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TRANS-HUDSON COMMUTING CAPACITY STUDY

Summary Report | September 2016

Prepared for:

THE PORT AUTHORITY OF NEW YORK & NEW JERSEY

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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 1).

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 Capacity Study provides 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 timeframe for planning and implementing a PABT replacement project.

The Capacity Study encompasses a number of technical memoranda responsive to the PANYNJ Board's Resolution, informed in part by an April 2016 day-long workshop including representatives of concerned agencies, transportation planners, and technology experts. The project team held working meetings focused on PABT and Lincoln Tunnel corridor operations, and reached out to agencies involved in trans-Hudson rail service planning, ferry operators, and Manhattan employers to inform its research.

Taken together, these efforts comprise the Capacity Study findings and form the basis for its recommendations. The findings are discussed in the following sections. The technical memoranda are outlined below and included as Appendices A through E.

- **Interstate Bus Network - Operational and Service Strategies (Appendix A)** – This assessment emphasizes that the PABT must be viewed as part of an interstate bus system, not a stand-alone facility. The technical memoradum evaluates 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. The strategies fall into two categories:
  - Strategies that **increase/manage capacity along the Lincoln Tunnel corridor**—either by improving corridor operations or PABT facility operations—to support a new PABT that accommodates forecasted peak demand as identified in the Midtown Bus Master Plan (MBMP)
  - Strategies that **address overall trans-Hudson commuter demand** through the use of other Hudson River crossings (besides the Lincoln Tunnel) for bus services, evaluating their potential to divert some commuters to buses using other crossings and transit nodes

TABLE 1: Existing and Future PABT Demand

Source: Midtown Bus Master Plan

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%)

- **Multi-Modal Network Strategies (Appendix B)** – This technical memorandum evaluates the extent to which a range of multi-modal network 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 technical memorandum complements the bus strategy assessment by considering opportunities to balance trans-Hudson commuter demand across modes, through increased use of the Port Authority Trans Hudson (PATH) system, NJ TRANSIT commuter rail, ferries, and light rail. The technical memorandum assesses the potential to add peak-period trans-Hudson capacity via other modes; their potential attractiveness as commuting alternatives for the trans-Hudson market; and the factors affecting the ability to implement these improvements in the timeframe established for PABT redevelopment planning.

- **Technology Implications and Opportunities (Appendix C)** – This technical memorandum discusses the utilization of new technologies to improve throughput and efficiency of existing facilities and to enhance commuter choice. The discussion highlights technologies that influence the demand and operation of the Lincoln Tunnel corridor and PABT, as well as those technologies that enable other operational or policy strategies that are considered important to the overall functionality of the corridor. A major focus of the technical memorandum is the opportunity to apply a range of connected and automated vehicle technologies to improve the operational efficiency of the Lincoln Tunnel corridor and the PABT. The technical memorandum provides details about the technology-based strategies, and also discusses approaches for communicating real-time information to meet rising customer expectations.

- **Summary of Capacity Study Workshop (Appendix D)** – The purpose of the workshop—held on April 14, 2016—was to convene a combination of local, national, and international industry leaders in transportation, policy, and technology, to evaluate advantages, disadvantages, and trade-offs of different strategies to address trans-Hudson capacity issues. The objectives of the workshop were to: identify major transportation network components for the effective operation of a PABT replacement to be located in West Midtown; probe relevant future workplace and regional travel trends; and assess prospects for other transportation investments with potential effect on PABT demand.

Through a combination of break-out sessions and group discussion among the workshop participants, a number of themes emerged that reinforced the overall charge of the Capacity Study.

» **Travel Demand Management Options (Appendix E)** – This complements the other technical memoranda by considering opportunities to reduce overall trans-Hudson peak-period travel demand. In conjunction with other strategies for meeting and managing the anticipated increases in trans-Hudson commuter demand, it could be possible to "reshape" or "flatten" the peak period through broader adoption of workplace flexibility by employers in the region. The means to promote travel demand management by employers could include offering employees additional options to telecommute, work at satellite offices/co-working hubs, and/or have an alternative work schedule/variable working hours. Additionally, public policy can promote travel demand management through the provision of incentives for commuters to travel outside the peak period.

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. In June 2016, the PANYNJ provided interim findings to the finalists in the D+D Competition. The bus-related work products from the Capacity Study informed the second phase of the D+D Competition. The overall Capacity Study provides additional regional context for the PANYNJ Board, which will receive the report of the independent jury for the D+D Competition and will hear public comments through this fall.

2 KEY STUDY FINDINGS

Planning for a reconstructed PABT should support the full 2040 forecast demand, while exploring bus demand management strategies and flexible terminal development options

When all factors affecting future demand for buses to access PABT are considered together—including strategies to accommodate commuters at other crossings and on other modes, factors that could affect patterns of bus travel, and the likely useful life of a replacement facility—the study authors do not believe a reconstructed bus terminal with substantially less capacity than the long-term need identified in the MBMP is justified.

Various methods to accommodate commuters outside the confines of the PABT are available, and in isolation, the Capacity Study suggests they could reduce bus flows to PABT by as much as 10-20 percent of the forecast 2040 demand. These figures are premised on the following:

- The Gateway Program being fully built out with a doubling of NJ TRANSIT peak-hour rail service
- Other trans-Hudson transit service alternatives diverting future PABT demand at the upper end of their projected levels of performance
- A relocation of some commuter bus services via other trans-Hudson crossings, in some instances to New York City streets
- A significant share of intercity buses continuing to pick up and drop off at locations in Manhattan outside of PABT

If these conditions are not met, the 10 to 20 percent range cannot be considered feasible.

This range does not assume implementation of the proposal to extend New York City Transit's No. 7 Line to Secaucus with a substantial bus transfer connection. This one project could reduce demand for buses to access PABT in 2040 by as much as 25 percent, but at present the idea is not part of the planning agenda for the Metropolitan Transportation Authority. Regardless, implementation of the No. 7 Line extension does not obviate the need to replace the existing PABT, and the combined cost of a No. 7 extension and a smaller Midtown Bus Terminal would still be significantly higher than a PABT with the capacity to accommodate the 2040 demand forecast.

A strong case can be made that testing potential additions to or expansions of commuter bus routes using other trans-Hudson crossings should be undertaken in the near term. These could offer an attractive alternative to some segments of the west-of-Hudson market currently served by bus routes terminating at the PABT. This would ease pressure on the over-capacity PABT, as bus passenger volumes continue to rise and completion of a replacement terminal remains years away. In parallel with planning for a new bus terminal, the PANYNJ could work with NJ TRANSIT and other operators to pilot routes using the George Washington Bridge Bus Station and the Holland Tunnel, and continue efforts to provide combined bus service to the Weehawken commuter ferry terminal.

The factors cited previously that open the possibility of a smaller PABT are not the only ones at work. Other influences exert pressure in the opposite direction. The Capacity Study team and participants in the expert workshop identified significant evidence of latent demand that would emerge to take advantage of an improved and more attractive trans-Hudson transit system. Today, at the peak, trans-Hudson bus operators are not able to provide enough service to meet customer demand. There is a distinct possibility that a new bus terminal with increased capacity could spur levels of customer demand at PABT above the current projections, which assume that passenger volumes on today's constrained trans-Hudson bus system accurately reflect demand. Furthermore, better bus flow along Route 495 and the Lincoln Tunnel during rush hour and a more pleasant, more reliable bus terminal could spur even higher levels of customer demand at PABT.

Even more important is the strong likelihood that a reconstructed bus terminal will be called to accommodate growing demand decades beyond the 2040 forecast year. For this reason alone, a reduced-size PABT would likely exceed its design capacity well before the end of its useful life, and a decision to limit the capacity of the facility based on the lowest available estimate of 2040 demand would inevitably be seen as short-sighted.

