Promoting Bus Rapid Transit Options on the New Tappan Zee Bridge and I-287 Corridor

May 2014

Professor: Dr. Floyd Lapp, FAICP
T.A.: Benjamin Engle

Studio Team:
Eric Blair-Joannou
Junda Chen
Yung Chun
Qihan Li
David Perlmutter
Yinan Tong
Crystal Wang

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Executive Summary

This report evaluates a series of bus rapid transit (BRT) proposals that are slated to be implemented along the new Tappan Zee Bridge and I-287 corridor, which spans Rockland and Westchester Counties in New York State. Our analysis builds from the State’s Mass Transit Task Force Final Report (henceforth referred to as “Task Force”) in February 2014. Constructing and operating bus rapid transit in a primarily low-density suburban environment is a significant undertaking and must be evaluated prudently.

First, this report analyzes commuting patterns and related demographics in the I-287 corridor. We then provide in-depth analysis of the suitability of bus rapid transit stations that the Task Force has proposed, using an outcomes matrix that amalgamates a variety of transportation, land use, and demographic criteria. Several of the Task Force’s proposed bus stations are not viable based on generally accepted standards of transit feasibility. It is well-established that low-density development patterns are a primary obstacle to the implementation of high-quality transit service. Therefore we examine Transit-Oriented Development (TOD) as a strategy to gradually increase population and employment density at several project sites that our clients are pursuing along the corridor.

We conclude that BRT - as proposed by the Task Force - does not appear to adequately reduce congestion on the corridor or significantly improve transit service. We evaluated the extent to which these objectives could be achieved more cost-effectively by upgrading existing bus routes, rather than full BRT implementation. Ultimately, neither BRT implementation nor upgrades to existing bus service may be enough to mitigate congestion on the corridor.

Given the need for both long-term auto congestion reduction and a viable finance model for the proposed BRT system, we explore several more aggressive demand-side policies, including transportation demand management, congestion pricing, variable lane tolling, and VMT taxation. Along with improvements to existing routes, measures are needed to reduce congestion generated from private automobiles. Various pricing mechanisms are recommended even though the strategies may be initially viewed as controversial. This situation points to the overall difficulty of enacting transit and auto congestion measures in a low-density environment.
1.2 Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>I-287</td>
<td>Interstate 287 corridor spanning Westchester and Rockland Counties, including the Tappan Zee Bridge.</td>
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<td>ACS</td>
<td>American Community Survey</td>
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<tr>
<td>BRT</td>
<td>Bus Rapid Transit</td>
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<td>CBIS</td>
<td>Commuter Business Improvement Survey</td>
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<td>CTPP</td>
<td>Census Transportation Planning Package</td>
</tr>
<tr>
<td>DOT</td>
<td>Department of Transportation</td>
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<td>GIS</td>
<td>Geographic Information Systems</td>
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<tr>
<td>HOT</td>
<td>High Occupancy Toll lane</td>
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<td>HOV</td>
<td>High Occupancy Vehicle lane</td>
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<tr>
<td>ITS</td>
<td>Intelligent Transportation Systems</td>
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<td>MNR</td>
<td>Metro North Railroad</td>
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<td>MTTF</td>
<td>Mass Transit Task Force</td>
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<td>NNYB</td>
<td>New New York Bridge</td>
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<td>Q Jump</td>
<td>Queue jump</td>
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<tr>
<td>SEQRA</td>
<td>State Environmental Quality Review Act</td>
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<tr>
<td>SOV</td>
<td>Single-occupancy vehicle</td>
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<tr>
<td>SQL</td>
<td>Structured Query Language</td>
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<td>TOD</td>
<td>Transit-oriented development</td>
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<td>TOR</td>
<td>Transport of Rockland</td>
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<td>TSP</td>
<td>Transit signal prioritization</td>
</tr>
<tr>
<td>TZB</td>
<td>Tappan Zee Bridge</td>
</tr>
<tr>
<td>TZx</td>
<td>Tappan Zee Express</td>
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<tr>
<td>VMT</td>
<td>Vehicle Miles Traveled</td>
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1.4 Acknowledgments

We wish to thank the following individuals for their invaluable contributions and guidance to this project, without whom this project would not have been possible:

- Bill Brady, Westchester County Department of Planning
- Ed Burroughs, Westchester County Department of Planning
- Tracey Corbitt, Westchester County Department of Planning
- Naomi Klein, Westchester County Department of Transportation
- Patrick Gerdin, Rockland County Planning Department
- Mike Prendergast, Rockland County Planning Department
- Doug Schuetz, Rockland County Planning Department
- Tom Vanderbeek, Rockland County Planning Department
- Chris Gomez, Village of Port Chester
1.5 Client and Context

Westchester County’s Departments of Planning and Transportation were this studio’s main clients. Rockland County Department of Planning provided important data sources. I-287 is the only route that directly bisects the two counties for East-West vehicular travel.
1.6 Project Goals

The good news is that a new Tappan Zee Bridge is scheduled for completion in 2018. However, this will not solve congestion problems if transit is not considered. It has been estimated that approximately 98% of the traffic crossing the TZB is by single-occupant vehicles (Higashide, 2007).

The primary issue for which we are assisting our clients is high traffic congestion and a lack of integrated, high-quality transit service along the TZB and I-287 corridor. The TZB corridor stretches from Port Chester in Westchester County to the east and Suffern, Rockland County on the west. Our mission is to provide both transit and non-transit recommendations along the TZB corridor based on the findings of the Mass Transit Task Force (MTTF).

We intend to plan for a high-quality bus rapid transit service that satisfies the following conditions: high frequency of service, connectivity with other transit modes, improved travel times, increased ridership, transit-oriented development, and regional branding of the BRT system that will in turn generate more transit trips.

In the event that BRT, as proposed by the Task Force, does not offer substantial benefits of congestion reduction or improved transit service, we investigate more cost-effective improvements to existing bus service. Finally, recognizing that neither BRT nor upgraded local bus service may be sufficient, we evaluate several demand-side policies - VMT taxation, variable lane tolling, and transit demand management, among others - aimed at reducing vehicular congestion and providing a viable financing platform for transit.

The MTTF is a 31-member group created in 2012 to advance a transit proposal for the opening of the new bridge in 2018. The Task Force consists of state and local officials, community group members, and transportation experts, and they are interested in developing transit across the I-287 corridor. Together, they advanced short-, medium-, and long-term transit recommendations for the corridor.

The Task Force decided early on that Bus Rapid Transit would be the most appropriate transit mode for the region given its potential ridership, lower capital and operating costs, and flexibility. Their BRT proposal was designed to be implemented by the time of the new bridge’s opening in 2018 (Figure 1 and Figure 2).

The mid-term transit goals are designed to be in place 15 years beyond the opening of the NNYB, or by 2033. By 2033, new infill stations would be built along the BRT route, and improvements such as a revamped Interchange 10 in South Nyack and a new White Plains TransCenter would be completed.

The long-term goals are for the period beyond 2033. Passenger service along the BRT route would be replaced by light rail or commuter rail transit. Generally, these mid- and long-term projects are more capital-intensive and require further transit demand and funding.
1.6 Project Goals

Figure 1: Short-Term Transit Goal - Proposed BRT Stations (MTTF)

Figure 2: Short-Term Transit Goal - Proposed Regional BRT System (MTTF)
2.0 Commuting Patterns in the I-287 Corridor

According to the Mass Transit Task Force, more than three fourths of entire trips are non-work, or discretionary (*Figure 3*). While the transportation planning profession generally focuses heavily on the journey to work, the overwhelming majority of trips in the TZB corridor are non-work trips. Although some of these trips coincide to further exacerbate the morning and evening peak hours of travel, most occur throughout the day and evening and are not the major concerns of traffic congestion.

*Figure 3: Discretionary Trips (Work vs. Non-Work)*

Source: NYSDOT, 2013
2.0 Commuting Patterns in the I-287 Corridor

*Figure 4* shows origin-destination analysis of commuters in both counties. Based on this graph, there are several transportation hubs which can anticipate large traffic volumes. According to the analysis, nearly half of commuter clusters (6 of 14) are formed along the 287 corridor.

