

TRANS-HUDSON COMMUTING CAPACITY STUDY

# Appendix A: Interstate Bus Network - Operational and Service Strategies

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Submitted by:



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# 1 Introduction

## 1.1 OVERVIEW

On October 22, 2015, the Port Authority of New York and New Jersey’s (PANYNJ) Board of Commissioners authorized a *Trans-Hudson Commuting Capacity Study* (the Capacity Study) to evaluate a range of strategies for meeting and managing the anticipated increases in trans-Hudson commuter demand to 2040, to inform its deliberations on conceptual planning for replacement of the Port Authority Bus Terminal (PABT) (Table 1).

Table 1: Existing and Future PABT Demand

EXISTING (2011)	FUTURE (2040)
232,000 Daily Customers	337,000 Daily Customers (+45%)
7,800 Daily Buses	9,100 Daily Buses (+15%)
615 PM Peak Hour Buses	855 PM Peak Hour Buses (+40%)

Source: Midtown Bus Master Plan

The fundamental premise of the Capacity Study is that the transportation network that accommodates trans-Hudson commuter demand is an integrated *system*, as opposed to a series of stand-alone corridors, facilities, and services. Accordingly, the intended outcome of the Capacity Study is an updated overview of that system that takes into account potential investments in physical transportation infrastructure, operational changes to existing transit services, implementation of emerging technologies, and modifications to public policy – and the prospects for their implementation in the time frame for planning and implementing a PABT replacement project.

Concurrent with the Capacity Study, the PANYNJ has commissioned an *International Design + Deliverability Competition* (the D+D Competition) seeking concepts for a new PABT. A major objective of the Capacity Study is to provide insight to the D+D Competition by evaluating the range of alternative strategies for serving the trans-Hudson commuter market via bus and other modes, which will inform the determination of the appropriate capacity and configuration of the new PABT. The interim and final work products from the Capacity Study will inform the D+D Competition and the PANYNJ Board, which will select a preferred design concept for a new PABT this fall.

The purpose of this technical memorandum is to develop a range of potential bus operations/service, roadway network, technology and policy strategies that could inform the planning and design (capacity and configuration) of the new PABT. This document identifies and evaluates a series of strategies, including a comparison of benefits, impacts, and policy issues. The strategy development and assessment were informed by: the Midtown Bus Master Plan (MBMP) effort, meetings and technical discussions with PANYNJ and NJ TRANSIT staff, and a Capacity Study Expert Workshop held on April 14, 2016. The final section of this technical memorandum provides targeted findings, including identification of factors relevant to the D+D Competition process. Subsequent technical memoranda will consider multi-modal network strategies and workplace flexibility strategies to

either complement or serve as alternatives to the bus network strategies in this technical memorandum.

## 1.2 STRATEGY DEVELOPMENT AND GUIDING PRINCIPLES

The strategies defined in the Capacity Study comprise a range of bus operational and service scenarios to meet projected peak period trans-Hudson commuter demand in 2040. They include a combination of investments in transportation infrastructure, modifications to existing bus routes, implementation of emerging technologies, and changes to public policy. The strategies fall into two categories:

- Strategies that **increase/manage capacity along the Lincoln Tunnel corridor** to support a new PABT that accommodates forecasted peak demand as identified in the MBMP
- Strategies that **address overall Trans-Hudson demand** including the use of other modes/crossings

The review of previous work efforts, discussions with PANYNJ and NJ TRANSIT staff, and input from the Capacity Study Workshop attendees led to the definition of several guiding principles that framed the development and assessment of strategies.

- **Apply a systems approach** – The PABT is just one component of a trans-Hudson bus transportation system that extends from 8<sup>th</sup> Avenue in Manhattan to the New Jersey Turnpike five miles to the west and beyond. In order to handle future demand for trans-Hudson bus travel during peak hours, all elements of this system – the approaches to NJ Route 495 from the NJ Turnpike and Route 3, the ramps that make up the ‘teardrop’, the Exclusive Bus Lane (XBL) and other lanes of 495, the Helix, the toll plaza, the Lincoln Tunnel tubes, the ramps leading into PABT, the PABT itself, and locations for bus storage and staging on both sides of the river – function as a system and future improvements should be configured accordingly. Each element is currently functioning at or near its capacity during peak periods on the average weekday such that investments or policy changes that expand throughput capacity in one segment without addressing upstream and downstream effects will not have meaningful system-wide results. Reconstruction of the PABT with provisions to accommodate increased ridership should proceed in coordination with other capital, operational, and policy changes that will support improved performance of the system for travelers and the communities on the network.
- **There is significant latent demand for trans-Hudson bus travel** – All future planning must consider that the trans-Hudson bus system has built-in latent demand such that capacity or service improvements are quickly filled with increased passenger activity. In robust but capacity constrained travel markets like trans-Hudson transit, the concept of latent travel demand is key to understanding how commuters will react to changes on the network. Currently, bus service at the PABT is limited by operational constraints, and operators offer less service at the peak than their customers desire to consume. In this context, if strategies are employed that shift demand from PABT as a way to create new capacity at PABT for anticipated future growth, the reality

is that existing latent demand would fill any additional capacity. NJ TRANSIT has experienced evidence of this phenomenon on prior trans-Hudson projects. NJ TRANSIT staff has advised the study team that it would add more peak-period service from certain markets to the PABT today if capacity were available. It is also important to note that latent demand implies growth above and beyond the demand forecasts. A more detailed discussion of latent demand is included in Section 4.1 of this technical memorandum.

- **Short-term improvements are needed** – Projected ridership growth will continue to put more pressure on the interstate bus network long before the new PABT is available, sometime between 2025-2030. Daily customer demand at the PABT is forecast to increase 20% by 2020 and 30% by 2030, compared to the 2011 base year. Wherever practical, the involved agencies should develop and advance interim strategies identified here to relieve capacity bottlenecks along the Lincoln Tunnel corridor and the connecting roadway network, some of which may require significant planning and capital investment. As the same time, the bus strategies for shifting some demand from the PABT to other trans-Hudson crossings should be considered by the involved operators and transportation agencies, including pilot services to test strategies that may provide attractive alternatives for some commuters in the near-term and test their potential as long-term options to route trans-Hudson bus service via other parts of the regional transportation network.

## 2 Lincoln Tunnel Corridor/PABT Facility Strategies

The Lincoln Tunnel corridor includes a series of elements that work as an integrated system to deliver buses to and from the PABT: the PABT facility itself, roadway/ramps that connect the Lincoln Tunnel and the PABT, the Lincoln Tunnel, the toll plaza, the Lincoln Tunnel Helix, Route 495/XBL, regional highways (NJ Turnpike, Route 3) and local approaches to 495 (Figure 1).

Figure 1: Lincoln Tunnel Corridor System Elements



Source: Trans-Hudson Commuting Capacity Study; Lincoln Tunnel XBL Capacity Enhancement Feasibility Study; Lincoln Tunnel HOT Lane Feasibility Study

The bus system capacity into the PABT is a function of bus type, service frequency, operating characteristics of the approach roadways, the capacity of the Lincoln Tunnel, the capacity of the bus terminal to process buses, customer demand, and the capacity of outbound roadways. It is also worth noting that many non-PABT buses use this corridor, including New York City Transit (NYCT) and Academy express buses from Staten Island, and private operators from New Jersey and Pennsylvania that offer their customers the option of one-seat crosstown service as an alternative to stopping at the PABT. Current projections for growing usage of a reconstructed PABT show a likely

increase in customer demand of 45% between 2011 and 2040, which is expected to increase peak hour PM bus departures from 615 in that base year to 855 in 2040. Broadly speaking, matching passengers with buses for afternoon departures requires far more physical space than morning arrivals, so the ultimate capacity and configuration of a reconstructed passenger terminal is driven by number of departing buses and passengers to be accommodated during the busiest afternoon rush hour (i.e., the PM peak hour, 5:30-6:30PM).

The following sections describe potential bus operational and service strategies that could increase or manage capacity along the Lincoln Tunnel corridor to support a new PABT that fully accommodates this projected future demand. The strategies are bundled into two groupings: (1) improved corridor operations; and (2) improved facility operations.

The strategies aim to address challenges facing the corridor in both the AM and PM peak periods. There are different challenges in the AM and PM peak periods—including, but not limited to, capacity of the XBL in the AM peak period, and travel time reliability for empty buses dispatched from New Jersey to the PABT in the PM peak period—that warrant different solutions. For instance, adding a second XBL would improve bus throughput to the PABT in the AM peak period, but it would not improve the challenges related to real-time dispatching of west-of-Hudson buses to serve the PABT in the PM peak period. Accordingly, many of the strategies discussed in the following sections are complementary in that they aim to address different challenges along the corridor and within the PABT.

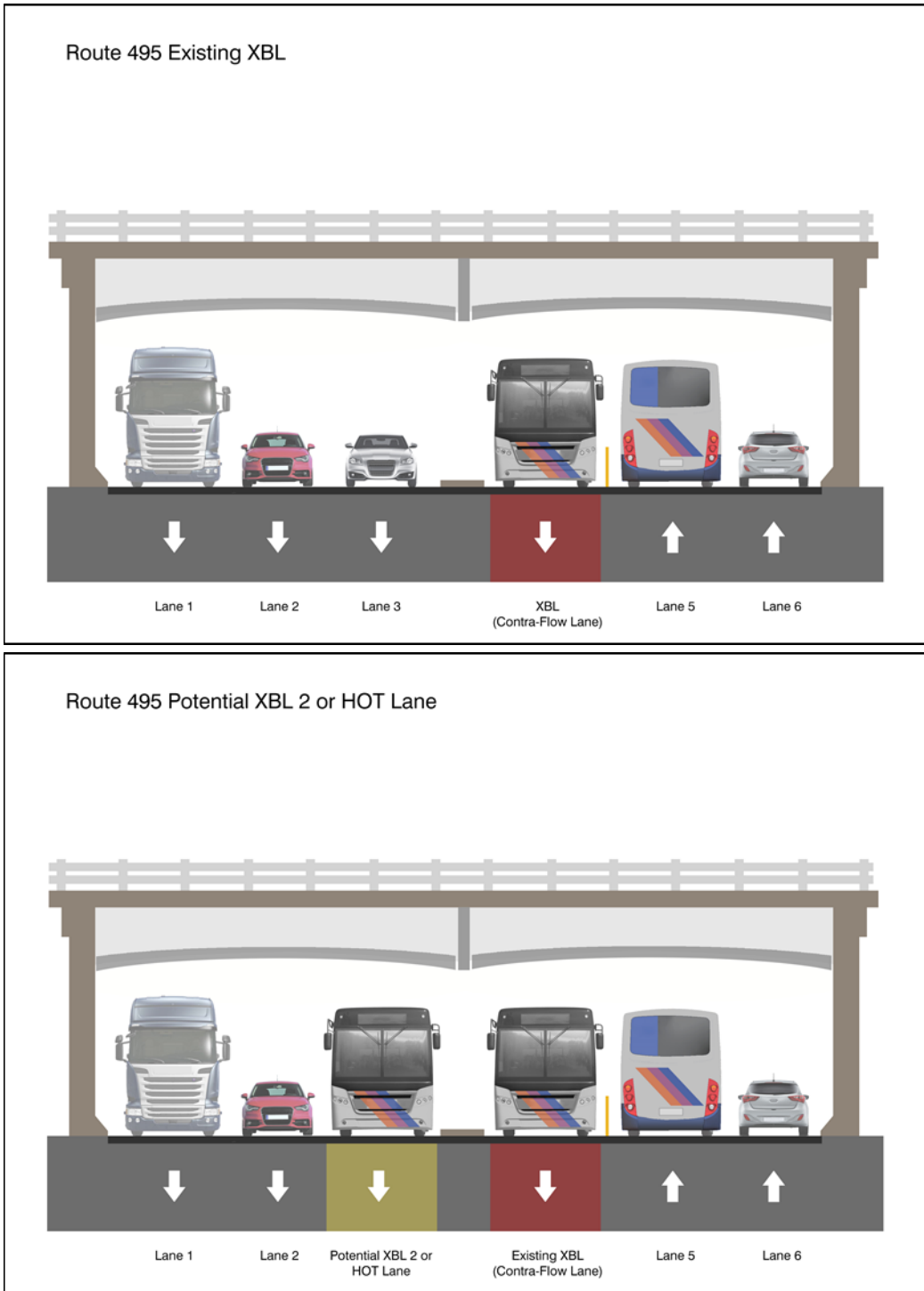
## 2.1 IMPROVED CORRIDOR OPERATIONS

The roadway network used to connect buses and other vehicles with the Lincoln Tunnel and local destinations in New Jersey is at or over its design capacity for a significant portion of the workday. Strategies to improve its capability to handle increasing bus volumes efficiently must address these constraints and balance the varied demands served by this critical corridor. The challenges include Route 495 itself, its connections to Route 3 and the NJ Turnpike, and local-access needs. Efforts to manage and prioritize the flow of buses and other traffic to and from the Lincoln Tunnel must be reconciled with growing volumes of local trips fueled by ongoing development along the corridor. Even with regard to the trans-Hudson bus flows, while the XBL feeds approximately 65,000 passengers along the Helix to the toll plaza and tunnel during the average morning rush (6-10 AM), approximately 30,000 more passengers travel on local bus routes that do not use Route 495 and instead access the tunnel from local streets that connect to the center ramp approach.

### 2.1.1 Second XBL or Route 495 HOT Lane

This strategy calls for adding either a second inbound XBL or a high-occupancy toll (HOT) lane on Route 495 to complement the existing inbound contra-flow XBL (Figure 2). The purpose of this strategy is to provide additional capacity for bus prioritization on Route 495, while also balancing overall vehicular demand with available capacity along the corridor. This strategy was examined in the *2006 Lincoln Tunnel XBL Capacity Enhancement Feasibility Study* and *2009 Lincoln Tunnel HOT Lane Feasibility Study*.

Figure 2: Route 495 Existing XBL and Potential XBL 2 or HOT Lane (Looking West, During AM Peak Period)



Source: Trans-Hudson Commuting Capacity Study; Lincoln Tunnel XBL Capacity Enhancement Feasibility Study; Lincoln Tunnel HOT Lane Feasibility Study

The 2009 study noted that, “the practical capacity of the XBL has been reached and periodically exceeded, with peak-hour volumes of 650 buses or more.” The 2.5 mile XBL is a critical link in the Lincoln Tunnel corridor, connecting the NJ Turnpike and Route 3 with the Lincoln Tunnel, which feeds the PABT. Given the combination of existing capacity constraints and projected future growth of PABT bus demand, the recent studies by the PANYNJ in 2006 and 2009 evaluated opportunities to enhance the capacity of the Route 495 XBL to accommodate additional buses.

The 2006 study suggested that a potentially feasible option for expanding bus prioritization along Route 495 during the morning rush would be to convert one of the three existing eastbound general purpose lanes to a second XBL. Other alternatives that were considered and eliminated from consideration due to a range of potential traffic and other environmental impacts included converting another westbound general purpose lane to function as a second contra-flow XBL or accommodating a second XBL by either widening Route 495 or constructing an elevated roadway for local traffic. The 2009 study advanced the previous work by noting that although a single XBL is not sufficient to service future bus demand, two such lanes offer more capacity than necessary, and identifying a preferred alternative that would enable full utilization of the second priority lane, thereby minimizing potential adverse traffic impacts along the corridor.

Specifically, the 2009 study proposed conversion of the left lane of eastbound Route 495 to a value-priced managed use lane (or HOT lane) in which buses could access the lane for free and other vehicles would also be permitted access for a variable charge. Based on travel demand projections, a second XBL would not be fully utilized by buses alone in the near-/mid-term, which would result in unused lane capacity along the already congested Route 495. This would exacerbate congestion upstream and also would impede access to local destinations along the route. A HOT lane would address this imbalance by imposing a charge on other vehicles to use the lane, and the price would be “changed dynamically to maintain free-flow conditions in the HOT lane.” The study noted that the pricing system could at times post “bus only” to restrict automobiles from accessing the HOT lane. In the long term, if growth in bus demand warrants exclusive use of the priority lane by buses, the HOT lane could be converted to a second XBL.

The 2009 study considered a total of eight alternatives for the HOT lane that varied based on access from the NJ Turnpike, pricing of carpools, and truck restrictions, but also shared a number of key assumptions. For instance, under all alternatives, vehicles on the Route 495 HOT lane would merge with additional high-occupancy traffic from the Center Ramp at the Lincoln Tunnel toll plaza and would use the right lane of the Lincoln Tunnel Center Tube. The study indicated that the need to merge with other traffic prior to entering the Lincoln Tunnel would be a “critical constraint to the maximum volume that can be accommodated in the HOT lane,” whereas the existing XBL connects Route 495 to the Lincoln Tunnel by way of a dedicated free-flow toll lane at the toll plaza. Accordingly, although the capacity of each lane of the Center Tube is assumed to be 1,200-1,400 vehicles per hour (depending on mix of vehicle types, and absent any connected vehicle technology), the capacity of the HOT lane may be lower because of the merge with other vehicles from the Center Ramp approach.

Other commonalities among the alternatives considered in the 2009 study included that all buses from Route 3 destined for the Lincoln Tunnel would use the HOT lane, while buses from the NJ Turnpike would continue to use the existing XBL and the left lane of the Lincoln Tunnel Center Tube. The study also acknowledged the PANYNJ's plan to implement all-electronic toll plaza operation at the Lincoln Tunnel.

The preferred alternative that emerged from the 2009 study included consideration for both a near-term solution—with no access improvements for NJ Turnpike traffic to access the proposed HOT lane—and a long-term solution, which would include extensive construction to enable direct access from the NJ Turnpike without the need to weave across Route 495.

Potential benefits associated with this strategy include increased capacity for bus prioritization along Route 495, improved travel time and reliability, and additional revenue generation for the PANYNJ (through collection of the HOT lane charge). Potential impacts associated with this strategy include diversion of auto traffic to other congested trans-Hudson crossings, additional delay in the remaining general purpose lanes, congestion at the NJ Turnpike approaches to Route 495 (because of the multiple-lane merge to access the potential HOT lane), and additional delay at the Lincoln Tunnel toll plaza. Public policy issues that would need to be addressed to advance this strategy include determination about the time of day for prioritization, number and location of access points to the lane, minimum desired speed to inform pricing for the lane, safeguarding local access and egress, and enforcement mechanisms. Other important considerations include timeframe for implementation and jurisdictional coordination, including a determination of agency responsibilities. Additionally, implementation of this strategy would include some ramping improvements with an associated capital cost.

It is important to note that the problem this strategy aims to address—insufficient AM peak hour capacity for bus flow into Manhattan—is also directly addressed in Section 2.1.3 regarding bus platooning (the ability to tightly group up a set number of buses essentially operating as a single unit). Indeed, these two strategies should be seen as alternate methods for achieving similar throughput goals. However, current demand projections do not appear to warrant the additional capacity that would result from both strategies being applied together. There are trade-offs associated with the two strategies. For instance, higher bus throughput in one lane rather than two has clear advantages for other eastbound vehicles, but a second lane would create a redundancy benefit that better technology cannot fully provide. For instance, in the case of a disabled bus or a glitch on an automated bus in a single lane, the entire operation could be compromised. With two lanes, however, some throughput could be maintained, and there could also be more flexibility in responding to the incident location.

**Conclusion: Demand currently approaches or exceeds capacity along the XBL, which provides prioritization for buses along Route 495 to access the Lincoln Tunnel enroute to the PABT. Implementation of a second XBL would improve AM operating conditions for buses, but it would not be fully utilized in the near-/mid-term and would degrade operating conditions for other vehicles remaining in the two general purpose lanes. Therefore, a HOT lane would be a better solution than a second XBL if lane utilization**

can be optimized. This corridor improvement can be accelerated for early implementation to address existing capacity constraints—which are projected to get worse in the future—for buses along Route 495, although implementation should be coordinated with measures to relieve bottlenecks to the Route 495 approaches (discussed in the next section). Additionally, whereas a second XBL would constrain automobile access, implementation of a HOT lane would enable continued use of the repurposed lane by some automobiles through payment of a variable charge. In the long term, the HOT lane could be converted to a second XBL if warranted based on projected growth in bus demand beyond 2040. A careful study of bus platooning technology should be undertaken to determine if the higher throughput needed to service an expanded PABT can be met without a second XBL or HOT lane.

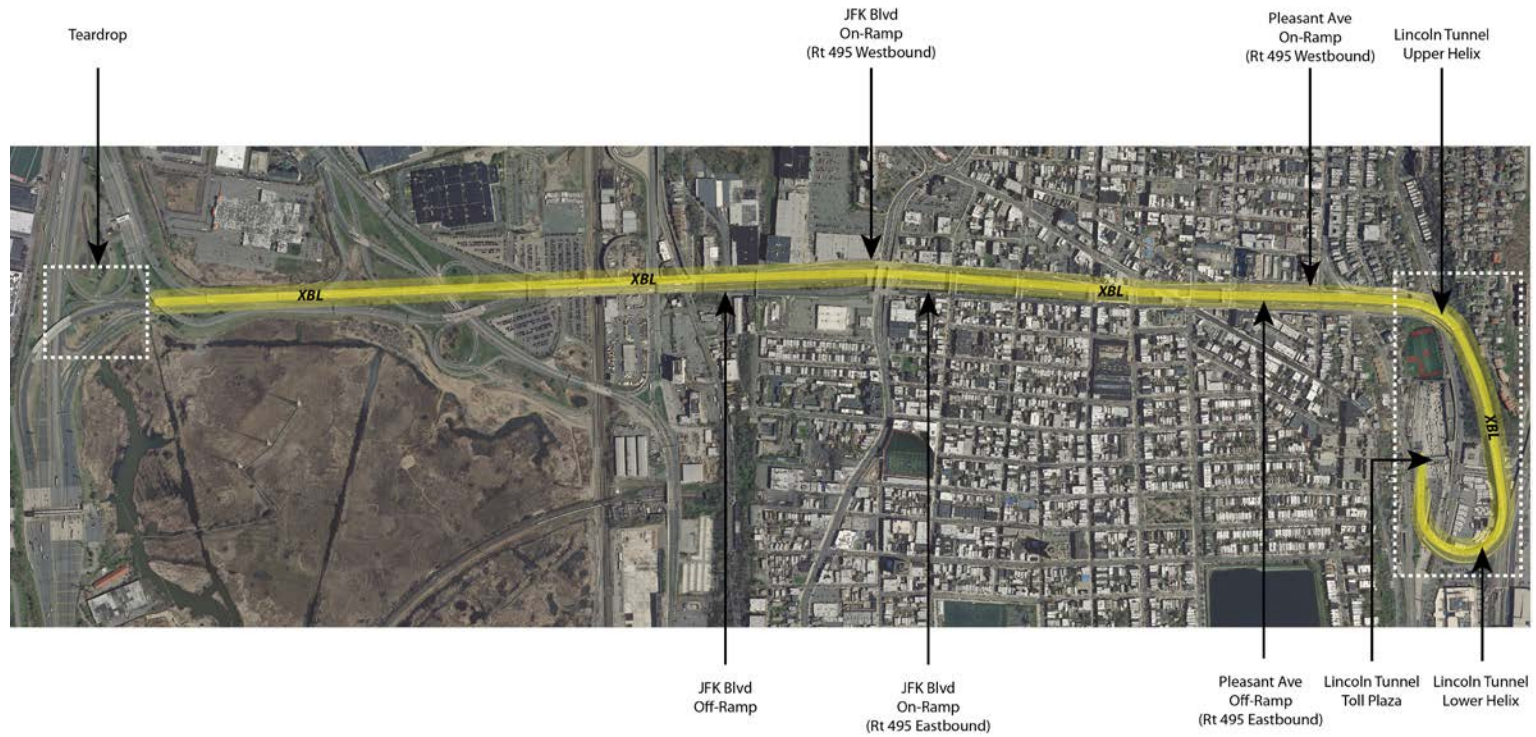
### 2.1.2 Enhanced Bus/HOV Priority Network

This strategy calls for improving bus/HOV priority within the existing Lincoln Tunnel corridor network, as well as adding bus/HOV priority on the major Route 495 approaches including Route 3 and the NJ Turnpike. The purpose of this strategy is to enhance the operation of the existing XBL and also supplement the XBL by providing additional bus prioritization farther upstream from the Lincoln Tunnel. Route 495 is shown on Figure 3. Corridor pinch points (from west to east) include NJ Turnpike Interchange 16E, the teardrop, protection of local access/egress at JFK Boulevard and Pleasant Avenue, and bus flow through the toll plaza.

This strategy builds upon ongoing studies and planned capital improvements by the PANYNJ. As part of the PABT Quality of Commute Program, the PANYNJ is advancing an initiative to improve incrementally bus prioritization at the approaches to the existing XBL. Specifically, the PANYNJ is proposing to realign the teardrop interchange that provides access to the XBL (Figure 4), which constrains the operational efficiency of the corridor due to pinch points in the merging area. The purpose of the proposed realignment is to provide additional length on the merging segment to increase the XBL throughput. Additional benefits of the proposed project include better alignment of the teardrop with the XBL, improved signage, and provision of a bus breakdown area and a protected area for PANYNJ police. The project is proposed for near-term implementation in coordination with the NJ Turnpike Authority.

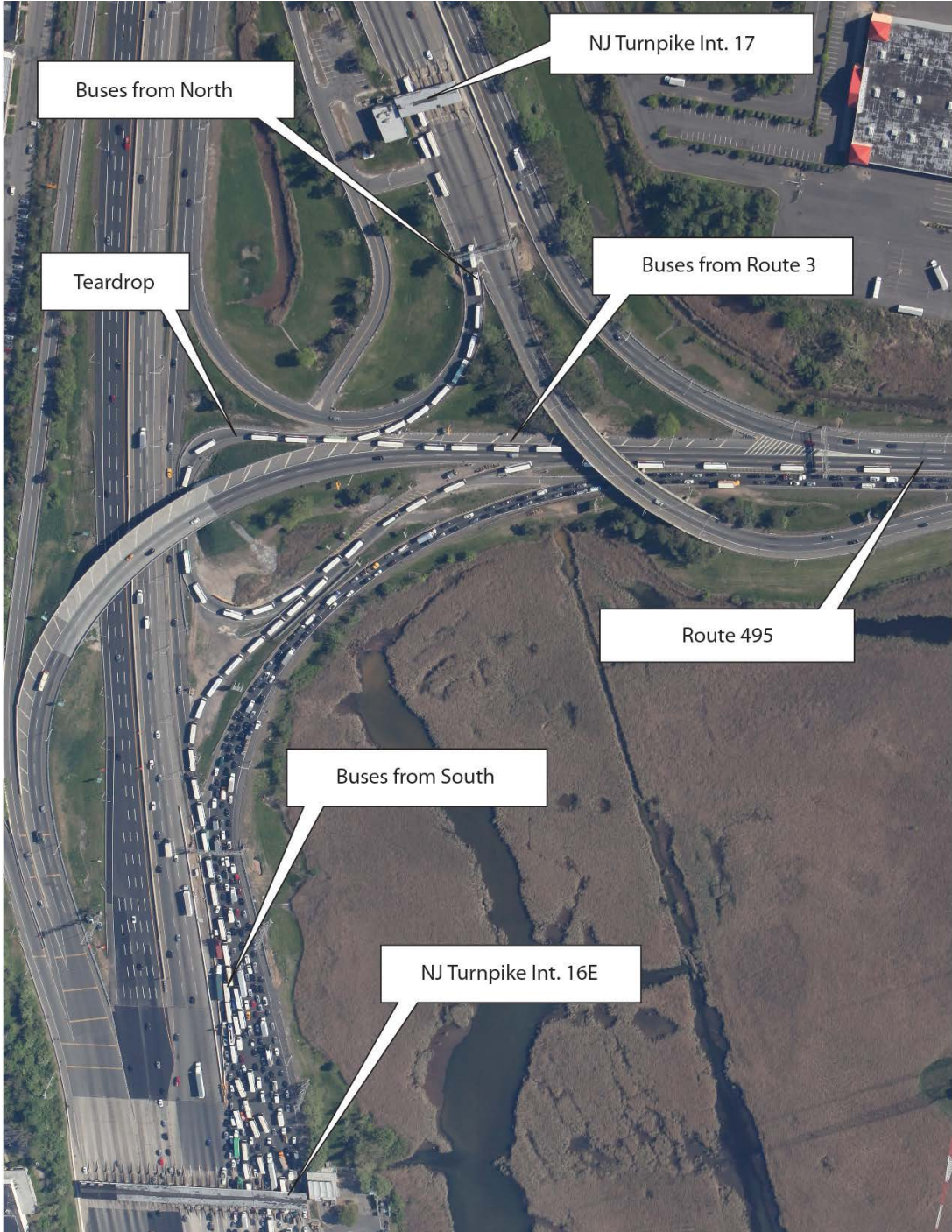
Nearby, another location that slows the efficient flow of buses toward the XBL is at the NJ Turnpike 16E interchange. Buses coming north on the Turnpike exit here in mixed traffic, navigating beyond the toll barrier in heavy peak-period volume toward a single lane that merges with buses coming through the teardrop. Identifying options to ease this bottleneck would improve reliability for this segment of the PABT-bound bus market.

Figure 3: Route 495



Source: Trans-Hudson Commuting Capacity Study

Figure 4: Teardrop Interchange



Source: Trans-Hudson Commuting Capacity Study

In addition to that effort, other potential actions could be taken to expand the priority network for buses that serve the trans-Hudson commuter market. Physical modifications to the teardrop to reduce merging conflicts would reduce delays at this bottleneck, providing more reliable travel time for buses and potentially reducing operating costs. Identifying capital resources for system enhancement projects like this is challenging as transportation agencies prioritize state-of-good-repair needs. Next steps for this initiative would be engaging the involved transportation agencies to discuss potential improvement options and scope a study including analysis of feasibility and impacts on travel times and overall traffic.

Public policy issues that would need to be addressed to advance this strategy include inter-agency coordination with the New Jersey Department of Transportation (NJDOT), the NJ Turnpike Authority, and municipalities with jurisdiction over local roadways that intersect the approaches to Route 495. Additionally, the evaluation of added bus prioritization options would need to consider the auto diversion factor. Specifically, while a reduction in the volume of private auto traffic during peak periods could provide significant benefits for bus operations, this strategy (and others that consider additional bus prioritization) would require more detailed analysis of impacts on general traffic and the resulting public policy implications (i.e., regional traffic, air quality, and transit-demand impacts).

It is also important to note that implementation of additional priority treatments along and at the approaches to Route 495 would need to maintain access for trips using this corridor that are oriented to local destinations in New Jersey. The New Jersey waterfront has experienced new development in recent years, and more growth is projected in the future, which underscores the need to preserve access to and from Route 495 for local trips that would not directly benefit from improved interstate bus service.

**Conclusion: The addition of bus prioritization at the Route 495 approaches could improve travel time, reliability, and operational efficiency of the Lincoln Tunnel corridor for trans-Hudson bus commuters. In conjunction with other Lincoln Tunnel corridor strategies, elements of this strategy could be accelerated for early implementation to address existing pinch points in the interstate transportation network that feeds the PABT. The full benefits of this strategy would likely only accrue if other strategies are advanced to improve capacity constraints along Route 495, within the Lincoln Tunnel, and at the PABT.**

### 2.1.3 Bus Platooning through Connected and Automated Vehicle Technologies

Emerging technologies can yield further improvements in capacity and flow beyond the high level of performance that drivers have sustained in the current intensive operation. Indeed, emerging technologies can safely and reliably assist drivers to enable existing lanes to serve many more buses and thus many more customers. Bus platoons refer to tightly spaced groups of buses, in this case enabled by connected technologies (such as systems for adjacent buses to communicate speed, distance, and braking information) and autonomous technologies (such as driver assist for lane keeping through driverless buses). There are already commercially available systems from passenger cars and trucks—as demonstrated in the April 2016 European Truck Platooning Challenge

(Figure 5)—that could be adapted to buses. Accordingly, near-term implementation within 10 years could potentially yield an increase in capacity of the XBL, as suggested by a collaboration of researchers at Princeton University and as discussed at the Capacity Study Workshop on April 14, 2016.

Figure 5: Route Successfully Completed by Truck Platoons from the April 2016 European Truck Platooning Challenge



Source: Arstechnica; EU Truck Platooning;

This strategy includes technology solutions such as Lane Keeping Assist, Blind Spot Warning (for drivers and pedestrians), Adaptive Cruise Control, Autonomous Emergency Braking, Collision Warning and Mitigation, and Obstacle Detection. Individually or in combination, most of these solutions exist today and can be implemented to immediately improve operations along the corridor. As discussed at the Capacity Study Workshop, and as noted in a presentation by Jerome Lutin and Alain Kornhauser at the 2014 Transportation Research Board Annual Meeting, some experts predict that the cost of installing these solutions could be recovered in as little as one to two years through reductions in casualty and liability claims alone.

A platoon could consist of two vehicles, or as many as four or five vehicles. A bus platoon would function as follows – As the vehicles “connect” into their platoon, their on-board computers would designate one vehicle as a lead and the others as followers. The key is that the lead bus would set the pace, the following buses would match their pace with shorter following distances, and—thanks to lane keeping and adaptive cruise controls—the platoon would maintain a steady trek down the corridor with consistent headway and speed. In the event the lead vehicle has to slow down, automatic braking technology in the follower vehicles could react quickly and efficiently to ensure the consistency and headway remains steady.

For the purposes of this strategy, the Phase 1 deployment would be limited to the XBL and Lincoln Tunnel where mixed vehicles are not present. Once there is more experience with bus platooning along the XBL, Phase 2 deployment could consider platoons in mixed traffic, such as in the off-peak direction.

The National Highway Traffic Safety Administration (NHTSA) defines five levels of automation from Level 0 (no automation) through 4 (the vehicle could drive unoccupied). The strategies currently being discussed for bus platooning are considered Level 2 - automation of at least two control functions designed to work in harmony when deployed together, such as Adaptive Cruise Control with Lane Keeping Assist. As the fleet begins to progress into Level 3 automation, there is limited self-driving available. It is in this case where it could be possible to begin implementation of connected and automated strategies to achieve solutions such as Cooperative Adaptive Cruise Control and Lane Keeping.

The combination of Lane Keeping with Cooperative Adaptive Cruise Control is the path to bus platooning along Route 495. This reveals the potential for increased capacity of the XBL. Under existing conditions, actual operation runs below its theoretical capacity due to a number of factors that both individually and collectively limit throughput in the corridor. These factors include: delays at merge points at both ends of the corridor; longer-than-necessary following distances; slow speeds due to sun glare; the need to take the XBL curve slowly because of narrow lane geometry; and occasional traffic collisions/breakdowns. Also, buses frequently dislodge the delineators that separate the XBL lane from the adjacent traffic lane leading to delays of 15 minutes or more due to disruptive collection and reset. Emerging technologies to automate certain functions and introduce more consistent headways could help to mitigate each of these factors and not only achieve the theoretical capacity, but potentially exceed it.

The primary benefits of connected/automated bus platooning are:

- Increasing XBL capacity, possibly to the point of avoiding or deferring creation of a second XBL lane or HOT lane (Section 2.1.1) to accommodate the projected bus demand. This is achieved through reducing bus headways and the variability in bus speeds.
- Reducing incidents of buses knocking XBL delineators out of place.

While there is always risk associated with implementing new technologies on machines as large as buses with human passengers, there are many steps to mitigate the risk. First, these technologies do not need to be developed from scratch for this application – there are limited real-world examples of many of the technologies described. As part of evaluation and program development, PANYNJ and NJ TRANSIT staff could visit such operators and companies for their first-hand experience. Piloting equipment on closed courses with local drivers would also be prudent. Many of these technologies are most reliable and yield the highest benefit when used within discrete stretches of managed roadways, which is consistent with the strategy as envisioned for the XBL and PABT. The buses would continue to operate with the driver in full control in their feeder areas and then transition to the connected/autonomous operation within the XBL and PABT.

From the transit operators' perspective, the comfort as well as the safety of bus passengers is another consideration in evaluating the application of these technologies in the intensive XBL/PABT environment. Vehicle weight, velocity, acceleration and deceleration rates matter. Availability of technology that can stop vehicles quickly may not be appropriate for passengers in the vehicle.

While bus platooning offers great promise to improve throughput along the Lincoln Tunnel corridor, it is important to qualify this optimism with an acknowledgement of the challenges associated with implementation. For instance, although many of the technologies necessary for bus platooning are already available or will be soon, the pathway for these technologies to be integrated into a system that can manage the needs of the Lincoln Tunnel corridor is less clear. Indeed, the complexity of the operating environment—including, but not limited to, the wide variety of bus agencies and companies that have buses currently using the XBL—poses a unique challenge for implementation along the Lincoln Tunnel corridor. Further policy development would be necessary to work out a safe and efficient transition as technologies proliferate through the fleet. At some time, to realize full benefit, certain technologies could become pre-requisites for use of the XBL, comparable to E-ZPass today.

Another important consideration is that buses can be in service for up to or more than a decade (depending on agency or operator), but computer technology becomes obsolete in 18 months to two years. Therefore, this strategy would require a plan not only for new installation, but for retrofit of existing inventory and plans for continuous measurement and updating. It is also important to note that agencies can have procurement practices that are so lengthy, there is risk that the technology could become obsolete by the time it is implemented.

One concern that has been raised is wind and suction effects from the connected buses traveling through the Lincoln Tunnel. However, there are several reasons why connected buses would not have the air flow concerns that would be present for trains in tunnels. The most advanced work in platooning is with trucks and it is based in part on reducing turbulent flows to improve fuel efficiency. By spacing vehicles closer together, each set only has turbulence after the final vehicle. Turbulence and pressure is not increased for the lead vehicle, rather, it just functions as a longer vehicle. The increased capacities projected for the XBL through bus platooning are due to shortening headways, not increasing speeds. Thus, even a bus going through the tunnel with no vehicles in front of it would not be pushing more air than the current unconnected vehicles. The project team followed up with a connected truck expert after the Workshop who concurred with these general principles and noted that he was not aware of any research into tunnel effects for connected trucks.

The need to move buses through the Lincoln Tunnel to the PABT led to the PANYNJ to establish the XBL, something that had not been done elsewhere. Continuing pressure to expand the passenger-handling capacity of the uniquely intensive Lincoln Tunnel corridor bus operation provides the impetus for PANYNJ once again to respond by introducing the additional innovation of bus platooning with its transit partners.

**Conclusion: The potential to increase bus throughput, safety, and reliability of the single XBL lane to meet forecasted demand levels is an extremely powerful incentive to**

**consider the deployment of connected vehicle (CV) technologies that will enable bus platooning in the near term, before completion of the PABT replacement effort. The complexity of the operating environment along the Lincoln Tunnel corridor poses a noteworthy challenge for implementation. Hurdles include availability of adequate funding, concurrence of multiple jurisdictions and bus operators, and coordination of retrofit and procurement cycles. However, the closed-loop nature of the XBL is a perfect location to test the viability and efficacy of bus platooning due to homogenous vehicle types and willing participants (bus companies interested in improving flow, safety, and reliability). Additionally, given the size and critical nature of the interstate bus network that feeds the PABT, as well as the marquee location of the PABT with respect to the Lincoln Tunnel portals, the PANYNJ is in a strong position to assume a leadership role in applying emerging technologies to support bus platooning. If proven reliable along the XBL, mixed-use traffic could be a future testing ground for limited platooning also, especially in helping to improve the throughput, safety, and reliability in reverse direction bus movements. However, any incremental implementation prior to completion of a new bus terminal would be conditioned on progress in managing traffic flow through the tunnel crossing and PABT operations.**

#### 2.1.4 Connected and Automated Bus Applications beyond Platooning

Although bus platooning is the application that most directly meets the need to increase capacity in the Lincoln Tunnel corridor, once the buses are outfitted with vehicle on-board units (OBU's), and roadways in and around the PABT are equipped with infrastructure roadside units (RSU's), there could be an opportunity to implement a number of future applications. CV applications are emerging that could include blind spot detection and advanced collision avoidance warning (based on conditions ahead of the vehicle). In mixed-traffic situations, these CV applications have safety, mobility, and liability benefits by reducing accidents and improving on-time dispatching performance. Additional CV applications include pedestrian detection and passing car detection to alert buses of cars pulling out around them.

