Getting Up to Speed

A Case for Bus Rapid Transit and Transit-Oriented Development in the Tappan Zee Bridge/I-287 Corridor

Tri-State Transportation Campaign

October 2007

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We would like to thank Bryan Cox of RTC of Southern Nevada, Vincent Marzella and James Carey of Transport of Rockland, and Andrew Ziegler of the Westchester County Bee-Line Bus System for their help in procuring up-to-date statistics from their respective transit agencies. John Bonsall of McCormick-Rankin International, Robert Cervero of UC-Berkeley, and Alan Hoffman of the Mission Group offered valuable insight into bus rapid transit's ability to shape development. Thanks also to Jon Orcutt and TSTC board member Jeffrey Zupan for their thoughts and comments on the report.

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Front Cover Images (clockwise from top): *The Tappan Zee Bridge; mixed-use development close to a Silver Line bus stop in Boston; a view of Los Angeles' Metro Liner bus (Deniz Durmas/ Los Angeles MTA).*

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Table of Contents

Graphs, Tables, and Charts

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Note: On June 8, 2007, the Tri-State Campaign invited local officials and stakeholders to the symposium "Finding Transit That Fits in the Tappan Zee Corridor: The Case for Bus Rapid Transit" *in order to close what NYS DOT Commissioner Astrid Glynn has called the "information gap" between bus rapid transit and better-known transit modes.*

Presenting were three internationally known transportation experts—John Bonsall, the former head of Ottawa's transportation agency and current president of McCormick-Rankin International; Robert Cervero, professor at the University of California at Berkeley; and Alan Hoffman, principal of the planning firm The Mission Group.

This report includes much of the information presented at "Finding Transit That Fits in the Tappan Zee Corridor," *as well as our earlier presentations and documents on BRT and land use in the region.*

Executive Summary

Traffic congestion on the Tappan Zee Bridge and along the I-287 corridor between Suffern and Port Chester is an obvious problem that is likely to worsen with time and cannot be solved through road widening or other highway improvements. As the Tappan Zee Bridge/I-287 Environmental Review moves forward, it is clear that mass transit must be a part of the Tappan Zee corridor's future.

The most pressing transportation need in the I-287 corridor is effective suburb-to-suburb transit. The majority of people crossing the Tappan Zee Bridge at rush hour are driving from dispersed homes in Rockland, Orange, and Bergen counties to dispersed jobs in Westchester County and Connecticut; providing these drivers with an effective mass transit alternative will do the most to reduce congestion in the corridor.

The transit modes under consideration in the Environmental Review are light rail, commuter rail, and bus rapid transit (BRT). Of these modes, BRT has some advantages over the others. It has the most flexibility to effectively serve the suburb-to-suburb commute. Unlike trains, BRT buses can travel both "on-corridor" in busways and "off-corridor" along regular roadways. BRT is therefore more likely to serve dispersed destinations like office parks without requiring passengers to transfer.

According to the Environmental Review study team, full corridor BRT from Suffern to Port Chester is projected to attract more east-west riders than any of the other transit alternatives under study—full corridor commuter rail, Suffern-to-Manhattan commuter rail with light rail in Westchester, and Suffern-Manhattan commuter rail with BRT in Westchester. Full corridor BRT is also cheaper to build and operate than the other alternatives. An alternative combining Suffern-Manhattan commuter rail and full corridor BRT, which was dropped from consideration by the Environmental Review team, has the highest projected ridership of any alternative and should be re-examined.

The addition of mass transit across the corridor will create new opportunities for municipalities to pursue transit-oriented development (TODs), a land-use strategy by which growth is channeled into dense, walkable, mixed-use developments oriented around transit stations. TOD is being embraced throughout the country as a more sustainable alternative to sprawl, one that conserves open space and is associated with lower automobile use, traffic-related pollution and congestion. Throughout the world, bus rapid transit has been proven to support TOD; and therefore is likely to effectively support this type of development pattern should communities along the I-287 corridor prove interested in the concept.

The I-287 corridor. Source: Tappan Zee Bridge/I-287 Environmental Review Alternatives Analysis.

Recommendations

The New York State Department of Transportation, as the lead agency in the Tappan Zee Bridge/I-287 Environmental Review, should:

- Take a leadership role in connecting land use and transportation, and in promoting transit-oriented development. For example, it should do more to educate stakeholders on the repercussions of sprawling development patterns, model various build-out scenarios as part of the Draft Environmental Impact Statement (DEIS), and include land use recommendations in the DEIS.
- Provide grants to towns to help them plan their communities before planned transit stations are located and built.
- Collaborate with the MTA to create a “transit village” program, as the NJ Department of Transportation and NJ Transit have done in their state, which would provide grants and technical assistance to towns seeking to develop around transit stations.
- Do more to educate stakeholders on bus rapid transit, which is a largely unfamiliar concept.
- As promised, include in the DEIS an intelligent BRT service plan that would effectively connect key locations in the I-287 corridor.
- Determine which institutions would operate new bus rapid transit, light rail, or commuter rail services *before* a transit alternative is selected, not afterwards.

Study, Recommend, Repeat: 25 Years of Tappan Zee Congestion Studies

- **1982** – "Transportation System Management Study: the Tappan Zee Bridge and its Approaches" (NYSDOT, Thruway Authority)
- **1984-1987** – "Tappan Zee Corridor Study" (NYSDOT, NYMTC)
- **1985-1987** – "I-287/Cross Westchester Expressway Development Study (FHWA, NYSDOT)
- **1988-1989** – "I-287 Suffern-Port Chester Corridor HOV/TSM Action Plan" (Task force of same name)
- **1988-1995** – "I-287/Cross-Westchester Expressway and NY State Thruway Design Report/Environmental Impact Statement" (FHWA, NYSDOT)
- **1989-1995** – "Feasibility and Benefit-Cost Study of Trans-Hudson, Cross-Westchester and Stewart Airport Rail Links." (MTA, Metro-North)
- **1997-1999** – "Tappan Zee Congestion Relief Pricing Study." (Thruway Authority, FHWA.)
- **1997-2000** – "Long-Term Needs Assessment and Alternative Analysis, I-287/Tappan Zee Bridge Corridor" (Governor's I-287 Task Force)
- **2001-present** – "Tappan Zee Bridge/I-287 Corridor Environmental Review" (NYSDOT, Metro-North, Thruway Authority}

During morning peak hours,* 98 percent *of eastbound trips across the Tappan Zee Bridge are made via automobile. Only* 2 percent *are made via transit.