Using data from the Census Transportation Planning Package (CTPP), 2006-2010, SQL queries were performed to select work destinations and home locations for residents of both Rockland and Westchester counties. These queries were matched to Census tracts using a spatial join, allowing the result to be represented in GIS. The result is a geographic dataset showing two groups important to understanding commuter flows in the corridor: commuters residing in either Westchester or Rockland Counties whose workplaces are in either County.

*Figure 4: Commuting Flows of Two Counties*

Source: Census Transportation Planning Package, 2006-2010
More than 40% of both counties' work trips have destinations outside of each county. Most notably, 11% of Rockland's work trips destinations are located in Westchester, while only 2% of Westchester residents work in Rockland County. As Figure 5 demonstrates, there is significantly more travel from Rockland to Westchester than the reverse.
Figure 6 shows the home locations of Rockland’s commuters, whose workplaces are located in either Westchester or Rockland Counties. Using CTPP data was then queried to reveal the following important groups of Rockland and Westchester commuters most likely to be traveling along the 287 corridor:

- Rockland residents living near the 287 corridor whose workplaces are in Westchester County (n = 1,627).
- Westchester residents living near the 287 corridor whose workplaces are in Rockland County (n = 580).

This spatial query includes only residents who live within the Census Tracts overlapping with the 287 corridor. This was done in order to focus on a likely cohort of transit riders, those residents who would be able to walk from their home to a proposed BRT station to finish their commute and avoid the time-consuming transfers that discourage transit use generally (Cervero, 1993).

Meanwhile, the shaded Census Tracts show the number of overall Rockland or Westchester residents who live in or near the 287 corridor with workplaces in either
2.0 Commuting Patterns in the I-287 Corridor

County. While these residents may be apt to ride BRT, there is less obvious imperative to do so since many of them are making intra-County commutes and avoiding crossing the TZB altogether.

The workplaces of more than 1,600 Rockland commuters, who live in or near I-287 Corridor, are located in Westchester and most of them would cross the Hudson River on Tappan Zee Bridge (Figure 7).

Figure 7: Home Locations of Rockland --> Westchester Commuters

Source: Census Transportation Planning Package, 2006-2010
**2.0 Commuting Patterns in the I-287 Corridor**

*Figure 8: Home Locations of Westchester --> Rockland Commuters*

Source: Census Transportation Planning Package, 2006-2010

*Figure 8* shows home locations of Westchester’s commuters, whose workplaces are located in Rockland (n=580). Among inter-county commuters, many more trips from Rockland to Westchester are made than the reverse.

However, the number of commuters are still considerable. Based on these illustrations, we can conclude that there are considerable number of work trips between both counties. Given that the Tappan Zee Bridge is the only way to connect two counties without detouring, it is obvious that expanding transit access to commuters crossing the TZB is of paramount importance.
2.1 Demographics in the I-287 Corridor

Figure 9: Distribution of Seniors Along the I-287 Corridor

Source: ACS Data 2008-2012

Figure 10: Distribution of Low-Income Households Along the I-287 Corridor

Source: ACS Data 2008-2012
Of particular concern to the analysis of the Task Force’s BRT proposal was the localized measure of transit-supporting density: number of households per acre with a half-mile walking distance of each proposed station (Figure 11). This is the most important metric of the Outcomes Matrix (p.23) because below the generally accepted threshold of seven households per acre, high-capacity transit like BRT is not likely to be cost-effective or viable.

Social equity concerns in the placement of BRT stations compelled the studio to map populations that have disproportionate rates of transit-dependency. Generally, transit dependency is defined as belonging to one or more groups known to have more limited access to private automobiles: low-income, elderly, or disabled individuals. Because of limited data on the disabled, only distributions of low-income (below $40,000 household income per year) and elderly (65+) are shown.
2.2 Congestion in the 287 Corridor

The current problem is that the Tappan Zee Bridge does not have enough capacity to handle its large peak time vehicular demand. When the Tappan Zee Bridge was constructed, the annual average daily trips were only 18,000, in 1955.

However, today, more than 170,000 vehicles cross the bridge daily. As a solution, a movable barrier system is in place eastbound during the morning peak and westbound during the afternoon peak. NYSDOT’s Transit Mode Selection Report in 2009 argued that without major transit investments, already unacceptable levels of congestion will occur in the corridor far into the future.

According to the NYSDOT estimates the Tappan Zee currently carries 140,000 vehicles each day, rising to 170,000 vehicles at busy times of year. If nothing is done to relieve congestion in the I-287 Corridor between Suffern and Port Chester, by 2030 traffic volumes crossing the bridge will increase to about 200,000 cars per day (Figure 9).

Figure 12: Vehicle Trip Growth - Past, Present and Future

Source: NYSDOT, Tappan Zee Bridge/I-287 Environmental Review, 2009
BRT is all about “Flexibility, quality, efficiency and performance” (FTA, 2004). Compared to the conventional bus, BRT could more substantially solve congestion problems and increase transit service. Passengers are more likely to ride it because it’s more reliable, more frequent, and has better station amenities (Institute for Transportation & Development Policy, 2012).

Compared to rail, BRT is less costly to construct, more rapid to implement and flexible to operate, which is important especially in low density area. It can also take advantage of existing transportation facilities without a significant impact on local neighborhoods.

“A flexible, high performance rapid transit mode that combines a variety of physical, operating and system elements into a permanently integrated system with a quality image and unique identity.”
----BRT Implementation Guidelines, Federal Transit Administration (FTA)

“BRT is an innovative mass transit system that combines the efficiencies and quality of metros with the flexibility and relative low cost of buses, while offering significant environmental benefits.”
----Institute for Transportation and Development Policy (ITDP)

To resolve significant disputes over what constitutes BRT rather than enhanced conventional bus service, ITDP produced a scoring rubric rubric entitled “The BRT Standard”. According to this foundational document, there are five essential characteristics of a BRT system.

**Busway alignment:**
Defines where a busway’s dedicated lane is located on the road (e.g. center aligned, exclusive road, or along one side of the street). The busway is best located where conflicts with other traffic can be minimized. Generally the central median of a roadway encounters fewer conflicts with turning vehicles than those adjacent to the curb.

**Dedicated right of way:**
A dedicated right-of-way is critical to ensuring that buses can move quickly and unimpeded by congestion. Enforcement of the dedicated lane can be handled in different ways, such as rumble strips, bollards, or colorized pavement. With the exception of the new Tappan Zee Bridge span itself and certain one-way streets in Downtown White Plains, the BRT line on the TZB corridor will lack a dedicated right of way on most streets.

**Off-board fare collection:**
Collecting fees before boarding, often through a “proof-of-payment” method, is one
of the most important factors in reducing travel time and improving the customer experience.

**Intersection treatments:**
There are several ways to increase bus speeds at intersections, all of which are aimed at increasing the green signal time for the bus lane. Forbidding turns across the bus lane and minimizing the number of traffic-signal phases where possible are the most important. Traffic-signal priority when activated by an approaching BRT vehicle is useful in lower-frequency systems, and is a key component of the Task Force’s BRT proposal. Traffic-signal priority is also known to be more effective in lower-use systems like the TZB corridor (Institute for Transportation & Development Policy, 2012).

**Platform-level boarding:**
Having the bus-station platform level with the bus floor is one of the most important ways of reducing boarding and alighting times per passenger. In addition, a useful method of better accommodating passengers with disabilities. The reduction or elimination of the vehicle-to-platform gap is also key to customer safety and comfort. There is a range of measures to achieve gaps of less than 5 cm (2 in.), including guided busways at stations, alignment markers, Kassel curbs, and boarding bridges.