As discussed at the Capacity Study Workshop, and as noted for the previous strategy, some experts predict that the cost of installing these solutions could be recovered in as little as one to two years through reductions in casualty and liability claims alone. The primary benefit of the connected and automated bus applications beyond platooning is safety. Secondary benefits include efficiency and liability.

Challenges associated with this strategy are similar to those associated with bus platooning, including the complexity of the operating environment, number of partners and operators involved, and the rapid cycling of technologies. Additionally, introducing these new technologies will take careful development and piloting prior to widespread roll-out. Nevertheless, the technology applications have great potential to improve operational efficiency and safety in the interstate bus network for trans-Hudson commuters.

**Conclusion:** The PANYNJ and NJ TRANSIT have both the need and the opportunity to be leaders in applying connected and autonomous technologies to buses, many of which could improve safety. While there are hurdles, recent advances in technology—including commercially available systems—mean that policy, perception, insurance, union, cost, and fleet turnover concerns are likely more limiting or slowing factors than the functioning of the technology itself.

#### 2.1.5 Increased Use of Higher-Capacity Buses

This strategy calls for expanded use of higher-capacity bus types—including double decker buses, articulated buses, and 45-foot coaches—by carriers that serve the PABT. The purpose of this strategy is to consider opportunities to run fewer trips on select high ridership routes through introduction of equipment that can carry more customers per vehicle than conventional transit buses. This is feasible only on certain routes where service and roadway infrastructure can accommodate these buses, as discussed below. The existing bus terminal cannot accommodate most double decker buses due to the limited vertical clearance within the terminal, and the facility’s geometry limits the ability to accommodate articulated buses. Even substituting 45-foot for 40-foot coaches affects bus operations within the terminal. Due in part to these structural limitations (in addition to capacity constraints), the existing PABT is also unable to accommodate several intercity bus carriers that use higher-capacity buses, such as Megabus, which currently serve curbside stops as opposed to gates within the PABT.

The design criteria outlined by the PANYNJ in the MBMP for a replacement bus terminal include accommodating taller and longer buses. This would function as a capacity management strategy because the use of higher-capacity buses with less frequent trips could reduce the number of vehicles along the congested Lincoln Tunnel corridor and within the PABT during peak periods, while still accommodating customer demand.

However, as noted in the design criteria, these benefits generally do not translate into reductions in the size of the replacement terminal, as articulated buses require additional platform areas and larger-capacity buses require more space for queuing the larger volumes of peak-period passengers each vehicle can carry. Some space savings may be possible in the future terminal through wider use of 45-foot coaches.

In conjunction with development of a new Midtown Bus Terminal, encouraging a long-term shift to higher-capacity buses is a potentially valuable strategy to improve service and efficiency of the interstate bus system as a whole. Increasing the average capacity of buses entering the PABT would allow for a reduction in the forecast increase in bus movements, and the benefits would cascade as total fleet size, operating costs, fuel consumption, and emissions would decline proportionally. In the long term, as PABT demand continues to grow, the use of higher-capacity buses could serve to accommodate more customers on the same number of buses (as a corollary to accommodating the same number of customers on fewer buses) than if the fleet only consisted of conventional transit vehicles.

However, it will take time and coordinated effort with west-of-Hudson partners to achieve meaningful benefits from bus-fleet changes. Higher-capacity buses are restricted on certain New Jersey roadways due to vertical clearance and axle weight constraints. Maintenance facilities would also need to either be substantially modified or constructed new to accommodate a new fleet. Finally, specifications would need to be developed and the new fleet would need to be procured. The potential application of this strategy in serving the trans-Hudson commuter market was examined during development of the MBMP as well as in the Capacity Study process.

**Double Decker Buses.** Given the real potential cost savings to bus operators from reduced fleet and driver requirements, it is likely that bus operators would generally be open to incorporating double decker coaches into their fleets where it is feasible and appropriate to do so. In the coming decades, significant growth is expected in intercity, long-distance commuter, and park-and-ride operations, and double decker buses are a logical choice for serving these markets. Major park-and-ride lots could be served in the future by double decker buses, but on many routes, these buses may not be practical, either because of the high number of stops (and the longer loading times associated with this fleet), the relatively low ridership, and/or roadway restrictions. A major re-orientation of bus networks toward more park-and-ride lots could have major consequences for local traffic. Corridors in which the use of double decker buses may be practical include Routes 3, 46, and 9.

A detailed feasibility and cost analysis of the potential for shifting to double decker buses on specific routes, while accounting for bridge clearances, axle weight restrictions, depot design, and route suitability, is beyond the scope of this study. However, a simple sketch exercise suggests that the conversion of appropriate routes from 45-foot coaches to double decker buses (bi-level coaches) could result in a net reduction of up to 25 PM nominal peak hour bus departures from the PABT. This is based on an assumption that only those routes that serve a very small number of stops would use double decker buses, including NJ TRANSIT and Academy routes that make 1-2 stops, and Pennsylvania bus companies' routes (which serve long-distance trips) that make 5-6 stops before starting the line haul portion of their routes. This conversion in bus fleet would provide a real benefit for bus circulation by reducing the number of PABT peak-hour buses, but would not provide a significant benefit with respect to terminal space requirements because of the need for longer boarding times and larger passenger queuing areas. The feasibility of this conversion in fleet type may be constrained by the considerations noted above regarding roadway and infrastructure limitations.

**Articulated Buses.** The MBMP developed bus terminal designs that were flexible enough to accommodate a higher share of articulated buses in the fleet. However, its bus activity forecasts assumed the continued use of articulated buses on routes where they are already present, but with no expansion of their use to new routes. This approach recognizes the real obstacles to greater use of articulated buses in some areas, including street geometry constraints, limited existing provisions for curb access, axle weight restrictions, and space constraints at legacy bus depots. Broader adoption of alternative vehicle types is a policy consideration, but one that requires the support of a coordinated infrastructure investment and revised service plan. This key qualifier reflects an earlier statement that the bus network must be considered as a system in which optimizing a new PABT also

involves other network investments/changes. Additionally, it is important to note that increased use of articulated buses would not significantly improve space productivity of the PABT. Articulated buses load passengers faster (i.e., less dwell time due to multiple doors), but they require longer bus slips and larger passenger queuing areas. Accordingly, as with double decker buses, this conversion in bus fleet would provide a real benefit for bus circulation by reducing the number of PABT peak-hour buses, but would not provide a significant benefit with respect to terminal space efficiency.

Nonetheless, significant population growth is expected in Hudson County and Eastern Bergen County, both of which have higher-density urban corridors that are a natural fit for articulated buses. Overall, the conversion of transit-style buses to articulated buses on appropriate routes could result in a potential net reduction of up to 35 PM nominal peak hour departures from the PABT. This is based on two assumptions: (1) that routes currently served by a mix of articulated and transit-style buses shift to a 100% articulated fleet (corresponding to a net reduction of approximately 15 PM peak hour bus departures); and (2) that routes currently served entirely by transit-style buses are converted to a 100% articulated fleet (corresponding to a net reduction of approximately 20 PM peak hour bus departures). This estimate does not account for constraints that must be overcome on the street network, depots, or other infrastructure. Because of the larger gates that these buses would require, there would be zero net change in bus demand equivalents used for terminal capacity planning purposes.

**45-Foot Coaches.** Another possible component of this strategy is expanded use of 45-foot coaches. The MBMP assumed that all 40-foot coaches in use by private operators would be phased out in favor of 45-foot models, but that NJ TRANSIT would continue to use 40-foot coaches for its own fleet due to space limitations at several of its older bus depots. Accordingly, the feasibility of shifting from 40-foot coaches to 45-foot coaches for NJ TRANSIT may be limited by land availability and infrastructure limitations at legacy bus depots, similar to the limitations associated with double decker and articulated buses noted above.

If pursued, the conversion in fleet for NJ TRANSIT from 40-foot coaches to 45-foot coaches on appropriate routes could result in a net reduction of up to 15 PM peak hour bus departures from the PABT. Unlike double decker and articulated buses, 45-foot coaches would provide a real benefit in terms of terminal space efficiency.

Overall, potential benefits associated with this strategy—assuming fewer bus trips—include newer vehicles that could be viewed favorably by customers, lower fuel consumption and emissions, and operating cost savings for bus operators (i.e., reduced fleet and driver requirements) on routes that are well matched for their physical characteristics. Increased use of higher-capacity buses could improve bus circulation by reducing the number of buses using the terminal access routes, ramps, and roadways, although—in the case of articulated buses and 45-foot coaches—the buses themselves are longer. Only the conversion of 40-foot coaches to 45-foot coaches yields space benefits for a future PABT, by providing a net reduction of up to 15 PM peak hour bus departures if impediments are overcome. The new PABT should be planned to accommodate significant numbers of all three types of larger vehicles.

Potential adverse impacts associated with this strategy include less frequent service for customers (since higher-capacity buses would result in fewer buses dedicated to the busier routes). There are several public policy issues that would need to be considered for this strategy, including coordination with NJDOT and the municipalities with roadway jurisdiction regarding vertical clearance and axle weight restrictions, infrastructure limitations at legacy bus depots, the potential need to special order double decker buses that meet the clearance restrictions in the Lincoln Tunnel, and ongoing coordination with NJ TRANSIT and other carriers regarding the feasibility of this strategy on different trans-Hudson bus routes. Significant capital investments may be needed to overcome these issues. Design criteria for the replacement terminal should incorporate sufficient waiting areas for the larger number of passengers. Additionally, as noted by the PANYNJ, a potential constraint associated with this strategy is the accumulation of passengers within gate areas during an operational disruption.

**Conclusion:** In terms of potential space-efficiency benefits for a new PABT, the increased use of 45-foot coaches has the potential to result in an estimated reduction of up to 15 PM peak hour bus departures from the PABT while still accommodating projected customer demand. Overall, maintaining design criteria for a new PABT that allows for use of double decker buses, articulated buses, and 45-foot coaches would enable the interstate bus system to accommodate the same customer demand using fewer vehicles. This is a long-term strategy that requires construction of a new PABT, as the existing PABT is unable to accommodate double decker buses or significantly more articulated buses. Although the utility of this strategy may be limited in the trans-Hudson commuter market, and significant capital investments may be required to upgrade west-of-Hudson roadways, bridges, and depots to accommodate these larger buses, it is still worthy of study and consideration from the perspective of the overall efficiency of the Lincoln Tunnel corridor as well as the PABT facility itself. Fleet mix is an important element of the PABT planning effort, both with respect to the capacity (total number of gates) and configuration (vertical clearance and gate layout) of the new terminal. The PABT planning effort should also consider the implications of additional passenger queuing and crowd management requirements for higher-capacity buses for routine operations as well as during service disruptions. Additional planning and coordination would be required with carriers that operate PABT commuter routes to confirm the potential reduction in peak hour bus demand associated with this strategy. However, due to the linear space required by articulated buses, and the additional loading time and queuing space needed for double decker buses, it cannot be concluded that potential shifts in fleet mix would allow for a smaller PABT, although the shift from 40-foot to 45-foot coaches could provide a real benefit in terms of terminal space efficiency. It is also important to note that this strategy could function to accommodate more customers as opposed to fewer buses. Specifically, rather than reduce the number of trips on high ridership routes in conjunction with the use of higher-capacity buses, it is possible that carriers could opt to run the same frequency of service to carry more passengers.

## 2.2 IMPROVED FACILITY OPERATIONS

### 2.2.1 Bus Staging and Storage

This strategy calls for development of a bus staging and storage facility in West Midtown to increase the operational efficiency of the PABT and the Lincoln Tunnel corridor overall. Direct access from a West Midtown bus staging and storage facility to the PABT would improve reliability and throughput, while reducing peak period demand along the Lincoln Tunnel corridor. *The Emerging Design + Deliverability Brief* stresses that, “A critical challenge to interstate bus operations is the scarcity of bus parking and staging capacity in West Midtown Manhattan,” and this strategy would directly address this shortcoming for the trans-Hudson bus commuter market.

One of the greatest challenges in operating a large transportation terminal is getting empty buses to the locations where customers board in a dependable manner. In a commuter terminal, operations are typically both heavily-peaked and have strong directional bias. Accordingly, in the morning, eastbound buses arrive at PABT with full customer loads. When buses depart PABT after initial offloading, some routes are in revenue service with reverse commuters headed back across the Hudson. Other buses, however, depart empty either to spend the midday period stored at a facility in New Jersey, or to go back to their New Jersey terminal to begin another eastbound revenue trip to PABT. The westbound buses that travel through the Lincoln Tunnel in the morning peak period face relatively few traffic constraints (compared to the evening peak), even with the removal of a westbound lane to accommodate the operation of the contra-flow XBL on Route 495.

In the evening peak, however, the situation is much more challenging. Every bus leaving the PABT must arrive at its assigned gate with sufficient time to board customers and depart on-time. Boarding time varies by route, but always requires at least several minutes. Some buses currently store during the day in Manhattan in the several blocks around the bus terminal, but a large number of buses spend the middle of the day in New Jersey.

At the PABT, it is necessary to time precisely the arrivals of empty buses from New Jersey. This is complicated by the fact that in the PM peak there are only two Lincoln Tunnel lanes available for eastbound traffic. Thus buses need to arrive at their gates on-time despite having no location to wait if they arrive early, and with no reliable method to predict eastbound congestion through the Lincoln Tunnel (although technology is being deployed to improve real-time traffic monitoring).

Insufficient daytime bus storage and staging capacity has multiple implications, including congestion within the PABT, congestion on New York City streets due to queues and diversions from the PABT, increased operational costs for bus operators, and decreased on-time performance and reliability for customers. These challenges collectively degrade bus operations and amount to a poor “quality of commute” for customers.

As part of the ongoing PABT Quality of Commute Program, which aims to improve current conditions at the existing PABT, the PANYNJ is currently converting two of its lots in Midtown West to serve as bus parking and staging areas. This is expected to result in operational improvements by providing improved access to the PABT and reducing queuing on local streets. Additionally, PABT/Lincoln

Tunnel Management have recently implemented an operational change whereby buses are directed to use a single inbound lane in the PM peak period, which has improved on-time performance and travel time reliability while reducing the number of buses arriving early at the PABT that must then circulate or park on local streets to await their departure time. Nevertheless, as affirmed by *The Emerging Design + Deliverability Brief*, “While new operating practices have reduced the frequency and duration of such diversions to manage heavy inbound bus demand, the balance of [PM] capacity and demand is fragile throughout the corridor.”

The PABT replacement planning effort has considered the possibility of developing a portion of the needed bus staging and storage capacity in New Jersey. During this Capacity Study process, PABT/Lincoln Tunnel management noted that staging in New Jersey would require proximity to the tunnel plaza and rigorous management of inbound Lincoln Tunnel lanes to ensure highly reliable dispatch of buses through the tunnel to their assigned gates. Although placing some bus staging and storage in New Jersey is certainly feasible, it inevitably leads to eastbound movement of empty buses in the Lincoln Tunnel during the PM rush. Since eastbound flows are limited to just two lanes during the PM rush, delays to eastbound traffic during this period are already substantial and are likely to grow worse. A policy of bus prioritization could improve the reliability of buses stored in New Jersey reaching their PABT gates at the appropriate times, but could exacerbate the already significant delays experienced by other vehicles trying to reach Manhattan during the PM rush.

As indicated in the MBMP planning effort, significant staging and storage capacity in Manhattan is important for efficient operation of the replacement terminal as well as the tunnel. Trans-Hudson buses stored on the west side of the Hudson River would have to travel empty from the PABT through the Lincoln Tunnel, and then travel empty back across the Hudson River to the PABT. This introduces unproductive bus miles and wastes fuel. The MBMP analysis also indicated that evening peak-period operation could not be supported fully without some staging and storage capacity in Manhattan.

A bus storage facility proximate to the PABT in West Midtown where buses could be warehoused and dispatched in real time would make a profound difference in the reliability of terminal operations. While trans-Hudson bus operators have stored many buses in the area over the past 20 years, much of this capacity has been lost to West Midtown development and Javits Center operations. There are three broad uses of such a facility. One function would be to store (park) buses that are not needed for midday service in Manhattan. These buses would not need to travel empty to New Jersey to be stored, only to return empty to Manhattan in the evening. If stored in West Midtown, buses would be “in place” for evening service. NYCT stores over 150 express buses for Staten Island and Queens services at Manhattan facilities during the midday period, and has done so for 20 years. Not only does this practice save payroll hours, fuel, and bus miles, but—most important—it helps to keep evening peak express bus service operating more reliably.

The second use would be as a location to stage (queue, sort, and ready for dispatch) buses for a short time, until space opens at their intended gate in the PABT. With real-time dispatch, the storage/staging facility would effectively function as an extension of the PABT. The third function would be as-needed as a customer facility. For instance, the lower floor of a staging and storage facility could be used for customer operations during major incidents, such as an extreme weather

event or a rail strike, and could potentially be permanently converted to a customer facility in the long term as demand grows beyond the 2040 projections.

If the staging and storage facility is sited close to both the current PABT location and the location of a new PABT, it should be constructed soon allowing for improvements in capacity and reliability at the current facility. Current thinking is that a storage/staging facility would be constructed over one of the portals of the Lincoln Tunnel. It would be highly desirable to accelerate the design and construction of this facility, as it would serve to increase the capacity of the current PABT complex. This is particularly important as demand is projected to continue to grow in the years before the new PABT will be built and operational. The design should be as flexible as possible to accommodate different bus types, and to allow for both static storage and for real-time dispatch. Although some ramps and approaches would likely need to be rebuilt as part of a new PABT project, the core of the building would remain and could have years of utility in the interim.

One of the fundamental “building blocks” of the MBMP was a bus staging and storage facility with connections to the PABT. Each of the concepts for a new PABT that were developed in the MBMP included accommodation for bus staging and storage. The MBMP did not establish a hard number of staging spaces required to serve the PABT commuter market, but concluded that the staging area would need to be flexible enough to handle a variety of configurations.

Potential benefits associated with this strategy include improved reliability of customer operations, reduced demand along the Lincoln Tunnel corridor, and increased near-term capacity of the existing PABT. Potential impacts associated with this strategy include loss of revenue potential for the PANYNJ associated with overbuild or high-rise development on the site for the staging/storage facility. However, one of the planning criteria in the MBMP was air rights development over either the bus terminal or staging/storage facility would be inherently difficult and costly. It is also worth noting that the properties at the portals may have limited development potential due to site constraints, security requirements, and—at Galvin Plaza—pedestrian access issues. Public policy issues that would be need to be addressed to advance this strategy include inter-agency coordination with the New York City Department of Transportation (NYCDOT) and the New York City Department of City Planning (NYCDCP), as well as coordination with local Community Boards.

**Conclusion: Bus staging and storage is one of the critical issues that can and must be addressed to improve the operational efficiency of the PABT, with consideration of early implementation. In addition to meeting and managing long-term projected demand at a new PABT, improved bus staging and storage can address current capacity constraints at the existing PABT and along the Lincoln Tunnel corridor. A bus staging and storage facility in West Midtown represents an essential component of the new PABT complex that would be amenable to modularity – the facility could have independent utility in the near-term, and could be integrated into a new PABT in the longer term. Further planning also should consider the option to develop some of the needed bus staging and storage capacity in New Jersey, at a close-in site with physical and operational provisions to assure reliable dispatch through the tunnel portal to the terminal. The October 22, 2015 PANYNJ Board resolution indicated that conceptual designs for a new**

**PABT developed in the D+D Competition should “allow for...sequential construction of key elements (including terminal facilities and bus-staging facilities) as estimates of future capacity needs are refined.” As such, the bus staging and storage facility should be accelerated as a first stage of the PABT replacement.**

### 2.2.2 ITS to Optimize Bus Dispatching and Circulation

As discussed in Sections 2.1.3 and 2.1.4, new technologies on buses and on the roadside offer a variety of emerging tools to improve efficiency and safety. This section covers Intelligent Transportation Systems (ITS) that focus more on the PABT itself, including throughput on the terminal’s ramps and merge points. The related topic of ITS to enable changes in gate assignment is covered in Section 2.2.3.

Better dispatching and circulation depends first and foremost on better awareness of vehicles. This strategy begins with improved deployment of sensors along the corridor (included in other strategies and described in more detail in the “Technology Implications & Opportunities” technical memorandum). Pinpoint locational awareness of all buses at all times is a necessity on both sides of the Hudson River. Projects are already underway to include better awareness inside the existing PABT through the use of E-ZPass readers as well as improvements in WiFi and GPS. Better awareness of vehicle location and conditions along the corridor as well as within the PABT would allow algorithms to more accurately predict arrival and departure times with improved precision, and would also enable other strategies such as enhanced travel information.

Once greater awareness of vehicle status and location has been achieved, the second element of this strategy is to include technology solutions to improve movement within the PABT. While there have been limited applications of such technology to buses so far, sensors and guidance systems are under development. As a proof of concept that would be available for near-term needs, it is worth noting that magnetic guidance for precision navigating and docking has been used by the Lane Transit District on revenue service in Eugene, Oregon (Figure 6). In that case, the guidance is used not only for Americans with Disabilities Act (ADA)-compliant docking of articulated multi-door low-floor buses, but to guide vehicles swiftly through narrow busways, across mixed-flow intersections, and along S-curves into and out of stations. It is expected that a non-invasive alternative would become available for design of the replacement PABT. Not only would non-invasive systems avoid disturbing the deck of a new facility, they would be more flexible to changes over time.

Figure 6: Example of Automated Steering and Precision Docking from Lane Transit District



Source: Lane Transit District; Jill Huang (UC Berkeley); YouTube

Great strides have been made in automated vehicle technologies for cars and for trucks that can drive on roads without infrastructure such as magnets. However, there are several reasons why the critical questions for the replacement PABT, such as the geometry of the ramps and number of levels, should not assume their availability and applicability. First, while the Google car has logged over one million miles, there are still significant technological hurdles for dealing with less than ideal driving conditions such as inclement weather. Also, these systems are currently, and understandably, very conservative. To achieve efficiencies within the bus terminal, buses would need to operate more efficiently than high-skilled and experienced professional drivers – not to drive conservatively. The path to the safe and efficient movement within the tight tolerances of the PABT is to leverage systems that integrate with the infrastructure for certain precision driving tasks.

Safe and smooth merging of buses within the proposed PABT's helical ramp system is required to enable projected peak period bus flows. Connected/automated vehicle technologies are required to achieve the throughputs assumed for the future PABT. That was the position of the MBMP and it was reinforced by this project team and the experts who participated in the Capacity Study Workshop on April 14, 2016.

As in-vehicle technology increases in availability—and as fleets begin to turn over or be rehabilitated—additional technology solutions such as lane keeping and precision movement and cooperative adaptive cruise control could guide buses more efficiently within the PABT as well as along the Lincoln Tunnel corridor, thereby reducing headways and improving overall flow. This would further increase the reliability of dispatching and estimated arrival/departure times.

The “game changer” for optimizing bus dispatching would be if fully driverless buses could make the buses virtually interchangeable. Under such a scenario, any bus, or perhaps any bus from the home garage, could serve the next route's departure. That would greatly simplify the operational side of dispatching, but its value would be offset in terms of inefficiencies regarding passenger queuing and loading. Another consideration to note is that while technology can be an enabler of optimized bus dispatching, technology is not necessarily the limiting factor with respect to the potential interoperability of buses. Indeed, even with fully driverless buses, there would be practical

limits due to varied locations of bus storage and other issues pertaining to the large numbers of bus carriers.

Even considering all of the technology advancements on the horizon for optimizing bus dispatching and circulation, given the complexities of a multi-level terminal serving so many different routes, it is not prudent to base design of a future terminal on a sustained average of more than 6 turns per hour per gate. That was the consensus of the participants in the Capacity Study Workshop, including among the technology experts. Nevertheless, technology can have a significant impact on facilitating the ramp movements and merges within the terminal.

The primary benefits of optimized bus dispatching and circulation are thus:

- Increasing precision and accuracy of dispatching buses. Until the time that a staging and storage facility is constructed in West Midtown (as suggested in Section 2.2.1), this strategy could optimize dispatching of empty buses from New Jersey to support reliable on-time departures from PABT without buses arriving early to use valuable space within the PABT or on NYC streets.
- Increasing safety and efficiency of bus circulation within the PABT with assistive technologies to smoothly, reliably, and swiftly move buses through the tight confines of the terminal, especially at merge points and within the helical ramps.

Leadership would be required on the part of the PANYNJ and NJ TRANSIT to evaluate, pilot, integrate, operate, and maintain the systems. Working together, they can address options for balancing investments in infrastructure and in-vehicle systems to achieve the most effective use of public resources in a rapidly evolving technological landscape. Eventually, the PANYNJ could consider how to mainstream the systems to other operators as well. In addition to explaining the benefits and leveraging the agreements for use of the PABT, some form of direct assistance or regulatory provision may also be necessary to bring about timely changes among many of the private operators.

**Conclusion: A robust bus and infrastructure sensor system within the PABT and on approaches is the foundation for connected and automated vehicle technologies to optimize bus dispatch and circulation. This will provide gains in efficiency and reliability, especially at merge points and within the helical ramps. These types of advances are assumed as part of the efficiencies transitioning from the PABT's current average of 4 bus turns per hour per gate to the 6 bus turns per hour per gate used in the MBMP. Many of these advances do not need to wait for the new PABT and could increase efficiencies within the next 10 years. However, technology is unlikely to make it possible to serve projected customer volumes with a terminal that has significantly fewer gates than envisioned in the MBMP.**

### 2.2.3 Enabling Various Adaptable Gate Assignment Strategies

Given the uncertainties around changing demand and changing technology over the lifespan of the current and future PABT, flexibility has been one of the recurring themes. The minor changes in design and addition of technology that enable, but do not mandate, a range of strategies related to gate assignment are likely a prudent investment. The PANYNJ would then have the flexibility to refine the most effective approach. There is a fundamental trade-off between providing flexibility to transit operators with respect to gate assignment and giving travelers advance notice. This is something that NJ TRANSIT has already experienced. Table 2 explains three major approaches (fully dynamic gate assignment, limited dynamic gate assignment, and flexible gate assignment) along with benefits and drawbacks to each.

Table 2: Overview of Various Adaptable Gate Assignment Strategies

	Fully Dynamic Gate Assignment	Limited Dynamic Gate Assignment	Flexible Gate Assignment
<b>Concept</b>	Underlying operation plan of gates changes everyday	Tool for managing incidents by as-needed changes within logical gate groupings	Facilitating changes of gate assignments to routes or carriers over the scale of months or years*
<b>Each route is assigned a typical gate</b>	No	Yes	Yes, but it can change over months or years*
<b>Gates are shared among operators</b>	Yes	Only limited situations, such as by long headway carriers	Allows changes over months or years*
<b>Routes would switch among floors</b>	Yes	No. Gates would be logically clustered.	Allows changes over months or years*
<b>Benefits</b>	More effective use of gates since buses do not need to wait for open gates	Mostly consistent for customers. More effective use of gates during disruptions.	More effective use of gates over time as needs change.*
<b>Concerns</b>	Customer inconvenience — uncertainty, waiting areas, walk time. Driver/operator confusion.	Potential customer inconvenience or confusion during disruptions.	Small potential for customer confusion.
<b>Enabling Technology</b>	Real time bus locations, dynamic signage for customers, traveler information, dynamic signage and communication to bus operators.	Real time bus locations, dynamic signage for customers, traveler information, dynamic signage and communication to bus operators.	Real time bus locations, dynamic signage for customers, traveler information, dynamic signage and communication to bus operators.

\* Also a policy decision to allow different weekend assignments, construction assignments, or other planned changes.

The limited dynamic gate assignment would be especially helpful when there are disruptions to bus flows, such as due to bad weather, incidents impeding buses from exiting the terminal, police activity, emergency maintenance, and disabled buses. Changes to typical gates would only be made when needed to mitigate those incidents.

To enable this flexibility, the dispatchers, operators, terminal operators, and passengers must all have clear information. Improved WiFi and GPS correction within the PABT would also increase the reliability and effectiveness of the current apps available from providers such as NJ TRANSIT. This could in turn increase usage and customer satisfaction, and also contribute to improved pedestrian movement within and around the PABT.

**Conclusion: Limited dynamic gate assignment and flexible gate assignment are promising operational strategies when used with enabling technology and within sound management practices, as a consideration in planning for the new Bus Terminal. However, fully dynamic gate assignment has operational and passenger concerns that outweigh potential advantages. Traveler information across a variety of sources is also essential to avoid degrading the customer experience as they re-route to their gates for occasional changes that minimize schedule disruption. However, no amount of technology can make the strategies work if the technology does not underpin a sound operational concept with experienced dispatchers and cooperative bus agencies and companies.**

## 3 Trans-Hudson Demand Strategies

To supplement the aforementioned strategies that increase/manage capacity along the Lincoln Tunnel corridor and within the PABT, this Capacity Study is also considering strategies that broadly address overall Trans-Hudson demand through the use of other crossings and/or modes. Subsequent work in the Capacity Study will include an assessment of multi-modal network strategies, and the following sections discuss trans-Hudson bus operational and service strategies that could potentially result in reduced utilization of the Lincoln Tunnel corridor and PABT by commuter buses.

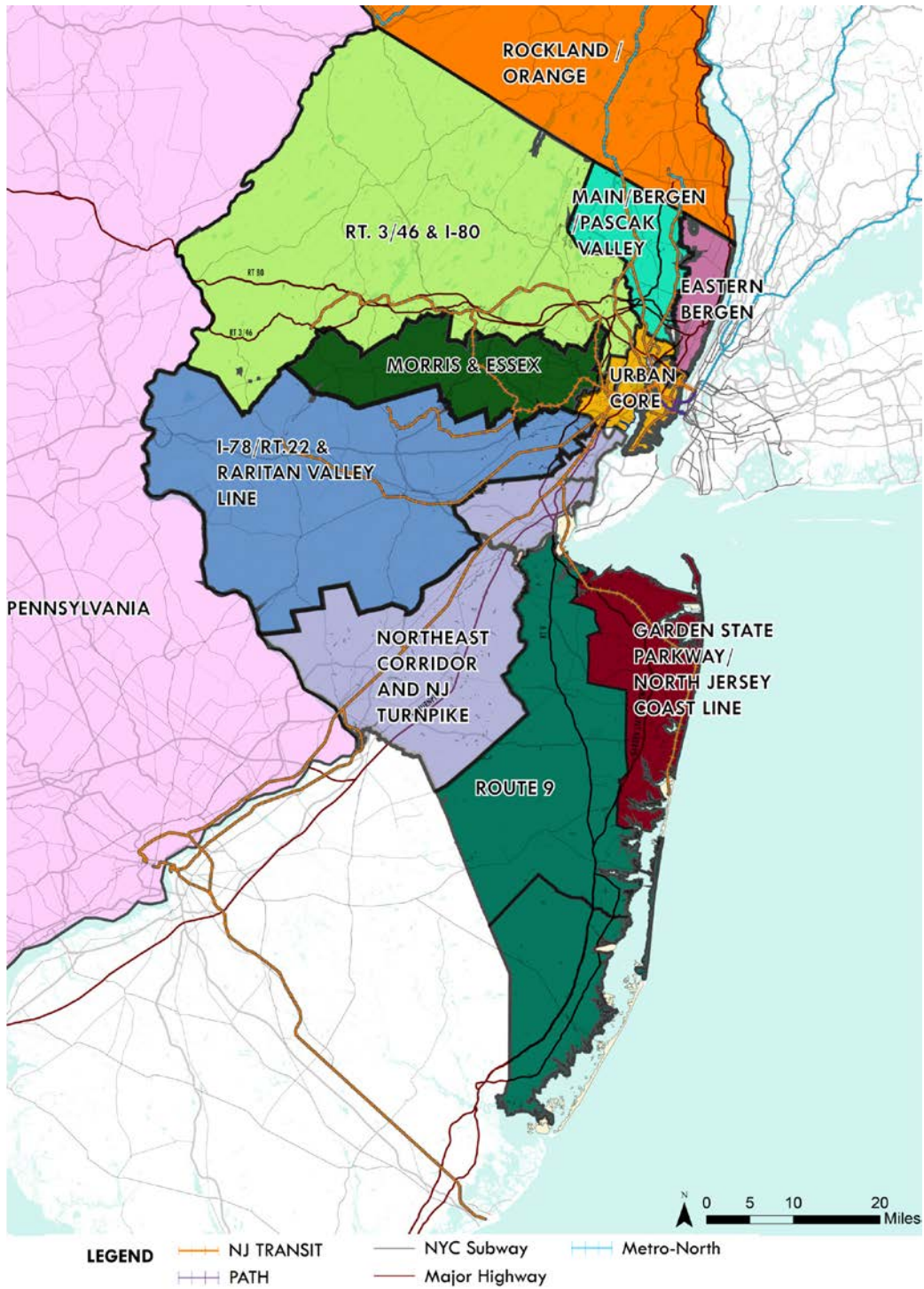
The strategy assessment includes identification of potential benefits, impacts, and public policy issues, as well as an estimate of the number of commuter buses that could potentially be diverted from the Lincoln Tunnel corridor and PABT. The findings section of this technical memorandum (Section 5) summarizes the implications of these strategies for the capacity and configuration of a new PABT to inform the D+D Competition.

Collectively, these strategies could result in a modest reduction of peak period demand along the Lincoln Tunnel corridor and at the PABT, so it is important not to overestimate the net impact of these strategies on the PABT demand forecast. Additionally, some concepts may have additional trans-Hudson commuting benefits beyond the scope of the PABT replacement, but that can further limit their modest potential to change the scale of a new PABT. For instance, new or improved bus service that uses Hudson River crossings other than the Lincoln Tunnel corridor could induce latent demand along the other crossings, thereby consuming some of the available capacity that would otherwise accommodate diverted customers from the PABT. Overall, while these strategies offer some promise with respect to reduction of peak period demand at the PABT, the potential reduction is not large.

### 3.1 EXPANDED BUS SERVICES THAT SHIFT BUSES AND DEMAND FROM PABT

The west-of-Hudson region can be divided into multiple trans-Hudson travel corridors (Figure 7) that have different modal orientations. As discussed in the following sections, the corridors also serve as an effective framework for identifying candidate bus routes that could be potentially be diverted from the Lincoln Tunnel corridor (and the PABT) to use other Hudson River crossings. This, in turn, could help to address overall trans-Hudson commuter demand in light of capacity constraints along the Lincoln Tunnel corridor. While incremental improvements can enhance bus operations and improve customer service, implementing lane prioritization for buses on additional corridors is unlikely unless volumes approach at least 200 buses per hour.

Figure 7: West-of-Hudson Trans-Hudson Travel Corridors



Source: Trans-Hudson Commuting Capacity Study, NJ TRANSIT

### 3.1.1 George Washington Bridge Bus Station

This strategy calls for leveraging the forthcoming completion of the GWBBS renovation by adding service to the attractive new terminal on a number of commuter bus routes that currently serve the PABT, and adjusting frequencies to the PABT in line with customer choices. The additional service to the GWBBS would correspond with increased use of the GWB instead of the Lincoln Tunnel to cross the Hudson River. Upon arrival at the GWBBS, customers could transfer to either the A subway line (via a direct connection), the 1 subway line (via an approximately 10-minute walk on city streets, although wayfinding to locate the station may pose challenges for customers), or a number of NYCT bus routes (via an approximately 1-minute walk) to access their final destination. To increase the attractiveness of the bus routes, this strategy could also include implementation of a range of transit priority measures and other improvements to enhance the customer experience. This strategy revisits assumptions based on a potential transportation demand management (TDM) measure that was associated with Concept 5 from the MBMP to reduce demand at a new PABT.

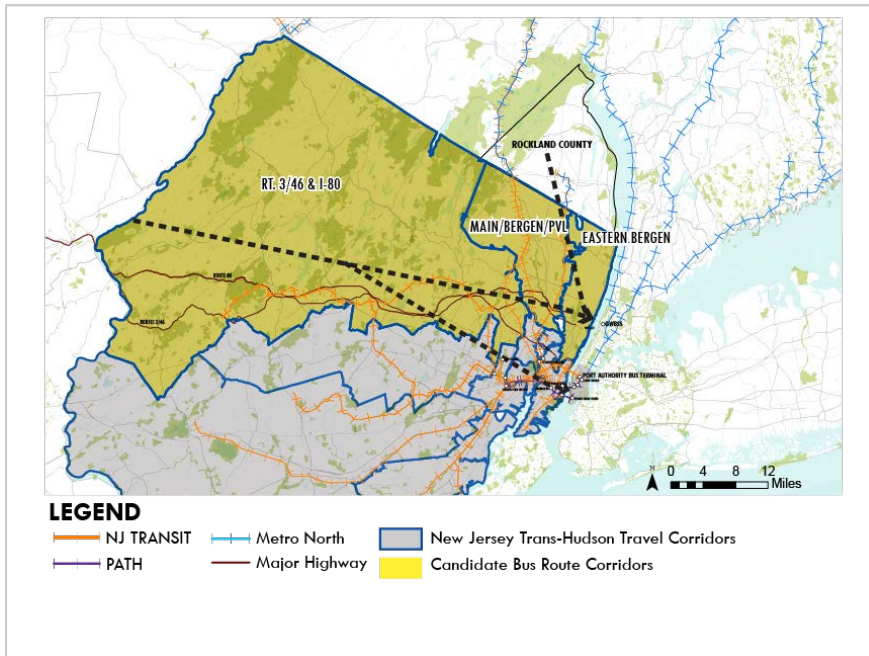
The GWBBS is well positioned to serve bus customers from points to the north and from along the I-80 corridor because of its location along I-95. Accordingly, candidate routes that could be considered for increased service to the GWBBS are those that originate in portions of the Eastern Bergen, Main/Bergen/PVL, and Route 3/46 & I-80 trans-Hudson travel corridors (Figure 8). Additionally, PABT commuter routes that originate in Rockland County could also be candidates for increased service to the GWBBS. Commuter bus routes that serve the GWBBS would likely be most appealing to PABT customers whose destination is north of 60<sup>th</sup> Street in Manhattan (or in the Bronx). From the GWBBS, customers traveling to the West Side would likely use the A or 1 subway lines, and customers traveling to the East Side would likely use the M98 NYCT bus route. The M98 is a peak-period limited-stop service which, after stopping adjacent to the GWBBS, operates non-stop on the Harlem River Drive and then operates southbound on Lexington Avenue and northbound on Third Avenue as far south as 67<sup>th</sup> Street. This is a fast and potentially attractive link for destinations on the Upper East Side such as Hunter College, Rockefeller University, Lenox Hill Hospital, the Hospital for Special Surgery, New York-Presbyterian Hospital, and the Memorial Sloan-Kettering Cancer Center, as well as the major employment center of Midtown East.

There are currently 13 commuter bus routes that serve the GWBBS, including seven NJ TRANSIT routes, two routes operated by Rockland Coaches, two by Saddle River Tours, and two operated by Spanish/Express Service. The GWBBS lost ridership for decades after opening, but has stabilized and started to make modest gains in the past five years. During this time, the market largely shifted from traditional carriers—including NJ TRANSIT and Coach USA—to jitney operators, which now carry roughly half the customers at the GWBBS, although the rising proportion of jitney riders may be indicative of more locally oriented trips rather than a Manhattan central business district (CBD) commuter market. It is possible that, over time, some current PABT customers could choose to change their commute if trans-Hudson travel via the GWB to the GWBBS is seen as an attractive option.

