Keeping Passenger Ferry Systems Afloat

What can Boston learn from other water transportation systems around the country?

A thesis submitted by

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Abstract

Waterways were once the dominant mode of transporting people and goods throughout the United States, but they fell out of favor with the explosive popularity of motor vehicles and the subsequent development of roadways and infrastructure. However, passenger ferries have made a comeback in recent decades, as cities around the country have taken advantage of the opportunity to redevelop waterfronts, technological improvements, and a relatively uncongested right-of-way to revitalize their ferry operations and help mitigate road congestion. Through case studies and interviews with employees at seven passenger ferry systems in six US cities, this thesis explores various ferry operations around the country and organizes themes that encompass the current state of ferry operations. As Boston seeks to expand its ferry system, a review of other cities' and states' passenger ferry operations can provide Boston with guiding best practices about funding, economic development, integration with other modes of transportation, environmental considerations, and services related to water transportation.

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List of Abbreviations

Alaska Department of Transportation and Public Facilities	Alaska DOT&PF
Alaska Marine Highway System	AMHS
Bay Area Rapid Transit	BART
Boston Harbor Cruises	BHC
Boston Harbor Now	BHN
Bureau of Transportation Statistics	BTS
Fixing America's Surface Transportation Act	FAST
Ferry Boat Discretionary Program	FBD
Federal Highway Administration	FHWA
Farebox Recovery Rate	FRR
Federal Transit Administration	FTA
Golden Gate Bridge, Highway, and Transportation District	GGBHTD
Golden Gate Ferries	GGF
Golden Gate Transit	GGT
Moving Ahead for Progress in the 21st Century Act	MAP-21
Massachusetts Department of Transportation	MassDOT
Massachusetts Bay Transportation Authority	MBTA
Metropolitan Planning Organization	MPO
Metropolitan Transportation Commission	MTC
North Carolina Department of Transportation	NCDOT
National Census of Ferry Operators	NCFO
New York City Department of Transportation	NYC DOT
Passenger Ferry Grant Program	PFG
Passenger Vessel Association	PVA
Regional Planning Organization	RPO
Virginia Department of Transportation	VDOT
Water Emergency Transportation Authority	WETA
Washington State Department of Transportation	WSDOT
Washington State Ferries	WSF

Chapter 1: Introduction

Congestion is a ubiquitous problem, affecting even the smallest of urban areas. As urban populations continue to increase, investment in and expansion of public transit in these urban areas is seen as a crucial step to enable cities to continue to grow without succumbing to detrimental gridlock. Moreover, motor vehicle trips – the predominant mode of transportation for decades – have been on the decline, as many people are replacing trips by car with alternative modes of transportation such as buses or rail (US Department of Transportation, 2017). This trend, along with strains on existing roadways and public transit infrastructure, provides an opportunity for water transportation to play a more significant role in facilitating the movement of people throughout congested urban areas located near waterways.

Alleviating congestion, however, is not the only driving force behind the renewed interest in water transportation. While providing an alternative to driving may be the impetus for many land-based transportation systems, water transportation systems have been developed in recent years for a variety of purposes, including renewed opportunity and desire to develop waterfronts, and the advancement of the technological capabilities of ferries to the point that they are financially competitive with other modes of transportation. Water transportation was an integral part of the early development of cities in the US, but it fell out of favor as cities focused on inland development, and roadways and railroads became the preferred means of transporting goods and people. Ferries have existed throughout time, but largely for recreational or tourism purposes rather than as an integrated mode of transportation. Interest in passenger ferries has been renewed in recent years, as coastal and river cities return to

their waterways as a possible alternative to increasingly congested roadways. State and local governments around the country have been making major capital investments in their waterfronts and in ferry infrastructure to take advantage of the opportunity for water transportation to become an integrated part of a city or region's transportation network (International Association of Public Transport, 2013).

Boston, in particular, is no stranger to traffic, ranking seventh in the list of most congested cities in the US (INRIX, 2016). Significant development in recent years has contributed to tremendous amounts of traffic coming into and out of the city from the North and South Shores. Paired with an often-criticized public transportation system, Boston is in need of exploring different ways of improving access and transportation in the Greater Boston area.

Boston's current ferry system connects to a few locations in Boston Harbor (Figure 1). While it has provided a more direct alternative mode of transportation to a select few locations along the shore, a comprehensive reassessment is planned for the system. *Imagine Boston 2030*, Boston's most recent city-wide plan, acknowledges the role that ferries can play in better connecting the communities in the Greater Boston area and providing an alternative mode of transportation (City of Boston, 2017a). Having recognized the potential of its ferry system, Boston is currently exploring the possibility of expansion, considering new sites for stops and strategies for expansion. Successful passenger water transportation

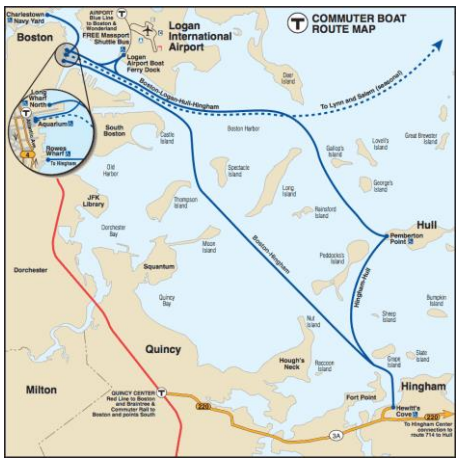

Figure 1 Boston's Ferries
Source: MBTA, 2018. Retrieved May 7, 2018, from https://mbta.com/schedules/ferry

exists in various forms in different cities and regions around the country, and though each case is unique, much can be learned from their experiences to help guide Boston's expansion.

The purpose of this thesis is twofold: (1) to find out how cities and states around the country have approached passenger ferries, and (2) based on other ferry systems' practices, offer recommendations for what Boston should consider when planning the expansion of its ferry system. The remainder of the thesis is organized as follows: Chapter 2 provides background on the history of water transportation in the US and context for the current state of ferries in the US. Chapter 3 describes the methodology I used, which included case studies and interviews in six US cities. Chapter 4 explains the cases individually based on my research, and chapter 5 highlights overarching themes that characterize public ferry systems in the US. Chapter 6 presents recommendations for Boston and concludes the thesis.

Chapter 2: Background

Before railways and roads dictated the development of the US, waterways were crucial to trade and transportation. The history of water transportation in the US is deeply intertwined with trade both locally and internationally. The abundance of natural resources in the original colonies and the ships that could transport those resources across the Atlantic Ocean back to England were critical factors in the settlement and expansion of the US.

Civilizations throughout history have naturally located along sources of water. The importance of "first nature advantages" – natural factors such as access to a waterfront – to cities' development is well-documented (Krugman, 1993). Locations that benefit from such access have in the past attracted large populations and economic development due to the superiority of ships over other modes of transportation for moving people and goods. This explains, at least in part, why many large cities have developed at ports along the coasts. Even after access to water became less immediately relevant as alternative modes of transportation were established, the initial growth of cities around ports led to their sustained growth (Fujita & Mori, 1996).

Beginning with steamboats in the late 1700s, water transportation was necessary for the development of the US, greatly reducing the cost of transporting both goods and people (Cleveland & Morris, 2014). From the 16th to 18th centuries, settlements in the colonies grew from small subsistence farming into larger economic endeavors that necessitated the use of waterways to transport crops such as cotton, tobacco, rice, and indigo (Thomas & Atkins, 2007). As agricultural production and development increased, so did the importance of the location of settlements along navigable waterways. The

relative speed, reliability, and lower cost of water transportation meant that inland production could be transported by ferry or barge to trading centers or ports on the east coast for shipment to the rest of the world. Though commuting by ferry in the modern sense was more or less nonexistent in colonial and early American history, ferries played an important role in maintaining the connections between major coastal cities and the sources of production (Cleveland & Morris, 2014).

In the 1800s, ferries began to not only transport goods and people, but also to facilitate the use of other modes of transportation. In fact, ferries were most popular in cities divided by a river for their ability to carry horse-drawn wagons and their cargo across the water, drastically reducing transport costs and time. The ability to easily cross rivers had a tremendous influence on the development of cities and towns, as people were driven by the desire to be close to the waterfront and the necessity of access to commerce (Ray, 2017).

In the late 1800s, the use of new materials in vessel design and construction such as iron and steel made vessels more lightweight, durable, and cheaper to build and repair. Ferries could be built stronger and larger, with increased capacities and dramatic improvements in safety. As the quality of ferries improved, they played an increasingly important role in the development of the US. Ferries were vital to the westward expansion of the US. Though railroads became the primary means of expansion, ferries could transport people much more quickly along rivers before railroads could be laid out. Roads, railways, and waterways connected western migration with the established cities on the east coast, allowing for more rapid and reliable transportation of people and goods to the population centers in the east (Bennion, 2010).

Ferries' Decline

The invention of automobiles in the late 1800s and their subsequent popularity eventually relegated passenger ferries to a secondary mode of transportation. With few exceptions, the ferry routes that existed in cities in the first half of the 20th century provided cross-river services, rather than transporting people along a river with multiple stops like other transportation systems. As the popularity of motor vehicles continued to explode, the need for infrastructure to support their movement became evident. Ferries were ultimately unable to keep up with the growing transportation demand, especially inland. Due to ferries' limited capacities and geographical constraints, cities and towns shifted their investment dollars toward the ever-expanding road network that offered greater flexibility – often at a far lower cost. Municipalities turned their attention toward bridges and tunnels that could more efficiently accommodate the increasing number of vehicles. Cross-river ferries could easily be replaced by infrastructure, which was often cheaper, required less maintenance, and could accommodate much larger capacities (Tanko & Burke, 2017). The San Francisco Bay Area, for example, had three times as many ferry routes between San Francisco and Alameda and Contra Costa Counties as exist today prior to the construction of the Bay Bridge in 1936. The Bay Bridge provided a more convenient means of transportation by car across the Bay, and ferries became less of an integrated component of the area (Goebel, 2016).

The diminishing economic importance of waterfronts and waterways also contributed to the decline of ferry services at this time. As development and industrial activity at waterfronts shifted further inland and ports became less of an economic priority, highways and rail connections assumed the role of ferries in a more efficient manner

(Tanko & Burke, 2017). The majority of the ferries that remained in the mid-1900s were for recreational or tourism purposes rather than as an integrated mode of transportation (International Association of Public Transport, 2013).

Ferries' Comeback

Many of the cities and towns that formed along waterways as a result of industrial activity saw their waterfronts decline as development shifted inland. Water transportation, though never quite disappearing, took a backseat to vehicles, and it is only in the past few decades in the US that interest in ferries as an element of transportation networks has been renewed. Beginning roughly in the 1980s, cities all over the US have focused on developing and expanding their water transportation systems and incorporating ferries into the large-scale movement of people to a much greater degree than they had previously. The newfound popularity of passenger ferries stems from a number of possible causes: the revitalization and development of waterfronts, improvement of ferry technology, and increasingly congested roadways (Thompson et al., 2006).

Following the decline in manufacturing and port uses, cities returned to their waterfronts with a different goal in mind – redevelopment. Cities embraced their waterfronts for commercial, residential, and recreational redevelopment, and locations along the water became desirable, upscale destinations. Water transportation naturally followed the active promotion of waterfronts, as cities embraced the image of being a "river city". The decline in the economic importance of cities' ports as manufacturing and shipping moved inland freed up space along the water and provided an opportunity for cities to rezone and reinvest in their waterfronts as more than industrial areas.

Waterfronts became a source of pride for cities, and people naturally enjoyed locating and recreating by the water (Tanko & Burke, 2017).

A second factor contributing to the revitalization of ferry use is the advancement of ferry technology to the point where ferries became a viable and competitive mode of transportation. Faster ferries with more attractive amenities helped to convert the reputation of water transportation from clunky and impractical to sleek and efficient. As technologies improved**,** ferries grew increasingly suitable as an alternative mode of transportation with faster, more reliable, and quieter vessels (Weisbrod & Lawson, 2003). Technological improvements also enabled the rise of urban linear ferries, which differ from the types of water transportation typically used in the past. As opposed to the ferries that largely ran across rivers where bridges and tunnels would serve an identical purpose, urban linear ferries operate along a linear route making stops at multiple destinations, much like other modes of transit. Advancements such as improved fuel efficiency and lighter, higher performing engines provided ferries with the speed and capacity necessary to operate such routes on a schedule that would make commuting not only viable, but competitive with land-based modes of transportation (Tanko & Burke, 2017).

Along with waterfront redevelopment and technological improvements was the increasing congestion in urban areas, which put pressure on existing transportation systems and drove cities and states to seek alternative solutions. Ironically, the very bridges and tunnels that replaced ferries in the mid-1900s became so congested that cities turned to ferries to alleviate the congestion. Planners recognized the potential for utilizing urban linear ferries as integrated components of transportation networks. Rather than using ferries to transport vehicles from roadway to roadway across rivers,

they could be used to add redundancy to a congested network, providing an alternative mode of transportation with a comparatively uncongested right-of-way. As a result, the ferry systems that have been rebuilt tend to more directly complement other modes of transportation because they attempt to alleviate congestion and serve similar routes, as opposed to the previous form of ferries, which competed with bridges and tunnels (Tanko & Burke, 2017).

Ferries in Boston

Ferries in Boston began to appear at nearly the same time as the city itself. Long before massive landfill projects drastically increased Boston's landmass and bridges connected Boston to its neighboring cities and towns, ferries were integral to the movement of people and goods between the Shawmut Peninsula – Boston's original landmass before hundreds of years of landfill shaped it into the land we know today – and its surrounding rural communities (Figure 2). These ferry routes were borne out of a dire need to reduce the amount of time it took farmers and residents to travel between Boston and Charlestown, Cambridge, and Chelsea. Before ferries, Boston was separated from these towns by as much as a two-day trip, inhibiting communication and economic activity between them. In fact, it was such a barrier that the Massachusetts Court of Assistance, set up by the Massachusetts Bay Company as the Legislature in the colony, offered a contract to establish a ferry service between the Shawmut Peninsula and the mainland. In 1631, operation of the first licensed ferry began between Boston, Charlestown, and Chelsea – the first chartered

Figure 2 Boston Landmass Over Time
Source: The Shawmut Project, 2010. Retrieved May 7, 2018 from http://www.theshawmutproject.org/

transportation service in the US. This ferry service, and other means of water transportation, persisted as the main connection between Boston and the mainland for hundreds of years (Massachusetts Bay Transportation Authority, n.d.; Sanborn, 1992).

Additional routes were added in the 1630s to Cambridge, as well as across the Neponset River and Fore River, and throughout the subsequent 200 years until bridges began to be built. In the early 1830s, steam ferries began to operate within Boston, connecting different parts of the city, including downtown, East Boston, and the North End. Ferries were not used solely for economic purposes – in the 1860s, leisure service began between Boston and Nantucket, bringing ferries into the realm of recreation and tourism on a large scale for the first time in the city's history. However, ferries were predominantly considered a part of the transportation system, with connections to the Boston, Revere, and Lynn Railroad beginning in 1875 and lasting until 1940. This period represents the height of ferry use in Boston, with over 10 million passengers and 900,000 carriages annually on the East Boston ferry alone. During this time, ferries thrived as a mode of daily transit as well as providing seasonal leisure service. It wasn't until the mid-1900s with the construction of the Callahan, Sumner, and Blue Line Tunnels that operations for many routes ceased as land-based infrastructure proved to be more effective for transporting people and vehicles (*Boston Inner Harbor Passenger Water Transportation Plan*, 2000).

Ferry services were gradually restored in Boston beginning in the 1970s, spurred by the need for congestion mitigation and the redevelopment of waterfront areas. Beginning with a route between Boston and Hingham in 1975, many of the routes that existed in the early 1900s were resurrected, and followed the same paths and utilize the same terminal locations as they did then (*Boston Inner Harbor Passenger Water*

Transportation Plan, 2000). Boston's current ferry system connects to a few locations in Boston Harbor, and it provides a more direct alternative mode of transportation to a select few locations along the shore. There are currently nine ferry routes in Boston and the North and South Shores (Table 1):

Table 1 Ferry Routes in Boston

Route	Owner	Operator	Funding	2016 Ridership	Fare
Boston ↔ Hingham	MBTA	Boston Harbor Cruises (BHC)	MBTA	827,000	$9.25
Boston ↔ Logan ↔ Hull ↔ Hingham	MBTA	BHC	MBTA	337,000	$9.25-$18.50
Long Wharf ↔ Charlestown	MBTA	BHC	MBTA	317,000	$3.50
Boston ↔ Salem	Salem	BHC	Salem	61,100	$8 (commuters)
Boston ↔ Lynn	BHC	BHC	MassDOT & Lynn	15,200 (2015)	$7
Boston ↔ Winthrop ↔ Quincy	Winthrop	Winthrop	Winthrop (temporary MBTA aid)	12,500	$8.50
Boston ↔ Provincetown	BHC & Bay State Cruise Company	BHC & Bay State Cruise Company	Farebox	70,000 (BHC, 2012)	$61
Boston ↔ Harbor Islands & Inter-island service	Boston Harbor Now (BHN)	BHC	Farebox	104,000*	$19.95
Hingham & Hull ↔ Five Islands	BHN	BHC	Farebox	104,000*	$19.95

**Ridership data is for all of the Harbor Island routes operated by BHC*
Source: Boston Harbor Now, October 2017. Retrieved June 2, 2018 from http://www.bostonharbornow.org/wp-content/uploads/2017/06/Water-Transportation-Study-Deliverable-2-FINAL-for-OPEN-HOUSE.pdf

These passenger ferry services are beneficial not only to Boston, but to the communities in the Greater Boston Area that rely on them to provide much needed congestion mitigation, economic development, and access to islands. The planned expansion of the ferry system helps Boston meet several of the goals outlined in *Go Boston 2030*, including expanding access to cities and towns along the shores and building for climate resiliency (Boston Transportation Department, 2017). Expanded ferry service links communities around the region and provides necessary connections into Boston for commuters and cross-community connections (Boston Transportation Department, 2017). Ferries provide routes to the otherwise inaccessible (except by plane or private boat) islands of Martha's Vineyard and Nantucket; even where other alternatives are available, they provide vital services. The Provincetown service offers the most direct route between Boston and the tip of Cape Cod, reducing a several-hour drive to a less than 90-minute trip (Boston Harbor Cruises, n.d.). Though ridership is nowhere near as high as other modes of transportation – with just over 4,700 weekday riders on the MBTA-owned ferries compared to 878,000 average weekday rail passengers and 447,000 average weekday bus riders– the ferries help to reduce congestion from the North and South Shores, drawing some commuters off the congested roads and rail system (Fiscal and Management Control Board, 2017). Even with relatively low ridership, the Salem, Winthrop, and Lynn ferries help reduce traffic on Route 1 going into and out of Boston during peak commute periods, draw riders from the commuter rail, and can even serve as an alternative to taking the Blue Line from as far North as Revere. Service from Hingham and Hull attracts over 3,500 weekday passengers who would otherwise contribute to traffic on Route 3 or attempt to cram onto the Red Line

from the Quincy or Braintree stations (Massachusetts Bay Transportation Authority, 2014).