*Figure 13: BRT Basics*

![BRT Basics Image](image)

Source: Institute for Transportation & Development Policy (ITDP), 2012
4.0 The Task Force's BRT Proposal

The Mass Transit Task Force has proposed this BRT system for the I-287 corridor, with four distinct routes and potential BRT stations shown in the yellow dots (Figure 14). Not shown on this map are an additional three routes that operate outside of the I-287 corridor: the Blue Line from Spring Valley to Yonkers, the Purple Line from Downtown White Plains to Westchester Medical Center, and the Gold Line from Downtown White Plains to the Bronx (Figure 1). A major objective of this studio is to analyze which BRT station locations are most suitably located, according to the generally accepted land use and demographic factors that drive ridership. In addition, we examine which potential TOD sites are best-suited to provide the kinds of transit-supportive land use that may be lacking in the 287 corridor today.

Figure 14: Task Force’s BRT Proposal (Red, Green, Navy, Platinum Lines)

Modified from NYSDOT, 2014
4.1 Transit-Supporting Density

The greatest obstacle to implementing any kind of mass transit such as BRT is the low-density settlement pattern that dominates most suburban areas, including the 287 corridor. It simply is not cost-effective or viable to build high-frequency transit service if the population density falls below the generally accepted threshold of seven housing units per acre (Downs, 2005: p.210). Below this threshold, it is difficult for BRT to attract enough ridership to be cost-effective to operate.

This reality is very important with respect to acquiring State and federal funding for transit. If local transit agencies such as Westchester Bee-Line or Transport of Rockland cannot justify adequate ridership on a new line, it will be very difficult to get the funding to build and implement the system in the first place. Unfortunately, the cliche of “if you build it, they will come” is not a valid approach in times of limited State and federal funding for transit.

*Figure 15* shows the average number of households per acre on the scale of three-mile "catchment areas" in our corridor, and they are not encouraging. Only Downtown White Plains exceeds the threshold for high-capacity transit. However, these figures are at three-mile catchment area scale and are not precise enough to determine which of the proposed BRT stations are viable and which are not. More evaluation criteria are required to determine which of the proposed stations are most suitable for BRT.

*Figure 15: Density Benchmark for Efficient BRT Performance*

<table>
<thead>
<tr>
<th>Location</th>
<th>Density Benchmark</th>
<th>Westchester Average Density</th>
<th>Rockland Average Density</th>
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<tbody>
<tr>
<td>Nanuet PnR</td>
<td>1.9</td>
<td>2.7 DU/acre</td>
<td>1.6 DU/acre</td>
</tr>
<tr>
<td>Nanuet &amp; Spring Valley</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palisades PnR</td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North White Plains</td>
<td>2.0</td>
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<tr>
<td>Downtown White Plains</td>
<td>10.7</td>
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<tr>
<td>White Plains &amp; Port Chester</td>
<td>2.8</td>
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Modified from NYSDOT, 2013
We use a wide range of criteria in determining which of the proposed BRT stations is most suitably located.

**Threshold of Transit-Supporting Density**

Transit-supporting density is the most powerful and well-accepted factor of whether a new station will generate enough ridership to be cost-effective (Downs, 2005).

In the absence of dense development patterns that meet the threshold of seven housing units per acre (transit-supporting density), it is important to look at factors that might enable municipalities to proactively increase their land use and employment densities.

**Primary Criteria**

**Transit-supporting zoning:**
This is one of the levers by which municipalities could promote denser development patterns to generate greater transit ridership. Using County land use datasets, this studio investigated whether the areas within a ¼ mile walkshed of the proposed BRT stations have zoning that supports medium and high-density residential or mixed-use. To rephrase this criterion another way: is the neighborhood ready, at least on paper - for TOD and denser development once the BRT transit station is built? Not surprisingly, land use analysis is commonly used a pre-requisite in BRT feasibility studies (Chicago Metropolitan Agency for Planning, 2012).

**Number of Households:**
The proposed BRT stations are intended to capture ridership from areas with the greatest number of total residents.

**Vacant Land Acreage:**
Vacant land acreage is relevant because we want to implement higher-density residential development and TOD, which is most feasible on vacant sites with lower construction costs rather than those that are already developed. According to the Chicago Metropolitan Agency for Planning, “identification of key vacant and underutilized sites will be critical to transitioning to a denser, more human-scale environment” (2012, p.22).

**Commuter Population:**
Using the CTPP data reviewed in *Figures 6-8*, it is possible to roughly estimate the number of commuters a station would serve within a half-mile. Commuters were counted in both directions - both incoming commuters whose workplace is nearby and outbound commuters who live nearby but work in either Westchester or Rockland County.
4.2 Outcomes Matrix: Stations

Secondary Criteria

Retail Square Footage is one of the less important criteria. Transportation and land use studies that retail land uses are a major generator of discretionary transit trips, (Cervero, 1993, p.109) which is hugely important given that more than ⅔ of trips in the 287 corridor are discretionary (Figure 5). This metric is limited by the fact that it was only possible to calculate the acreage of retail parcels, not the building footprints themselves, due to limitations of the GIS data received from Rockland and Westchester counties.

Rail Access is an important criteria to take into account. The BRT system must have connectivity with other transit modes, and MTA’s Metro North Railroad is a major carrier of transit riders between Westchester and destinations further South (Metro North Commuter Railroad, 2011).

Current Bus Ridership is important because as planners there is an equity obligation to maintain adequate service for current riders. It would be undesirable to replace a highly-used local bus route with a less effective or less frequent BRT route that skipped popular stops.

Parking is a final criterion that drives ridership demand, especially in low-density areas like the TZB corridor. In the long-term, surface parking should be discouraged in the corridor as much as possible. Parking experts such as Don Shoup point out that there is a high cost to providing parking - especially free parking - near transit stations. Parking drives up the cost of new housing and development, and may make TOD development less effective (Shoup, 2011). It also leads to a streetscape that is more hostile to pedestrians and may end up depressing ridership as a result in the long-term.

However, in the short-term we recognize that our clients aim to implement a BRT system in a corridor that is mostly low-density suburban, where the private automobile is the primary means of transportation. A station that lacks available parking (paid or otherwise) will deter potential riders, especially for discretionary trips where the passenger has the option to drive alone. We therefore view parking near stations as a temporary solution that can encourage ridership in the short-term from car-owners while TOD is implemented and promotes higher density over the long-term when much less parking will be needed.

Goodwill and Hendricks provide a concise strategy for how parking could be both provided and actively managed without depressing transit ridership or reducing the overall effectiveness of TOD development:

“To balance the needs of automobiles with the needs of other transportation modes, parking and access management is also an important component of TOD. TOD typically has a lower
parking-to-occupant ratio compared to conventional suburban development. Shared parking is utilized, and parking is placed on the street (on-street parking takes up much less land area than off-street parking), behind buildings, underground, and in carefully designed and located parking structures rather than large surface lots.”

-----Goodwill and Hendricks (2002)

**Decision Process**

To combine all of the criteria just mentioned, we created a modified outcomes matrix. Our decision process is both quantitative and qualitative. Our most important criterion is transit-supporting density; without the necessary seven households per acre (within a half-mile), we generally consider a station to be unsuitable for BRT. However, in several cases we do make an exception for stations that perform well in our other criteria but fall just short on transit-supporting density.

For all other criteria, we rank each station in quartiles in comparison with the rest.

### Evaluation Criteria for Proposed BRT Stations

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Supporting Density</td>
<td></td>
</tr>
<tr>
<td>Transit Supporting Zoning</td>
<td></td>
</tr>
<tr>
<td>Number of Households</td>
<td></td>
</tr>
<tr>
<td>Vacant Land Acreage</td>
<td></td>
</tr>
<tr>
<td>Commuter Population</td>
<td></td>
</tr>
<tr>
<td>Parking</td>
<td></td>
</tr>
<tr>
<td>Retail</td>
<td></td>
</tr>
<tr>
<td>Rail Access</td>
<td></td>
</tr>
<tr>
<td>Current Bus Ridership</td>
<td></td>
</tr>
<tr>
<td>Transit-Dependent Population</td>
<td></td>
</tr>
</tbody>
</table>

Image Credit: Yung Chun
4.2 Outcomes Matrix: Stations

of the County's stations. The top performing quartile gets a mark of “Most Favored”. The bottom performing quartile gets a mark of “Least Favored”. The middle two quartiles are neutral, which is to say the station’s performance is neither favored nor disfavored.