This could potentially be achieved by a combination of improved bus service, reduced fares, and a better terminal experience. One way to improve bus service to the GWBBS is to eliminate merges and conflicts at the bus slip under Lemoine Avenue and improve access from the bus slip to the toll

plaza, which could address an area where buses currently experience delays. This strategy could also include a reduced fare for the GWBBS bus services to encourage patronage and to avoid a fare penalty for transfer to NYCT. Nevertheless, nearly half of PABT customers already use the subway as their mode of access from the PABT to their destination, so the transfer at GWBBS could be comparable for some to their current travel experience. A better terminal experience at the GWBBS is imminent, as the ongoing station renovation is scheduled for completion in 2016. Sample renderings of the renovated GWBBS and station environs are shown on Figure 9.

Figure 8: Origins of Candidate Bus Routes to Serve the GWBBS



Source: Trans-Hudson Commuting Capacity Study

Figure 9: Renderings of Renovated GWBBS



Source: PANYNJ

The renovation will result in a reduction of bus gates at the GWBBS, but there will still be excess capacity such that the station could accommodate additional peak hour buses. According to the PANYNJ, upon completion of the renovation, the GWBBS will have 15 deep sawtooth gates available for commuter buses, in addition to two gates for long distance carriers and four mini bus gates for jitneys. Three of the 15 commuter bus gates will be needed to handle projected PM peak hour bus arrivals, so there will be 12 gates available for PM peak hour commuter bus departures. Based on a theoretical capacity of 4 bus departures/hour/deep sawtooth gate, the renovated GWBBS will have a capacity of 48 bus departures in the PM peak hour. There are 18 PM peak hour bus departures currently forecast for the GWBBS in 2040, and thus the station could accommodate an additional 30 PM peak hour departures. However, this strategy would not necessarily use all available excess capacity at the GWBBS; the number of additional buses that would serve the GWBBS would be informed by demand, as well as consideration for other opportunities such as improved transit connections in the future between Bergen and Westchester Counties or increased intercity service from the GWBBS.

The intent of this strategy is to expand the potential of the GWBBS as an attractive commuting option, and not to force PABT customers to change their travel patterns. As such, this strategy calls for two broad approaches. One action would improve the frequency and reliability of existing GWBBS services to make them more marketable. The second action would involve drawing more riders to the GWBBS by adding service to the renovated station on routes now serving PABT, in conjunction with modified service frequencies to the PABT to reflect customer choices. A potential pilot program could be instituted by one or more commuter bus carriers upon completion of the GWBBS renovation project.

Potential benefits associated with this strategy include demand shedding for the Lincoln Tunnel corridor and PABT, time savings for certain trans-Hudson commuters, and reduction in bus operating costs for certain routes. Additionally, in conjunction with technology strategies discussed previously (and expanded upon in the “Technology Implications & Opportunities” technical memorandum), increased use of the GWBBS could prove useful for real-time diversions of customers during major incidents along the Lincoln Tunnel corridor or at the PABT as a means to improve travel time reliability. For instance, it could be beneficial to provide customers with real-time information about delays at the PABT and the alternative of the GWBBS to enable a more seamless shift in commuting option. Furthermore, commuter bus carriers that serve the PABT could dispatch additional buses to the GWBBS as a diversion plan during major incidents.

Potential impacts associated with this strategy include additional congestion along the GWB and its approaches and reduction in bus operating revenue (if a fare reduction is offered and/or if ridership declines). Public policy issues that would need to be considered for this strategy include jurisdictional coordination regarding fare policy, improvements to NYCT subway and bus access, and improvements to the GWB approaches. The timing and marketing of this strategy should include coordination with NYCT as it continues to invest in improved facilities, subway service, and customer information.

**Conclusion:** Increased service to the renovated GWBBS, and a corresponding adjustment of service frequencies to the PABT, has the potential to result in a modest reduction of peak hour demand at the PABT. For purposes of a potential pilot program, an estimated 10 PM peak hour bus trips that currently serve the PABT could instead serve the GWBBS. This strategy aims to leverage the completion of an attractive new GWBBS by refreshing the routes that serve it, improving travel times, increasing service frequencies, and reducing fares to attract customers that currently use the PABT. If the potential pilot program is successful and viewed as an attractive option for trans-Hudson commuters, approximately 20 additional PM peak hour buses that currently serve the PABT could instead serve the GWBBS to use the remaining excess capacity, for a total of approximately 30 PM peak hour buses.

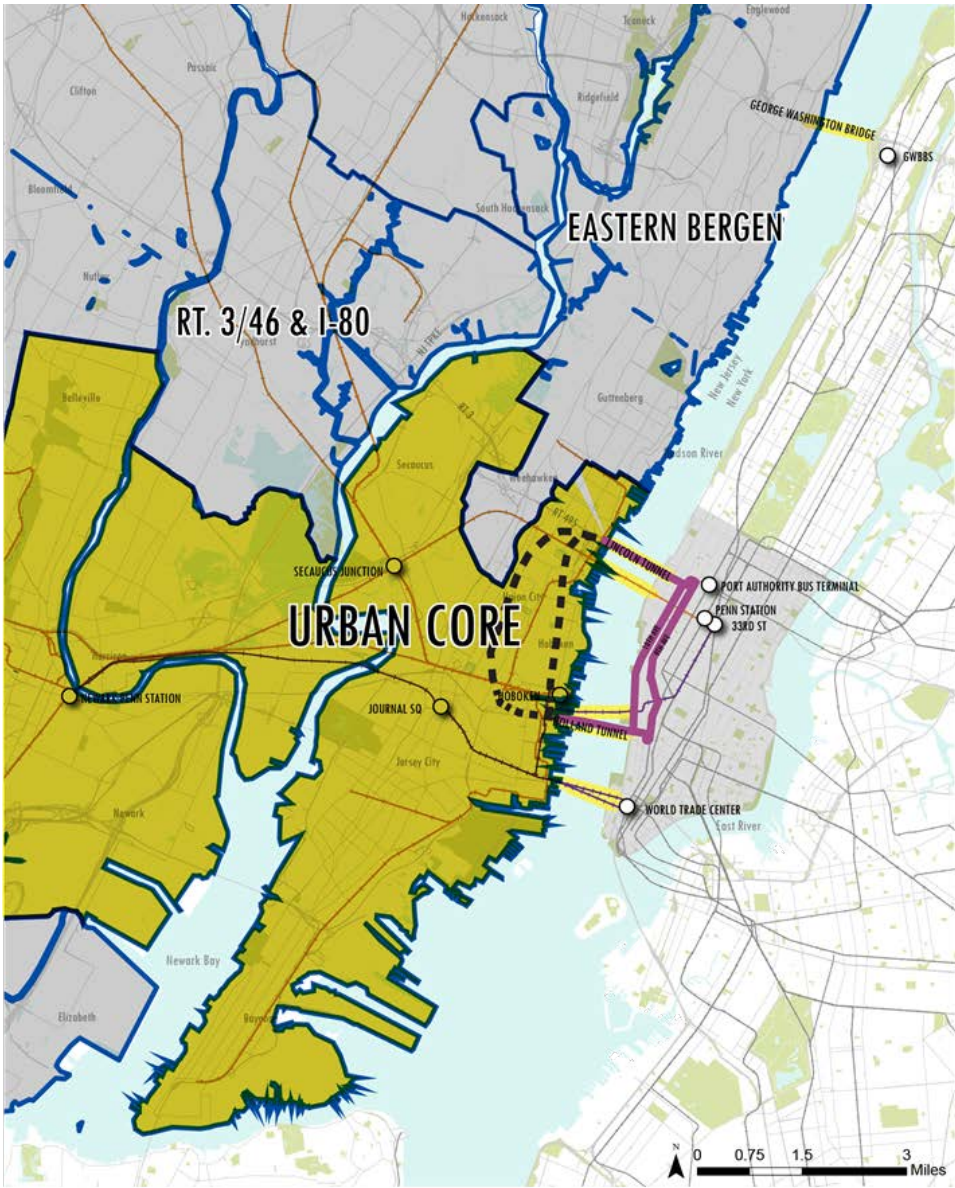
### 3.1.2 Holland Tunnel/Lincoln Tunnel Bus Loop

This strategy calls for implementing new variants on existing services such that select commuter bus routes would cross the Hudson River using the Lincoln Tunnel in one direction and the Holland Tunnel in the other direction, instead of using the Lincoln Tunnel for both inbound and outbound service. Rather than serve the PABT, the route variants would serve new on-street bus stops in Manhattan (with connections to NYCT subway and bus routes) that would be located near the emerging employment corridor on the far West Side between these crossings. This strategy validates and revisits assumptions based on a potential TDM measure that was associated with Concept 5 from the MBMP to reduce demand at a new PABT.

Candidate routes that could be considered for the loop operation are those that originate in the Urban Core New Jersey trans-Hudson travel corridor due to proximity to the Lincoln and Holland Tunnels (Figure 10). For instance, bus routes that serve Jersey City and the Hoboken waterfront could be candidate routes for the loop operation. Under this strategy, any commuter bus routes that use the loop operation would likely be most appealing to PABT customers whose destination is in Midtown West or Manhattan Valley, and specifically between the Lincoln and Holland Tunnels. For instance, the loop operation could effectively serve new employment destinations in/near Hudson Square, Hudson Yards, Chelsea, and Soho.

Similar to the GWBBS strategy, the intent of this strategy is to offer a submarket of trans-Hudson commuters an attractive new alternative for their journey to/from work, and not to force PABT customers to change their travel patterns. As such, this strategy does not call for re-routing all candidate bus routes, but rather to consider a potential pilot program that splits a select high-frequency candidate route such that certain trips would operate using the loop and other trips would continue serving the PABT.

Figure 10: Origins of Candidate Bus Routes for the Potential Lincoln Tunnel/Holland Tunnel Loop



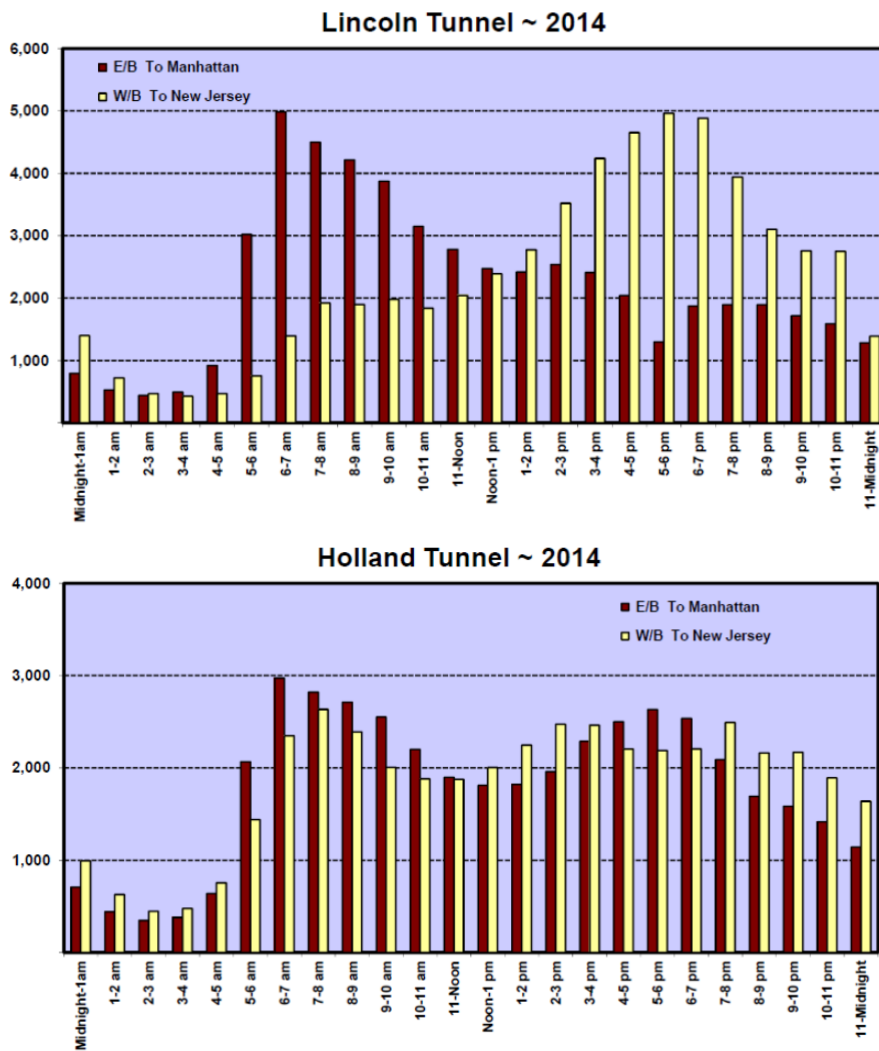
**LEGEND**

- NJ TRANSIT
- PATH
- NYC Subway
- Major Transit Stations
- Manhattan CBD
- New Jersey Trans-Hudson Travel Corridors
- Candidate Bus Route Corridors
- Holland Tunnel/Lincoln Tunnel Bus Loop

Source: Trans-Hudson Commuting Capacity Study

The loop operation would utilize both the Holland and Lincoln Tunnels, which could allow the routes to be adaptable to peak hour demand of the tunnels. Therefore, the bus routes that use the loop operation could operate either clockwise or counter-clockwise depending on traffic and available capacity of the tunnels and tunnel approaches (although customers will expect outbound routings to be consistent). Figure 11 shows the hourly vehicular volumes in the Lincoln and Holland Tunnels (based on 2014 data), which could inform the determination about the direction of travel for the loop operation. It should also be noted that, based on preliminary discussions with NJ TRANSIT during this Capacity Study process, it could be beneficial from a customer service perspective for the loops to be bi-directional at all times of day.

Figure 11: Hourly Vehicular Volumes in the Lincoln and Holland Tunnels (2014)



Source: NYC Bridge Traffic Report 2014

Within Manhattan, the buses could potentially operate on 9<sup>th</sup> or 10<sup>th</sup> Avenues (in the southbound or northbound direction, depending on the direction of the loop operation), as the intended purpose of this strategy is to directly serve workplaces and maximize connectivity to other transit options, which would not be fully accomplished if the buses were to operate on Route 9A.

Potential benefits associated with this strategy include demand shedding for the PABT (as well as the Lincoln Tunnel corridor in either the inbound or outbound direction, depending on the direction of the loop operation), as well as time savings, more direct service, and additional travel options for certain trans-Hudson commuters. This strategy would remove customers and buses from the PABT during the peak period by utilizing on-street bus stops instead of gates within the PABT. Potential impacts associated with this strategy include additional congestion along the Holland Tunnel and its approaches, as well as additional congestion within Manhattan on New York City streets. The loop operation is only a viable option if there is travel time reliability for the bus operators and customers. It could be possible to explore opportunities for implementation of transit priority measures within Manhattan, especially for outbound movements in the afternoon, to further reduce travel time and increase the attractiveness of the bus routes. Additionally, as discussed in the context of other strategies, roadway improvements and/or the expansion of existing bus prioritization at the New Jersey approaches to the tunnels could also improve travel time.

Public policy issues that would need to be considered for this strategy include integration with existing NYCT bus service as well as coordination with the NYCDOT in order to establish on-street bus stops within Manhattan. Though it is likely that the bus operator(s) could apply for a bus stop in New York City, infrastructure would still need to be put in place for customer boarding and alighting and to provide shelter from the elements. Coordination with local Community Boards and NYCDOT would also be critical to address potential concerns about adding additional bus traffic to an already congested road network.

**Conclusion: Implementation of a Lincoln Tunnel/Holland Tunnel loop operation as a variant of existing bus services, in conjunction with serving on-street bus stops instead of the PABT, has the potential to result in a modest reduction of peak hour demand along the Lincoln Tunnel corridor and at the PABT. For purposes of the potential pilot program, an estimated 10 peak hour bus trips could be diverted from the PABT to on-street bus stops. If the potential pilot program is successful and viewed as an attractive option for trans-Hudson commuters, additional variants of candidate route(s) could be implemented to use the loop operation, thereby diverting additional buses from the PABT.**

### 3.1.3 Increased Use of the Holland Tunnel for Direct Downtown Service

This strategy calls for implementing new variants on existing services such that select commuter bus routes would cross the Hudson River using the Holland Tunnel instead of the Lincoln Tunnel. Rather than serve the PABT, the route variants would serve on-street bus stops in Lower Manhattan that would be located near major employment centers.

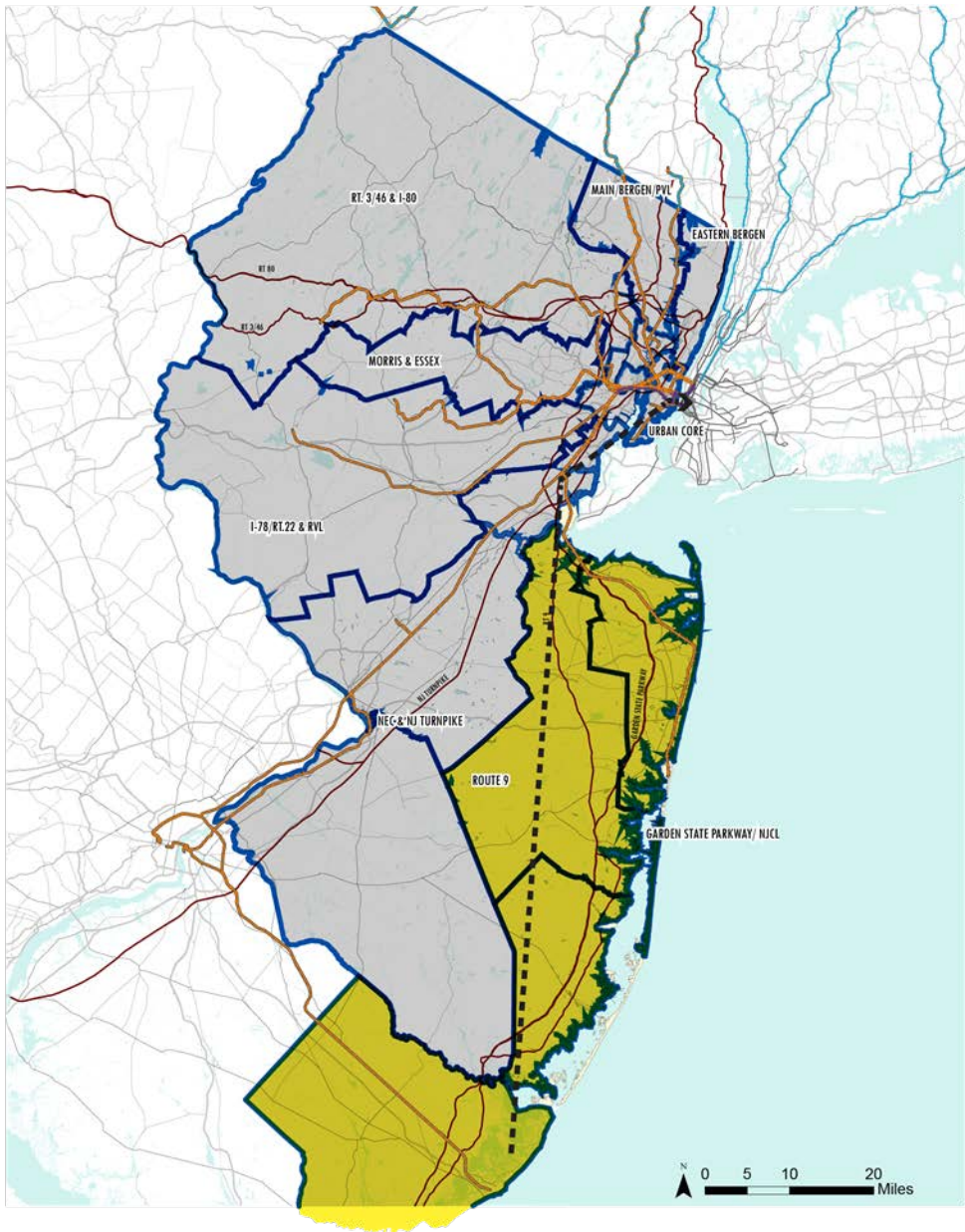
The Holland Tunnel is well positioned to serve bus customers from points to the south because of its location relative to the Lincoln Tunnel. After Bergen and Hudson Counties, the largest PABT customer markets are Middlesex, Monmouth, and Ocean Counties to the south, and these markets present opportunities for increased use of the Holland Tunnel for trans-Hudson commuting. Accordingly, candidate routes that could be considered for this strategy are those that originate in the Route 9 and Garden State Parkway/North Jersey Coast Line trans-Hudson travel corridors (Figure 12). While there are relatively few candidate routes from these travel corridors, it could be possible to also consider candidate routes from Hudson County, which is a significant PABT commuter market. This strategy would likely be most appealing to current PABT customers whose destination is in Lower Manhattan.

Similar to the other demand shift strategies, the intent of this strategy is to expand the potential of the Holland Tunnel as an attractive commuting option, and not to force PABT customers to change their travel patterns. As such, this strategy calls for modifying certain trips on candidate bus routes to serve Lower Manhattan using the Holland Tunnel, while other trips on the same routes would continue to serve the PABT. For instance, a potential pilot program could include implementing a route variant on two trips per hour for candidate routes, with the balance serving the PABT. Additionally, it could be possible to limit the Holland Tunnel service to the peak hours.

There are currently 14 commuter bus routes (plus several low-frequency intercity bus routes) that cross the Hudson River using the Holland Tunnel, most of which are operated by Academy Bus Lines. In addition to one NJ TRANSIT bus route (120 – Bayonne – Lower Manhattan), there are also individual bus routes operated by DeCamp Bus Lines, Lakeland Bus Lines, Suburban Transit, and Trans-Bridge Lines that currently use the Holland Tunnel to provide trans-Hudson service. There are two fairly robust clusters of activity in Lower Manhattan, each served in part by buses using the Holland Tunnel: (1) commuter routes that serve Wall Street and the Financial District, primarily along the Church Street/Broadway corridors; and (2) intercity routes that primarily serve Chinatown, which tend to be clustered around the Manhattan Bridge. Combined with the Staten Island express buses that serve the Financial District via the Battery Tunnel, the Church Street/Broadway corridor is close to saturated with buses during peak hours. In sum, trans-Hudson bus service to Lower Manhattan already exists and is well used, and its small size relative to the PABT is largely a function of market demand.

According to the 2014 Hub Bound Travel Data Report, only approximately 60 buses use the Holland Tunnel for outbound service in the PM peak hour, compared to approximately 680 buses that use the Lincoln Tunnel. This strategy aims to increase or add service via the Holland Tunnel to Lower Manhattan from potential markets that are currently underserved, thereby potentially helping to shed demand at the PABT. For example, commuter markets from Hudson County—which is a huge source of demand at the PABT—that are not well served by PATH, ferries, and NJ TRANSIT's Route 120 could be interested in bus service to the Financial District.

Figure 12: Origins of Candidate Bus Routes for Increased Use of the Holland Tunnel



**LEGEND**

-  NJ TRANSIT
-  PATH
-  NYC Subway
-  Major Highway
-  Metro North
-  New Jersey Trans-Hudson Travel Corridors
-  Candidate Bus Route Corridors

Source: Trans-Hudson Commuting Capacity Study

In addition to historical restrictions on use of the Holland Tunnel by certain buses and carriers because of the narrow width of the tubes (compared to the Lincoln Tunnel), there are several potential reasons to explain the low utilization of the Holland Tunnel by the trans-Hudson bus market. These reasons could include—but are not necessarily limited to—capacity constraints and associated travel time unreliability within the Holland Tunnel and at its approaches, significant congestion within Manhattan south of Canal Street, the absence of customer amenities in Lower Manhattan, and restrictions on which carriers can operate and drop off/pick up customers on New York City streets.

The lack of bus priority in the outbound direction from Lower Manhattan to and through the Holland Tunnel is particularly significant as an impediment to reliable outbound PM bus operations. A bus priority solution has eluded combined staff efforts at the PANYNJ and NYCDOT for decades. In short, many of these actions have been evaluated in the past. Improved access from the north via Varick Street may be easier to achieve, but even if this action could be implemented, it would not improve travel times for Lower Manhattan commuters. Achieving a noteworthy improvement in bus priority and speed from Lower Manhattan through the Holland Tunnel would require real local support to enable the participating agencies to move forward.

This strategy aims to increase use of the Holland Tunnel by making this crossing a more attractive option for trans-Hudson bus commuters. For instance, expansion of the existing bus/HOV lane in Jersey City at the 12<sup>th</sup> Street approach to the Holland Tunnel may help improve bus access from immediately adjacent origins. Additional operational changes could be considered on 14<sup>th</sup> Street in Jersey City as well as the New Jersey Turnpike Newark Bay Extension to improve bus travel times. Furthermore, under this strategy, all Holland Tunnel buses could be outfitted with Traffic Signal Priority (TSP) equipment to take advantage of existing TSP on Water Street and other corridors within Manhattan, such as Church Street, where it could be implemented. On the approaches to the Holland Tunnel and through the tubes, eastbound bus priority could be considered during the AM peak period in order to take advantage of directional flow imbalances. In addition, bus priority or a queue bypass could be considered to speed westbound buses into the tunnel in the PM peak period. To further improve the customer experience, several stops in Lower Manhattan could be designated as primary boarding/alighting locations and could be prioritized for capital investment to add ticketing, real-time arrival displays, shelter from the elements, benches, and other customer amenities.

Potential benefits associated with this strategy include modest demand shedding for the Lincoln Tunnel corridor and PABT, time savings and cost savings for certain trans-Hudson commuters (with no need to transfer to the subway to get to Lower Manhattan), and reduction in bus operating costs for certain diverted routes. Potential impacts associated with this strategy include additional congestion along the Holland Tunnel and its approaches, as well as additional congestion within Manhattan on New York City streets. Impacts on bus operating costs could be neutral if time savings approaching the Holland Tunnel were to be off-set by additional travel time costs operating on New York City streets. Furthermore, from a customer's perspective, service to Lower Manhattan would be less frequent than service to the PABT under the potential pilot program associated with this strategy, which could limit the attractiveness of the service.

Public policy issues that would need to be considered for this strategy include but are not limited to those pertaining to the aforementioned Lincoln Tunnel/Holland Tunnel bus loop operation strategy. Coordination would also be necessary with NJDOT and the municipalities with roadway jurisdiction, as well as the bus operators, to identify suitable bus priority measures and stopping locations in New Jersey. Additional coordination would be necessary with NYCDOT and NYCT to establish reasonably unified routings for Lower Manhattan bus services and to establish fewer, but higher-quality bus stops. At a minimum, each stop should have a shelter with benches, real-time variable message signage (VMS) displays, and adequate space for customer queuing. Additionally, this strategy would ideally include a location for staging/storage of a small number of buses in Lower Manhattan.

**Conclusion:** Increased use of the Holland Tunnel to serve Lower Manhattan instead of the PABT has the potential to result in a modest reduction of peak hour demand at the PABT. For purposes of the potential pilot program, an estimated 20 PM peak hour bus trips could be diverted from the PABT to Lower Manhattan. If the potential pilot program is successful and viewed as an attractive option for trans-Hudson commuters, additional variants of candidate route(s) could be implemented to use the Holland Tunnel and serve Lower Manhattan. Similar to the Lincoln Tunnel/Holland Tunnel loop operation strategy, it is possible that capacity limitations of the Holland Tunnel and its approaches could be a constraint in fully realizing the potential demand shift from the Lincoln Tunnel corridor and PABT. Implementation of this strategy should consider opportunities to increase bus priority on both sides of the Hudson River, to the extent that such opportunities are operationally feasible. The success of this strategy is also dependent upon identification of new commuter markets that currently lack service to Lower Manhattan. There is no expectation that improving bus access into and out of Lower Manhattan through the Holland Tunnel is easy to achieve, but there are potential benefits to trans-Hudson commutation, so there could be value in further exploring these actions.

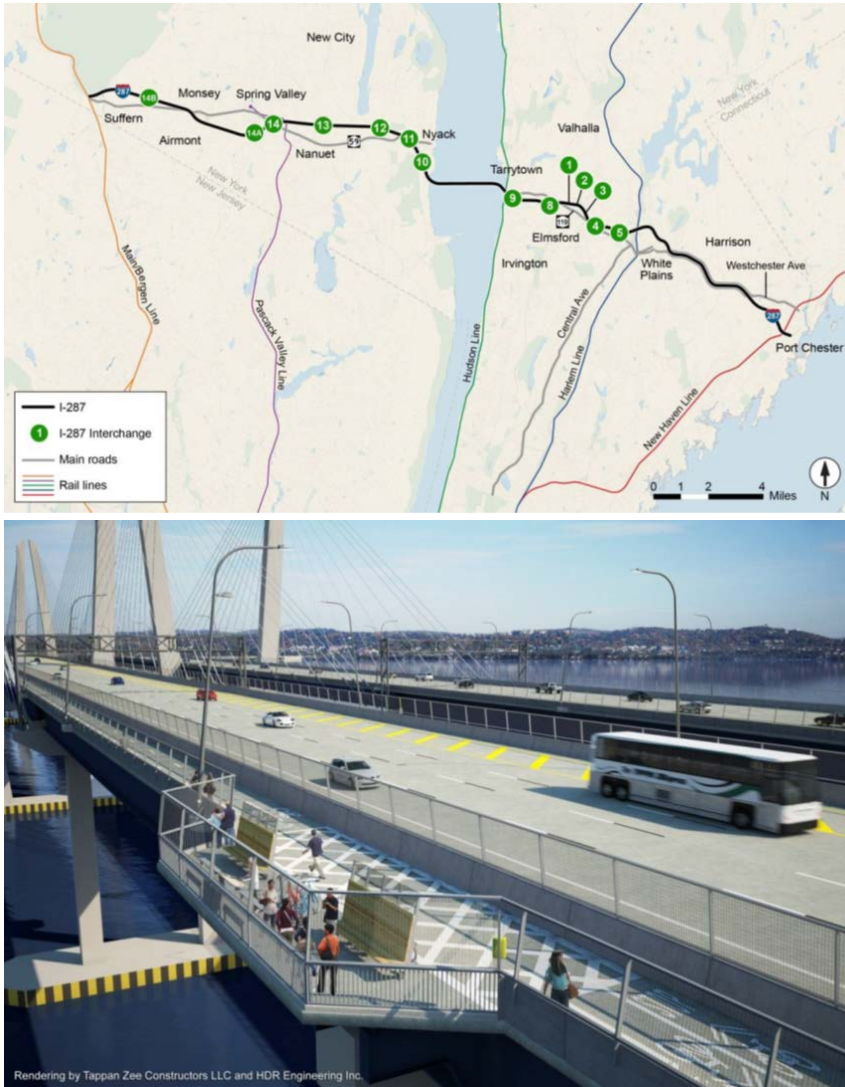
#### 3.1.4 Lower Hudson Transit Link/New NY Bridge (Tappan Zee Bridge Replacement)

This strategy calls for promoting the use of the planned enhanced commuter bus service across the New NY Bridge by trans-Hudson commuters, and a commensurate reduction in bus service to the PABT via the Lincoln Tunnel corridor. Rather than use commuter bus routes that serve the PABT, customers would use the planned enhanced commuter bus service across the New NY Bridge that would serve White Plains and Tarrytown, where customers could transfer to the Metro-North Railroad to access Midtown Manhattan.

Upon its scheduled completion in 2018, the New NY Bridge could serve Manhattan-bound trans-Hudson bus commuters from points to the north in New York along the I-287 corridor. As discussed in the MBMP, approximately 7% of customers on PABT commuter routes (approximately 6,500 customers) live in Orange or Rockland Counties or elsewhere in New York State, and these customers could be candidates for use of this strategy because of their residence location. However, the 7% figure should be qualified to note that some passengers are destined to West Side locations that

would not benefit from this strategy. Accordingly, this strategy would likely be most appealing to customers whose destination is in East Midtown. Figure 13 shows the I-287 corridor in Rockland and Westchester Counties, as well as a rendering of the New NY Bridge.

Figure 13: I-287 Corridor and Rendering of New NY Bridge



Source: New NY Bridge Mass Transit Task Force, Final Transit Recommendations

This strategy aims to leverage the planned enhanced commuter bus service that would connect Rockland and Westchester Counties by way of the New NY Bridge. The enhanced commuter bus service, which is anticipated to use double decker buses for added capacity, would connect Rockland County to White Plains on the Harlem Line and Tarrytown on the Hudson Line of the Metro-North Railroad. There are plans for a variety of bus priority measures along I-287 and the adjacent

arterial highways. The enhanced commuter bus service would make it more convenient for trans-Hudson commuters from points to the north in New York to ride Metro-North Railroad into Grand Central Terminal.

With marketing, fare integration, and schedule integration, this link has the potential to divert additional customers from Rockland and Orange Counties who currently ride PABT buses.

With respect to both fare and trip time, this strategy may not be competitive with continued use of PABT commuter bus services. A monthly pass (40-trip discounted commuter book) on Coach USA's Route 49—which connects points in Rockland County to the PABT—costs \$300, and a monthly pass on the Metro-North Railroad from White Plains to Grand Central Terminal costs \$259, which excludes the additional fare (not yet known) that would be required to use the enhanced commuter bus service from Rockland County to White Plains. Additionally, during the peak period, a commuter trip on Coach USA's Route 495 takes approximately one hour to travel to the PABT (from Spring Valley in Rockland County), while a trip to Grand Central Terminal using the proposed enhanced bus service from Spring Valley and a transfer to Metro-North Railroad at White Plains would take approximately 80 minutes (excluding transfer time). Accordingly, this strategy that includes a two-seat ride may cost more and/or take longer for a commuter than the existing bus service that offers a one-seat ride for commuters from Rockland County to the CBD. However, it may be an attractive option for PABT customers who work in East Midtown, many of whom already have a two-seat ride if they transfer to the subway to access their final destination. Additionally, a convenient connection to Metro-North Railroad east-of-Hudson service may provide more frequent and/or reliable service, with appeal to East Midtown workers.

Potential benefits associated with this strategy include modest demand shedding for the Lincoln Tunnel corridor and PABT, as well as possible time savings for certain trans-Hudson commuters (although it is important to note the possible shortcomings discussed above). Potential impacts associated with this strategy include one additional transfer for current PABT customers who walk to their work destination, loss of revenue for the PANYNJ if fewer buses use the PANYNJ-owned Hudson River crossings, and possible higher fares for the customers (compared to the commute to the PABT). Public policy issues that would need to be considered for this strategy include jurisdictional coordination regarding fare policy, marketing, and scheduling of service.

**Conclusion: The use of the planned enhanced bus service across the New NY Bridge by trans-Hudson commuters has the potential to result in a modest reduction of peak hour demand at the PABT. It is not unreasonable to anticipate that, over time, up to 1,000 daily commuters who currently use the PABT could switch to a transit link over the New NY Bridge. If this were to happen, it could reduce PABT demand by approximately 15-20 buses. However, since planning for transit over the new bridge is ongoing, it is premature to assign a number to the potential reduction in buses for use in planning the PABT replacement. Overall, this strategy may well be a viable alternative for some commuters from Rockland and Orange Counties to the East Side of Manhattan if the service along the New NY Bridge is sufficiently robust and total fare/trip time do not render it uncompetitive.**

## 4 Additional Considerations

### 4.1 INCENTIVE-BASED CAPACITY MANAGEMENT PROGRAMS VS. MANDATED VEHICULAR ACCESS POLICIES

The discussion of Lincoln Tunnel corridor/PABT strategies included consideration for a second XBL or HOT lane along Route 495 to support expanded bus prioritization (Section 2.1.1). Another possible way to achieve the operational goal of increased bus throughput into Manhattan during the AM peak period would be to prohibit use of the Lincoln Tunnel by Single Occupancy Vehicles (SOVs) during rush hour. This would reduce demand for car trips during the peak period, make additional capacity available for buses, and reduce travel time for carpools.

Limiting SOVs during rush hour could be expected to free up sufficient capacity in the Lincoln Tunnel to meet the projected AM throughput goal. However, this action would have greater ancillary effects on drivers than would the second XBL/HOT lane strategy. Creating capacity for buses using a HOT lane would allow drivers a choice: they could participate in a carpool<sup>1</sup> or pay a variable charge for a quicker trip, or opt for a slower, less costly trip. The ultimate choice would lie with each individual driver. The benefit of limiting SOVs could include a reduced infrastructure cost and faster implementation, but it relies on a potentially difficult public policy shift requiring extensive coordination and public outreach. It is noted that prohibiting SOVs during the AM rush hour may be a desirable policy choice, but it would have no greater benefit for buses than imposing a second XBL/HOT lane.

In sum, access to the Lincoln Tunnel for cars could be limited to HOVs during the morning rush hour, and doing so could be expected to generate sufficient capacity for buses to achieve the necessary throughput to serve an expanded XBL. However, this objective could also be met by adopting a second XBL/HOT lane in a way that still allows SOV access during the AM rush, and might also be met by using bus platooning (Section 2.1.3). Limiting travel of SOVs may be desirable from a policy point of view, but it provides no additional benefits for buses than could be achieved by other means.

### 4.2 IMPACT OF LATENT DEMAND

Latent demand is desire for transportation that goes unmet by the existing supply of transportation services. This latent demand generally cannot be observed, but can become real growth in passenger activity after transportation system capacity is increased. Generally, in a traditional

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<sup>1</sup> It should also be noted that the 2009 *Lincoln Tunnel HOT Lane Feasibility Study* considered whether HOVs would be able to access the HOT lane for free. The study recommended against this policy because of the expense and challenge associated with verification of HOV occupancy in light of the PANYNJ's possible migration to all-electronic tolling procedures.

planning process, if population remains the same and service characteristics like travel time and cost do not change, it is assumed that there would not be growth in passenger activity on the service. However, if a transit service is highly congested, then simply increasing service will induce additional travel even if the observable characteristics of the service do not change. On the trans-Hudson bus network, where service is limited at the peak by operational constraints, bus operators currently provide less service than their customers desire. For the PABT planning process, this means that latent demand could induce travel at the future terminal being considered by the PANYNJ beyond the projections of the travel demand models, which use ridership on existing services as a baseline input.

An example of this phenomenon is the impact to trans-Hudson travel when the Frank R. Lautenberg (FRL) Station in Secaucus opened in 2003. The FRL station allowed NJ TRANSIT customers on the Main, Pascack Valley and Bergen County lines—previously destined to Hoboken to transfer to PATH or ferry for service to Manhattan—to instead conveniently transfer for direct service to Penn Station New York (PSNY). NJ TRANSIT reconfigured a number of bus routes from Bergen County, with the expectation that customers would shift from bus to rail for this new service to PSNY. It was expected that several thousand commuters would make this choice, with the net result being higher use of PSNY and corresponding lower use of PABT. When the service changes were initiated, use of NJ TRANSIT rail increased as expected. However, use of PABT did not see a corresponding decrease. It is believed that this was due to latent demand – as seats were freed-up on buses headed to PABT by commuters choosing rail, others who had been using neither bus nor rail saw an opportunity. These might be people previously drove to New York or were not making the crossing at all.

This phenomenon has several implications for PABT reconstruction. First, if significant latent demand exists, it cannot be assumed that strategies to increase use of a mode or crossing other than the Lincoln Tunnel/PABT system will simply rebalance existing demand. The result could be more demand on the improved service or facility with little or no reduction in demand at PABT. Connected vehicle technology which would enable more buses to flow through the XBL and shared-vehicle technologies that allow customers to more easily connect to transit in New Jersey could also add to the attractiveness of the system and tap latent demand. Additionally, efforts to enable a smaller reconstructed bus terminal by handling demand at PABT more efficiently using design, storage and staging, or technology may not have the desired effect. Rather than the same commuters simply using a smaller but more efficient facility, new commuters could flock to the improved facility in even greater numbers than expected due to its new-found attractiveness and efficiency.

