherst Island, Loyalist Township, http://www.loyalisttownship.ca/index.cfm/residents/public-transportation/amherst-island-ferry/ontario-building-fully-electric-ferry-for-amherst-island/
[16] Stena Line introduces battery power, Stena Line, https://news.cision.com/stena-line/r/stena-line-introduces-battery-power%2Cc2464070
[17] Fares Frederikshavn – Gothenburg, Stena Line, https://www.stenaline.nl/en-GB-nl/crossings/frederikshavn-gothenburg/fares
[18] Alabama seeks to have first U.S. all-electric vehicle ferry, WorkBoat, https://www.workboat.com/news/shipbuilding/alabama-looks-first-u-s-electric-ferry/
[19] Tickets, HMS Ferries, http://www.geesbendferry.com/tickets/
[20] Hybrid - you mean like hybrid car?, Scandlines, https://www.scandlines.com/about-scandlines/greenagenda/hybridsystem
[21] ZERO EMISSION: ferry operation covered by pure battery power on Rødby-Puttgarden, Scandlines, https://www.scandlines.com/about-scandlines/greenagenda/zero-emission

on the 4km Helsingborg to Helsingör route. The company is committed to implementing all-electric ferries on each of its routes although a schedule for implementation has not yet been announced.[22]

Washington State Ferries (WSF)

WSF intends to upgrade its Jumbo Class II ferries to all-electric propulsion with backup on-board diesel generators as part of the class' mid-life upgrade which began in October 2019 and will be completed in 2021[23]. These vessels operate on routes varying between 5 and 6.5 NM in length and can carry up to 202 vehicles and 2,499 passengers.

The WSF commissioned two reports regarding electric propulsion: a conversion study for its existing Jumbo Mark II vessels (Hybrid Electric Propulsion Conversion Project[24]), and a hybrid charging feasibility study (Washington State Ferries Medium Voltage Shore Power Feasibility Study[25]). Although the purpose of the former is for the conversion of existing diesel vessels, it contains significant information and discussion of current battery technology, as well as the needs of a large ferry vessel comparable to what would be needed for a prospective Chesapeake Bay service. The latter report discusses the onshore electrical connections and infrastructure necessary for all-electric propulsion and is comparable to the needs of a prospective service on the Chesapeake Bay.

WSF concluded that a conversion of three Jumbo Mark II vessels would be fiscally, environmentally, and operationally advantageous. Subsequently, in 2018, the Washington State legislature included $600,000 for WSF to develop a request for proposal (RFP) to convert these vessels to all-electric propulsion with diesel backup. The conversion process entered the design phase in October 2019 with construction to follow in 2021[26].

Other technology

Other environmentally friendly ferry technology includes solar and hydrogen fuel cell vessels. Solar panels are currently in use on some vessels as a supplemental source of electrical power for amenities[27]. Hydrogen fuel cell vessels are currently in the feasibility stage with vessels such as the Water-Go-Round serving as a testbed[28]. This technology is not yet ready for operational service.

[22] ForSea Foresees the Future, Ferry Shipping News, https://www.ferryshippingnews.com/forsea-foresees-the-future/
[23] WSF Press Release, 2019-10-22
[24] Hybrid Electric Propulsion Conversion Project, Washington State Ferries, https://www.wsdot.wa.gov/NR/rdonlyres/6C78A08B-19A1-4919-B6E6-E9EF83E6376D/125314/WSFHybridElectricPropulsionConversionProject.pdf
[25] Washington State Ferries Medium Voltage Shore Power Feasibility Study, Washington State Ferries, https://www.wsdot.wa.gov/NR/rdonlyres/6C78A08B-19A1-4919-B6E6-E9EF83E6376D/123057/HybridChargingFeasibilityStudy.pdf
[26] Washington State Ferries, Press Release ‘New funding secured for cleaner, greener ferries’, 2019-10-22
[27] New Dutch hybrid ferry, Marine Battery Forum, https://maritimebatteryforum.com/news/new-dutch-hybrid-ferry
[28] Water-Go-Round, https://watergoround.com/

4 - Traffic Data and Calculations

For the purposes of this feasibility study, an 'appreciable' impact is defined as maintaining the 2017 Average Daily Traffic (ADT) volumes on the existing Bay Bridge by accommodating the additional traffic volume with ferry service. This method is consistent with the Chesapeake Bay Crossing Study: Tier 1 NEPA (Bay Crossing Study) which uses a horizon year of 2040 and provides consistent criteria for identifying whether a ferry service should be considered as a standalone alternative.

This section details the traffic data that was used and how the additional volume to be accommodated was determined.

Traffic Volume on the Existing Crossing

2017

Traffic volume data was obtained from counts conducted in 2017 and is broken down by direction and hour. This is the same data used in the current Bay Crossing Study. Both weekday and summer weekend data were collected. Summer weekend data is presented as worst-case scenario for each direction: i.e. eastbound is for a typical Friday, and westbound is for a typical Sunday between Memorial Day and Labor Day.

2040

Traffic volumes were projected to 2040 using the 2017 volumes and the Maryland Statewide Travel Model (MSTM). The MSTM is a multi-layer travel-demand model working at national, statewide, and urban zone levels to forecast and analyze key measures of transportation system performance.

Weekdays

In 2017, the Bay Bridge handled about 69,000 total vehicles on an average non-summer weekday. This demand is comprised of a notable number of commuters traveling to and from the Eastern Shore to the Western Shore as evidenced by the directional nature of peak hour traffic flows. Peak volumes were approximately 3,400 vehicles per hour. In 2040, weekday volumes are projected to grow to approximately 84,500 vehicles per day representing a growth of 22 percent. Peak volumes are anticipated to be close to 4,100 vehicles per hour; an increase of around 700 vehicles per hour over 2017 volumes. Table 1 shows non-summer weekday hourly traffic volumes, Level of Service (LOS)[29] and the dominant direction flow of traffic across the Bay Bridge.

[29] The Highway Capacity Manual (HCM) 6th Edition (Transportation Research Board, 2016) defines LOS as, “A quantitative stratification of a performance measure or measures that represent quality of service, measured on n A-F scale, with LOS A representing the best operating conditions from the traveler’s perspective and LOS F the worst.”

Table 1 – Bay Bridge Non-Summer Weekday Traffic Volumes, Level of Service (LOS), and Dominant Direction Flow

	2017 Non-Summer Weekday					2040 Non-Summer Weekday				
Time	**Eastbound**	**LOS**	**Westbound**	**LOS**	**Dominant Flow**	**Eastbound**		**Westbound**		**Dominant Flow**
12-1AM	275	A	161	A	EB	329	A	204	A	EB
1-2AM	173	A	135	A	EB	207	A	171	A	EB
2-3AM	149	A	148	A	EB	178	A	189	A	WB
3-4AM	167	A	322	A	WB	200	A	409	A	WB
4-5AM	294	A	888	B	WB	352	A	1,128	B	WB
5-6AM	550	A	1998	C	WB	658	B	2,539	D	WB
6-7AM	995	C	3176	D	WB	1,197	C	4,020	E	WB
7-8AM	1362	C	3448	D	WB	1,644	D	4,348	F	WB
8-9AM	1452	C	2729	D	WB	1,753	D	3,441	D	WB
9-10AM	1524	C	2212	C	WB	1,854	D	2,762	D	WB
10-11AM	1652	D	1819	B	WB	2,025	C	2,244	D	WB
11AM-12PM	1720	D	1677	B	EB	2,109	C	2,069	D	EB
12-1PM	1807	D	1713	B	EB	2,215	C	2,114	D	EB
1-2PM	1988	D	1758	B	EB	2,436	D	2,170	D	EB
2-3PM	2568	D	1761	C	EB	3,148	E	2,173	D	EB
3-4PM	3233	E	1761	C	EB	3,888	F	2,199	D	EB
4-5PM	3287	E	1801	C	EB	3,884	F	2,276	D	EB
5-6PM	3395	E	1683	C	EB	4,012	F	2,127	D	EB
6-7PM	2712	D	1271	C	EB	3,224	E	1,611	C	EB
7-8PM	2043	C	917	B	EB	2,444	D	1,166	B	EB
8-9PM	1380	C	756	A	EB	1,651	D	960	A	EB
9-10PM	1120	C	647	A	EB	1,340	C	823	A	EB
10-11PM	753	B	436	A	EB	901	B	554	A	EB
11PM-12AM	539	A	244	A	EB	644	B	310	A	EB
Total	**35137**		**33461**			**42,294**		**42,006**		

Summer Weekends

On a summer Sunday in 2017, traffic volumes were approximately 119,000 total vehicles per day on average. This demand includes notable numbers of recreational travelers journeying to and from destinations on the Atlantic coast. Peak volumes are approximately 4,300 vehicles per hour. In 2040, summer weekend volumes are projected to grow to approximately 135,000 vehicles per day representing a growth of 14 percent. Peak volumes are anticipated to be close to 5,100 vehicles per hour, an increase of 19 percent. Table 2 shows a summary of summer weekend volumes.