At the same time, the authors recognize the potentially significant uncertainties in the long-term forecast and assumptions regarding future multi-modal network capabilities. This underscores the value both of considering a scalable approach in planning for a new PABT and parallel efforts to pursue demand-management strategies and monitor other relevant trans-Hudson planning efforts as the PABT planning process proceeds.

The PABT is a component of a larger Trans-Hudson bus system, and all parts of this system must be able to accommodate future expected peak-hour bus flows

The bus terminal building is just one component of a trans-Hudson bus transportation system extending from 8th Avenue in Manhattan 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.

The strategy of encouraging increased use of higher-capacity buses illustrates this principle. Physical constraints at the existing bus terminal preclude access by most double-decker buses and limit the extent to which articulated buses can be accommodated. Though not suitable for all west-of-Hudson routes, higher-capacity buses would reduce the volume of additional bus trips required to serve forecasted growth in demand. The PANYNJ's design criteria for the replacement terminal recognize the need to accommodate these modern bus types with higher ceilings, new platform designs, reconfigured queuing areas, and generally better and more flexible space utilization. However, the extent to which larger buses will actually be used is a function of the constraints facing bus operators, including fleet replacement budgets and timing, vertical clearances at bus maintenance facilities, and roadway and bridge configurations.

Improvements to various components of the interstate bus system can and should get underway even as planning proceeds for a reconstructed PABT

This report identifies several steps to ensure that all parts of the interstate bus system can deliver buses to a reconstructed PABT at a rate consistent with its design capacity. Some of these improvements would logically proceed on the same schedule as the reconstructed terminal itself, but others could deliver benefits sooner and should be considered for implementation even as planning for a new terminal continues.

A bus staging and storage facility in West Midtown could have independent utility in the near term and become a vital component of a new PABT in the longer term. Benefits would include fewer movements of empty buses back and forth along the Lincoln Tunnel corridor and overall better performance at the bus terminal. In addition, the Capacity Study suggests it is operationally feasible to accommodate some bus staging and storage in New Jersey, provided

Lincoln Tunnel Exclusive Bus Lane
Source: PANYNJ

Bus Platooning
Source: Auto Road Vehicles

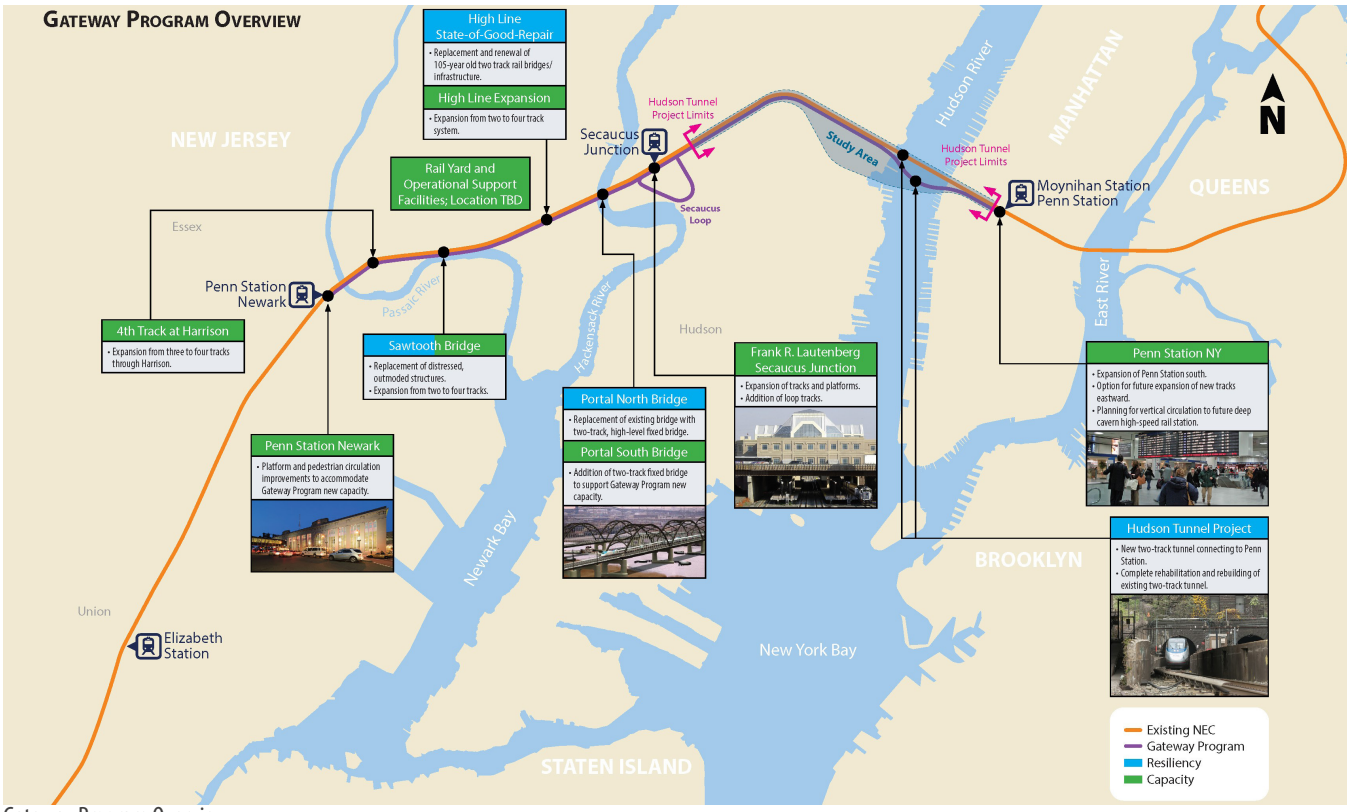
that the facility location and access to the Lincoln Tunnel entrance allow reliable dispatch of buses through the tunnel for on-time arrival at their assigned gates. This should be supported by technology assists and prioritization of PM bus flows through the toll plaza to the tunnel.

Finally, the PANYNJ should consider taking a leadership role in developing an integrated technology platform for platooning groups of buses to and through the Lincoln Tunnel and dispatching them in real time at the PABT. Bus platooning using coordinated adaptive cruise control (CACC) and other technologies may be possible within 10 years and could significantly increase throughput of the existing XBL. Many of the necessary technologies are already available or will be soon, but the pathway for integrating them into a system appropriate to the unique needs of the Lincoln Tunnel corridor will require multi-agency collaboration. The PANYNJ could take the lead working with NJ TRANSIT, private bus operators, and other agency partners in setting out requirements for such a system and sponsoring the needed technology and operational integration. A technology solution to the capacity constraints of the XBL would have many fewer negative effects on the other users of Route 495 than moving to a two-lane XBL during the morning rush, although a second priority lane would create a redundancy benefit that technology cannot fully provide.

A new PABT is one element of a multi-modal strategy for Trans-Hudson capacity expansion

The trans-Hudson commuting market is served by a number of distinct transportation systems, including the PABT/Lincoln Tunnel corridor, NJ TRANSIT commuter rail serving Penn Station, and PATH service. Plans to improve each system are under consideration. While it may be tempting to think of these proposals as fungible, where investment in one can take the place of investment in another, the Capacity Study does not support this conclusion. For various historical and practical reasons, the different modes serve somewhat distinct commuting markets, and improvements to one tend to be of little benefit to the core market served by the others.

For example, improvements to the PATH system—longer trains, more frequent service, and potentially an extension to Newark Liberty International Airport—offer many benefits, but their effect on future demand at PABT would be modest. Most of the specific locations served by PATH are not markets that generate significant bus commuting. A similar pattern holds for the NJ TRANSIT rail system. In most communities with NJ TRANSIT rail stations, rail commutation is high and bus commutation is relatively low. Outside these areas, bus travel is often the only reasonable alternative and the pattern is reversed. The Gateway



Gateway Program Overview
Source: Amtrak

Program could as much as double capacity into Manhattan on the NJ TRANSIT rail system, but no new communities would receive rail service. Commuters living in bus-dependent areas would see little reason to change their behavior.