It is important to note that the ridership forecast prepared for the MBMP and used as an input to this Capacity Study does not fully account for the effects of latent demand. As noted in the MBMP Final Report Appendix B (*Bus & Passenger Activity Forecasts*), although the results of the ridership forecast are unconstrained by transit capacity, “The results [of the forecast] do not include the additional ridership induced by increased service frequencies due to agencies increasing their schedules to meet demand.” Additionally, the ridership model projects future demand based on base year ridership, and to the extent that the base year is not reflective of existing demand (due to capacity constraints), the future projections could underestimate likely demand. Indeed, NJ TRANSIT staff has advised the study team that it would add more peak-period service from certain

markets to the PABT today if capacity were available. Accordingly, latent demand implies growth above and beyond the demand forecasts.

In sum, latent demand could substantially reduce or offset any benefits obtained by shifting demand to other time periods or other modes. Due to growth from better service and a better terminal, a longer horizon year, and inevitable uncertainties, there may be the need for another (higher) forecast. Even if that number is not used for the design, it will be important to prepare a contingency plan for how the terminal might be expanded to accommodate more riders beyond the 2040 forecasts.

### 4.3 CUMULATIVE EFFECTS

Although the discussion in this technical memorandum so far has concentrated on strategies that could reduce peak hour bus demand to PABT (and/or increase the operational efficiency of the Lincoln Tunnel corridor/PABT facility), policy makers should be aware that there are as many factors that could increase demand for peak hour access to PABT as could reduce it. Some of the bus strategies described in this technical memorandum have potential to increase operating efficiency of the terminal itself in the PM peak beyond the six turns per gate per hour assumed for the MBMP. In particular, it may be possible to combine well-designed staging and storage in Manhattan with new bus tracking and dispatch technology to make more efficient use of bus gates and achieve the promised level of peak hour throughput with fewer gates. This opens the possibility to achieving desired performance with a smaller, less costly facility.

However, there are also reasons to be cautious. First and foremost, the Capacity Study team has found no other bus facility in the world that has implemented a comparable package of design and advanced technology solutions to use as a benchmark. Additionally, the nature of the PABT as a multilevel facility where vertical circulation is at least as important as horizontal circulation makes it different from most other large bus terminals. This is not a reason to shy away from aggressively pursuing these strategies. However, planners should recognize the uncertainties that limit the ability to accurately predict how effective they will ultimately prove to be.

Even if gate throughputs that are consistently higher than assumed for the MBMP can be achieved, there is reason to suspect that other factors may tend to work against any such gains. Several bus strategies described in this technical memorandum have the ability to reduce bus delays in addition to expanding bus throughput. During the AM peak, buses are delayed in several locations in gaining access to and transiting the Route 495 corridor/XBL, and several strategies have been proposed to reduce these delays. During the PM peak, buses are delayed getting to gates and, once loaded, in reaching the Lincoln Tunnel. These delays could be significantly reduced by the technology and staging/storage strategies discussed previously.

The net result would be both higher throughput and more reliable trip times for commuters (and perhaps even some time savings subject to traffic conditions elsewhere on their routes). Various plans have been proposed to increase capacity on the other main trans-Hudson transit crossings – PATH

trains and NJ TRANSIT rail – but in each case the likely outcome is higher throughput without much change in trip time for the average commuter. The cumulative result could be that bus travel becomes relatively more attractive than competing modes compared to today. Although there are a limited number of commuters who have the option to take either bus or rail due to route structure and other factors, nonetheless the result of improvements to the PABT system could be higher than anticipated demand.

#### 4.4 OTHER BUS NETWORK STRATEGIES CONSIDERED BUT NOT CARRIED FORWARD

This technical memorandum focuses on the most promising strategies to meet and manage existing and projected future trans-Hudson commuter demand. However, the list of strategies discussed in this technical memorandum is not exhaustive. Other strategies have been identified in prior trans-Hudson planning initiatives and/or during the Capacity Study process, but were deemed less promising than those outlined in this technical memorandum.

For instance, there is recurring interest in a **Westbound XBL**. The existing XBL facilitates efficient throughput for inbound buses to serve the PABT in the AM peak period, but there are no comparable provisions for bus priority in the outbound direction. However, the concept of a westbound XBL is difficult to justify because of the large number of exit points off Route 495, including Route 3 and both northbound and southbound NJ Turnpike. Whereas in the eastbound direction, these access points to Route 495 feed the Lincoln Tunnel, in the westbound direction, the situation is reversed, and the tunnel distributes traffic to a range of destinations. This presents a key operational constraint to the concept of a westbound XBL. Furthermore, the existing eastbound XBL was created in part to provide a bypass for buses to avoid the Lincoln Tunnel toll plaza, which is not an issue in the westbound direction. As such, this Capacity Study is not advancing a strategy that calls for the addition of a westbound XBL.

Another strategy that is not considered in this Capacity Study is the concept of spreading PABT buses across a number of **dedicated crosstown routes** in the Manhattan CBD (i.e., introducing a crosstown busway or bus boulevard) in lieu of a centralized bus terminal. The principal shortcoming, and indeed a fatal flaw of such an approach, is the challenge of turning buses around and providing layover space in East Midtown, especially for large volumes of buses. Another issue with this strategy would be the slow and highly variable bus travel time for crosstown operations. Even with the most effective bus priority treatments, crosstown bus speeds in Midtown would still be barely faster than walking, and there are concerns about the ability of west-of-Hudson buses to run crosstown and get back across the Hudson River with reliable running times during peak periods. Furthermore, the added congestion, emissions, fuel consumption, and bus miles could potentially result in adverse impacts to neighborhoods in Midtown. While some customers would be taken closer to their Manhattan destination, these customer benefits could also be offset by the introduction of on-street boarding. For all of these reasons, this strategy is not considered in this Capacity Study.

Other potential strategies were previously considered in the Capacity Study but not advanced for further evaluation based on feedback from PANYNJ staff. For instance, a strategy that was

previously identified but eliminated from consideration called for use of **elevators to facilitate bus storage**. Based on prior work, PANYNJ staff has considered this as not feasible for a commuter bus terminal.

There are also other potential strategies that have not been a focus of this Capacity Study to date but that nevertheless warrant recognition for their potential effect on the operational efficiency of Lincoln Tunnel corridor and/or the broader interstate transportation system. For instance, a potential strategy could call for **diverting current and future Staten Island-to-CBD bus demand** from the Lincoln Tunnel to the Staten Island Expressway (I-278) and the Battery Tunnel. Currently in the morning peak period, there are approximately 100 NYCT bus trips (X17J, X21, X22, X30, X31) that operate from Staten Island west over the Goethals Bridge, north along the NJ Turnpike, and back east across the Hudson River through the Lincoln Tunnel, taking advantage of the XBL. In the evening peak period, there are approximately 90 outbound trips through the Lincoln Tunnel. In addition, Academy Bus (X23, X24) operates approximately 32 inbound trips from Staten Island via the same path and approximately 28 companion outbound trips. These trips do not enter or use the PABT, but they add to bus volumes through the tunnel, and on Route 495 in both peaks.

The current Staten Island-Manhattan express-bus pattern reflects a balance between trips operating via New Jersey and through the I-278 bus priority corridor. Programmed improvements underway on the Verrazano-Narrows Bridge and the Gowanus Expressway in Brooklyn are expected to improve the performance of the bus-priority operation on I-278. Given the number of Staten Island buses operating on Route 495 and through the Lincoln Tunnel in peak hours, it could be beneficial to ask NYCT and Academy Bus if they would be amenable to re-evaluating operating practices to determine if the path via New Jersey is still the fastest and most dependable path. It may well be that circumstances have changed for certain routes, but the attractiveness of re-routing would likely depend on whether the enhanced managed use lane corridor on I-278 would offer those riders comparable or better travel times than the present route via New Jersey. However, it is worth noting that customers find these services very attractive, and may object if their route is redirected via a different path.

The technical memoranda for the Capacity Study will include additional analysis related to the most promising bus network strategies discussed in this technical memorandum (in addition to the strategies to be discussed in the “Multi-Modal Network Strategies” technical memorandum), as well as consideration for other strategies that may merit evaluation in the context of meeting and managing trans-Hudson commuter demand.

#### 4.5 LIFESPAN OF A NEW PABT BEYOND THE DESIGN YEAR 2040

As a matter of necessity, transportation planners must always select a future design year for the purpose of forecasting demand. For this technical memorandum, demand forecasts are made for 2040, 24 years in the future. This is consistent with standard practice in the transportation industry of forecasting demand 20-30 years into the future, and it represents the future year for which the most comprehensive data are available.

However, simply relying on forecasts for 2040 may not be ideal for PABT for several reasons.

First, it will take many years for a reconstructed PABT to be completed. Funding has yet to be secured and it is unknown how long this will take. In addition, design, engineering, environmental review and construction will all take time. A reasonable estimate for when a new facility might open could be 2025 at the earliest, and could stretch to 2030.

If a new facility is able to open in 2025, in the forecast year, 2040, it would be just 15 years old, well short of its actual useful life. If the often-used figure for a facility's useful life of 30 years is applied, the facility will not reach this age until 2055. However, a 30-year useful life is almost certainly too low for a facility of this kind. The south wing of the current facility opened 66 years ago; the north wing 37 years ago. Given the challenge currently facing the region as it considers renewing such a heavily used facility located in such a confined space, it is reasonable to expect that future policy makers will want to get every bit of utility possible out of a reconstructed PABT before renewing it yet again.

If planners were to assume a facility opening in 2025 and a 50-year useful life for a reconstructed PABT, an argument could be made for considering demand projections as far into the future as the year 2075 as being potentially relevant. Another perspective is to consider a potential 75-year design life (i.e., a horizon year of 2100), as would be assumed for a bridge.

Given the high level of uncertainty involved in projecting so far into the future, it may not be practical to generate and rely on numerical forecasts for 2075 or beyond. However, the real possibility that a reconstructed PABT may need to function for decades beyond the current 2040 horizon year suggests that policy makers should be wary of designing a facility that is strictly sized to meet only forecasted demand for 2040. Nevertheless, it should be noted that current PANYNJ forecasts assume that growth for the trans-Hudson commuting market will level-off significantly after 2040-2050, based on socioeconomic and demographic forecasts adopted by the region's two metropolitan planning organizations (i.e., New York Metropolitan Transportation Council (NYMTC) and North Jersey Transportation Planning Authority (NJTPA)). The NYCDCP similarly anticipates that population and employment growth in New York City will slow significantly after 2040.

In the PABT replacement planning effort, it is also important to consider the implications of the useful life of a new PABT in the context of the facility itself. For instance, PANYNJ staff has noted that it could be possible to rehabilitate the new PABT in phases (e.g., one helix at a time) and in perpetuity. Accordingly, future capital renewal of a new PABT must be considered in the design of the facility.

#### 4.6 IMPACTS OF SHIFTING THE NEW PABT FARTHER WEST/NEW 10<sup>TH</sup> AVE STATION

The existing PABT occupies the blocks between West 40<sup>th</sup> and West 42<sup>nd</sup> Streets and Eighth and Ninth Avenues in midtown Manhattan. The terminal provides direct connections to the Eighth Avenue A, C, and E subway lines and a passageway under 41<sup>st</sup> Street connects to Seventh Avenue 1, 2, 3, N, Q, R, S, and 7 subway lines.

The Port Authority Working Group concluded that the most promising approach to replacing the PABT would involve constructing a new bus terminal on available Port Authority-owned property one block west of the current structure, between Ninth and Eleventh Avenues. Under MBMP Concept 3, passenger gates would be relocated between Ninth and Eleventh Avenues, in order to allow the existing terminal to remain in operation throughout construction of the new bus terminal. Post-construction, the existing PABT site would be available for commercial development.

Shifting the new PABT one block farther west creates both challenges and opportunities. As noted in *The Emerging Design + Deliverability Brief* (Appendix A in the D+D Competition materials), approximately 50% of existing PABT's customers walk from the terminal and 40% use the subways to reach their final destination. More than half of PABT's customers are destined for Midtown Manhattan, east and north of the existing PABT. The shift of one city block would add approximately 6-7 minutes each way to customers' travel time for those who walk or access the subway.

The MBMP Peer Review conducted on November 16-18, 2015 identified several key issues including a major concern for increased walking distances and travel time as compared to the current facility. They noted that the pedestrian experience will need to be comfortable and efficient and that interim conditions are important as well as the long term.

The current No. 7 Extension to West 34th Street and 11th Avenue originally included provisions for a station at 10th Avenue. The current concept for providing this future station would include two side-platforms with connecting passageways. There would be two entrances: one at West 42nd Street between Dyer and 10th Avenues through the Related Companies' new mixed-use development, MiMa, and the second at 455 West 40th Street between Dyer and 10th Avenues. The conceptual design of the future station is currently being reviewed by NYCT. The proximity of this proposed station to the west side of a new PABT at 10th Avenue provides an opportunity to allow for convenient customer connections to the 7 Line to serve trips destined for Hudson Yards, East Midtown and Queens.

Overall, there is a significant travel time penalty as a result of shifting the new PABT farther west one city block. The design of the new PABT must take this into account and look for opportunities to create a more attractive experience for customers who are walking or transferring to the subway. Additionally, the planning process for the new terminal should investigate the benefits should the previously deferred construction of the No. 7 Line Extension 10th Avenue station go forward, especially with convenient pedestrian connections to a new PABT.

#### 4.7 INTERCITY BUS SERVICE ACCOMMODATION

Intercity bus operations have very different characteristics and demand from commuter buses and one argument is that they should not be included in a new PABT due to severe space limitations. Another side of the argument is that all bus operations should be unified in a new facility. This discussion will evaluate the pros and cons of the two courses of action.

Typically, commuter buses spend far less time at their gate than do intercity buses. Commuters, for the most part, understand the service pattern and how and where to board their bus. Intercity customers, however, need to allow more time for ticketing, to find their gate, confirm that they are on the correct bus and to stow baggage. Because intercity buses typically operate every several hours, customers strive to arrive early, to make sure that they do not miss their bus. Commuter buses typically operate much more frequently, so missing a bus is less of a concern. For these reasons, a proper waiting room is beneficial for intercity services.

This difference in behavior patterns means that, on average, gates dedicated to intercity service are not as intensively used as gates dedicated to commuter services. A commuter bus gate can be cycled every 10-15 minutes under most circumstances. Certain commuter routes, with simple fare collection and low-floor transit-style buses, could reliably cycle every 8 minutes. Intercity buses cycle 20 or 30 minutes for the reasons cited above. As a consequence, intercity bus gates are inherently less efficiently used. This then forces of question of whether there is room in a new PABT for intercity services.

It has also been proposed that intercity services would be not be permitted to depart the facility during the PM peak period. An advantage of moving intercity buses out of the terminal would be to free up additional space at the existing PABT for an expansion of commuter operations. While there is some logic to this approach from the view of the terminal operator, it creates issues for intercity customers and would severely constrain operations for the intercity operator. The comparison to rail operation is instructive. Amtrak does not load long-distance trains at Penn Station during the PM peak, because such trains take very long to load with many customers being assigned cabins, and to different rail cars for different destinations. Amtrak does, however, load regional trains during the PM peak period, because that is time that so many customers want to travel. It is not ideal to restrict intercity bus departures in the PM peak.

That said, there is no harm in offering incentives to intercity bus operators to shift some demand from the peak of the peak to less busy times. This would accomplish two complementary objectives. First, it would use scarce gate space in the PABT more effectively, and second, it would encourage intercity operators to stage departures at less congested times, thus speeding service for their customers.

If the decision is made to build a new free-standing intercity terminal, such a terminal could reasonably and feasibly be located away from the Lincoln Tunnel ramps complex. Intercity bus service thrives in locations throughout New York City that are not connected to bus priority infrastructure. Successful intercity bus service can be found throughout Midtown, around Hudson Yards, in Chinatown, and (including seasonal and casino routes) in neighborhoods throughout Manhattan and the other boroughs. Infrequent, lower volumes of intercity buses may be more compatible with on-street operations than high-frequency commuter services from a community impact/pedestrian safety perspective. Circulating on city streets, however, is bad for the quality of the service delivered to the customer and would increase operating costs for the carriers.

It is important to note that expenses associated with a separate facility for intercity buses would include both upfront capital costs and ongoing operating and maintenance costs. From the PANYNJ's

perspective, a new intercity facility would ideally be managed and operated by one or more of the carriers. However, if such an arrangement cannot be developed, management and operation of the facility would likely fall back to the PANYNJ, thereby leaving the PANYNJ with the added expense of managing two bus facilities in the place of one.

In order for a stand-alone intercity terminal to accommodate all of the carriers envisioned for it with only 35 gates, it will require some provision for bus layovers. Layover time is slack time independent of passenger boarding/alighting operations for driver rest and light interior cleaning of the bus. In the existing PABT, intercity operators tend to layover buses in passenger gates because no reliable alternative exists. However, off-site bus layovers are common in New York City by curbside carriers and in other cities around the world.

The MBMP envisioned that the staging/storage facility would also be used for intercity bus layovers. If a staging/storage facility is not completed when a new intercity terminal opens, some interim provision for layovers will need to be made for the new facility to be fully efficient.

Overall, intercity bus carriers have introduced low-cost travel options that are beneficial to and valued by the public. The MBMP anticipated a need to accommodate a few of the largest curbside operators in a new PABT, while other operators would continue to provide curbside service. The much-cited projection of 855 PM peak hour bus departures at a new PABT accounts for commuter buses and those intercity buses that currently serve the existing PABT. The projection does not include approximately 25 “additional Midtown-based intercity buses with sufficiently robust schedules and financial stability to be suitable as tenants in a future bus terminal”—as described in the MBMP Final Report Appendix B (*Bus & Passenger Activity Forecasts*)—but that currently provide curbside service. To accommodate these additional intercity buses, the bus demand at the new PABT in 2040 would be approximately 880 departures during the PM peak hour, whereas the demand would be approximately 820 departures during the PM peak hour if the PABT would not accommodate any intercity buses. The effort to right-size the PABT must consider whether intercity carriers will be accommodated in the new facility, and if so, whether some carriers would continue to provide curbside service.

## 5 Findings

The purpose of this technical memorandum is to investigate possible future strategies for trans-Hudson bus infrastructure and operations that could help optimize the capacity and configuration of a reconstructed Port Authority Bus Terminal (PABT).

While a new bus terminal will need to provide more room for bus customers on escalators, in waiting areas and along passageways, the crucial factor in modeling the ultimate capacity of a reconstructed facility will be the logistics of handling the buses themselves. Accordingly, analysis performed for this technical memorandum considered strategies that fall into two categories:

- Strategies that increase/manage capacity along the Lincoln Tunnel corridor
- Strategies that **address overall Trans-Hudson demand** including the use of other crossings (to be supplemented in the “Multi-Modal Network Strategies” technical memorandum by strategies that consider other modes)

The final number of gates needed at a reconstructed PABT, and thus the facility’s ultimate capacity and cost, is heavily influenced by the implications of these strategies with respect to meeting projected peak period trans-Hudson commuter demand.

Due to the timing and other parameters laid out at the beginning of the Capacity Study process, this technical memorandum’s findings are largely qualitative, and recommendations are made in several places suggesting where additional quantitative assessments are appropriate. It is important to note that, based upon the Port Authority of New York and New Jersey (PANYNJ) Board resolution of March 24, 2016, the analysis in this technical memorandum did not consider an option that would include construction of a bus terminal in New Jersey. However, the assessment included consideration of infrastructure improvements and operational initiatives in New Jersey important for reliable commuter service and containment of traffic impacts on both sides of the Hudson River.

Initial findings, which are revisited as appropriate in subsequent technical memoranda in the Capacity Study, are as follows.

1. **PABT is not a stand-alone facility; it is part of a system.** The bus terminal is just one component of a trans-Hudson bus transportation system extending from 8<sup>th</sup> Avenue in Manhattan all the way to the New Jersey Turnpike five miles to the west and beyond. To handle future demand, all parts of this system – the ‘teardrop’ and other approaches to Route 495, the Exclusive Bus Lane (XBL) and other lanes of Route 495, the Helix, the toll plaza, the Lincoln Tunnel tubes, the ramps leading into PABT, and locations for bus storage and staging on both sides of the Hudson River – must function as a system. Investments or policy changes that increase throughput in one segment without addressing upstream and downstream effects will not have the desired results.

Additionally, strategies are needed to address system-wide operational constraints for both the AM and PM peak periods.

- 2. Infrastructure and operations must be considered together.** Any future design for this integrated system must be grounded in a concept for how its individual parts will be operated. This includes factors from the size of buses to be used, where buses are staged and stored, and how buses move from storage to bus gates, to operation of the reversible lanes and the role technology will play in guiding bus movements. Proposals for facility design cannot be evaluated without understanding how they will be operated, and operational innovations cannot be implemented without supportive design. Each depends upon the other.
- 3. The infrastructure and operational plan for the future of the PABT must be arrived at through a process of collaboration.** The key facilities and procedures that make up the Lincoln Tunnel corridor/PABT system are in the hands of multiple government agencies and private operators spread across two states. As such, no single party can simply select a solution and implement it unilaterally. The future must be determined collaboratively, with each party clearly communicating its needs and priorities while respecting the needs and priorities of others. The ability of the interstate transportation system to accommodate projected commuter demand is dependent upon active cooperation and engaged working relationships across jurisdictional boundaries, including the City of New York, municipalities in New Jersey and agencies in both states. This includes collaboration with respect to bus staging and storage, pick-up/drop-off locations, roadway improvements, and implementation of additional bus prioritization.
- 4. Bus staging and storage is a critical issue that can and must be addressed in the short term.** A bus staging and storage facility in West Midtown represents an essential component of the new PABT complex in both the short and long term – such a facility could have independent utility in the near-term, and would be an important component of a new PABT in the longer term. A West Midtown bus staging and storage facility could result in improved reliability of customer operations, reduced demand along the Lincoln Tunnel corridor, and increased near-term capacity of the existing PABT, and thus should be accelerated as a first stage of the PABT replacement. During this Capacity Study process, PABT/Lincoln Tunnel management suggested that some—but not all—bus staging and storage should be accommodated in New Jersey, also noting that a facility in New Jersey would require proximity to the tunnel plaza and rigorous management of inbound Lincoln Tunnel lanes to ensure highly reliable dispatch of buses through the tunnel to their assigned gates. It would be advantageous to accommodate bus staging and storage on both sides of the Hudson River to promote balance in the interstate transportation network.
- 5. Strategies that accommodate trans-Hudson buses using other crossings, including the George Washington Bridge and the Holland Tunnel, have some potential to reduce demand at the PABT.** This technical memorandum has discussed three potential strategies that could siphon off some of the projected demand at the PABT by implementing new variants on existing commuter bus services from select trans-Hudson travel corridors. The route variants would use Hudson River crossings other than the Lincoln Tunnel as part of a pilot program. The technical memorandum also considers a strategy that calls for promoting the use of the planned enhanced

commuter bus service across the New NY Bridge by residents of Rockland and Orange Counties who currently use PABT bus routes. The intent of these strategies is to expand the potential of alternate Hudson River crossings as attractive commuting options, and not to force PABT customers to change their travel patterns. The preliminary assessment completed for this technical memorandum found that approximately 40 buses per hour could be diverted from the PABT when considering the potential cumulative effects of these pilot programs. This represents approximately 5% of the projected 855 PM peak hour bus departures at the PABT in 2040. If the pilot programs are successful and viewed as attractive options for trans-Hudson commuters, additional route variants could be implemented, which could result in a commensurate reduction in peak period demand at the PABT. Overall, while these strategies offer some promise with respect to reduction of peak period demand at the PABT, the potential reduction is not significant, and should not be overstated.

6. **Changes to the infrastructure and operations of Route 495 and points farther west in the New Jersey roadway network would have benefits to interstate bus operations and local traffic conditions preceding a reconstructed PABT, and would balance the capacity of the west-of-Hudson network with a new terminal designed to accommodate the 2040 demand forecast.** During the AM peak, buses are delayed in several locations in gaining access to and traversing the Lincoln Tunnel corridor. Demand currently approaches or exceeds capacity along the XBL, so capacity improvements for additional bus prioritization could productively be accelerated for early implementation to address existing capacity constraints. Over the longer term, without increases to the throughput capacity of this system, money spent on a higher capacity PABT will not generate the desired performance gains. It will almost certainly be necessary to either convert one general purpose inbound lane of Route 495 and the Lincoln Tunnel to a second XBL or combined XBL/HOT lane during the AM peak, or to implement bus platooning technology that will allow a significantly higher level of bus throughput in the current single dedicated XBL. Additionally, network improvements to support expanded and more efficient bus operations are also needed on the major Route 495 approaches, including Route 3 and the NJ Turnpike. Indeed, to support existing and projected future demand, there is a need to enhance the operation of the existing XBL and also supplement the XBL by providing additional bus prioritization farther upstream from the Lincoln Tunnel.
7. **Emerging technology to support bus platooning offers an opportunity for major performance improvements to the Route 495/Lincoln Tunnel system.** Implementation of bus platooning may be possible within 10 years and could significantly increase throughput of the existing XBL, assuming commensurate efficiencies are achievable crossing into Manhattan. Many of the technologies necessary for such a system are already available or will be soon. However, the pathway for these technologies to be integrated into a system that can manage the unique needs of the Route 495/Lincoln Tunnel corridor is less clear. The PANYNJ should seriously consider taking a lead role in setting out requirements for such a system and sponsoring the needed technology integration. A technology solution would have less effect on other users of Route 495 than dedicating a second bus lane during the morning rush, although a second priority lane would create a redundancy benefit that technology cannot fully provide.

- 8. Increased use of higher-capacity buses on routes with sufficient demand can improve the efficiency of the Lincoln Tunnel corridor and PABT, and should be seriously considered.** Some bus routes serving PABT carry very high volumes. On these routes, policy makers should seriously consider replacing conventional transit buses with higher-capacity double decker buses or articulated buses. Doing so could serve passenger demand with fewer bus movements, fewer bus gates, a smaller fleet, less fuel consumption, and lower operating costs, although it is possible that increased use of higher-capacity buses could function to accommodate more customers as opposed to fewer buses at the PABT. Ceiling height and other geometry issues limit the ability to use these vehicles in the terminal today, but the new terminal should be designed to accommodate the maximum reasonable usage of larger buses that could be possible given projections for customer demand. Although such a change to the bus fleet offers real promise, implementation would be complex. Many public agencies and private operators would be involved, height restrictions and axle loading standards on New Jersey roads would need to be addressed, as well as the size and configuration of bus garages and maintenance facilities. The key message for design of the new bus terminal is that uncertainty over future fleet mixes and service models require flexible designs and adaptable terminal configurations.
- 9. The combination of capacity management and demand management initiatives could potentially reduce the necessary capacity of a new PABT, if viable strategies are demonstrated during planning and project development.** This technical memorandum has outlined a range of strategies to manage capacity and improve the operational efficiency of the Lincoln Tunnel corridor/PABT facility, as well as strategies that address overall trans-Hudson demand. Collectively, these strategies—in concert with other multi-modal trans-Hudson strategies under consideration—could potentially reduce the capacity requirements of a new PABT. The PABT planning effort should consider the extent to which progress in advancing transit-service alternatives and demand management strategies could provide a sufficient and more cost-effective approach to a reconstructed PABT, while providing efficient terminal operation that also contains traffic impacts on the Lincoln Tunnel and surrounding streets. This is consistent with the objective to permit scalable and modular terminal solutions that may be phased over time. In turn, ongoing operational changes and potential projects that might divert some of the projected 2040 PABT demand will need to be assessed for their local impacts as well as transit service benefits.
- 10. Improvements at the PABT and along the Lincoln Tunnel corridor may actually increase demand for buses to use the PABT, underscoring the need for ongoing partnership efforts to improve bus-network efficiency and balance available interstate services across modes and corridors.** Reducing delays around the XBL and inside the PABT would generate both higher throughput and, crucially, more reliable end-to-end trip times for commuters (and perhaps even some time savings subject to traffic conditions elsewhere on their routes). This would likely occur in an environment where trip times on competing transit modes (PATH trains and NJ TRANSIT rail) hold steady even if investments to increase throughput capacity are made. The net result could be bus travel becoming relatively more attractive to commuters than competing modes. Although there are a limited number of commuters who have the option to take either bus or rail due to route structure and other factors, nonetheless the result could be demand for peak hour

bus access to the PABT that is actually higher than currently projected. This latent demand could cancel out the initial net reductions in peak-hour bus demand at the PABT from strategies to accommodate bus commuters via other crossings or improve the operational efficiency of the PABT.

- 11. There are as many factors that could increase demand for peak hour bus access to the PABT as could reduce it.** This statement was one of the primary conclusions of the participants in the April 14, 2016 experts' workshop undertaken as part of the Capacity Study. Although attendees generally agreed that many strategies were available to more efficiently manage the Lincoln Tunnel corridor/PABT system, there was a general consensus that policy makers should take seriously the possibility that projections for future bus demand as just as likely to be too low as too high. For instance, the uncertainty of achieving the full Gateway rail service expansion (discussed in the "Multi-Modal Network Strategies" technical memorandum) could increase future PABT bus demand. An additional consideration is that the travel time penalty of shifting the new PABT west could adversely impact ridership demand at the terminal.
- 12. A reconstructed PABT will likely need to accommodate growing demand well beyond the design year of 2040.** It will take many years for a new PABT to be designed, funded and built. For these reasons an opening date prior to 2025 seems unlikely. If this estimate is correct, in the forecast year of 2040 the new facility would be just 15 years old, well short of its actual useful life. In addition, future policy makers will likely want a reconstructed PABT to last longer than the 30 year life span considered standard for many infrastructure projects. The north wing of the current facility opened 37 years ago; the south wing, 66 years ago. The consequences of this could be significant: a new terminal opening in 2025 with a 50-year useful life would be called upon to accommodate growing demand until 2075. Nevertheless, it should be noted that current PANYNJ forecasts assume that growth for the trans-Hudson commuting market will level off significantly after 2040-2050, based on socioeconomic and demographic forecasts adopted by the region's two metropolitan planning organizations (i.e., New York Metropolitan Transportation Council (NYMTC) and North Jersey Transportation Planning Authority (NJTPA)). While it is not practical to produce exact demand forecasts as far out as 2075, the real possibility exists that a reconstructed PABT would need to function for decades beyond 2040. This suggests that policy makers should be wary of designing a facility that is strictly sized to meet only demand forecasted for 2040.
- 13. A policy decision must be made regarding accommodation of intercity bus service at a new PABT.** Today, some but not all intercity carriers that serve Midtown Manhattan enter the PABT, while others use on-street bus stops. This is due to a number of factors, including capacity constraints and structural limitations of the existing PABT. Operating characteristics for intercity buses are different from commuter buses, and there is a reasonable argument to be made that intercity buses should not be included in a new PABT due to the high cost of constructing a replacement facility large enough to serve both intercity and commuter buses. An argument can also be made to unify bus operations in a new facility. The much-cited projection of 855 PM peak hour bus departures at a new PABT accounts for commuter buses and those intercity buses that currently serve the existing PABT. The projection does not include approximately 25 additional Midtown-based intercity buses deemed to be suitable as tenants in a future bus

terminal but that currently provide curbside service. To accommodate these additional intercity buses, the bus demand at the new PABT in 2040 would be approximately 880 departures during the PM peak hour, whereas the demand would be approximately 820 departures during the PM peak hour if the PABT would not accommodate any intercity buses (based on demand projections in the MBMP Final Report Appendix B). The effort to right-size the PABT must consider whether intercity carriers will be accommodated in the new facility, and if so, whether some carriers would continue to provide curbside service.

Based on these findings, this technical memorandum reaches the following preliminary conclusions:

**Bus strategies are available to manage trans-Hudson travel in ways that could curb peak hour bus demand at PABT and process buses that do use the PABT more efficiently. Together, these approaches, if successful, open the possibility of a reconstructed facility that meets demand with fewer gates at a lower cost. Considering a terminal concept with less gate capacity than estimated to meet forecast demand would be feasible only if little or no accommodation for intercity buses is made in the new terminal, and the other bus network strategies considered in this technical memorandum—as well as the strategies to be considered in the “Multi-Modal Network Strategies” technical memorandum—are aggressively implemented and perform at the high end of available estimates.**

**However, factors are at work that may lead to levels of customer demand substantially higher than what is currently projected, and this would cause a facility with less than capacity required to support the project 2040 demand to exceed its design capacity relatively quickly. This countervailing pressure is further enhanced by the likelihood that a reconstructed terminal will be called upon to accommodate growing demand decades beyond the 2040 forecast year.**

**In sum, the authors have not found convincing evidence that the bus strategies considered in this technical memorandum can be relied upon to allow future demand for trans-Hudson bus travel to be accommodated at a bus terminal with substantially fewer gates than the full-build options presented in the MBMP. Some adjustments in capacity and scope may be possible but large reductions in the number of bus gates are not likely.**

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TRANS-HUDSON COMMUTING CAPACITY STUDY

# Appendix B: Multi-Modal Network Strategies

September 2016

Version Final

Prepared for:

**THE PORT AUTHORITY**  
OF NEW YORK & NEW JERSEY

Submitted by:



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## ATTACHMENTS

Attachment: Ferry Analysis

# 1 Introduction

On October 22, 2015, the Port Authority of New York and New Jersey’s (PANYNJ) Board of Commissioners authorized a *Trans-Hudson Commuting Capacity Study* (the Capacity Study) to evaluate a range of strategies for meeting and managing the anticipated increases in trans-Hudson commuter demand to 2040, to inform its deliberations on conceptual planning for replacement of the Port Authority Bus Terminal (PABT) (Table 2).

Table 1: Existing and Future PABT Demand

EXISTING (2011)	FUTURE (2040)
232,000 Daily Customers	337,000 Daily Customers (+45%)
7,800 Daily Buses	9,100 Daily Buses (+15%)
615 PM Peak Hour Buses	855 PM Peak Hour Buses (+40%)

Source: Midtown Bus Master Plan

The fundamental premise of the Capacity Study is that the transportation network that accommodates trans-Hudson commuter demand is an integrated *system*, as opposed to a series of stand-alone corridors, facilities, and services. Accordingly, the intended outcome of the Capacity Study is an updated overview of that system that takes into account potential investments in physical transportation infrastructure, operational changes to existing transit services, implementation of emerging technologies, and modifications to public policy – and the prospects for their implementation in the time frame for planning and implementing a PABT replacement project.

Concurrent with the Capacity Study, the PANYNJ has commissioned an *International Design + Deliverability Competition* (the D+D Competition) seeking concepts for a new PABT. A major objective of the Capacity Study is to provide insight to the D+D Competition by evaluating the range of alternative strategies for serving the trans-Hudson commuter market via bus and other modes, which will inform the determination of the appropriate capacity and configuration of the new PABT. The interim and final work products from the Capacity Study will inform the D+D Competition and the PANYNJ Board, which will select a preferred design concept for a new PABT this fall.

This technical memorandum evaluates a range of multi-modal network strategies/projects and their potential effect on projected trans-Hudson travel demand. The evaluation considers the extent to which these strategies may reduce demand on the constrained and congested elements of the trans-Hudson transportation network, with a focus on the Lincoln Tunnel corridor and PABT. The principal objectives of this technical memorandum are to assess the potential to add peak-period trans-Hudson capacity via other modes; their potential attractiveness to the trans-Hudson market; and the factors affecting the ability to implement these improvements in the time frame established for PABT redevelopment planning. The strategy development and assessment were informed by the Midtown Bus Master Plan (MBMP) effort and other previous plans and studies; meetings and technical discussions with PANYNJ and NJ TRANSIT staff; new research and operator interviews on commuter ferry services; and a Capacity Study Expert Workshop held on April 14, 2016. The final section of this technical memorandum provides targeted findings, including identification of factors relevant to the PABT replacement effort.

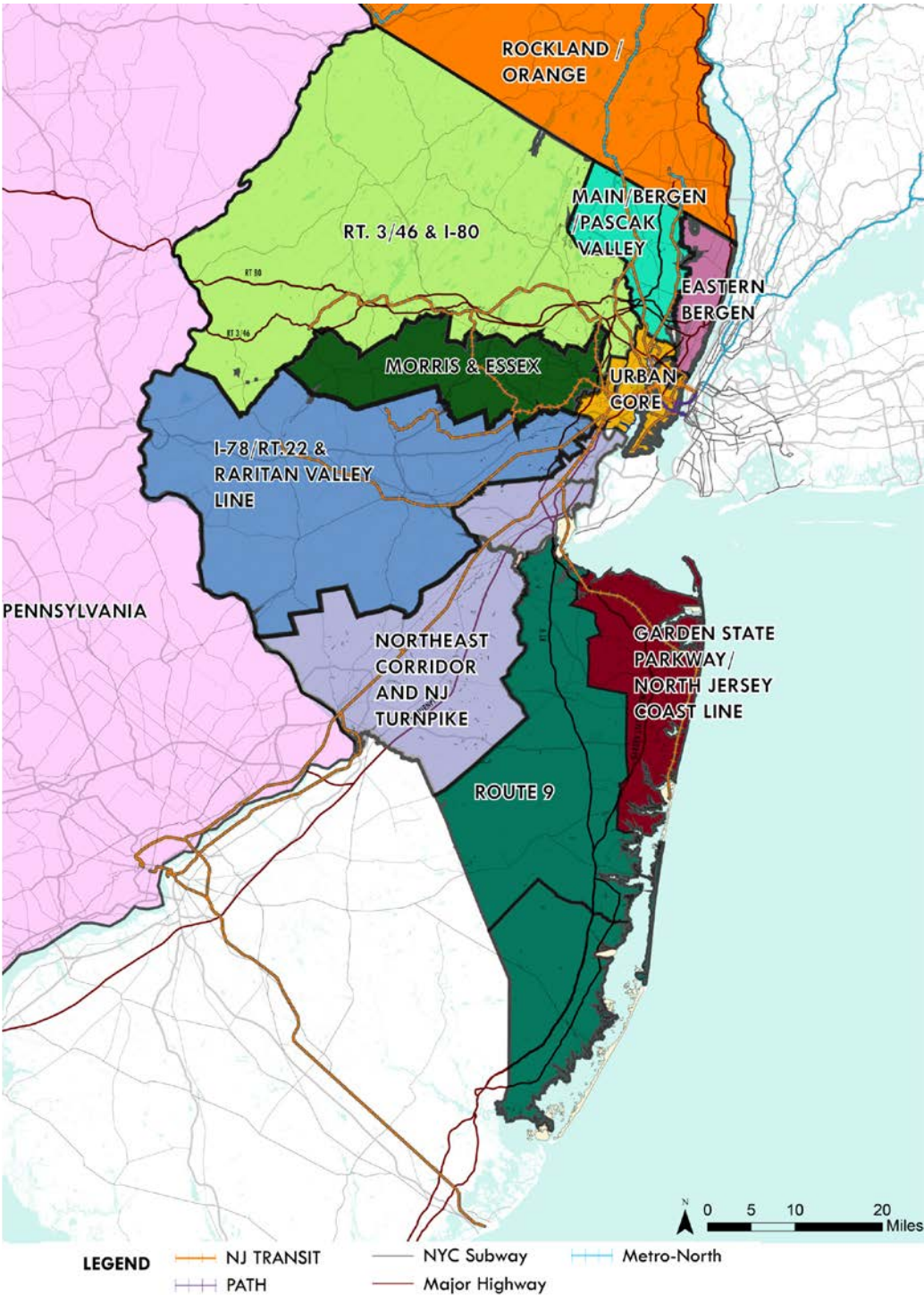
## 2 Multi-Modal Network Strategies

This technical memorandum builds upon and complements the work completed in the “Bus Network Operational/Service Strategies” technical memorandum. Whereas the bus network strategies aim to address trans-Hudson commuter demand through the use of other Hudson River crossings (besides the Lincoln Tunnel) for bus services, the multi-modal strategies discussed in this technical memorandum consider opportunities to balance demand across modes (with a focus on modes other than commuter bus).

There are several active projects in the region that could affect trans-Hudson travel. Indeed, the PANYNJ and other regional transportation agencies are currently advancing a number of initiatives related to the multi-modal interstate transportation network that could have implications for the trans-Hudson commuter market. Some of the initiatives are in the early planning stages, while others are further along in the project development process, ranging from design to construction.