The Tappan Zee Corridor

The Tappan Zee corridor spans the 30 miles between Suffern and Port Chester, passing through a blend of low-, medium-, and high-density communities which includes rural sections of Rockland County, denser suburbs in Westchester County, and urban White Plains. This stretch of highway also includes some of the region's largest economic engines: The Palisades Center shopping mall in West Nyack, the White Plains business district, and the "Platinum Mile" of corporate offices between White Plains and Purchase.

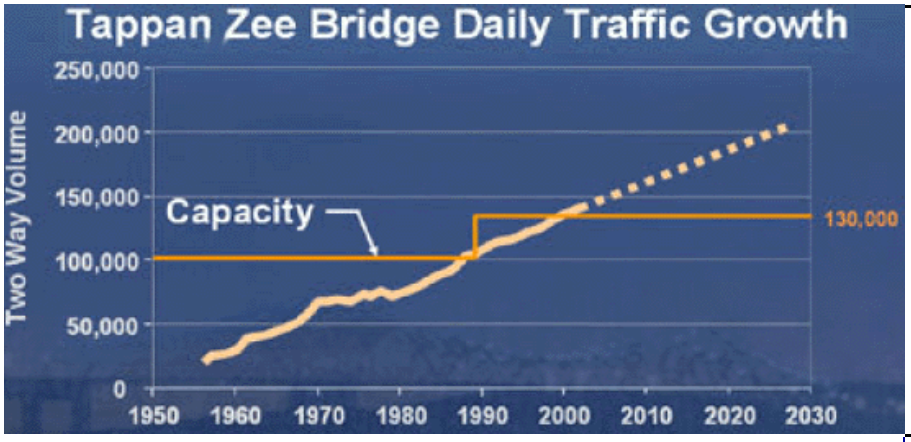
The corridor's current mass transit systems effectively serve the Manhattan commute. Metro-North operates five commuter rail lines which run north-south through the corridor and terminate in Manhattan. In Rockland County, the Port Jervis and Pascack Valley lines are operated in conjunction with NJ Transit and provide service to Penn Station (riders on both lines must transfer at Secaucus Junction). The Hudson, Harlem, and New Haven lines run through Westchester, Dutchess, and Putnam Counties in New York, as well as Fairfield and New Haven Counties in Connecticut, and end at Grand Central Terminal.

Intra-county mass transit is provided by buses. Westchester's Bee-Line bus service brings about 96,000 daily weekday riders throughout the county and to New York City.[1] In April 2007, the Bee-Line began accepting MetroCard, allowing free transfers between the Westchester and NYC transit systems. This has already boosted Bee-Line ridership, a trend which is likely to continue. Rockland's bus system is by comparison much smaller, but ridership has steadily increased, from 6,300 daily weekday riders in 2005 to almost 9,000 thus far in 2007.[2]

For those traveling *across* the corridor there are few mass transit options. Rockland County's Tappan Zee Express buses cross the bridge into Westchester, bringing riders to Tarrytown and White Plains; average weekday ridership on the Tappan Zee Express has risen from about 1,200 in 2005 to just over 1,400 so far in 2007.[3] However, these buses are subject to traffic congestion and do not travel east of White Plains. The vast majority of cross-corridor travel is done in cars on I-287—during the morning rush, 98 percent of noncommercial eastbound trips across the Tappan Zee Bridge are made via automobile.[4] (The other two percent of trips are made in Tappan Zee Express buses.)

The Tappan Zee Bridge has served as a crucial transportation link for more than half a century. When the bridge opened in 1955, it carried 18,000 vehicles per day. In combination with new highways like the Cross-Westchester Expressway, the bridge allowed automobile-dependent development to sprawl across the region. Increasing development led to increases in traffic, and by the 1980s the bridge was nearing its capacity of 100,000 vehicles per day.

To deal with congestion, various studies (see left) have been commissioned over the years, resulting in highway expansion and new park-and-ride lots in Rockland County, cross-Hudson ferry service, express



While the addition of a reversible lane increased capacity on the Tappan Zee Bridge from 100,000 daily vehicles to 130,000, traffic on the bridge now exceeds 140,000 vehicles per day.

(**Source**: Tappan Zee Bridge Urban Planning Studio Team's "Spanning the Tappan Zee Bridge: The Land Use-Transportation Connection," Columbia University Graduate School of Architecture, Planning, and Preservation, 2005.)

bus service on I-287, and feeder bus service to the Tarrytown rail station. In 1990, a movable barrier was introduced which allows the seven-lane bridge to offer four eastbound lanes during the morning peak hours and four westbound lanes during evening peak hours. This raised bridge capacity to 130,000 vehicles per day.

This capacity was quickly met, however, and the Tappan Zee Bridge now carries more than 140,000 vehicles on an average weekday.[5] The 51-year-old bridge is in a poor state of repair, particularly on its western half. Pieces of the concrete deck have broken off and fallen into the river, and the New York State Thruway Authority has begun a partial replacement of the deck that will cost $147 million.[6] Because the bridge has no shoulder lanes, breakdowns and accidents create nightmarish delays and are difficult for emergency vehicles to reach.

In 2000, driving east from Suffern to Port Chester took 30 minutes in uncongested traffic.

During the morning rush, the same drive took 70 minutes.

Urgency to control traffic growth reached a climax in 1997, when Governor Pataki formed a task force to study congestion in the I-287 corridor. The task force released its study in 2000 and defined congestion in bleak terms. The study found that driving from Suffern to Port Chester took 30 minutes in uncongested traffic and **70 minutes** during the morning rush due to congestion.[7] Without infrastructural improvements, eastbound congestion would continue to rise while westbound congestion would increase dramatically. The study found that driving from Port Chester to Suffern took 33 minutes during the afternoon rush hour, but estimated that by 2020 this trip would be **88-117 minutes** long.[8]

In 2000, driving west from Port Chester to Suffern took 33 minutes during the afternoon peak period.

How could this bumper-to-bumper future be avoided? The study concluded that building mass transit across the I-287 corridor would significantly alleviate congestion and would increase capacity to a greater extent than highway widening. In order to accommodate mass transit, the Tappan Zee Bridge would need to be replaced.

The 2000 study reviewed commuter rail, light rail, and dedicated busways as transit options, but did not evaluate their environmental impacts in detail. Thus the Thruway Authority and Metro-North began the Tappan Zee Bridge/I-287 Environmental Review in 2001. The NYS Dept. of Transportation took control of the project in 2004 after progress stalled. Like the 2000 study, this study has concluded that a transit solution is needed. In the Alternatives Analysis Report released in January 2006, the study team found that there is "a demand for traffic in the corridor that cannot be accommodated by highway improvements alone."[9]

In 2020, increases in traffic (largely due to uncontrolled and scattered development) will have made this an 88-117 minute drive.