Although improvements to the major non-PABT trans-Hudson commuting systems would have relatively minor effects on PABT demand, it does not follow that the enhancements proposed for these systems are somehow lacking. The truth is just the opposite. The inability of these improvements to materially affect long-term demand at the PABT demonstrates the distinct nature of the travel markets served by the major trans-Hudson commuting systems and the need to consider each one largely on its own terms.

The infrastructure and operational plans for the future of the PABT should be achieved through a process of collaboration

The key facilities and procedures that make up the Lincoln Tunnel corridor/ PABT system are under the jurisdiction 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 while minimizing impacts to communities on both sides of the Hudson River depends on active cooperation and engaged working relationships across jurisdictional boundaries with parties that include the City of New York, municipalities in New Jersey, and multiple agencies in both states. Collaboration will be needed with respect to bus pilot programs intended to shift demand away from PABT, bus staging and storage, pick-up/drop-off locations, roadway improvements, and implementation of additional bus prioritization.

Expanded adoption of flexible work schedules warrants further investigation as a stratgey to ease "peak of the peak" pressure on the Trans-Hudson network

Trans-Hudson infrastructure and services are straining under current levels of commuter demand, and significant expansion in capacity of the bus, rail, and PATH services are years in the future. As both a near-term and potentially long-term strategy, wider adoption of flexible work schedules, telecommuting, and other strategies by employers in the Manhattan Central Business District (CBD) could help maintain acceptable service levels and moderate the peak-hour targets for additional commuter capacity on the interstate bus system and other modes. Research and limited surveying performed for the Capacity Study suggest there may be sufficient potential benefits to warrant a more comprehensive effort in this regard in cooperation with the City of New York, Manhattan employers, and partner agencies. The full report package includes examples of other metropolitan areas testing programs that can persuade both employers and commuters to adopt more flexible work arrangements.

Capacity Study Workshop
Source: Trans-Hudson Commuting Capacity Study

"Peak of the peak"
Source: Flickr, Tri-State Transportation Campaign

In addition to these major findings, the Capacity Study has identified two additional considerations that deserve prompt attention from policymakers

» ***Accommodation of intercity buses at a new PABT.*** Today, some but not all intercity carriers that serve Manhattan use 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 a reasonable argument can be made on both transportation efficiency and cost grounds for intercity buses to pick up and drop off in a dispersed manner as they do today. Other considerations can be cited to argue for unifying intercity and commuter bus operations in a single new facility. Regardless of the eventual decision, a resolution of the issue will allow the planning process for a reconstructed PABT to proceed with greater efficiency.

» ***The effects of moving the PABT west of its current site.*** The existing PABT occupies the blocks between West 40th and West 42nd Streets, stretching from 8th to 9th Avenues in Midtown Manhattan—a site that is extremely well served by various transit lines and systems. A Working Group of the PANYNJ Board concluded that the most promising approach to replacing the PABT would involve constructing a new bus terminal on available PANYNJ-owned property west of the current structure between 9th and 11th Avenues.

  Building a new PABT west of the current facility would create both challenges and opportunities. More than half of PABT's customers are destined for Midtown Manhattan east and north of the existing PABT; approximately 50 percent of these walk and 40 percent use the subways to reach their final destination. A shift in location of one crosstown block would add approximately 6-7 minutes each way to these customers' travel times. The MBMP Peer Review conducted in November 2015 identified increased walking distances resulting from a new location as a major consideration. Planning for a reconstructed PABT should recognize the importance of changes in travel times that would result from a new location, and should investigate the potential value of the previously deferred construction of the No. 7 Line's 10th Avenue station.

Exterior of Port Authority Bus Terminal
Source: PANYNJ

FIGURE 1: Major Crossings and Stations Serving the Manhattan Central Business District

Source: Trans-Hudson Commuting Capacity Study

3 BACKGROUND

The transportation network that accommodates trans-Hudson travel includes a number of crossings as well as transportation terminals in both New York and New Jersey that are owned and operated by a variety of public agencies. Figure 1 shows the interstate crossings that serve the majority of the trans-Hudson commuter market to the Manhattan CBD—defined as Manhattan south of 60th Street. These crossings include three vehicular crossings (the George Washington Bridge, Lincoln Tunnel, and Holland Tunnel) with a total of 24 travel lanes , a commuter/intercity rail crossing (the Hudson River/North River Tunnel) with two tracks , and two heavy rail rapid transit crossings (i.e., the PATH Uptown and Downtown Hudson Tubes) with a total of four tracks. Additionally, the Tappan Zee Bridge provides an important trans-Hudson connection for commuters from Orange and Rockland Counties.

There has been substantial growth in trans-Hudson travel to and from the Manhattan CBD since 1980, driven by significant increases in transit ridership. The trans-Hudson transit network consists of complementary services provided by different modes that serve different markets. As summarized in The Profile of the Regional Interstate Transportation Network (Discussion Draft May 7, 2015) (with updated percentages of average weekday customer growth from the MBMP):

- **NJ TRANSIT** commuter rail (215% increase since 1980) provides longer-distance line-haul service to Midtown Manhattan, Hoboken, and Newark business districts.
- **PATH** (46% increase since 1980) connects commuter rail with Lower Manhattan and Jersey City business districts, and connects transit hubs at Newark, Journal Square, Hoboken, Exchange Place, and Lower Manhattan.
- **The bus network** (115% increase since 1980) serves both short- and long-distance commuter markets not well served by rail transit with an extensive network that reaches close to where people live.
- **Ferry services** provide a small but critical supplement to trans-Hudson transit capacity, and provide the overall system with a resilient alternative in the case of network interruptions.*

The west-of-Hudson region can be divided into multiple trans-Hudson travel corridors (Figure 2) that have different modal orientations. Mode choice in each corridor is informed by a number of factors, including—but not limited to—service frequency; relative ease of access; trip time and reliability; and number of transfers. Due to these factors, mode split for trans-Hudson trips varies considerably by origin. For instance, PATH is the primary mode choice for trans-Hudson trips from the Urban Core travel corridor, NJ TRANSIT commuter rail is the dominant mode from the Northeast Corridor (NEC) and NJ Turnpike travel corridor, and the Eastern Bergen travel corridor is primarily a bus market. Nevertheless, Figure 3 demonstrates that there is a unique bus dependence for the trans-Hudson commuter market. More than one-third of travelers from New Jersey use buses to access the CBD.

The bus network plays a particularly critical role in trans-Hudson commuting north of 30th Street in Manhattan, and the Lincoln Tunnel accommodates a significant percentage of the trans-Hudson bus commuter market. The Lincoln Tunnel corridor includes a number of features that collectively enable efficient bus throughput to accommodate inbound peak-period demand (shown on Figure 4, and discussed in Section 4.2). According to the PANYNJ, although buses comprise approximately 22 percent of peak-hour vehicles in the Lincoln Tunnel, buses carry approximately 89 percent of peak-hour customers in the Lincoln Tunnel. The vast majority of buses that use the Lincoln Tunnel serve the PABT.

Similar to the overall trans-Hudson commuter market, the market for PABT commuters draws from a variety of origins in the metropolitan region. The largest PABT customer markets are Hudson and Bergen Counties (about 46 percent collectively), as well as the Route 9 corridor to the south (encompassing parts of Middlesex, Monmouth, and Ocean Counties), which are not well served by commuter rail. Approximately half of PABT customers walk to/from the terminal, and more than 40 percent use New York City Transit subways.