Table 2 – Bay Bridge Summer Weekend Traffic Volumes, Level of Service (LOS), and Dominant Direction Flow

	2017 Summer Weekend					2040 Summer Weekend				
Time	**Eastbound**	**LOS**	**Westbound**	**LOS**	**Dominant Flow**	**Eastbound**	**LOS**	**Westbound**	**LOS**	**Dominant Flow**
12-1AM	509	A	964	A	WB	594	A	1,129	A	WB
1-2AM	300	A	589	A	WB	350	A	690	A	WB
2-3AM	234	A	329	A	WB	273	A	385	A	WB
3-4AM	225	A	243	A	WB	263	A	285	A	WB
4-5AM	384	A	301	A	EB	448	A	353	A	EB
5-6AM	726	B	432	A	EB	847	B	506	A	EB
6-7AM	1396	C	654	A	EB	1,678	D	801	A	EB
7-8AM	2116	D	923	A	EB	2,604	D	1,165	A	EB
8-9AM	2354	C	1508	B	EB	2,897	D	1,904	B	EB
9-10AM	2802	D	2422	C	EB	3,193	E	2,837	C	EB
10-11AM	3663	E	3410	D	EB	3,845	F	3,728	D	EB
11AM-12PM	3987	E	3492	D	EB	4,185	F	3,817	D	EB
12-1PM	4119	E	4170	E	WB	4,323	F	4,559	F	WB
1-2PM	4196	E	3971	E	EB	4,404	F	4,341	E	EB
2-3PM	4116	E	3934	D	EB	4,320	F	4,301	E	EB
3-4PM	4189	E	3858	E	EB	4,648	F	4,430	E	EB
4-5PM	4299	F	4003	E	EB	5,020	F	4,816	F	EB
5-6PM	4115	E	3989	E	EB	4,805	F	4,799	F	EB
6-7PM	4229	E	3638	E	EB	4,936	F	4,323	E	EB
7-8PM	4113	E	4071	E	EB	4,799	F	4,769	F	EB
8-9PM	3054	D	4051	E	WB	3,563	E	4,745	F	WB
9-10PM	2355	C	3948	E	WB	2,748	D	4,625	F	WB
10-11PM	1533	D	2589	D	WB	1,789	D	3,033	D	WB
11PM-12AM	967	B	1109	B	WB	1,128	C	1,299	B	WB
Total	**59981**		**58598**			**67,660**		**67,640**		

Travel Delay

Average delay times include the approach roadways on US 50 and the Bay Bridge itself, expressed in minutes.

Weekdays

Travel delay studies conducted in 2017 indicated average weekday trip delays of up to ten minutes along the US 50 approaches and the Bay Bridge during the evening peak hour. By 2040, this delay is projected to increase up to 30 minutes in the morning peak hour, and up to 45 minutes during the evening peak hour. Additionally, by 2040, trip delays greater than 5 minutes in duration could occur from 6am to 10am and 3pm to 9pm every weekday. Table 3 shows a summary of existing (2017) and projected 2040 travel delays (in minutes) on non-summer weekdays.

Table 3 – Bay Bridge Non-Summer Weekday Travel Delay, Level of Service (LOS), and Dominant Direction Flow

	2017 Non-Summer Weekday					2040 Non-Summer Weekday				
Time	Eastbound	LOS	Westbound	LOS	Dominant Flow	Eastbound	LOS	Westbound	LOS	Dominant Flow
12-1AM	0	A	0	A	WB	0	A	0	A	WB
1-2AM	0	A	0	A	WB	0	A	0	A	WB
2-3AM	0	A	0	A	WB	0	A	0	A	WB
3-4AM	0	A	0	A	WB	0	A	0	A	WB
4-5AM	0	A	0	B	WB	0	A	0	B	WB
5-6AM	0	A	0	C	WB	0	B	0	D	WB
6-7AM	0	C	1	D	WB	0	C	9	E	WB
7-8AM	0	C	2	D	WB	0	D	30	F	WB
8-9AM	0	C	0	D	WB	0	D	30	D	WB
9-10AM	0	C	0	C	WB	0	D	14	D	WB
10-11AM	0	D	0	B	WB	0	C	1	D	WB
11AM-12PM	0	D	0	B	WB	0	C	0	D	WB
12-1PM	0	D	0	B	WB	0	C	1	D	WB
1-2PM	0	D	0	B	WB	0	D	1	D	WB
2-3PM	0	D	0	C	WB	2	E	1	D	EB
3-4PM	3	E	0	C	EB	19	F	1	D	EB
4-5PM	5	E	0	C	EB	34	F	1	D	EB
5-6PM	10	E	0	C	EB	45	F	1	D	EB
6-7PM	3	D	0	C	EB	47	E	0	C	EB
7-8PM	0	C	0	B	WB	38	D	0	B	EB
8-9PM	0	C	0	A	WB	28	D	0	A	EB
9-10PM	0	C	0	A	WB	2	C	0	A	EB
10-11PM	0	B	0	A	WB	0	B	0	A	WB
11PM-12AM	0	A	0	A	WB	0	B	0	A	WB

Summer Weekends

On summer weekends in 2017, average trip delays of up to 43 minutes occurred on Friday and up to 29 minutes on Sunday evenings. Travel delays of 5 minutes or more in duration occurred from noon to 9pm on Fridays, and 12pm to 10pm on Sundays. By 2040, the maximum travel delay is expected to increase to up to 95 minutes on Friday evenings, and up to 101 minutes on Sunday evenings. The period of time for which delays greater than 5 minutes per trip are expected to occur will increase to between 12pm and 12am on Fridays and Sundays by 2040. Table 4 shows a summary of existing (2017) and projected 2040 travel delays (in minutes) on summer weekends.

Table 4 – Bay Bridge Summer Weekend Travel Delay, Level of Service (LOS), and Dominant Direction Flow

	2017 Summer Weekend					2040 Summer Weekend				
Time	Eastbound	LOS	Westbound	LOS	Dominant Flow	Eastbound	LOS	Westbound	LOS	Dominant Flow
12-1AM	0	A	0	A	WB	0	A	0	A	WB
1-2AM	0	A	0	A	WB	0	A	0	A	WB
2-3AM	0	A	0	A	WB	0	A	0	A	WB
3-4AM	0	A	0	A	WB	0	A	0	A	WB
4-5AM	0	A	0	A	WB	0	A	0	A	WB
5-6AM	0	B	0	A	WB	0	B	0	A	WB
6-7AM	0	C	0	A	WB	0	D	0	A	WB
7-8AM	1	D	0	A	EB	0	D	0	A	WB
8-9AM	0	C	0	B	WB	0	D	0	B	WB
9-10AM	0	D	0	C	WB	0	E	0	C	WB
10-11AM	1	E	1	D	WB	2	F	1	D	EB
11AM-12PM	2	E	1	D	EB	4	F	2	D	EB
12-1PM	5	E	5	E	WB	12	F	12	F	WB
1-2PM	9	E	7	E	EB	29	F	27	E	EB
2-3PM	15	E	9	D	EB	35	F	33	E	EB
3-4PM	26	F	10	E	EB	44	F	40	E	EB
4-5PM	33	F	14	E	EB	59	F	52	F	EB
5-6PM	36	F	20	E	EB	70	F	63	F	EB
6-7PM	40	E	14	E	EB	84	F	69	E	EB
7-8PM	43	E	23	E	EB	95	F	81	F	EB
8-9PM	32	D	28	E	EB	91	E	91	F	WB
9-10PM	1	C	29	E	WB	76	D	101	F	WB
10-11PM	0	D	3	D	WB	68	D	92	D	WB
11PM-12AM	0	B	0	B	WB	52	C	62	B	WB

Origin-Destination

Origin-Destination data was obtained from the Bay Crossing Study Purpose and Need Document:

> The capacity provided by the Bay Bridge supports travel demand for both local trips (e.g., work related and discretionary trips) with origins and destinations (O-D) relatively close to the shores, and regional trips (e.g., commerce, recreation, regional travel) with O-Ds throughout and beyond Maryland. Current travel patterns are observed from origin-destination surveys of trips crossing the Bay Bridge conducted between June and August 2016 and 2017, and October and May 2016 and 2017.

Table 5 shows a summary of origins and destinations for trips across the Bay Bridge. Of note is the majority of traffic on both non-summer weekdays and summer weekends has an origin or destination in areas near the bridge.

Table 5 - Origins and Destinations of Trips Across the Bay Bridge

	Non-Summer Weekday (Tuesday through Thursday)				Summer Sunday			
	EB Trip Origins	EB Trip Dest.	WB Trip Origins	WB Trip Dest.	EB Trip Origins	EB Trip Dest.	WB Trip Origins	WB Trip Dest.
Near western end of the bridge[1]	62.7%			60.6%	57.5%			51.1%
Near eastern end of the bridge[2]		66.3%	67.4%			55.5%	49.9%	
Beyond vicinity of bridge	37.3%	33.7%	32.6%	39.4%	42.5%	44.5%	50.1%	48.9%

Note: EB = eastbound, WB = westbound
[1]Anne Arundel and Prince George's counties, MD; Washington, D.C.; Arlington and Alexandria VA
[2] Caroline, Queen Anne's and Talbot counties, MD

Vehicular Capacity to be Accommodated by Ferries

Tables 6 and 7 show hourly Level of Service (LOS) values for 2017 and 2040 on the left, and volume calculations for ferry capacity on the right (calculated by subtracting 2017 volumes from projected 2040 volumes).