**Figure 16: Outcomes Matrix: Rockland County**

**Figure 16** shows the results of our outcomes matrix for Rockland County BRT stations. The stations that are most suitable overall are Monsey and Spring Valley. The stations that are least suitable are Interchange 10 (South Nyack) and Campbell Avenue. It is important to qualify these statements - performing poorly on the outcomes matrix does not mean that a location can never or will never support BRT service, only that the location is less suitable given the current land use and demographic conditions, which may change in the future.
Figure 17: Outcomes Matrix: Rockland County (Revised)

Figure 17 shows the BRT system after eliminating Campbell Avenue and Interchange 10 from the Rockland side of the system. These stations lacked the necessary transit-supporting density to be viable, and did not offer any other compelling advantages. The station at Palisades Center, however, was preserved even though it falls short on transit-supporting density. This is because Palisades Center is a major employment center as well as destination for discretionary trips.
In Westchester County, the stations that are most suitable according to our criteria are the three in Downtown White Plains (Westchester County Center, White Plains Transcenter, and The Westchester) and two in Port Chester (Haseco Ave and Downtown Port Chester). The least suitable stations are the three on Platinum Mile and Benedict Avenue, which are notable for their low population densities and lack of high performance for most other criteria.
Figure 19: Outcomes Matrix: Westchester County (Revised)

Figure 19 shows what the Westchester side of the system looks like with Platinum Mile and Benedict Avenue stations eliminated. Two stations in Tarrytown were preserved because these areas have both Metro North access and high commuter populations.
4.2 Outcomes Matrix: Stations

Proposed BRT station location at Spring Valley, located adjacent to Spring Valley’s Metro North Railroad station. This location scored highly in the outcomes matrix due to its transit-supporting density, relatively high percentage of transit-supportive zoning, rail access, and high transit-dependent population.

Image Credit: David Perlmutter

Transit-supportive land use featuring an attractive, walkable retail environment near Spring Valley’s proposed BRT station.

Image Credit: David Perlmutter
4.2 Outcomes Matrix: Stations

Westchester Bee-Line passenger waiting for the bus near the proposed BRT station at Benedict Avenue, Tarrytown. This station location was found to be unsuitable for BRT due to a lack of transit-supporting density and low performance on most other criteria.

Image Credit: Yung Chun

Downtown White Plains exhibited generally high performance across all criteria, including transit-supporting density, rail access, and transit-dependent population.

Image Credit: Yung Chun
4.3 Our Streamlined BRT Proposal

Figure 20: Streamlined BRT Proposal

BRT Lines
N Navy Line
G Green Line
R Red Line
P Platinum Line
The relationship between transportation and land use in the corridor is critical. The main barrier to effective, high-frequency transit service in the 287 corridor is the low-density suburban settlement pattern that dominates both counties.

So the next step is to determine which sites are most suitable to change those trends by implementing Transit-Oriented Development. This studio has analyzed seven potential TOD sites in the corridor that our clients are pursuing to help achieve this transformation to higher density. The criteria used to evaluate the sites are:

**Site Size**
Is the parcel significantly large enough to promote TOD and attract riders?

**Transit-Supporting Zoning**
Does current zoning support medium/high density and mixed use? This is very important, since TOD can only be implemented in sites with appropriate zoning.

**Nearby Bus Lines**
How many non-BRT lines are within walking distance?

**Nearby Vacant Land**
Could nearby or adjacent parcels be developed in concert to have a post facto impact on transit?

**Transit-Supporting Density**
Is the site in an area dense enough to support transit in the first place? This criterion is carried over from the earlier Outcomes Matrix for Stations.

**Intersection Density**
Does the area have small blocks and a walkable street grid?

**Existing Sidewalks**
Does the site have the basic infrastructure in place to become transit-oriented and walkable?
4.4 Outcomes Matrix: TOD Sites

Figure 21: Potential TOD Sites on the I-287 Corridor

- Monsey Park & Ride
- Former GM site - Tarrytown
- Industrial property - Elmsford
- Crossroads Plaza - Greenburgh
- White Plains Trans Center
- USPS site - Platinum Mile
- United Hospital - Port Chester

Projected Completion: 2016
Project Postponed: 2007
Projected Completion: 2033
Under SEQRA review
This studio examined seven potential TOD sites under consideration by our clients. These sites may have the potential to provide additional residential and/or employment density along the TZB corridor. However, in most instances they would not be developed in the first year short-term, which is through 2018. Only in the medium-term, up to 2033, are these potential developments likely to promote BRT or existing bus ridership.

**Monsey Park & Ride - Monsey, NY**
In Rockland County we have the NY State Thruway property along Route 59 that is being developed into a Park & Ride by 2016. That project does not qualify as true TOD, but may help promote ridership to the BRT station at Monsey.

**Former GM Site - Tarrytown, NY**
This is a large site at the former GM plant in Tarrytown which has a great deal of TOD potential. It has a valuable riverfront location and large size at 65 acres. Several developer proposals have come and gone for this site due to conflict with local permitting and zoning regulations. While this project is currently on hold since negotiations last broke down in 2007, that does not preclude it from being developed as a major TOD site in the future.

**Crossroads Plaza - Elmsford, NY**
This is a large suburban shopping center at Crossroads Plaza in Elmsford. There have not been any proposals for this site to date, but it could be an ideal candidate for a “suburban retrofit” development model (Chicago Metropolitan Agency for Planning, 2012).

**White Plains TransCenter - White Plains, NY**
Our most promising TOD site is the garage property across the street from White Plains TransCenter, the most important transit hub in the 287 corridor. Westchester County recently received a $1 million grant to study a reconstructed transit center at this location, which may include additional housing, commercial, or mixed-use spaces. This project is expected to be complete by 2033 when the BRT system is already in place.

**United Hospital Site - Port Chester, NY**
Finally, there’s the United Hospital site in Port Chester. Unfortunately, this site is just outside of the walkshed of the Port Chester BRT station. Nevertheless, the hotel chain Starwood Group is proposing a large, mixed-use complex with 750 housing units and high-end retail. This project is currently under SEQRA review.
4.4 Outcomes Matrix: TOD Sites

Rendering of completed United Hospital TOD development
Source: Port Chester Daily Voice

Rendering of proposed development at former GM site in Tarrytown, NY. This proposal was abandoned after negotiations broke down in late 2007.
Source: The New York Times, 2/11/07
Results of Outcomes Matrices - Stations/TOD Sites:
The sites most suitable for TOD development are White Plains TransCenter, the GM site in Tarrytown, and the United Hospital site in Port Chester.

Of the 21 BRT stations the MTTF proposed, we conclude that 15 are likely to be successful:

5 stations in Rockland
10 stations in Westchester

Of the 7 TOD sites we reviewed, we conclude that the following are the most well-suited for TOD:

GM site - Tarrytown
White Plains TransCenter - White Plains
United Hospital site - Port Chester
Now that it has been established which stations and TOD sites are most suitably located, we turned to the question of how many people will ride the BRT system. We analyzed the volume-capacity ratio of the BRT system under the Task Force’s proposed frequency of buses every 15 minutes.

Volume-capacity ratio is a standard metric of transit cost-effectiveness, along with other more intensive metrics like total subsidy per passenger or cost per mile (NYSDOT, 2009). Essentially our goal is to estimate the typical percentage of passenger seats that will be filled on a BRT bus trip. Lacking the proper modeling software to accurately estimate ridership, we applied the Task Force’s estimate of 8,300 riders per day on our four routes. Unfortunately the result of 31% is quite low, not at all what we’d expect from a high-quality bus route, and hardly cost-effective.

**Figure 23: Scenario 1 - Ridership Projections under MTTF’s Proposal**

Scenario 1: MTTF’s Proposal:
Total daily system capacity: 26,520
Projected Ridership: 8,300 by 2018
How much does the new BRT system improve upon existing service? Here we have the total ridership levels of local service in each county from the State’s Draft EIS document. Based on volume/capacity ratios in the I-287 corridor, Westchester Bee-Line system is more efficient than Transport of Rockland with a 57% volume/capacity ratio compared to just 17% in Rockland County.