The ferry system has been a significant boon to the economies of many of the coastal communities, most notably Hingham, which recently underwent a major renovation of the shipyard surrounding its ferry terminal. Ferries support local economies where stops exist, not only attracting local visitors, but passengers from other communities who come to use the ferry for access to the region. They are particularly beneficial for areas such as the Seaport in Boston, where ferries can help mitigate the limited road capacity and insufficient transit access in an area that has seen significant job growth fueled by recent development. Ferries' contribution to Massachusetts' tourism industry is also significant, especially to Martha's Vineyard and Nantucket which rely heavily on tourism, as well as to the Harbor Islands (MassDOT, 2012).

Ferries in the US

There is no definitive legal definition of "ferry" in the US that is shared by all federal agencies. Different agencies involved in the oversight of ferry activity in the US, including the Federal Highway Administration (FHWA) and the Bureau of Transportation Statistics (BTS), define the term differently, with some agencies distinguishing between "ferry", "ferry boat", and "passenger ferry". However, the majority of definitions appear to agree upon the fact that ferries operate on a fixed route with a regular schedule across bodies of water smaller than oceans (Chambers, 2011).

Best practice guides and toolkits, while abundant for land-based modes of transportation, are virtually nonexistent when it comes to utilizing passenger ferries for transportation. The literature has yet to catch up to the renewed interest in ferries. The

majority of literature about water transportation has come out of Australia, where ferries are much more common and are treated like land-based transit systems. Even so, there has been no comprehensive review of ferry operations, certainly not to the degree of attention that other modes of transportation have received.

Although national-level data on ferry operations and ridership is readily available from a number of agencies, analysis of the data beyond summaries is difficult to find. Moreover, the lack of consistent legal definitions to distinguish between different types of water transportation has made it difficult to compare data collected by different agencies (Chambers, 2011).

At least one organization has attempted to serve as a unifying body for ferries - The Passenger Vessel Association (PVA). PVA is a national trade group for the owners and operators of passenger-carrying vessels in the US. Their membership consists of 580 companies and organizations of all types and sizes, including all but one (Texas) of the state ferry systems. They represent not only public ferry transit systems, but purely recreational services as well, including dinner boats, excursion boats, duck boats, and water taxis. PVA provides tools and resources for passenger ferries to help meet regulatory requirements and facilitate information-sharing among members. They also provide safety and security guidance and tools to operators, and they work with the Coast Guard to provide guidance on how to comply with a new rule or regulation. Though they don't offer funding themselves, PVA connects members to federal grant programs that provide funding for new vessels or systems and provide insurance information and coverage to members. They also offer an environmental stewardship program – Green Waters – that facilitates the adoption of environmentally-friendly operation practices (Passenger Vessel Association, 2009).

Beyond safety and security, PVA performs lobbying and government relations work on behalf of the owners and operators in the industry. They play a key role in sharing information and expertise among companies and organizations, and host conferences around the country to provide updates and develop best practices on the newest issues and regulations impacting the industry.

Through their members, PVA is able get a nationwide perspective on what is impacting the entire industry. According to PVA's Public Affairs and Development Director, recent issues include how to tackle cybersecurity vulnerabilities – particularly regarding navigation, the availability of Coast Guard resources for an increasingly large passenger ferry industry, and the growing number of recreational boat owners using their personal boats to illegally charter trips for passengers. Another major concern for passenger ferries is the increased usage of waterways by recreational users, which, while generally a positive development**,** causes problems for passenger ferry operators. As the number of recreational users of federal waterways and navigation lanes grows, dangerous encounters between commercial boats and users who are unaware of the rules of the waterways occur more often. The Coast Guard has common communication rules that commercial boats follow, but PVA's Public Affairs and Development Director noted that the increased diversity of users with varying degrees of understanding of safety rules and procedures has contributed to increased safety concerns among owners and operators.

US Ferries' Characteristics

Data on ferries in the US is recorded by a number of organizations. The American Public Transportation Association (APTA) is a nonprofit organization that publishes an annual

Fact Book for all modes of public transportation in the US. The National Census of Ferry Operators (NCFO) is a biennial survey of all ferry operators in the US conducted by the Bureau of Transportation Statistics. The National Transit Database is survey of all transit systems in the US that receive funding from the Federal Transit Administration (FTA).

Each of these data sources suggest that ferry ridership has grown consistently over the past few decades, keeping pace with the overall growth in transit ridership in the US. However, water transportation use is still relatively limited compared with other major modes of transportation, accounting for just 0.8% of all passenger miles traveled in the US, a figure that has remained relatively consistent over the past few decades as ferry ridership has kept up with the overall growth in all modes of transportation (American Public Transportation Association, 2017).

The total number of passenger ferry operators providing transit services has nearly tripled since 1979 (Figure 3). Similarly, the total miles traveled by ferries and total number of unlinked passenger trips have increased steadily since 1995. Unlinked trips measure each time a passenger boards and departs a different vessel or vehicle, as opposed to linked trips, which represent a passenger's entire journey, even if they transfer between modes. In 2014, there were 79 million total unlinked trips taken on ferries providing transit service

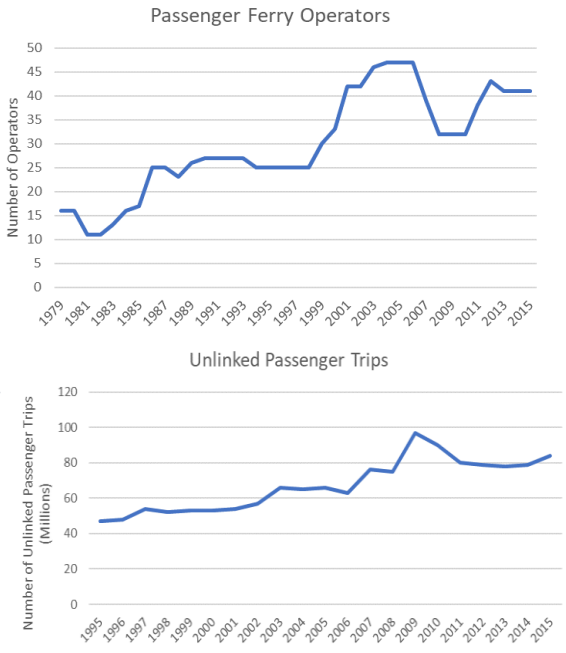

Figure 4 Number of Unlinked Passenger Ferry Trips in the US (1995-2015)
Source: APTA 2017 Fact Book Data

(Figure 4), far fewer than the 5.27 billion trips taken on buses and 4.96 billion trips taken on rail modes of transportation (American Public Transportation Association, 2016).

Routes and Terminals

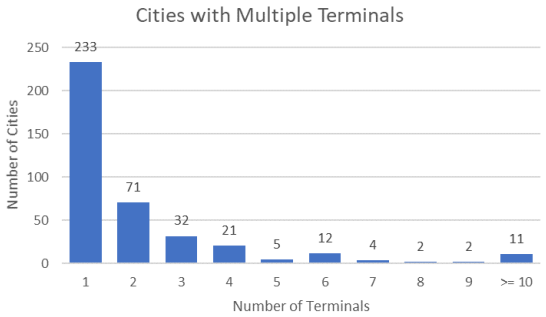

Figure 5 Number of Terminals in US Cities (2015)
Source: 2016 NCFO Data

The 2016 NCFO collected data from 162 of the estimated 220 ferry operators that provide "itinerant, fixed route, common carrier passenger and/or vehicle roll-on, roll-off ferry service" in the country, representing both public and private operators in 39 states (Bureau of Transportation Statistics, 2016). It recorded 546 terminals in nearly 400 cities in the US, a 23.8% increase from 441 terminals in the 2014 NCFO. The majority of these terminals are used for transportation between cities rather than within cities and are not connected to other ferry terminals. Most cities have just one terminal, offering transportation strictly between two cities, and do not connect to any other water transportation routes (Figure 5).

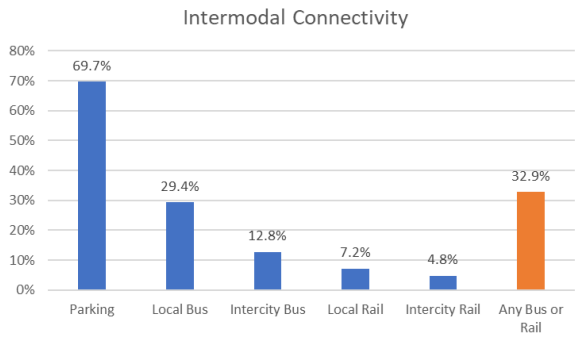

Figure 6 Percentage of Terminals with Connections to Other Modes of Transportation (2015)
Source: 2016 NCFO Data

The 2016 NCFO data reveals that intermodal connectivity is relatively low, with just under one third of all terminals having any rail or bus connection (Figure 6). This is significantly lower than intermodal connectivity for most other modes of transportation. A 2013 Bureau of Transportation Statistics intermodal passenger connectivity database found that bus stations are more

likely to offer intermodal connections, and rail stations are two to three times more likely to do so than ferry terminals (Bureau of Transportation Statistics, 2013). Additionally, terminals located in urban areas are much more likely to support intermodal connections. Connections to local buses are most common, while connections to airports, though not recorded in NCFO data, are the least common (Goldberg, 2009). Even among poorly connected terminals, however, ridership can be high. Over 50% of all passenger routes carry more than 10,000 passengers each year, with nearly 25% carrying more than 100,000 (Figure 7).

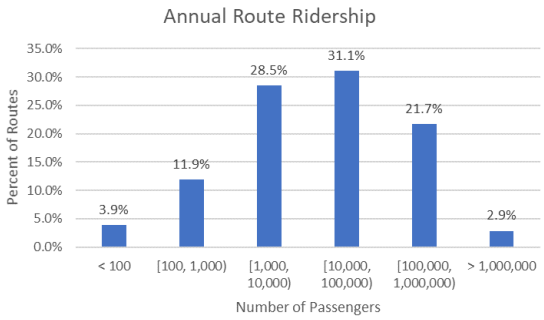

Figure 7 Ridership of US Ferry Operators (2015)
Source: 2016 NCFO Data

The NCFO accounts for 880 routes comprising over 20,000 miles, an increase of 19% from 2014. The majority of route segments for passenger routes – the distance between stops – are shorter than ten miles, with the median distance at 5.8 miles from stop to stop. The average trip length for a passenger on a ferry is 6.4 miles – slightly higher than bus or rail, but significantly lower than commuter bus or rail (American Public Transportation Association, 2016).

Ferry passenger trips accounted for 0.7% of all passenger trips taken on all modes of public transportation in the US in 2014. Ferries have much larger per-vehicle capacities than other modes, with some of the largest vessels capable of transporting over 5,000 passengers at a single time. Ferries carried an average of over 125 passengers per vessel mile in 2015, nearly four times as many as the next highest mode – commuter rails, with 34.2 passengers per vehicle-mile per entire train (Federal Transit Administration, 2016). However, ferries often travel at some of the lowest speeds at roughly 10 miles per hour,

comparable to trolley buses. This shortcoming is counterbalanced by the fact that they operate on uncongested rights-of-way, and as a result are far more reliable than land-based modes that must share their right-of-way. Unimpeded by congested roadways, ferries' on-time percentage is consistently above 90%, with over 95% of trips completed as scheduled for most ferry operators (Lester, 2015). Ferries in Boston, for example, are the most reliable mode operated by the MBTA, with an on-time performance of 95% compared with roughly 75% for buses, 85% for light and heavy rail, and 90% for the commuter rail (Fiscal and Management Control Board, 2017). Ferries also tend to be the oldest transportation vehicles in use, with an average age of 28 years, due in part to the high capital costs of vessels compared with the cost-effectiveness of refurbishing or upgrading vessels (American Public Transportation Association, 2017).

Ferries are also generally the least accessible mode of transportation, with under 60% of vessels accessible by lift, ramp, or station infrastructure compared to 80-100% for all other modes of transportation besides vanpools. Ferry terminals do offer amenities such as real-time information displays, Wi-Fi, or restrooms more frequently than bus or rail stations, supporting the notion that ferry travel is more pleasant and accommodating than other modes (American Public Transportation Association, 2017).

Of the over 650 vessels in the 2016 NCFO study, over 93% carry passengers, including 48% exclusively carrying passengers, 42% carrying both vehicles and passengers, and 3% transporting passengers and freight. Only five vessels are used solely for transporting freight. Vehicles are predominantly carried by the larger state-operated systems, often run by State Departments of Transportation, though a single service provider, Washington State Ferries, accounts for nearly 44% of all vehicle transportation on ferries in the country.

Funding

The primary source of funding for the 162 ferry operators is through their farebox – more than half of revenues for 64% of ferry operators surveyed in the 2016 NCFO come directly from ticket sales (Figure 8). Other sources include state funding (roughly 23% of all operators), federal funding (17% of operators), and local funding (16%). Of the operators that rely on government funding, 13 rely solely on state funding and four solely on federal funding, while seven are fully funded through local governments. Aside from farebox recovery and government aid, ferry operators also rely on funding from advertising, and public or private contracts.

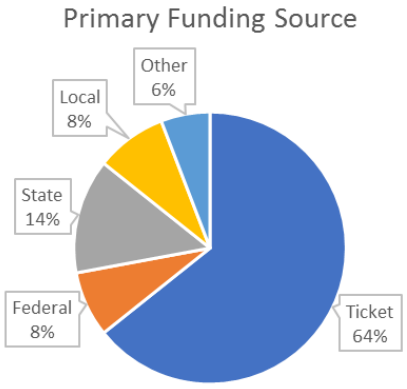

Figure 8 Primary Sources of Operational Funding for Ferry Operators (2015) Source: 2016 NCFO Data

This is a stark contrast from other modes of transportation, which rely much more heavily of government funding and less on their own fareboxes. The farebox recovery rate (FRR) is an important financial indicator for transit systems and measures the amount of the total operating expenses that are covered by fare revenues. Ferries' high FRR provides more money to funnel back into the system, which allows ferries to function with less financial aid.

The majority of federal funding for ferries comes from FHWA via the Ferry Boat Discretionary (FBD) Program. It was created in the Intermodal Surface Transportation Efficiency Act of 1991 by the federal government to provide a special funding category for the construction of ferry boats and terminals. Funding is allocated to eligible ferry

systems using NCFO data based on the number of passengers and vehicles they transport, and the total route miles they run (Federal Highway Administration, 2017).

Funding for ferry systems through the FBD Program has increased significantly over time, from $38 million in 2005 to $80 million budgeted annually for 2017 through 2020. Through the FBD Program, funding is available for the construction, operation, or maintenance of publicly owned or operated, or majority publicly owned ferry boats and ferry terminal facilities within the US and US territories. Eligible ferries must mainly operate in domestic waterways, and the fares must be charged by the public entity that owns or operates the system. Funding is prohibited for the construction of highway structures such as bridges or tunnels or for private ferry boats or terminals (Federal Highway Administration, 2013).

In 2012, the Moving Ahead for Progress in the 21st Century Act (MAP-21) reauthorized funding for ferries for $67 million each year for 2014 and 2015 based on the following formula: 20% is based on the number of ferry passengers carried by each ferry system, 45% is based on the number of vehicles carried, and 35% is based on the total route miles serviced (Federal Highway Administration, 2013).

In 2015, the Fixing America's Surface Transportation (FAST) Act provided $80 million in annual funding from 2016 through 2020 from the Highway Trust Fund for the FBD Program. The formula for funding allocation was modified to 35% based on passengers, 35% based on vehicles carried, and 30% based on the total route miles. This funding scheme rewards the largest systems, and especially prioritizes vehicles, as roughly 45% of total FBD funding in 2017 went to just two operators – Washington State Ferries and the Alaska Marine Highway System (Federal Highway Administration, 2016b).

The Passenger Ferry Grant (PFG) Program through the Federal Transit Administration (FTA) also provides funding for passenger ferries in urban areas. Grants may be awarded to public organizations that provide public passenger ferry services in urban areas for modernizing ferry infrastructure, supporting existing service, or establishing a new ferry service. In 2017, $30 million was available through the PFG Program based on a set of criteria that included age and condition of ferry infrastructure, possible benefits to passengers, and connectivity to other modes of transportation (Federal Transit Administration, 2017).

Service Provision

Service provision models range from pure public models, where governments own and operate services, to pure private models, where government is only involved in regulation, and ownership and operation of ferry services are left to private companies in a competitive market. In between these two extremes are quasi-public and quasi-private models, where ownership and operation is divided or contracted out between public and private entities (Khazabi, 2017).

Though there has not been a great deal of research regarding the differences in performance between the types of service provision models, public models tend to have higher safety records, service reliability, and customer satisfaction, as well as transparency and availability of information. Private models, on the other hand, emphasize efficiency and profitability, and often yield higher FRRs and profit margins, as well as lower operating costs (Khazabi, 2017). The range of service provision models highlights the various approaches a city or state can have toward ferry service, as different circumstances lend themselves better to different types of service.

Chapter 3: Methodology

Methods

This thesis explores passenger ferry systems in cities and regions in the US. Based on a set of criteria identified in the literature review and interviews with representatives from these ferry systems, this thesis describes common themes of the systems and lessons learned to provide recommendations to Boston regarding its future water transportation initiatives.

The focus is on the US, because of the ease of conducting the research as well as relevance of my findings to Boston. The use of water for the transportation of goods and people is by no means exclusive to the US, but the unique political and social climate surrounding both waterways and transportation in the US makes intranational examples more relevant and transferable to Boston.

I took a case study approach consisting of two components: (1) research individual cases, as well as Boston, and (2) conduct interviews with individuals at the organizations responsible for ferry systems. Much of the information on the selected cases could be found online, but this is limited to mostly physical characteristics and facts, rather than understanding the motivations behind decisions and their impacts. Where available, long-range transportation plans that incorporate ferries were used to provide additional information, and in several cases exact statistics, on many of the ferry systems' characteristics and any plans owners or operators have for the future of their ferry systems.

Interviews served to supplement the data found through my own research and to better understand the motivation of operators' or planners' actions. They helped to ensure the

accuracy of the information I found on my own and helped me understand the decision-making and planning process. Interviews were conducted with individuals at six systems. Primary targets for interviews included employees in the organizations or Departments of Transportation. Interview questions can be found in Appendix A.