Cells that are shaded grey represent hours or directions where there is no change to LOS between 2017 and 2040 and, therefore, unlikely to be any demand for ferry service.

Table 6 below shows non-summer weekday volume calculations. The peak hour for ferry service (highlighted in orange) in 2040 would be 7am-8am when 899 vehicles would have to be accommodated in the westbound direction.

Table 6 - Non-Summer Weekday Necessary Ferry Volume

	Weekday Level of Service and Dominant Direction of Travel						Extra Volume 2017 to 2040		Traffic Volume to be Accomodated per Sailing (Three per hour)	
	2017			2040						
Time	**EB LOS**	**WB LOS**	**Dominant Flow**	**EB LOS**	**WB LOS**	**Dominant Flow**	EB	WB	EB	WB
12-1AM	A	A	EB	A	A	EB				
1-2AM	A	A	EB	A	A	EB				
2-3AM	A	A	EB	A	A	WB				
3-4AM	A	A	WB	A	A	WB				
4-5AM	A	B	WB	A	B	WB				
5-6AM	A	C	WB	B	D	WB	108	541	36	180
6-7AM	C	D	WB	C	E	WB	202	844	67	281
7-8AM	C	D	WB	D	F	WB	282	899	94	300
8-9AM	C	D	WB	D	D	WB	301	712	100	237
9-10AM	C	C	WB	D	D	WB	330	549	110	183
10-11AM	D	B	WB	C	D	WB	373	426	124	142
11AM-12PM	D	B	EB	C	D	EB	388	392	129	131
12-1PM	D	B	EB	C	D	EB	408	401	136	134
1-2PM	D	B	EB	D	D	EB	449	411	150	137
2-3PM	D	C	EB	E	D	EB	580	412	193	137
3-4PM	E	C	EB	F	D	EB	655	438	218	146
4-5PM	E	C	EB	F	D	EB	597	475	199	158
5-6PM	E	C	EB	F	D	EB	617	444	206	148
6-7PM	D	C	EB	E	C	EB	512	339	171	113
7-8PM	C	B	EB	D	B	EB	401	248	134	83
8-9PM	C	A	EB	D	A	EB	271		90	
9-10PM	C	A	EB	C	A	EB	220		73	
10-11PM	B	A	EB	B	A	EB				
11PM-12AM	A	A	EB	B	A	EB				

Table 7 below shows summer weekend volume calculations. The peak hour for ferry service (highlighted in orange) in 2040 would be 4-5pm on Sundays when 813 vehicles would have to be accommodated in the westbound direction. Although the dominant flow for vehicles crossing the Bay Bridge in that hour is in the eastbound direction, the additional vehicles added are predominantly in the westbound travel direction as shown in the 2017 to 2040 extra volume column. The following section contains calculations of ferry vessel capacity necessary to convey the volumes in Tables 6 and 7.

Table 7 - Summer Weekend Necessary Ferry Volume

	Summer Weekend Level of Service and Dominant Direction of Travel						Extra Volume 2017 to 2040		Traffic Volume to be Accomodated per Sailing (Three per hour)	
	2017			2040						
Time	**EB LOS**	**WB LOS**	**Dominant Flow**	**EB LOS**	**WB LOS**	**Dominant Flow**	EB	WB	EB	WB
12-1AM	A	A	WB	A	A	WB				
1-2AM	A	A	WB	A	A	WB				
2-3AM	A	A	WB	A	A	WB				
3-4AM	A	A	WB	A	A	WB				
4-5AM	A	A	EB	A	A	EB				
5-6AM	B	A	EB	B	A	EB				
6-7AM	C	A	EB	D	A	EB	282	147	94	49
7-8AM	D	A	EB	D	A	EB	488	242	163	81
8-9AM	C	B	EB	D	B	EB	543	396	181	132
9-10AM	D	C	EB	E	C	EB	391	415	130	138
10-11AM	E	D	EB	F	D	EB	182	318	61	106
11AM-12PM	E	D	EB	F	D	EB	198	325	66	108
12-1PM	E	E	WB	F	F	WB	204	389	68	130
1-2PM	E	E	EB	F	E	EB	208	370	69	123
2-3PM	E	D	EB	F	E	EB	204	367	68	122
3-4PM	F	E	EB	F	E	EB	459	572	153	191
4-5PM	F	E	EB	F	F	EB	721	813	240	271
5-6PM	F	E	EB	F	F	EB	690	810	230	270
6-7PM	E	E	EB	F	E	EB	707	685	236	228
7-8PM	E	E	EB	F	F	EB	686	698	229	233
8-9PM	D	E	WB	E	F	WB	509	694	170	231
9-10PM	C	E	WB	D	F	WB	393	677	131	226
10-11PM	D	D	WB	D	D	WB	256	444	85	148
11PM-12AM	B	B	WB	C	B	WB	161	190	54	63

5 - Ferry Service Considerations

'Appreciable' Impact to Bay Bridge Congestion

Traffic congestion was already a significant concern during weekday and summer weekend peak periods according to 2017 data[30]. LOS are less than ideal during peak periods and are projected to worsen by 2040 in both duration and intensity. An analysis of hourly LOS projected for the Bay Bridge in 2040 indicates that congestion (LOS E or F) will occur during almost all daytime hours on weekdays and summer weekends.

For the purposes of this study, an 'appreciable' impact was defined as maintaining 2017 ADT volumes on the existing bridge between now and 2040 and accommodating the additional traffic volume with ferries. This approach is consistent with the Bay Crossing Study.

Routes

Prospective ferry service across the Chesapeake Bay would involve catering to the differing needs of weekday and weekend travelers in order to alleviate congestion on the existing Bay Bridge. The viability of a ferry route is heavily influenced by ridership levels with potential routes considered based on their ability to attract the necessary volumes of users.

Weekday Travelers

Upwards of 60 percent of weekday traffic travels between counties near the Bay Bridge using the available arterial roadway network[31]. The directional nature of the traffic volumes (westbound in the morning, eastbound in the evening) suggest that commuting is a contributing generator of traffic on weekdays in addition to other purposes such as errands, day trips, etc.

Summer Weekend Travelers

Recreational travelers during the summer come from a broader range of locations than weekday commuters. However, counties near the bridge still account for approximately 50 percent of all summer weekend traffic[31]. These trips are represented by residents traveling for purposes such as errands, family visits, day trips, etc. The Friday evening peak on summer weekends consists of both commuters and recreational travelers heading eastbound. The remaining 50 percent of summer weekend trips are dispersed across a wide number of areas on either side of the Bay within Maryland and beyond.

Route Selection

Prospective ferry route selection is dependent on a wide array of factors in addition to anticipated demand. This study does not consider the details of such aspects as speed restrictions, navigational constraints, noise restrictions, local zoning, and community concerns. Additional study would be needed in these areas.

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[30] Tier 1 NEPA Purpose and Need Document, Bay Crossing Study
[31] Tier 1 NEPA Purpose and Need Document, Bay Crossing Study: Western shore: Anne Arundel and Prince George's counties, MD; Washington, D.C.; Arlington and Alexandria VA; Eastern Shore: Caroline, Queen Anne's and Talbot counties, MD

Based on previous studies, ferry crossing routes north and south of the existing bridge are potentially viable, subject to service parameters such as journey time and ticket price. This study considers only the ability of an all-electric ferry service that would significantly reduce congestion on the existing Bay Bridge; it does not take into consideration viability based on service parameters. Ferry crossing routes north and south of the existing bridge were considered and excluded from the study for the reasons outlined below, which are based on the existing and projected origin-destination data for traffic on the Bay Bridge outlined in Section 4, as well as the known operational capabilities of all-electric vessels outlined in Section 3.

Northern Ferry Routes

Ferry routes in the Chesapeake Bay north of the Patapsco River and Rock Hall were considered based on the location of metropolitan Baltimore on the western shore and the existence of a previous ferry route between a point near Baltimore and Tolchester. This route was excluded based on traffic forecast data developed for analyzing a crossing in the Bay Crossing Study Corridors 3, 4 and 5; a crossing located in these corridors would, at best case, cause volumes at the existing Bay Bridge in 2040 to drop to at or below existing levels on summer weekends but not on non-summer weekdays[32].

Southern Ferry Routes

Ferry routes in the portion of the Chesapeake Bay south of Chesapeake Beach and Tilghman Island were considered based on their closer proximity to Washington DC, the opportunity to connect to Eastern Shore destinations such as Cambridge, and the lack of an existing bridge connection, which could shorten journey time for travelers in this portion of the state. Potentially viable ferry routes identified in previous studies include Chesapeake Beach to Cambridge, and Solomons Island to Crisfield. These routes were excluded based on traffic forecast data developed for the Bay Crossing Study Corridors 9 through 14; a crossing located in these corridors would not cause volumes at the existing Bay Bridge in 2040 to drop to or below existing levels on either summer weekends or non-summer weekdays[32].