We forecast the ridership growth by 2018, when those respective figures are 59% and 19%. We also have the projected ridership once BRT is built, and the figures account for riders who are expected to switch from a local bus route to the BRT.

Even though relatively few of the seats on our BRT will be filled - just 31% - the ridership gains are still significant over a “no-build” scenario. These gains are 34% in Rockland and 61% in Westchester above what the local routes in this corridor would have without BRT. Nevertheless, the 31% average volume/capacity is not encouraging, so we explored methods to further increase passenger utilization.

**Figure 24: BRT Ridership Growth over “No-Build” Scenario**

<table>
<thead>
<tr>
<th></th>
<th>Rockland</th>
<th>Westchester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current daily ridership on TZB Corridor (2012)</td>
<td>5,700</td>
<td>4,042</td>
</tr>
<tr>
<td>Peak Volume/Capacity Ratio</td>
<td>17%</td>
<td>57%</td>
</tr>
<tr>
<td>Projected ridership 2018 (No build)</td>
<td>6,200</td>
<td>4,134</td>
</tr>
<tr>
<td>% growth 2012-2018</td>
<td>8.77%</td>
<td>2.29%</td>
</tr>
<tr>
<td>Projected Peak Load Volume/Capacity Ratio (2018)</td>
<td>19%</td>
<td>59%</td>
</tr>
<tr>
<td>Projected Total Daily Ridership with BRT</td>
<td>8,300</td>
<td>6,667</td>
</tr>
<tr>
<td>% Change post-2018 with BRT over &quot;no build&quot; scenario</td>
<td>34%</td>
<td>61%</td>
</tr>
</tbody>
</table>

Although BRT buses may not be adequately filled, they would still provide an increase in ridership over projected baseline ridership of 2018.
Fortunately, there are several generally accepted means of increasing transit ridership on a given line, one of which is simply increasing the bus frequency during peak times. According to Fehr and Peers (2005), increasing the frequency of AM/PM peak hour buses by 50% would yield a ridership increase of 24%. However, increasing the frequency requires increasing the capacity or number of bus trips even more. We now see only 22% of passenger seats filled with this higher frequency service, and we’ve therefore made the system less cost-effective.

Although the 50% increase in peak service has grown our ridership significantly, our system is now less cost-effective with only 22% of seats filled. Clearly we need to do more than increase service frequency.

We must also comprehensively increase our land use and employment density along the corridor by concentrating development into focused TOD zones near each station. However, doing so would require coordinated zoning reforms in dozens of municipalities, something that is unlikely to take place in the five year short-term period. The ridership gains from high-frequency BRT service seem to be not enough to reduce congestion on this corridor. We now explore whether upgrading existing bus routes would be a more suitable approach.

**Figure 25: Scenario 2 - Ridership Projections under 10-minute Headways**

*Scenario 2: Increased BRT Service*

- 10 min peak headways, 15 min off-peak headways
- Total daily system capacity: 45,760
- Projected Ridership: 10,292 by 2018
5.0 Upgrading Existing Bus Service

Alternative Approach to the Problem
Is there a way to solve traffic problems along the I-287 corridor and improve transit service other than establishing BRT? Enhancing the existing bus service may be an alternative approach.

Considerations to Improve Existing Transit Service
Current service along the I-287 corridor includes Bee-line Route 13, TOR 59 and TZx. Improvements such as connectivity and wayfinding upgrades, queue jump, TSP, real time information systems, stop skipping, reducing peak time headway and service consolidation were analyzed.

Based on our team’s field observations, on eastbound trips of Beeline 13, the average number of passengers on bus was about 30 and the total ridership averaged roughly 80. For westbound trips, an average of 20 passengers is on the bus at any given time, and the total ridership reached 70.

For TZx, the ridership declines greatly. On westbound trips, only about 15 passengers are on the bus to Rockland. For eastbound TZx trips, the average number of passengers on the bus is 17, and totally 25, which is still much lower than the ridership in Westchester, which is not satisfactory. Therefore, we are thinking of upgrading existing bus service to solve the low ridership, long waiting time, low speed and reliability problems.

Figure 26: Observed Ridership Patterns on the I-287 Corridor

Source: Observed passenger counts by Yinan Tong - 2/1/14 - 2/14/14
5.0 Upgrading Existing Bus Service

Figure 27: Improved Connectivity between Bus and MNR

Source: Google Maps

Improve Connectivity between Bus and Train
Building better connections between bus and train can improve existing service by making the travel less time consuming and more reliable. The Metro North Station in Suffern is far away from the nearest bus station. To provide improved rail/bus links, the location of the bus stop can be moved and building signage can be provided.
Queue Jumps and TSP

Another way to improve current bus service is the concurrent implementation of queue jump and transit signal prioritization, which cost relatively less and reduces travel time significantly. A queue jump consists of an additional lane and could work together with signal priority for the bus. For locations that are not appropriate for queue jump, for example in Downtown White Plains, we may use Transit Signal Priority only. TSP involves installing a sensor on the bus and give it green light priority when it arrives at an intersection. Figure 28 is an example how queue jump and transit signal priority system would be applied. By checking TOR 59 and Bee-line 13 service routes we concluded that several intersections (shown with stars in Figure 29) are busy enough for queue jump and have enough roadway space to implement it. The numbers on the map represent the traffic volume (AADT) on the road and the picture show what those intersections look like.
5.0 Upgrading Existing Bus Service

Figure 29: Proposed Sites for Queue Jump and TSP Implementation
Stop Skipping
Based on Bee-Line 13 ridership data at each stop, several stops with fewer riders were selected to be skipped in order to improve the efficiency of the service along the route while having the least impact on service equity. The table shows the list of stops to be skipped for Beeline 13. The first is stops in pairs for both directions, and the second are single stops without its pair on the reverse trip. For TOR 59 and TZx routes in Rockland County, stop-level ridership data was unavailable, so no analysis could be made for stop skipping on these routes.

**Figure 30: Cost/Benefit Analysis of Bee-Line 13 Improvement**

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Time Saving (minutes)</th>
<th>Potential Ridership Increase</th>
<th>Cost Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish Transit Signal Priority (TSP) System throughout the route and Queue jump for appropriate intersections</td>
<td>8</td>
<td>6% 250</td>
<td>$620,000</td>
</tr>
<tr>
<td>Real Time Information System</td>
<td>0</td>
<td>4.5% 185</td>
<td>$960,000</td>
</tr>
<tr>
<td>Skip Stops within Walking Distance</td>
<td>4</td>
<td>2.5% 105</td>
<td></td>
</tr>
<tr>
<td>Wayfinding Signage between Train Stations and Bus Stops</td>
<td>0</td>
<td>2% 85</td>
<td></td>
</tr>
<tr>
<td>Reduce peak time headway from 20 minutes to 15 minutes</td>
<td>0</td>
<td>10.5% 435</td>
<td>$600,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>25.5% 1,060</strong></td>
<td><strong>Approximately $2,200,000</strong></td>
</tr>
</tbody>
</table>
Cost/Benefit Analysis Process

First, TSP along the route could save 8 to 10 seconds per intersection and contribute to 5 minutes saving along the whole 60 minute trip. With 3 queue jumps we assume one minute travel time saving each, such that they could contribute 3 minutes time saving (Transportation Research Board, 2007). The cost of TSP implementation is around $13,000 per intersection and queue jump will cost much higher, up to $100,000 for each because of road entrance expansion (USDOT, Federal Transit Administration, 2008).

Based on TCRP Report 118, the implementation of real time information system at each bus stop could improve the reliability of bus service and attract an additional 4.5% in ridership (Transportation Research Board, 2007). The cost of implementation is $6,000 for each stop. With 80 stops along the route for each direction of Beeline 13, the total cost becomes $960,000.

The time saving by stops skipping is calculated by the assumption of average bus
operation speed at 25 mph, acceleration and deceleration rate at 2mph/hour. The travel time is saved from not braking to a stop and accelerating to operation speed again at the stops skipped. The total time saving could be up to 4 minutes, equating to a 2.5% increase in ridership.