The following sections discuss the multi-modal network strategies, including consideration for increased use of the Port Authority Trans Hudson (PATH) system, NJ TRANSIT commuter rail, ferries, and light rail by trans-Hudson commuters. The strategy assessment includes identification of potential benefits, impacts, and public policy issues associated with each strategy, as well as the potential for each strategy to result in peak period demand reduction along the Lincoln Tunnel corridor and at the PABT. Where applicable, the strategy assessment refers to specific trans-Hudson travel corridors (Figure 1) to identify the origins of trans-Hudson commuters for whom the respective strategy could potentially be an alternative to travel by bus via the Lincoln Tunnel and PABT. The strategies, in turn, could help to address overall trans-Hudson commuter demand in light of capacity constraints along the Lincoln Tunnel corridor.

Figure 1: West-of-Hudson Trans-Hudson Travel Corridors

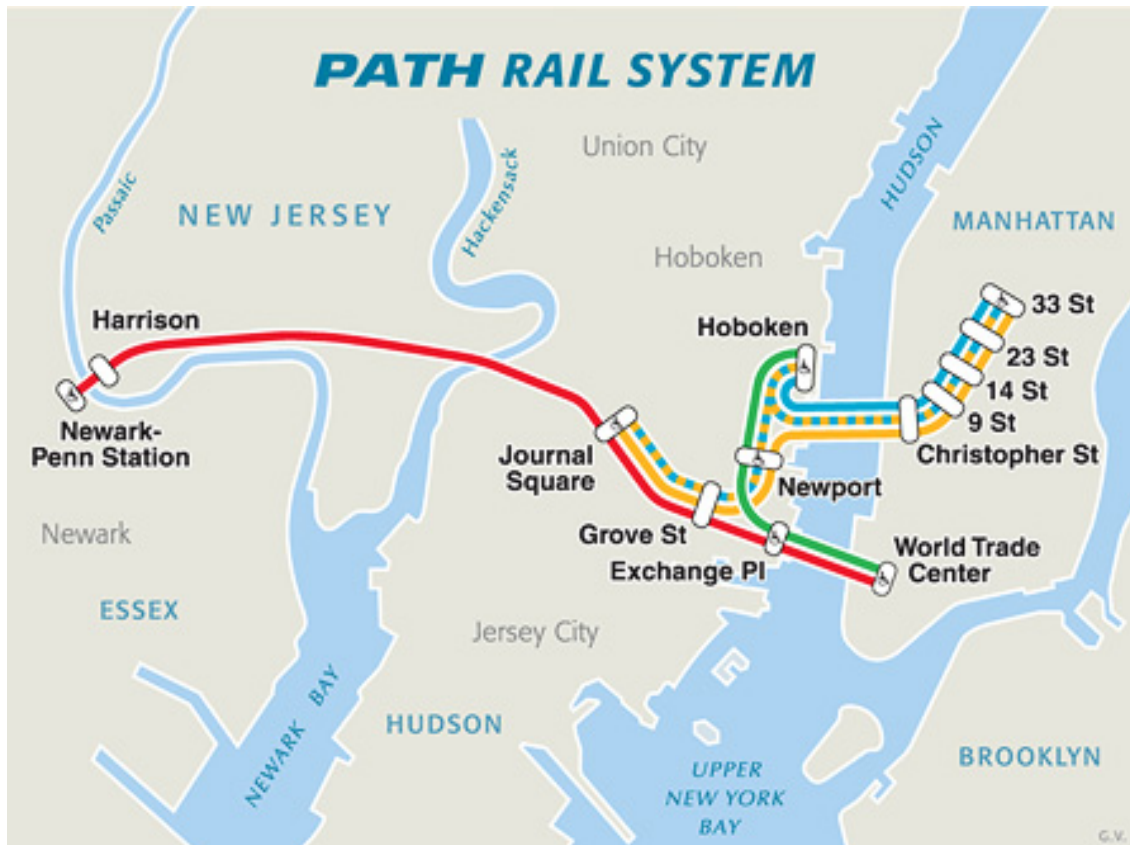


Source: Trans-Hudson Commuting Capacity Study, NJ TRANSIT

## 2.1 PATH SERVICE CAPACITY EXPANSION

This strategy calls for implementation of capital and operating improvements and policy changes to support expanded peak-period PATH service. The purpose of this strategy is to increase capacity along PATH lines for which peak hour demand approaches or exceeds capacity now or in the future. To demonstrate the need for this strategy, it is important to understand the existing and projected future demand outlook of the PATH system (Figure 2) by line.

Figure 2: PATH System



Source: PANYNJ

An April 2016 PANYNJ analysis of the PATH market and services described existing and projected future demand in comparison to capacity. For several PATH lines, peak demand occasionally if not regularly exceeds capacity under existing conditions, meaning that “passengers experience crush loading in excess of planning guidelines [110 passengers/car], or that passengers may not be able to board the first train that arrives and must queue on the platform.” Based on the expected effects

of other programmed transportation investments on PATH ridership, projected future trends in demand vary by PATH line:

- **Hoboken-33<sup>rd</sup> Street Line**

- Peak demand frequently exceeds capacity on this line today, but baseline projections indicate that pressure on this line will ease as some travel shifts to the downtown branch. In these baseline projections, peak demand is expected to exceed existing capacity in the 2030s, which points to the need to expand capacity in the long-term. Additionally, ridership on this line could grow faster than projected due to NJ TRANSIT capacity constraints under the Hudson River, a potential increase in NJ TRANSIT rail service frequency at Hoboken (refer to Section 2.6), and the potential extension of the Hudson-Bergen Light Rail (HBLR) system to Englewood as part of the Northern Branch Corridor Project (refer to Section 2.3).

- **Hoboken-WTC Line**

- At some point between 2020 and 2030, peak demand is expected to exceed existing capacity, which indicates a need for capacity expansion in the mid-term. As with the Hoboken-33<sup>rd</sup> Street Line, ridership could grow faster than projected depending on capacity shortfalls or network expansions on the NJ TRANSIT commuter rail or light rail systems.

- **Journal Square-33<sup>rd</sup> Street Line**

- Peak demand regularly exceeds capacity on this line today, but baseline projections indicate that pressure on this line will ease as some travel shifts to the downtown branch. Existing capacity is expected to be sufficient to accommodate demand beyond 2040. Therefore, capacity expansion is not expected to be necessary for this line based on current demand forecasts.

- **Newark-WTC Line**

- Due to improvements in the downtown transportation network, restoration of service on the 1 and W lines, and completion of the World Trade Center towers, passenger demand on this line is expected to grow rapidly. At some point between 2015 and 2020, peak demand on this line is expected to exceed existing capacity, which indicates a need for capacity expansion in the near-term. Demand is projected to continue to grow beyond 2020, reaching as much as 75% higher than 2015 levels by 2040. Ridership on this line could grow faster than projected due to the potential extension of the PATH system to Newark Liberty International Airport (EWR) (refer to Section 2.2).

To address the capacity constraints outlined above, this strategy includes two initiatives that are among those under consideration in ongoing development of the long-term PANYNJ Capital Program:

**1. PATH Signal System Replacement Program/Purchase of Additional Cars**

- This project includes the replacement of an outdated signal system with a computerized Automatic Train Control (ATC) System using Communications-Based Train Control (CBTC) technology. In addition to complying with Federal Railroad Administration (FRA) mandates for Positive Train Control (PTC), this project will also allow for increased capacity to meet growing ridership demand by permitting trains to operate safely in closer proximity to each other. Based on current demand projections, the additional capacity would likely be allocated to the Newark-WTC, Hoboken-WTC, and Hoboken-33<sup>rd</sup> Street Lines (Table 2) to address existing and projected future capacity constraints. The anticipated completion date for the signal replacement program is 2018. Increasing peak period service to take advantage of this additional capacity will require expansion of PATH railcar fleet (discussed below) by 50 cars.

Table 2: PATH Capacity Expansion Associated with the Signal System Replacement Program (CBTC) – Illustrative Service Plan

PATH Line	Existing Peak Capacity		Peak Capacity with CBTC	
	Trains per Hour	Headway	Trains per Hour	Headway
Hoboken-33 <sup>rd</sup> Street	9	7 minutes	10	6 minutes
Hoboken-WTC	10	6 minutes	13	5 minutes
Journal Square-33 <sup>rd</sup> Street	15	4 minutes	15	4 minutes
Newark-WTC	15	4 minutes	20	3 minutes

Source: PATH Capacity Analysis and Fleet Expansion, 12/15/2015

**2. PATH Newark-WTC 10-Car Program**

By the mid-2020s, the additional capacity that would be enabled by the Signal System Replacement Program is likely to be insufficient to fully accommodate projected demand on the Newark-WTC Line. Capacity on the Newark-WTC Line could be expanded by an additional 25% by enabling use of 10-car trains instead of 8-car trains on this line. Completion of the Newark-WTC 10-Car Program would require:

- Completion of the Harrison Station Replacement Project (under construction);
- Completion of Phase 2 of the Grove Street Station Capacity Enhancements and Station Modernization Project;
- The purchase of 48 additional railcars; and
- Several other projects that are not currently in the PANYNJ Capital Plan:
  - The Exchange Place Emergency Egress Project

- Newark Platform Improvements
- Extension of the Running Repair Shop

According to PANYNJ input during this Capacity Study, the 10-Car Program would likely not be operational until 2028 if approved today, given the design and construction timeline for the associated projects.

Furthermore, the viability of this capacity expansion would be endangered by a delay in purchasing the needed railcars, since it will no longer be feasible to purchase PA-5 railcars after the expiration of the PANYNJ's current railcar procurement contract.

Both the Signal System Replacement Program and the Newark-WTC 10-Car Program would require fleet expansion for the PATH system that is not currently programmed. At a cost of approximately \$2.5 million per car, it would cost approximately \$125 million (i.e., the purchase of 50 cars) to fully achieve capacity increases enabled by the Signal System Replacement Program. To fully achieve capacity increases enabled by the Newark-WTC 10-Car Program, it would cost an estimated \$189 million (beyond projects that are currently included in the PANYNJ Capital Plan), including the purchase of an additional 48 cars (for a total of 98 cars, when also considering the 50 cars for the Signal System Replacement Program) and completion of the other necessary capital projects. The estimated \$125 million and \$189 million are additive, such that it would cost an estimated \$314 million beyond currently programmed projects to fully achieve capacity increases enabled by both projects.

Looking farther ahead, another potential initiative is the Hoboken-WTC 8-Car Program, which would further increase capacity of this line (beyond the Signal System Replacement Program) by enabling use of 8-car trains instead of 7-car trains on this line. The increase in capacity would require reconfiguration of the tracks and platforms at Hoboken, as well as an expansion of the station box at Newport, with an estimated cost of \$550 million. This is not currently under consideration for the new capital program but may be warranted in the future based on projected demand.

Overall, potential benefits associated with expanded PATH peak period capacity include increased peak hour service frequency on the Hoboken-33<sup>rd</sup> Street, Hoboken-WTC, and Newark-WTC Lines. Another important consideration is that ridership may be higher than projected due to other investments (or lack thereof) in the regional interstate transportation network—including but not limited to the Gateway Program (refer to Section 3.2)—in which case the increase in capacity associated with this strategy may not be sufficient to fully accommodate demand. Public policy issues that would need to be considered for this strategy include the decision regarding whether (and when) to prioritize funding for the fleet expansion and other necessary investments not currently programmed in the PANYNJ Capital Plan.

It is important to note that it is unlikely that increasing PATH capacity would result in substantial peak hour demand reduction at the PABT. Although the PATH system and bus network provide complementary service between the Manhattan central business district (CBD) and certain trans-Hudson travel corridors (e.g., Urban Core, Morris and Essex), the two modes largely serve different

markets (as discussed in the “Summary of Previous Trans-Hudson Planning Work” technical memorandum). However, Hudson County is a noteworthy exception, as it is one of the largest PABT markets, despite the fact that PATH is the primary mode choice for residents who commute to the Manhattan CBD. There are parts of Hudson County where PATH and PABT bus service both are available, though some Manhattan-bound commuters choose the bus, likely due to considerations of travel time, ease of access, and other factors that influence mode choice. Nearly 20% of customers on PABT commuter routes reside in Hudson County (second only to Bergen County), yet there is direct competition between buses and PATH, particularly in Hoboken. For this reason, a failure to expand PATH system capacity to keep pace with demand would likely create significant new growth pressures at the PABT.

This is further highlighted by the fact that the travel demand forecasts prepared for the MBMP and used as an input in the Capacity Study reflect demand projections independent of capacity constraints, and in fact the No-Build condition assumed completion of the PATH service capacity expansion. Accordingly, the travel demand forecasts reflect a scenario in which anyone who would want to use PATH would be able to do so. This reinforces the premise that if a decision were made to forego investment in PATH such that capacity would be constrained, it is likely that PABT demand would be higher than projected, which underscores the relevance of this strategy in the context of the PABT replacement effort.

Nevertheless, while increasing PATH capacity would be an enormously beneficial investment, it would not change the capture area of PATH service. Additionally, the overall number of new commuters that could use PATH, even if new investments are made, is not large enough to significantly reduce PABT demand. Indeed, the potential future capacity of the PATH system after accounting for the aforementioned investments amounts to a small fraction of projected PABT demand. Accordingly, this strategy is unlikely to affect the necessary capacity and configuration of the new PABT.

**Conclusion: This strategy includes two initiatives that would address existing and projected future capacity constraints on the PATH system. Individually and together, the two initiatives (fleet expansion for expanded service after completion of the Signal System Replacement Program and the Newark-WTC 10-Car Program) would enable increased capacity along PATH lines for which peak hour demand approaches or exceeds capacity and is projected to increase in the future. The purchase of additional PATH rail cars is necessary to fully realize the increased capacity enabled by the two initiatives. Additional capital projects that are not currently funded must also be completed to achieve the capacity increases made possible by the Newark-WTC 10-Car Program. It is not anticipated that this strategy would have a sizable effect on peak hour PABT demand because of the different markets served by the PATH system and bus network, but it should still be viewed as a priority in future updates to the PANYNJ Capital Plan to address capacity constraints for PATH commuters.**

## 2.2 NEW INTERMODAL TRANSFER FACILITY AT PATH-NEC RAIL LINK STATION

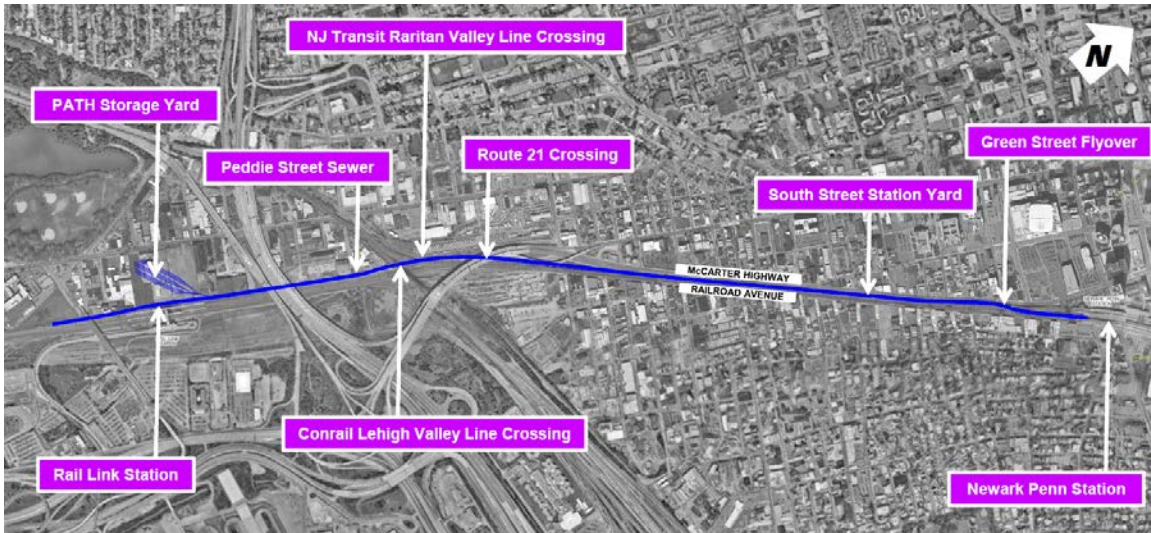
This proposed project calls for extending PATH service to the Northeast Corridor (NEC) Rail Link Station at Newark Liberty International Airport (EWR), and creating a new intermodal transfer facility at this location. The current proposed scope includes consideration of the potential to leverage the PATH extension to the airport by adding bus service to the new intermodal transfer station at EWR on a number of commuter bus routes that currently serve the PABT, and adjusting frequencies to the PABT as appropriate to align with customer choices. By way of a transfer to the PATH system at the Rail Link Station, this new connection may offer additional trans-Hudson commuters the option of avoiding both the Lincoln Tunnel and PABT, although many commuters already take trans-Hudson buses directly to Wall Street or transfer from buses to PATH at downtown Newark. This concept revisits assumptions based on a potential transportation demand management (TDM) measure that was associated with Concept 5 from the MBMP to reduce demand at a new PABT.

The PATH extension would provide new access to the Rail Link Station from surrounding communities, including Newark and Elizabeth. Additionally, the proposed project would also expand the reach of the PATH system, which could potentially create an additional travel option for certain trans-Hudson commuters. For instance, commuter bus routes that serve the Rail Link Station with a seamless connection to the Newark-WTC PATH Line may be appealing to current PABT customers whose destination is in Lower Manhattan and who live in portions of Union County, Middlesex County, and/or southern Essex County. However, based on preliminary feedback provided by NJ TRANSIT during the Capacity Study process, this proposed project may not have significant potential to divert PABT commuters. The potential attractiveness of this proposed project to serve the trans-Hudson market will not be known until the current ridership analysis and collaborative review with NJ TRANSIT are complete.

The scope of the PATH extension to NEC Rail Link Station includes the following elements:

- Construct rail infrastructure for elevated and at-grade track from Newark Penn Station to the Rail Link Station (Figure 3)
- Modifications at Newark Penn Station to accommodate bidirectional passenger flow as well as limited vertical circulation improvements
- Construct a new platform and associated station passenger infrastructure at the Rail Link Station with connections to the existing Rail Link Station
- Construct a rail storage yard near the Rail Link Station
- Investigate a Public-Private Partnership to construct a parking garage/multi-modal facility near the Rail Link Station for non-aviation commuters

Figure 3: PATH Extension to NEC Rail Link Station



Source: PANYNJ

The possibility of constructing a multi-modal facility near the Rail Link Station could have implications for how long-term trans-Hudson travel demand is accommodated across different modes and corridors in the interstate transportation system. The capacity of the potential multi-modal facility will be informed by the results of the ongoing ridership forecast. Under the baseline scenario, which includes no garage, the Rail Link Station could accommodate five bus bays, which is a function of the configuration of the site. As currently envisioned, the five bus bays under the baseline scenario would accommodate the local NJ TRANSIT bus routes that currently pass the Rail Link Station. Depending on projected demand, various garage configurations on an over-build of the site could result in additional bus bays at the Rail Link Station. These additional bus bays could potentially accommodate longer distance commuter bus routes that originate within a broader catchment area, including Union County, Middlesex County, and southern Essex County.

The PATH extension to the NEC Rail Link Station is currently in an early phase of planning, which includes conceptual design and environmental review in addition to ridership forecasting. According

to the current project schedule, which is subject to revision, construction is estimated to be completed in 2026, although funding is not yet secured for work after this first phase.

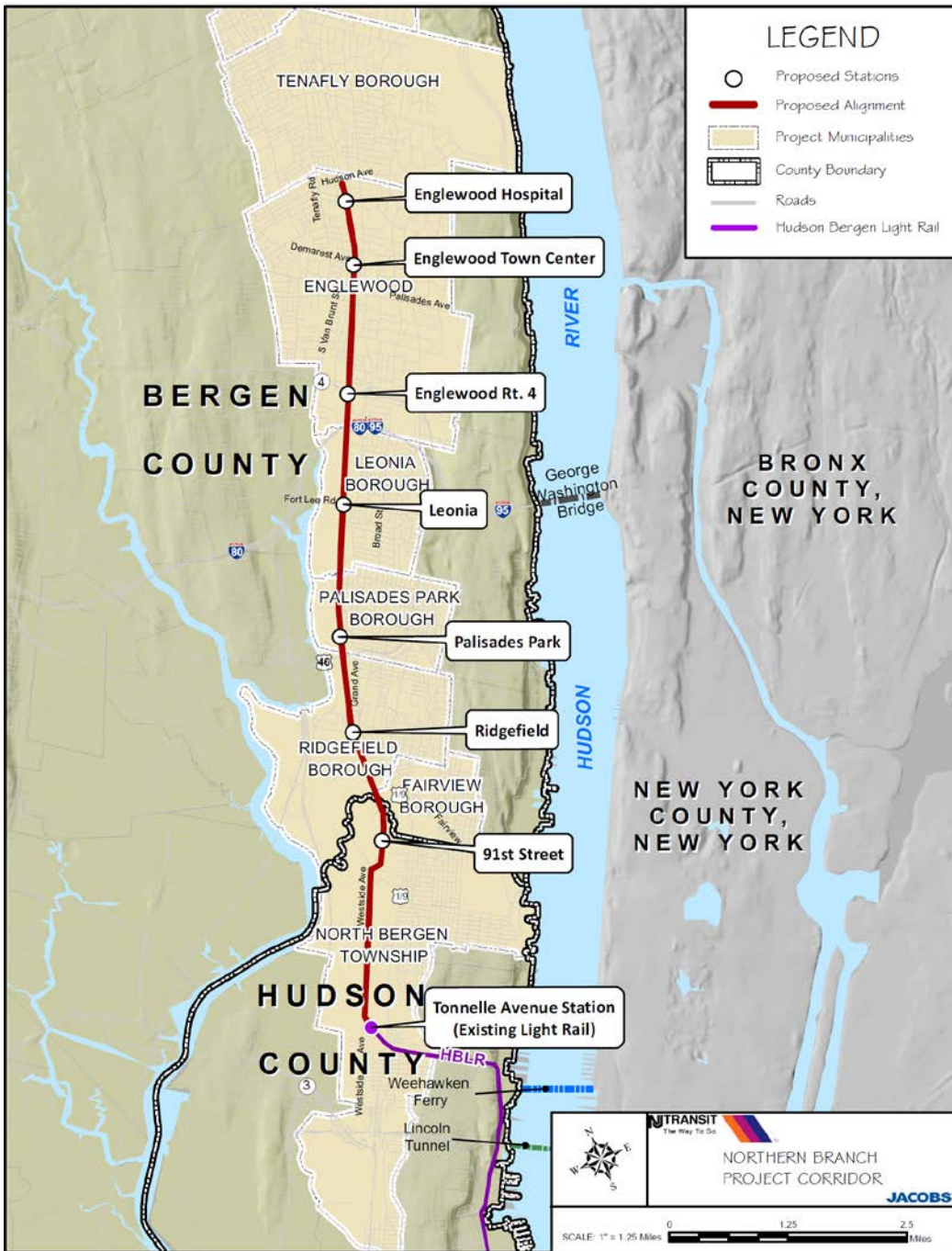
Benefits associated with this proposed project potentially include modest demand shedding for the Lincoln Tunnel corridor and PABT, travel time savings for certain trans-Hudson commuters (with no need to transfer to the subway to get to Lower Manhattan), and a reduction in bus operating costs for bus operators if certain candidate routes are truncated to terminate at the Rail Link Station instead of the PABT. Potential impacts associated with this proposed project include additional modal transfers for trans-Hudson commuters (the implications of which are discussed in Section 4.1) and congestion on the roadway network in the vicinity of the Rail Link Station (associated with potential increases in bus trips to and from the Rail Link Station). Additionally, while this proposed project could offer a new option for certain PABT customers, and might create more bus diversion to PATH, by itself it does not increase throughput capacity across the Hudson River. The Signal System Replacement Program and NWK-WTC 10-Car Program (discussed in the previous section) should be considered prerequisites to the Rail Link Station extension in order to ensure that the required peak capacity is available on the line.

**Conclusion:** In addition to improving regional access to and from EWR for airport passengers, as well as providing greater redundancy in the interstate transportation network, this proposed project would expand the reach of the PATH system, thereby potentially creating an additional travel option for certain trans-Hudson commuters. At this location, PATH service to and from Lower Manhattan could be an attractive option for some PABT customers who currently transfer to the subway upon arriving at the PABT. Accordingly, the PATH extension to the NEC Rail Link Station may have the potential to result in a modest reduction of peak hour demand at the PABT. However, since the ridership forecasting effort is ongoing, it is premature to assign a number to the potential reduction in buses for use in planning the PABT replacement. Additionally, since existing commuting options from New Jersey already include trans-Hudson bus service directly to Wall Street as well as bus-to-PATH service at downtown Newark, this proposed project may not play a substantive role in serving the trans-Hudson market. Based on a project briefing during the Capacity Study process, the initial focus is on bus routes serving the local market, followed by the analysis of potential attraction for current PABT-bound bus commuters.

### 2.3 HUDSON-BERGEN LIGHT RAIL TRANSIT EXTENSION

This strategy calls for implementing the proposed Northern Branch Corridor Project to extend existing Hudson-Bergen Light Rail (HBLR) service from North Bergen to Englewood (Figure 4). This strategy would offer certain commuters to Manhattan the option of using the HBLR to access either the Port Imperial Ferry Terminal or Hoboken Terminal and transfer to a trans-Hudson mode other than the bus (i.e., ferry at Port Imperial; ferry or PATH at Hoboken) to reach their destination. This would enable certain trans-Hudson commuters to avoid both the Lincoln Tunnel and PABT.

Figure 4: Proposed HBLR Northern Branch Corridor Project



Source: Northern Branch Corridor Project

Expanding the reach of the HBLR system, potentially could attract existing PABT customers from points to the north in the Eastern Bergen trans-Hudson travel corridor (refer to Figure 1). The strategy would likely be most effective in providing an alternative trans-Hudson commuting option to those who live within walking/biking distance of the proposed stations along the Northern Branch. It is not anticipated that this strategy would be appealing to those commuters who would have to travel by bus to the HBLR due to the additional transfer that would be required (in addition to the subsequent transfer to a trans-Hudson mode). Furthermore, this strategy would likely be most appealing to current PABT customers whose destination is in Lower Manhattan because it could eliminate the need for certain trans-Hudson commuters to transfer to the subway upon arriving in Manhattan.

The proposed Northern Branch Corridor Project would extend light rail service from the current northern terminus of the HBLR at Tonelle Avenue in North Bergen to the Englewood Hospital and Medical Center in Englewood. The project includes seven proposed stations along the proposed alignment in northern Hudson County and southeastern Bergen County. The preferred alternative from the Draft Environmental Impact Statement (DEIS) that was completed in 2011 included an extension of the HBLR farther north to Tenafly, and the alignment was refined based on comments received on the DEIS. As noted on the project website, the project as currently proposed “results in changes to the service plan and potential environmental and social impacts explored in the DEIS,” so the new alignment is the subject of a Supplemental DEIS.

The work completed in the DEIS offers insight into the potential attractiveness of the proposed project for trans-Hudson commuters, particularly because the DEIS includes estimated travel times from each proposed station to both the Port Imperial Ferry Terminal and Hoboken Terminal. Based on estimates in the DEIS, the travel time by light rail along the Northern Branch Corridor to Port Imperial would range from four minutes (from Tonelle Avenue) to 20 minutes (from Englewood Hospital), and travel time to Hoboken would range from 16 minutes (from Tonelle Avenue) to 32 minutes (from Englewood Hospital). From either Port Imperial or Hoboken, trans-Hudson commuters could transfer to another travel mode to complete their journey to work.

Potential benefits associated with this strategy include modest demand shedding for the Lincoln Tunnel corridor and PABT, as well as possible time savings for certain trans-Hudson commuters. Potential impacts associated with this strategy include additional modal transfers for trans-Hudson commuters (the implications of which are discussed in Section 4.1). It is also possible that this strategy could increase passenger demand on the PATH lines at Hoboken that connect the HBLR system with destinations in Manhattan. Additionally, although it is anticipated that trans-Hudson commuters would likely walk to the proposed HBLR stations, it is possible that the proposed HBLR extension could result in additional traffic congestion on the local west-of-Hudson road network that feeds the stations.

This strategy could pose an opportunity to use pricing to draw trans-Hudson commuters onto PATH instead of PABT-bound commuter bus routes. Commuters with NJ TRANSIT monthly and weekly rail passes are currently able to use their pass for any HBLR light rail trip at no additional charge during the period the pass is valid. Additionally, the Hudson Go Pass (discussed in the following section) allows HBLR customers to transfer at the Port Imperial Ferry Terminal to one of three NY Waterway

ferry routes to Manhattan. Fare reciprocity with the PATH system could further increase the attractiveness of this strategy as a potential trans-Hudson travel option.

It is also important to note that another HBLR project—the Route 440 Extension—is further along in the implementation process, as a Finding of No Significant Impact (FONSI) was released in 2014. The proposed Route 440 Extension would extend the HBLR system from the West Side Avenue Station approximately 0.7 miles west to a new station that will serve the planned Bayfront development in Jersey City near Culver Avenue, west of Route 440 (Figure 5). This project would provide a new transit option for commuters from the western waterfront of Jersey City, who could subsequently transfer to ferry or PATH to cross the Hudson River. However, similar to the proposed Northern Branch Corridor Project, the potential PABT demand reduction associated with the Route 440 Extension is not anticipated to be substantial, in part because the target neighborhood is not part of a major trans-Hudson bus corridor.

**Conclusion: This strategy considers the potential implications for the trans-Hudson commuter market of extending an intrastate transportation service in New Jersey. The proposed Northern Branch Corridor Project would extend existing HBLR service farther north to North Bergen, Ridgefield, Palisades Park, Leonia, and Englewood. This project would enable a new trans-Hudson commuting option for residents of northern Hudson County and southeastern Bergen County by means of a transfer to ferry or PATH. The proposed Route 440 Extension would have similar implications for residents along the western waterfront of Jersey City. The primary benefits of both extensions will be to significantly improve inter-county travel options within New Jersey. The potential PABT demand reduction associated with these projects is not anticipated to be considerable, and thus this strategy is unlikely to affect the necessary capacity or configuration of a new PABT.**

Figure 5: Proposed HBLR Route 440 Extension



Source: Route 440 Extension

## 2.4 EXPANDED BUS SERVICES TO PORT IMPERIAL FERRY TERMINAL

This strategy calls for implementing new variants on existing bus services such that select commuter bus routes would provide increased service to the Port Imperial Ferry Terminal in Weehawken. This would offer commuters the option of crossing the Hudson River by ferry instead of by bus, thereby avoiding both the Lincoln Tunnel and PABT. This strategy revisits assumptions based on a potential TDM measure that was associated with Concept 5 from the MBMP to reduce demand at a new PABT.

This strategy would likely be most effective in providing an alternative commuting option to heavily bus-dependent markets, as opposed to areas that are well served by commuter rail or PATH. Candidate bus routes that could be considered for this strategy are those that originate in portions of the Eastern Bergen trans-Hudson travel corridor (refer to Figure 1). Upon arriving at the Port Imperial Ferry Terminal, bus customers would transfer to Midtown or Lower Manhattan ferry service and subsequently either walk or transfer again to ferry shuttle buses to reach their final destinations. This strategy would likely be most appealing to current PABT customers whose destination is very close to the Hudson River in Midtown or in Lower Manhattan, and could also be appealing to those whose destination is in Midtown but beyond walking distance from the PABT. For current PABT customers whose destination is within walking distance of the bus terminal, this strategy would introduce two additional modal transfers to their commute (i.e., commuter bus to ferry, and ferry to shuttle bus). For other commuters, including those who transfer to either subway or bus upon arriving at the PABT, this strategy would only add one additional modal transfer to their commute.

Similar to the other PABT demand shift strategies, the intent of this strategy is to expand the potential of an alternative trans-Hudson commuting option, and not to force PABT customers to change their travel patterns. This strategy aims to draw more riders to the Port Imperial Ferry Terminal by adding service on routes now serving PABT, in conjunction with modified service frequencies to the PABT to reflect customer choices. As such, this strategy does not call for re-routing all candidate bus routes, but rather to consider a potential pilot program that splits select candidate routes such that certain trips would serve the Port Imperial Ferry Terminal and other trips would continue serving the PABT.

This strategy builds upon the ongoing partnership between NJ TRANSIT and NY Waterway to promote increased use of the ferry by trans-Hudson commuters through the new Hudson Go Pass (Figure 6). Launched in February 2016, the Hudson Go Pass allows customers on certain NJ TRANSIT buses (specifically, the 156R, 158, and 159R routes that serve the Palisade Avenue/River Road corridor) as well as HBLR customers to transfer at the Port Imperial Ferry Terminal to one of three NY Waterway ferry routes to Manhattan:

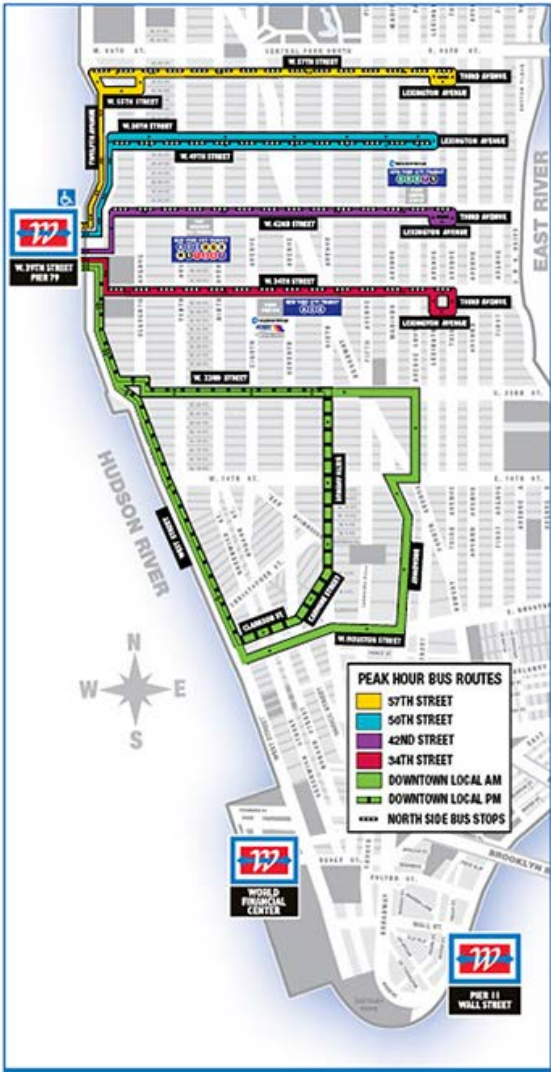
- An eight-minute ferry trip to Midtown/West 39th Street Midtown Ferry Terminal, where customers are offered a free transfer to one of several NY Waterway shuttle bus routes that meet every arriving ferry and provide connecting service to Midtown Manhattan
- A 16-minute ferry trip to the World Financial Center in Lower Manhattan
- An 18-minute ferry trip to Pier 11/Wall Street in Lower Manhattan

Figure 6: Hudson Go Pass

### One GO PASS for Bus, Light Rail & Ferry!



#### Free Manhattan Buses To Midtown Terminal



Source: PANYNJ

#### Free New Jersey Evening Bus Service



As noted on the Hudson Go Pass webpage (<http://www.nywaterway.com/HudsonGoPass.aspx>), the pass “provides great value, enabling customers to cost effectively avoid Lincoln Tunnel & bus terminal delays by seamlessly connecting with the Port Imperial Ferry.”

In complementing the ongoing efforts by NJ TRANSIT and NY Waterway, this strategy would provide additional bus service to the Port Imperial Ferry Terminal. The MBMP team identified a range of necessary site improvements at the ferry terminal (with an order-of-magnitude estimated cost of \$1 million) to accommodate additional bus service, including the provision of shallow sawtooth gates (by modifying street curbing/extending an existing bus loading zone) and the addition of bus shelters with customer amenities. Implementation of this strategy should include a detailed site planning exercise to determine necessary site improvements.

Potential benefits associated with this strategy include modest demand shedding for the Lincoln Tunnel corridor and PABT, time savings for certain trans-Hudson commuters (with no need to transfer to the subway to get to Lower Manhattan), and reduction in bus operating costs for certain diverted routes. Potential impacts associated with this strategy include additional modal transfers for trans-Hudson commuters (the implications of which are discussed in Section 4.1) and additional traffic congestion in Manhattan (if increased ferry ridership results in additional trips for NY Waterway shuttle buses) and/or New Jersey.

A key public policy issue that would need to be considered for this strategy is the need for coordination among service providers with respect to fare policy. Building upon the Hudson Go Pass, an integrated fare structure (including fare media) would help to market this strategy as an appealing alternative to PABT customers. Anecdotal information from the ferry operator suggests that there are less than 100 inbound and outbound weekday transfers between these buses or HBLR service and the ferry. Additionally, the issue of fare pricing sensitivity and the potential for ferry fare subsidies should be considered in advancing this strategy. This is discussed below with respect to the potential to decrease fares to incentivize additional ferry ridership.

**Conclusion:** Expanded bus services to the Port Imperial Ferry Terminal have the potential to result in a modest reduction of peak hour demand at the PABT. For purposes of a potential pilot program, an estimated 10 peak hour bus trips could be diverted from the PABT to the Port Imperial Ferry Terminal. If the potential pilot program is successful and viewed as an attractive option for trans-Hudson commuters, additional variants of candidate route(s) could be implemented to serve the Port Imperial Ferry Terminal, thereby diverting additional buses from the PABT. Under such a scenario, it could be worthwhile to consider an expansion of existing ferry services (building upon the strategy discussed in Section 2.5.1) as necessary to accommodate the additional ridership. The ridership potential of this strategy, which would complement the Hudson Go Pass, would likely be influenced by the introduction of additional modal transfers and the sensitivity to fare pricing for trans-Hudson commuters.

## 2.5 EXPANDED TRANS-HUDSON FERRY SERVICES

In addition to providing redundancy in the transportation system, ferries also offer promise in helping to address capacity constraints. As summarized in *The Profile of the Regional Interstate Transportation Network (RITN)* (Discussion Draft May 7, 2015):

Trans-Hudson ferries currently operate at only 25% of capacity in the AM peak hour, and provide the most easily deployable means for the region to add additional Trans-Hudson transit capacity when surges in demand run up against the constraints of the existing transit system.

As discussed in the following sections, this strategy calls for actions to expand the ridership potential of existing trans-Hudson ferry services as well as the addition of new ferry routes. Additional details are discussed in the Attachment.

### 2.5.1 Expansion of Ridership Potential for Existing Ferry Services

There are currently 18 ferry routes that serve the Hudson River commuter market operating between 12 New Jersey terminals and four Manhattan terminals. All of the privately-owned and operated ferry companies—New York Waterway (NYW), BillyBey Ferry, Seastreak, Hornblower, and Statue Cruises—are in public-private partnerships for use of public terminals, piers and/or property for parking as part of their business. Ferries provided an average of 28,000 weekday trans-Hudson trips in 2015, with ridership higher in the summer months than in the winter months. NJ TRANSIT estimates that ferry customers represent approximately 4% of current trans-Hudson commuters.

According to NJ TRANSIT's 2013 Trans-Hudson Ferry Survey, current ferry customers report a high level of satisfaction with their ferry commute and have higher-than-average incomes for trans-Hudson commuters. These customers place higher value on their time and are less price sensitive than other commuters, as ferries are typically not the least cost option. Incomes for ferry customers are much higher than bus customers. Whereas almost 83% of ferry rider households earned at least \$100,000 per year, just 39.5% of bus customer households reported income on that scale.

In addition to the prior strategy to expand bus service to the Port Imperial Ferry Terminal, additional actions to increase ridership potential on existing ferry routes may include increasing parking options at ferry terminals and decreasing fares of the existing services.