The route would be approximately 25 nautical miles in length for the Chesapeake Beach-Cambridge route and 40 nautical miles for the Solomons Island-Crisfield route. Based on the projected capacity needed as identified in the Bay Crossing Study (50 cars per vessel) and the size of vessels that would operate, all-electric vessels do not currently feature the necessary operational range for such a service. The EV Ellen, which has the largest on-board battery capacity for an all-electric vessel, has a maximum range of 26 nautical miles in fair weather[33].

Viable Routes

Given the volumes needed to be accommodated, a ferry route at or near the existing bridge would be necessary to accommodate those travelers who form a majority of non-summer weekday traffic, half of summer weekend traffic, and are expected to continue to do so through 2040. These travelers are likely to continue to use the existing major arterial roadway (US 50)

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[32] Bay Crossing Study Fall 2019 Open House, MDTA, https://baycrossingstudy.com/fall-2019-open-house-displays
[33] E-ferry, http://e-ferryproject.eu/

for a portion of their travel. A ferry route near the existing bridge would maximize potential ridership and minimize additional travel distance and time compared to a ferry route located elsewhere. A ferry route located farther from the Bay Bridge is unlikely to attract sufficient numbers of existing Bay Bridge users to make an impact on bridge congestion. In addition, it would likely require upgrades to existing roadways, as well as increase total journey travel time for users.

Ferry Vessel Requirements

Vessel Capacity

To maintain average daily traffic at or below 2017 levels, ferry vessels would need to have the capacity to accommodate the daily increase in traffic volume in the dominant travel direction during the maximum peak hour volume. As shown in Table 6, in 2040, that would be 899 total westbound vehicles between 7-8am on non-summer weekdays (1,182 total vehicles in both travel directions during that hour). Table 7 shows that the summer weekend 2040 peak hour volume is slightly lower at 813 westbound vehicles during 4-5pm on a Sunday. The non-summer weekday peak hour westbound volume (899 vehicles) is used to determine vessel capacity because it is higher than summer weekend peak hour directional volume. Ferry vessels would also have to accommodate an acceptable level of potential additional demand.

The capacity analysis does not account for travel delay or individual traveler's decision regarding mode of travel across the Chesapeake Bay.

Number of Vessels

The study determined that three vessels would be needed based on traffic volumes to be conveyed, crossing time, and loading/unloading time. Three vessels represent an acceptable balance between vessel size, number, and sailing schedule.

Given the traffic volume that would need to be accommodated in the peak hour in 2040 (899 vehicles on weekdays during the 7-8am hour), larger vessels would be able to convey such vehicles more efficiently than smaller vessels. This is because loading and unloading times are not the limiting factor in an all-electric system; the limiting factor is vessel charging times, which are discussed below.

Based on the peak hour traffic volume and a three-vessel fleet, the minimum necessary capacity of each vessel is 300 vehicles. As this value does not account for fluctuations in demand, an additional amount of capacity is necessary so that terminals and nearby roads are not overwhelmed during periods of overcapacity. Accommodating an additional 100 vehicles (one third of needed capacity) would mean vessels with the capability of carrying 400 vehicles. Passenger numbers in the amount of 800-1,000 are based on existing vehicular ferry capacities. For a size frame of reference, Figure 1 shows the M/F Berlin, a Scandlines hybrid diesel-electric vessel that can accommodate up to 460 cars and 1,300 passengers, and is 557 feet long. There are currently no existing all-electric vessels in operation that would provide the capacity needs identified above. The study assumed vessels could be designed and constructed to meet the required capacity; otherwise operational efficiencies would diminish and costs would increase.

Figure 1 - The Scandlines vessel M/F Berlin

The prospective ferry route would only accommodate passenger vehicles. Trucks would not be permitted as the additional regulations and the facilities they require on-board may not be economically feasible for the number of potential truck users. Connections to local transit would be provided at the terminals on either shore with transit users crossing the Bay as pedestrian passengers on ferry vessels. It is not anticipated that public transit vehicles would board ferry vessels as part of their route. Charter buses could be accommodated with prior authorization.

One additional vessel would be necessary in case of breakdown or emergencies, as well as periods when one vessel within the fleet is undergoing routine maintenance, bringing the total vessels needed to four.

Vessel Design

Ferry vessel design is diverse. Cruise ferries accommodate both vehicles and walk-on pedestrians with on-board amenities providing for a pleasurable experience. Ro-Ro ferries have higher vehicle capacities at the expense of amenities and pedestrian capacity. It is anticipated that a Chesapeake Bay ferry service would utilize the Ro-Ro design due to the journey time (under 1 hour) and a desire to prioritize vehicle capacity over amenities that are more suited to longer journeys.

Ferry vessels would be of a double-ended design to eliminate the need to physically turn vessels around while under way. Vessels would feature multi-lane bi-level ramps at each end with additional boarding ramps on the front side which would permit concurrent loading and unloading during busy periods.

Travelers cannot remain in their vehicles during the sailing for safety reasons and seating room would be provided in addition to restroom facilities. On-board amenities such as dining or retail would not be provided.

Schedules

Vessel Charging Times

Charging times are dependent on factors such as battery type, charging station capacity, and connector type, with potential variations due to weather conditions. The EV Ellen, and other all-electric systems operate on a 10-20 minute charging period[34]. Washington State Ferries estimated that 20 minutes would be an acceptable balance between infrastructure lifespan, demand on the electrical grid, and sailing schedules[35]. The Washington State Ferries value was used in this study's analysis. The charging schedule for vessels in a Chesapeake Bay ferry service would be determined by their design and choice of battery technology. The EV Ellen charges once per roundtrip but other vessels charge every trip.

Loading and Unloading Times

It is presumed that loading and unloading of vessels could take place within the twenty-minute time period necessary for charging the on-board batteries. This is also an acceptable turnaround time for large ferries if multi-lane bi-level loading ramps are available at terminals, which permit simultaneous loading and unloading[36]. These are discussed further under terminal requirements.

Vessel Journey Times

Journey times are based on the normal operating speed of the vessel. Washington State Ferries Jumbo Mark II vessels operate at 18 knots. The 550-vehicle vessel Stena Jutlandica operates at 21.5 knots but in open seas with considerably higher power than the Washington vessels[37]. For a 400-vehicle vessel operating in the Chesapeake Bay, 14 knots is an appropriate and conservative estimation for the short route length.

The total one-way journey time is estimated to be 50 minutes as shown in Table 8 below. This does not include wait time at the terminal.

Table 8 - Summary of One-Way Journey Times

Activity	Time
Board Vessel (average)	10 minutes
Maneuver from dock	5 minutes
Under way	20 minutes
Maneuver to dock	5 minutes
Disembark Vessel (average)	10 minutes
Total One-Way Journey Time	**50 minutes**

[34] E-ferry, http://e-ferryproject.eu/
[35] Washington State Ferries Medium Voltage Shore Power Feasibility Study, Washington State Ferries, https://www.wsdot.wa.gov/NR/rdonlyres/6C78A08B-19A1-4919-B6E6-E9EF83E6376D/123057/HybridChargingFeasibilityStudy.pdf
[36] Pg. 11, 22-24, Scandlines Press Kit, https://www.scandlines.com/about-scandlines/press/press-kit
[37] Stena Jutlandica, Stena Line, https://www.stenalinefreight.com/ships/Stena-Jutlandica

Sailing Frequency and Wait Time at Terminal

The study assumed two operating schedules: peak and off-peak. Peak operation would see three vessels in continuous operation which would provide for one vessel loading and unloading on each shore while one vessel transits the Bay. This schedule would provide for a maximum of three sailings from each shore with minimal turnaround time during peak hours. Under normal operating conditions wait times for vehicles at the boarding terminal would be a maximum of 20 minutes during the peak hour (7am-8am on non-summer weekdays, and 4-5pm on summer weekends). Off-peak schedules were assumed to be one or two vessels in operation with at least one sailing per hour from each terminal.

Hours of Operation

Weekday services in 2040 would feature a peak schedule from 6am to 10am before operating on an off-peak schedule until 2pm when a peak schedule would resume and operate until 8pm. In 2040, summer weekend service would be on a full-time, continuous daytime peak schedule, with extended evening hours on Fridays and Sundays to accommodate the additional demand.

Alternative Operating Schedules

With distinct periods of peak demand in the morning and evenings during the week, and during periods on summer weekends, there is sufficient flexibility within the schedule to accommodate additional sailings outside of the periods where a peak sailing schedule is anticipated to operate. As the weekday service would operate year-round, alternative operating schedules would be limited.

Terminals

Required facilities

Infrastructure required for all-electric ferry system terminals on each shore:

- Docks for vessels
- A vehicle ramp to permit the loading and unloading of vessels
- A staging area where vehicles can wait prior to boarding
- Fare collection prior to boarding
- Charging stations for the on-board batteries
- Administration buildings

Additional features may include:

- Gangway for walk-on pedestrian passengers
- Transit station connecting to local routes
- Rest and leisure amenities for travelers
- Storage and maintenance dock

Vehicle Staging Requirements

Acceptable vehicle staging requirements at the terminals should include an overload factor between 1.3 and 2.2 times the maximum vessel capacity[38] to accommodate greater than normal demand without vehicle queues impacting local roadways. Based on the 400-vehicle capacity of the ferry vessels, this would mean accommodating between 520 and 880 vehicles. For this study, 650 vehicles representing an overload capacity of 1.5 was chosen.