The effect of additional ridership attraction from wayfinding improvement is also derived from the TCRP report 118 and it is about 2% ridership increase (Transportation Research Board, 2007).

The final issue under consideration is to reduce the peak time service headway. Currently the peak time headway of Beeline 13 is 20 minutes. If the headway were reduced to 15 minutes between 630am and 9am for morning peak and 430pm to 7pm for afternoon peak, the change of ridership could be estimated by the elasticity of ridership change from service frequency (Fehr and Peers, 2005; Transportation Research Board, 2007). This could roughly attract more than 10% of current riders to take transit. To accommodate this change in service, one more conventional bus is needed in the peak time service cycle, resulting in an additional cost of $600,000. The total improvement would cost around $2,200,000 and achieve 25% more ridership for Beeline 13.

Cost and Benefit of TOR 59 Improvement
The assumptions and calculation methods are the same as that of Beeline 13. The TSP, Queue Jump and Wayfindings improvement could attract around 10% more ridership. Because the cycling time of TOR 59 is 75 minutes, two more buses are needed to support a more frequent peak time service. A headway reduced from 20 minutes to 15 minutes would attract around additional 10% ridership. The additional buses could be borrowed from other service route, so the improvement in TOR 59 will cost around $930,000 in all, to attract a 20% increase in ridership.

Existing Service Situations of the TZx
The current service situation of the Tappan Zee Express is unusual. Because it runs on a route nearly identical to TOR 59 and makes only express stops to ensure an efficient service, the daily ridership of TZx is just around 1500, which is only about one third of the ridership of TOR 59. The major reason forth is is because of the three exclusive service options of TZx. The first option is from Suffern to White Plains (skipping Spring Valley). The second is from Spring Valley to White Plains. The third one is the peak time only nonstop service between Palisades Mall and Tarrytown, to provide a park and ride transfer for Rockland residents to Metro North.

In order to gain higher ridership, the low frequency problem could be solved by consolidating the three service options into a uniform one to ensure a much higher service frequency and reliability.
5.0 Upgrading Existing Bus Service

**Figure 32: Existing TZx Service**

### Table: Existing TZx Service

<table>
<thead>
<tr>
<th>Option</th>
<th>Peak time headway</th>
<th>Non-Peak time headway</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30 min</td>
<td>60 min</td>
<td>No service between 830 AM and 1130 AM</td>
</tr>
<tr>
<td>2</td>
<td>20 min</td>
<td>60 min</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5-15 min</td>
<td>NA</td>
<td>Peak only, nonstop service</td>
</tr>
</tbody>
</table>

**New Service Proposal for TZx**

For the new Tappan Zee Express service, we would propose a uniform route from Suffern to White Plains. In Rockland, it departs from Suffern, take the same route with TOR 59 but just make express stops as Airmont Road, College Road, Monsey, Spring Valley, Nanuet Mall, Palisades Mall, West Nyack, Nyack and then cross the river and runs on the I-287 corridor directly to White Plains. Therefore the TZx could provide a much higher frequency along the whole route and coordinate with TOR 59 to provide a more efficient travel for Rockland County residents.
5.0 Upgrading Existing Bus Service

Figure 33: New Service Proposal for TZx

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Time Saving (minutes)</th>
<th>Potential Ridership Increase</th>
<th>Other Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSP, Real Time Info, Wayfinding as TOR 59</td>
<td>3</td>
<td>8.5% 170</td>
<td></td>
</tr>
<tr>
<td>Consolidate three options to one</td>
<td>0</td>
<td>15% 300</td>
<td></td>
</tr>
</tbody>
</table>

Increase peak time frequency

<table>
<thead>
<tr>
<th>Total</th>
<th>3 (total: 90min)</th>
<th>68.5% 1370</th>
<th>7 Fewer buses</th>
</tr>
</thead>
</table>
5.0 Upgrading Existing Bus Service

The TZx improvement provides additional benefit from a cost/benefit perspective. The TSP, queue jump, and real time info system would lead to a 7% increase in ridership. If the TZx improvement is implemented in concert with the improvements to TOR 59 and Bee-Line 13 routes, the cost would be zero because the TZx shares the same route with TOR 59 and Beeline 13. The consolidation of service will provide a more reliable service and increase ridership by roughly 15%. In addition, by adding greater frequency of the TZx service, the ridership would grow significantly by around 45%. By consolidating the service options, even adding peak time service frequency will still reduce 7 buses in the whole service cycle. The 7 buses could be shifted to additional TOR 59 buses needed for higher frequency at peak time and reduce the cost significantly by avoiding the purchase of new buses.

**Neither BRT Nor Upgrading Existing Bus Service May Be Sufficient to Reduce Congestion**

To summarize, upgrading existing bus service would cost around $3,130,000, and increase ridership from 10,300 to 13,600. Compared to 8,300 increase by BRT, this upgrading would have a less significant improvement in ridership, in that the percentage of ridership gain over the “no build” scenario is also lower. The lower volume-capacity ratio of less than 50% indicates that both upgrading existing bus service and introducing BRT provide generally inefficient service. Therefore a higher density zoning land use policy and employment density and Transit Oriented Development may be required. Optimistically, if the ridership increase of 3,300 passengers is subtracted only from single occupancy vehicle trips, this amounts to only 9% of the total daily peak time volume of 36,000 car trips along the corridor (Higashide, 2007). Apart from introducing BRT or upgrading existing transit service, it is clear that increasingly aggressive demand-side policies to discourage SOV trips - parking cashout, congestion pricing, or VMT taxation - may be necessary to reduce congestion on the I-287 corridor.
Key Aspects of Corridor Transportation Conditions
Congestion is growing along the I-287 corridor. Both eastbound or westbound, limited capacity of Tappan Zee Bridge is causing congestion and long travel time. At the same time, the shoulder time is increasing as well. Secondly, passenger cars represent between 87 and 95 percent of all vehicle traffic along the corridor in weekdays (Vollmer Associates, 2000). The corridor exhibits a very high demand for automobile travel given the high proportion of trips, which is 85%, being made in single occupant vehicles. As a preliminary measure, Parking Cashout and TransitChek were evaluated as means to curb demand for SOV trips.

Parking Cash Out & TransitChek
Under a parking cashout program, an employer gives employees a choice to keep a parking space at work or to accept a cash payment and give up the parking space (Shoup, 2005). When commuters choose cash instead of a free parking space, the demand for transit is increased and demand for SOV trips reduced.

TransitChek allows employees to pay for qualified commuter parking on a daily or monthly basis using tax-free dollars (up to $130/month for transit and up to $250/month for qualified parking) (TransitChek). Qualified commuter parking means that a parking lot belongs to the company or near the transit hub. There are several cities that accept TransitChek benefits, like New York, San Francisco and Chicago. Both Westchester Bee-Line Bus and Rockland Coach transit services accept TransitChek.

Benefits
The benefits are substantial: employees receive broader and more equitable commuter benefits, traffic and emissions decrease, and the employer may be able to reduce the long-term cost of providing parking. These two programs encourage commuters not to drive alone to work without taking away the existing parking benefit. Parking Cash Out program and TransitChek add new choices for many commuters who may have previously lacked any economic incentive to take transit.

Case Studies of Travel Changes After Cash Out in CA
There are two separate case studies for Parking Cash Out program and TransitChek. The purpose of these two case studies is to introduce some alternatives for solo drivers to attract commuters to transit. From there it can be determined whether these two incentive solutions are suitable for the I-287 corridor.

Figure 34 shows the commuter mode shares before and after parking cash out program in Los Angeles, California. Eight employers in Los Angeles County were selected for the case studies. They range in size from 120 to 300 employees, with a combined total of 1,694 employees. This figure shows the commuter mode shares for all employees before and after parking cash out. After cash out, the drive-alone share fell from 76 percent to 63 percent. There were increases in carpooling and transit ridership, of 7% and 3% respectively. In contrast, the combined walk/bicycle share rose modestly from 3 percent to 4 percent. According to the data below, there is a clear connection between...
6.0 Transportation Demand Management

Parking Cash Out program and a reduced demand for SOV trips. The mode share of commuters driving to work alone (SOV) declined 13%. Meanwhile, three times more SOV drivers switched to carpools than to public transit, which shows that parking cash out can work even where public transit is not attractive or available.