Case Study Selection

Figure 9 Selected Ferry Systems

My research focused on six locations: Jamestown, Virginia; eastern North Carolina; San Francisco, California; Washington State; southern Alaska; and New York City (Figure 9). Research on each of these locations focused on a single ferry operator, with the exception of San Francisco, which included two operators. These locations were selected because they represent a range of sizes, demographics, and climates, as well as funding schemes and ridership, among other factors related to water transportation. The choice of these locations was limited by the availability of information online and the willingness of organizations involved to be interviewed. I was able to speak with owners or operators of each system with the exception of one of the San Francisco operators – Golden Gate Ferries – though they provided resources for me to use (Table 2).

Table 2 Interviews

Organization	Position
Virginia Department of Transportation	Facility Manager
North Carolina Department of Transportation: Ferry Division	Deputy Director
Golden Gate Ferries	-
Water Emergency Transportation Authority	Planning & Development Manager
Washington State Ferries	Web Agent
Alaska Marine Highway System	Marketing Manager
Staten Island Ferry	Chief of Staff
Passenger Vessel Association	Public Affairs and Development Director

These six locations were selected from a sample of 162 possible public and private passenger ferry operators identified by the 2016 NCFO. There are far fewer comprehensive ferry systems in US cities as compared with other major modes of transportation, so the sample population to choose from is relatively small. Data from the NCFO suggests that there are over 220 ferry operators with 880 routes between terminals in nearly 400 cities (Figure 10) (NCFO, 2016). The majority of these routes and

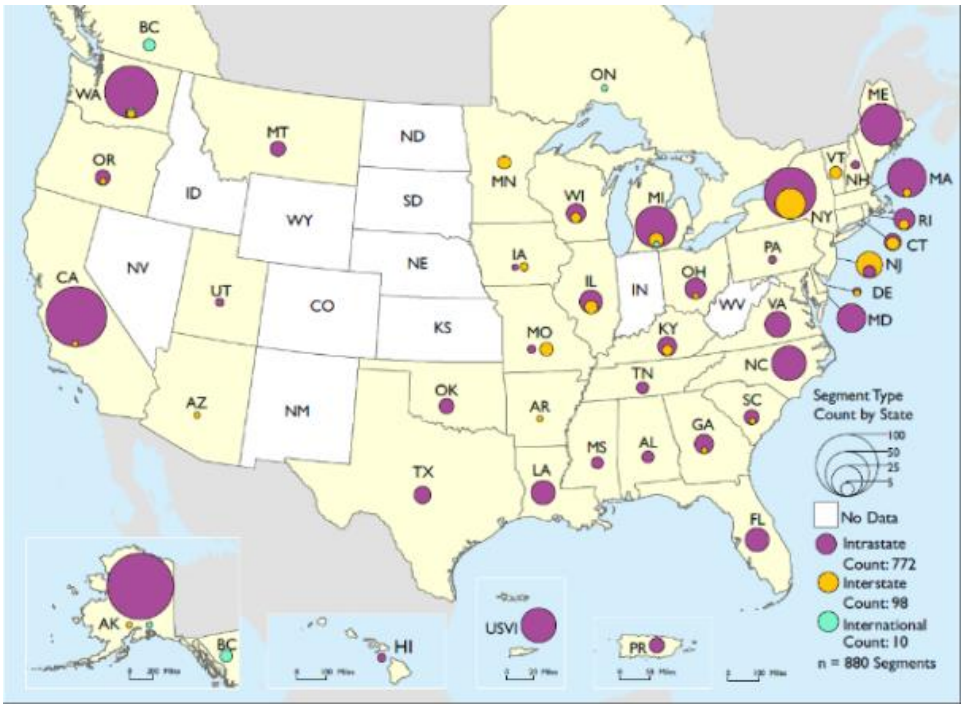

Figure 10 Ferry Routes in the United States by State
Source: NCFO, 2016. Retrieved May 7, 2018 from https://www.bts.dot.gov/NCFO

terminals, however, are small and not part of a comprehensive system in the same way as Boston's ferry system. Of these nearly 400 cities, fewer than half have more than one terminal (Bureau of Transportation Statistics, 2016).

The case selection sample consists of locations in the US that currently operate regular passenger ferry services. The sample includes large, state-wide ferry systems such as the one in Alaska, as well as smaller systems such as in Jamestown, Virginia. The range of systems is intended to provide a broad perspective of passenger ferries in the US with the objective of understanding the variety of ways cities and states approach water transportation.

Though my focus will be on public and quasi-public service provision, I'm interested in not only the locations that are geographically or demographically similar to Boston, but systems with varying sources of public funding, vessel passenger and vehicle capacities, frequencies, or other characteristics beyond just the size and ridership of the system. I am also interested in the use of passenger ferries within a transportation system – whether as a standalone water transportation system or as part of a larger, integrated transportation network. These locations were selected because they represent a range of such factors, and as Boston seeks to expand into a more comprehensive system, it is important to consider those that are already extensive and those that are small but sufficient to suit local needs. Each location, even cities with just a single route, can offer different lessons for Boston.

Research Categories

Based on a review of existing literature and research into the various ferry systems around the country as well as Boston's, I organized my analysis into five categories: 1)

Funding, 2) Economic Development, 3) Integration with Other Modes of Transportation, 4) Environmental Considerations, and 5) Services.

1) Funding: Water transportation requires large capital investments but is often cost-effective to operate. Though per-vehicle operating costs are higher than other modes of transportation, per-passenger costs tend to be similar to other modes due to their larger capacities. Recreational ferries can charge higher prices than commuter ferries, so some operators provide commuter services during peak times and recreational services during off-peak times (International Association of Public Transport, 2013). Though passenger ferries tend to be more self-sustaining than other modes, there are a number of state and federal funding programs that ferry systems can take advantage of for financial assistance.
2) Economic Development: Ferries have the ability to promote economic development by increasing land values, attracting discretionary spending, and encouraging tourism. Harnessing this developmental potential of ferries can be a useful way for cities or regions to ensure the financial sustainability and expansion of their water transportation systems (Weisbrod & Lawson, 2003).
3) Integration with Other Modes of Transportation: For a ferry system to be successful as a form of transportation, it should be integrated as part of a connected multimodal network along with other modes of transportation. Much like other modes of transportation, linking the ferries with other transit systems can promote the growth of the ferry system and have a positive impact on the communities served. This is most effective when paired with information

campaigns to make potential riders aware of their options and the various means of transportation (Weisbrod & Lawson, 2003).

4) Environmental Considerations: Given the innate requirement of being on water, ferries are naturally vulnerable to some of the most pressing impacts of climate change, including sea-level rise and flooding. But ferries can also be viewed as an adaptation to climate change, depending on whether cities and states are shying away from their waterfront or investing in it.
5) Services: Service quality is a crucial component of the water transportation system. Water transportation offers a number of advantages over land-based modes of transportation with regards to passenger experience and flexibility, but also raises additional concerns in terms of safety and security. One of the most appealing features of ferries is just how different they are from other modes of transportation – they offer unique views, often more comfortable and spacious seating, on-board amenities, and a congestion-free ride. Boats can also play a particularly vital role in emergency situations, as they can be a useful for evacuating people or providing emergency services (Magee, 2002). Accessibility on ferries is also often more difficult to accommodate than on other land-based transportation due largely to the construction and age of most vessels.

Analysis

The findings of the research and interviews allowed for conclusions *within* each individual case to be drawn, as well as comparisons *across* cases to identify common themes that emerged in multiple systems. The within-case analysis became the case write-ups, and combined the information garnered through research and interviews to

allow me to identify how the individual systems function and what their role is in a local or regional transportation context.

The cross-case analysis took a broader perspective in attempting to identify the similarities and differences between each ferry system. Categorizing the research questions allowed for trends to emerge across cases by examining the various issues systems face and the similar or dissimilar approaches different systems take to address those issues. This revealed a more holistic picture of water transportation around the country, as well as what is unique to each system. These themes are especially useful for extracting recommendations for Boston based on what elements may be shared with other locations.

Chapter 4: Cases

This section provides an overview of the seven ferry operations (Table 3). All are publicly owned, and represent a mix of government ownership, from special district to city to state. Though some operate only a single route across a river while others traverse bays and serve coastal regions, all are heavily utilized ferries, with annual ridership ranging from 350,000 passengers on the Alaska Marine Highway System to nearly 24 million passengers who used the Staten Island Ferry in 2017. Four of the seven systems carry vehicles, with Washington State Ferries transporting 10.6 million in 2017. There are commonalities between them, but each operates in a distinct manner tailored to their region's transportation needs.

Table 3 Characteristics of Selected Ferry Systems

Location	System	Level of Government	Owner	Operator	2017 Ridership	2017 Vehicles Transported	Number of Vessels	Number of Routes	Miles of Routes	Number of Terminals	Year Established	Max Frequency of Service
Jamestown	Jamestown-Scotland Ferry	State	Virginia Department of Transportation (VDOT)	VDOT	1.2 million	936,000	4	1	2.2	2	1945	25 minutes
North Carolina	North Carolina Department of Transportation	State	North Carolina Department of Transportation (NCDOT)	-	2 million	1.6 million	22	7	~110	13	1950	30 minutes
San Francisco Bay Area	Golden Gate Ferry	Special District	Golden Gate Bridge, Highway, and Transportation District (GGBHTD)	GGBHTD	2.5 million	-	7	4	38	4	1970	30 minutes
	San Francisco Bay Ferry	City	Water Emergency Transportation Authority (WETA)	Blue and Gold Fleet	2.6 million	-	13	15	~122	9	1999	30 minutes
Washington	Washington State Ferries	State	Washington State Ferries (WSF)	WSF	24.5 million	10.6 million	23	10	220	20	1951	30 minutes
Alaska	Alaska Marine Highway System	State	Alaska Department of Transportation and Public Facilities (Alaska DOT&PF)	Alaska DOT&PF	350,000	100,000	11	42	~6,500	35	1963	Multiple times per day
New York City	Staten Island Ferry	City	New York City Department of Transportation (NYC DOT)	NYC DOT	23.9 million	-	8	1	5.2	2	1905	15 minutes

Jamestown Ferry

The Jamestown-Scotland Ferry connects Jamestown, Virginia to Scotland, Virginia across the James River (Figure 11). It is owned and operated by the Virginia Department of Transportation (VDOT). The ferry transports 1,180,000 passengers and 936,000 vehicles annually along the two-mile route, connecting Virginia State Route 31 across the river. VDOT's fleet consists of four vessels with capacities of up to 70 cars, and ferries can carry cars, bicycles, and buses across the river. The ferry is free, and operates 24 hours a day, year-round, with ferries departing as often as every 25 minutes during peak commuting periods (Virginia Department of Transportation, 2018).

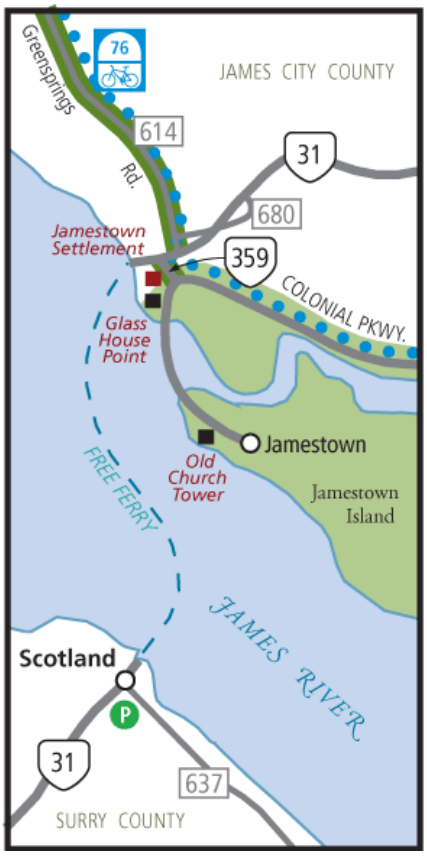

Figure 11 Jamestown-Scotland Ferry Source: VDOT, February 2018. Retrieved May 7, 2018, from http://www.virginiadot.org/travel/ferry-jamestown-history.asp

Though it began as a private service in 1925, it has been owned and operated by VDOT since 1945. The ferry's annual $12 million operations budget is funded almost entirely by the state. VDOT also operates two other ferries in Virginia, across the Little Wicomico River and Corrotoman River near Chesapeake Bay, which are very similar to the Jamestown Ferry. VDOT is currently looking to refurbish some of their older vessels, specifically those constructed in 1936 and 1979, and are anticipating a new vessel scheduled for July 2018.

The route operates as a highway connection rather than a transit service. However, the Jamestown Ferry not only serves as a vital link for locals between Jamestown and Scotland, but also as a popular tourist attraction, drawing high volumes of recreational riders. Jamestown is located about five miles outside of Williamsburg, a popular tourist destination, and the ferry is commonly recommended as a free attraction for tourists who also want to experience the colonial history in Jamestown or enjoy a scenic trip across the James River. The south side of the river in Scotland is rural, with a population of just over 200 people.

Because it connects Route 31, local riders are well-aware of the service and use it as an extension of the highway to travel between Jamestown and Scotland. The Jamestown Ferry also transports a bus operated by Williamsburg Area Transit across the James River.

North Carolina

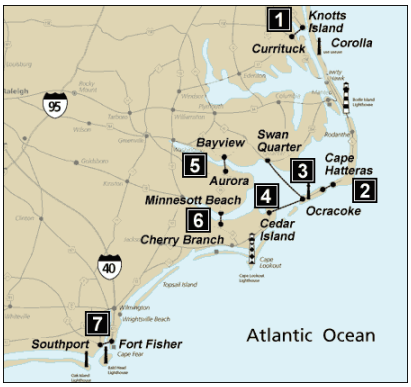

Figure 12 NCDOT Ferry Routes
Source: NCBeaches. Retrieved May 7, 2018 from http://www.ncbeaches.com/Features/Attractions/Ferries/

The North Carolina Department of Transportation (NCDOT) Ferry Division operates seven routes across the Currituck Sound, Pamlico Sound, Cape Fear River, Neuse River, Pamlico River and Hatteras Inlet, connecting the various islands in the Outer Banks with the mainland (Figure 12). It is the second largest state-operated ferry system in the US behind Washington State Ferries, providing service to roughly two million passengers and 1.6 million vehicles and connecting NC Highway 12 along the Outer Banks (Figure 13). NCDOT's fleet consists of 22 vessels with capacities ranging from 20 to 50 vehicles and up to 300 passengers (North Carolina Department of Transportation, n.d.-a). Ferries run year-round, with frequencies as often as every half hour during peak commuting periods, though the majority of the routes depart only once every one to three hours. Only three of the seven routes charge fares, at a cost of $1 per passenger and an additional $5-$45 per vehicle. Because of this, their FRR is uncommonly low, with just 6% of operating costs recovered through fares (North Carolina Department of Transportation, 2017).

Figure 13 NC Highway 12 Linked by Ferries on the Outer Banks
Source: NCDOT. Retrieved May 7, 2018 from https://www.ncdot.gov/nc12/

The current system began in the mid-1920s as privately owned with a single service, which grew until it was purchased by the state in 1950. Their 2016-17 operations budget is $41 million and comes from the state, and the ferries compete for funding with the

other NCDOT- operated non-highway modes: aviation, rail, public transit, ferries, and bicycles (Rodewald, 2018).

The NCDOT Ferry Division is particularly important for NC Highway 12, the roadway travelling along the Outer Banks, which serves as a vital connection for residents, tourists, commuters, and schoolchildren. Ocracoke Island, for example, is accessible only by ferry, and residents and visitors rely on the ferry system for transportation.

NCDOT operates an emergency route connecting NC-12 and US-264 between the north end of Hatteras Island and the North Carolina mainland that can become operational within two hours of an emergency to provide transportation services when the roadway becomes impassible. The roadways on the Outer Banks have been vulnerable to hurricanes and when the roadways flood, the only way to access much of the Outer Banks is by ferry. According to the NCDOT Ferry Division's deputy director, they have utilized the emergency route three times in the past decade when roadways have flooded.

Golden Gate Ferry

Golden Gate Ferry (GGF) is a regional ferry operator that serves the San Francisco Bay, connecting San Francisco with Larkspur, Sausalito, and Tiburon in Marin County (Figure 14). It also offers rides from Larkspur to AT&T Park in San Francisco for sporting and music events. GGF has a fleet of seven ships with capacities of 400-750 passengers and provides rides to over 2.5 million passengers annually (Golden Gate Bridge, Highway, and Transportation District, 2017). Ferries operate year-round with frequencies between every half-hour to an hour and a half. The average fare for a one-way ride in 2017 was $7.93, with an FRR of 54%.

Figure 14 Golden Gate Ferry Routes (not including Tiburon)
Source: Golden Gate Ferry. Retrieved May 7, 2018 from http://goldengateferry.org/services/visitors/escape.php

GGF is operated by the Golden Gate Bridge, Highway and Transportation District (GGBHTD), which also oversees the operation of the Golden Gate Bridge and the Golden Gate Transit (GGT) bus system. GGF was created in 1971 for the integration and expansion of ferry service in the area (Golden Gate Bridge, Highway, and Transportation District, 2017). GGBHTD began operating as a bus and ferry service to alleviate traffic on the Golden Gate Bridge, and has also played an important role in the provision of emergency services during disruptions where other modes are not operational (Golden Gate Bridge, Highway, & Transportation District, n.d.).

GGF operates as a transit service, running redundant routes that complement roadways and other modes of transit to provide an additional commuting option between San Francisco and Marin County. Terminals offer connections to other modes of

transportation, and GGF provides comprehensive information about transfers to make it easier for commuters to utilize the ferry within the region.

The operation of both buses and ferries by the same organization in the same region provides an opportunity for comparison of performance between the two modes. GGT's 2017 ridership was 3.1 million, over 20% higher than GGF's 2.5 million. However, transit ridership has been declining since 2005, while ferry ridership has increased over the same period. Ferries outperform buses with regards to farebox recovery by a wide margin, with 54% of operating expenses recovered through passenger fares on ferries compared with just 19% on buses. GGF's on-time percentage of 93% is better than GGT's 86%, and GGF ferries have a lower mechanical failure rate than GGT buses, with an average of over 39,000 miles between breakdowns compared with 20,000 for buses (Golden Gate Bridge, Highway, and Transportation District, 2017).

The 2016-17 operating expenses totaled $38 million, $20 million of which came directly from their farebox. GGF's FRR is more than twice as high as GGT's, which is significant because GGT's total operating expenses for 2016-17 – $98 million – are higher than GGF's. As a result, GGT's 2017 subsidies were $53.4 million compared to GGF's $8.8 million, which is remarkable considering transit ridership was only 20% more during the same period. This suggests that 2017 per-passenger subsidies for GGT were roughly $17, while GGF saw a much lower figure of around $3.50 (Golden Gate Bridge, Highway and Transportation, 2017). This dramatic disparity highlights the relative cost-effectiveness of ferry operations for GGF and explains why GGBHTD is investing more money into the future of ferry services than transit. Roadways in the region are already highly congested, and the cost of investing in additional transit services – and the return on that investment – is far less attractive than investing in ferries.