Mass Transit Alternatives

At this point in the environmental review, the project team is considering four transit alternatives for the I-287 corridor. The team is also evaluating a "no build" alternative (Alternative 1 in the Alternatives Analysis) and a bridge rehabilitation alternative which includes no highway or transit improvements (Alternative 2). All four transit alternatives include highway improvements in Rockland County and a new bridge with four general purpose lanes and one HOT (high-occupancy toll) lane in each direction, as well as a bicycle/pedestrian walkway. HOT lanes are free for carpools and buses; single-occupancy vehicles can enter by paying a toll which varies with the level of traffic demand and is priced to keep the lane moving freely. HOT lanes are being implemented around the nation as a means to provide a congestion-free lane for carpools, buses, and emergency vehicles; to generate revenue for transportation improvements; and to offer riders the choice of paying for uncongested travel.

All four transit alternatives would provide connections to the five commuter rail lines in the I-287 corridor. Construction is scheduled to begin as early as 2010 and is estimated to take five years to complete.

Alternative 3: Full Corridor Bus Rapid Transit (BRT)—$5.0 - $6.5 billion*

Bus rapid transit systems use several features, including dedicated lanes, to offer faster and more reliable service than traditional bus systems (BRT is explained in further detail in a following section). Buses would run in HOT lanes on I-287 in Rockland County and on the new bridge. In Westchester County, buses would run in exclusive lanes on Route 119 and I-287, travel through downtown White Plains, and return to exclusive lanes on I-287. Buses could travel on and off of the busway, allowing for one-seat rides between many different origins and destinations.

Alternative 4A: Full Corridor Commuter Rail Transit (CRT)—$11.5 - $14.5 billion*

A commuter rail line would be built between Suffern and Port Chester. A station would be built at the east end of the Tappan Zee Bridge; from here a connecting spur would link the new line and the Hudson Line, allowing for a one-seat ride between stops in Rockland County and Grand Central Station in Manhattan. (One-seat service would not be provided between stops on the new line and Hudson Line stations north of the Tappan Zee Bridge; shuttle bus service would run between the Tappan Zee station and Tarrytown.)

Alternative 4B: Suffern-Manhattan CRT with Westchester Light Rail Transit (LRT)—$10.0 - $12.5 billion*

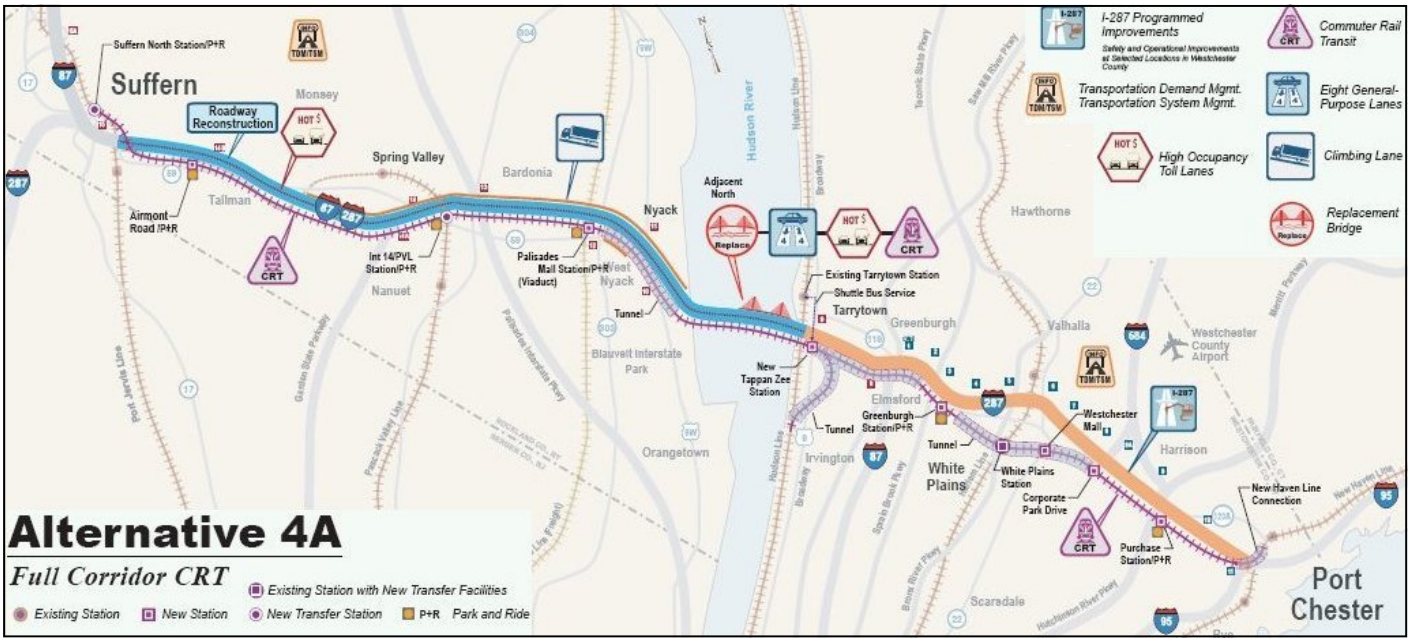
A commuter rail line would be built between Suffern and a new station at the east end of the Tappan Zee Bridge, and would connect to the Hudson Line for one-seat service between Rockland County and Grand Central. Light rail would be built between Tarrytown and Port Chester, with transfers between the light rail and commuter rail available at the new Tappan Zee station. (LRT is slower than CRT, but is less obtrusive and would make more stops.)