Although the interstate transportation network processes significant throughput to enable hundreds of thousands of daily trips across the Hudson River, there are a number of existing capacity constraints that collectively jeopardize the ability of the network to accommodate trans-Hudson commuter demand. Specifically, there are emerging capacity constraints facing the Lincoln Tunnel corridor (including at the PABT), the PATH system, and the NJ TRANSIT commuter rail system. With inaction, the capacity constraints will get worse over time due to forecast growth in trans-Hudson travel.

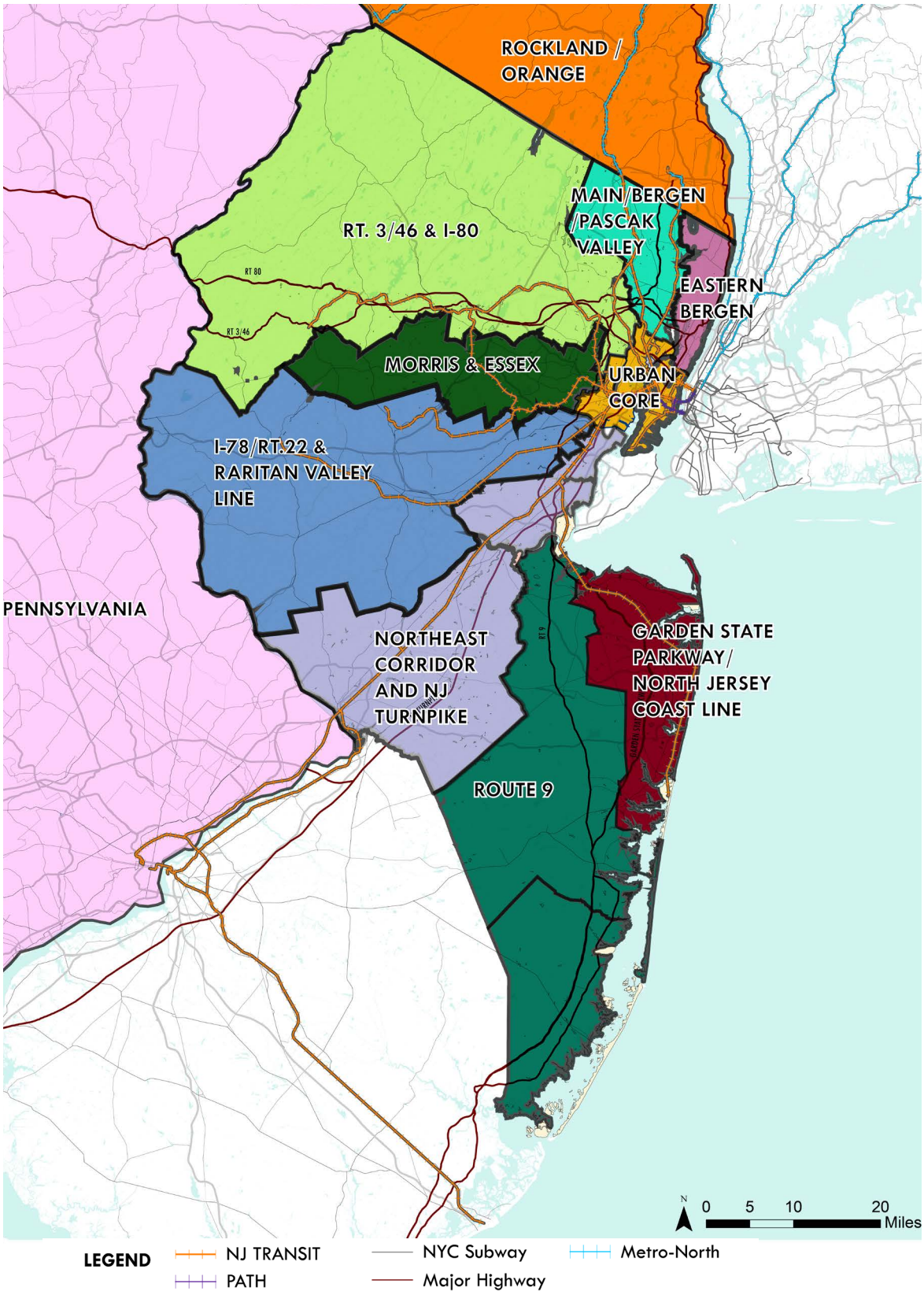
The combination of projected population growth in New Jersey and west-of-Hudson New York counties with employment growth in New York City reflects the projected increase in peak direction trans-Hudson commuter demand. Additionally, the reverse commute market will likely also expand based on continued projected growth in employment centers along the NEC and on the Hudson County waterfront in New Jersey. Between 2010 and 2040, all of the trans-Hudson transit modes are projected to experience significant increases in peak-period demand. PANYNJ forecasts indicate an increase in total peak-hour trans-Hudson transit ridership of about 50 percent.

However, one significant caveat is that these projections reflect demand independent of capacity constraints. As noted in The Profile of the Regional Interstate Transportation Network, "With virtually all trans-Hudson modes at or near capacity, there are few options available for addressing this projected demand growth." However, while no individual action may be able to tackle this challenge in its entirety, it is possible that a combination of mutually supportive strategies could collectively meet and manage the anticipated increases in trans-Hudson commuter demand.

* Percentage growth for weekday travel by ferries since 1980 is unavailable because trans-Hudson passenger ferry service was re-introduced in 1986