San Francisco Bay Ferry

Figure 15 San Francisco Bay Ferry
Source: WETA. Retrieved May 7, 2018 from http://sanfranciscobayferry.com/node/332

San Francisco Bay Ferry operates in the San Francisco Bay, between San Francisco, Oakland, Alameda, and Vallejo (Figure 15), and is owned by the Water Emergency Transportation Authority (WETA), a regional public transit agency. Operation and maintenance of the ferries is contracted out to Blue and Gold Fleet, a company that also operates other ferries in the area specifically for sightseeing and tourism. The system transports over two million passengers annually – both commuters and tourists – with 12 passenger-only vessels connecting nine terminals along 13 routes. One-way fares cost $6.80, $7.10, or $14.20, with ferries running as often as every 30 minutes.

Ferries were once the predominant means of crossing the San Francisco Bay, and though they largely contracted in the mid to late 1900s, the San Francisco Bay Ferry system was revitalized due to the role ferries played following major disruptions to the transportation network. Ferries provided much needed transportation services after a fire shut down Bay Area Rapid Transit (BART) services in 1979 and the Loma Prieta earthquake in 1989 halted other modes of transportation, cementing the importance of ferries' emergency services in the area (San Francisco Bay Crossings, 2000). The ferries were intended to be the first available service in the event of a major disruption, such as a natural disaster, and their terminals and vessels were created with that role in mind.

Operational expenditures total $33 million and come from their farebox – with an FRR of 50% – and bridge tolls. Ridership on SF Bay ferries during weekdays is 80% commuters and 20% recreational during peak periods, and the reverse proportion during the midday period.

SF Bay Ferry function as an integrated part of the regional transit system, adding redundancy to an already dense transit system. SF Bay ferries carry 8% of the total peak-hour San Francisco Bay crossings, or 2,400 passengers. Though this figure may seem insignificant, ferries provides huge relief for other modes of transportation across the Bay. Those 2,400 peak-hour cross-Bay commuters would otherwise require three BART trains, 48 buses, or up to 2,400 single-occupancy vehicles, none of which could be accommodated by the current transportation systems in the Bay Area. Ferry terminals are generally located in areas served by other modes as well, with shuttle and public transit connections.

Washington State Ferries

Washington State Ferries (WSF) is a public agency that operates the ferry system in Washington on behalf of the Washington State Department of Transportation (WSDOT). It is the largest water transportation system in the US, with 23 vessels capable of carrying between 34 and over 200 vehicles and 20 terminals across Puget Sound and the inland waterways (Figure 16). WSF serves eight counties in Washington as well as British Columbia, providing rides to over 24.5 million passengers and 10.6 million vehicles in 2017 (Washington State Department of Transportation, n.d.). Fares for a one-way trip range from $3.35-$19.85, with free inter-island service on the San Juan Islands. Vehicle fares cost between $11.15 and $68.95 during peak periods, which contribute heavily to their 76% FRR.

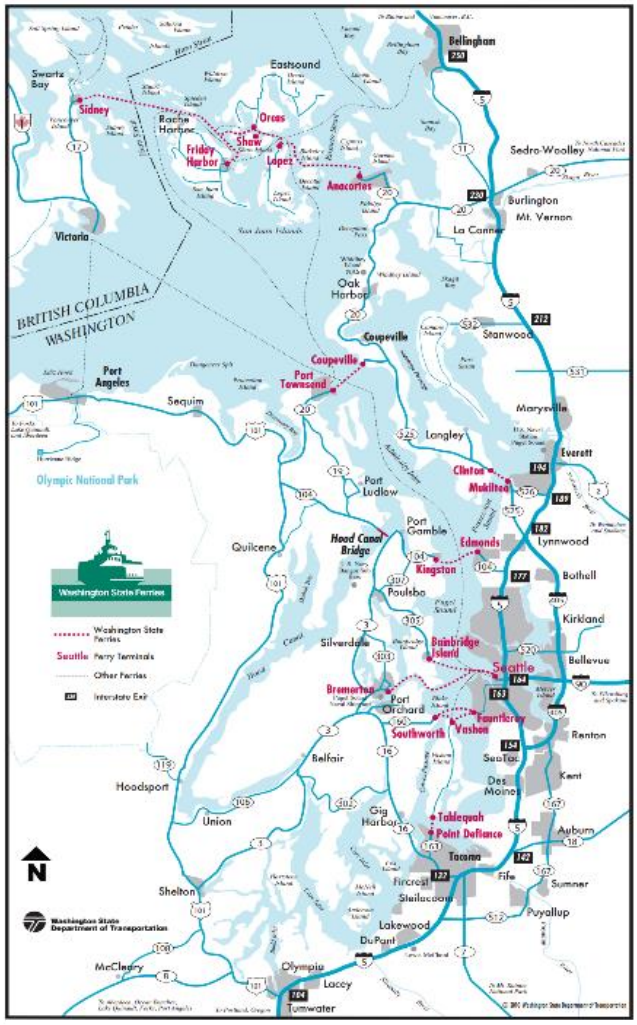

Figure 16 Washington State Ferries
Source: WSF, 2010. Retrieved May 7, 2017 from http://www.wsdot.wa.gov/ferries/pdf/wsfroutemap.pdf

WSF was founded in 1951 after Washington State purchased all private ferry operators on the Puget Sound. It became a part of WSDOT in 1977 and has since become the third largest transit service provider in the state. The system has seen an annual increase in

ridership and revenues in recent years, coming from both an increase in the number of recreational riders and a significant decrease in the cost of fuel from in $3.63 per gallon in 2012 to $1.95 per gallon in 2017. Total operating expenses for 2017 were $241 million, a large portion of which comes from Washington's motor vehicle fuel tax. (Washington State Ferries, 2017)

WSF serves two main functions: The first is as a marine highway system, linking communities across the Puget Sound. Because of the emphasis on transporting vehicles on ferries, WSF acts as an extension of the highway system, and is treated as such by WSDOT. Vessels are designed to accommodate commercial vehicles, which has proven to be valuable for industries that rely on the transportation of goods. Many routes also serve as the only connection between islands and the urban areas on the eastern Puget Sound. Their second function is as a transit provider, with rapid service across Puget Sound and connections to other modes of transportation at terminals (Washington State Department of Transportation, 2009).

Ferry service is not only beneficial to commuters, but has also been an important asset in promoting the regional tourism industry. WSF has focused more on attracting recreational riders in recent years, as the proportion of passengers who use the system for leisure has been increasing, up to 46% of riders in 2013 (Washington State Department of Transportation, 2014).

Ferries can be used for emergency services for those living on islands who may be in need of medical attention. In serious cases, and if a helicopter is unavailable or weather prohibits air travel, WSF ferries are used to reach and possibly transport those in need of aid (Washington State Department of Transportation, n.d.).

Alaska Marine Highway System

Figure 17 Alaska Marine Highway System
Source: AMHS, 2015. Retrieved May 7, 2018 from http://www.dot.state.ak.us/amhs/routes.shtml

The Alaska Marine Highway System (AMHS) is a state-owned and operated ferry system that operates along the southern coast of Alaska, connecting the eastern Aleutian Islands to the continental US in Bellingham, Washington (Figure 17). AMHS operates year-round, and transports 350,000 passengers and 100,000 vehicles annually between 33 communities with a fleet of 11 vessels capable of carrying up to 500 passengers and 133 vehicles (Alaska Marine Highway System, 2015b).

The 2016-17 operating expenditures were $135 million, aided by a 29% FRR. Fares can cost anywhere from tens to hundreds of dollars for a single passenger on some of the longer routes, with vehicle fares reaching well into the thousands of dollars for routes that require overnight accommodations. Due to high operating costs, AMHS has often found itself on the chopping block when other state-provided services require more immediate funding. As recently as March 2018, AMHS faced the threat of a shutdown by mid-April if the Alaska Legislature could not approve an appropriations bill. Though funding was ultimately provided, the continual struggle is concerning for the long-term operations of the system (Brooks, 2018).

The ferry system in Alaska started in the late 1940s with weekly service, though it wasn't until 1963 that the Division of Marine Transportation was established and AMHS began to extend throughout the Alaskan coast. It has since expanded to provide 6,500 miles of ferry routes.

As its name suggests, AMHS functions as a marine highway system – it serves as the lifeline of many of the residents, as many of the communities are on remote islands or are in areas not accessible by the road system. Of the 33 communities it serves, only five are connected to Alaska's road system. As a result, the ferry system is the sole surface transportation service provider and means of cheaply and reliably transporting goods to and from the majority of the communities it serves. Many communities rely on the system for a variety of uses, ranging from the provision of groceries or supplies to access to health care in larger municipalities along the coast. However, the tourism industry also benefits from the system, as ridership consists of 70% Alaska residents and 30% visitor traffic.

There are three types of ferries used for the different types of routes offered: mainline ferries, day boat ferries, and shuttle ferries. Mainline ferries transport passengers along routes that take multiple days to travel. They are the largest vessels and typically see a high percentage of tourists. Day boats are used for trips between smaller communities, and are used mainly by residents in Southeast Alaska, connecting regional commerce, government, and health service centers. Shuttle ferries are capable of transporting people along routes over shorter distances. All types of vessels offer a large variety of amenities to ensure travel is as comfortable as possible, ranging from restaurants to playgrounds to heated observation decks.(Alaska Marine Highway System, 2016a).

AMHS is used is assist in emergency situations when natural disasters such as mud slides, avalanches, or severe weather occur and block road or air access to communities. In this case, AMHS will modify their schedules to provide more frequent trips to these areas to bring additional groceries, supplies, or equipment to assist with clean-up efforts.

Staten Island Ferry

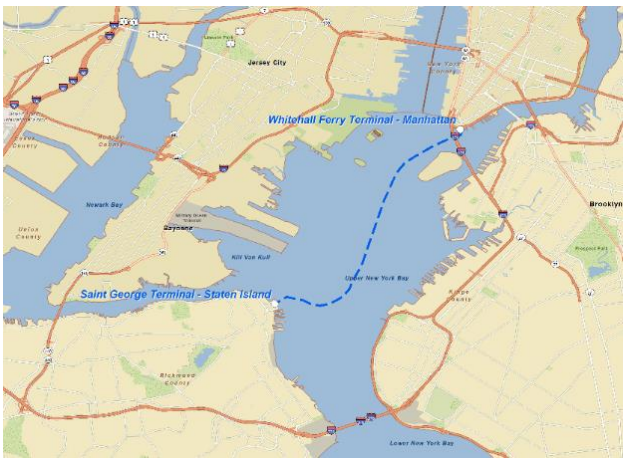

Figure 18 Staten Island Ferry
Source: ESRI Streetmap North American Data

The Staten Island Ferry connects Whitehall Terminal in Manhattan with St. George Terminal in Staten Island (Figure 18). It is operated by the New York City Department of Transportation (NYC DOT) and has been free since 1997 to promote free transfers among modes throughout the city (Sontag, 1997). The ferry transported 23.9 million passengers in 2017, and operates 24 hours a day, 365 days a year with trips every 15 minutes during rush hour and every half hour otherwise. There are eight vessels that run the 5.2-mile route, capable of carrying up to 6,000 passengers on a single trip. It is the most reliable form of transit in New York City, with an on-time performance of nearly 93%, and has a per-passenger subsidy of $5.16, which indicates that, were they to charge for ferry services, a $5.16 fare – similar to what many other systems are charging – would provide a 100% FRR (The City of New York, 2017).

Private ferries have been running the route between Staten Island and Manhattan since the early 1800s, though it wasn't until 1905 that the Staten Island Ferry was incorporated by the City and made public. Ridership has increased significantly over the past few years, with an additional 2.5 million annual passengers from 2013 to 2017. This increase may be attributed to the increasing congestion in Manhattan, as roadways and other modes are unable to meet transportation demand during peak hours.

The ferry plays a key role in the city's transportation network. The system functions so that a passenger can take a bus or train from the southern tip of Staten Island to St. George Terminal at the northern end, take the ferry across the harbor to lower Manhattan, get a free transfer from Whitehall Terminal to a subway and take the subway all the way up to the northern end of Manhattan and through the Bronx, all for a single $2.75 fare. The Staten Island Ferry operates between two multimodal transportation hubs, with connections to bus routes and light rail in both boroughs.

Tourism, though not promoted by NYCDOT, is nonetheless a beneficiary of the Staten Island Ferry's services. Many tourist companies market the ferry as an attraction, but NYC DOT plays no role in such promotions. A large portion of the increased ridership since 2013 has come at night and on weekends, indicating that tourists are responsible for this growth, even without direct marketing.

The Staten Island Ferry operated through 9/11 to bring first responders, emergency vehicles, and medical staff to areas in Manhattan where they were needed. The ferry also served as an evacuation route out of Manhattan for many people who otherwise could not leave because most other modes of transportation were shut down. However, the ferry is generally not used for minor or even other major disruptions to the transportation network. Because of the size of the vessels, they are limited by the number of slips at which they can dock, which restricts the routes they are able to run.

Chapter 5: Analysis

Though each ferry system operates in a distinct manner, there are a number of commonalities between them. In analyzing the research and interview responses, several themes emerged within the five categories. This chapter describes common characteristics of the selected ferry systems with regards to funding, economic development, integration with other modes of transportation, environmental considerations, and services.

Funding

The first category discusses themes that relate to the fares and sources of funding (Table 4). FRR's for systems that charge fares range from 6% for North Carolina to 76% for Washington State Ferries, with fares between $1 in North Carolina and several hundreds of dollars for some of the longer routes in Alaska. All systems receive federal funding primarily from FHWA or FTA for capital expenditures, and all but San Francisco Bay Ferry rely heavily on state funding for operational expenses, while only the Staten Island Ferry and the two systems in San Francisco receive operating funding from the local government.

Table 4 Categories of Analysis: Funding

Location	System	Funding									
		Farebox Recovery Rate	Passenger Fare	Vehicle Fare	Fare Regulator	Fare Revenue	Operating Expenses	FBD Allotment (2017)	State Funding Sources (Operating Expenses)	Local Funding Sources (Operating Expenses)	Primary Federal Funding Sources (Capital Expenditure)
Jamestown	Jamestown-Scotland Ferry	-	$0	-	-	-	$12 million	$1.6 million	VDOT (Fuel tax, Sales and Use tax, user fees)	-	FHWA
North Carolina	NCDOT	6%	$0-$5	$5-$45	NC Board of Transportation	$2.3 million	$41 million	$1.6 million	NCDOT (Motor fuel tax, highway use tax, misc. fees)	-	FHWA
Bay Area	Golden Gate Ferry	54%	$7.93 average	-	GGBHTD	$20 million	$38 million	$681,000 (GGBHTD)	Caltrans (fuel tax, sales tax, misc. fees)	Metropolitan Transportation Commission	FHWA, FTA
	San Francisco Bay Ferry	50%	$6.80, $7.10, or $14.20	-	WETA	$16.4 million	$33 million	$822,000	-	Metropolitan Transportation Commission	FHWA
Washington	Washington State Ferries	76%	$3.35-$19.85	$11-$69	Washington State Transportation Commission	$183 million	$241 million	$16.4 million	WSDOT (Gas tax, motor vehicle license tax and fees)	-	Department of Homeland Security, FTA, US DOT
Alaska	Alaska Marine Highway System	29%	$10 - $100s	$100s - $1000s	Alaska DOT&PF	$39 million	$135 million	$16.9 million	Alaska Marine Highway Fund	-	FHWA
New York City	Staten Island Ferry	-	$0	-	New York City Council	-	$98.8 million	$5.2 million	New York State DOT State Operating Assistance	NYC DOT	FTA

The farebox is a vital funding source for services that act as transit passenger ferries and charge fares. The FRR tends to be much higher for ferries than for other major modes of transportation. For the ferry systems in this analysis that charged fares for all routes, the average FRR was over 52%, consistently higher than many other transit systems (American Public Transportation Association, 2016). Washington and both San Francisco systems received over half of their operating expenses from the farebox. These systems complement other transit services and operate ferry services that are more similar to other modes of transit in terms of frequency, routes, and cost.

A great deal of effort is spent by operators who charge fares to try to improve the FRR. Because these systems rely on attracting choice riders, they want to remain competitively priced with other transit services and provide an appealing alternative driving. GGBHTD, for example, is looking into ways to further improve the ferry FRR, including charging for parking, reducing maintenance costs, and re-examining their fare structure. While many operators have relied on fare increases in the past to maintain sufficient funding, most are trying to avoid charging more to raise revenue. However, this is not always possible, and some operators rely on fare increases to meet FFR targets. For example, fares in Washington are set to increase by 2.5% each year from 2017 to 2026 (Washington State Department of Transportation, 2017).

In spite of high farebox recovery rates, state funding is still the largest source for the state-owned systems in this analysis. Even for systems with high FRRs, local, state, and federal aid is necessary. Each system receives money through the FBD Program, which allocates a certain amount of funding to states to distribute to ferry operators each year for capital expenditures – $80 million annually for 2017 through

2020. State funding, however, may be more susceptible to budget cuts, as evidenced by the Alaska Marine Highway System's recent financial struggles. Though federal funding may be more consistent, some operators feel it tends to favor the larger, more expansive systems as it apportions funding with a high weight placed on route-miles due to the greater operations and maintenance burden larger distances entail. This leads to systems such as the Alaska Marine Highway System or Washington State Ferries, which have much greater distances to cover, receiving a greater percentage of available funding, while other systems such as those in North Carolina, which transport large volumes of passengers and vehicles across shorter distances, receive a significantly smaller amount. FHWA, however, has recently modified the formula to prioritize ridership of passengers and vehicles to a much greater extent.

Capital expenditures are costly while operating expenses can be low. Federal funding is primarily for capital expenditures, while state funding tends to be predominantly for operational expenses. Infrastructure for ferries requires large capital investments, with 1.7% of total transit capital expenditures even though total US ferry ridership is only 0.7% of total transit ridership (American Public Transportation Association, 2016). Though there often are far fewer terminals and vessels than there are stations or stops and vehicles for other modes of transportation, ferry infrastructure costs more to construct and repair than other modes. A high-quality bus stop can be constructed for a few thousand dollars, whereas a ferry terminal can easily cost several million dollars to construct, with additional multimillion capital expenditures required for upgrades and repairs through its lifetime (Golden Gate Bridge, Highway, and Transportation District, 2017; Lester, 2015).