Figure 34: Commute Mode Shares Before and After Parking Cashout (Los Angeles, CA)

![Figure 34: Commute Mode Shares Before and After Parking Cashout (Los Angeles, CA)](image)

Source: Shoup, 2005.

TransitChek (2010 Commuter Benefit Impact Survey)
This sample was weighted by company size, according to 2006 Census data, to ensure representation of the business population in the three target cities: Chicago, New York and San Francisco. Figure 35 shows the relationship between TransitChek and commuter mode share. According to the 2010 CBIS, there is a 3% increase in transit from 2009 to 2010. The share of transit increased from 18 percent to 21 percent during this period. At the same time, the share of park-n-ride and vanpooling both rose, which are 3 percent and 4 percent separately. After offering the TransitChek program, employees are more and more willing to take public transit to work.
% Non-SOV Commuter by CBIS

*Figure 36* shows a clear connection between commuter benefits and commuting choice. The 2010 CBIS data shows a higher number of employees commuting by transit, vanpool and carpool at companies offering commuter benefits compared to companies that do not offer commuter benefits. Employees are willing to use TransitChek as their commuter benefits. Employees would like to take transit more than carpool.

*Figure 36: % Non-SOV Commuter by Benefits Offered (New York, San Francisco, Chicago)*
 Recommendation for Suffern - Parking Cash Out

Nearly 95% of employers offer free parking in Rockland County. For suburban employers, they may not consider TransitChek program, because they tend to own or lease parking in large blocks and almost always provide it free of charge to employees. Therefore, tax-free parking or transit is not that attractive to Rockland County people. However, Parking Cash Out program is different. According to the results from LA case study, Parking Cash Out program will work well on switching solo drivers to carpools. It did not have that much influence on transit. For White Plains, parking spaces, particularly in urban areas, are costly. At the same time, TransitChek is more easy for employers to manage. Expand use of TransitChek to increase employers participation and achieve greater use. People get their transit or commuting covered by vouchers. This program is also a welfare to attract more people and also can save a substantial amount of money in reducing the number of parking spaces required.
7.1 Variable Lane Tolling and HOT Lanes

In addition to parking cash-out, TransitChek, and VMT pricing, another transit financing option is congestion pricing. There are two main types of congestion pricing methods: variable priced lanes and variable tolls on entire roadways. Variable priced lanes are variable tolls on separated lanes within a highway, for example Express Toll Lanes or High Occupancy Toll (HOT) lanes. Variable tolls on entire roadways are tolls both on toll roads and bridges, as well as existing toll-free facilities during AM/PM peak hours. The case studies have been split into these two categories- the locations with congestion pricing approaches within the “variable priced lanes” category are San Diego, Houston, and Orange County, and those within the “variable tolls on entire roadways” category are Lee County and Washington State.

The purpose of these case studies is to introduce several ways in which different cities throughout the country have successfully implemented congestion pricing programs. From there, it can be determined how best to implement congestion pricing along the I-287 corridor.

Variable Lane Tolling

San Diego I-15 Express Lanes
San Diego's form of value pricing is the I-15 Express Lanes, which allows single occupant vehicles (SOVs) to use the existing HOV lanes on the I-15 for a fee. The tolls generally vary between $0.50-$4.00 per trip, but can reach up to $8.00. The tolls are based on current traffic levels in the HOV lanes and the time of day. The goal of this congestion pricing project was to make better use of the existing capacity on the I-15 while maintaining free-flow traffic conditions on the HOV lanes, and to generate revenues to support transit service in the corridor. This project was implemented in 1998, and using all of the toll funds generated since then, a new BRT system will begin running on the Express Lanes in June 2014.

Houston QuickRide HOV
The Katy Freeway in Houston normally restricts its HOV lanes to vehicles with 3 or more occupants, but the QuickRide program allows vehicles with just 2 occupants to pay a $2 toll (plus a $2.50 monthly administrative fee) to travel more rapidly on the HOV lanes. Single occupant vehicles are always excluded. The QuickRide program operates during peak hours on weekdays only. The 13-mile HOV lane is located in the median of the freeway (Katy Fwy I-10 and Northwest Fwy US 290) and has direct connections to Park and Ride lots, which has helped aid in increased transit ridership on Houston’s Express bus service. The general public opposed this project because freeway users did not anticipate using the service daily. However, studies have shown that this program can provide drivers with time savings between 15-17 minutes.
Orange County SR-91 Express Lanes
The Orange County SR-91 Express Lanes in California are a 4-lane toll road in the median of the freeway, with 2 lanes travelling in each direction. To determine the toll fee, the OCTA (Orange County Transportation Authority) monitors hourly traffic volumes, then adjust tolls when traffic volumes consistently reach a point of saturation where traffic flow becomes unstable, known as super peak hours. Other non-super peak tolls are adjusted annually by inflation. One unique feature about this express lane program was that it was originally privately funded and operated. The California Private Transportation Company (CPTC) originally owned the Express Lanes, but due to issues with a non-compete clause in their contract which barred public transportation agencies from increasing highway capacity on other roads within one-and-one-half-miles of SR-91, the Express Lanes were sold back to the OCTA in 2003. Public opinion was positive for providing toll facilities, but negative with respect to for-profit toll operations. This particular strategy is not practical for implementation in the I-287 corridor due to lack of available roadway space.
Long Island Expressway (1-495) HOV
The Long Island Expressway is instructive as a case study because it is located in New York and may provide a better idea of what is actually feasible in terms of congestion pricing in New York. The restrictions on the HOV lanes of the Long Island Expressway are in effect during AM and PM peak hours. During this time, the HOV lanes are reserved for 2+ carpools, buses, motorcycles, and Clean Pass Vehicles. The New York State DOT said it would consider additional studies to allow unlimited access between the LIE’s regular travel lanes and the HOV lanes, to potentially become HOT (high-occupancy toll) lanes in the future (NYSDOT, 2013).

Lee County Variable Bridge Tolls
Lee County’s approach to congestion pricing was to provide a monetary incentive to travel outside the peak periods rather than penalize those travelling during the peak periods. Therefore Lee County’s pricing scheme involved no toll increases, only toll decreases, during the shoulder hours just before and after the morning and evening rush hours. (6:30 – 7:00 am, 9:00 – 11:00 am, 2:00 – 4:00 pm, and 6:30 – 7:00 pm). Due to this incentive-based approach to tolling, this congestion pricing program was generally well-received by the public. Ultimately, the variable tolls helped generate a 5% shift from peak to off-peak travel, and up to 13% reduction in travel times.
Truck Tolling on the TZB
Currently there is a truck toll reduction program from Interchange 14A going eastbound to the Tappan Zee Bridge, shown in Figure 33. The toll prices change in 15 minute intervals; the earlier the interval, the lower the toll, but this reduced rate ends at 7AM. This toll reduction program could possibly be used for application with single occupant vehicles, similar to the congestion pricing approach taken by Lee County.

Figure 37: Truck Toll Rates on the TZB

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Source: New York State Thruway Authority, 2014
7.2 Dynamic Bridge Tolling

Washington SR520 Bridge Toll
This case study was chosen because of its similarities with the Tappan Zee Bridge. Similar to the Tappan Zee Bridge, this span of the SR520 highway is a bridge in need of replacement, and the tolls are expected to help pay for a new replacement bridge. The new bridge is also planned to have a bike/pedestrian path like the new Tappan Zee Bridge. In this particular case, vanpools have increased by 18%, and there has also been a 10% increase in bus ridership since bridge tolling started (according to Washington State DOT).

In summary, these case studies show us that congestion pricing methods taken in different approaches throughout the U.S. have consistently led to some reduction in travel times, which may in turn lead to positive public reaction. Another congestion pricing method that seems to contribute to positive public reaction is the incentive approach to pricing, where there are toll decreases during the time periods just before and after peak periods.