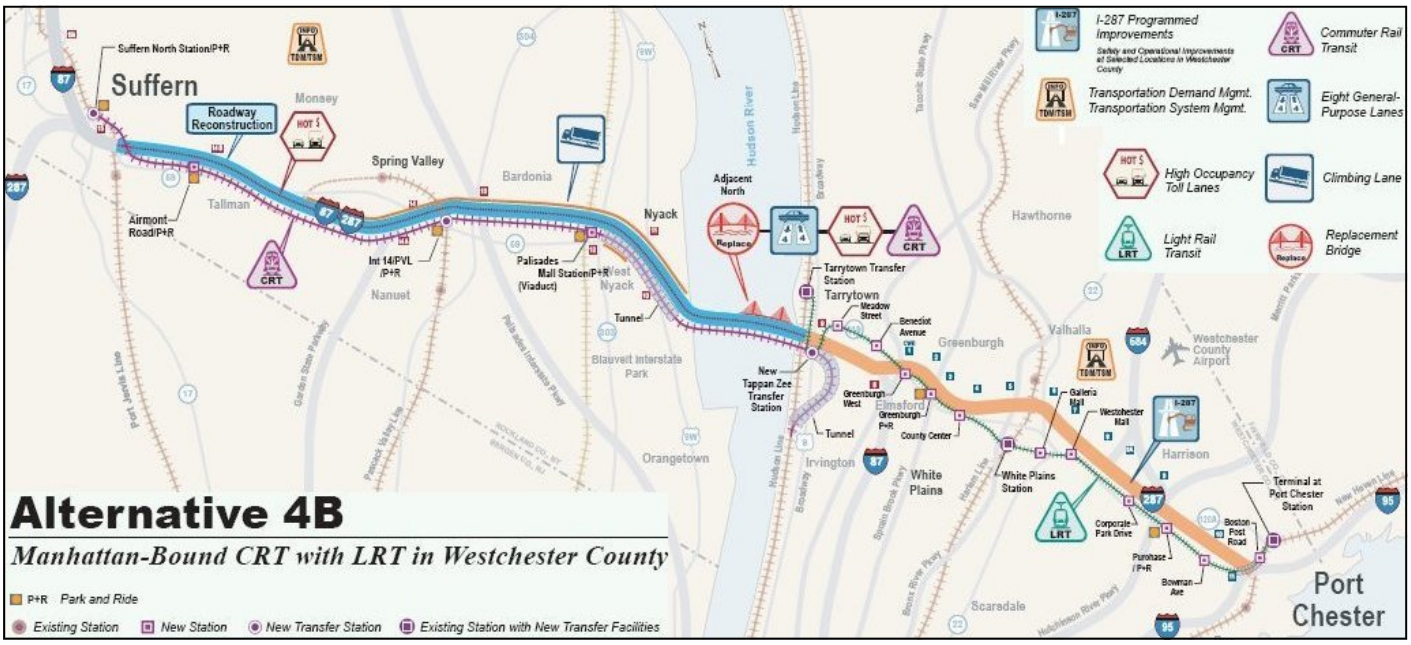
Alternative 4C: Suffern-Manhattan CRT with Westchester BRT—$9.0 - $11.5 billion*

A new commuter rail line would be built between Suffern and a new Tappan Zee station and connect with the Hudson Line, as in Alternative 4B. Bus rapid transit would run between Tarrytown and Port Chester, with transfers between the new rail line and the BRT available at the Tappan Zee station.

** All cost figures are in 2004 dollars and include the cost of a replacement bridge. Cost figures are taken from the Tappan Zee Bridge/I-287 Corridor Environmental Review Alternatives Analysis (Jan. 2006).*

Source: Tappan Zee Bridge/I-287 Environmental Review Alternatives Analysis (Jan. 2006)


I-287 Programmed Improvements
Safety and Operational Improvements at Selected Locations in Westchester County
Commuter Rail Transit
Transportation Demand Mgmt. Transportation System Mgmt.
Eight General-Purpose Lanes
High Occupancy Toll Lanes
Climbing Lane
Replacement Bridge
Suffern North Station/P+R
Suffern
Roadway Reconstruction
Monsey
Spring Valley
Bardonia
Nyack
Tallman
Airmont Road/P+R
Int 14/PVL Station/P+R
Palisades Mall Station/P+R (Viaduct)
West Nyack
Nanuet
Tunnel
Adjacent North
Replace
Existing Tarrytown Station
Shuttle Bus Service
Tarrytown
Greenburgh
New Tappan Zee Station
Elmsford
Greenburgh Station/P+R
Irvington
Orangetown
Blauvelt Interstate Park
Hawthorne
Valhalla
Westchester County Airport
Westchester Mall
Harrison
White Plains
White Plains Station
Corporate Park Drive
Purchase Station/P+R
New Haven Line Connection
Port Chester
Scarsdale
Hudson River
Alternative 4A
Full Corridor CRT
Existing Station with New Transfer Facilities
Existing Station
New Station
New Transfer Station
P+R Park and Ride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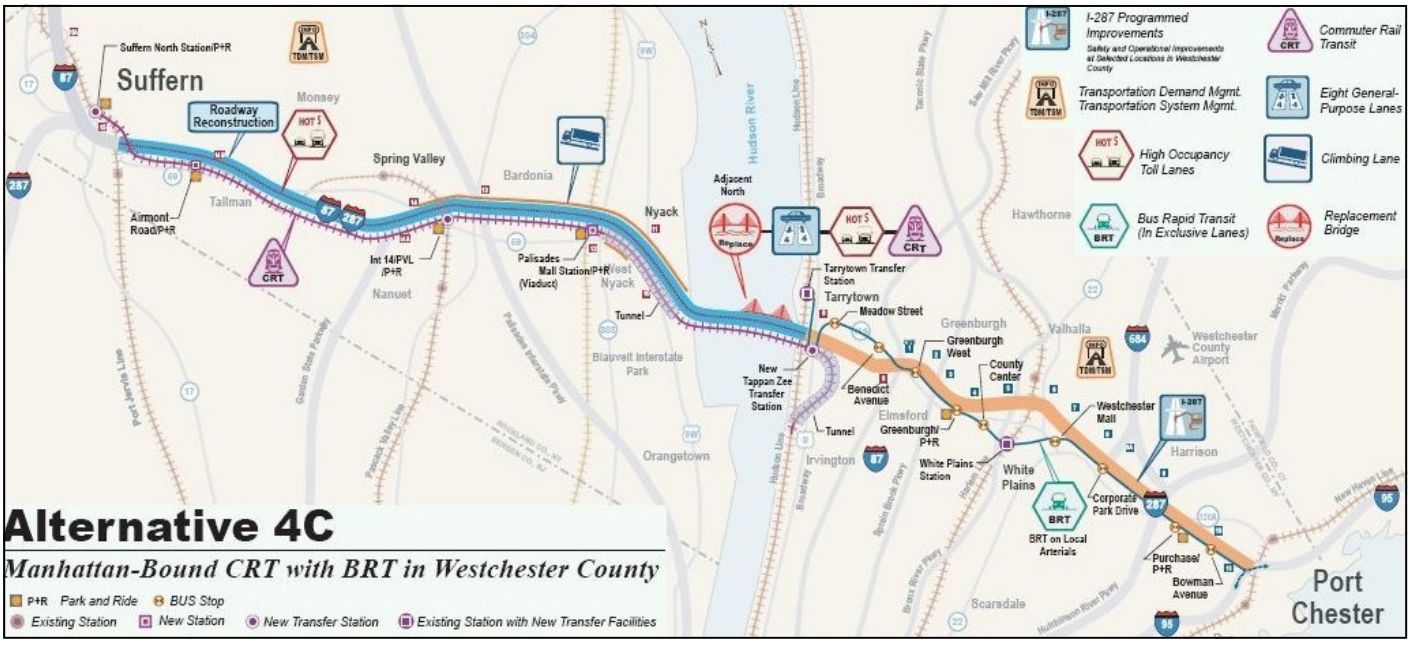
Int 14/PVL /P+R
Palisades Mall Station/P+R (Viaduct)
West Nyack
Nanuet
Tunnel
Adjacent North
Replace
Tarrytown Transfer Station
Tarrytown
Meadow Street
Benedict Avenue
Greenburgh
Greenburgh West
New Tappan Zee Transfer Station
Elmsford
Greenburgh P+R
County Center
Irvington
Orangetown
Blauvelt Interstate Park
Hawthorne
Valhalla
Westchester County Airport
Galleria Mall
Westchester Mall
Harrison
White Plains
White Plains Station
Corporate Park Drive
Purchase /P+R
Terminal at Port Chester Station
Boston Post Road
Bowman Ave
Port Chester
Scarsdale
Hudson River
Alternative 4B
Manhattan-Bound CRT with LRT in Westchester County
P+R Park and Ride
Existing Station
New Station
New Transfer Station
Existing Station with New Transfer Facilities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Greenburgh
Greenburgh West
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Benedict Avenue
New Tappan Zee Transfer Station
Elmsford
Greenburgh P+R
Irvington
Orangetown
Blauvelt Interstate Park
Hawthorne
Valhalla
Westchester County Airport
Westchester Mall
Harrison
White Plains
White Plains Station
Corporate Park Drive
BRT on Local Arterials
Purchase P+R
Bowman Avenue
Port Chester
Scarsdale
Hudson River
Alternative 4C
Manhattan-Bound CRT with BRT in Westchester County
P+R Park and Ride
BUS Stop
Existing Station
New Station
New Transfer Station
Existing Station with New Transfer Facilities