Per-passenger operating costs for ferries are competitive with other modes of transit, as they are often lower than buses but higher than rail services. However, ferries are most cost-effective when existing services are operating near or at capacity. In areas that are already built at high densities, such as San Francisco, expansion of land-based modes of transportation, even for minor additions, can be extremely costly. Ferries, by making use of what is largely an uncongested right-of-way, can provide additional capacity at a significantly lower cost and with significantly less disruption or additional infrastructure required.

Because of the high capital costs, when agencies purchase new terminals or vessels or make large upgrades it is an important signal that they believe in the long-term viability of the system. The operators in this study are eyeing expansion of their ferry systems and many have either recently made or plan to undertake large capital projects – a sign that they are optimistic about the direction in which the passenger ferry industry is headed.

Economic Development

The second category compares the impacts of ferries on economic development (Table 5). Some of the systems contribute directly to residential or commercial development around the terminals. In some locations such as San Francisco and New York City, this is due to developers who seek to take advantage of the transportation services and waterfront location. Development in other locations, such as North Carolina and Alaska, is because ferries are the sole service provider and the area around the terminals has been built up due to the access the ferries provide. Tourism makes up a significant portion of ridership for all systems, though the reliance on recreational riders varies.

Table 5 Categories of Analysis: Economic Development

Location	System	Economic Development		
		Cause of Development at Terminals	Sole Service Provider for Routes	Heavy Tourism Ridership
Jamestown	Jamestown-Scotland Ferry	N	Y	Y
North Carolina	NCDOT	Y	Y	Y
Bay Area	Golden Gate Ferry	N	N	Y
	San Francisco Bay Ferry	N	N	Y
Washington	Washington State Ferries	Y/N	Y/N	Y
Alaska	Alaska Marine Highway System	Y	Y	Y
New York City	Staten Island Ferry	Y	Y	Y

Ferries promote economic growth particularly where they are the sole service provider. Where ferries add redundancy to the transportation network, they do not directly cause growth, though they do contribute to it. Systems such as those in San Francisco, New York, or much of Washington do not directly drive economic activity. These services tend to act more as modes of rapid transit, as they are integrated into the transit network and run predominantly between already highly developed areas. However, where ferries are the only transportation option, especially for islands, terminals tend to attract economic activity, and ferries play a larger role in the economies of those locations. Terminals in North Carolina, Alaska, or on islands in

Washington have developed as local commercial centers, as people living in these otherwise unconnected areas utilize these terminals to take advantage of the transportation of goods and people and the stores that have opened up there. Ocracoke in North Carolina, in particular, has seen new retail and restaurants in the past ten years around its southern ferry terminal. This is largely due to the fact that it is only accessible by ferry, and the area around the southern terminal in Ocracoke has become an important, albeit small, commercial center for the island. As a result of ferries being the only access, the growth that the island has seen – with a population increase of 23% between 2000 and 2010 (Nolan, 2011) – and especially that surrounding the terminal can be attributed at least in part to the ferry system and the access it provides.

Tourism drives ferry activity and vice versa. Ferries both benefit and benefit from the tourism industry. Ferries facilitate travel throughout the system for tourists, as they often connect popular tourist destinations within or outside of urban areas such as in Washington or North Carolina. Tourists utilize these services because they are enjoyable and don't require the use of a vehicle. Ferries are also an attraction in and of themselves, as people travel and take ferries for the unique views they offer**.** Jamestown, for example, sees traffic from other areas of Virginia that travel solely to ride on the free ferry. Many of the ferry systems in this study promote their recreational services just as much if not more than they promote commuter services, because ferries have the ability to attract ridership and recreational riders are often willing to pay more than commuters. Ferries in Washington, for example, have been vital for regional tourism industry. The ferry is a major tourist attraction for Washington for the views it offers and connections it provides. And when ferries are not operating, the tourism industry suffers, particularly for the islands that rely on the ferries to bring tourists. In

the summer of 2017, ferry service to the San Juan Islands was drastically reduced for a two-week period due to maintenance issues with multiple vessels. This prevented many tourists from travelling, and threatened the island's tourist-related economic activity, as many people were forced to cancel their trips (Walsh, 2017).

Ferries can drive up housing costs in some locations, while in others they can help mitigate housing issues. When ferry terminals are located in already highly developed areas, the development that occurs as a result of ferries tends to drive up the price of housing, as is common with other modes of transportation. For example, the current residential developments around the St. George Terminal in Staten Island are not intended for the communities that are already living in the area. Instead, the upscale developments being built around the terminal are geared toward a demographic that does not yet live there in anticipation that people will choose to move for the access into Manhattan that the ferry provides. However, ferries can also be used to provide access to more affordable housing. Ferries in Washington connect dense urban areas and some of the islands on the eastern Puget Sound, which enables many people to live in the region who would otherwise be unable to do so. Rapid transit service across the Puget Sound allows for people to reside in areas with more affordable housing and take the ferry to school or work who would otherwise be priced out of areas that are a similar distance from employment centers on the eastern Puget Sound.

Integration with Other Modes of Transportation

The third category discusses the ways in which ferries are integrated with other modes of transportation, including roadways, buses, and rail (Table 6). Some of the systems, including the Jamestown Ferry and North Carolina Ferries, operate as marine highway

systems much like roadways. Other systems, including Golden Gate Ferry and San Francisco Bay Ferry, provide services more similar to other modes of transit and operate along similar routes as bus or rail. Ferries can also provide both types of service, such as in Alaska, Washington, and New York City. To better integrate ferries with the transportation network, many terminals have connections to other modes of transportation to allow for transfers. Connections to bus terminals is far more common than rail, though several of the systems provide transfer to rail at a significant portion of terminals.

Table 6 Categories of Analysis: Integration with Other Modes of Transportation

Location	System	Integration with Other Modes of Transportation					
		Marine Highway System	Transit Service Provider	Percent of Terminals Connected to Other Modes		Route Redundancy: Alternative Modes	Coordination with Other Transit Operators
				Bus	Rail		
Jamestown	Jamestown-Scotland Ferry	Y	N	0%	0%	-	N
North Carolina	NCDOT	Y	N	0%	0%	-	N
Bay Area	Golden Gate Ferry	N	Y	100%	50%	Buses	Y
	San Francisco Bay Ferry	N	Y	100%	25%	Rail, buses	Y
Washington	Washington State Ferries	Y	Y	85%	10%	Buses	Y
Alaska	Alaska Marine Highway System	Y	Y	14%	6%	-	N
New York City	Staten Island Ferry	Y	Y	100%	100%	-	Y

Ferries can serve as a marine highway system and/or transit service provider. There are two distinct types of services provided by operators in this study. Ferries can be considered as part of the highway system, connecting roadways in place of bridges or tunnels, or they can be used to increase the redundancy of a transportation network, providing services that complement alternative modes of transportation so that riders have options. The first is much more similar to how ferries used to operate in the US, providing services across bodies of water between roadways. Notably, these services always carry vehicles, as their primary purpose is to complete the road network. Ferries in Virginia, North Carolina, and much of Alaska and Washington act as marine highway systems. The second is more consistent with the idea of urban linear ferries, transporting people much like a transit provider from terminal to terminal. These systems, including those in New York, San Francisco, and some of Alaska and Washington, provide alternative means of transportation to alleviate the strain on existing transportation services and roadways. They tend to connect locations that serve as transportation hubs, often in areas that are already transit-rich.

Ferries are an important part of the larger regional transportation system but should not be the primary mode of transit unless they are the sole service provider. Integrating ferries into the transportation system includes both marine highway systems and transit service providers. Ferries functioning as marine highways complete what would otherwise be a fractured road network. As a transit service, ferries compete with alternative modes of transportation, and often perform better in terms of indicators such as reliability and customer satisfaction. In areas that are already built at high densities, expansion of land-based modes of transportation, even for minor

additions, can be extremely costly and cause substantial disruptions. Ferries, by making use of what is largely an uncongested right-of-way, can provide additional capacity at a significantly lower cost and with significantly less disruption.

However, with the exception of when they are the sole service provider, ferries are not a substitute for other modes of transportation. Ferries are capable of accommodating transportation demand where they are the only regularly scheduled mode of transportation, such as several of the islands in Washington or Alaska. Commuting in these locations may be possible only by ferry, but in dense urban areas ferries are not suitable to be the primary mode of transportation, because they are unable to transport the capacities that buses and especially light rail are capable of. Though per-vessel capacities are far greater, ferries are limited by the speeds they can reliably travel and the frequencies at which they can operate. Even the Staten Island Ferry, with its tremendous capacity and high frequency service, is having trouble keeping up with growing demand. This raises another issue, as dwell times – the amount of time it takes to load and unload passengers at a stop – are far longer for ferries than they are for other modes of transit. Coupled with the fact that a ferry operator cannot possibly operate as many ferries as a bus operator can operate buses, ferries are simply unable to meet the massive transportation demand in a dense urban area that a bus or light rail system can. This is not to say that ferries serve no role in serving communities, as some commutes are only possible by ferry. However, when ferries operate redundant routes, they are most effective as a secondary and complementary mode of transportation. Even Washington State Ferries, the largest ferry service in the country, is only the third largest transit system in Washington. Moreover, San Francisco Bay Ferry is by no means able to compete with light rail's ability to move large volumes of people. BART's

capacities, frequency, and travel times across the Bay are far superior to San Francisco Bay Ferry's, which is limited to at best 20 to 30-minute frequencies and a travel time of approximately 20 minutes compared to BART's seven minutes across the Bay.

Ferries that provide transit services coordinate with other modes to facilitate intermodal connectivity. The intention of these services is to allow for the use of a city or region's transportation network as an integrated system. This requires coordination between transit agencies to allow for timely transfers between modes where terminals serve as intermodal hubs. Connections to other modes involve the coordination of schedules and provide an opportunity for discounted fares for transfers between modes, as in San Francisco and Washington. Additionally, coordination of schedules tends to fall on agencies in charge of other modes of transportation, as it is easier for buses or rail operators to align schedules with ferries, rather than for ferry operators to attempt to do so with the numerous bus or rail services. For San Francisco Bay Ferry, the rich amount of transit in San Francisco facilitates connections even without careful planning and coordination required on the part of WETA. Additionally, many commuters rely on employer shuttles, whose schedules are often aligned with ferry service. In New York City, bus and subway schedules are coordinated with the Staten Island Ferry, though not by the ferry itself. Control towers for bus operators are able to keep track of the ferry's location at St. George Terminal and hold buses for a reasonable amount of time if the ferry is running behind schedule.

Regional planning organizations can be involved with passenger ferries in a variety of ways. Regional planning in the form of Regional Planning Organizations (RPO) or Metropolitan Planning Organizations (MPO) can play a role in the provision of

ferry services throughout a region in some cases. As many of the ferry systems provide regional transportation services, RPOs and MPOs are often involved in the project prioritization process, and they can highlight and potentially fund ferry infrastructure projects if they consider the ferry system as part of the regional transportation system. The Hampton Roads Transportation Planning Organization (TPO) includes Jamestown, and although ferries appear to be less of a priority than other modes, they are exploring opportunities for new ferry systems, with several ferry service improvements included in the 2040 Long Range Transportation Plan Candidate Projects List and the Transportation Improvement Plan (Hampton Roads Transportation Planning Organization, 2017). The Albemarle Regional Planning Organization, which includes the Outer Banks in North Carolina, recognizes that ferry upgrades are necessary to allow businesses to efficiently import and export resources and goods and acknowledge that there are gaps in service to ferry terminals to fill via other modes of transportation, such as a shuttle or Park and Ride during the tourism season (Albemarle Commission, 2017; Albemarle Rural Planning Organization, Mid-East Rural Planning Organization, & Peanut Belt Rural Planning Organization, 2013). The Metropolitan Transportation Commission in San Francisco outlines projects in their regional transportation plan including the expansion of ferry service to South San Francisco and new vessels to add frequency to existing routes. They also play a large role in providing funding for ferry operations in the Bay Area. (Metropolitan Transportation Commission, 2013). The Puget Sound Regional Council in Washington is heavily involved with ferry activity, and their 2018 Regional Transportation Plan emphasizes the need for maintenance of ferry infrastructure, marketing ferry services to maximize investments, and the importance of ferries to the region. They highlight the need to address the demographic shifts that

impact ferry demand, and the financial burdens of capital funding needs for vessels and terminals, and allocate a portion of $260 million in transportation funding from FHWA and FTA to ferry projects (Puget Sound Regional Council, 2018). The Anchorage Metropolitan Area Transportation Solutions is not very involved with ferries in Alaska, as they are focused more on Anchorage itself and the immediate areas surrounding the city, rather than large-scale connections. Upgrades to the ferry terminal to improve access are included in their Metropolitan Transportation Plan, as well as the potential construction of a ferry terminal (Anchorage Metropolitan Area Transportation Solutions, 2012). The New York Metropolitan Transportation Council provides funding for projects through FHWA and FTA, and are involved in a number of individual ferry efforts, including the collection and analysis of data to provide forecasts for future ferry ridership. They have also conducted mobility studies, examined potential sites for ferry facilities, and recommended the expansion of passenger ferry services between Brooklyn and Manhattan (New York Metropolitan Transportation Council, 2017, n.d.).

Environmental Considerations

The fourth category describes the various approaches ferry systems take to try to reduce their environmental impacts (Table 7). Each system uses strategies or technologies that are suitable for their types of vessels and for the environment in which they operate. Common methods include alternative fuels and vessel upgrades, though some of the more ambitious technologies include hybrid or electric vessels.

Table 7 Categories of Analysis: Environmental Considerations

Location	System	Environmental Considerations
		Environmental Mitigation/Technology
Jamestown	Jamestown-Scotland Ferry	Vessel, dock, and pilings upgrades
North Carolina	NCDOT	ISO 14001 certified, vessel upgrades
Bay Area	Golden Gate Ferry	Vessel refurbishment, biodiesel fuel
	San Francisco Bay Ferry	Selective catalytic reduction, biodiesel fuel, electric vessels
Washington	Washington State Ferries	Efficient routes, hybrid vessels, alternative fuels
Alaska	Alaska Marine Highway System	Environmental guide, recycling programs, alternative fuels
New York City	Staten Island Ferry	Vessel upgrades

There is a tradeoff between environmental performance and efficiency. Though ferry systems work to comply with all environmental regulations, reducing environmental impacts beyond that point is largely a political question. Developing and implementing environmentally friendly technologies may conflict with financial goals and service targets. Operators must consider the tradeoff between reducing environmental impacts and providing the services that riders demand in a cost-effective manner. Ferries must be able to travel at certain speeds and provide certain capacities for the system to be able to properly function for passengers, but the technology that would be necessary to allow for the operation of high-performing vessels with minimal environmental impacts has simply not been fully developed yet. As a result, many operators have been independently working on developing ways of reducing their

environmental impacts. WETA, for example, is exploring the potential for electric boats, which are in use internationally in places such as Norway but have not yet been implemented in the US. Current technology is insufficient for electric vessels that are capable of providing the efficiency necessary for SF Bay Ferry routes.

However, some measures can be both environmentally and financially beneficial. Fuel reduction efforts taken as a way of reducing operating costs are not only environmentally advantageous, but economically valuable as well. By reducing fuel consumption or utilizing alternative fuels, WSF's fuel savings initiative has had a large impact on the profitability of the ferry system as well as improving their environmental performance (Washington State Department of Transportation, n.d.). Smaller environmental measures can also have financial benefits, such as VDOT upgrading all lighting to LED and replacing wooden pilings with high density polyethylene (HDPE) pilings that not only reduce the impact on the James River, but save in maintenance costs as well**.**

Different operators use different methods and technologies for minimizing environmental impacts. Because there is no "one-size-fits-all" technological panacea for ferries to improve environmental performance, operators have utilized a number of different methods to do so. What works for some operators will not work for others, as evidenced by the issues the Staten Island Ferry has had with biodiesel fuel. All operators focus predominantly on improving vessels, with the refurbishment of engines a common practice. The use of alternative diesel fuel is also popular, as is finding ways of reducing fuel consumption. Yet beyond that, each operator has taken a unique environmental approach. VDOT has focused on upgrading shoreside facilities, with new dock hydraulic

systems that use biodegradable hydraulic fluid. NCDOT is ISO 14001 compliant – a voluntary certification that indicates that the NCDOT Ferry Division meets internationally recognized environmental management systems standards (North Carolina Department of Transportation, n.d.-b) – and has developed a plan for refurbishing and upgrading older, more environmentally harmful engines. WETA utilizes a selective catalytic reduction system – a fuel additive that reduces particulate emissions – and is researching the potential for electric vessels. WSF is exploring a hybrid electric propulsion system, and did an internal study of the relationship between vessel speeds and fuel consumption that contributed to savings of 180,000 gallons of fuel each year on a single route. Different operators take different approaches to mitigate environmental issues, and there doesn't appear to be a lot of information sharing among organizations, in spite of the efforts the PVA has made to bring the industry together.

Services

The fifth category compares the services offered, including emergency services, marketing, and accessibility (Table 8). All systems with the exception of the Jamestown Ferry have provided emergency services when natural disasters or disruptions prevent the operation of other modes. Most of the systems are marketed as tourist attractions, either through their own promotions or by local tourism companies. All of the systems are accessible for people with limited mobility.

Table 8 Categories of Analysis: Services

Location	System	Services		
		Emergency Services	Marketing	Accessibility
Jamestown	Jamestown-Scotland Ferry	N	Promoted by tourism companies	Y
North Carolina	NCDOT	Y	Promoted by tourism companies	Y
Bay Area	Golden Gate Ferry	Y	Tourists and commuters	Y
	San Francisco Bay Ferry	Y	Commuters	Y
Washington	Washington State Ferries	Y	Tourism and local recreational riders	Y
Alaska	Alaska Marine Highway System	Y	Tourism	Y
New York City	Staten Island Ferry	Y	Promoted by tourism companies	Y

Ferries play an important role in the provision of emergency services. In areas without access to other modes of transportation as well as in areas that are served by other modes, ferries provide vital services in emergency situations. Ferries are often the fastest service provider after an emergency, and can operate in conditions that other emergency modes, such as helicopters, may not be able to. They can be used to reach islands quickly, as in Washington, Alaska, and North Carolina, and to send medical aid. When major disruptions such as natural disasters or – as in New York, terrorist attacks – shut down other modes of transportation, ferries are often the first mode able to provide service. For ferries that connect roadways, service becomes even more

important when the roadways are unusable. Operators can run additional routes when land-based modes of transportation are unavailable, as in North Carolina where NCDOT ferries are vital to the Outer Banks when weather impacts Route 12.