In order to adequately stage 650 cars, terminals would need 13,000 feet of storage length (assuming 20 feet per vehicle). Since it is desirable to use multiple lanes for operational purposes, the concept developed uses thirteen 1,000 foot lanes which would hold 50 cars each.

Roadway Access

Access to the terminal would be by way of the existing road network which includes a major arterial (US 50) in addition to collector and local roads. Terminals would require new access roads to connect to this roadway network. However, if it is determined that the local road network cannot handle the volumes expected to use the terminal, upgrades would be necessary. These upgrades could include additional lanes, intersection improvements, and safety improvements. The amount and cost of upgrades is dependent on the sites chosen for the terminals and were not estimated as part of this study.

Prospective Terminal Concepts

A number of existing ferry terminals were researched to determine the likely size, facilities, and access requirements necessary. The Washington State Ferries terminals at Seattle and Bainbridge Island are the only American terminals that are comparable to a prospective Chesapeake Bay ferry service that would make an appreciable impact to traffic on the Bay Bridge. In Europe, Scandlines' Puttgarden terminal in Germany, and the opposing Rødbyhavn terminal (shown in Figure 2) in Denmark were identified as being comparable to potential terminals on the Chesapeake Bay. Puttgarden handles over 6 million passengers per year.[39] Figure 3 shows a closeup aerial view of the Rødbyhavn terminal with features labelled.

Of these two services, potential terminals for a Chesapeake all-electric service would be more like the Scandlines terminals, and less like Washington State Ferries terminals. Whereas Washington's terminals are near or within urban areas with constrictive designs, the Scandlines terminals are in more rural areas with flatter terrain. In addition, the Scandlines terminals feature more comparable staging areas and loading facilities that a Chesapeake Bay ferry service would most likely need.

A method of fare collection was not identified as part of this study and would be analyzed during the design phase. Figure 4 shows the entrance gates to the Puttgarden terminal which features cash and electronic fare collection.

[38] Transit Capacity and Quality of Service Manual (2nd Edition), Transportation Resource Board
[39] Puttgarden, Scandlines, https://www.scandlines.com/about-scandlines/about-scandlines-frontpage/ferries-and-ports/puttgarden

Figure 2 - Aerial view of the Rødbyhavn Terminal

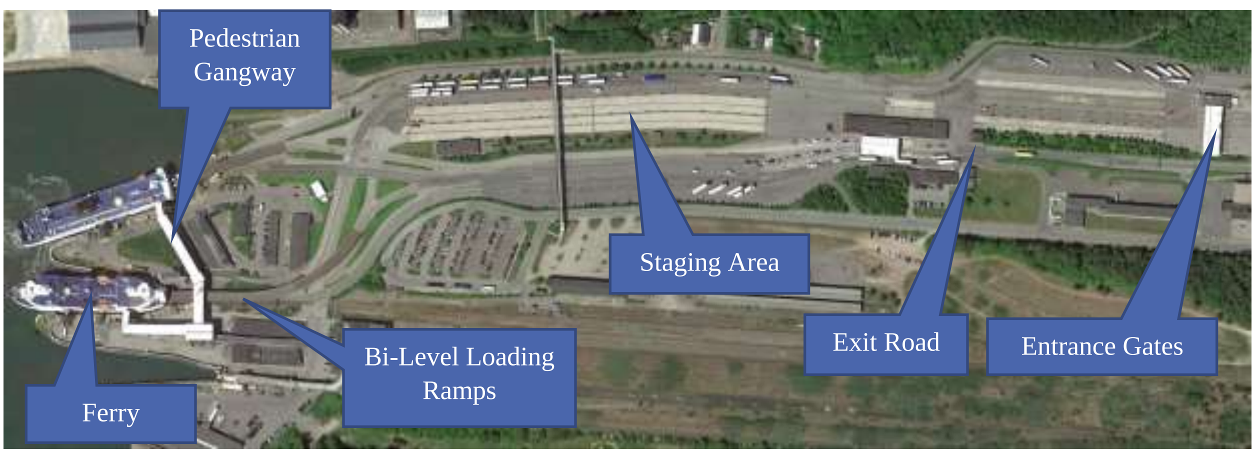

Figure 3 - Close-up of the Rødbyhavn terminal with facilities labelled

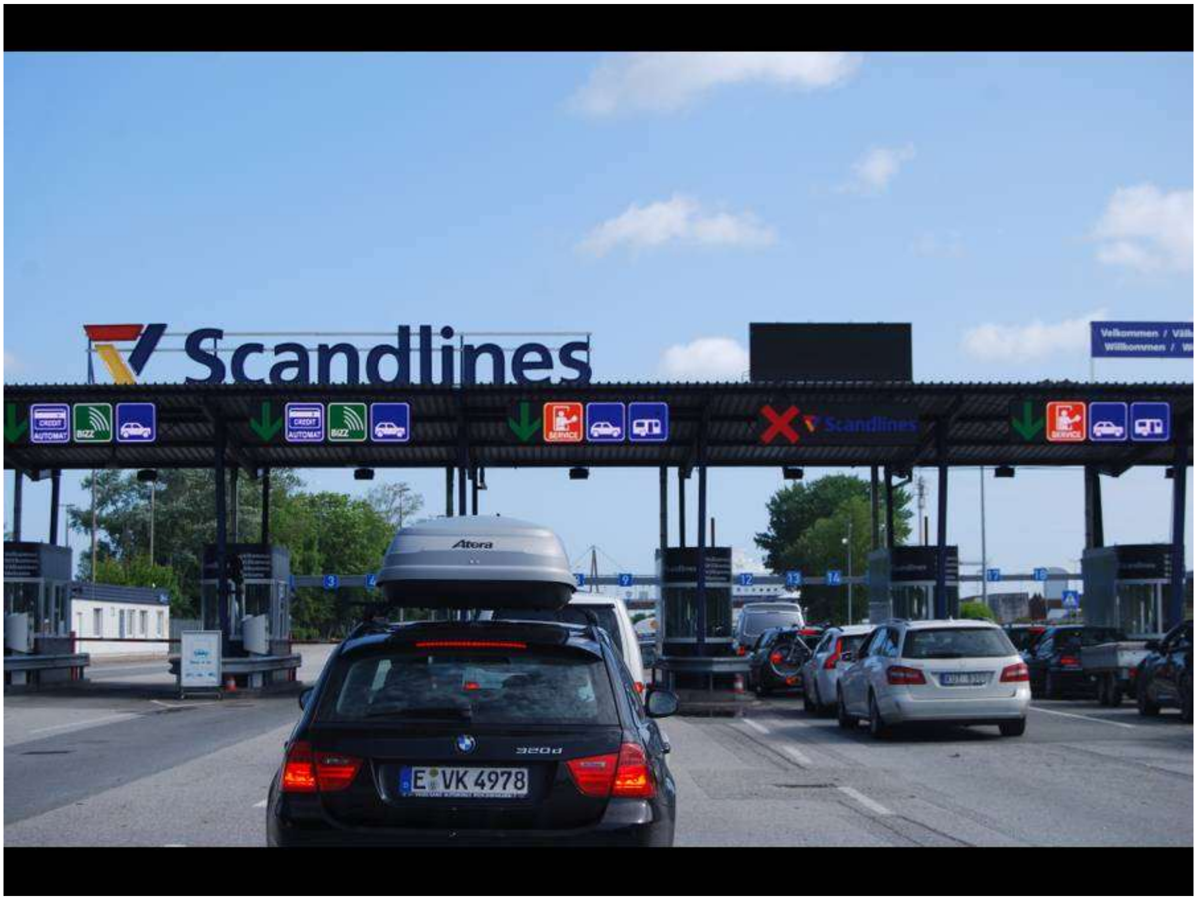

Figure 4 - Entrance gates to the Puttgarden terminal where fares are collected. The two gates on the left are being used for electronic fare collection. A method of fare collection for a Chesapeake Bay ferry service was not identified as part of this study.

Conceptual Terminal

The conceptual terminal for a Chesapeake Bay ferry service utilizes the Puttgarden and Rødbyhavn terminals as a guide. The design of facilities such as the bi-level and side-loading ramps (as shown in Figure 5), the lane configuration, and location of the entrance gates were used. The staging area was sized per the requirements identified as part of this study. The conceptual terminal does not consider access to an existing road, as that is dependent on an actual location which was not identified as part of this study.

Figure 5 - Ferry vessel docked at Puttgarden.
Loading/unloading ramps and roads visible with staging area in the foreground

Costs for the conceptual terminal are on a major quantity basis with certain categories estimated on a percentage basis. A 40 percent contingency is used which is standard practice at the planning level. Costs are discussed in Section 7.

6 - Additional Considerations

Direct and Indirect Services

Personnel Needs

A required vessel crew would consist of a captain and first officer, with approximately thirteen crewmembers undertaking tasks such as directing vehicles, onboard maintenance, guest services, etc. Approximately eight to ten landside staff per terminal would be required for directing vehicles, charging the vessel, and administration. This does not include security personnel, which is discussed below.