Interviews with the ferry companies were conducted during the Capacity Study to discuss these concepts. The interviews were used to supplement prior ferry research and modeling conducted for a regional passenger ferry study sponsored by the PANYNJ in conjunction with New York City agencies, NJ TRANSIT, and other partners. This updated assessment also drew on ongoing work for the North Jersey Transportation Planning Authority (NJTPA) to develop a transportation waterborne inventory, including potential sites for new ferry landings.

Two concepts that are not included in the discussion below are increasing frequency and decreasing in-vehicle time for existing ferry services. Ferries are already operating with significant excess capacity and therefore, on purely economic grounds, operators will not add additional service to

improve service frequency. Speeding up existing ferries is plausible from a purely operational standpoint, but even if fuel costs continue to decline, regulatory restrictions on ferry speeds make this infeasible. Boat speeds in New York State are not restricted when at least 100 feet from shore, however, wakes generated by boats are restricted and therefore the potential damage to shoreline facilities and anchored or docked vessels from wakes imposes strict limits on ferry operating speeds. Failing a drastic shift to vessels that can operate with higher speeds and lower wakes, there is little room for ferry operators to raise ridership by reducing in-vehicle time.

The discussion below focuses on the potential to increase parking options and decrease fares to incentivize additional ferry ridership on existing routes.

### ***2.5.1.1 Increasing Parking Options***

Increasing parking options at ferry terminals in New Jersey could have the effect of increasing ridership on ferry routes into Manhattan. This is particularly the case for the services offered from Monmouth County. For both the NYW ferry service from Belford and the Seastreak ferry service from the Atlantic Highlands, almost all ferry customers arrive at the terminals by car. According to the 2013 Trans-Hudson Ferry Survey, 90% of these customers drive and park, and 3% carpool or are dropped off.

Parking at these terminals is free and incorporated into the ferry fare. Currently, utilization of parking capacity ranges from 80% to 90% at these locations, based on interviews conducted with the ferry operators. Seastreak recently bought additional land near its terminal to accommodate another 300 cars for surface parking. Elevated parking garages have been discussed but are not anticipated to be financially viable and there are concerns that an elevated structure may block waterfront views and be deemed locally unacceptable. For the northern New Jersey ferry market, parking is less of a factor for ferry commuters as there is a higher percentage of commuters able to walk to the ferry terminals or take an intermodal connection through a shuttle, PATH, or HBLR. Paid parking for the northern New Jersey ferry market is available at Weehawken. However, 80% of this capacity is utilized currently and parking is not exclusive to ferry customers. There is no parking availability at Edgewater. Increasing parking availability is difficult at these locations and may increase local vehicle miles traveled (VMT) to drive to and from these terminals. These are recognized challenges to efforts at increasing ridership of ferry services at these locations.

For some commuters, bicycles may provide another means of accessing ferries for commutation between New Jersey and New York City. The NYW and Billybey routes allow bicycles on board for an additional \$1.00 per trip fee. Seastreak charges an additional \$2.50. Passengers pay no additional charge to bring bicycles on board for the Liberty Landing service. Bicycle parking is available for ferry passengers and other transit users at the intermodal Hoboken Terminal and at the PANYNJ's World Financial Center terminal in Manhattan, and at NYW's Weehawken and Midtown Manhattan terminals.

NYW reports an average of 200 weekday bicycle ticket sales on trans-Hudson ferry routes, 80% as single-trip purchases and 20% bought on a monthly ticket. Their data show nearly half of the

single-trip and monthly bicycle ticket purchases on the Paulus Hook-World Financial Center service alone. Seastreak and Liberty Landing report minimal usage of bicycles on their ferries.

#### **2.5.1.2 Decreasing Fares**

The City of New York recently has established a policy of decreasing fares as a key tool to increase ridership, starting with the East River ferry services. What makes the trans-Hudson ferry market different from the East River market is the number of intermodal connections typically required to make a commute from New Jersey to the Manhattan CBD. In NYCEDC's 2013 Citywide Ferry Study, it was clear that most of the existing and prospective new East River ferry customers are within a ½-mile walk radius to the respective ferry terminal. A primary threshold was within a ¼-mile walk radius and secondary market threshold was a ½-mile radius. Ridership largely came from new high-rise residential construction along the East River waterfront in Brooklyn and Queens, which are largely areas that were formerly industrially-zoned and far from the closest subway line.

On the trans-Hudson market, it appears that commuters evaluating their choice of mode are more sensitive to the length of their commute over the price of available options. In examining the elasticity of the ferry fares, a decrease in fares did not produce significant numbers of new ferry customers. Holding all other variables constant, it would take a large proportional decrease in the fare to attract a significant number of customers. One may deduce from this relationship that the ferry is not considered a good substitute for alternate modes of transport owing to both the fare relative to other modes and the transfers required to and from ferry landings on both sides of the Hudson River.

Also, as these services have been privately operated for some time, one can assume that the fares have been set to meet expenses and provide a profit and a return on capital for the operators. To lower ferry fares for the trans-Hudson services would present a difficult policy choice, as this would require a public operating subsidy for privately-operated services in lieu of investments to existing publicly-owned transit services that serve higher volumes of passengers generally from wider segments of the trans-Hudson market.

Moreover, based on interviews with ferry operators, there is a reluctance to lower fares to the extent that ferries would no longer be perceived as a premium service. For the Monmouth County services that are well subscribed, one operator noted that they have been asked by customers to increase prices rather than lower prices to limit demand for parking at the terminal. NYW, which operates with capacity on its routes from the northern market, also noted that their customers prefer the private crosstown shuttle over use of a public bus, and that they value the premium nature of the service. In sum, decreasing fares may not render significant diversion from bus to ferry, and this policy may not be acceptable to current ferry operators who have built a premium brand targeting high-income commuters.

#### **2.5.2 Addition of New Ferry Routes**

The introduction of new trans-Hudson ferry routes may draw additional ridership, some of which may be drawn from the existing PABT bus market. This assessment focused on three suggested routes representing a range of potential trans-Hudson ferry service enhancements. They include:

- South Amboy to Lower Manhattan
- Edgewater to West 125th Street – West Harlem Piers
- Hoboken to a new West 34th Street Ferry Terminal

The following is a preliminary investigation of these new routes.

#### ***2.5.2.1 South Amboy to Lower Manhattan***

In recent interviews with ferry operators and county planners as part of the NJTPA Waterborne Transportation Inventory Assessment, South Amboy was suggested as having potential to expand ferry ridership from Middlesex and Monmouth Counties. South Amboy is in Middlesex County on Raritan Bay and southwest of the southern tip of Staten Island. The waterfront site has good access to a regional road network off U.S. 9 where access to a new terminal would not require traffic to weave through a residential community.

A South Amboy to Lower Manhattan ferry route previously served the trans-Hudson market. This service was initiated in February 2002 to accommodate area commuters after the attacks of September 11, 2001. The service was discontinued in 2005 as high fuel costs combined with lower than expected ridership and dredging costs made the route uneconomical for the operator. The City of South Amboy plans to build a permanent ferry terminal as part of a larger waterfront development project. South Amboy also hosts a NJ TRANSIT commuter rail station.

South Amboy is at the northern tip of the Garden State Parkway/North Jersey Coast Line trans-Hudson travel corridor (refer to Figure 1). This travel corridor is forecasted by NJ TRANSIT to have an 11% bus market share for trans-Hudson trips in 2040, a 35% rail share, and an 8% ferry share, with the remainder commuting predominantly by auto. Though the public sector has provided infrastructure including ferry landings and terminals, trans-Hudson ferry service operations are unsubsidized by public agencies and consequently are a relatively expensive choice for daily commute and discretionary travel. For the Atlantic Highlands to Manhattan service, commuters may purchase discounted tickets in a 40-trip book at a cost of \$655 or \$16 for a one-way cost trip. By comparison, a monthly train pass from the South Amboy station to Penn Station New York is \$380 and would take one hour. A new ferry service from South Amboy, unlike at the Belford and Atlantic Highlands locations, would have to compete directly with the commuter rail option.

A ferry terminal at this location is also likely to be constrained by local adjoining vehicle parking capacity. Unlike many of the new East River ferry terminals being planned in the NYCEDC Citywide ferry expansion, a new South Amboy terminal is not currently being planned in conjunction with up-zoning for high-rise residential development. This option is unlikely to draw price-sensitive commuters from the bus market but may still be attractive to high-income commuters working in Lower Manhattan.

### 2.5.2.2 Edgewater to West 125<sup>th</sup> Street – West Harlem Pier



Source: NYW

NYW currently operates a trans-Hudson ferry service connecting the Edgewater ferry pier in Bergen County to the West Manhattan Ferry Terminal/Pier 79 at West 39<sup>th</sup> Street. Approximately 900 one-way trips are made daily on this route, according to recent ferry ridership reporting to NJ TRANSIT and the PANYNJ. There may be additional ferry opportunities in this commuter market as there is no direct rail competition to the ferry in eastern Bergen County. This market is also worth further exploring for potential peak PABT demand mitigation given the high percentage of bus customers commuting from this area.

A new ferry service from Edgewater directly to the newly constructed West Harlem Pier at West 125<sup>th</sup> Street in Manhattan has been suggested by officials in the Town of Edgewater to supplement the existing service to Pier 79. This route could offer a new option for trans-Hudson commuters to access Midtown Manhattan via a connection to the Broadway (No. 1) subway line, as opposed to the existing ferry route, which requires bus connections on congested streets on both sides of the Hudson River. The West Harlem Pier, which is newly constructed by NYCEDC, is a 6-minute, 1/3-mile walk to the 125<sup>th</sup> Street subway station on the No. 1 Line.

Capacity utilization of vessels on the existing ferry route from Edgewater to Pier 79 route is, like other ferry services, very light. Adding a new route from Edgewater to West 125<sup>th</sup> Street could therefore be feasible with existing vessels. It would cut several minutes to the trip over water (compared to the existing ferry route from Edgewater) but could also reduce travel time for commuters accessing destinations close to West 125<sup>th</sup> Street. An efficient connecting service to the subway would likely be a critical element for the success of this service, as the 1/3-mile walk to the subway, however short, may not appeal to all commuters.

An analysis of origin/destination locations of customers from the 2013 Trans-Hudson Ferry Survey indicates that only 4% of ferry customers take a subway to their final destination in Manhattan, and

that 61% of customers walk to their final destination. The average distances traveled for ferry customers by terminal are shown in Table 3. The overall average is 0.7 miles (or about a 15-minute walk at a speed of 3 miles per hour). The median distance is just 0.3 miles (or a 6-minute walk at 3 miles per hour).

Table 3: Average Distance to Final Destination by Landing for Ferry Customers

Destination Ferry Terminal	Average Distance in Miles	Observations
East 35th St.	1.64	76
Midtown West 39th St.	1.70	263
Pier 11/Wall St.	0.61	1,494
World Financial Center	0.50	939
<b>Overall</b>	<b>0.70</b>	<b>2,772</b>

Source: 2013 Trans-Hudson Ferry Survey; Cheng Solutions

According to the 2012 PANYNJ Interstate Bus Analysis, bus customers overwhelmingly walk (48.5%) or take a connecting subway (44.8%) to access their final destination. This suggests that ease of connecting services is important for bus customers using the PABT. On average, however, bus customers travel a significantly longer median distance (1.14 miles or a 23-minute walk) to reach their final destination than ferry customers. This suggests that having access to the connecting subway/bus service is a critical factor in the attractiveness of the bus to PABT.

Moreover, this may indicate that a new ferry service from Edgewater to the West 125<sup>th</sup> Street terminal may have limited appeal to most current ferry customers because of the small percentage of ferry customers that take the subway for a connection to their final destination (as noted above). However, this potential new route may eventually draw customers if the Port Imperial Ferry Terminal continues to experience greater roadway congestion as through traffic increases with organic population growth as well as greater waterfront residential development on River Road. The shorter water access trip from Edgewater to 125<sup>th</sup> Street may offer an upper Hudson ferry congestion relief valve should other options worsen in levels of service.

**2.5.2.3 Hoboken South to a New 34<sup>th</sup> Street Ferry Terminal**



Source: NYcurbed.com and MTA

Another potential new route is a ferry service operating between Hoboken and a new West 34<sup>th</sup> Street terminal to take advantage of the newly-opened 34<sup>th</sup> Street Hudson Yards subway station and proximity to the new Hudson Yards development. This potential route would provide service between the Hoboken/NJ TRANSIT Terminal and a new Manhattan ferry terminal at West 34<sup>th</sup> Street, south of the Lincoln Tunnel ventilation towers, as a replacement of the current West Midtown Terminal at Pier 79 at 39<sup>th</sup> Street. Currently, NYW operates services connecting the Hoboken/NJ TRANSIT Terminal with the ferry terminals at the World Financial Center and at Pier 11 Wall Street. The existing Hoboken to World Financial Center route is used by approximately 2,000 commuters daily and is the most intermodal of all trans-Hudson ferry routes.

The proposed route would enable commutation from six of NJ TRANSIT’s commuter rail lines as well as the Hoboken Terminal of the HBLR system to proximity with the subway system at Hudson Yards. For this market (including Hoboken and Jersey City), 35% of customers access the ferry in New Jersey via NJ TRANSIT rail, and 5% via HBLR, according to the 2013 Trans-Hudson Ferry Survey.

The opening of the No. 7 Line subway connection at Hudson Yards creates the possibility of a more efficient crosstown route for commuters than the existing terminal, which relies on NYW-operated crosstown buses to connect customers to their destination. This presents ridership opportunities for the proposed ferry route. The Hudson Yards development will also host additional office and commercial space that will present a draw for commuters.

Two primary public policy issues would need to be addressed to advance this proposed route:

- The existing terminal at 39<sup>th</sup> Street is only 12 years old and has extensive support facilities. According to NYW, its long-term operating agreement with NYCEDC to 2035 prohibits NYCEDC from building a competing terminal within 20 blocks of the 39<sup>th</sup> Street facility
- A new terminal will require agreement from the Hudson River Park Trust for an additional transportation facility within the park

Furthermore, the degree to which this route will substantially increase ridership, as opposed to shifting existing ridership from the current West Midtown Ferry Terminal, is subject to factors such as:

- Increased efficiency for intermodal transfers compared to the existing terminal that would shift the destination mode choice of customers who primarily take the crosstown NYW bus to the subway
- Expected growth of Hudson Yards development as a new location for office and retail-related commutation

### 2.5.3 Summary

While there is potential growth in ferry ridership that may be captured from the new routes examined above, it is unlikely that the ferry will draw enough customers from the bus commuter market to affect the sizing of a new PABT. The ferry offers a premium service for largely high-income commuters that is not likely to draw significant ridership from lower-income commuters. While ferries do not compete well in the number of customers compared with other modes in a head-to-head competition, ferries may offer flexibility to supplement other modes should those modes be capacity constrained. In the interviews conducted with ferry operators, it was clear that if any of the trans-Hudson rail tunnels and/or the PABT were to be unavailable for commuters, the market for ferries would be very different.

**Conclusion: Increasing parking options, decreasing fares, and/or adding new routes may increase ferry ridership. Additionally, maintaining bicycle access and assuring adequate bicycle parking capacity at ferry facilities on both sides of the Hudson River should be a consideration in future planning. However, it is unlikely that the increase in ferry customers would have sufficient mode diversion effects from buses that would affect the peak-period capacity of a new PABT. The commuter bus and ferry markets have a different customer base. There may not be significant numbers of inland bus customers that would find an additional intermodal connection with a ferry to be an attractive daily commutation choice given that bus customers already have longer commutes than current ferry customers. However, given the dynamic nature involved in estimating ridership among different modes, a stated preference survey should be completed for improved certainty of these effects. Ferries do offer flexible opportunities as interim commutation capacity should rail or bus capacity be constrained during the construction of improvements, as well as during any potential work outages due to labor issues. The ferry companies already have experience in working with public authorities on emergency transportation planning through leases of additional vessels and arrangements for shuttle connections at park-and-ride lots and locations such as Liberty State Park, which would be useful in planning PABT interim construction-related capacity.**

## 2.6 HOBOKEN TERMINAL RAIL EXPANSION

This strategy calls for implementation of capital and operating improvements to support expanded peak-period NJ TRANSIT commuter rail operations to and from Hoboken Terminal. The purpose of this strategy is to expand capacity at Hoboken Terminal to enable more frequent NJ TRANSIT commuter rail service.

As shown on Figure 7, five commuter rail lines serve Hoboken Terminal: the Pascack Valley Line; the Main-Bergen County Line; the Montclair-Boonton Line; the Morris & Essex Line; and the North Jersey Coast Line. In addition to its strategic role in the regional commuter rail network, Hoboken Terminal is also a major trans-Hudson transportation hub because it offers multi-modal connections between commuter rail, light rail, bus, ferry, and PATH services. Until new trans-Hudson rail capacity is completed, NJ TRANSIT's only option for increasing rail service in Northern New Jersey is to run additional trains to Hoboken Terminal.

The strategy to expand capacity at Hoboken Terminal builds upon the ongoing Long Slip Fill and Rail Enhancement project. The Long Slip project is one of several interrelated projects within the NJ TRANSIT Resilience Program that individually and collectively aim to improve system-wide resiliency. In response to the flooding of Hoboken Terminal and the adjacent Hoboken Yard associated with the surge created by Superstorm Sandy, NJ TRANSIT was awarded approximately \$146.5 million through the Federal Transit Administration's Emergency Relief Program to advance the Long Slip project, which will include construction of six new tracks on the filled Long Slip canal (Figure 8) to serve three high-level ADA-accessible boarding platforms. As noted on the NJ TRANSIT Resilience Program webpage, the project "will allow NJ TRANSIT to operate train service longer and recover more quickly from storm events." Although primarily a resiliency project, the construction of new tracks and platforms also creates an opportunity to increase commuter rail service frequency to and from Hoboken Terminal. However, major capital investments beyond the Long Slip project would be required to achieve the increased capacity at Hoboken Terminal, including—but not limited to—the Westbound Waterfront Connection Project.

The Westbound Waterfront Connection Project is included in the 2015 New Jersey State Rail Plan as one of a number of potential long-term projects "to improve service and expand capacity to meet future increases in demand." The project would create a grade-separated crossing at the Dock East interlocking to address an existing bottleneck in the commuter rail network. As discussed in the State Rail Plan, the existing bottleneck "severely [restricts] the number of trains that can be reliably operated today with current volumes, let alone trains to meet future growth." The Westbound Waterfront Connection Project would increase capacity along the Northeast Corridor for NJ TRANSIT commuter rail, but it is in the early planning stages and has no schedule or cost estimate at this time.

Figure 7: Hoboken Terminal Station Area



Source: NJ TRANSIT

Figure 8: Long Slip Canal



Source: NJ Resilience Program

Overall, potential benefits associated with this strategy include increased peak period service frequency on multiple commuter rail lines to and from Hoboken Terminal. There are also significant benefits associated with this strategy beyond the primary focus of the Capacity Study, most notably with respect to system redundancy. During emergency situations, NJ TRANSIT trains can be diverted into and out of Hoboken Terminal. As such, the expanded capacity at Hoboken Terminal enabled by this strategy would reinforce the role of this intermodal hub as a critical node in the interstate transportation system.

Comparable to the PATH capacity expansion strategy, it is unlikely that this strategy would result in any substantial peak hour demand reduction at the PABT, because NJ TRANSIT capacity expansion would primarily benefit existing commuter rail customers as opposed to attracting PABT customers. Due to the locations of NJ TRANSIT stations in New Jersey, there is only modest overlap among likely NJ TRANSIT rail customers and likely PABT customers. As discussed in the “Summary of Previous Trans-Hudson Planning Work” technical memorandum, despite the fact that the two modes are complementary and interdependent, the interstate bus network serves commuter markets that are

not well served by rail transit. For instance, this strategy would not benefit heavily bus-dependent trans-Hudson travel corridors, such as Eastern Bergen or Route 9.

It is possible that this strategy could result in increased trans-Hudson travel by PATH or ferry from Hoboken to Manhattan above projected volumes. As noted in *The Profile of the Regional Interstate Transportation Network*, “it would be in the region’s interest to keep options open for future capacity expansion on [the Hoboken-WTC PATH Line] by ensuring the redevelopment of Hoboken Terminal...provides space to accommodate [the Hoboken-WTC 8-Car Program]” (refer to Section 2.1). Accordingly, it is important to acknowledge the potential policy implications of this strategy with respect to levels of peak period demand requiring additional trans-Hudson capacity via other modes.

**Conclusion:** This strategy includes multiple initiatives—including the Long Slip and Westbound Waterfront Connection projects—that would collectively increase commuter rail capacity at Hoboken Terminal. Construction of six new tracks on the filled Long Slip canal is an enabling project, but it is insufficient to realize the potential increase in peak period frequency on NJ TRANSIT commuter rail lines that serve Hoboken Terminal. The Westbound Waterfront Connection Project, which is not currently active and has no timetable for implementation, is an example of a major capital investment that is necessary to unlock the capacity increase enabled by the Long Slip project. It is not anticipated that this strategy would have a sizable effect on peak hour PABT demand because of the different markets served by the NJ TRANSIT system and bus network, but it could potentially result in increased trans-Hudson travel by PATH or ferry beyond current ridership forecasts. Nevertheless, this strategy is critical to the NJ TRANSIT system because Hoboken Terminal is a strategic asset and an important safety valve in the interstate transportation network, providing opportunities to not only accommodate growth in travel demand but also—through the Long Slip project—enable rapid recovery of transit services following an extreme weather event.

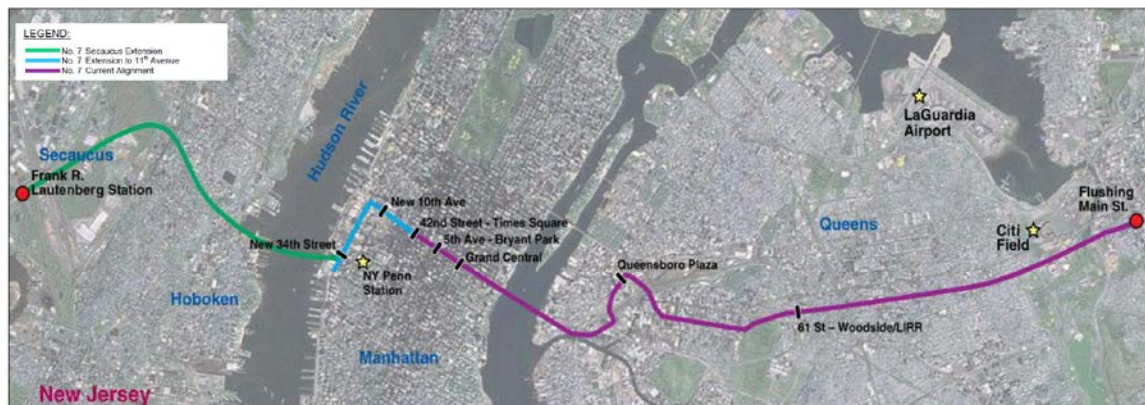
## 3 New Trans-Hudson Rail Transit Infrastructure

### 3.1 NO. 7 LINE EXTENSION TO SECAUCUS

In 2013, the Mayor's Office of the City of New York issued the No. 7 Line Secaucus Extension Feasibility Analysis Final Report, which evaluated options for extending the Metropolitan Transportation Authority's (MTA) No. 7 Line from West Midtown to the Frank R. Lautenberg (FRL) station in Secaucus with a new bus transfer facility. The project proposed a new two-track tunnel under the Hudson River, two tracks south of the existing Northeast Corridor, a new No. 7 Line/bus terminal adjacent to FRL, and the construction of the previously deferred No. 7 Line station at 10<sup>th</sup> Avenue (Figure 9). The project would provide cross-Midtown distribution by linking Secaucus with West Midtown, East Midtown, and Queens. As proposed, the potential project would include a two-story, 60-bay bus facility at the FRL station, which would be designed to serve 250 buses in the peak hour, including approximately 200 interstate buses that were previously destined for the PABT. As such, implementation of this potential project could reduce peak hour PABT bus demand in 2040 by approximately 25% below projected levels. However, even if this were to occur, peak hour bus demand at PABT in 2040 would still be at or above current levels, which suggests that a reconstructed PABT would need to offer at least as much capacity as the current facility.

The study determined that the project was technically feasible and could be justified from a ridership perspective. However, several key institutional issues were identified, including availability of funding, operational and labor-union considerations, zoning, and land acquisition. Next steps would include closer examination of the business case for the project, as well as investigation of operational concerns and required improvements to existing Manhattan stations. Currently, the MTA does not support further development of this concept amid other demands on its system. No funding has been identified for further phases of analysis.

Figure 9: Potential Trans-Hudson Capacity Expansion: No. 7 Line Secaucus Extension



Source: *No. 7 Line Secaucus Extension Feasibility Analysis Final Report*

Despite this project’s potential to shift a significant number of PABT buses, the obstacles bring to question whether this project has any potential to move forward. Although it could reduce the need for peak hour bus capacity at PABT in 2040 by a significant amount, a reconstructed facility with at least as much capacity as PABT offers today would still be needed. The resulting savings from a smaller reconstructed PABT would be much less than the cost of the No. 7 Line extension project. The net cost of pursuing both projects would be higher than a reconstructed and expanded PABT. The potential of this project to allow a reduction in the peak-period demand a new PABT would need to serve, would depend on the region’s ability to implement the subway extension as well as the new PABT and long-term expansion of commuter and intercity rail capacity.

### 3.2 GATEWAY PROGRAM/NEC FUTURE

As currently conceived, the Gateway Program (Figure 10) will include the addition of a new two-track Hudson River tunnel, expanding the existing mainline to four tracks between Newark and New York Penn Station (PSNY), replacement of the Sawtooth Bridge, a new Portal Bridge, loop tracks at Secaucus, and expansion of PSNY, with new tracks, platforms, and concourses. Some specific projects contained in the Gateway Program are related to current state of good repair conditions while others relate to increased train capacity.

Figure 10: Potential Trans-Hudson Capacity Expansion: Gateway Program of Projects



Source: Amtrak

It has been determined that certain specific projects will be advanced immediately given their independent utility and criticality to maintaining the current level of rail service on the Northeast Corridor between New Jersey and New York. To this end, work is now underway to complete an Environmental Impact Statement (EIS) for the Hudson Tunnel Project. Previously, an EIS was prepared for the Portal Bridge project and a Record of Decision was issued by the Federal Railroad Administration. The federal government and the states of New York and New Jersey have committed to cost sharing and a governance structure for the program, but actual construction funds have not yet been obtained for the Hudson Tunnel Project. Once the design and construction of the new tunnel is complete, the existing tunnel will need to be taken out of service one tube at a time for rehabilitation. The tunnel rehabilitation will need to be completed, and Penn Station will need to be expanded with new tracks and platforms, before increased morning and evening peak period rail service can be implemented.

There is a range of possible outcomes and timeframes for the resolution of the trans-Hudson transportation capacity shortfall over the long-term. While bridge replacements are well-defined, the exact alignment of the new tunnel and associated track connections in New Jersey and on the west side of PSNY are still being finalized, and the expansion of PSNY and potential additional tunnel and track connections require further study and decision-making. These decisions could substantially affect when new capacity for trans-Hudson travel becomes available. Construction of the full Gateway Program could enable as much as a doubling of capacity for NJ TRANSIT rail trains during peak travel times, but for the reasons described above, significant capacity increases will not likely occur until some years beyond 2025.

The Federal Railroad Administration (FRA), as part of the NEC FUTURE initiative, is in the process of defining a long-term vision and initial first phase investment plan for the entire Northeast Corridor. While the FRA has not yet selected a Preferred Alternative or defined future service levels and patterns, the representative service plans from the NEC FUTURE Tier 1 Draft Environmental Impact Statement offer insight into the range of possible outcomes. NEC FUTURE Alternative 1 and Alternative 2 both add two new tracks under the Hudson River for a total of four Hudson River tracks, as proposed in the Gateway Program. Alternative 2 also assumes two new tracks under the East River, expanded track capacity in New Jersey, and additional train storage east of the East River and in New Jersey at locations not yet determined. NEC FUTURE Alternative 3 adds another pair of Hudson River rail tracks over and above what is contemplated for Gateway (six total Hudson River tracks), as well as the additional track capacity and train storage.

The NEC FUTURE travel demand model forecasts that travel between New Jersey and New York will far exceed what the trains alone can deliver. Thus, even with the considerable increases in rail service, demand for trans-Hudson bus services remain strong and will grow substantially. This reflects both the anticipated strong growth in overall demand for trans-Hudson travel and the inherent strength of the bus market, particularly in the corridors where rail service does not exist or is constrained (i.e., Route 9 corridor, Eastern Bergen County, NJ Route 3/US Route 46 corridor). Based on the Bus Passenger and Operations Forecast developed for the MBMP (and as documented in MBMP Appendix B), a full build scenario for the trans-Hudson rail network—that would double NJ TRANSIT capacity and create a one-seat ride to Manhattan from the Main/Bergen/Port Jervis and

Pascack Valley Lines—would only result in a 7.5% decline in PABT peak hour passenger demand, compared to the No-Build condition in 2040. For the same level of expanded rail service, the Access to the Region's Core (ARC) Final Environmental Impact Statement (FEIS) analysis estimated only a 4% reduction in PABT demand, although it is important to note that the ARC analysis considered daily trips (as opposed to peak hour passengers) for a horizon year of 2030 (as opposed to 2040). The NEC FUTURE Interregional Model forecasts a reduction of 6%-8% in daily intercity bus demand (for the overall intercity bus market within the NEC FUTURE study area) associated with the Action Alternatives in 2040.

The summary documentation of the Bus & Passenger Activity Forecasts completed for the MBMP Appendix B includes instructive details to explain the modest reduction in projected demand at the PABT associated with significant expansion of trans-Hudson rail capacity. Specifically, the document notes that “for most customers, the primary effect of the Gateway project would be to provide more capacity, not change the time or convenience of rail service. From any given location in New Jersey, the relative tradeoffs between rail and bus will remain unchanged by the expansion in rail service.” Indeed, although there is some overlap between the west-of-Hudson rail and bus networks, the two modes largely serve different markets for trans-Hudson commuting. Accordingly, while increasing commuter rail capacity would be an enormously beneficial investment, it would not change the capture area of the commuter rail service, thereby resulting in only a modest change in projected PABT demand.

However, the MBMP Appendix B also indicates that “a significant increase in trans-Hudson rail capacity could induce transit operators to make changes to bus service,” such as re-routing some routes to terminate at Secaucus Junction and discontinuing direct service into Manhattan, which could potentially result in “significant additional reduction in demand at the bus terminal.” The forecasts cited above assume no such modifications to bus service. Furthermore, the potential effects of commuter rail capacity expansion cannot be viewed in isolation from the rest of the interstate transportation network, including but not limited to the role of the PATH system in addressing future projected trans-Hudson travel (discussed in Section 2.1).

## 4 Additional Considerations

### 4.1 POLICY IMPLICATIONS OF MODE TRANSFERS AND PRICING

The assessment of Trans-Hudson modal strategies leads to the discussion of how transfers and pricing may impact customer decision making. There have been a significant number of studies evaluating the cost and impacts of ridership associated with transfers within and between transit modes. Transfers are a common occurrence in public transportation systems, especially in large multimodal networks, or between distinct operating services. For example, approximately 42% of the bus passengers entering the PABT today transfer to the subway, and approximately 52% of commuter rail passengers at PSNY transfer to/from the subway (with another 18% transferring to/from the bus, based on the 2006 Moynihan Station FEIS). According to a 2007 American Public Transportation Association (APTA) report (*A Profile of Public Transportation Passenger Demographics and Travel Characteristics Reported in On-Board Surveys*), 40% of public transportation trips in the United States include at least one transfer, with 29.3% including one transfer, 8.4% including two transfers, and 2.3% including three or more transfers.

From a policy standpoint, the transfer penalty is a fundamental issue, and is a key factor in the determination of overall ridership demand. Nearly all forecasting procedures assume that the impact of transfer time is greater than just the simple time spent changing from one route (or service) to another. For instance, the Federal forecasting models add 5 minutes of time for each transfer above and beyond the actual time required to transfer between routes.

It is important to consider, however, that future trans-Hudson travel decisions may depend on other factors, in addition to equivalent travel time:

- In cases where the system is near its person-hauling capacity, travelers may elect to avoid the crowded no-transfer option in favor of the less crowded option that involves a transfer.
- Technology is quickly evolving and the accuracy and timeliness of transit information available to the customer would promote the use of alternative routes/modes/transfers.
- Unified ticketing technology across multiple trans-Hudson modes/agencies would also promote the use of alternative routes/modes/transfers.
- Providing opportunities for flexibility and convenience may also promote the use of alternative modes (i.e., creating park-and-ride options that allow customers to use bus and rail interchangeably; providing amenities at park-and-ride locations such as dry cleaners, auto repair, pharmacy; etc.)
- Pricing strategies that promote the use of alternative modes.

Key to understanding and shaping the future of trans-Hudson technology/ticketing/pricing/transfer options is (1) establishing regional transit agency collaborative working groups to explore and institute technology and coordination options; and (2) engaging customers through outreach and surveys to test transfer options and pricing strategies. These next steps could become a focus of future research or pilot pricing initiatives.

## 5 Findings

This is the second of two technical memoranda that assess strategies for serving future trans-Hudson travel demand. For each technical memorandum, the primary goal is to determine if a particular strategy will accommodate sufficient demand to allow meaningful reductions in the size and cost of a reconstructed PABT. The “Bus Network Operational/Service Strategies” technical memorandum looks at strategies involving improvements to and reconfiguration of bus service; this technical memorandum looks at all other trans-Hudson modes of travel.

The strategies presented here cover a wide range, from large investments such as the Gateway Program for new Hudson River rail tunnels, to more incremental improvements such as improvements to trans-Hudson ferry service. Given the wide range of scope and cost of these strategies, expected effects on the potential size and scope of a reconstructed PABT also cover a wide range.

On the high end, one strategy – the No. 7 Line Extension to Secaucus – would have a large effect on future PABT bus demand, larger than any other strategy considered in this technical memorandum or in the “Bus Network Operational/Service Strategies” technical memorandum. This one project could reduce demand for buses to access the PABT by as much as 25% below projected levels in 2040, and could justify a reconstructed bus terminal that is both substantially smaller and significantly less expensive than currently projected.

These benefits would come at a substantial cost. A preliminary assessment of the No. 7 Line Extension to Secaucus estimated cost at or around \$10 billion, an amount far greater than the likely cost reductions it would allow by enabling a reduction in capacity of a replacement Midtown Bus Terminal. Although the project may be worth pursuing for many reasons, it would not represent a net reduction in the cost of infrastructure to serve the trans-Hudson market. It also would bring its own set of construction and physical and operational impacts as well as benefits on both sides of the Hudson River, and an additional financing challenge over and above the various trans-Hudson projects already on the region’s agenda, most driven by a combination of state-of-good-repair imperatives as well as capacity-expansion opportunities.

At this writing, the No. 7 Extension shows no signs of advancing through the transportation planning and funding process. However, should this change, it could significantly affect the design of a constructed PABT, but for the moment it must be seen as more an idea than a plan.

Other strategies considered in this technical memorandum have much smaller effects on future demand for buses to access the PABT. Extension of the Hudson-Bergen Light Rail and improvements to trans-Hudson ferry service have been discussed for many years and would offer many benefits to the region, but cannot be expected to have significant effects on future PABT bus demand.

Improvements that increase both the reach and capacity of the PATH rail system fall somewhere in the middle. The PATH system offers a high quality trans-Hudson option to New Jersey commuters in certain markets, and improvements to the system could increase this value over time. These improvements—longer trains, more frequent service, and an extension to Newark Liberty Airport—offer many benefits, but their effect on future demand for buses to access the PABT would be modest. This is largely because the specific locations served by PATH are not markets that generate significant bus travel to PABT (with the notable exception of Hudson County). Improved PATH service would benefit these communities but would leave bus demand largely unaffected.

This highlights an important issue for policy makers in both states, though not directly related to the PABT: The primary effects of the trans-Hudson bus strategies assessed in the “Bus Network Operational/Service Strategies” technical memorandum would be on bus commuters and the infrastructure that serves them. As such, decisions of whether to implement these strategies can be made based largely on their effects on PABT and the larger bus system. This is not the case for the strategies assessed in this element of the Commuting Capacity Study. It is important to understand the effects that improvements to the PATH system would have on PABT, for example, but it does not follow that decisions about these investments should be made based on their effects on the bus system. In fact, for many strategies assessed in this technical memorandum, the effects on the bus system and PABT are minor and ancillary compared to other effects, and as a result, a decision of whether to pursue the project should be based mostly on these other factors.

There is no trans-Hudson initiative for which this is more true than the Gateway Program. It is the most costly strategy considered in this technical memorandum or in the “Bus Network Operational/Service Strategies” technical memorandum by a wide margin, and it can be argued that its effects would be the most far reaching. One of these effects would be a modest reduction in future demand for buses to access PABT, likely a percentage reduction in the mid-single digits. The reasons for this relatively modest effect are similar to those cited for improvements to the PATH system. Gateway would significantly increase the capacity of NJ TRANSIT trains to carry passengers into Manhattan, but this effect would be felt mostly in communities with NJ TRANSIT rail stations. These communities are on the whole not major generators of bus demand, and so the diversion effect from improved NJ TRANSIT rail service would not be large.

However, effects on bus demand and the PABT reconstruction are not the reasons to either pursue or not pursue Gateway. It would affect the region in many ways—through improved resilience, higher capacity commuter rail service, and better connections up and down the Northeast Corridor—and as a project it should rise or fall based on these factors.

Future investment to substantially increase trans-Hudson capacity over and above what is delivered by the Gateway Program could have multiple forms and likely will require a multimodal investment strategy: greatly increased bus service and with increased capacity and efficiency on the Lincoln

Tunnel Corridor and in a replacement bus terminal, extension of a NYCT subway line to New Jersey,<sup>1</sup> and/or even more commuter rail service. Growth in ferry service is possible, but would be insufficient to meet the totality of projected 2040 demand on its own. Either of the potential rail investments – subway or regional rail – would divert some but not all trans-Hudson bus trips and would reduce peak-period demand for interstate bus service to and from Manhattan, but the need would still exist for a substantial bus terminal. Expanding PATH peak-period service is possible through additional car purchases and other potential capital improvements in New Jersey, though these may be needed to serve growth from local Hudson County markets as well as transfers from other modes at Hoboken Terminal and Newark Penn Station. Ferries can provide some supplemental capacity, with limited potential to divert bus commuters with inland origins.

The estimated diversionary effects of the strategies outlined in this technical memorandum that have the potential to reduce peak hour PABT demand (and for which the potential PABT reduction is quantified) are summarized in Table 4. It is important to note that the effects are not necessarily additive—and thus the cumulative effects cannot be inferred—because there could be overlap between the potential bus diversions associated with the respective strategies. Additional strategies specific to the interstate bus network that could divert demand from the PABT are discussed in the “Bus Network Operational/Service Strategies” technical memorandum.

Table 4: Summary of Potential PABT Bus Diversions from Applicable Strategies

Strategy	Potential PABT Diversions (Number of Peak Hour Buses)
Expanded Bus Services to Port Imperial Ferry Terminal	10
Expanded Trans-Hudson Ferry Services	10-20
Gateway	50-60
No. 7 Line Extension to Secaucus	200

Source: Trans-Hudson Community Capacity Study; MBMP; No. 7 Line Secaucus Extension Feasibility Analysis Final Report

In summary, even when policy makers are successful in advancing the Gateway Program to construction and if NJ TRANSIT is able to double rail service into PSNY, it is not expected that the Gateway Program alone will meaningfully reduce demand at PABT. Demand for trans-Hudson transit service is expected to grow by 30% or more by 2040, which will fully utilize all of the capacity created by the Gateway Program and require investment in even more additional capacity. Increasing and improving bus service to PABT, made possible by a reconstructed terminal, is necessary to meet growing trans-Hudson demand prior to 2040. The well-developed network of bus routes and services feeding PABT has proven to be a convenient, productive, and competitive means of trans-Hudson transit service, and will remain a critical asset for travelers. This is especially the case in areas of northern and central New Jersey where rail service is unavailable or constrained.