Ferries are marketed as either a tourist attraction or a transit service. Marketing for ferries that act as an extension of the highway system tends to be geared more toward recreational riders rather than as a transportation service. In Jamestown and North Carolina, commuters and residents are well aware of the system, and therefore marketing efforts are not aimed at locals. These systems are instead promoted by tourism agencies or websites that highlight the ferries as an attraction for visitors, as well as a means of access to tourist destinations. Additionally, GGF and AMHS target recreational riders, which can be financially beneficial as they are often willing to pay higher fares for leisure services. WETA, GGF, and WSF promote their services as a transit alternative to other more congested modes by highlighting the relative comfort and ease of ferries, as well as their ability to provide relief for other modes of transportation. As a transit service, they also market the opportunity for their systems to be utilized in conjunction with other modes of transportation by promoting ferry service as an integrated part of the transportation system with connections to other modes.

Accessibility on vessels is difficult but not impossible. Due to the high costs of purchasing a new vessel, many vessels in operators' fleets are decades old, having been refurbished several times. The age of these vessels, as well as the manner in which they were initially constructed, has made it difficult to accommodate passengers with mobility issues. However, all operators have found ways to make vessels and terminals

accessible, ranging from assistance from staff to ensuring that all facilities are ADA compliant. But even vessels that are fully accessible can fall out of compliance when tides fall below a certain level, and ramps between the dock and vessel become too steep to be used. Ferry operators are slowly working to improve accessibility while upgrading or retrofitting vessels.

Chapter 6: Recommendations & Conclusion

The findings describe general themes and approaches shared by the selected passenger ferry operators in the US. Current practices in the ferry industry can offer lessons for Boston to consider as the city moves forward. These recommendations are specifically aimed at expansion as opposed to what Boston is doing currently. They revolve around considerations for the MBTA, Boston Harbor Cruises who operate most of the ferry services in Boston, or the cities and towns who are also involved with the provision of ferry service. "Boston" in this section refers to any of the above entities, as they all play a valuable role in the provision and potential expansion of ferry services.

Connectivity

With the potential expansion of Boston's ferry system, it is important to consider what type of services they intend to provide. They already offer recreational services to the Harbor Islands and transit services throughout the Inner Harbor and North and South Shores. Additional routes could take the form of urban linear ferries, making multiple stops along the shore and terminating and originating in Boston, or they could be point-to-point services between single destinations. From their initial plans, it appears that the MBTA intends to invest largely in the use of ferries for transit services in an attempt to allow even more people to commute into Boston by ferry. With the goal of alleviating congestion and providing an alternative mode of transit, Boston should consider connectivity – not just to other modes of transit at terminals, but within the ferry system itself.

With any new terminals, the MBTA should make sure that they are able to align schedules with the ferry, as is done to a large extent in San Francisco, Washington, and

New York. Coordinating with other modes of transportation to provide seamless connections is the key to an integrated transit system. The north-south single-fare connection through New York City provides a great example of how a fully integrated transportation system can incorporate ferries. These sorts of connections are essential for the larger transit ferries to be able to provide the additional capacity to congested transportation networks.

Boston may also consider implementing additional cross-shore routes between terminals that would carry vehicles and be connected to roadways, instead of routes directly into and out of downtown Boston. Such connections would facilitate access between the cities and towns in the Greater Boston area, and alleviate congestion in Boston as well, because the highway system is set up so that roadways, bus routes, and rail lines go into and then out of the city in order to get around it.

Congestion

When considering where and how to expand the ferry system in the Greater Boston area, the relationship between ferries and other modes of transit is an important factor. By drawing passengers from other modes of transit or roadways, ferries provide vital relief for strained and often over-burdened infrastructure, as has occurred with the services that exist in the area already. Ferries' ability to mitigate congestion may be an incentive for system expansion and should be an important determinant of the location of routes and terminals.

Where to provide additional services should therefore include the consideration of not only connectivity, but of how ferries can best reduce congestion on the transportation network in the Greater Boston area. With the exception of service to areas that do not

have other modes of transit, ferries should aim to add redundancy to the transportation network to provide riders with as many choices as possible for commuting. Ferries used for transit services are best utilized as a complement to existing transit service, as is done in San Francisco, rather than a supplement. For Boston, this may mean additional routes to cities and towns on the North and South Shores that are already served by the Red Line or Blue Line, the commuter rail, or bus routes that connect to rail. These routes would provide commuters with a choice of which mode to use.

The relationship between ferries and housing cost is an important one too. On one hand, terminals attract development and can drive up land values and housing costs, as is the case with St. George Terminal in Staten Island. Current development surrounding the terminal threatens to price out many of the people who live there now. The impact of transit on housing costs is well-documented (Wardrip, 2011), and there is no reason to suggest that ferries would be any different. On the other hand, ferries can be used to help alleviate some of the negative impacts of increased housing costs by connecting downtown areas with locations much farther away with much more affordable housing. As in Washington with routes across the Puget Sound, routes that connect Boston to areas outside the city on the North and South Shore can allow people to commute into the downtown area without having to pay as much in terms of housing and commuting. Consideration of these impacts should be given to the decisions of the location of any new terminals.

Marketing

Boston should consider how to market the ferry system to maximize awareness of the services and connections it provides**.** Depending on where any new routes operate**,** the

ferry should be promoted as a service for both tourists and commuters. Tourism is a major source of ridership for all systems and has contributed to significant growth in New York City and Washington in particular. If Boston wants to increase its recreational ridership, targeting the estimated 19 million tourists that visit the city each year is a good place to start (*Boston's People and Economy*, n.d.). This can be economically advantageous not only for Boston, but for the communities connected by ferry that would see additional visitors as well. A marketing effort can also attract recreational riders who live in the Greater Boston area and are not aware of the ferry services, such as those to the Harbor Islands.

Service for commuters should be marketed as part of the transportation network in the Greater Boston area as opposed to a distinct system. Golden Gate Ferry and Washington State Ferries provide extensive information on transfers available to other modes of transportation at terminals. This can help attract passengers by informing them of how the ferry can fit into a commute, even if it may not originate or terminate at a ferry terminal. Ferry services should be promoted on other modes of transit as well, so that people who use the system understand that there may be a faster or more enjoyable alternative route.

Boston should take advantage of the idea that people are naturally drawn to water, and that ferries offer a more aesthetically enjoyable ride than other modes. The quality of the experience is far better, which can be a more meaningful factor to transit than many agencies would care to admit. With superior on-board amenities, ferry commuters prefer the comfort and experience of ferry transport to the often overcrowded and uncomfortable bus or train ride. Alaska is perhaps an extreme example of how luxurious ferry travel can be. Though of course Boston does not need to provide restaurants or

playgrounds on their vessels, prioritizing and marketing the comfort of the ferry system can be a powerful incentive to attract ridership.

Environmental Considerations

Expansion entails the acquisition of additional vessels, and with that comes the opportunity for improved vessels that are much more environmentally friendly. Vessels could even help Boston with their GHG reduction goal of a 25% reduction by 2020 in a similar manner as in Washington (City of Boston, 2017b). Boston should continue to explore environmental technologies, but they should communicate with other passenger ferry systems around the country to ensure that they are implementing the best available technology. Boston would also benefit from extending this communication to ferry systems around the world, as some of the European and Australian systems in particular have implemented more advanced vessels and practices than in the US.

What works for some operators will not work for others. For example, the New York City Council recently passed legislation requiring all city ferries to use biodiesel, which, NYC DOT found would reduce the Staten Island Ferry's fuel efficiency because of the enormous size of the vessels and the filtration system they use. Boston should consider which systems are most similar in terms of the routes they operate and the size of the vessels, such as WETA, and collaborate to develop more environmentally friendly technologies or practices. Constructing vessels that are environmentally friendly from the get-go can save a significant amount of money in avoiding refurbishments or upgrades, or if regulations get more stringent in the future. Similarly, deferring the construction of new vessels until technologies have improved is also a strategy to

consider. With a number of research projects around the country looking into the use of alternatively-powered vessels, it may be beneficial to wait on expanding to a certain degree until the technology has been developed. Rather than acquiring all of the vessels and then undergoing costly retrofits, if technologies are close, waiting may prove to be more advantageous. By communicating with other passenger ferry operators, Boston can determine how to proceed in the most efficient way possible.

Limitations

The depth of my analysis was limited by the number of operators I was able to include. Due to time constraints and my inability to get in contact with several ferry operators, I was only able to interview and conduct thorough research on seven operators. Though I attempted to select a sample that was representative of the range of characteristics of publicly-owned ferries, the availability of information dictated a large portion of the selection process. Therefore, the recommendations I proposed and the conclusions I have drawn may not be as substantial as they would be with a larger sample.

I had also hoped to add a quantitative component alongside the qualitative research that considered the demographics, economies, and transportation systems in relation to one another and to Boston. However, due to time constraints and the lack of accessible data, I was unable to add this component which would have strengthened the relationship between my analysis and the recommendations for Boston.

Further Research

My analysis was focused exclusively on publicly-owned passenger ferry systems in the US. Expanding this sample to include private ferry systems would likely add context to the current state of ferries in the US. Looking at the differences between public and

private ferries, such as the different fare structures, amenities provided, or locations served, would contribute to understanding ferries' role in the transportation context of the US. Additional conclusions about the different types of services within public and quasi-public providers could also be drawn with a larger sample. For example, SF Bay Ferry, like Boston, is publicly-owned but privately operated, and it would be interesting to explore the differences of the different service provision models.

I had initially intended to contact metropolitan planning organizations and regional planning organizations for each location to find out what their role is in water transportation, and if they consider the ferry system as part of the regional transportation system. Due to time constraints I was unable to do so, and was only able to use information on the organizations' involvement with passenger ferries that was available online. Additional research into MPOs would reveal more about how ferries operate within a regional context. The level of influence of MPOs varies, and for those that are more heavily involved, such as the Metropolitan Transportation Commission in San Francisco, it would be useful to understand how they utilize ferries.

Conclusion

Once the dominant method of moving goods and people, water transportation was ousted in the early 1900s by motor vehicles and land-focused transportation infrastructure. It is only in the past few decades, as cities invest in the revitalization of their waterfronts and seek alternative ways of alleviating congested roadways that ferries have once again returned to the spotlight. This thesis reviewed a selection of publicly owned passenger ferry operations in the US to glean lessons for Boston as the city prepares to expand its ferry system. I conducted research and interviews with employees of ferry service providers in six locations – Jamestown, Virginia; eastern

North Carolina; San Francisco, California; Washington State; southern Alaska; and New York City. These cities' and states' approaches to issues concerning funding, economic development, integration with other modes of transportation, environmental impacts, and the provision of services contributed to a number of recommendations for Boston in expanding its ferry system, including enhancing connectivity, mitigating congestion, improving marketing, and collaborating on environmental issues.

The selected cases provide a number of potentially generalizable conclusions to the Boston system. For example, the Jamestown Ferry highlights the usefulness of water transportation even in rural areas without connections to other modes of transit. NCDOT Ferries exemplifies how ferries can be used as an extension of the roadway to connect the highway system across bodies of water. GGF and SF Bay Ferry demonstrate the potential for ferries to be incorporated into a city's transit network. WSF and AMHS are the quintessential examples of large, fully public, state-owned ferry systems. The Staten Island Ferry is the epitome of free, integrated ferry transportation. Though each system is unique, they have been operating for decades, and much can be learned from the range of policies and practices that ferry operators have implemented.

Water transportation is growing. As evidenced by NCFO data, the use of ferries as a mode of transportation is becoming more popular. Cities and states have made significant capital investments in ferry infrastructure to provide additional vessels and terminals, confident that ferry systems will continue to be utilized and are here to stay. As more cities embrace the potential of water transportation, ferries can help to mitigate congestion, drive economic activity, and continue to provide essential transportation services in the US.

Appendix A: Interview Questions

1) Funding:
    a. What are the different sources of funding, including subsidies or partnerships?
    b. How financially sustainable is the ferry system? What is the farebox recovery ratio?
    c. What evaluation metrics are used, and do they work? Are there any that should or should not be included? What data is collected?
2) Economic Development:
    a. Has there been any notable development as a result of the ferries?
    b. Are the ferries promoted as tourist attractions or in conjunction with tourism?
3) Integration with Other Modes of Transportation:
    a. Is the ferry system considered part of the larger transportation network?
    b. How does the ferry system compare with other modes of transportation? This would include travel time, population served, and cost, but would also consider other factors such as comfort, flexibility, and aesthetics that influence people's commuting decisions.
    c. Does the ferry system span multiple jurisdictions or include both public and private actors, and if so how is that coordinated?
    d. Is there any interaction/communication with other water transportation systems?
4) Environmental Considerations:
    a. How much attention is given to environmental considerations?
    b. What sorts of technologies have been implemented?
    c. Have any environmental organizations been consulted?
5) Services:
    a. Are ferries used for emergency services?
    b. How is accessibility managed?
    c. How are weather-related issues addressed? Are there different policies in place for the winter season?
    d. How is marketing done? Are people aware of the ferry system? How easy is it to get access to information? Is it marketed as a part of the transportation system or as recreation?

Appendix B: Full Case Descriptions by Category

Jamestown Ferry

Funding

The Jamestown Ferry relies almost entirely on state funding, though VDOT also receives roughly $1.6 million of its $12 million budget annually from the FBD Program, and they compete for federal grants for projects when they are available and applicable. Though the free Jamestown ferry does not provide any revenue to maintain operations, the funding supply is as sustainable as the state government budget is, and VDOT does not foresee the ferry losing funding any time soon. There is essentially no need for expansion, though they can request additional funding for vessel upgrades, and as it is considered part of the highway system and is state-operated and mainly state-funded, reliable funding is not a major concern.

Economic Development

Economic development as a result of the Jamestown Ferry is largely nonexistent. Throughout its 90+ year lifespan, the ferry has served as an extension of Route 31 to cross the James River rather than a source of development. The south side of the river in Scotland is still rural, with a population of just over 200 people, and has seen essentially no economic impacts of the ferry. The north side in Jamestown also has not seen a great deal of activity that could be attributed to the ferry. This is due to the fact that the ferry terminals are not major nodes and are not economic centers themselves. With frequent service and a relatively short trip of just 15 minutes, the ferry doesn't connect what could be considered *destinations* in the broader sense, but rather it serves as a connection to facilitate vehicle transportation across Route 31.

However, the ferry isn't promoted as a transportation service as much as it is for tourism or recreation. Local tourist organizations promote the ferry as an attraction, as Jamestown is located about five miles outside of Williamsburg, a popular tourist destination. The ferry is commonly recommended as a free attraction for tourists who also want to experience the colonial history in Jamestown or enjoy a scenic trip across the James River**.** Tourism makes up a significant portion of ridership, and the ferry is busiest over holidays and weekends. Because the tourism business they see is largely incidental to Williamsburg, it has not been sufficient to drive economic development surrounding the ferry.

Integration

Though it is promoted by local tourist organizations as an attraction, VDOT considers the Jamestown Ferry to be part of the larger transportation network. It serves as a crucial connection along Route 31 between Jamestown and Scotland, as evidenced by its high ridership compared to its relatively limited operations. Williamsburg Area Transit has a bus that uses the ferry to connect Route 31, but this ferry route does not operate as a

transit service, because there are no destinations or connections to other modes of transit at either end. It is not an urban linear ferry, as it operates as ferries originally did in the US – connecting roadways across rivers. Therefore, the ferry does not compete with the alternative modes, but instead is used to facilitate highway travel and other local modes of transportation.

VDOT has found that people tend to find its ride much more enjoyable than other modes of transportation. This is hardly surprising, and can be attributed to a number of factors, including the relative calm and comfort of water transportation compared with highway travel, the aesthetic and natural enjoyment of water itself, and the views the ride provides.

Environmental Considerations

The Jamestown Ferry complies with all federal regulations regarding environmental standards. With older vessels, environmental mitigation can be difficult and costly. VDOT is currently looking to refurbish some older vessels, which includes plans to install more environmentally friendly main engines in the two oldest vessels, constructed in 1936 and 1979, as well as a larger upgrade to their newest vessel's engines. The replacement for their 82-year-old vessel scheduled for July 2018 will be tier III compliant with the International Maritime Organization's (IMO) emissions standards, which apply to diesel engines installed after 2015 (International Maritime Organization, n.d.). Other facilities improvements to reduce environmental impacts include upgrading dock hydraulic systems to use biodegradable hydraulic fluid and replacing pilings at their terminals with ones that will last longer and be less disruptive to the local environment. VDOT ferries also have a "no bottom construction period" between mid-February and August due to sturgeon migration, and they also provide nesting areas for ospreys.

Services

The Jamestown Ferry is not used by VDOT for emergency services. Williamsburg Hospital is on the north side of the river in Jamestown, and although rescue squads used to use the ferry to travel between the hospital and Surry on the south side of the river, the construction of two hospitals on the south side of the river have eliminated the need for this route. According to VDOT's facility manager, they have, however, had three babies born on the boat or pier in the past three years.

VDOT concedes that the Jamestown Ferry is not particularly accessible for people who are disabled, in spite of their best accommodation efforts. The crew continues to work to facilitate use by people with disabilities at the terminals. Additionally, the new vessel will have handicap restrooms on deck and wider egress lanes to aid in managing accessibility concerns.

Winter does not require separate policies for ferry operation and weather rarely interrupts ferry services, with the decision to halt operations left to the Captain and

Operations Manager. VDOT has access to wind speed and tide data predictions supplied by NOAA 36 hours in advance, so they can attempt to preempt dangerous conditions and notify the public if operations may be impacted. High tides more frequently prevent vessels from getting under the ramps, prohibiting passengers from boarding and alighting, which halts services. Hurricanes can also be an issue, and VDOT has an agreement with the Port of Richmond roughly 40 miles downriver to allow them to moor there if there is a need to evacuate, though this has happened only twice in the past thirty years.

North Carolina Department of Transportation

Funding

Funding for NCDOT ferries, much like other state-operated transportation systems, comes from a combination of state and federal sources**.** The Ferry Division received $48 million from NCDOT for the 2017/18 fiscal year, just under 14% of the total funding appropriated for their five non-highway modes (aviation, rail, public transit, ferries, and bicycles) (Rodewald, 2018). The majority of their annual operations budget comes from the state, along with what generally amounts to between $1.3 and $1.6 million annually from FHWA.

NCDOT is currently working on a new high-speed passenger ferry project between Hatteras and Ocracoke. Funding for this project must come from a proposed one-time appropriation from the North Carolina General Assembly through the Federal Lands Access Program, which provides funding from the Highway Trust Fund to states for transportation facilities located on or adjacent to Federal lands (Federal Highway Administration, 2016a).

The NCDOT Ferry Division considers their budget to be more sustainable now than a decade ago, because they have developed a system for planning and replacing vessels, which allows them to replace one vessel every two years if necessary. This fund consists of an annual allotment of $4 million, plus toll revenues they generate, which amount to between $1.7 million and $2 million each year. This has provided greater assurance of operations for the near future, as unpredictable vessel break-downs can severely strain an already thin operations and maintenance budget without such funding.