FIGURE 2: West-of-Hudson Trans-Hudson Travel Corridors

Source: Trans-Hudson Commuting Capacity Study, NJ TRANSIT



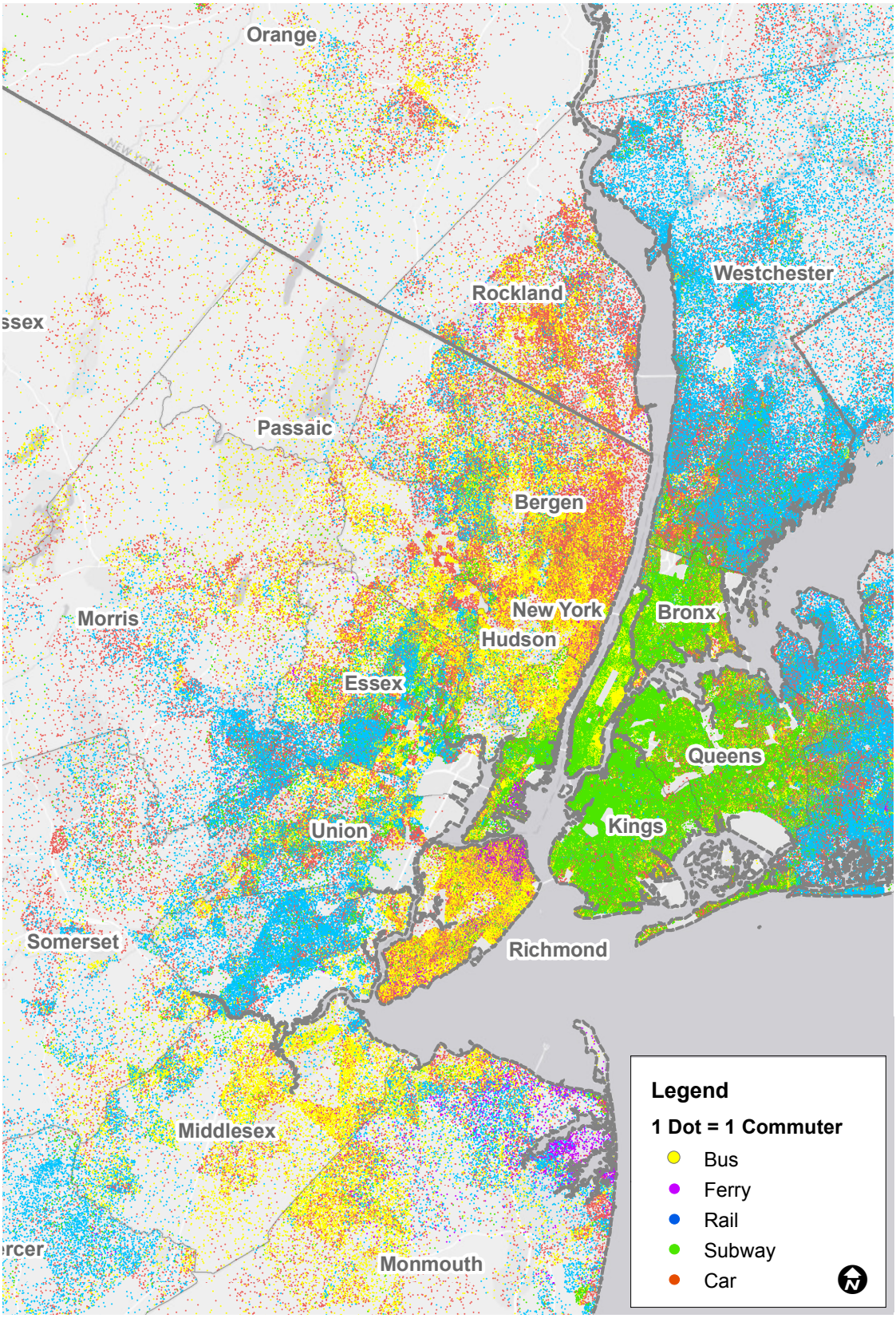


FIGURE 3: Mode Split by Origin for Commuters Working in Manhattan

Source: PANYNJ, American Community Survey 2006-2010 Special Tabulation: Census Transportation Planning

FIGURE 4: Lincoln Tunnel Corridor System Elements

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

Lincoln Tunnel
Source: D+D Competition Appendix A

Lincoln Tunnel Helix
Source: Bing Maps

Image Sources: PANYNJ, NY Waterway, Flickr.com

4 SUMMARY OF CAPACITY STUDY STRATEGIES

A key outcome of the Capacity Study is the definition and evaluation of a range of strategies for meeting and managing the anticipated increases in trans-Hudson commuter demand to 2040. In total, 21 strategies are defined and grouped into four categories, as indicated in Table 2. The following sections present an overview of each strategy category, as well as summary tables that include strategy descriptions and explanations of benefits with respect to overall trans-Hudson capacity and the interstate bus network/PABT.

TABLE 2: Capacity Study Strategies

CATEGORY	STRATEGY
Maintaining and Expanding Core Bus Terminal Capacity	• New PABT
Strategies to Improve Lincoln Tunnel Corridor/PABT Operations	• Enhanced Bus/High-Occupancy Vehicle (HOV) Priority Network (Route 495 Approaches) • Bus Platooning through Connected and Automated Vehicle Technologies • Second XBL or Route 495 Bus/High-Occupancy Toll (HOT) Lane • Increased Use of Higher-Capacity Buses • Bus Staging & Storage (in both New York and New Jersey) • Intelligent Transportation Systems (ITS) to Optimize Bus Dispatching and Circulation • Adaptable Bus Gate Assignment within PABT
Trans-Hudson Bus Network Demand Strategies	• Expanded Bus Services to the George Washington Bridge Bus Station (GWBBS) • Holland Tunnel/Lincoln Tunnel Bus Loop • Increase Use of the Holland Tunnel for Direct Downtown Service • Lower Hudson Transit Link/New NY Bridge
Trans-Hudson Multi-Modal Network Demand Strategies	• PATH Service Capacity Expansion • New Intermodal Transfer Facility at PATH-NEC Rail Link Station • Gateway Program • Hudson-Bergen Light Rail (HBLR) Transit Extension • Expanded Bus Services to Port Imperial Ferry Terminal • Expanded Trans-Hudson Ferry Services • Hoboken Terminal Rail Expansion • No. 7 Line Extension to Secaucus • Expanded Adoption of Workplace Flexibility by Employers

4.1 Maintaining and Expanding Core Bus Terminal Capacity

The PABT faces a number of operational and physical challenges that constrain capacity, which are summarized in the MBMP. In fact, NJ TRANSIT has deferred its desired service expansion due to the lack of capacity at the PABT. Customer demand exceeds capacity at the PABT in both the morning and evening peak periods, and inadequate pedestrian facilities lead to over-crowded queuing areas and vertical circulation elements. Furthermore, the structure is functionally obsolete due to the advent of larger, heavier buses (which also precludes accommodation of a number of intercity bus carriers within the PABT), and the structure's remaining useful life is 15-25 years. All of these limitations, in addition to insufficient and dwindling daytime bus storage and staging capacity, are informing the ongoing planning efforts to replace the PABT (Table 3). Other strategies discussed below to improve PABT operations are also relevant for both the existing and future new facility.

4.2 Strategies to Improve Lincoln Tunnel Corridor/ PABT Operations

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, roadways/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 Route 495 (Figure 5). Several of these elements are currently functioning at or near their capacity during peak periods on the average weekday. Strategies to improve Lincoln Tunnel corridor/PABT operations—summarized in Table 4—would address existing capacity constraints and also support a new PABT that accommodates forecasted peak demand.

The Capacity Study considers two strategies to address this capacity constraint along the XBL: (1) convert one general-purpose inbound lane of Route 495 to a second XBL or combined bus/HOT lane during the AM peak; and (2) implement bus platooning through connected and automated vehicle technologies to increase bus throughput in the existing XBL. Both options meet future demand needs; however, the bus platooning option is recommended, which does not require taking a general-purpose lane for the second XBL and has fewer negative impacts on other Route 495 users.

Adding capacity to the existing XBL alone will not accommodate projected future bus demand. Specifically, improvements to the teardrop interchange that provides access to the XBL are also necessary in order to realize the potential capacity benefits of either the second XBL/HOT lane strategy or the bus platooning strategy. PANYNJ planning staff and facility management anticipate that the buses converging on the toll plaza from the contraflow XBL, eastbound Route 495 lanes, and local access can continue to be guided to the tunnel portals with operational adjustments as bus volumes grow, and that the Lincoln Tunnel itself could serve more buses if necessary in the future with the assistance of traffic management strategies.

Overall, efforts to advance strategies to improve Lincoln Tunnel corridor/PABT operations must acknowledge that investments or policy changes that increase throughput in one segment without addressing upstream and downstream effects will not have the desired results. Indeed, capacity constraints at an individual location along the corridor can have cascading effects that inhibit efficient operation of the system as a whole.