Phasing in Congestion Pricing
It may be impolitic to introduce congestion pricing right at the start. Instead, one option is to start by phasing in the idea of an HOV lane that includes bus travel, then introduce private vehicles onto the HOV lanes with a fee (or in other words, to convert those HOV lanes into HOT lanes).

One potential unknown constraint in this analysis is the impact of both variable lane and dynamic bridge tolls on transit ridership. According the Federal Highway Administration, variable-lane tolls and dynamic bridge tolls have only a marginal impact on transit ridership, although their ability to raise revenue for transit is well-established (U.S. Department of Transportation, 2009). Therefore it is difficult to accurately forecast the impact of future toll increases - which the New York State Thruway Authority has yet to announce - on transit usage in the I-287 corridor.

Source: Washington State Department of Transportation
7.3 VMT Taxation

Though Governor Cuomo recently announced a $20 million grant to the New NY Bridge (Miller, 2014), it will still require a significant amount of capital fundraising and revenue streams put in place before its completion. Perhaps an easier alternative to even traditional congestion pricing is the VMT or vehicle miles traveled tax for the corridor, such a scheme that could later be implemented throughout the State of New York.

Most tolls and taxes are currently based on usership and neglect to take into account “global” miles traveled over time, even within a corridor. Alternatively, the VMT Tax accounts for the total number of miles a vehicle travels during a given amount of time.

The states of Illinois and Oregon have already begun such programs. In Illinois, VMT pricing is built into vehicle registration fees (higher fees are charged for more miles traveled) and the maximum number of miles driven is monitored by statewide transponders. In Oregon, the Department of State has implemented a pilot program for 5000 volunteer residents who receive a state gas tax reimbursement in exchange for paying a VMT fee (again, monitored by transponders). The coming years will bring a full rollout of the program statewide.
The Tappan Zee Bridge currently has no mileage-based pricing options and NY State at large has no registration fee add-ons that account for miles traveled. Vehicles traveling on the TZB are subject simply to time-staggered fees for various truck sizes and a flat fee for cars.

In terms of a political narrative that would make this desirable for a number of stakeholders, such a VMT tax within this corridor and throughout NY State could be considered an innovative experiment and a part of the positive image of the groundbreaking “New” NY Bridge project, as Governor Cuomo has titled it. The potential for the TZB to test this option before it is adopted throughout the State would establish a substantial mandate for the future. VMT pricing is additionally favorable to a variety of political persuasions and the system would serve to raise revenue significantly couched in “fees” as opposed to “tolls” or taxes. It could furthermore be an alternative to traditional congestion pricing that has the potential to raise revenue based upon similar usership regulatory schemes alongside passively reducing congestion. Registration fees indirectly discourage unreasonable and unnecessary car ownership within families and households. Finally, the public is incentivized to pilot the program by a small net reimbursement on state gas taxes.

In terms of the rollout, in the short term would begin the state gas tax reimbursement and mileage fee pilot period for volunteers, as well of an inflation-adjusted increase in the tolls for those outside of the pilot program. VMT-based pricing (of roughly 1.5 cents per mile) would be in the TZB corridor only, for now. The medium term would bring
a statewide adoption of mileage-based vehicle registration fees alongside an inflation-adjusted increase in tolls throughout the TZB corridor for out-of-state vehicles. The long term would bring a statewide adoption of mileage fees and a permanent decrease in the state gas tax.

NY State also has the chance to receive federal funding for a pilot period. Though the State Government has received Federal grants for the TZB project, the only alternative to continuing to attempting to account for shortfalls is significantly higher tolls for in-state and out-of-state traffic or a expansion of the current corridor to extend tolling beyond the current boundaries. VMT taxation would be a positive alternative that would not only finance the New NY Bridge project but would work to reduce congestion over time.

Both VMT taxation and variable-lane tolling appear increasingly opportune given the Obama Administration’s recent proposal to allow States to begin tolling Interstate highways, of which I-287 is one (Halsey, 2014). The proposal, contained in a four-year, $302 billion White House transportation bill, would reverse a long-standing federal prohibition on most interstate tolling. It is also very much aligned with the Task Force’s stated goals of reducing congestion and raising TZB tolls to pay for transit improvements. The Obama Administration’s proposal is especially relevant to this project because it doubles the committed funding for transit and rail projects, from $12.3 billion to $22.3 billion. While we can only speculate how the Task Force’s proposed BRT system ranks in relation to other transit systems competing for these new federal grants, it is a welcome step in the right direction.
8.0 Conclusion

Conclusion
In order to reduce SOV trips and increase transit ridership on the new Tappan Zee Bridge and along the I-287 corridor, a combination of transit improvements and demand-side policies must be implemented.

Constructing and operating BRT in a primarily low density environment is a significant undertaking. Several of the stations that the Mass Transit Task Force proposed along the corridor are not viable according to the generally accepted land use and demographic factors governing transit ridership. Although BRT service is likely to significantly increase ridership beyond that of a “no-build” scenario, it is unlikely that such a system alone would have measurable impact on traffic congestion.

The record of BRT implementation in the United States has so far been mixed; many municipalities have implemented systems that incorporate only rudimentary improvements to existing bus service - low-floor buses, off-board fare payment systems, and little else - under the moniker “BRT”. Such marginal improvements have far less efficacy in reducing travel times or increasing ridership than full BRT systems containing all of ITDP’s five essential components. In addition, the poor performance of such systems compared with true high-capacity transit may damage the political capital of BRT and make future implementation less favorable. To avoid this negative outcome, State and local officials should ensure that any BRT implemented along the I-287 corridor has, wherever possible, the internationally recognized elements to ensure its effectiveness: dedicated rights of way, transit-oriented intersection modifications, center-lane orientation, and high-quality station environments (ITDP, 2012). Without these elements in place, BRT may only yield marginal improvements over existing bus service.

In the event that implementation of full BRT proves to not be cost-effective or politically feasible in certain areas of the I-287 corridor, we conclude that targeted upgrades to existing bus service may yield comparable ridership gains and travel time reductions. By increasing service frequency, consolidating routes, and adding improvements such as queue jumps, transit signal prioritization and stop skipping, local routes TOR 59, Bee-Line 13, and TZx may be able to replicate the predicted gains of BRT with much lower capital expense.

Retrofitting a low density environment in less than five years to support an active bus rapid transit system and reduce traffic congestion is more likely to occur in the midterm 15 year, 2018-2033 time period mentioned by the Task Force, especially given the potential of implementing a number of large sites with more compact, transit-supporting densities. Of the 21 BRT stations proposed by the Task Force, 15 are viable based upon generally acceptable criteria. Similarly, upgrading the three existing bus services are also likely to be insufficient to reduce private vehicular congestion. As a result of these conditions, more aggressive demand side policies, including congestion pricing, variable lane tolling, mileage metering and transportation demand management are recommended. However, the timeline for acceptance and implementation are not
likely to fit into a short term period. A new bridge with a fourth lane in each direction and high occupancy vehicles operating along the shoulder of the structure will be helpful but there is no single ‘silver bullet’ solution that will reduce congestion. Rather, a coordinated strategy of transit improvement, demand-side congestion management, and significant increase in residential and employment density will be required to have meaningful impact.


9.0 Bibliography


Orange County Transportation Authority. 91 Express Lanes. (2014). Retrieved from OCTA website: http://www.octa.net/express-lanes/


9.0 Bibliography


## 10.0 Appendix I: Data Dictionary

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**Appendix II: Results from Outcomes Matrix - Stations**

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**Notes:**
- TOD Site: Transit Oriented Development Sites
- Site Acreage: Site area size
- TOD Size: TOD development size
- Number of Transit Intersections: Number of transit stops within 1/2 mile
- Bus Station Frequency: Frequency of bus stations
- Bus Stop Frequency: Frequency of bus stops
- TOD Site (within 1/2 mile): TOD sites within 1/2 mile radius

**Promoting Bus Rapid Transit Options on the New Tappan Zee Bridge and I-287 Corridor**

2020-2021 Route: 1/2 mile radius from TOD Site
2020-2021 Route: 1/2 mile radius from TOD Site
2020-2021 Route: 1/2 mile radius from TOD Site
2020-2021 Route: 1/2 mile radius from TOD Site