Fare Collection

The ferry service would ultimately have to cater to both commuters and tourists and the ticketing system would need to reflect the travel patterns of both groups. Annual, monthly, or weekly passes could be offered to commuters at a discounted rate to encourage regular use. Tickets could also be sold via kiosks at entrance gates to the terminals.[40]

Security

Security within the ferry system would be provided by the MDTA Police who have jurisdiction over all MDTA facilities.[41] Full-time security services would be required at both ferry docking locations, as well as a minimum of one security officer per vessel during operation.

Navigation

The Chesapeake Bay is an important navigation route for many vessels. Besides recreational fishing and pleasure craft, commercial vessels travel to and from the Port of Baltimore. A ferry service operating across the Bay would traverse the federally maintained navigation channel that runs along the length of the Chesapeake Bay[42].

Commercial traffic in federal channels under pilotage has priority right-of-way. The Port receives more than 3,500 vessel calls each year[43] (resulting in Bay transits on average, once every two hours) which do not operate on a regular schedule. Operations at the Port are continuous, 24 hours a day, 365 days a year. Implementation of a ferry service would require constant coordination with the Port as well as other stakeholders such as the Baltimore Maritime Exchange, and the Baltimore Port Alliance. The presence of maritime vessels may lead to service delays or disruption of services as priority for the channel would be provided to all Port-bound vessels over ferry services.

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[40] Current Fares, Washington State Ferries, https://www.wsdot.wa.gov/ferries/pdf/WashingtonStateFerries-CurrentFares.pdf
[41] MDTA Police, https://mdta.maryland.gov/Police/Police_Main.html
[42] NOAA: https://charts.noaa.gov/OnLineViewer/12280.shtml, and USACE: https://www.nab.usace.army.mil/Portals/63/docs/Navigation/1DE/Map/map.pdf
[43] Port of Baltimore, Port Profiles, Bureau of Transportation Statistics, United States Department of Transportation, https://www.bts.dot.gov/ports

The Chesapeake Bay is relatively shallow with an average depth of approximately 21 feet[44]. Choice of navigational routes, especially for larger vessels, is limited by this shallow depth and other factors such as vessel size restrictions, protected areas, etc. Any prospective ferry service would require a thorough investigation of potential navigational routes to ensure that they are both feasible and practical. Given the size of the vessels necessary for a modeled service, it is anticipated that dredging would be necessary as part of terminal construction. Data from the Stena Jutlandica (a 550-vehicle ferry) show a draft of almost 20 ft[45]. Vessels of a similar size within the Chesapeake Bay would likely require dredging along any designated ferry route. Finding an appropriate dredged spoil site would also be required.

Weather conditions must be also be considered as potential hazards to ferry service. Extreme weather events such as hurricanes, fog, and snowstorms have the potential to disrupt or prevent sailings. Ice is a potential hazard during the deep winter months, which could disrupt sailings without mitigation measures (or at an increased operational cost to keep operations running). The Coast Guard issues regular bulletins regarding ice hazards.[46]

Environmental

Although all-electric ferries do not emit polluting gases during operation, implementing ferry service could produce other impacts to the environment. The Chesapeake Bay is a diverse habitat for wildlife and is rich in social and cultural history. Potential impacts to the following items known to exist within the Bay are possible:

- Environment
    - Sensitive Species
    - Forest Interior Dwelling Species
    - Waterfowl
    - Oyster Sanctuaries
    - Shellfish
    - Conservation lands
    - Protected lands
    - Wetlands
- Cultural and Historical
    - Churches
    - Graveyards
    - Community facilities
    - Maryland Inventory of Historic Places
    - National Register of Historic Places
    - Maryland Historical Trust Places

[44] Chesapeake Bay Program, https://www.chesapeakebay.net/discover/facts
[45] Stena Jutlandica, Stena Line, https://www.stenalinefreight.com/ships/Stena-Jutlandica
[46] US Coast Guard: https://content.govdelivery.com/accounts/USDHSCG/bulletins/22c2eb1

As ferry vessels would be operating in waters under the jurisdiction of federal agencies, a study in accordance with the National Environmental Policy Act (NEPA) would be necessary to investigate and quantify potential impacts to the environment. Such a study would more thoroughly document any impacts to the following:

- existing wildlife habitats and ecosystems
- existing land and water environmental features
- Air quality & noise
- Social, historical, and cultural resources

A NEPA study would also identify potential indirect and cumulative effects caused by the introduction of a ferry service: "Indirect effects (effects caused by the project, but occurring later in time or farther removed in distance than direct impacts) include changes in land use attributable to the project (induced growth) and impacts on environmental resources that occur as a result of the project's influence on land use[47]." Cumulative effects are defined[48] as: "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions."

Cultural

Ferry use is often rooted in an area's culture forming an important element of its connection to the wider world. In areas such as Washington State where there are either no or very few transportation alternatives, ferry use is considered a normal part of daily life[49]. The presence of the metropolitan city of Seattle on the eastern side of Puget Sound provides a destination for commuters living on the western shores. Similarly, the ferries of New York City provide important transportation links across the city's harbor and Hudson River to Staten Island and cities in New Jersey.

The cultural value of these ferry services is in contrast to a possible Chesapeake Bay ferry service that would relieve congestion on the existing Bay Bridge. First, the other systems that this study uses as a point of comparison do not have a competitive component – they are the only direct source of transportation across that particular body of water. Having the Bay Bridge as a viable alternative (and most likely a quicker alternative) will likely cause commuters to choose the quicker alternative, which means the ferry service could potentially become economically unviable. Secondly, there are no major metropolitan destinations located at either shoreline that provide a destination for commuters for whom the Bay Bridge forms only a portion of their overall journey. A Chesapeake Bay ferry would perform a similar role, functioning primarily as a transportation connection within a wider journey.

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47 https://connect.ncdot.gov/projects/planning/TPB%20Documents/ICE_in_Planning_Overview_Handout.pdf
48 Introduction to Cumulative Effects Analysis, Council on Environmental Quality: https://ceq.doe.gov/docs/ceq-publications/ccenepa/sec1.pdf
49 Hartnett, Margi, The Joys of Commuting Aboard a Washington State Ferry, The Daily Herald, January 2, 2018

The continued presence of the Bay Bridge would mean that the use and social value of a ferry would not achieve the same levels as the Washington and New York City ferries, where communities rely on them instead of making a choice to use them.

MDTA Facilities

MDTA does not possess any institutional knowledge of ferry service operations. Implementation of a service would require a full scale build out of knowledgeable staff, requiring the MDTA to hire additional staff with professional experience with ferry services and operations. Training of new staff would be a necessity.

The original ferry terminals at Sandy Point, Matapeake, Romancoke, and Claiborne are in the ownership of a variety of entities. Sandy Point is the only terminal owned by MDTA and is used as a dock for vessels and barges that provide maintenance to the Bay Bridge. Very little infrastructure and docking facilities of the original ferry terminal remain, and the remaining terminals do not meet the necessary requirements of a new terminal facility with regard to waiting areas, docks, loading ramps, and available space for supporting infrastructure and would require total reconstruction.

Adapting the Sandy Point facility is unlikely due to its inadequate size, environmental constraints which make expansion difficult, and the need to relocate Bay Bridge maintenance facilities to a new location. Adapting other MDTA facilities is also infeasible as none are located in areas where ferry service would be viable.

Thus, the MDTA would need to acquire the appropriate land near locations that would make ferry services possible. This could potentially be located near communities, and this could present other ancillary logistical challenges.

7 - Fiscal Analysis

Total implementation (capital and operating) costs for a ferry service over the 40-year lifespan of the vessels would range from $3.3-$3.4 billion and require an upfront cash investment of $147 million; this estimate includes the following:

- Total design and construction costs for the four-vessel fleet ranging from $692-$780 million
- Total terminal costs of $190-$210 million
- Total charging station costs of $16-$20 million
- Total utility upgrade costs of $12-$16 million
- Total vessel battery replacement costs of $60 million
- Total charging station battery replacement costs of $8 million
- Financing interest payments of $410 million
- Operating costs:
  - Direct costs of $570 million
  - Indirect costs of $393 million
  - Fixed costs of $926 million

Total operating costs including direct, indirect, and fixed costs are estimated to be approximately $45 million per year, on average, over 40 years and includes crew, maintenance, insurance, marketing, management, and other miscellaneous overhead.

The per-vehicle cost is determined using the total implementation cost of $65 million and ridership in the first full year of operation. Table 9 below shows one-way per-vehicle costs based on various percentages of full capacity ridership.

Table 9 - Comparison of First Year One-Way Per-Vehicle Cost

Annual Ridership (Percentage of full capacity)	Annual Ridership (Percentage of full capacity, vehicles)	One-way per-vehicle cost
100%	1,761,150	$37
80%	1,408,920	$47
50%	880,575	$75
25%	440,288	$150

Overview

The fiscal analysis of a prospective all-electric ferry service consisted of multiple steps. An initial total cost was calculated using the Ferry Lifecycle Cost model developed by the Volpe Center of the U.S. Department of Transportation[50]. This model was developed to assist federal land management agencies who receive funding for ferry services but lack prior knowledge of the costs associated with such services. The model considers capacity and route information along with vessel criteria and produces annual capital and operating costs for a projected 40 years of service. The model does not include capital costs associated with terminals; these were calculated separately.