<sup>1</sup> This assumes adequate institutional support is found in both states and especially within the MTA to pursue such a proposal, and that such an extension can be proven to provide adequate benefits, especially in addressing projected future travel demand.

Finally, it is important that any strategies to reduce projected demand at PABT in the forecast year of 2040 be considered in light of the likely useful life of a reconstructed PABT regardless of the size and configuration that are selected. This issue was addressed in the findings of the “Bus Network Operational/Service Strategies” technical memorandum and apply equally here, and are presented here verbatim:

It will take many years for a new PABT to be designed, funded and built. For these reasons an opening date prior to 2025 seems unlikely. If this estimate is correct, in the forecast year of 2040 the new facility would be just 15 years old, well short of its actual useful life. In addition, future policy makers will likely want a reconstructed PABT to last longer than the 30 year life span considered standard for many infrastructure projects. The north wing of the current facility opened 37 years ago; the south wing, 66 years ago. The consequences of this could be significant: a new terminal opening in 2025 with a 50-year useful life would be called upon to accommodate growing demand until 2075. While it is not practical to produce exact demand forecasts as far out as 2075, the real possibility exists that a reconstructed PABT would need to function for decades beyond 2040. This suggests that policy makers should be wary of designing a facility that is strictly sized to meet only demand forecasted for 2040.

Based on these findings, this technical memorandum reaches the following tentative conclusions:

The non-bus strategies assessed in this technical memorandum could have some effect on the appropriate future size of a reconstructed PABT, but the only strategy that could lead to a significant size and cost reduction – the No. 7 Line Extension – is unlikely to be implemented in the foreseeable future. Improvements to PATH service and incremental improvements to ferry service and light rail in New Jersey may be worth pursuing on their own merits, but would not meaningfully change the parameters for PABT reconstruction. The Gateway Program may be the most important transportation investment for the region currently being planned, but its effect on bus demand at a reconstructed PABT would be modest.

These factors, together with need for a reconstructed PABT to accommodate trans-Hudson bus demand well beyond the 2040 forecast year, lead the authors to conclude that the non-bus trans-Hudson strategies assessed in this technical memorandum do not provide a basis to reduce the current projected capacity at full build-out of a reconstructed PABT.

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TRANS-HUDSON COMMUTING CAPACITY STUDY

# Appendix B Attachment: Ferry Analysis

September 2016

Version Final

Prepared for:

**THE PORT AUTHORITY**  
OF NEW YORK & NEW JERSEY

Submitted by:



CHENG SOLUTIONS LLC

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# 1 Introduction

## 1.1 OVERVIEW

There are currently 18 ferry routes that serve the Hudson River commuter market operating between 12 New Jersey terminals and four Manhattan terminals. All of the privately-owned and operated ferry companies – New York Waterway (NYW), BillyBey Ferry, Seastreak, Hornblower, and Statue Cruises – are in public-private partnerships for use of public terminals, piers and/or property for parking as part of their business. Ferries provided an average of 28,000 weekday trans-Hudson trips in 2015, with ridership higher in the summer months than in the winter months. NJ TRANSIT estimates that ferry riders represent approximately 4% of current trans-Hudson commutes.

According to NJ TRANSIT's 2013 ferry passenger survey, current ferry customers report a high level of satisfaction with their ferry commute, and have higher-than-average incomes compared to trans-Hudson commuters overall. Given that ferries are not the lowest cost option available, one can deduce that these customers place greater monetary value on their time and are not as price sensitive as other commuters.

Strategies that have been frequently discussed to expand ferry ridership, similar to other modal strategies, are largely centered upon:

- Increasing parking options at ferry terminals;
- Decreasing fares on existing services; and,
- Providing new ferry routes to capture additional market.

This report addresses the extent to which these strategies would likely cause bus commuters to shift to ferry commutation in numbers sufficient to affect peak period usage of a new PABT. Following an analysis of the effects of additional parking, the report discusses the potential impact of reduced fares on existing services and the likely market for three new routes (proposed as part of the North Jersey Transportation Planning Authority's (NJTPA) *Waterborne Resources Transportation Inventory*) on ferry and bus ridership. *The report presents an estimate of potential ridership that may be diverted specifically from bus to ferry.*

Specifically, this report assesses the degree to which current trans-Hudson bus commuters may be significantly diverted to the ferry mode and how this would affect the design capacity of a new redeveloped Port Authority Bus Terminal (PABT). It is not a market analysis or a ridership study. Finally, it is important to note that this report relies heavily on ferry elasticity calculations provided by the 2011 Port Authority of New York and New Jersey (PANYNJ) *Interagency Study of Regional Private Passenger Ferry Services in the New York Metropolitan Area*. Interviews with ferry operators also were conducted to provide current and additional perspectives for this analysis.

## 2 Ridership Analysis on Current Routes

### 2.1 PARKING

Increasing parking options at ferry terminals in New Jersey could have the effect of increasing overall ridership on a few ferry routes into Manhattan. This is particularly the case in the services offered from Monmouth County. For both the NYW ferry service from Belford and the Seastreak ferry service from the Atlantic Highlands, almost all ferry customers arrive at the terminals by car. According to the 2013 Trans-Hudson Ferry Survey, 90% of these customers drive and park, and 3% carpool or are dropped off. Parking at these terminals is free but incorporated into the ferry fare. Currently, parking utilization ranges from 80% to 90% of capacity at these locations, based on interviews conducted with the ferry operators. Seastreak recently bought additional land near its terminal to accommodate another 300 cars for surface parking. Elevated parking garages have been discussed but are not anticipated to be financially viable. There also are concerns that an elevated structure could block waterfront views and therefore not be deemed acceptable to the public.

For the northern New Jersey ferry market, parking is less critical for ferry commuters since a higher percentage of commuters are able to walk to the ferry terminals or take an intermodal connection through a shuttle, Port Authority Trans-Hudson (PATH), or Hudson-Bergen Light Rail (HBLR). Paid parking for the northern New Jersey ferry market is available at Weehawken, however, capacity is at 80% and parking is not exclusive to ferry customers. There is no parking availability at Edgewater. Increasing parking at these locations would be difficult and would increase local vehicle miles traveled (VMT) at the terminals. Hence, this could be a challenging public project to implement in order to increase ridership.

Increasing parking does not address the diversion of *bus commuters* to the ferry mode as most bus customers walk to their bus stop. This is important because parking is often cited as a key issue for ferry ridership expansion. However, it is not relevant for the specific research question of this effort as it relates to PABT redevelopment.

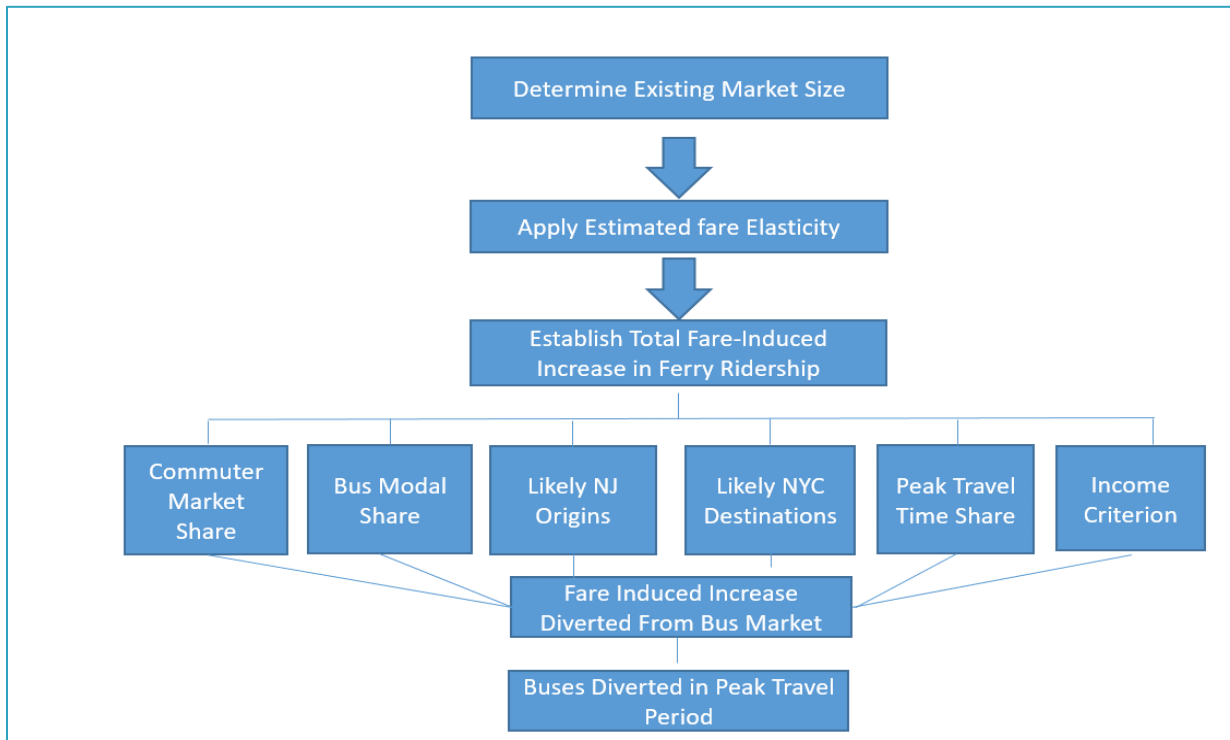
For some commuters, bicycles may provide another means of accessing ferries for commutation between New Jersey and New York City. The NYW and Billybey routes allow bicycles on board for an additional \$1.00 per trip fee. Seastreak charges an additional \$2.50. Passengers pay no additional charge to bring bicycles on board for the Liberty Landing service. Bicycle parking is available for ferry passengers and other transit users at the intermodal Hoboken Terminal and at the PANYNJ's World Financial Center terminal in Manhattan, and at NYW's Weehawken and Midtown Manhattan terminals.

NYW reports an average of 200 weekday bicycle ticket sales on trans-Hudson ferry routes, 80% as single-trip purchases and 20% bought on a monthly ticket. Their data show nearly half of the single-trip and monthly bicycle ticket purchases on the Paulus Hook-World Financial Center service alone. Seastreak and Liberty Landing report minimal usage of bicycles on their ferries.

# 3 Increasing Ridership on Current Routes

Though the public sector has provided infrastructure including ferry landings and terminals, trans-Hudson ferry service operations are unsubsidized by public agencies and consequently are a relatively expensive choice for daily commute and discretionary travel. Moreover, because landside connections are limited, the geographic (eastbound) market tends to be confined to the immediate areas surrounding the waterfront landings, and Manhattan-bound commuters are heavily comprised of residents who live within or near these neighborhoods. In addition, once a ferry customer arrives at a landing in Manhattan, limited shuttle service to ultimate destinations presents another barrier for riders. Unless the Manhattan landing is within walking distance (on par with a train, bus or subway service) to the ultimate destination, there is little incentive to opt for a ferry when there are other more convenient and significantly less costly alternatives available. In order to entice more ferry riders, issues of fare, overall transport costs (including value of time) and ease of access must be addressed (Figure 1).

Figure 1: Existing Routes Methodology Flowchart



Source: Cheng Solutions, 2016

The impact of the fare on ferry ridership can be calculated by estimating the price elasticity of demand. Using either revealed or stated preference data, researchers can estimate the percentage change in ridership for a given percentage change in the fare. A recent effort using both types of data was completed in 2011 by a team of consultants for the PANYNJ, in collaboration with partner agencies in both states. The *Interagency Study of Regional Private Passenger Ferry Services in the New York Metropolitan Area* provided a forecast of ferry ridership driven by fares (defined as daily rates and converted to real values using the consumer price index), employment in the finance industry, regional unemployment, and housing starts. Since the data was monthly, there are controls for seasonality as well as service interruptions due to weather or other phenomena. The econometric model constructed with these data yielded an estimated (short-term) fare elasticity of -0.27. It was assumed that the elasticity does not vary with the level of the fare. In other words, the response of riders to fare changes is the same across all plausible values of the fare. In most cases this is a reasonable assumption since fare levels will seldom vary more than 10% up or down in real terms. The specification of the model enabled the researchers to estimate a short-term elasticity only. Short term responses to fare increases are likely to be smaller than the longer term response since riders cannot usually make an immediate transition from one mode to another in response to a change in fare. For many reasons, riders would initially experience some duration of inertia.

The interpretation of the elasticity estimated in the PANYNJ report is as follows. Holding all other variables constant, a 10.0% increase in the fare will reduce ridership by 2.7%. Similarly, a 10.0% decrease in the fare will generate a 2.7% increase in ridership, all else being equal. At this level, the estimated elasticity is similar to estimates for other forms of transit. Over the past thirty years, estimates of transit elasticities have ranged from -0.2 to -0.5 in the short term, to between -0.6 and 0.9 over the long run. It is reasonable to assume a larger long-run elasticity for the trans-Hudson market even if its exact level is unknown.

Stated preference<sup>1</sup> survey data collected for the study, including socioeconomic characteristics of riders and transport market attributes such as in-vehicle time, out-of-vehicle time, and headway, provided further confirmation of the ferry fare elasticity. This data was used to develop an econometric mode choice model designed to gauge general interest in ferry transport relative to other modes. The mode choice model generated an estimated short-run elasticity of ridership with respect to fare of -0.24, almost precisely on par with the results of analyzing the revealed preference data within the same study. Thus according to the stated preference data, a 10.0% change in the fare would result in a 2.4% change in ridership in the opposite direction. Again this comports well with previous transit studies undertaken in recent decades.

The estimated elasticities derived from both the revealed and the stated preference data are considered inelastic because they are less than 1.0 in absolute value. This means that the proportional change in ridership is less than the proportional change in the fare. Therefore, holding

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<sup>1</sup> Stated preference data is different from revealed preference data in that it refers to a survey technique that extracts from respondents their views and preferences under a hypothetical set of circumstances and product attributes. In transportation research, survey respondents may be shown a list of modal attributes including fares, in-vehicle transit time, access time etc. then asked to choose which is the most attractive to them.

all other variables constant, it would take a large proportional decrease in the fare to attract a significant number of riders. One may deduce from this relationship that the ferry mode is not considered an equal substitute to alternate modes of transport, owing to both the fare relative to other modes and the difficulty of ferry landing access on both the east and west sides of the Hudson. Trans-Hudson ferry service can in fact be characterized as a “premium service” that is differentiated along price and service attributes:

Two policy implications of this analysis are:

- On existing routes, holding all other variables constant, even large decreases in the fare will go largely unheeded by the traveling public; and
- The main considerations for new routes should be reducing the cost of access and/or taking advantage of population densities in relatively high-income areas.

### 3.1 HEADWAY

Transit service frequency is called headway. Previous studies<sup>2</sup> reveal an elasticity of ridership to headway of -0.50, such that—on average—a 10.0% increase in headway (reduction in service frequency) cuts ridership by 5.0%, all else being equal. In the PANYNJ report, the impact of headway on ferry riders was derived via the stated preference survey component. The elasticity of ferry riders with respect to headway was found to be -0.62, which is relatively high in light of average estimates in the literature. It indicates that a 10.0% increase in headway will generate a 6.2% decrease in ferry riders, all else being equal. This may be at least partially explained by the wide availability of substitute transport modes and the relatively high value of time of Manhattan-bound New Jersey customers. Commuters can make the switch to an alternative mode with relative ease should the ferry headway increase. But the relationship, as in the case of all elasticities, is symmetric. Thus a 10.0% decrease in ferry headway will generate a 6.2% increase in ridership. The fact that commuters are relatively more sensitive to headway than to fares again reflects the region’s relatively high wages and value of time.

The difference between headway and fare elasticities may be an important policy consideration. According to the stated preference results, more riders are generated per unit decrease in headway than per unit decrease in the fare. In fact, holding all other variables constant, a decrease in headway will generate more riders than an equal percentage increase in the fare. However, there are limitations on the ability of providers to reduce headway. Ferries are already operating with significant excess capacity. Consequently, on purely financial grounds, providers are not likely to add additional capacity to improve service frequency. Speeding up existing ferries may be another alternative from a purely operational standpoint. However, even if fuel costs continue to decline, regulatory restrictions on ferry speeds make this impossible.

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<sup>2</sup> See Littman, Todd “Transit Price Elasticities and Cross-Elasticities” *Journal of Public Transportation*, Vol. 7, No. 2, 2004 (pp. 38

### 3.2 IN-VEHICLE TRANSIT TIME

The final key point to consider is the responsiveness of ridership to changes in in-vehicle time. The stated preference survey results from the PANYNJ report showed that the elasticity of ridership to in-vehicle time, specifically the time in-transit from origin ferry landing to destination ferry landing is -0.24. This is identical to the stated preference fare elasticity. Thus a 10.0% increase in transit time aboard the vessel will reduce ridership by 2.4%, all else being equal. Such an increase in operational speeds would also reduce headway, potentially eliminating the need for an increase in the number of ferryboats while deriving the ridership benefits of the relatively high headway elasticity. However, given the current regulatory environment raising operational speeds is infeasible. Boat speeds in New York State are not restricted when at least 100 feet from shore. However, wakes generated by boats are restricted. The potential damage to shoreline facilities and anchored or docked vessels from excessive ferry wakes has resulted in strict limits on ferry operating speeds. Failing a drastic change in boat design to vehicles that can operate at higher speeds with lower wakes, there is little room for ferry operators to raise ridership by reducing in-vehicle time.

### 3.3 QUANTITATIVE RESULTS - FARE ELASTICITY EFFECTS

In order to gauge how ridership might respond to various fare changes, we applied the estimated ferry fare elasticities discussed above to ferry ridership data provided by the PANYNJ.<sup>3</sup> The objective of this exercise was to determine how many commuters may be diverted from the bus to the ferry should the fare differential between the two modes narrow. The analysis was conducted for 15 ferry routes operating between New Jersey and Manhattan. The Rockland County service was not included, as it is too small to be statistically relevant. For purposes of this study, the bus market includes only those riders accessing the PABT in midtown. Riders accessing the terminal at the George Washington Bridge or any other destinations outside of the PABT are not included.

In order to arrive at final estimates, we have made several research-based assumptions about the relevant market. These include the share of commuters currently taking the bus, the share of trips occurring in the peak travel period, the share of bus riders whose ultimate destination is in close proximity to the Manhattan ferry landings, and the share of bus riders whose household income is on par with typical ferry riders. The peak month of July was chosen as the base for ridership. A quantitative description of these assumptions is displayed in Table 1. We did not empirically address inland connection issues such as bus, shuttle, jitney, private auto drop-off/park and sail, or other means of access to the New Jersey-side landings.

The analysis proceeded in steps and was designed to generate an estimate by ferry route of peak daily bus diversions. The first step was to generate changes in peak month ferry ridership by simulating the effects of reduced fares. Next we converted this to additional ferry riders per day during the peak month. We subsequently applied our research-based assumptions about the bus

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<sup>3</sup> Staff at PANYNJ provided Cheng Solutions with monthly one-way ferry ridership across all trans-Hudson routes from January 2014 through April 2016

commuter market to estimate the number of additional riders that will divert to the ferry from the bus, as opposed to from rail and autos.

Table 1: Bus Rider Market Assumptions

Origin-Destination	% County of Bus Users	% Bus Share	% Commuting	% of Bus Riders Traveling to Area	% of Peak Month	% Peak Period Trips	% in Ferry Income Class
Hoboken-Pier 11	64.7	36.3	79.6	15.7	10.1	17.7	47.2
Hoboken-World Financial Center (WFC)	64.7	36.3	79.6	2.8	10.1	17.7	47.2
Paulus Hook-Pier 79	64.7	36.3	79.6	9.3	10.1	17.7	47.2
Paulus Hook-WFC	64.7	36.3	79.6	2.8	10.1	17.7	47.2
Port Liberte-Pier 11	64.7	36.3	79.6	15.7	10.1	17.7	47.2
Liberty Harbor-Pier 11	64.7	36.3	79.6	15.7	10.1	17.7	47.2
Paulus Hook-Pier 11	64.7	36.3	79.6	15.7	10.1	17.7	47.2
Weehawken-Pier 79	64.7	36.3	79.6	9.3	10.1	17.7	47.2
Weehawken-Hoboken N-WFC	64.7	36.3	79.6	2.8	10.1	17.7	47.2
Hoboken North-Pier 79	64.7	36.3	79.6	9.3	10.1	17.7	47.2
Weehawken-Pier 11	64.7	36.3	79.6	15.7	10.1	17.7	47.2
Lincoln Harbor-Pier 79	64.7	36.3	79.6	9.3	10.1	17.7	47.2
Edgewater-Pier 79	23.9	36.3	79.6	9.3	10.1	17.7	47.2
Belford-Pier 11	19.7	36.3	79.6	15.7	10.1	17.7	47.2
Atlantic Highlands-Pier 11	19.7	36.3	79.6	15.7	10.1	17.7	47.2
Atlantic Highlands-E 34 <sup>th</sup> St	19.7	36.3	79.6	15.0	10.1	17.7	47.2

Source: Cheng Solutions, 2016

We control for the likely origin and destination of ferry riders, the share of trips made during the peak month and hour, the current modal share of buses in the overall Manhattan commutation market (to ensure that it is only bus riders who are relevant switchers), and finally, bus rider income. Average bus capacity adjusted for capacity utilization is given as 58.5 seats per bus. The results for fare reductions of 10%, 20% and 50% are displayed in Table 2. Given our assumptions as stated, there is virtually no diversion from buses to the ferry even with a 50% discount on the fare.

Table 2: Potential Bus Diversion in Peak Travel Hour

Origin-Destination	10% Fare Reduction		20% Fare Reduction		30% Fare Reduction	
	Diverted PABT Riders	Diverted PABT Buses	Diverted PABT Riders	Diverted PABT Buses	Diverted PABT Riders	Diverted PABT Buses
Hoboken-Pier 11	4	0	8	0	19	0
Hoboken-WFC	1	0	1	0	3	0
Paulus Hook-Pier 79	0	0	1	0	2	0
Paulus Hook-WFC	1	0	2	0	4	0
Port Liberte-Pier11	0	0	1	0	2	0
Liberty Harbor-Pier11	1	0	2	0	4	0
Paulus Hook-Pier 11	2	0	5	0	12	0
Weehawken-Pier79	5	0	11	0	27	0
Weehawken-Hoboken N-WFC	0	0	0	0	1	0
Hoboken North-Pier 79	2	0	4	0	10	0
Weehawken-Pier 11	1	0	3	0	7	0
Lincoln Harbor-Pier 79	2	0	3	0	8	0
Edgewater-Pier 79	0	0	1	0	1	0
Belford-Pier 11	1	0	2	0	4	0
Atlantic Highlands-Pier 11	1	0	2	0	4	0
Atlantic Highlands-E 34 <sup>th</sup> St	1	0	1	0	3	0
<b>Totals</b>	<b>22</b>	<b>0</b>	<b>45</b>	<b>0</b>	<b>112</b>	<b>0</b>

Source: Cheng Solutions, 2016

### 3.4 DIFFERENCE BETWEEN TRANS-HUDSON AND EAST RIVER FERRY MARKETS

There have been public policy discussions calling for decreasing fares as a key tool to increase ferry ridership, particularly in context of growth in the New York City (NYC) East River ferry market. What makes the trans-Hudson ferry market different from the East River market is the number of intermodal connections typically required to make a commute from New Jersey to the Manhattan CBD. In New York City Economic Development Corporation’s (NYCEDC) 2013 Citywide Ferry Study, it was clear that most of the existing and prospective new East River ferry customers are within a ½-mile walk radius to the respective ferry terminal. A primary threshold was within a ¼-mile walk radius and secondary market threshold was a ½-mile radius. Ridership largely came from new high-rise residential construction along the East River waterfront in Brooklyn and Queens, which are largely areas that were formerly industrially-zoned and far from the closest subway line.

On the trans-Hudson market, it appears that commuters evaluating their choice of mode are more sensitive to the length of their commute over the price of available options. In examining the elasticity

of the ferry fares, a decrease in fares did not produce significant numbers of new ferry customers. Holding all other variables constant, it would take a large proportional decrease in the fare to attract a significant number of customers.

Also, as these services have been privately operated for some time, one can assume that the fares have been set to meet expenses and provide a profit and a return on capital for the operators. To lower prices as a public policy would present a policy challenge as this would require a public subsidy for privately-operated services. Implementation of such a policy in lieu of investments to existing publicly-owned transit services could present challenges given the limited numbers of customers that would be served, many of them in high-income brackets versus bus commuters living further inland and away from the ferry terminals.

Finally, based on interviews with ferry operators, there is a reluctance to lower fares to the extent that ferries would no longer be perceived as a premium service. For the Monmouth County services that are well subscribed, one operator noted that they have been asked by customers to increase prices rather than lower prices to limit demand for parking at the terminal. NYW, which operates with capacity on its routes from the northern market, also noted that their customers prefer the private crosstown shuttle over use of a public bus, and that they value the premium nature of the service. In sum, decreasing fares may not render significant diversion from bus to ferry, and this policy may not be acceptable to current ferry operators who have built a premium brand targeting high-income commuters.

## 4 Ridership Analysis on Potential New Routes

New ferry terminal locations have often been discussed, most recently as part of NJTPA's *Waterborne Resources Transportation Inventory* (currently underway). The goal of that effort, which is being undertaken for future planning purposes, is to evaluate sites in terms of their prospective for ferry or waterborne freight use.

Three new routes that have the potential to divert bus commuters to the ferry have been identified. These include Edgewater – 125th Street West Harlem Piers, Hoboken – New West 34th Street Ferry Terminal, and South Amboy – Manhattan to Pier 11, World Financial Center (WFC) and East 34th Street.

- **Edgewater to West Harlem 125th Street.** While there is an existing NYW stop in Edgewater NJ, the possibility of a new route directly to the pier at West 125th Street is proposed in response to a new pier. From the new pier, it is a 6-minute walk to the subway station on the #1 train line, which provides connections to midtown and downtown. This route may also provide an opportunity to alleviate vehicular congestion at the Weehawken and midtown ferry terminals.
- **Hoboken/NJ TRANSIT to a new West 34th Street terminal.** This route would take advantage of the newly opened 34th Street Hudson Yards No. 7 subway station. It would pair the Hoboken South ferry terminal and a new Manhattan ferry terminal at West 34th Street, south of the Lincoln Tunnel ventilation towers. The new terminal would serve as a replacement for the current West Midtown Terminal at Pier 79 at 39th Street. Currently, NYW operates services connecting the Hoboken South/NJ TRANSIT Terminal with the ferry terminals at the World Financial Center and at Pier 11 Wall Street. Pairing Hoboken South with the proposed route opens up commutation with six NJ TRANSIT's commuter rail lines, as well as the Hoboken terminal of the HBLR system to New York City Transit's (NYCT) No. 7 subway station at Hudson Yards.
- **South Amboy to Manhattan.** This potential new route was identified for two reasons. First, South Amboy was the terminus site of a prior successful commuter ferry operation to NYC. Second, both the Belford and Atlantic Highlands ferries are beginning to experience saturation as the availability of surface parking is proving to be a constraint to further growth. There is parking availability at Perth Amboy. Additionally, there is no other appropriate growth option in Monmouth County with the exception of the Perth Amboy.

Evaluating these potential new services entail the following steps. The team used US Census Journey-To-Work to determine total trans-Hudson commuter market size (includes relevant New Jersey counties and Rockland and Orange Counties in New York State). To estimate the total number of bus riders with potential to divert to the ferry, we applied the same bus modal share as was used in the 2011 Interagency Study. Commuter survey data provided by the NJTPA and the PANYNJ was utilized to ascertain commuting patterns and socioeconomic attributes of ferry riders and determine the extent to which bus user characteristics match those of ferry users. Bus riders who

present a similar profile are considered eligible to switch to the ferry. For example, we eliminate potential bus riders whose share of expenditures out of household income would exceed that for current ferry riders.<sup>4</sup> Another condition relates to geographic commutation patterns. For instance, any bus commuter that lives within walking distance of their bus stop is eliminated from the potential market as it is unlikely that they would surrender that convenience for additional travel to a ferry landing.

Once the relevant market set was established, the ferry fare elasticity was applied to various price differentials that bus riders could face to access the ferry. An elasticity of -0.24 was used, based on the previously mentioned 2011 Interagency Study.<sup>5</sup>

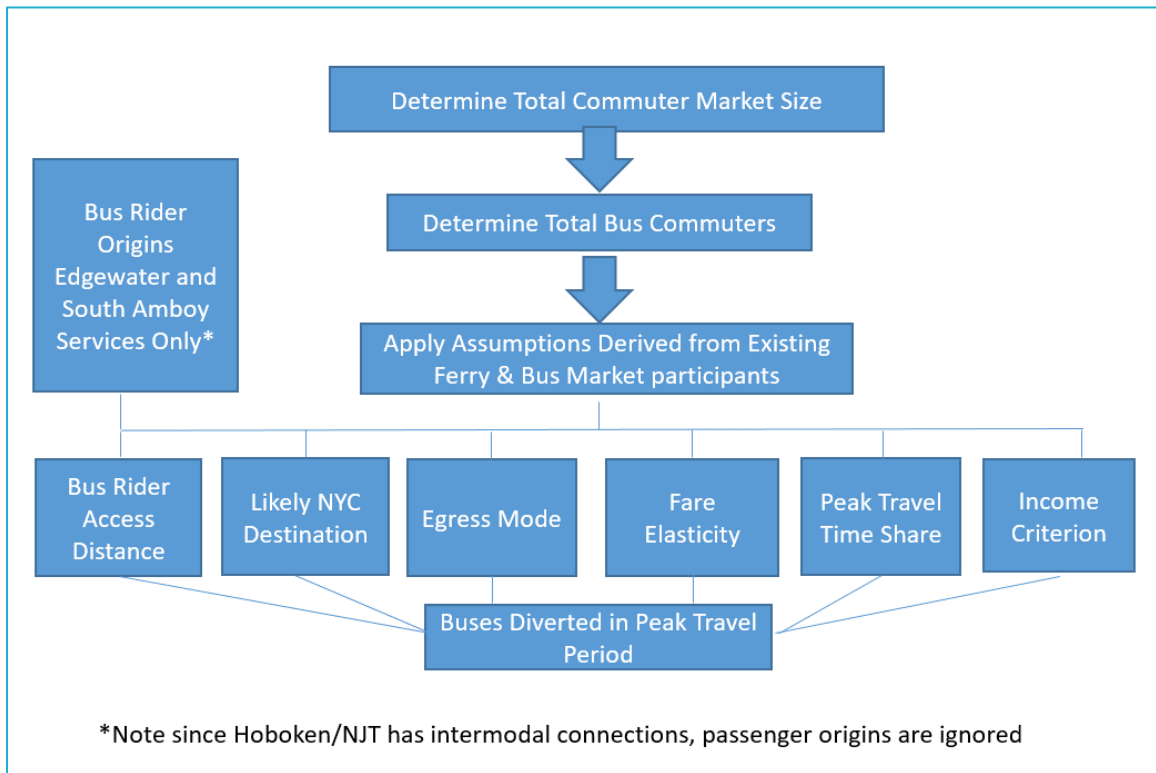
It is important to note that the elasticity utilized was estimated for current ferry riders and may not be the best fit for current bus riders. The elasticity for a bus rider is likely to be higher since they are more likely to consider substitute modes of transport such as rail or car pool. Ferry riders enjoy a “premium service” and are unlikely to view alternate modes as comparable substitutes. Thus their elasticity with respect to fare is likely to be significantly lower. It would be preferable to have an elasticity of ridership specific to bus riders to provide a more accurate gauge of modal switching behavior. This could be estimated via a stated preference survey of trans-Hudson commuters. However, for the purposes of estimating modal switch for this effort, we applied the existing elasticities from prior efforts. The analysis for each service is described below, and Figure 2 provides a comprehensive outline of the process.

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<sup>4</sup> Examination of ferry ridership survey data indicated that on average, ferry commuters spend roughly 2% of their annual household income on commutation.

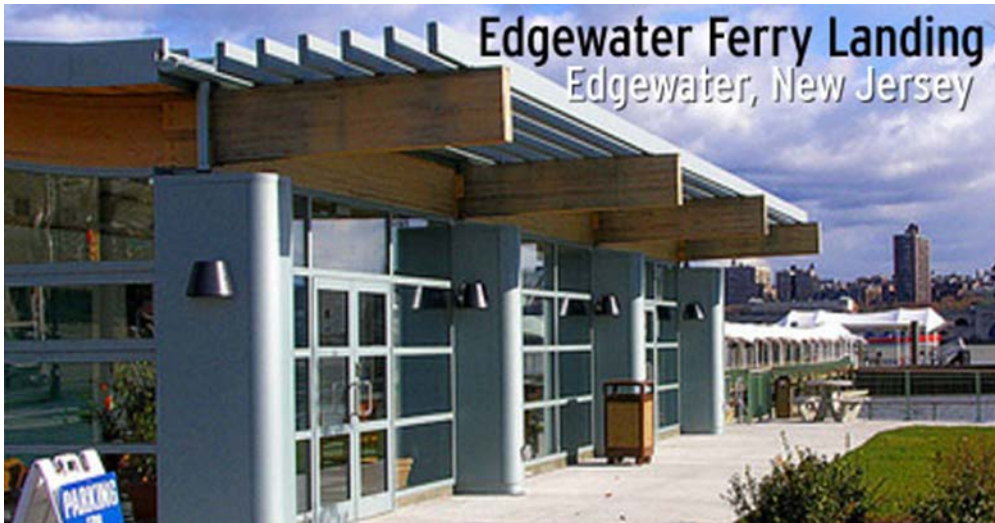
<sup>5</sup> We chose to use the Stated Preference derived -0.24 over the revealed preference study estimate of -0.27 as the latter applies only to current ferry riders while the former incorporates the preferences of all trans-Hudson commuters.

Figure 2: New Routes Methodology Flowchart



Source: Cheng Solutions, 2016

#### 4.1 EDGEWATER – WEST 125TH STREET



Source: NYW

NYW currently operates a trans-Hudson ferry service connecting the Edgewater ferry pier in Bergen County to the West Manhattan Ferry Terminal/Pier 79 at West 39<sup>th</sup> Street. Approximately 900 one-way trips are made daily on this route, according to recent ferry ridership reporting to NJ TRANSIT and the PANYNJ. There may be additional ferry opportunities in this commuter market as there is no direct rail competition to the ferry in eastern Bergen County. This market is also worth further exploring for potential peak PABT demand mitigation given the high percentage of bus customers commuting from this area.

A new ferry service from Edgewater directly to the newly constructed West Harlem Pier at West 125<sup>th</sup> Street in Manhattan has been suggested by officials in the Town of Edgewater to supplement the existing service to Pier 79. This route could offer a new option for trans-Hudson commuters to access Midtown Manhattan via a connection to the Broadway (No. 1) subway line, as opposed to the existing ferry route, which requires bus connections on congested streets on both sides of the Hudson River. The West Harlem Pier, which is newly constructed by NYCEDC, is a 6-minute, 1/3-mile walk to the 125<sup>th</sup> Street subway station on the No. 1 Line.

Capacity utilization of vessels on the existing ferry route from Edgewater to Pier 79 is, like other ferry services, very light. Adding a new route from Edgewater to West 125<sup>th</sup> Street could therefore be feasible with existing vessels. It would cut several minutes off the trip over water (compared to the existing ferry route from Edgewater) and also could reduce travel time for commuters accessing destinations close to West 125<sup>th</sup> Street. An efficient connecting service to the subway would likely be a critical element for success of this service, as the 1/3-mile walk to the subway, however short, may not appeal to all commuters.

A new ferry service from Edgewater would predominantly attract Manhattan-bound commuters from Bergen County in New Jersey and possibly Rockland County in New York. Access times for commuters from counties south of Bergen would likely be prohibitive relative to other transportation options. This assumption is supported by NJ TRANSIT's origin and destination survey data for the Edgewater-Pier 79 route. Nearly all of the survey respondents commuting on the ferry to Manhattan from Edgewater began their trip in Bergen County, and 72% started in Edgewater itself. See Table 3 for a breakdown of the point of origin for the Edgewater-West 39th St Ferry passengers.

In addition to point of origin constraints, the current Edgewater – West 39th Street service is limited by a lack of intermodal connections at the destination terminal. There are no convenient connections to the NYC transit system from the 39th Street terminal, although commuters journeying to areas outside this immediate area are able to take an operator-provided bus service closer to their ultimate destination. As a result, this service is convenient primarily for commuters who work within walking distance of Pier 79 in Midtown Manhattan. Indeed, the current customer base for this service is predominantly composed of such commuters.

Table 4 breaks down the ultimate destinations of the Edgewater ferry passengers. It shows that 45.8% of riders end their trip in the Manhattan neighborhoods of Midtown, Chelsea or Clinton; 39.3% end up in the Gramercy Park, Murray Hill neighborhoods. Edgewater ferry passengers heading downtown were 8.5% of the sample and uptown commuters were 5.4% of the sample.

Table 3: Edgewater Ferry Passenger Origins

Origin County	Origin City	Origin State	Observations	Percent
Bergen	Cliffside Park	NJ	7	3.5
Bergen	Dumont	NJ	1	0.5
Bergen	Edgewater	NJ	142	71.7
Bergen	Englewood	NJ	1	0.5
Bergen	Englewood Cliffs	NJ	2	1.0
Bergen	Fort Lee	NJ	35	17.7
Bergen	Leonia	NJ	2	1.0
Bergen	Park Ridge	NJ	1	0.5
Bergen	River Vale	NJ	1	0.5
Bergen	Teaneck	NJ	1	0.5
Bergen	Tenafly	NJ	1	0.5
Hudson	Weehawken	NJ	1	0.5
Rockland	New York	NY	1	0.5
Rockland	Tappan	NY	1	0.5
Union	Union City	NJ	1	0.5
<b>Totals</b>			198	112

Source: NJ TRANSIT Ferry Customer Study Report, June 2014 Final Report

Proximity to the NYC subway system would be the major advantage for an Edgewater service to the landing at 125th Street - presumably West Harlem Piers - over the current service to West 39th Street. West Harlem Piers lies only 0.3 miles from a NYC subway connection at 125th Street and Broadway, a six-minute walk at an approximate speed of three miles per hour. It is conceivable that such a connection would expand the market to include Bergen County commuters traveling to anywhere in Manhattan and the remaining four boroughs. However, this service would be most convenient and therefore attractive to commuters whose ultimate destination is anywhere on the Westside of Manhattan, Upper Manhattan, Inwood, Midtown and even as far south as Lower Manhattan, the financial district and downtown Brooklyn.

It is not clear, however, that commuters currently taking the bus to the PABT and ending their trip in Midtown or other areas via walking or easy connections to NYCT would find much advantage in switching to a more expensive ferry to 125th Street. Such a service would put these commuters further from their ultimate destinations and would require walking another 0.3 miles for an additional connection to the NYC subway. Perhaps as importantly, relative to the bus, the Edgewater – 125th Street service would likely require additional access time to the Edgewater landing from points in New Jersey as there are currently no parking facilities in Edgewater. Hence, park-and-ride commuters would require a shuttle bus connection once in the area. This would add significantly to the total travel time. By comparison, according to the NJ TRANSIT Ferry O&D survey data, the median distance the Bergen County bus commuter travels to their bus stop is just 0.4 miles, about a 10-minute walk.