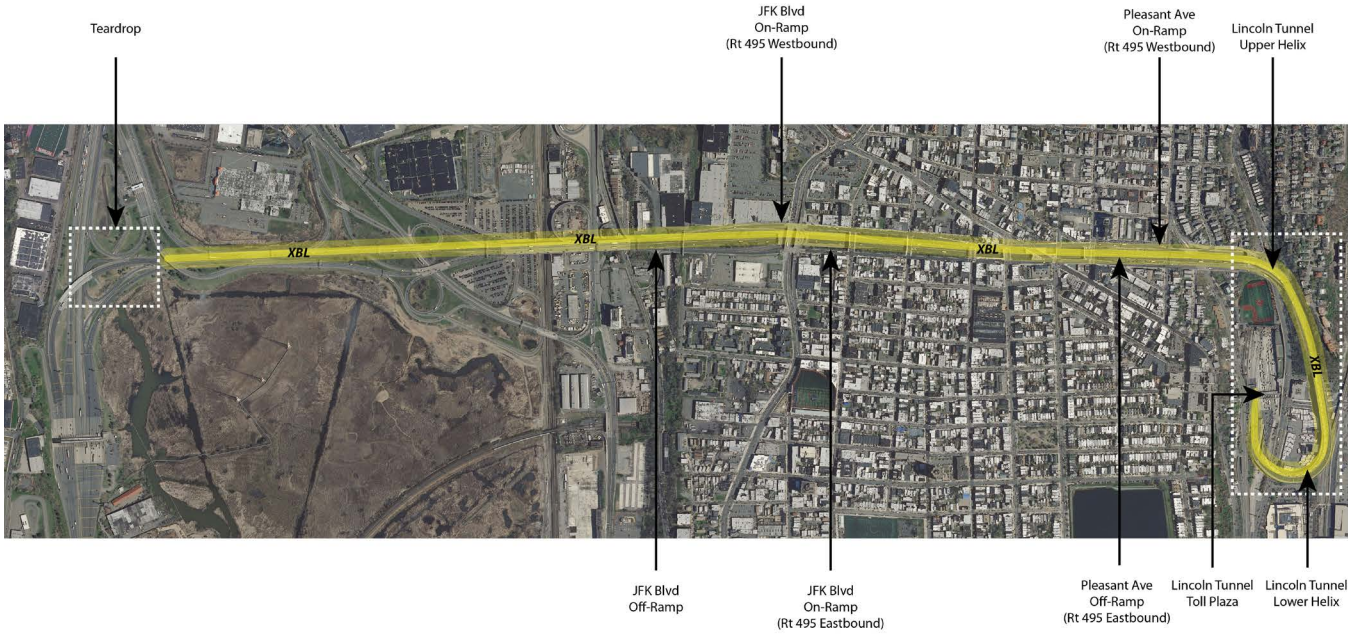
TABLE 3: Strategy Summary – Maintaining and Expanding Core Bus Terminal Capacity

Image Source: D+D Competition

STRATEGY		SUMMARY DESCRIPTION	ADDITION TO OVERALL TRANS-HUDSON CAPACITY	IMPROVEMENTS TO INTERSTATE BUS NETWORK/PABT
New PABT		Construct a replacement PABT	Accommodates projected increases in trans-Hudson travel by commuter bus (i.e., 855 PM peak-hour bus departures in 2040, up from 615 in 2011, an increase of 40 percent)	Replaces the functionally obsolete and capacity-constrained existing PABT with a new PABT that has increased capacity and operational efficiency; assumes 6 bus turns/gate/hour (compared to the PABT's current average of 4 bus turns/gate/hour)

Just as the new PABT should support forecast demand at full-build out, the elements of the Lincoln Tunnel corridor should similarly be designed to efficiently process bus throughput into and out of the new PABT. One of the principal findings from this Capacity Study is that the existing XBL plus bus platooning, and improvements to the teardrop, could provide the theoretical capacity to meet future demand to 2040.

While the PANYNJ, NJ TRANSIT and partner agencies work continuously to improve performance of the Lincoln Tunnel corridor, none of these strategies currently are programmed or funded for full implementation. The potential teardrop improvements and additional bus priority treatments have been studied as potential initiatives independent of planning a new bus terminal.



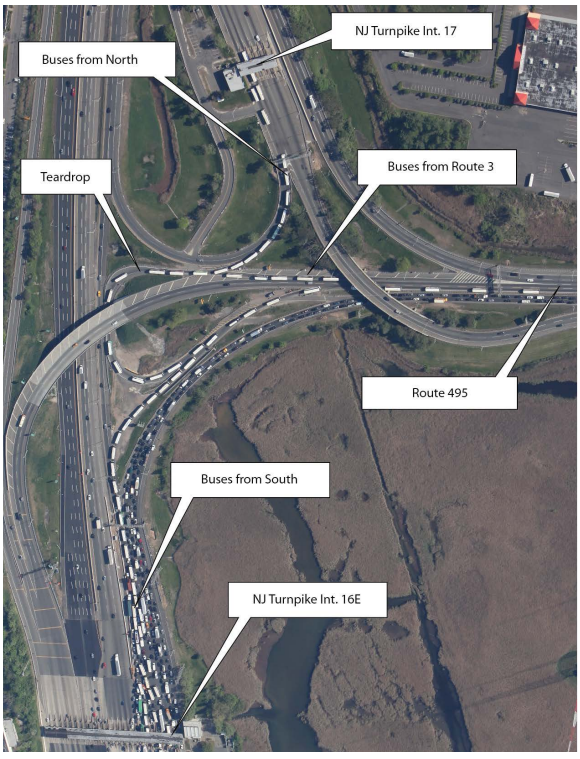


FIGURE 5: Route 495 and Teardrop Interchange

Source: Trans-Hudson Commuting Capacity Study

TABLE 4: Summary of Strategies to Improve Lincoln Tunnel Corridor/PABT Operations

Image Sources: Trans-Hudson Commuting Capacity Study; Lincoln Tunnel XBL Capacity Enhancement Feasibility Study; Lincoln Tunnel HOT Lane Feasibility Study; Auto Road Vehicles

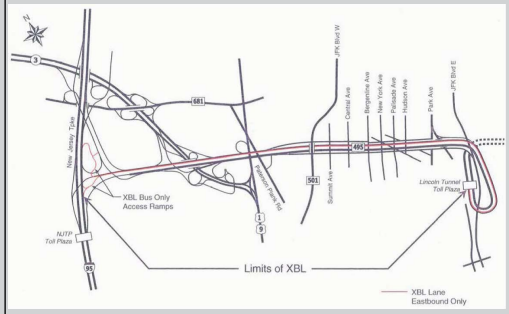
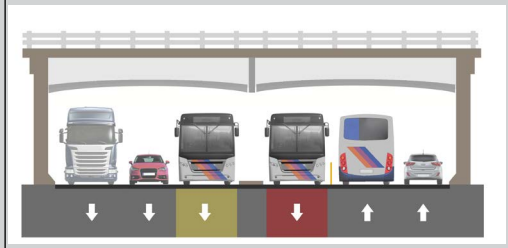
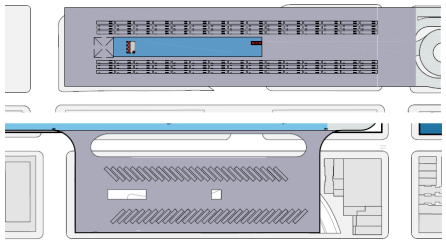
STRATEGY		SUMMARY DESCRIPTION	ADDITION TO OVERALL TRANS-HUDSON CAPACITY	IMPROVEMENTS TO INTERSTATE BUS NETWORK/PABT
Enhanced Bus/ HOV Priority Network (Route 495 Approaches)		Improve bus/HOV priority within the existing Lincoln Tunnel corridor network, realign merges at the teardrop, and add bus/HOV priority on the major Route 495 approaches including Route 3 and the NJ Turnpike	Enhances the operation of the existing XBL and supplements the XBL by providing additional bus prioritization farther upstream from the Lincoln Tunnel	Addresses existing pinch points in the interstate transportation network that feeds the XBL/Route 495
Bus Platooning through Connected and Automated Vehicle Technologies		Apply emerging technologies to enable bus platooning along the XBL/Lincoln Tunnel corridor	Increases the capacity of the existing XBL to address capacity constraints (without providing an additional lane for bus prioritization on Route 495) by reducing bus headways and the variability in bus speeds	Increases bus throughput along Route 495 to support a new PABT that accommodates forecasted peak demand
Second XBL or Route 495 Bus/HOT Lane		Add either a second inbound XBL or a Bus/HOT lane on Route 495 to complement the existing inbound contraflow XBL	If needed, provides an additional lane for bus prioritization on Route 495, with the potential to augment the practical capacity of the existing XBL, which experiences peak-hour volumes of 650 buses or more	Increases bus throughput along Route 495 to support a new PABT that accommodates forecasted peak demand