The model also only considers a traditional diesel-engine vessel design. Operating costs for an all-electric service were calculated by substituting diesel usage and unit cost for electricity Kilowatt-hour (KW-h) usage contained in comparable studies and KW-h rates from the Maryland Public Service Commission. Capital costs for vessel construction were based on Scandline vessels of comparable size to those identified by the study[51] and were input manually into the model. Costs for the regular replacement of the battery packs onboard vessels and within charging stations were included using the values outlined in the Washington State Ferries Hybrid System Integration Study[52].

The Ferry Lifecycle Cost model incorporates the ability to analyze financing (via loans, bonds, etc.) which was used since it represents a conservative choice.

All tables and results contained in this section are from the U.S. Department of Transportation (DOT) Volpe Center's Ferry Lifecycle Cost Model.

Service Parameters

Table 10 below shows the general parameters of a ferry service that are manually input to the model. Of note are the docked time values which are per stop, per trip due to the way the model calculates total roundtrip journey time. A ferry running between two points would have a ten-minute docked time at each end for one trip, resulting in a 20-minute total turnaround time.

For the purposes of this analysis, peak season is during the summer months (May through August) and all other times are off-season.

[50] U.S. Department of Transportation Volpe Center: https://www.volpe.dot.gov/transportation-planning/public-lands/department-interior-bus-and-ferry-lifecycle-cost-modeling
[51] Pg. 16, Scandlines Press Kit, https://www.scandlines.com/about-scandlines/press/press-kit
[52] Hybrid Electric Propulsion Conversion Project, Washington State Ferries, https://www.wsdot.wa.gov/NR/rdonlyres/6C78A08B-19A1-4919-B6E6-E9EF83E6376D/125314/WSFHybridElectricPropulsionConversionProject.pdf

Table 10 - Ferry Service & Vessel Parameters

Ferry Service	
Is this a new service, or will it be a new route added to an existing system?	New Service
What is the estimated round-trip route distance in nautical miles?	8
How many stops will there be?	1
Will the ferry transport vehicles?	Yes
If yes, how many during the peak hour?	900
What is the estimated daily vehicle demand?	15,835
How many hours per day will the service operate?	16
What is the estimated annual passenger demand	1,761,150
Total operating hours on this route/service	1,728
Vessels	
Service Speed/ Max Speed=	0.8
Docked Time (min)	10
Labor Overhead Rate	20%
Crew Hours/Vessel Operating Hours	1.3
Captain Hourly Wage Rate	$30.00
Deckhand Hourly Wage Rate	$15.00
Electricity cost (per KW-h)	$0.08
Annual Change in electricity	6%
Lubricant Cost/Gallon	$8.00
Annual Vessel Depreciation (as % of vessel purchase price)	2.3%
Annual inflation	2.0%
Loan period (years)	25
Loan Interest rate	5%
Annual Marketing, Admin cost per passenger	$1.00
Is a spare vessel needed?	Yes
Vessel owner equity / down payment (as % of vessel costs)	20%
On average, how old will the vessels used for the service be?	New
Average age of purchased vessels	0
Price of vessels as % of new price	100%

Ferry Vessel Characteristics

Table 9 below shows the various characteristics and operational data for ferry vessels. Passenger capacity reflects the high estimation of ferry use. Vessel costs were input manually based on the cost of vessels (€140/$150 million each) operated by Scandlines that are similar in size and capacity to a prospective Chesapeake Ferry service but are hybrid-electric[53], not fully electric; a cost increase of 15-30 percent was added to reflect the fact that an all-electric vessel of the size needed does not currently exist and could incur presently-unknown costs.

Table 9: Ferry Vessel Characteristics

Typical Vessel Characteristics	
Service Speed (knots)	14
Passenger Capacity	1,200
Crew requirement	15
Estimated cost per vessel (low)	$173,000,000
Estimated cost per vessel (high)	$195,000,000
Service/Fleet Summary	
Round-Trip time (min)	53
Passenger capacity/vessel-hr	1,815
Minimum Service Vessels Needed	3
Total crew required for full fleet	45
Total Operating Hours	1,728
Total Vessel Hours	5,040
Percent of Vessel Hours at Idle	
Operating hours	**Assume 1/2 peak and off-peak hours**
Service Vessels Needed	3
Crew needed	45
Headway (min)	18
Operating Hours	20
Vessel Hours	2,160
Passenger capacity/hr	5,446

Costs

Capital Costs

Vessels

Vessel cost represents, by far, the largest portion of capital costs related to ferry service. For a 400-vehicle vessel, total cost is likely to be at least $173-$195 million, depending on final design criteria and shipbuilder. This reflects the fact that all-electric vessels are currently more expensive than traditional designs[54]. Total vessel costs would be between $692 and $720 million for the required four-vessel fleet.

[53] Pg. 16, Scandlines Press Kit, https://www.scandlines.com/about-scandlines/press/press-kit
[54] Murray, A, BBC News, *Plug-in and sail: Meet the electric ferry pioneers*, January 14, 2020, https://www.bbc.com/news/business-50233206

Table 11 below shows the capital costs associated with the ferry vessels on an average basis. The "Equity Investment" is the upfront capital amount (20 percent) input in the Service Parameters table and would be the amount of money to be invested into the service. The "Start-up cost" (Year 0) represents the working capital necessary to fund one-time capital costs to get the service up and running.

Table 11 - Average Ferry Capital Costs

Cost per Vessel	$184,000,000
Total Fleet Cost	($736,000,000)
Fleet cost allocated to this service/route	($736,000,000)
Equity Investment	$147,200,000
Start-up cost (Year 0)	($440,288)
Debt Allocated to this service/route (Year 0)	($589,240,288)
Annual Debt Payment	$41,335,680
Annual Fleet Depreciation	($16,928,000)

Terminals

Terminals would cost between $95-105 million, not including charging stations. Estimated terminal costs include access roads, vehicle queueing areas, charging stations, rest facilities, entrance gates, and miscellaneous construction costs. Vessel charging stations at both terminals would represent an additional estimated capital cost of $8-10 million depending on type and storage size chosen. Upgrades to existing electrical infrastructure may be necessary to accommodate the additional demand. As a conservative measure, upgrades are assumed and are estimated to be in the region of $6-8 million at each terminal[9]. Total estimated terminal costs are therefore between $109-$123 million each ($218-$246 million total for two terminals.)

Ferry Operations and Maintenance Costs

Table 12 below shows the average recurring annual costs associated with running a ferry service after Year 0. The middle column indicates the cost category: "D" for direct costs, "I" for indirect costs, and "F" for fixed costs. Protection and Indemnity (P&I) insurance covers a broad range of liabilities related to ferry service.

Table 12 - Average Ferry Recurring Annual Costs

Vessel Hours		5,040
Annual On-Board Labor Cost	D	$1,886,976
Annual Electricity + Lubricant Cost	D	$2,946,096
Annual Maintenance Cost	I	$2,500,000
Hull and P&I Insurance	F	$15,336,403
Marketing, Advertising, Management, Overhead	I	$1,831,150
Year 1 Total Operating Costs		**$24,501,000**
Operating Cost per vessel hour		$4,861
Operating Cost per operating hour		**$14,179**

Miscellaneous Capital Costs

Additional costs that would be incurred include design of the terminals, property acquisition, and associated infrastructure. Permit and license fees for vessel operation would also be incurred prior to the initiation of service. These costs were not included in this study. The cost of ferry vessel design is included within the cost per vessel quoted in Table 11 above.

Battery Replacement

Current technology limits battery lifespan which is measured by the number of charge/discharge cycles they can undergo before their capacity drops below acceptable operational thresholds. Washington State Ferries estimated[25] a four-year replacement cycle for all vessel batteries within an all-electric system in addition to a twenty-year replacement cycle for landside charging facilities. Costs for these replacements are estimated at $1.5 million per vessel ($6.0 million for all four vessels) and approximately $2 million for each charging station. These costs are included within the annual operating costs for analysis purposes but are listed here because they represent a capital outlay.

Operating Costs

Electricity

The cost of electricity would be dependent on the supplier and charging station type chosen. Charging stations at both terminals are presumed as each shore has a different local electrical grid, and for redundancy within the all-electric system. Electricity use is based on the WSDOT study[55] which is comparable in power needs to a prospective Chesapeake Bay ferry. Electricity costs are based on local Maryland rates and would be around $1-1.5 million per year. Sources of electricity (including alternative or renewable options) were not investigated as part of this study.

Crew & Staff

Using the federal lifecycle model and local hourly rates, the annual cost for a crew of 15 was estimated to be approximately $1.8-2 million. Terminals would require approximately ten employees for fare collection, directing traffic, and performance of other duties, including maintenance. MDTA Police would require approximately five to six officers during operating hours (one per vessel and one per terminal) with one officer stationed at each terminal during non-operating hours.

Maintenance

Maintenance costs would be approximately $2.5 million per year for four vessels. All-electric vessels have fewer moving parts which leads to lower maintenance needs. However, this does not result in significant savings as the complex battery banks and associated equipment have a higher cost of replacement and require more specialized labor skills. Maintenance costs are based on the Washington State Department of Transportation study[53] and also include standard vessel and terminal maintenance.