Transit Ridership, Density, and the Suburban Problem

Before discussing which transit alternative is the best fit for the Tappan Zee corridor, it is worth discussing how transit works—why governments build transit, how people decide to ride transit, and why density and transit ridership are related.

To maximize ridership, a transit system must connect many different places and do so quickly, affordably, and pleasantly, relative to driving.

There are a number of social, environmental, and economic benefits to building transit. Transit provides access to jobs and shopping for those who do not own cars, and provides a choice to those who do. It reduces traffic congestion and pollution when it attracts riders who would otherwise drive. Transit access has also been proven to increase real estate values and drive land-use changes.[10]

There are additional incentives for transit agencies to maximize system ridership. All other variables equal, higher ridership means higher farebox revenue for a transit agency, and less reliance on government funding (which can change year-to-year with the whims of elected officials). Most transit capital projects are partially funded by the federal government, and ridership is one of the determining factors federal agencies use in deciding which projects to fund. Competition for federal transit funding has increased as interest in transit has intensified across the United States.

Multiple studies have shown that density is correlated with the percentage of trips made by transit. Boris Pushkarev and Jeff Zupan identify 7 dwelling units per acre as a threshold density (in the U.S.) above which transit use dramatically increases.[11] According to Peter Newman and Jeff Kenworthy, this density translates to roughly 14-16 persons/acre.[12]

This relationship becomes explicable when one considers why people choose to take transit. At "Finding Transit That Fits in the Tappan Zee Corridor," Alan Hoffman of the planning firm The Mission Group identified three questions that people ask themselves when considering whether or not to take transit:[13]

- *Will transit take me from where I am to where I want to go?* American case studies suggest that most people are willing to walk up to a half-mile to and from a transit station, a distance which varies with the "friendliness" of the pedestrian environment.[14] In denser areas, this half-mile radius will include more origins and destinations, and the pedestrian environment will generally be safer and more attractive. In car-dependent areas, destinations are dispersed and rarely connected to transit stations by safe walking routes.

- *Will it take me there quickly?* Hoffman finds that whether or not a vehicle gets stuck in traffic is the primary concern of the "choice" market.[15] Some customers also strongly dislike waiting at stations and perceive waiting as taking much longer than it actually does.[16] In denser, more congested areas, trains and buses in dedicated lanes can move significantly faster than cars.

Densities of Selected Municipalities in the Tappan Zee Corridor

Municipality	Density (Persons/Acre)	Municipality	Density (Persons/Acre)
Suffern	8.23	Tarrytown	5.82
Airmont	2.66	Elmsford	6.67
Monsey	10.24	Greenburgh	4.44
Spring Valley	18.94	White Plains	8.46
Chestnut Ridge	2.48	Rye Brook	3.87
Nanuet	4.81	Rye (city)	4.04
Nyack	13.67	Port Chester	18.47
New York City	*41.25*	*Manhattan, NYC*	*104.59*

Source: TSTC calculations using data from 2000 U.S. Census.

- *Will it make me feel good about my decision to take transit?* Clear announcements, visible security measures, understandable route maps, and "next bus/train" information displays can greatly enhance the customer experience. Making transfers as convenient as possible, or eliminating them outright, is also critical. Research suggests that transit riders abhor transfers so much that they perceive them as taking up to three times as long as they actually do.[17]

We would add another question:

- *Is transit affordable and cost-competitive with driving?* Transit planners often use as a rule of thumb the Simpson-Curtin formula, according to which a 10% increase in fares leads to a 3% decrease in transit ridership; recent studies suggest that ridership is more sensitive to fare changes today, though factors like economic growth can change these predictions.[18] Governments can encourage transit use by keeping fares at a reasonable level, allowing free transfers between modes or between transit agencies, and by reducing driver subsidies like untolled roadways and free parking.[19] In denser areas, congestion increases drivers' fuel costs and the market tends to drive up the cost of parking.

Land-use patterns are fully intertwined with the effectiveness of a transit system. Nationwide, one of the toughest challenges for transit is serving suburb-to-suburb commuters traveling from many origins to many destinations. Buses can connect many origin-destination trip pairs but get stuck in traffic. Trains have the opposite problem: they beat congestion but cost-effectively connect only a limited number of places, as the dense centers of activity required for train stations to be used to capacity are few and far between.

To a large extent, this is the challenge transit faces in the Tappan Zee corridor.

Nationwide, one of the toughest challenges for transit is serving suburban commuters traveling from many origins to many destinations.

Weighing the Transit Alternatives

As the previous section makes clear, transit planning exists not in a vacuum but in the context of a region's topography, settlement and travel patterns, and political environment. Below is a comparison of the proposed mass transit alternatives for the I-287 corridor in this context.