TABLE 4: Summary of Strategies to Improve Lincoln Tunnel Corridor/PABT Operations (Continued)
Image Sources: Flickr.com; D+D Competition Appendix A; Lane Transit District; Jill Huang (UC Berkeley); YouTube; NJ TRANSIT

STRATEGY		SUMMARY DESCRIPTION	ADDITION TO OVERALL TRANS-HUDSON CAPACITY	IMPROVEMENTS TO INTERSTATE BUS NETWORK/PABT
Increased Use of Higher-Capacity Buses		Expand the fleet of high-capacity buses—with an option to run fewer trips—on select high ridership trans-Hudson routes	Has the potential to reduce the number of additional buses needed to accommodate growth in commuter demand along the Lincoln Tunnel corridor	Has the potential to improve terminal space efficiency and reduce PABT demand by the equivalent of up to 15 peak-hour buses due to expanded use of 45-foot coaches. Increased use of double-decker and articulated buses is more dependent on west-of-Hudson infrastructure investments and does not improve the space-efficiency of the bus terminal itself.
Bus Staging & Storage (in both New York and New Jersey)		Construct a bus staging and storage facility in West Midtown, in conjunction with developing some of the needed staging and storage capacity in New Jersey in close proximity to the Lincoln Tunnel	Reduces peak-hour demand along the Lincoln Tunnel corridor by providing direct access from a West Midtown bus staging and storage facility to the PABT	Increases the operational efficiency and reliability of the existing PABT. Design can provide modularity to be integrated into a new PABT in the longer term, when it will be required to help increase gate productivity (from 4 to 6 turns/gate/hour for the future PABT).
ITS to Optimize Bus Dispatching and Circulation		Deploy bus and infrastructure sensor systems within the PABT and on its approaches	Increases locational awareness of buses, thereby improving the precision and accuracy of dispatching buses from New Jersey	Increases the efficiency of circulation within the PABT, including at merge points, the helical ramps, and gates (from 4 to 6 turns/gate/hour for the future PABT)
Adaptable Bus Gate Assignment within PABT		Implement limited dynamic or flexible gate assignment strategies	Enables flexibility in bus operations	Increases the efficiency of gate utilization at the PABT

4.3 Trans-Hudson Bus Network Demand Strategies

To supplement the aforementioned strategies that increase/manage capacity along the Lincoln Tunnel corridor and within the PABT, this Capacity Study also considers strategies that broadly address overall trans-Hudson demand. Table 5 identifies several strategies that could siphon some of the projected demand at the PABT by implementing new variants on existing commuter bus services from select west-of-Hudson trans-Hudson travel corridors. The route variants would use Hudson River crossings other than the Lincoln Tunnel as part of a pilot program. 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-hour demand at the PABT. 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.

4.4 Trans-Hudson Multi-Modal Network Demand Strategies

Whereas the strategies summarized in Table 5 address trans-Hudson commuter demand through the use of other Hudson River crossings (besides the Lincoln Tunnel) for bus services, Table 6 presents opportunities to balance demand across modes (with a focus on modes other than commuter bus). The multi-modal network strategies include consideration for increased use of the PATH system, NJ TRANSIT commuter rail, ferries, light rail, and subway by trans-Hudson commuters, as an alternative to travel by bus via the Lincoln Tunnel and PABT. The strategies, in turn, could help to meet and manage overall trans-Hudson commuter demand in light of capacity constraints along the Lincoln Tunnel corridor. While the primary benefits of several of these strategies (e.g., improved resilience, higher-capacity commuter rail service, and enhanced multi-modal connectivity) are not directly related to PABT demand, these strategies can make important contributions to easing capacity pressures and helping balance demand on the interstate transportation network.

TABLE 5: Summary of Trans-Hudson Bus Network Demand Strategies

Image Sources: PANYNJ; Trans-Hudson Commuting Capacity Study; New NY Bridge Mass Transit Task Force, Final Transit Recommendations

STRATEGY		SUMMARY DESCRIPTION	ADDITION TO OVERALL TRANS-HUDSON CAPACITY	IMPROVEMENTS TO INTERSTATE BUS NETWORK/PABT
Expanded Bus Services to the GWBBS		Improve the frequency of existing GWBBS services, and add service to the renovated GWBBS on a number of commuter bus routes that currently serve the PABT, in conjunction with modified service frequencies to the PABT to reflect customer choices	Increases travel options for certain trans-Hudson commuters by providing a new bus service	Has the potential to divert an estimated 10-30 peak-hour buses from the PABT to the GWBBS as part of a pilot program
Holland Tunnel/ Lincoln Tunnel Bus Loop		Implement new variants on a number of commuter bus routes that currently serve the PABT to use a Holland Tunnel/Lincoln Tunnel bus loop operation and serve on-street bus stops	Increases travel options for certain trans-Hudson commuters by providing a new bus service	Has the potential to divert an estimated 10 peak-hour buses from the PABT to on-street bus stops between the Holland Tunnel and Lincoln Tunnel as part of a pilot program
Increase Use of the Holland Tunnel for Direct Downtown Service		Implement new variants on existing bus routes that currently serve the PABT to cross the Hudson River using the Holland Tunnel and serve on-street bus stops	Increases travel options for certain trans-Hudson commuters by providing a new bus service	Has the potential to divert an estimated 20 peak-hour buses from the PABT to on-street bus stops in Lower Manhattan
Lower Hudson Transit Link/New NY Bridge		Promote the use of the planned enhanced commuter bus service across the New NY Bridge, in conjunction with a commensurate reduction in bus service to the PABT via the Lincoln Tunnel corridor	Increases travel options for certain trans-Hudson commuters by providing a new bus service	Has the potential to result in a modest reduction of peak-hour demand at the PABT by encouraging transfer to the Metro-North Railroad in White Plains and Tarrytown, but it is premature to assign a number to the potential diversion of buses/passengers from the PABT

TABLE 6: Summary of Trans-Hudson Multi-Modal Network Demand Strategies

Image Sources: PANYNJ; Amtrak; NJ TRANSIT; Bergen Dispatch

STRATEGY		SUMMARY DESCRIPTION	ADDITION TO OVERALL TRANS-HUDSON CAPACITY	IMPROVEMENTS TO INTERSTATE BUS NETWORK/ PABT
PATH Service Capacity Expansion		Complete the Signal System Replacement Program and Newark-World Trade Center 10-Car Program, and purchase additional rail cars, to support expanded peak-period PATH service	Enables increased capacity along PATH lines for which peak-hour demand approaches or exceeds capacity and is projected to increase in the future	Has the potential to result in a slight reduction of peak-hour demand at the PABT by encouraging use of PATH, and avoids creating new growth pressures at the PABT
New Intermodal Transfer Facility at PATH-NEC Rail Link Station		Extend PATH service to the NEC Rail Link Station at Newark Liberty International Airport (EWR); create a new intermodal transfer facility at this location and add bus service on a number of commuter bus routes that currently serve the PABT, and adjust frequencies to the PABT as appropriate to align with customer choices	Increases travel options for certain trans-Hudson commuters by expanding the reach of the PATH system, although by itself it does not increase throughput capacity across the Hudson River	Has the potential to result in a slight reduction of peak-hour demand at the PABT by encouraging use of PATH, but it is premature to assign a number to the potential diversion of buses/passengers from the PABT
Gateway Program		Add a new two-track Hudson River tunnel, expand the existing mainline to four tracks between Newark and New York Penn Station (PSNY), replace the Sawtooth Bridge, complete a new Portal Bridge, loop tracks at Secaucus, and expand PSNY, with new tracks, platforms, and concourses	Could enable as much as a doubling of capacity for NJ TRANSIT rail trains during peak travel times	Has the potential to divert an estimated 50-60 peak-hour buses from the PABT based on doubling of peak-hour rail service by encouraging use of commuter rail
HBLR Transit Extension		Implement the proposed Northern Branch Corridor Project to extend existing HBLR service from North Bergen to Englewood, and implement the proposed Route 440 Extension to extend existing HBLR service to the western waterfront of Jersey City	Increases travel options for certain trans-Hudson commuters by expanding the reach of the HBLR system	Has the potential to result in a slight reduction of peak-hour bus demand at the PABT by encouraging use of HBLR to access PATH or ferry in place of buses from Bergen County