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[55] Washington State Ferries Medium Voltage Shore Power Feasibility Study, Washington State Ferries, https://www.wsdot.wa.gov/NR/rdonlyres/6C78A08B-19A1-4919-B6E6-E9EF83E6376D/123057/HybridChargingFeasibilityStudy.pdf

Miscellaneous
Miscellaneous costs include advertising, ticketing and IT infrastructure, passenger comfort, etc. These are included within the U. S. Department of Transportation's Ferry Lifecycle Cost model[56].

Total Implementation Cost Summary

The table below contains a summary of the total outlay, financing, and operating costs associated with a prospective all-electric ferry service in the Chesapeake Bay, minus the cost of the terminals. Direct operating costs include: on-board labor; electricity and lubricant; maintenance; insurance; and marketing, overhead and management. Indirect operating costs include: ongoing marketing; reservations; management and general administration. Fixed operating costs include insurance costs in the first 15 years, including hull, protection, and indemnity insurance.

Table 13 - Average Total Ferry Service Implementation Cost (less terminals)

Investment	$147,200,000
Financing	$1,033,392,000
Terminals	$200,000,000
Direct Operating Expenses	$569,921,000
Indirect Operating Expenses	$392,389,000
Fixed Operating Expenses	$926,349,000
TOTAL COST (Year 0-40)	**$3,269,251,000**

Revenues

The MDTA's bond indenture requires facilities to achieve break-even operating performance within five years of opening. Assuming the fares would not be subsidized by roadway tolls, the bond indenture mandates that MDTA recover operating costs through passenger fares. For the first five years, it is estimated that the total operating costs for the estimated 27 million trips would be approximately $90 million. Based on full operation and capacity usage, the minimum estimated cost per vehicle trip (one-way) in the initial year of operation would be $37 (assuming 100% ridership usage). Less than full utilization could result in significantly higher fares.

[56] U.S. Department of Transportation Volpe Center: https://www.volpe.dot.gov/transportation-planning/public-lands/department-interior-bus-and-ferry-lifecycle-cost-modeling

As of 2019, toll rates for two-axle users of the Bay Bridge are shown in Table 14:

Table 14 - 2019 Bay Bridge Toll details

Toll Type	Toll Rate
Cash	$4.00
E-Z Pass	$2.50
Shoppers*	$2.00
Commuter**	$1.40
Ferry Cost (one-way)***	$37.00-$150.00

*Bay Bridge Shoppers Discount Plan: Pay $2.00 per trip for 10 two-axle trips that can be used Sunday through Thursday and are valid for 90 days. The total cost for used and unused trips is $20.00.
**Commuter discount plans are available for customers with valid E-ZPass Maryland accounts driving two-axle vehicles. The plan for the Bay Bridge is $35.00 and offers 25 trips. Plans end after 45 days or when all of the trips are used, whichever comes first.
***$37 represents full-capacity ridership and lowest possible cost per vehicle, $150 represents cost per vehicle at 25% capacity usage. See Table 9 for additional ridership level costs.

Ferry service would offer an alternative to crossing the Bay Bridge, but the choice of facility would remain with travelers. There is a risk that travelers' tolerance of congestion continues to increase which would affect the appeal and therefore the economic viability of a ferry service. With heavy adoption of electronic navigation (Google Maps, Waze, etc.), the minute-by-minutes decision to use a ferry versus bridge would be a function of time and cost. With on demand access to travel time estimates provided by various smart phone Apps, travelers have the ability to factor into their decision making the ferry journey time versus any bridge delay and ultimately may choose the faster alternative, with some additional consideration of cost.

Grants and Other Public Programs

Opportunities for federal grants and other public funding are limited. The Ferry Boat Program of the Federal Highway Administration provides grants for eligible ferry systems that are publicly owned and operated; the program's total annual budget is only $80 million through FY 2020, with no guarantee of future funding levels[57]. The US DOT BUILD program provides grants up to $25 million for programs that: "...emphasize improved access to reliable, safe, and affordable transportation for communities in rural areas. This includes projects that improve infrastructure condition, address public health and safety, promote regional connectivity, facilitate economic growth or competitiveness, deploy broadband as part of an eligible transportation project, or promote energy independence."[58] A Chesapeake Bay ferry service could potentially apply for funding under the FHWA Ferry Boat program and BUILD program. This study does not include any federal funding in its analysis.

The MDTA is self-sufficient and receives no funding from the State's General Fund. In addition, the MDTA does not receive any gas taxes, motor vehicle fees, or other revenue from the Transportation Trust Fund. The MDTA's facilities are fully financed, operated, maintained, improved, and protected with toll revenues paid by customers using those facilities.

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[57] Federal Highway Administration Ferry Boat Program: https://www.fhwa.dot.gov/fastact/factsheets/ferryboatfs.cfm
[58] US Dept. of Transportation BUILD Grants: https://www.transportation.gov/BUILDgrants

8 – Conclusion

Feasibility of an All-Electric Ferry Service

A MDTA-operated ferry service utilizing all-electric ferries is not a feasible alternative to a third crossing of the Chesapeake Bay, based on the findings presented in this study. There are currently no existing all-electric vessels in operation that would provide the capacity needs identified above and the service would be cost prohibitive from the user and operator standpoints.

Cost Estimates

Total implementation (capital and operating) costs for a ferry service over the 40-year lifespan of the vessels would range from **$3.3-$3.4 billion** and require an upfront cash investment of **$147 million**. This includes the following costs:

- Design and construction costs for the four-vessel fleet ranging from $692-$780 million (assuming 400 vehicle vessels can be produced)
- Terminal costs of $190-$210 million
- Charging station costs of $16-$20 million
- Utility upgrade costs of $12-$16 million
- Vessel battery replacement costs of $60 million
- Charging station battery replacement costs of $8 million
- Financing interest payments of $410 million
- Operating costs:
    - Direct costs of $570 million
    - Indirect costs of $393 million
    - Fixed costs of $926 million

Total operating costs including direct, indirect, and fixed costs are estimated to be approximately $45 million per year (2019 dollars) over 40 years and include electric, crew, maintenance, insurance, marketing, management and other miscellaneous overhead.

Per Trip Cost

The one-way per-vehicle cost is determined using the total implementation cost and ridership in the first full year of operation.

Table 1 - Comparison of First Year One-Way Per-Vehicle Cost

Annual Ridership (Percentage of full capacity)	One-way per-vehicle cost
100%	$37
80%	$47
50%	$75
25%	$150

Supporting Infrastructure

Implementation of an all-electric ferry service that would make an appreciable impact on Bay Bridge traffic congestion would require a larger vessel design and production than what is currently in operation today. The largest all-electric ferry vessels in current operation between Denmark and Sweden have a capacity of only 240 cars and 1,250 passengers[59]. If ferries of sufficient size and design could not be manufactured (400 vehicles per trip), a ferry service using smaller vessels would have a diminishing effect on traffic congestion and/or an increase in costs.

Ferry terminals would need to accommodate queuing for 650 cars with the additional spaces over vessel capacity providing for fluctuations in demand, vessel delays, and other foreseeable variations in operations[60]. Each terminal facility would need to be approximately 25 acres in size including entrance gates, storage areas, ramps, and docks. Entrance gates would need to process approximately 30 arriving vehicles per minute during the peak weekday hours. Access to and from existing roadways would need to be provided. For this study, it was assumed that terminals would be located near existing roadways and would require short access roads. Terminal sites located a longer distance from existing roads could require the construction of longer access roads at an increased cost. Improvements to existing roadways could also potentially be required.

Additional Findings and Challenges

Suitability of all-electric vessels for service on the Chesapeake Bay: Prospective service on the Chesapeake Bay would require all-electric vessels of a size that are not currently in operation, with unknown operational performance. The size and number of vessels needed in conjunction with a desire to minimize charging times could mean that the charging and infrastructure costs are greater than this study's estimate and may require more significant upgrades to local utilities than what is anticipated.

Navigation concerns: There are numerous navigational concerns that would have to be addressed or overcome before ferry service could be initiated. These include, but may not be limited to: vessel traffic to and from the Port of Baltimore which could interrupt ferry sailings, the need to identify a precise route alignment, the need to dredge a portion of an identified route alignment to accommodate the expected draft of the vessels, and the possibility of weather disrupting sailings.

Potential environmental impacts caused by the introduction and operation of ferry service: Providing ferry service may have impacts to the natural, social, and cultural environment which would need to be studied in detail through the NEPA process

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[59] Ferries, Foresea, https://www.forseaferries.com/about-forsea/ferries-and-port/

[60] Transit Capacity and Quality of Service Manual (2nd Edition), Transportation Resource Board

Ferry Service as an Alternative to a Third Chesapeake Bay Crossing

Results of the Bay Crossing Study screening process show that as a standalone option, a ferry service does not meet the Study's Purpose and Need[61]. If a Corridor Alternative is approved by the Federal Highway Administration in the Bay Crossing Study Tier 1 Record of Decision, the National Environmental Policy Act (NEPA) process could move into a Tier 2 study. Ferry service would be studied in combination with other alternatives in Tier 2 NEPA.

[61] Fall 2019 Open House display boards, Bay Crossing Study