Ridership and Congestion Relief

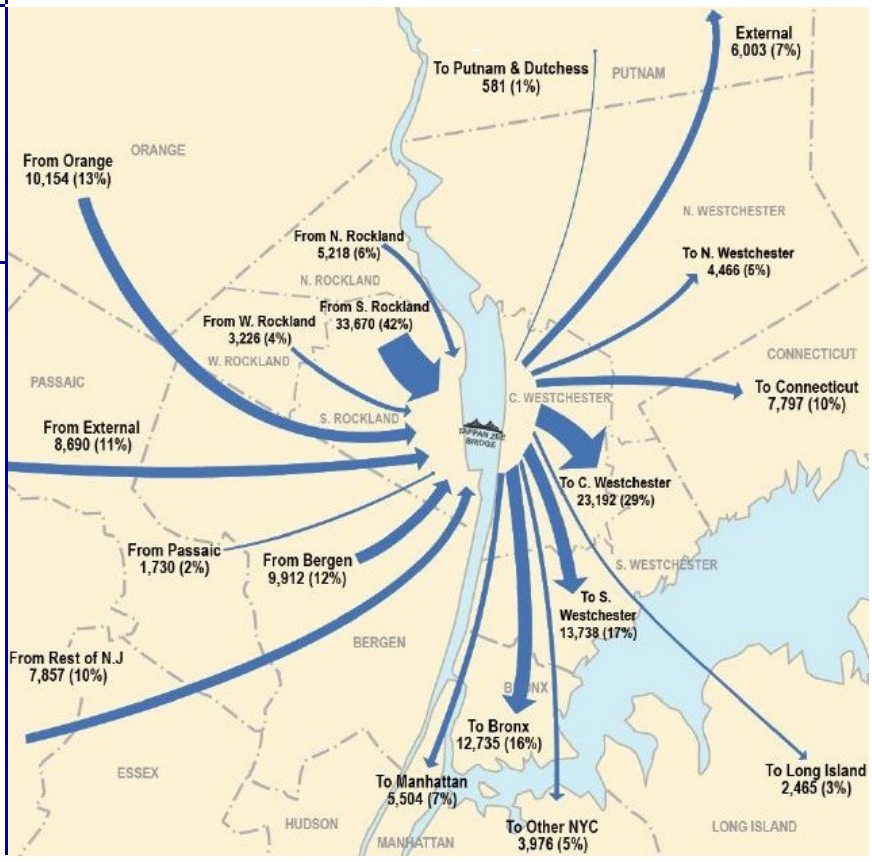
Most users of the Tappan Zee Bridge are driving east-west* across *the corridor,* not *going to Manhattan.

It should be self-evident that in order to reduce congestion on I-287, a transit system must attract the commuters who would otherwise drive on the highway. So who's driving? The Environmental Review project team surveyed eastbound commuters on the Tappan Zee Bridge (roughly 98% of whom drive) and found that, on an average weekday, 65% of trips across the bridge begin in Orange or Rockland County. Slightly more than half (51%) of trips end in Westchester County with another 10% ending in Connecticut; only 28% of trips end in New York City, with more than half of those trips ending in the Bronx. Only 7% of trips across the Tappan Zee Bridge end in Manhattan.[20]

In other words, the main cause of congestion on the Tappan Zee Bridge is not the Manhattan-bound commuting market but east-west travelers commuting to suburban jobs. It follows that the transit alternative which serves the most east-west riders will do the most to relieve bridge congestion. According to the Tappan Zee Bridge Alternatives Analysis, this alternative is full corridor BRT, which the

Tappan Zee Bridge Eastbound Average Weekday Person Trips (Non-Commercial Vehicles, Including Transit)

Source: TZ Bridge/I-287 Corridor Environmental Review Study Team



Mass Transit Alternative	Daily East-West Riders (Projected by 2025)	Total Daily Riders	Capital Cost Per East-West Rider	Capital Cost Per Rider
Full Corridor BRT	**42,000**	**49,000**	**$45,238**	**$38,776**
Full Corridor BRT + Suffern-Manhattan CRT (no longer under consideration)	33,700	63,700	$157,270	$83,203
Suffern-Manhattan CRT + Westchester BRT	30,700	61,700	$146,580	$72,934
Full Corridor CRT	24,000	57,000	$279,167	$117,544
Suffern-Manhattan CRT + Westchester LRT	21,400	54,000	$233,645	$92,593
Existing Tappan Zee Express Bus	—-	~1,400 (current ridership)	—-	—-

Sources: Tappan Zee Express ridership data from Transport of Rockland (2007); all other data from Alternatives Analysis (Jan. 2006).

Methodology: "Capital Cost Per Rider" and "Capital Cost Per East-West Rider" were calculated by dividing the minimum capital cost estimate of each alternative by the number of projected riders and east-west riders, respectively, and do not include the cost of the bridge. Using average or maximum capital cost estimates would not change the ranking of the alternatives.

project team estimates will attract 42,000 east-west commuters a day by 2025—more than 10,000 more east-west riders than any other option currently being considered.[21]

Currently, the two west-of-Hudson rail options are Metro-North's Port Jervis and Pascack Valley lines. Manhattan-bound riders of these lines must transfer at Secaucus Junction for service to Penn Station on Manhattan's west side. Metro-North has long held an interest in providing one-seat service between Rockland County and Grand Central Terminal on Manhattan's east side.[22] To that end, three of the alternatives under consideration include a commuter rail line which runs from Suffern to Tarrytown and then joins Metro-North's Hudson Line, terminating at Grand Central.

However, such a line may not attract enough riders to be cost-justifiable, especially after planned improvements on the Port Jervis and Pascack Valley lines. NJ Transit's cross-Hudson ARC Tunnel will allow both lines to offer one-seat rides to Penn Station, and will also increase capacity on the Port Jervis line.[23] NJ Transit is also building passing sidings which will add midday, evening, and weekend service on the one-track Pascack Valley line by late October 2007.[24]

The project team did not account for the impact of the ARC tunnel in the Alternatives Analysis, meaning that projected ridership on the Manhattan-bound transit alternatives is likely overly high. The effects of ARC will be modeled in the Draft Environmental Impact Statement, the next phase of the environmental review.[25]

Accessibility

Bus rapid transit is projected to carry more east-west riders than any other transit mode because it can, without requiring transfers, connect more origin-destination pairs than light or commuter rail. Rail

provides one-seat rides only to those commuters who live and work within walking distance of stations; other commuters must drive or take transit to the nearest train station, transfer to rail, then transfer to a shuttle bus in order to reach their destinations.

Bus rapid transit can combine all three of these functions in one vehicle. During the morning rush, BRT could pick up commuters in Rockland neighborhoods, enter congestion-free lanes on I-287, then leave I-287 to drop passengers off at Westchester office parks—all without requiring a transfer. In the afternoon, those commuters could get a one-seat ride home.