Economic Development

The NCDOT ferry system has contributed to some economic growth around the terminals, especially at Hatteras and Ocracoke. Ocracoke in particular has seen new retail and restaurants in the past ten years around its southern ferry terminal. This is largely due to the fact that it is only accessible by ferry, and the area around the southern terminal in Ocracoke has become an important, albeit small, commercial center for the island. As a result of ferries being the only access, the growth that the island has seen – with a population increase of 23% over the past decade (Nolan, 2011)

– and especially that surrounding the terminal can be attributed at least in part to the ferry system and the access it provides.

Integration

The NCDOT ferry system is considered part of the highway system, as it provides connections between roadways that otherwise would not be connected. Operation by NCDOT allows for the routes to be considered in conjunction with highways and the other non-highway modes of transportation operated by NCDOT in terms of planning the system as a whole.

Securing adequate funding can be a struggle compared to other modes of transportation operated by NCDOT, as the Ferry Division often has to compete with other non-highway modes for funding. Their budget has been stagnant over the past seven to eight years in spite of their increasing expenses, which has put greater pressure on the Ferry Division to continually review and revise their schedule and make adjustments to operations to work within their budget while still providing a level of service that is sufficient to meet the needs of tourists and commuters.

Environmental Considerations

The NCDOT Ferry Division has implemented an Environmental Management System, which focuses on recognizing and attempting to minimize the environmental impact of ferries, particularly through improved dredging and fueling practices. They have been ISO 14001 compliant since 2006, which is a voluntary certification that indicates that the NCDOT Ferry Division meets the internationally recognized environmental management systems standards (North Carolina Department of Transportation, n.d.-b)

NCDOT is able to acquire additional funding from the state to better meet EPA standards, which they have used to install more environmentally friendly engines on five vessels. They are currently working to develop a capital improvement plan to upgrade vessels with improved environmental standards. They don’t have sufficient funding to implement a full vessel replacement program, so they are undergoing a lifecycle analysis to determine which vessel can be refurbished, and which must be replaced.

Services

NCDOT operates an emergency route between the north end of Hatteras Island and the North Carolina mainland. The roadways on the Outer Banks have been vulnerable to hurricanes and when the roadways flood, the only way to access much of the Outer Banks is by ferry. NCDOT Ferry Division formed an emergency route that can become operational within two hours of an emergency to provide transportation services when the roadway becomes impassible. This emergency route connecting NC-12 and US-264 is a free service with six scheduled trips each day for local residents and emergency

services. NCDOT has utilized the emergency route three times in the past decade when roadways have flooded.

With regards to accessibility, all of the NCDOT vessels that have been built in the past 15 years are fully ADA compliant, including an on-board elevator and accessible passenger waiting areas on the main deck level.

Besides hurricanes, there are no established policies in place for severe weather or seasonal conditions. NCDOT has an internal threshold for wind speeds of 35mph for securing operations, and decisions on weather-related issues are made by the captains who can determine for themselves whether conditions are too dangerous for operation.

Golden Gate Ferry

Though I was unable to speak with anyone at GGT, I was able to find a great deal of information on their website and in their Short-Range Transit Plan and Annual Budget. GGF is operated by the Golden Gate Bridge, Highway and Transportation District (GGBHTD), which also oversees the operation of the Golden Gate Bridge and the Golden Gate Transit (GGT) bus system. GGF was created in 1971 as a result of a long-range transportation plan which called for the integration and expansion of ferry service in the area (Golden Gate Bridge, Highway, and Transportation District, 2017). GGBHTD began operating as a bus and ferry service to alleviate traffic on the Golden Gate Bridge. It has also played an important role in the provision of emergency services during extreme weather events and earthquakes, as well as when other modes of transportation were not functional (Golden Gate Bridge, Highway, & Transportation District, n.d.).

GGF operates four routes between San Francisco and Sausalito, Larkspur, and Tiburon, which started in 2017 and had previously been operated by Blue and Gold Fleet ferries, a private company. GGF also provides special event service between Larkspur and AT&T Park for Giants games or other events held at the stadium. This route began operation in 2000 and provides service for approximately 90 events each year. Service for all routes is marketed for recreational riders and tourists, especially with the special event service, and for commuters who utilize the service as a transit alternative into San Francisco.

GGBHTD publishes a Short-Range Transit Plan (SRTP) every two years, which evaluates the state of their transit systems and outlines future transit developments. The most recent SRTP covers 2016-2017 through 2025-2026, in which GGBHTD found that although transit ridership is declining, GGF ferry ridership is increasing. The SRTP also discussed potential future expansions or services changes. Because ferry ridership is strong, GGF is considering expansion of Larkspur Ferry service, as well as a route from the North Bay to the Golden State Warriors' new arena in San Francisco. They also plan to expand their fleet, as all of their vessels are utilized at times with the addition of the new Tiburon route (Golden Gate Bridge, Highway and Transportation, 2017).

Funding

GGF's 2016-17 operating revenues totaled $38 million, $20 million of which came directly from transit fares. The remainder came from a mixture of state and local operating grants and federal funding. FRRs for GGF ferries have consistently been higher than their target of 40%, hovering around 50% in recent years, though fares for special event service must cover the full operating cost as required by GGBHTD. GGF's FRRs are more than twice as high as GGT's, which is indicative of a more self-sustaining transit system, and places less pressure on the agency to find external sources of funding. This is significant because GGT's total operating expenses – at $98 million – and per-passenger expenses for 2016/17 are higher than those of GGF – at $38 million. Moreover, GGT collected $15.4 million in fares compared to GGF's $19.7 million. As a result, subsidies for GGT service were roughly six times greater than those for ferries – $53.4 million compared to $8.8 million – in 2017, which is remarkable considering transit ridership was only 20% higher during the same period. This suggests that per-passenger subsidies for GGT in 2017 were roughly $17, while the GGF figure of $3.50 was much lower (Golden Gate Bridge, Highway and Transportation, 2017).

This dramatic disparity highlights the relative cost-effectiveness of ferry operations and explains why GGBHTD is investing more money into the future of ferry services than transit. Roadways in the region are already highly congested, and the cost of investing in additional transit services – as well as the return on that investment – is far less attractive than investing in ferries, which operate on an uncongested right-of-way.

Economic Development

There was no information readily available online.

Integration

GGF functions as a transit system, with seasonal schedule adjustments to improve ferry performance, and a focus on attracting choice riders who also have the option of driving. GGF is an integrated element of the Bay Area transportation network, providing another alternative in an already transit-rich region. GGT and GGF are major transit providers in Marin County, connecting the area north of San Francisco to the city and centers of employment.

GGF's terminals offer connections to other modes of transportation, and they provide comprehensive information about transfers to make it easier for commuters to utilize the ferry within the region. All GGF routes originate or terminate in San Francisco, and although ferry services are not provided between other terminals in Marin County, they also operate a Ferry Shuttle Bus during AM and PM peak periods and occasionally on weekends to facilitate travel to and from ferry terminals in Marin County.

Environmental Considerations

GGF has made a significant effort in recent years to reduce ferry emissions. They contributed to the development of the California Air Resources Board (CARB) emissions regulations for ferries and have prioritized upgrading and improving existing vessels. This includes refurbishment of older vessels with more efficient engines that meet or exceed EPA and CARB emission standards, new vessels that are less harmful to the environment, and the use of biodiesel fuel in the newer engines (Golden Gate Bridge, Highway, & Transportation District, 2010).

Services

One of GGBHT's explicit objectives is to "provide equity in serving the mobility needs of transit-dependent riders". This includes a commitment to public outreach and environmental justice, as well as an effort to improve transparency and public involvement in planning efforts. GGBHTD has three public advisory committees and conducted an on-board passenger survey in 2015 to aid in avoiding, minimizing, or mitigating harm to disproportionately impacted populations. This includes the provision of paratransit services and accessible vehicles. All GGF vessels are accessible and GGBHTD sponsors an Advisory Committee on Accessibility to ensure that seniors and people with disabilities are able to properly utilize transit and ferry services (Golden Gate Bridge, Highway and Transportation, 2017).

San Francisco Bay Ferry

Ridership on SF Bay ferries during weekdays is 80% commuters and 20% recreational during peak periods, and the reverse proportion during the midday period. Weekend service consists almost entirely of recreational riders. Many of the routes that SF Bay Ferry operates have been in place for over 30 years, and as a result, there is a great deal of awareness among residents and commuters of the services they provide. Marketing efforts are largely aimed at attracting commuters and choice riders to utilize ferry services. Though they previously used a more targeted marketing approach to attract recreational riders, WETA feels that they already capture a significant portion, and have stopped promoting the ferries' leisure services.

WETA occasionally coordinates with Golden Gate Ferries, the other major passenger ferry operator in the Bay Area, mainly for sharing vessels during major disruption events such as the Bay Area Rapid Transit (BART) strike or when the Bay Bridge is shut down. Nationally, WETA communicates with ferry services in New York City, and helped advise NYCDOT on the introduction of their NYC Ferry service in the East River in 2017.

Funding

SF Bay Ferry's operations expenditures total $33 million a year and come from two sources – the farebox and bridge tolls. The Bay Area Toll Authority provides WETA with an annual fixed stipend of $15.3 million, which has not been raised since it was set in 2008. The system-wide FRR hovers around 60%, providing the remainder to cover

operating costs. The rigidity of their funding arrangement with bridge tolls makes it difficult to account for annually increasing operation costs compared to other California transit agencies, which have more substantial sources of funding, such as sales or property taxes. Because their allocation from the Bay Area Toll Authority is set at a fixed percentage, funding of the ferry system is highly subject to their farebox. Sustainability of the system therefore requires a strong ridership base willing to put up with higher fares to receive the same quality and frequency of service. The possibility of an additional bridge toll increase in the Bay Area would help alleviate some of their financial issues, as such an increase is projected to provide $35 million annually.

Economic Development

SF Bay Ferry has contributed to some development around the terminals, though the large-scale waterfront redevelopments that are occurring in the San Francisco Bay are not a consequence ferry services. Instead, the ferries tend to be located in areas that are ripe for redevelopment – former industrial waterfront areas that are being converted into residential or office developments that have higher densities of people who may rely on public transportation to get to or from work. Oakland and Alameda in particular have seen a great deal of these developments.

Though SF Bay ferries may not be directly responsible for the development occurring around ferry terminals and along waterfronts, ferries are often promoted in conjunction with the residential and office developments. Developers love the proximity to ferry terminals, and tout the access provided by the ferry system. Local officials in the East Bay and South San Francisco have cited ferry access as a critical factor for attracting the biotech industry in particular. In fact, developers of large-scale projects have contributed capital funding for two ferry terminals in Alameda and Treasure Island, because they recognize the potential that the mode of transportation has to attract interest.

Integration

SF Bay Ferry intended to be an integrated part of the Bay Area transportation system as it seeks to expand to Berkeley and Richmond, with potential future expansions to other areas in San Francisco Bay. As little as ten years ago, ferry services were predominantly recreational – the use of passenger ferries for commuting has come a long way in that time, with SF Bay ferries carrying 8% of the total peak-hour San Francisco Bay crossings, or 2,400 passengers. Though this figure may seem insignificant, ferries provide huge relief for other modes of transportation across the Bay. Those 2,400 peak-hour cross-Bay commuters would otherwise require three BART trains, 48 buses, or up to 2,400 single-occupancy vehicles, none of which could be fulfilled by the current transportation systems in the Bay Area.

Because SF Bay Ferry runs redundant routes, they also play a vital role in the Bay Area transit network, providing transportation services when disruptions to bus and rail services threaten transit operations. In February 2018, when BART service as shut down due to a fire on the tracks, ferry ridership jumped 40%. For minor events, such as track fires or periods of heavy congestion, or major events, such as the BART strike in 2013, the ferry system can help absorb the additional capacity and alleviate the strain on other transit systems.

Ferry terminals are generally located in areas served by other modes as well, especially in San Francisco. There isn't a great deal of feeder bus service on the East Bay, though where local bus connections do exist, SF Bay Ferries offers a transfer arrangement so that passengers can discount the cost of the bus fare from their ferry fare. Ferry schedules are not coordinated precisely with other public transportation to allow for transfer between the ferry terminals and further in-land destinations. However, the rich amount of transit in San Francisco facilitates connections even without careful planning and coordination required on the part of WETA. Additionally, many commuters rely on employer shuttles, whose schedules are often aligned with ferry service.

SF Bay Ferries are by no means able to compete with light rail's ability to move large volumes of people. BART's capacities, frequency and travel times across the Bay are far superior to SF Bay ferries', which are limited to at best 20 to 30-minute frequencies and a travel time of approximately 20 minutes compared to BART's seven minutes across the Bay. Transit fares and convenience are also in BART's favor, as traveling by rail is cheaper and often more convenient for commuters. Ferries outperform BART in comfort and reliability – trains and buses are often so crowded and congested that people cannot access them or have to wait, and are largely subject to traffic and roadway congestion. Ferries do not have to compete with other modes in waterways, and travel time variability is almost nonexistent in comparison. Ferries do not suffer from track fires, congestion, or accidents as frequently, and as a result run on much more precise and accurate schedules.

SF Bay Ferry collects data on ridership and schedule adherence, which they analyze seasonally to assess and modify service to improve performance. The need for service modifications is based on peak-hour occupancy: if a route is significantly above or below the target of 65%-75% occupancy, they begin to think about adding or reducing service.

Environmental Considerations

The primary method of reducing emissions from SF Bay ferries is with a selective catalytic reduction (SCR) system on all vessels, which is a fuel additive that reduces particulate emissions and allows them to adhere to the stricter California emissions standards. SCR allows SF Bay ferries to be tier 4 compliant with the IMO's emissions standards.

Managing environmental impacts is a significant priority for WETA, though it often conflicts with other priorities such as efficiency or profitability, because the technology isn't there yet for environmentally friendly marine vessels to perform as needed to properly provide transportation services. As a result, they are currently exploring new environmental technologies aimed at reducing the impact of their ferries, including a new kind of "renewable diesel" called R99 that is made from biological sources.

Services

In an area constantly threatened by earthquakes, a fundamental part of WETA's purpose is to provide emergency services when other transportation systems are unavailable. The ferries were intended to be the first available service in the event of a major disruption, such as a natural disaster, and their terminals and vessels were created with that role in mind. When there are minor disruptions, WETA is able to increase their service provision to attempt to reduce the congestion and delays that would be caused by a lack of other transportation services. These sorts of disruptions happen relatively frequently, as often as once a week, while major events that threaten other modes of transportation occur far less often.

Though accessibility can be a challenge, WETA has ensured that all of their facilities are fully accessible. There are certain periods during the day where the tides push the ramps up to the vessels outside of ADA compliance, and staff must assist passengers in boarding and alighting.

Weather can cause issues for some terminals that are more vulnerable, such as those in San Francisco. There are policies for cancelling service when weather prevents safe ferry operation, in which case routes are replaced by buses operated by a private contractor to ensure that service is still provided.

Washington State Ferries

WSF functions as both a marine highway system and a transit service provider and is an integrated part of the state highway network, serving eight counties in Washington as well as British Columbia. Much of its financial success, however, can be attributed to the high volume of vehicles it transports, and passengers' reliance on the system. Their vessels are capable of carrying between 34 and over 200 vehicles each. WSF operates under a fully public service provision model, owned and operated by the state, with publicly owned terminals and vessels. The system has seen an annual increase in ridership and revenues since 2012, with the majority of growth coming from recreational riders (Washington State Department of Transportation, n.d.).

WSF developed a Long-Range Plan for the ferry system that outlines its goals of enhancing transit infrastructure, revising pricing to control costs, expanding marketing to increase non-peak ridership, and deploying a vehicle reservation system to allow for fewer terminal facilities while still providing high level-of-service. The plan received

extensive input from the public, and included a comprehensive survey that revealed how vital the ferry system is to residents throughout the Puget Sound. It also found that roughly one third of passengers use the ferries to commute to work or school, which suggests the system has many recreational riders as well (Washington State Department of Transportation, 2009).

Funding

Total expenses for 2017 decreased by over $1 million compared with 2016 to $241 million. Total revenues were $188 million, leaving a $53 million funding gap, which was supplied by both federal and state sources (Washington State Ferries, 2017). WSF received over $16 million from FHWA through the FBD Program, the most of any ferry system after the Alaska Marine Highway System. This considerable amount of funding is a result of the substantial ridership that WSF maintains, as well as the volume of vehicles that the system transports. WSF receives state funding from WSDOT, which predominantly comes from Washington's motor vehicle fuel tax of 49.4 cents per gallon, of which WSDOT receives 37.5 cents per gallon and allocates a portion (1.08 cents per gallon) to WSF. WSDOT has also allocated roughly $375 million between 2017 and 2019 for capital expenditures for ferry vessels and terminals (Washington State Department of Transportation, 2017).

WSF benefits from an FRR of over 75%, which has increased from 66.2% in 2012. This is a result of the decrease in costs per rider while ridership increased, leading to reduction of the per-passenger subsidy to $2.21 in 2017. Declining fuel prices played a key role in this, dropping from over $3 per gallon in 2011 to just above $1.50 per gallon in 2017. Fuel costs in 2012 accounted for over a quarter of WSF's total expenses. However, since then fuel costs plummeted, resulting in a 42% decrease in total fuel expenditures even as fuel consumption increased. Annual fuel costs for 2017 were $36.5 million, just 15% of total annual expenses. In spite of this decrease, overall expenses increased by over $10 million during the same period due to labor cost increases (Washington State Ferries, 2017).

Economic Development

WSF contributes to the economies of urban areas around the Puget Sound in that it attracts commuters, employers, and communities across the Sound, who can take advantage of the system to live in less costly areas and commute, as well as residents who live on islands who rely on the system for the transportation of goods. The region as a whole is growing quickly, and areas surrounding terminals are especially active, as a concentration of transportation services and waterfront locations has attracted commercial and residential development (Washington State Department of Transportation, 2009).

Ferry service is not only beneficial to commuters, but has also been an invaluable asset to promoting the regional tourism industry. WSF has focused more on attracting recreational riders in recent years, as the proportion of passengers who use the system for leisure has been increasing, up to 46% of riders in 2013 (Washington State Department of Transportation, 2014). The ferry is a major tourist attraction for Washington for the views it offers and connections it provides. And when ferries are not operating, the tourism industry suffers, particularly for the islands that rely on the ferries to bring tourists. In the summer of 2017, ferry service to the San Juan Islands was drastically reduced for a two-week period due to maintenance issues with multiple vessels. This prevented many tourists from travelling, and threatened the island's tourist-related economic activity, as many people were forced to cancel their trips (Walsh, 2017).