TABLE 6: Summary of Trans-Hudson Multi-Modal Network Demand Strategies (Continued)
Image Sources: Flickr.com; NY Waterway; NJ TRANSIT; No. 7 Line Secaucus Extension Feasibility Analysis Final Report; Business Wire

STRATEGY		SUMMARY DESCRIPTION	ADDITION TO OVERALL TRANS-HUDSON CAPACITY	IMPROVEMENTS TO INTERSTATE BUS NETWORK/PABT
Expanded Bus Services to Port Imperial Ferry Terminal		Implement new variants on a number of commuter bus routes that currently serve the PABT to provide increased service to the Port Imperial Ferry Terminal in Weehawken, in conjunction with modified service frequencies to the PABT to reflect customer choices	Increases travel options for certain trans-Hudson commuters by expanding bus-to-ferry connectivity	Has the potential to divert an estimated 10 peak-hour buses from the PABT to the Port Imperial Ferry Terminal as part of a pilot program
Expanded Trans-Hudson Ferry Services		Increase parking options, decrease fares, and add new trans-Hudson ferry routes (South Amboy to Lower Manhattan; Edgewater to West 125th Street; and Hoboken to a new West 34th Street Ferry Terminal)	Increases travel options for certain trans-Hudson commuters by incentivizing ferry ridership and introducing new Hudson River crossings; facilitating access to trans-Hudson ferries by cyclists may offer some potential to attract additional riders	Has the potential to divert an estimated 10-20 peak-hour buses from the PABT to ferry terminals offering new trans-Hudson routes
Hoboken Terminal Rail Expansion		Implement capital and operating improvements to support expanded peak-period NJ TRANSIT commuter rail operations to and from Hoboken Terminal	Increases NJ TRANSIT commuter rail service to a major trans-Hudson transportation hub	Has the potential to result in a slight reduction of peak-hour demand at the PABT by encouraging use of PATH or ferry
No. 7 Line Extension to Secaucus		Extend the No. 7 Line from West 34th Street and 11th Avenue in New York City to an expanded No. 7/Bus Multi-modal Facility at Frank R. Lautenberg Station (FRL Station) in Secaucus	Provides cross-Midtown distribution from New Jersey by linking Secaucus with West Midtown, East Midtown, and Queens	Has the potential to divert an estimated 200 peak-hour buses from the PABT to an expanded No. 7/Bus Multi-modal Facility in Secaucus
Expanded Adoption of Workplace Flexibility by Employers		Increase opportunities for employees to telecommute, work at a satellite office, and/or have an alternative work schedule	Reduces demand for peak-hour trans-Hudson travel by shifting some trips to times when transit services have available capacity	Reduces demand for peak-hour travel on the interstate bus network through increased workplace flexibility

4.5 Summary of Potential Reduction in PABT Demand

Many of the strategies defined in the previous sections could reduce peak-hour PABT demand. Table 7 summarizes the estimated diversionary effects for those strategies in which the potential PABT reduction is quantified. The effects are not necessarily additive—and thus the cumulative effects cannot be inferred—because there could be overlap among the commuters drawn to the respective strategies for reducing 2040 peak-hour bus demand at the PABT. Based on the previous study commissioned by the City of New York, the No. 7 Line extension to Secaucus—with a major bus transfer facility at that location—would have the greatest potential effect in reducing future PABT demand. However, it is not on the region's transportation planning agenda. The other strategies evaluated for this report could reduce the 2040 PABT demand by 10-20 percent, if all were successful.

The status of these initiatives varies widely, as detailed in the Capacity Study appendices. The alternative bus services using the George Washington Bridge or Holland Tunnel are proposed in this Capacity Study as potential pilots for further discussion with the relevant bus carriers and with the New York City Department of Transportation regarding Manhattan routings, on-street stops, and traffic impacts. The Lower Hudson Transit Link is programmed for implementation as part of the New NY Bridge Project under construction. Potential new ferry routes and service expansions are an ongoing subject of planning by transportation agencies, local governments, and private ferry operators.

Investments to expand peak-period service on the PATH system are under consideration in the PANYNJ's long-term capital program, and the potential PATH extension to Newark Liberty International Airport with a potential transfer opportunity for New York-bound commuters is under active study. NJ TRANSIT has received federal funding for a significant expansion of rail facilities at Hoboken Terminal. Planning and environmental review are complete for the HBLR Transit extension.

Potential expansion of NJ TRANSIT rail service to Manhattan will be the subject of planning for Amtrak's Gateway Program and also will be addressed in the Federal Railroad Administration's NEC FUTURE tiered environmental review process and corridor service plan development. However, the current focus for the corridor investment is securing the approvals and funding necessary to implement the Portal Bridge South replacement and the Hudson Tunnel Project, infrastructure projects essential to maintaining the existing level of rail service on the Northeast Corridor. The potential extension of the No. 7 Line to Secaucus is not under active study.

TABLE 7: Summary of Potential PABT Bus Demand Reduction from Applicable Strategies

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

STRATEGY	POTENTIAL PABT DEMAND REDUCTION (NUMBER OF PEAK-HOUR BUSES)
Increased Use of Higher-Capacity Buses	15
Holland Tunnel/Lincoln Tunnel Bus Loop	10
Expanded Bus Services to Port Imperial Ferry Terminal	10
Expanded Trans-Hudson Ferry Services	10–20
Expanded Bus Services to the GWBBS	10–30
Increased Use of the Holland Tunnel for Direct Downtown Service	20
Gateway Program	50–60
No. 7 Line Extension to Secaucus, including bus terminal at Secaucus	200*

*Not included in aggregate estimate of demand reductions

5 CONCLUSION

The key conclusion of this Capacity Study is as follows:

The authors have not found convincing evidence that a reconstructed bus terminal with substantially fewer gates than the full-build options presented in the MBMP could be relied upon to accommodate future demand for trans-Hudson bus travel over the useful life of the facility. Some adjustments in capacity and scope may be possible, but the evidence does not support large reductions in the number of bus gates.

The review of available trans-Hudson alternatives and commuter market trends affirms that there is no effective or practical substitute for expanded trans-Hudson commuter bus service. Meeting this regional need will require a replacement PABT with expanded peak-period operations capacity, as well as infrastructure and operational innovations west-of-the-Hudson, especially along the Lincoln Tunnel corridor, that would enable the tunnel and the replacement PABT to operate with increased efficiency that contributes to safer and less congested mobility in West Midtown.

In addition to this conclusion, the Capacity Study has identified several key items for the PANYNJ and its partners in the region to consider as the PABT replacement planning effort and other complementary trans-Hudson initiatives progress:

- Accommodation of intercity buses at the new PABT
- The effects of moving the new PABT farther west on commuter choices and circulation
- Near-term actions with independent utility to improve the interstate bus network (e.g., improvements to the Lincoln Tunnel corridor, bus staging and storage, bus route pilot programs)
- Bus platooning as a unique technology solution to address capacity constraints along the Lincoln Tunnel corridor
- The potential for wider adoption of travel demand management strategies
- The importance of collaboration across jurisdictional boundaries

TRANS-HUDSON COMMUTING CAPACITY STUDY

September 2016

Image Source: Flickr.com