Full corridor BRT's capital and operating costs are substantially lower than those of the other alternatives. On a capital-cost-per-rider basis, full corridor BRT is about one-third as expensive as commuter rail.

While BRT might not be able to cost-effectively offer a one-seat ride to all commuters, it could do so to a far greater extent than rail. The Environmental Review project team notes in the Alternatives Analysis that compared to commuter rail, BRT "would provide greater transit access to residents and businesses in Rockland and Westchester due to location and number of transit stops."[26]

Full corridor BRT would also serve east-west commuters more effectively than the two hybrid alternatives, which would require Rockland-Westchester commuters to transfer from commuter rail to light rail or BRT at a new station at the east end of the replacement Tappan Zee Bridge.

Cost

How the Tappan Zee project will be funded is unclear and is being examined by the project team in a separate study. It will have to compete for a limited amount of federal funding; any portion of the project not covered by federal monies will have to be paid by state and local governments—an important consideration for a potentially multi-billion dollar project.

Full corridor BRT's capital costs are substantially lower than those of the other three transit alternatives under consideration. Not only is BRT generally cheaper to build than light and commuter rail, but the challenging topography of the Tappan Zee makes a rail bridge difficult and expensive to build.

The project team has estimated that BRT infrastructure will cost $5.0-6.5 billion to build, including the cost of a replacement bridge. Full corridor commuter rail, in comparison, is estimated to cost $11.5-14.5 billion including a replacement bridge.[27] On a cost-per-rider basis, full corridor BRT is about one-third as expensive as full corridor commuter rail. The two hybrid alternatives are also far more expensive than full corridor BRT, with Suffern-Manhattan commuter rail/Westchester BRT costing $9-11.5 billion and Suffern-Manhattan commuter rail/Westchester LRT costing $10-12.5 billion.

Full corridor BRT also has the lowest projected operating and maintenance costs of any alternative—$30 million a year, compared to

$52 million/year for full corridor commuter rail and the Suffern-Manhattan commuter rail/Westchester BRT alternative.[28] The Suffern-Manhattan commuter rail/Westchester light rail would be the most expensive to operate at $63 million/year.

Institutional Concerns

Another unresolved issue is which agency would operate a cross-corridor transit service. For commuter rail, the answer is simple—Metro-North. But who would operate a light rail or bus rapid transit service is an open question. In the two hybrid alternatives, light rail or BRT would operate solely in Westchester County and could be run by the county Department of Transportation. Westchester DOT runs the heavily used Bee-Line bus service and is studying implementing bus rapid transit on Central Avenue between White Plains and New York City; it might therefore be a natural fit to operate BRT in its portion of the Tappan Zee corridor.

Full corridor BRT would fall in a unique situation. It would cross county lines, meaning that county agencies might be unwilling to operate it. Metro-North has no experience running buses. Two speculative options include a new agency under the aegis of the Metropolitan Transit Authority or a partnership between Rockland and Westchester counties.

A combination of Suffern-Manhattan commuter rail and full corridor BRT has a higher projected ridership than any alternative being considered—and would cost less than full corridor commuter rail.

The Lost Alternative

Strangely, an alternative combining Suffern-Manhattan commuter rail and full corridor BRT has been dropped from consideration by the study team. This alternative is projected to attract 63,700 daily riders, more than any alternative under consideration, and would cost less to build that full corridor commuter rail*. As with all alternatives which include Manhattan-bound commuter rail, the ridership projection may be optimistic. However, this alternative merits further study given its ridership and/or cost advantages over the alternatives under consideration.

In response to requests from the Tri-State Transportation Campaign, the Regional Plan Association, and others, the project team has said it may reconsider this alternative in the Draft Environmental Impact Statement, the second phase of the environmental review.[29] However, while a commuter rail line between Suffern and Manhattan may improve access to New York City for Rockland commuters, the project team's top priority should be providing effective transit to cross-corridor commuters who are starved for it. Based on the available data, full corridor BRT seems at this point to be the most effective solution for the corridor's suburb-suburb commuters.

** Because the Suffern-Manhattan commuter rail/full corridor BRT alternative was dropped from consideration, the project team did not estimate capital costs including the cost of a bridge; not including the cost of a bridge this alternative would cost $5.3-6.8 billion compared to $6.7-8.5 billion for full corridor commuter rail. (Alternatives Analysis)*

What is Bus Rapid Transit?

Bus rapid transit (BRT) has ridership and cost advantages in the I-287 corridor, but is an emerging technology that is still largely unknown; no BRT systems exist in the tri-state area. This lack of familiarity with BRT may be biasing the policy discussion in the Tappan Zee corridor and was the impetus for the Tri-State Campaign's "Finding Transit that Fits in the Tappan Zee Corridor" symposium. A review of existing bus rapid transit systems shows that BRT and the city bus have only a few things in common.

The Federal Transit Administration has defined bus rapid transit as "a rapid mode of transportation that can provide the quality of rail transit and the flexibility of buses."[30] Like rail, BRT carries many passengers and provides fast, frequent service that avoids automobile congestion. Like a traditional bus system, BRT can serve dispersed, low-density areas in ways rail cannot.

Riding a typical bus is often an exercise in waiting—waiting in traffic, waiting for passengers to embark and disembark, waiting so that buses stick to their published timetables. Bus rapid transit is designed to overcome these obstacles both on the road and at the station:

On the road, buses escape automobile traffic and move quickly through congested areas by running on **dedicated rights-of-way**. These include bus-only highways ("busways") and bus-only lanes on general purpose roads; these must be physically separated from general traffic or vigorously enforced if they are to succeed. In many situations buses can also share high-occupancy vehicle or high-occupancy toll lanes (HOV lanes that single-occupancy vehicles can pay a toll to enter). In many BRT systems, buses are given **traffic signal priority**, using transponders to "hold" green lights open or cause red lights to change early so that buses can clear intersections without stopping or with shorter than usual waits.

At heavily trafficked stations, efforts to speed up boarding can dramatically reduce delays. **Off-vehicle fare payment** can be implemented in different ways. In Curitiba, Brazil, riders pay upon entering a bus station, then walk through a turnstile and to their bus. In Los Angeles, tickets are purchased at station vending machines and randomly checked by inspection personnel on board buses. Because riders no longer need to pay on the bus, they can board faster and at **multiple doors**.

Better bus design also speeds boarding. Low-floored buses with wide doors eliminate the need for passengers to walk up stairs to get to their seats. These buses can be driven so that the floor aligns with the platform or curb edges, allowing for **level boarding**, a particular benefit to mobility-impaired riders.