Table 4: Edgewater Ferry Passenger Ultimate Destinations

Destination Borough	Destination Area	Observations	Percent
Brooklyn	Sunset Park	1	0.6
Manhattan	Central Harlem	1	0.6
Manhattan	East Harlem	2	1.2
Manhattan	Gramercy Park and Murray Hill	66	39.2
Manhattan	Greenwich Village and Soho	8	4.8
Manhattan	Lower East Side	3	1.8
Manhattan	Lower Manhattan/Financial District	3	1.8
Manhattan	Midtown, Chelsea, and Clinton	77	45.8
Manhattan	Upper East Side	4	2.4
Manhattan	Upper West Side	2	1.2
Queens	Northwest Queens	1	0.6
<b>Totals</b>		<b>168</b>	<b>100.0</b>

Source: PANYNJ Ferry Rider Origin and Destination Survey

Given the foregoing, it is reasonable to eliminate all Bergen County bus commuters whose ultimate destination is Midtown New York from the potential Edgewater – 125th Street ferry market, as

Midtown is generally within walking distance of the PABT and to abandon it for the ferry would require a NYC subway ride. Further, since parking in Edgewater is a major constraint, the majority of passengers for a new ferry service would most likely be drawn almost exclusively from the town of Edgewater and the bordering towns of Fort Lee and Cliffside, each of which constitutes 71.7%, 17.7% and 3.5%, respectively, of current ferry riders from Edgewater.

Finally, it is unlikely, given the NYC subway shuttle connection to Grand Central Station, that bus commuters originating from the above three towns who are currently accessing points on the East Side including, the Upper East Side, Murray Hill, Gramercy Park, the East Village and the Lower East Side, would consider switching to the ferry at 125th Street, since it lands much further away from their ultimate destination. Therefore, the pool of potential Edgewater-125th St ferry riders that can reasonably be extracted from the Bergen County bus commutation market is confined to bus commuters who begin their trip in Edgewater, Fort Lee and Cliffside and end their commute in Upper Manhattan and the Bronx, the Upper West Side, Lower Manhattan and downtown Brooklyn.

#### 4.1.1 Origin Market

According to the US Census Journey to Work dataset, the total size of the market for commuters from Bergen County to NYC is 80,002 people. Multiplying by an estimated bus modal share of 36.3%<sup>6</sup> leaves 29,041 Bergen-NYC bus commuters. The potential market is adjusted further by considering only commuters originating in the towns of Edgewater, Fort Lee and Cliffside Park, which according to the NJ TRANSIT Bus Origin and Destination survey data, aggregates to 19.6%. Therefore, based on point of origin, the total size of the bus market that could conceivably switch to an Edgewater – 125th Street ferry service is 5,694 persons.

#### 4.1.2 Ultimate NYC Destination

The share of bus commuters from the relevant three-town Bergen County market (Edgewater, Fort Lee and Cliffside Park) traveling to Upper Manhattan and the Bronx, the Upper West Side, Lower Manhattan/Financial District and downtown Brooklyn amounts to 8.5%. Table 5 summarizes the ultimate destinations. Controlling for origin and ultimate destination pares the potential market for converted bus-to-ferry to 484 new riders.

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<sup>6</sup> This figure is provided in the 2011 Interagency Study of Regional Private Passenger Ferry Services in the New York Metropolitan Area.

Table 5: Edgewater, Fort Lee and Cliffside Park Bus Commuter Ultimate NYC Destinations

Locale	Observations	Percent
Borough Park	2	0.2
Bushwick and Williamsburg	2	0.2
Central Bronx	1	0.1
Central Brooklyn	2	0.2
Central Harlem	5	0.5
East Harlem	4	0.4
Flatbush	1	0.1
Gramercy Park and Murray Hill	228	23.9
Greenpoint	2	0.2
Greenwich Village and Soho	38	4.0
Inwood and Washington Heights	1	0.1
Lower East Side	24	2.5
Lower Manhattan/Financial District	52	5.5
Manhattan	120	12.6
Midtown, Chelsea and Clinton	384	40.3
North Queens	4	0.4
Northwest Brooklyn	3	0.3
Northwest Queens	15	1.6
Outer Borough	1	0.1
Outside	10	1.1
Southeast Bronx	1	0.1
Southwest Queens	1	0.1
Sunset Park	1	0.1
Upper East Side	24	2.5
Upper West Side	11	1.2
West Central Queens	1	0.1
West Queens	6	0.6
Unknown	7	0.7
<b>Totals</b>	<b>952</b>	<b>100.0</b>

Source: NJ TRANSIT Bus Origin &amp; Destination Survey

### 4.1.3 Income Constraint

In keeping with an assumption that annual transportation outlays should be no more than 2% of total household income, we estimate that 39.7% of current bus commuters in the Edgewater, Fort Lee and Cliffside Park market meet this criterion (see Table 6).<sup>7</sup> This reduces the potential Edgewater-125<sup>th</sup> St ferry market to 193 riders. We arrive at this share by assuming that the monthly ferry fare from Edgewater to 125th Street will be the same as the current fare from Edgewater to Midtown West 39th Street, or \$231.50. This amounts to \$2,778 on an annualized basis. Therefore, to meet the 2% criterion, a commuter must have an annual household income of \$138,900. Unfortunately, the income categories given in the NJ TRANSIT Bus survey are not sufficiently granular, forcing us to settle on the figure of \$100,000 per year. Nonetheless, this comports well with previous research conducted for the PANYNJ<sup>8</sup> that found a positive relationship between ferry ridership and household income of at least \$100,000 per year

Table 6: Edgewater, Fort Lee and Cliffside Park Bus Commuter Income

Household Income	Observations	Percent
Under \$15,000	31	3.9
\$15,000-\$24,999	32	4.1
\$25,000-\$34,999	28	3.5
\$35,000-\$49,999	76	9.6
\$50,000-\$74,999	171	21.6
\$75,000-\$99,999	138	17.5
\$100,000-\$149,999	175	22.2
\$150,000 and Over	139	17.6
<b>Totals</b>	<b>790</b>	<b>100.0</b>

Source: NJ TRANSIT Bus Origin & Destination Survey

### 4.1.4 Peak Period

According to the PANYNJ, 21.6% of trans-Hudson total bus arrivals, including both NJ TRANSIT and other commuter buses, occur during the peak period, defined as between 7-8 AM.<sup>9</sup> Further adjusting the pool of new ferry commuters to include only peak period travelers reduces the total number from 193 to just 42 potential ferry riders who are likely to be diverted from bus service to PABT.

<sup>7</sup> A 2% share of household income would roughly align with expenditures of current trans-Hudson ferry riders, based on an analysis of ferry rider characteristics documented in the 2014 NJ TRANSIT Ferry Customer Study Report.

<sup>8</sup> See 2011 Interagency Study Of Regional Private Passenger Ferry Services in the New York Metropolitan Area.

<sup>9</sup> See PANYNJ "Midtown Bus Master Plan Bus & Passenger Activity Forecasts" Prepared By Planning & Regional Development Department August 1, 2013, Revised January 5, 2016

#### 4.1.5 Fare Elasticity

Interviews with ferry operators (see Appendix A) strongly suggest that fares will not be reduced unless a public agency commits to a significant subsidy. The effect of fares on potential ridership is therefore derived based on current fares, applying an elasticity of  $-0.24$ <sup>10</sup> - the same parameters as were used for existing markets in the 2011 *Interagency Study of Regional Private Passenger Ferry Services in the New York Metropolitan Area*. The use of current fares will constitute the “base case.” In order to gauge how ridership may be affected should a subsidy be offered, the ferry fare was subsequently simulated to fall by 10%, 20% and 50%, respectively. The elasticity is applied to the percent differential in monthly fares. Table 7 displays the results for each level of market size and fare reduction. Note that at a 50% reduction in ferry fare, the differential between the ferry and bus fares becomes negative such that ferry ridership increases.

Table 7: Ferry Ridership Edgewater-West 125<sup>th</sup> Street – Varying Fare Scenarios<sup>11</sup>

Fare Scenario	Percent Reduction in Ridership from Final Market Estimate	Ridership	Peak Period Buses Diverted
Base Case Ridership	15.2	35	0.6
Reduced Fare – 10%	11.0	37	0.6
Reduced Fare – 20%	6.8	39	0.7
Reduced Fare – 50%	-5.9	88	1.5

Source: Cheng Solutions

#### 4.1.6 Final Estimates

Using the above qualifications on the market in the base case produces 35 ferry passengers per day. At a capacity of 58.5 persons per bus, this amounts to less than one bus diverted per day in the peak period. A 50% reduction in the ferry fare results in 88 new ferry commuters. This amounts to 1.5 peak-period buses diverted per day, or two buses when rounding to the highest integer.

<sup>10</sup> This falls in the inelastic range such that an increase in the fare would result in a less than proportional decrease in ridership. But this elasticity was measured by examining current ferry riders who demand a premium service and do not see other modes as appropriate substitutes. Thus given their need for a premium luxury service they are a more “captive” market. Bus riders, on the other hand are not in the same mindset. Their fare elasticity, as a consequence is likely to be significantly higher as they consider the bus and rail as substitutes. Thus a small increase in prices is liable to yield a much larger proportionate decrease in ridership. Knowing the elasticity for a broader market is not possible given the current information set, the Interagency Study level of  $-0.24$  was applied, with the caveat that in reality, this figure is likely to be significantly higher.

<sup>11</sup> At a 50% fare reduction, the number of eligible riders increases as exponentially more of them can achieve the 2% of income constraint. In the case of Edgewater – 125<sup>th</sup> Street, the income constraint falls to \$50,000 per year for which 78.9% of bus riders can satisfy

## 4.2 HOBOKEN – 34TH STREET



Source: NYcurbed.com and MTA

A second possible ferry service is one that connects the terminal at Hoboken South / NJ TRANSIT to a new terminal at 34th Street on the West Side of Manhattan at Hudson Yards. NYW currently runs a service from the Hoboken NJ TRANSIT terminal to both Pier 11/Wall Street and to the World Financial Center. NYW also runs a service from Hoboken North to Midtown West 39th Street. It is assumed that the new terminal at Hudson Yards will replace the Midtown West 39th Street terminal, but not change the travel behavior for those already traveling there from Hoboken North. The analysis is therefore confined to the potential ridership from the Hoboken/ NJ TRANSIT terminal to Hudson Yards.

The primary advantage for the Hudson Yards/34th Street terminal will be connecting service to the MTA via the new No. 7 Line subway extension and the M34 Select Bus Service. Moreover, Hudson Yards will be an attractive destination for commuters in its own right as planned office and retail development in the area proceeds.

### 4.2.1 Access to New Jersey Sites

The Hoboken/NJ TRANSIT Terminal offers no free parking. Paid parking is available, but it is expensive and for many commuters currently crossing the Hudson by bus would be cost prohibitive. Moreover, it has insufficient capacity. There are instead several mass transit connections to the terminal including NJ TRANSIT trains and buses, light rail service, private buses (Academy) and the PATH train.

Because of its connections to mass transit, the customer base at the Hoboken/NJ TRANSIT ferry terminal is far more geographically diverse than its Hoboken North counterpart. Whereas almost all of the Hoboken North commuters (work trips only) arrive there from Hudson County, only 35.9% of commuters using Hoboken/NJ TRANSIT begin their trip in Hudson County. The remainders were composed of Bergen County commuters (24.3%), followed by Essex County (13.4%), Union County (5.4%), Morris County (5.0%), Passaic County (4.8%) and Rockland and Orange Counties in New York (5.2%).

Just under 19% of commuters at this terminal walked; 63.4% took NJ TRANSIT and 3.5% arrived via the Hudson-Bergen light rail. Only 4.1% took a NJ TRANSIT bus; 2.3% took some other bus, and only 3.0% drove and parked.

Table 8 and Table 9 make clear that the market for trans-Hudson ferry commutation at the Hoboken/NJ TRANSIT terminal extends from Hoboken itself to anywhere in New Jersey and New York State where NJ TRANSIT provides service either via rail or bus. Therefore, the geographic market is defined as bus commuters travelling to NYC from nine counties west of the Hudson River – seven in New Jersey and two in New York. Counties that accounted for less than 2% of the commuter ridership were excluded as being outliers.

Table 8: Ferry Commuter Origins at Hoboken/NJ TRANSIT Ferry Terminal

County	Observations	Percent
Bergen	203	24.3
Essex	112	13.4
Gloucester	4	0.5
Hudson	298	35.6
Hunterdon	1	0.1
Middlesex	4	0.5
Monmouth	15	1.8
Montgomery	2	0.2
Morris	42	5.0
Orange	26	3.1
Pennsylvania	1	0.1
Passaic	40	4.8
Rockland	19	2.3
Somerset	18	2.2
Sullivan	1	0.1
Sussex	3	0.4
Ulster	1	0.1
Union	45	5.4
Warren	1	0.1
<b>Total</b>	<b>836</b>	<b>100.0</b>

Source: NJ TRANSIT Ferry Customer Study Report, June 2014 Final Report

Table 9: Ferry Access Mode at Hoboken/NJ TRANSIT Ferry Terminal

Access Mode	Observations	Percent
Auto/Drive & Park	28	3.0
Bicycle	10	1.1
Carpooled/Dropped Off	23	2.5
Hudson-Bergen Light Rail	32	3.5
NJ TRANSIT Bus	38	4.1
NJ TRANSIT Rail	584	63.4
Other	1	0.1
Other Bus	21	2.3
Taxi	12	1.3
Walk Only	172	18.7
<b>Total</b>	<b>921</b>	<b>100.0</b>

Source: NJ TRANSIT Ferry Customer Study Report, June 2014 Final Report

The total commuter market for these nine counties is given by the US Census Journey to Work data and is displayed in Table 10.

Table 10: Workers Journeying to NYC by Key Market County

County	Commuters	Percent
Bergen	80,002	25.6
Essex	41,106	13.2
Hudson	91,971	29.5
Morris	13,495	4.3
Orange	17,207	5.5
Passaic	12,510	4.0
Rockland	24,408	7.8
Somerset	8,399	2.7
Union	22,982	7.4
<b>Total</b>	<b>312,080</b>	<b>100.0</b>

Source: US Census Journey to Work 2013

From the 2011 Interagency Study the trans-Hudson bus mode share is 36.3%. This is a broad estimate that in all likelihood varies significantly by county depending upon the distance, speed and most importantly availability of a bus service. Nevertheless, the application of this mode share to the total commuter market yields 113,285 potential trans-Hudson bus commuters eligible to switch to the proposed ferry service.

#### 4.2.2 Access Modes

According to the NJ TRANSIT Bus Origin and Destination Survey data, the overwhelming majority of bus commuters (82.6%) walk to their bus stop at median distance of 0.40 miles (Table 11).<sup>12</sup> At a speed of three miles per hour, that is about a 10-minute walk.

It is doubtful that bus commuters would prefer to abandon that convenience for longer access time to the ferry landing at Hoboken/NJ TRANSIT, particularly if they must access their final NYC destination via another ride on public transit. This significantly reduces the market potential for the ferry to comprise only those who drive and park. The reasoning is that since they are already driving and parking, it can be assumed that they are more likely to have the financial means to drive and then pay for parking facilities at the Hoboken/NJ TRANSIT terminal. The application of the share of commuters using private autos or carpools (13.6%) for bus access reduces the potential market to 15,401 riders.

Table 11: Access Modes at NJ TRANSIT Bus Commuters

Access (to NJ TRANSIT) Mode	Observations	Percent
Another Bus/Shuttle	32	1.1
Bike	1	0.0
Carpooled/Dropped Off	67	2.3
Drove Car and Parked	388	13.6
Jitney/Van	1	0.0
Light Rail	4	0.1
NJ TRANSIT Train	1	0.0
PATH	1	0.0
Taxi	2	0.1
Walked	2,357	82.6
<b>Total</b>	<b>2,854</b>	<b>100.0</b>

Source: NJ TRANSIT Bus Origin and Destination Survey

#### 4.2.3 Egress Modes

Table 12 provides the egress modes of bus commuters arriving at the PABT from the aforementioned key market area to NYC. As in the case of the proposed service from Edgewater – 125th Street, it is assumed that NJ TRANSIT bus riders who work within walking distance to the PABT are unlikely to switch to a ferry for which they would have to take a NYC subway from Hudson Yards to their final destination. However, NJ TRANSIT bus riders who access the PABT then connect to NYCT may consider a ferry if the transit connection could either be eliminated or significantly eased. Therefore,

<sup>12</sup> Distances for each leg of the commuter's journey were not given directly in the survey data, however, map coordinates were given. Cheng Solutions used these coordinates to access the Google maps distance matrix to derive exact walking and driving distances. Travel times were imputed from distance and mode.

we include as potential riders those commuters currently using the subway or bus to access their final destination (46.1%) from the PABT. This reduces the potential market to 7,092 persons.

Table 12: Egress Modes of Bus Commuters Arriving at the PABT

Egress Mode	Observations	Percent
Another Bus/Shuttle	11	0.2
Bike	3	0.0
Carpooled/Dropped Off	11	0.2
Drove Car and Parked	13	0.2
Jitney/Van	7	0.1
NJ TRANSIT Train	1	0.0
NYC Bus	256	3.8
Other	6	0.1
PATH	1	0.0
Subway	2,846	42.3
Taxi	38	0.6
Walked	3,543	52.6
<b>Total</b>	<b>6,736</b>	<b>100.0</b>

Source: NJ TRANSIT Bus Origin and Destination Survey

#### 4.2.4 Ultimate NYC Destination

A service from Hoboken/NJ TRANSIT to Hudson Yards offers no advantage for commuters ending their trip in Lower Manhattan, as there is already a service from Hoboken/NJ TRANSIT to Pier 11 and to the WFC. Hudson Yards would be attractive for those remaining strictly in Midtown/Clinton/Chelsea, and could plausibly pick up some commuters traveling to Gramercy/Murray Hill as long as the No. 7 Line extension is available. The number of commuters traveling to Midtown and Gramercy/Murray Hill accounts for 64.6% of the sample. The application of this share leaves 4,583 commuters in the market.

#### 4.2.5 Income Constraint

With respect to income, the same principle applied to the Edgewater – 125th Street service is applied here as well. Assuming the ferry fare charged on the Hoboken North to Lower Manhattan service prevails for service to Hudson Yards, the total annual fare is \$2,748. Under the aforementioned 2% assumption, this means that to be eligible to switch to a ferry service, the bus commuter household income must be at least \$137,400. Because of the lack of granularity in the NJ TRANSIT Bus data, the cut off for income was again placed at \$100,000 per year. The data show that 44.4% of bus commuters meet this criterion (Table 13) and are therefore included in the final potential market. We stress that this is an optimistic estimate. Not all commuters earning above \$100,000/year will make the switch, but it is from this group that the ferry will likely draw most of its riders. After application of the income constraint, the size of the market falls to 2,036.

Table 13: NJ TRANSIT Bus Commuter Household Income (Key 9-County Market)

Income	Observations	Percent
Under \$15,000	110	1.8
\$15,000-\$24,999	151	2.5
\$25,000-\$34,999	250	4.1
\$35,000-\$49,999	551	9.1
\$50,000-\$74,999	1,216	20.1
\$75,000-\$99,999	1,078	17.9
\$100,000-\$149,999	1,273	21.1
\$150,000 and Over	1,410	23.3
<b>Totals</b>	<b>6,039</b>	<b>100.0</b>

Source: NJ TRANSIT Bus Origin and Destination Survey

#### 4.2.6 Peak Period

As in the case of Edgewater – 125th Street, we include the PANYNJ's peak period hour of 7-8 AM only, which accounts for 21.6% of trans-Hudson bus arrivals. After application of this share the Hoboken/NJ TRANSIT – Hudson Yards ferry commuter market falls to 441 riders.

#### 4.2.7 Price Elasticity

Finally, the issue of pricing and price sensitivity must be addressed. While there is currently a public discussion about reducing ferry fares via public subsidy, for purposes of this study, price sensitivity is considered at present rates. As with the potential Edgewater – 125th Street service, we applied a ferry fare elasticity of -0.24 to the likely differential between the monthly ferry and bus fares. Since average fares are not given in the bus survey data, we calculate the difference between the monthly bus fare to NYC from the Hoboken/NJ TRANSIT terminal (\$107) and the monthly ferry fare to Pier 11/WFC from the same terminal (\$229). Application of the elasticity to this price differential reduces the potential diversion of bus riders to the ferry to 305 riders per day.

#### 4.2.8 Final Estimates

The above qualifications yield a base case of 305 trans-Hudson bus passengers per day that could plausibly make the switch to a ferry service in the peak period. At a capacity of 58.5 persons per bus, this amounts to 5.2 buses (6 after rounding) diverted per day in the peak period. As was stressed earlier, this is an optimistic estimate. It will be reduced if, among other factors, not all potential bus riders that meet the income criterion actually make the switch and/or the elasticity of ridership with respect to fare is higher than what was given in previous literature. Both scenarios are extremely likely. For example, if only 50% of those meeting the income constraint actually make the switch, the number of buses diverted falls to 3. If we assume the elasticity is double what has been used here as well as assuming only 50% of our income class make the switch, the number of diverted riders falls to 2. The model can accommodate variations in all other variables discussed in this analysis as well. Table 14 shows results for varied ferry fare reductions according to proposals for existing services.

Table 14: Ferry Ridership Hoboken-NJ TRANSIT – West 34<sup>th</sup> Street Under Varying Fare Scenarios

Fare Scenario	Percent Reduction In Ridership from Final Market Estimate	Peak Period Ridership	Peak Period Buses Diverted
Base Case – No Change	27.4	320	5.5
Riders at 10% Reduced Fare	22.2	343	5.9
Riders at 20% Reduced Fare	17.1	365	6.2
Riders at 50% Reduced Fare	-1.7	804	13.7

Source: Cheng Solutions

Note that because 82.4% of the nine-county bus commuters meet the income requirement when ferry fares are reduced by 50%, and ridership climbs to 804.

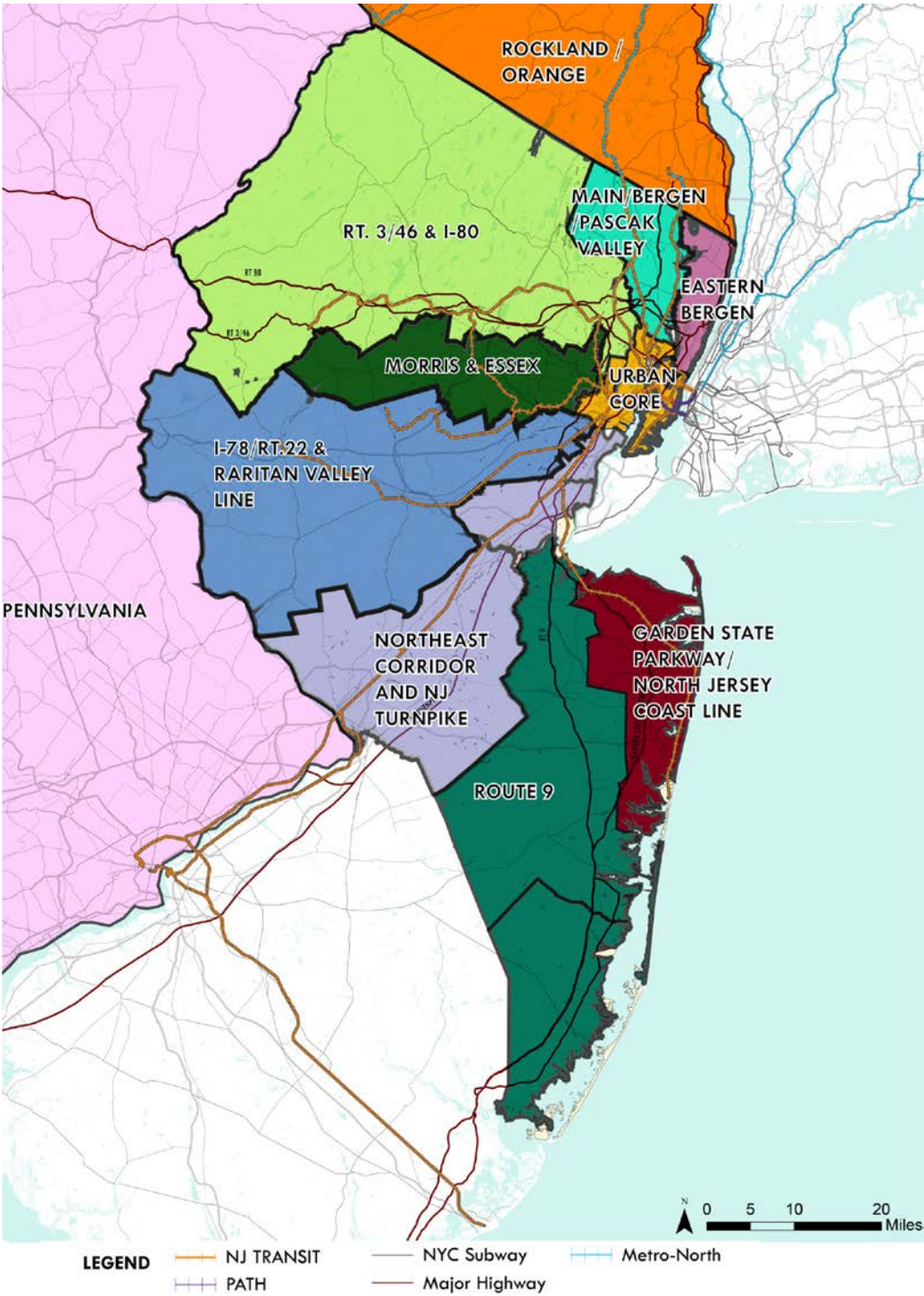
### 4.3 SOUTH AMBOY – MANHATTAN

Also under consideration for expansion is a potential new ferry service from South Amboy, New Jersey to Pier 11/Wall Street, World Financial Center and East 34th Street. In recent interviews with ferry operators and county planners as part of the *NJTPA Waterborne Transportation Inventory Assessment*, South Amboy was suggested as having potential to expand ferry ridership from Middlesex and Monmouth Counties. South Amboy is in Middlesex County on Raritan Bay and southwest of the southern tip of Staten Island. The waterfront site has good access to a regional road network off U.S. 9 where access to a new terminal would not require traffic to weave through a residential community.

A South Amboy to Lower Manhattan ferry route previously served the trans-Hudson market. This service was initiated in February 2002 to accommodate area commuters after the attacks of September 11, 2001. The service was discontinued in 2005 as high fuel costs combined with lower than expected ridership and dredging costs made the route uneconomical for the operator. The City of South Amboy plans to build a permanent ferry terminal as part of a larger waterfront development project. South Amboy also hosts a NJ TRANSIT commuter rail station.

South Amboy is at the northern tip of the Garden State Parkway/North Jersey Coast Line trans-Hudson travel corridor (refer to Figure 3). This travel corridor is forecasted by NJ TRANSIT to have an 11% bus market share for trans-Hudson trips in 2040, a 35% rail share, and an 8% ferry share, with the remainder commuting predominantly by auto. An unsubsidized ferry service is expensive compared to the public-sector transit alternatives in this market. For the Atlantic Highlands to Manhattan service, commuters may purchase discounted tickets in a 40-trip book at a cost of \$655 or \$16 for a one-way cost trip. By comparison, a monthly train pass from the South Amboy station to Penn Station New York is \$380 and would take one hour. A new ferry service from South Amboy, unlike at the Belford and Atlantic Highlands locations, would have to compete directly with the commuter rail option.

Figure 3: West-of-Hudson Trans-Hudson Travel Corridors



Source: Trans-Hudson Commuting Capacity Study, NJ TRANSIT

A ferry terminal at this location is also likely to be constrained by local adjoining vehicle parking capacity. Unlike many of the new East River ferry terminals being planned in the NYCEDC Citywide ferry expansion, a new South Amboy terminal is not currently being planned in conjunction with up-zoning for high-rise residential development. This option is unlikely to draw price-sensitive commuters from the bus market but may still be attractive to high-income commuters working in Lower Manhattan.

#### 4.3.1 New Jersey Market

We consider only commuters from Middlesex County as potential South Amboy customers. First, there is already a ferry service from Atlantic Highlands as well as Belford in Monmouth County, which suggests that any Monmouth County commuters with a propensity to ride the ferry would already be doing so. This logic would exclude all counties south of Monmouth as well including Ocean and Burlington Counties. It is also unlikely that many customers will be drawn from north of South Amboy since access to this proposed service would entail traveling away from the ultimate destination. Mercer County just to the west is possible but commuters from this market would be required to drive a significant distance for access to South Amboy as there are no NJ TRANSIT bus services between these counties. Thus from the US Census Journey-To-Work data, the total number of commuters to NYC from Middlesex County is 39,224.

As in the cases of Edgewater – 125th Street and Hoboken/NJ TRANSIT – West 34th Street, we apply a trans-Hudson bus mode share of 36.3%. The total estimated potential number of trans-Hudson bus commuters eligible to switch to divert to ferry service is therefore 14,238.

#### 4.3.2 Access Modes

In the NJ TRANSIT Bus Origin and Destination survey data set there are relatively few observations of bus riders from Middlesex County (16) traveling to Manhattan for work purposes. Eleven out of the 16 drove and parked for NJ TRANSIT access. By applying the same logic that commuters currently walking to the NJ TRANSIT bus stop are unlikely to abandon that convenience, we consider only commuters (68.8%) who drive and park to catch their bus. The potential market therefore falls to 9,789.

#### 4.3.3 Egress Modes and Ultimate Destination

The proposed South Amboy – Manhattan service would land at Pier 11/ Wall Street, WFC and East 35th Street terminals. Thus Middlesex bus commuters (40%) accessing Lower Manhattan and Gramercy/Murray Hill were considered. Midtown commuters are likely to prefer to stay on the bus since for much of Midtown, East 35th Street is not within easy walking distance. The number of riders is pared down to 3,916.

#### 4.3.4 Income Constraint

With respect to the income constraint, the same principles as the Edgewater – 125th Street service and the Hoboken – 34th Street service were applied. However, the ferry fare, listed by Seastreak's current service from Monmouth County is significantly more expensive (\$655/month) than the

Hoboken and Edgewater services. Annualized to the fare is \$7,860 which if our 2% condition holds, would require a household income of at least \$393,000. The bus rider household income statistics only capture income of \$150,000 and up. We therefore use the share (13.3%) earning at least \$150,000. This condition leaves 522 potential riders.

**4.3.5 Peak Period**

Application of the peak period share of buses further pares this market down to 113 riders.

**4.3.6 Price Elasticity**

Using the same pricing and price sensitivity methodology as Edgewater and Hoboken services yields the results shown below. We assume a ferry fare of \$655 per month and a monthly bus fare of \$267 per month.

Like the cases of Edgewater – 125th Street and Hoboken/NJ TRANSIT – Hudson Yards, reducing the ferry fare by 50% raises the share of bus riders who meet the income constraint.

**4.3.7 Final Estimates**

Under the base case of no change in ferry fares, the above qualifications yield 69 passengers per day that would potentially make the switch to a ferry service from the bus. At a capacity of 58.5 persons per bus, this amounts to 1.2 buses (2 after rounding up) diverted per day in the peak period (Table 15).

Table 15: Ferry Ridership South Amboy-Pier 11/Wall Street – East 34<sup>th</sup> Street Under Varying Fare Scenarios

Fare Scenario	Percent Reduction from Final Market Estimate	Ridership	Peak Period Buses Diverted
Base Case Ridership	39.2	69	1.2
Reduced Fare – 10%	32.6	76	1.3
Reduced Fare – 20%	26.0	84	1.4
Reduced Fare – 50%	-6.1	106	1.8

Source: Cheng Solutions

## 5 Proposed Routes Summary

Based on the analysis of available data, opportunities to greatly increase ferry ridership directly from the pool of bus commuters on the three proposed routes appear limited. While the new ferry routes may offer better options for a niche commuting (high-income) public, absent drastic degradations in the level of service of competing modes, they appear to have limited impact on the peak-period bus commutation market. We attribute this primarily to the more onerous intermodal connections required by the ferry and a large difference in the household incomes of ferry riders compared to bus riders.

Table 16 provides a summary of diverted bus riders various fare levels. Note again that this analysis is specific to examining the degree to which ferries will draw only from bus commuters. The extent to which commuters using any other mode would switch is not relevant for the current exercise. Hence this analysis should not be viewed as a total ridership analysis or market analysis regarding the viability of these new routes.

Table 16: Summary Bus to Ferry Riders All Proposed Services

Fare Scenario	Ridership	Peak Period Buses Diverted
Base Case — No Change	424	7.3
Riders at 10% Reduced Fare	456	7.8
Riders at 20% Reduced Fare	488	8.3
Riders at 50% Reduced Fare	998	17.1

Source: Cheng Solutions

## 6 Conclusions

Increasing parking options, decreasing fares, and/or adding new routes may increase ferry ridership. Additionally, maintaining bicycle access and assuring adequate bicycle parking capacity at ferry facilities on both sides of the Hudson River should be a consideration in future planning. However, it is unlikely that the increase in ferry customers would have sufficient mode diversion effects from buses to affect the peak-period design capacity of a new PABT. The commuter bus and ferry markets have different customer bases. There may not be significant inland bus customers that would find an additional intermodal connection with a ferry to be an attractive daily commutation choice given that bus customers already have longer commutes than current ferry customers.

However, given the dynamic nature involved in estimating ridership among different modes, a stated preference survey should be completed for improved certainty of these results. Ferries do offer flexible opportunities as interim commutation capacity should rail or bus capacity be constrained during the construction of improvements, as well as during any potential outages due to labor or storm events. The ferry companies already have experience in working with public authorities on emergency transportation planning through leases of additional vessels and arrangements for shuttle connections at park-and-ride lots and locations such as Liberty State Park, which would be useful in planning PABT interim construction-related capacity.

### 6.1 NEXT STEPS

This analysis was done for the sole purpose of addressing the larger planning question of whether ferry ridership can increase to levels that may merit design changes for a redeveloped PABT. This analysis is not meant to assess the market feasibility of new ferry routes from a commercial perspective or whether ferries deserve increased governmental support. Ferries have demonstrated themselves to be an important component of a network for transportation resiliency and may have positive attributes that are not addressed by this effort.

Additional studies, such as a comprehensive mode choice model using either stated preference or revealed preference survey data would be required particularly since levels-of-service among the other modes have changed since the 2011 Interagency Study was completed. The ferry and bus origin and destination data used in this study is a good beginning to a more comprehensive modal choice analysis. To complete a trans-Hudson mode choice analysis, similar information for rail customers and commuters who drive and park or car pool would be required. This would enable an analyst to more accurately gauge the relationships between mode choice and travel time, travel costs including the fare, modal attributes and the socio-demographics of the commuting public. These relationships would be quantified such that estimates of ridership could be extracted under simulated changes in any of the critical variables. For instance, the user of the final mode could determine how ferry ridership might change if bus fares increased or bus services changed either for the better or for the worse.

## 7 Interviews with Trans-Hudson Ferry Operators

As part of the Trans-Hudson Commuting Capacity Study, to help inform an analysis on the potential of the ferry mode to manage trans-Hudson and PABT peak demand, Cheng Solutions solicited feedback from current ferry operators. Feedback was solicited through phone interviews with senior executives of current ferry companies, including Hornblower (interview conducted 6/9/16), NYW (interview conducted 6/13/16), and Seastreak (interview conducted 6/17/16). Each phone interview lasted approximately one hour. A list of questions—included below—was provided to the interviewees in advance of the phone interview.

Representatives from these organizations were asked to comment on the following topics:

- Overall ferry market and constraints
- Inland connections to the ferry terminal
- Service cost issues
- Potential areas for expansion

Not every interviewee was able to respond to every question nor was every question covered given the specific organization's business model and/or the allotted time for the interview. This document provides a summary of the feedback.

### 7.1 SUMMARY

Major common themes that emerged from the interviews include:

- All operators cited insufficient parking as a constraint towards growing their ridership in all or some of their routes. However, the operator with this as their most pronounced constraint is Seastreak, as the bulk of their customers arrive at their Atlantic Highlands terminal via car. Parking adversely affects the opportunity to grow ridership for NYW for their Belford service, but their service is diversified with other locations where riders access the ferry by walking or various transit modes.
- Fare reduction is not seen as a desirable strategy to grow ferry ridership. Operators do not expect to gain ridership with decreasing fares, but rather expect to lose money. The operators of trans-Hudson ferry service see their ferries as offering a high-quality service to a clientele that is seeking a premium service over public transit, in contrast to the NYCEDC's East River ferry system. There is a concern that reducing prices, even for a trial period or to accommodate commuters stranded from a rail transit strike, may have the undesirable effect of driving away loyal customers that are inconvenienced by a surge in demand. However, public partnerships

are welcomed in the development of landside facilities such as parking and terminals as well as in the provision of grants to assist with upgrading vessels to meet stricter governmental air quality regulations.

- Liberty State Park (LSP) may offer potential to accommodate greater ferry ridership. Both Hornblower and NYW mentioned greater use of LSP as a park-and-sail lot to increase ferry ridership. Hornblower noted that the current pricing policy of \$7 per day, which is the same seven days per week, deters commuter use. It was suggested that LSP could lower its price to park during weekdays to encourage ferry commutation.
- All operators cited their emergency contingency plans with NJ TRANSIT as a template for potential pilot projects. While ferries are currently a premium transit service, all operators noted that if the commuter rail and/or bus infrastructure were to be significantly impaired, the demand for ferries would exceed their current capacity. Their emergency contingency plans, which entail leasing additional vessels and implementing shuttles from various parking lots, could be used to increase ferry capacity.

## 7.2 INTERVIEW QUESTIONS

The following preamble and list of questions were prepared to guide the interviews with the ferry operators:

The PANYNJ is evaluating the potential effect on projected trans-Hudson travel demand as it relates to the redevelopment of the Port Authority Bus Terminal (PABT). Specifically, the Trans-Hudson team is assessing the potential to balance demand across modes and corridors. The expansion of existing trans-Hudson ferry services and/or addition of new routes, including landside connections on both sides of the Hudson River, is being examined for its potential role in balancing trans-Hudson travel demand.

### The Ferry Market

1. Is there any defined catchment area (in terms of radial distance) around landings that can be reasonably designated as the geographic market?
2. Are there any points in time when operators have noticed a spike in ridership not related to seasonal conditions? E.g., does ridership materially increase when NYC tolls increase?

### Inland Connections and Access

3. How critical are transport connections for your ferry riders? Should such connections to transport hubs not be available what would be the impact on ridership?
4. Is the current capacity of connecting services adequate? Are customers satisfied with such connections or are there things that can be done to improve them? What might be the impact of such improvements on ferry ridership?

5. How important are parking facilities at your NJ ferry landings? What percentage of ferry riders drive and park at or close to the landings as opposed to accessing them via public transport? Is current parking capacity adequate? Will expansion be required in the near future?

#### **Service Costs**

6. Do you see any potential increase in ridership if ferries shared a common fare platform with the transit agencies (e.g. Orca card in Seattle, Octopus card in Hong Kong)? NJ TRANSIT has the MyTix app.
7. How do you regard the future for operating and fixed costs? E.g., what is the outlook for fuel, labor, maintenance, insurance and other costs?
8. Have you evaluated decreasing fares to increase ridership to a revenue neutral level?
9. Does the size of the current system limit efficiency? That is, if the system were expanded, would operators experience improvement in operating efficiency, i.e., better capacity utilization?
10. Do public policy initiatives play any role in determining the economic viability of a ferry service? E.g., are there tax policies and/or business incentives that are in force now or in the past that have had an impact (positive or negative) on service viability?

#### **Potential for Expansion**

11. What do you see as opportunities to increase ferry ridership?
12. Which mode of transport is considered the biggest competitor to ferry service? Bus, rail or private auto? In other words, if ferry service were to expand, which mode of transport would the expansion be primarily drawing riders from? What percent might come from the bus?
13. What is the role of terminals in increasing and maintaining ridership?
14. How would you think your ridership would change if one or two of the Penn Station rail tunnels would be unavailable for a year or two while improvements are being made?
15. How would you think your ridership would change if the PABT would be unavailable for a year or two during construction?
16. What pilot projects make sense to serve commuters as an interim mode during down time when infrastructure has to be maintained or rebuilt (rail station and/or PABT)?