For the islands that are accessible only by ferry, WSF is vital. Vashon Island in the South Puget Sound and the San Juan Islands in the northwestern corner of the state rely heavily on the ferry system, and especially the transportation of commercial vehicles. WSF's commercial vehicle services offer a much more cost-effective and faster provision of supplies for these communities (Washington State Department of Transportation, 2009).

Integration

WSF serves two main functions: The first is as a marine highway system, linking communities across the Puget Sound. Because of the emphasis on transporting vehicles on ferries, WSF acts as an extension of the highway system, and is treated as such by WSDOT. Vessels are also designed to accommodate commercial vehicles, which have proven to be valuable for industries that rely on the transportation of goods. Their second function is as a transit provider, with rapid service across Puget Sound and connections to other modes of transportation at terminals. WSF is the third largest transit system in Washington and commuters rely heavily on the ferry system, which alleviates pressure from other transit providers. With over 75,000 Puget Sound residents using WSF to commute to work or school weekday mornings, the regional transportation systems would not be able to absorb the additional ridership (Washington State Ferries, 2018).

WSF also provides connections between islands, such as Bainbridge Island and Vashon Island, to urban areas on the eastern Puget Sound. Though some of these islands are connected by roadways, the ferry dramatically reduces the time it would take commuters to travel by bus or motor vehicle. Providing such connections also enables many people to live in the region who would unable to do so. Rapid transit service across the Puget Sound allows for people to reside in areas with more affordable housing and take the ferry to school or work who would otherwise be priced out of

areas that are a similar distance from employment centers on the eastern side of Puget Sound (Washington State Department of Transportation, 2018).

Environmental Considerations

Like other ferry systems, WSF is concerned with mitigating their impact on the environment, and has implemented an environmental management system as part of their Safety Management System to ensure the protection of the Puget Sound and improve the sustainability of their transportation services (Washington State Ferries, 2018).

Beyond local environmental impacts, WSDOT sees WSF as essential to meeting their long-range Greenhouse Gas (GHG) reduction targets. 2020 emissions goals for all state agencies in Washington are set at 2008 baseline levels, with additional 25% and 35% reductions for 2035 and 2050. WSF is the largest contributor of GHG emissions in WSDOT, with the majority of their impacts a direct result of fuel consumption. Minimizing fuel consumption and efficiency is a primary concern of their environmental efforts, as WSF uses roughly 17 million gallons of fuel each year. Though reduced fuel costs have contributed to financial savings in recent years, WSF also priorities the reduction of fuel consumption of their vessels. This is done through the development a hybrid electric propulsion system, as well as the exploration of alternative fuels, such as biodiesel or liquefied natural gas, to reduce the environmental harm of their use. The hybrid propulsion system is expected to account for a large proportion of WSDOT's 2020 emissions reduction targets (Washington State Ferries, 2018).

Fuel reduction efforts also include an internal study of the relationship between vessel speeds and fuel consumption that recommended "revised throttle settings to maximize fuel efficiency" and contributed to savings of 180,000 gallons of fuel each year on a single route (Washington State Ferries, 2018).

Ten of the WSF terminals are EnviroStars certified, which indicates that they have made significant efforts to reduce waste and protect waters from harmful materials. WSF's environmental efforts are also certified by the PVA's Green Waters Program, which highlights their success in finding practical and cost-effective ways for adopting and expanding environmentally friendly practices

Services

Ferries can be used for emergency services for those living on islands who may be in need of medical attention. In serious cases, and if a helicopter is unavailable or weather prohibits air travel, WSF ferries are used to reach and possibly transport those in need of aid. The use of ferries for emergency purposes is not uncommon, with some locations requiring the service several times a week. Though such use of vessels can occasionally throw off schedules, delays and the reasons for them are communicated to passengers on impacted routes (Alzola, 2017).

Accessibility varies at different terminals, and at those with less accessible facilities, staff assists passengers. Vessels' accessibility similarly varies, with extensive upgrades to the majority of refurbished vessels to improve accommodations for disabled passengers.

Ferry services may be cancelled by strong winds or tidal currents, with the decision left up to ferry captains and administrators. Low tides can also hinder the loading and unloading of trucks or larger motor vehicles on some routes, so WSF doesn't permit these vehicles to operate during certain times.

Alaska Marine Highway System

Funding

Multiple levels of government are involved in the funding of AMHS. Operations funding predominantly comes from the state's General Fund. Once they receive the annual budget, AMHS develops an operating plan which includes maintenance projects. AMHS also receives federal funding, including $16.9 million from the FBD Program in 2017, the most of any ferry system. Total federal and state operations funding amounted to over $89 million in 2017, a 6% decrease from the previous year. Both total operating expenses and operating revenues decreased over the past few years, while the system-wide FRR has remained the same at below 30% (Alaska Marine Highway System, 2016a).

AMHS is not financially sustainable, and funding has been a challenge in the past. Budget constraints have required AMHS to consider the tradeoff between cost and service. The frequency of service has declined in recent years, and the number of vessels in operation has been reduced to try to lower costs. Other cost saving measures include the elimination of some on-board and terminal amenities, reduced marketing, the elimination of several vessel and shoreside positions, and the installation of more fuel-efficient engines. Some discount programs were altered and tariffs were increased in 2015 to try to raise additional revenue to support AMHS service. Alaska DOT tracks impacts of budget reductions on service levels, customer satisfaction, and on-time performance to try to achieve cost savings without disproportionately impacting services (Alaska Department of Transportation & Public Facilities, 2015).

Because it costs so much to operate, AMHS has often found itself on the chopping block when other state-provided services require more immediate funding. For example, in March 2017, Medicaid spending was significantly higher than projected, so $23 million was pulled out of the Alaska Marine Highway Fund to fill the gap (Schoenfeld, 2017). As recently as this past March, the system yet again faced the threat of a shutdown by mid-April if the Alaska Legislature could not approve an appropriations bill. Though funding was ultimately provided, the continual struggle is concerning for the long-term operations of the system (Brooks, 2018).

Economic Development

In spite of funding challenges, AMHS is vital to the overall economic health of the Alaska and the communities all along the state's southern coastline. In 2016, AMHS published a report that outlined the impacts of the ferry system on Alaska's economy and those who rely on it. The report was intended to demonstrate the necessity of the system and the benefits it provided as it (and the state) faced severe financial struggles. AMHS serves as the lifeline of many of the residents, as many of the communities are on remote islands or are in areas not accessible by the road system, so it is often the way residents in these communities transport their vehicles. Of the 33 communities it serves, only five are connected to Alaska's road system. As a result, the ferry system is the sole service provider and means of cheaply and reliably transporting goods to and from the majority of communities.

One of the largest contributions AMHS has to local economies is the transportation of container vans. In 2014, AMHS transported 3,862 vans which contained perishable goods to be delivered to communities throughout the southern Alaskan coast. Businesses (and individuals) that require fresh meat, seafood, dairy products, and vegetables rely on the ferry system for regular deliveries from the larger cities connected by the ferries. Shipping these goods by ferry is cheaper and allows for more frequent deliveries than sending them by air or other freight vessels (Alaska Marine Highway System, 2016a).

Apart from transporting container vans, AMHS contributes to economic activity in a number of ways. Many communities rely on the system for a variety of uses, ranging from the provision of groceries or supplies to access to health care in larger municipalities along the coast. AMHS works with the Alaska Tourism industry to promote the system, with a 2015 study finding that over 100,000 nonresident passengers from outside of Alaska spent an average of $1,300 per person per trip in 2014 in Alaskan communities (Alaska Marine Highway System, 2016b).

Integration

AMHS is not so much integrated with the transportation network as it is the transportation network for much the southwestern coastal region. For the terminals that are connected to the road network, passengers use the system to transport their vehicles to reach otherwise unconnected parts of Alaska. A few terminals are also connected to rail routes that travel inland in Alaska and Canada. Service is divided into three regions: Southwest Alaska, Cross Gulf, and Southeast Alaska. The vast geographies and sheer scale of the AMHS means there are many different types of services provided in these regions. Some trips can take days to travel between two terminals with access to the road network in Alaska. Others transport people and vehicles between smaller communities and to the larger terminals served by roadways. More rapid services are

also offered between multiple communities, stopping at several terminals each day (Alaska Marine Highway System, 2016a).

There are three types of ferries used for the different types of routes offered: mainline ferries, day boat ferries, and shuttle ferries. Mainline ferries transport passengers along routes that take more than a day to travel. They are the largest vessels and typically transport a high percentage of tourists. Day boat ferries are used for trips between smaller communities, where the vessel returns to home port at the end of the day. They are used mainly by residents in Southeast Alaska, connecting regional commerce, government, and health service centers. Shuttle ferries are most similar to urban linear ferries in that they are capable of efficiently transporting people along routes over shorter distances (Alaska Marine Highway System, 2016a).

Environmental Considerations

With such an expansive system, AMHS is concerned with minimizing their impacts on the environment, and they are Green Waters certified by the PVA for their commitment to doing so. AMHS employs a full time Environmental Specialist who oversees compliance with environmental regulations as well as the fulfillment of internal environmental plans for vessels and terminals. They also developed a “Ship to Shore” Environmental Guide, to provide guidance for employees on how to address environmental issues. As with other systems, finding ways to reduce environmental impacts without compromising efficiency or cost is a challenge, and AMHS is currently exploring new technologies, such as more efficient alternative fuels, and are developing programs to improve recycling and waste reduction and disposal practices (Alaska Marine Highway System, 2015b).

Services

As a state entity, AMHS is used is assist in certain emergency situations, and the Governor can decide to utilize their resources to provide aid. Ferries are used for emergency services when natural disasters, such as mud slides, avalanches, or severe weather, occur and road access to communities. In this case, AMHS will modify their schedules to provide more frequent trips to these areas to bring additional groceries, supplies, or equipment to assist with clean-up efforts. For example, during the Exxon-Valdez oil spill in 1989, one of AMHS’s vessels was used as a response boat, while another was turned into a command center for emergency teams (Alaska Marine Highway System, 2015a).

As some trips can last days, vessels offer a large variety of amenities so that travel on AMHS is comfortable and relaxing. Most mainline vessels include cabins for rent, cafes and restaurants, and a playground, as well as a heated solarium and observation lounges for views. Day boats provide showers for passengers who wish to use them, and

similarly offer a heated solarium and observation lounges (Alaska Marine Highway System, 2015a).

All vessels have elevator access and vessels that have cabins all have at least one wheelchair accessible cabin. Accessibility is managed by the Passenger Services department.

Seasonality has a large impact on ferry operations. During the fall, winter, and spring, service is reduced so that vessels can undergo maintenance for several weeks on a rotational schedule. During this time, ships may be refurbished and upgraded to maintain compliance with regulations. Aside from these service reductions, policies are consistent throughout the year, though services may be cancelled in the event of extreme weather.

Staten Island Ferry

Funding

As a city agency, funding for the Staten Island Ferry primarily comes from the city's budget. Municipal ferry operations and maintenance received $87.5 million in 2017, which includes the Staten Island Ferry as well as the Hart Island Ferry services which runs just twice a month to Hart Island in the Bronx. $51.2 million comes directly from the city, with an additional $33.3 million from the state and federal government and $3 million from various other sources (The Council of the City of New York, 2017). They received over $5 million for the FBD Program in 2017. However, they are attempting to rely less on federal assistance in the near future, as there are concerns over the availability of federal money.

Because the Ferry is free, no funding can be recouped through the farebox. However, the $5.16 per-passenger subsidy indicates that, were they to charge for ferry services, a $5.16 fare – similar to what many other systems are charging – would provide a 100% FRR.

Economic development

Though attributing all of the economic activity in Staten Island and especially in Manhattan surrounding the terminals would certainly not be accurate**,** the Ferry is directly responsible for a number of current developments around the St. George Terminal in Staten Island. A ferry route between Manhattan and Staten Island has been operating since the 1740s, long before it was incorporated by New York City in 1905. As a result, the Ferry has promoted much of the economic activity between Staten Island and Manhattan for hundreds of years.

The current, primarily residential, developments around the St. George Terminal are not intended for the communities that are already living in the area, which tend to be much lower socioeconomically. Instead, the upscale residential developments being built around the terminal are meant strictly for those who will use the Ferry to commute into

Manhattan. The stores are apartments being constructed in this area are geared toward a demographic that does not yet live there in anticipation that people will choose to move for the access into Manhattan that the Ferry provides. Housing costs around the terminals in both boroughs have been skyrocketing, though of course Staten Island is still far cheaper than Manhattan, so people would prefer to take the large discount of living in Staten Island with a direct, free commute into Manhattan.

Tourism, though not promoted by NYCDOT, is nonetheless a beneficiary of the Staten Island Ferry's services. Many tourist companies market the Ferry as an attraction, but NYCDOT plays no role in such promotions. Though NYCDOT does not keep track of the ratio of commuters to recreational riders, a large portion of the increased ridership since 2013 has come at night and on weekends, indicating that tourists are responsible for this growth, even without direct marketing.

Integration

The Ferry route predates much of the transportation network in New York City, and plays a key role in the city's transportation network. The system functions so that a passenger can take a bus or train from the southern tip of Staten Island to St. George Terminal, take the ferry across the harbor into Manhattan, get a free transfer from Whitehall Terminal to a subway and take the subway all the way up Manhattan through the Bronx, all for a single $2.75 fare.

Ridership has increased significantly over the past few years, with an additional 2.5 million annual passengers between 2013 and 2017. This annual growth is three times as large as previous projections had predicted, even before the new developments in Staten Island have opened. These numbers may be a symptom of the growing population of New York City, but they may also be attributed to the increasing congestion in Manhattan. People who work in Manhattan must find a way of getting there every day, and the roadways are so congested that buses, even with all of the improvements NYCDOT is making, are not able to meet the demand for efficient transportation during peak hours.

The Staten Island Ferry operates between two multimodal transportation hubs: St. George in Staten Island and Whitehall in Manhattan. St. George offers connections to 22 bus routes and Staten Island Rapid Transit. Whitehall Terminal similarly provides connections to four bus routes and four subways lines at the terminal, with many more within a walking distance, including NYC Ferry for services across the East River. Schedules are coordinated with the Staten Island Ferry, though not by the Ferry itself. With the number of buses and trains that connect to the terminals, it is easier for bus and subways operators to plan according to the Ferry's schedule. Bus ramps are attached to the St. George Terminal in Staten Island, which allows for control towers for bus operators to keep track of the Ferry's location and hold buses until for a reasonable amount of time if the Ferry is running behind schedule.

However, with an on-time percentage consistently above 90%, the Staten Island Ferry is much more reliable than other modes of transportation in NYC. Though the waterway in which it operates is heavily trafficked by tankers and container vessels, conditions are far superior to the gridlock that buses face. Harbor traffic can occasionally cause delays, but these are insignificant compared with what buses deal with. Compared with the deteriorating infrastructure of the NYC subway system, the Staten Island Ferry is in far better shape.

The terminals were redesigned and rebuilt in the past 15 years, but the redesign was not ideal for moving large amounts of people. In the summer or during peak hours, each trip can transport over 2,000 passengers. To adhere to the scheduled 30 minutes per trip with the 25 minutes it takes to travel across the Harbor, the Ferry must be able to unload 2,000 passengers and then load 2,000 more in five minutes. St. George Terminal in particular is prohibitive to this mass movement of people, which can be detrimental to adhering to the schedule. NYCDOT is working with consultants to try to mitigate this issue, since ridership is expected to continue to increase and they are already at a critical mass for keeping the schedule trying to move 2,000 passengers on vessels that can carry up to 5,300.

Environmental Considerations

Environmental considerations generally do not extend beyond regulatory compliance. The Staten Island Ferry strictly adheres to the various regulatory bodies. While some of their facilities have incorporated more environmentally friendly technologies, such as a solar farm on the roof of a maintenance facility, they generally do not make major efforts to mitigate environmental impacts beyond what is required.

The New York City Council recently passed legislation requiring all city ferries to use biodiesel. However, NYCDOT has pushed back on this, because their own research demonstrated that the fuel would not perform well with their vessels. Because of the enormous size of the vessels, the filtration system they use would remove the benefits of the biodiesel and would have to be replaced far more frequently, possibly even contributing to a reduction in fuel efficiency.

Services

NYCDOT is currently constructing three new vessels at a cost of $294 million, with the first expected to begin operating in late 2019 (The City of New York, 2017). Their current fleet of eight vessels consists of six large boats – with capacities of up to 5,300 passengers – and two small boats – with capacities of roughly 1,100 passengers – that are used for service at night. With the addition of three vessels, NYCDOT is decommissioning two boats that have outlived the 45-year useful lifespan at which NYCDOT tries to replace them and using some parts for the construction of the new vessels to lower costs.

The net addition of a single vessel is necessary due to the rapidly increasing ridership on the Staten Island Ferry. As ridership grows, the strain on the Staten Island Ferry infrastructure and vessels increases, and maintenance issues become more frequent. They also must adhere to a regulatory requirement for boats to be dry docked twice every five years, which cost over $2.8 million in 2017 (The Council of the City of New York, 2017). A full rush hour schedule requires four vessels in operation at one time. In 2017, there was a period of two weeks where, due to dry docked vehicles and maintenance issues, they were only able to operate three vessels, and were forced to run a reduced schedule to the ire of passengers and politicians. Though a few of the larger vessels have vehicle capacities, no vehicles have been allowed on the Ferry since September 11th, 2001 for security and efficiency purposes.

The Staten Island Ferry has played a major role in the provision of emergency services in New York City. They operated through 9/11 to bring first responders, emergency vehicles, and medical staff to areas in Manhattan where they were needed. The Ferry also served as an evacuation route out of Manhattan for many people who otherwise could not leave because most other modes of transportation were shut down. The decision to do so was made by the Mayor, who much like the Governor for state-operated services, can direct the Ferry's service in emergency situations.

Though the Ferry was vital for providing transportation to and from Manhattan on 9/11, it is generally not used for minor or even other major disruptions to the transportation network. Because of the size of the vessels, they are limited by the number of slips at which they can dock, which restricts the routes they are able to run. Therefore, they are not well suited to providing services when other modes of transportation are unable to, which usually falls to the private ferry operators in New York City.

The Ferry complies with Coast Guard and ADA regulations regarding accessibility, and they are audited by the FTA to ensure compliance with accessibility requirements. They also received $600,000 from the city in 2018 to implement lower level boarding at the Whitehall Terminal, which not only facilities boarding for people with limited mobility, but also increases boarding efficiency by allowing larger volumes of passengers to board at once (The City of New York, 2017).During inclement weather or periods of reduced visibility, service is reduced to either 20 or 30-minute headways compared with the regular 15 depending on the severity. They are also subject to wind speed restrictions enforced by the Coast Guard which may prohibit the operation of certain vessels or require certain decks to close. For extreme weather events, such as Hurricane Sandy in 2012, services are shut down entirely.

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