Faster Boarding: From Long Lines...

This traditional bus in Boston has a farebox at the front of the vehicle. At busy stops, this leads to long delays as customers wait to pay. Photo: Mika Tomczak/MIT.

...To No Lines:

Boarding on Las Vegas' MAX bus rapid transit system is significantly faster than on its regular buses. MAX's delay-reducing features include off-vehicle fare payment, level boarding, and buses with multiple doors. Photo courtesy RTC of Southern Nevada.

While any of these innovations can be used to improve regular bus service, in combination they allow a BRT system to operate like a rail system, carrying many more passengers than a traditional bus network. As on a metro or subway system, a high-capacity BRT line is usually a simple corridor with stops spaced far apart and with frequent service (at least 6 buses/hour). In Ottawa, Canada, the busiest points on the Transitway (the dedicated busway at the heart of Ottawa's BRT system) handle 10,000 passengers per direction per hour, the equivalent of ten freeway lanes.[31] The system in Curitiba, Brazil uses multi-lane busways and carries more than 15,000 passengers per hour.[32]

These capacities are less than the theoretical capacity of light rail (many light rail systems are severely underused) and less than that of metro/subway, which can carry more than 50,000 passengers per hour.[33] However, such massive capacities are required only in very dense urban areas. Moreover, BRT can be constructed at less cost than rail systems. One estimate puts BRT's average capital costs at $7-55 million per mile for a system using busways compared to $12.4-118.8 million per mile for light rail.[34]

The upshot of this is that BRT can, in all but the densest areas, provide rail-like service at a fraction of the capital cost. But BRT can also effectively serve low-density neighborhoods, delivering service penetration unmatched by rail. This is because buses can leave the busway and enter suburban roads, stopping more frequently at dispersed stops; BRT can act like a traditional bus when doing so makes sense.

At "Finding Transit That Fits in the Tappan Zee Corridor," Ottawa was cited as particularly relevant to the I-287 corridor. Outside of its central business district, Ottawa is a city of suburban character; it is less dense than many of the municipalities in the I-287 corridor (see table at right). Yet 20% of all travel within the city—and 70% of commuting to downtown—is done via public transit.[35]

Many of Ottawa's most popular BRT routes connect suburban and rural neighborhoods off of the Transitway with employment centers on the Transitway. In residential areas, the BRT acts more like a traditional bus, stopping more frequently to collect passengers. The bus then enters the Transitway to avoid congestion and brings commuters to job sites. 95 percent of Ottawa residents who use transit live within a quarter-mile of a bus stop, reducing the need for large "park and ride" facilities.[36]

One challenge for BRT is to attract riders who may justifiably think of buses as slow, crowded, and unreliable. In the short term, BRT systems can overcome this bias through aggressive marketing, branding, and modern design of buses and stations. In the long term, of course, BRT must distinguish itself from regular bus by providing quality service. Systems that have done this, including those in Los Angeles and Las Vegas, have attracted riders who chose transit though they had other options, like driving.

BRT Speeds Through Congested Areas...

Bus lanes and busways allow buses to escape traffic congestion and provide fast, reliable service. Unlike a train, a BRT bus can effectively serve low-density neighborhoods by leaving the busway. Above, Pittsburgh's Martin Luther King Busway.

...And Serves Lower-Density Places

Comparison of Municipal Densities in the I-287 Corridor and in Ottawa, Canada

Municipality	Density (Persons/Acre)
Suffern	8.23
Monsey	10.24
Spring Valley	18.94
Nyack	13.67
Elmsford	6.67
White Plains	8.46
Port Chester	18.47
Ottawa (urban area)	**8.03**
New York City	*41.25*

Source: TSTC calculations using data from 2000 U.S. Census, 2001 Census of Canada, and 2005 Ottawa Land Use Survey.

Note: Ottawa's "urban area" holds nine-tenths of its population but makes up only 12.6% of the municipality's total area; the rest is largely undeveloped greenbelt land and rural farms and villages. Thus the urban area's density is a more accurate indication of the densities that can support BRT.

Ottawa is a city of suburban character—yet 20% of all travel within the city is done via public transit.

An Emerging Solution

While early adopters of bus rapid transit, such as Curitiba (whose system opened in 1974), Pittsburgh (1977), and Ottawa (1983), have shown that BRT is an effective transit mode, it is only over the last decade and a half that interest in BRT has skyrocketed to its current level as its ability to serve lower-density neighborhoods and its cost advantages over other modes have become better known. Today, BRT systems operate in 19 countries on five continents, with many more systems being constructed or planned.

Interest in the mode has also come from the federal level. Since 1999, when the Federal Transit Administration launched a BRT demonstration program, BRT systems have been implemented in Boston; Eugene-Springfield, Ore.; Santa Clara County, Calif.; and are currently being implemented in Cleveland; Hartford, Conn.; Houston; New York City; Westchester County; and other places. Out west, there are two American success stories:

Las Vegas

In 2004, the Regional Transportation Commission of South Nevada introduced MAX (Metropolitan Area Express), a BRT line acting as a supplement to the heavily-used Route 113 bus line in Las Vegas. This service incorporated architecturally pleasing stations, high-capacity European buses with multiple doors, off-vehicle fare payment, dedicated bus lanes on most of the route, signal priority, and level boarding at bus stations. After six months, ridership on the corridor had increased by 25 percent (from 7,800 to 9,800 passengers per day), and 25 percent of MAX riders said they were new to transit.[37] MAX cut travel time on the 7.5-mile corridor in half (to 25 minutes) and gained a reputation for reliability and convenience (as measured by passenger surveys).

Below: The Civis vehicle used by Las Vegas's MAX bus rapid transit system. Photo courtesy RTC of Southern Nevada.

Los Angeles

Los Angeles is often considered the city of the automobile, but it has also engineered two successful experiments in bus rapid transit. In 2000, the city unveiled "Metro Rapid" bus service on two demonstration corridors. Metro Rapid lines incorporated simple routes, frequent service, signal priority, level boarding, and an aggressive branding and marketing campaign; this "BRT-lite" (not incorporating dedicated lanes, high-capacity buses, off-vehicle payment, or multiple-door boarding) service improved travel time on both corridors by more than 20%, increased ridership by about 40% (daily ridership on the two corridors was 77,000 before Metro Rapid service began, and 107,400 after), and was perceived by riders as "a quantum leap in service performance and quality."[38] About a third of the increase in ridership was from new transit users. Los Angeles has since created additional Rapid corridors and will have a total of 28 Rapid lines by 2008.

In 2005, Los Angeles opened the Orange Line, a full-fledged BRT service which featured a dedicated busway, off-vehicle payment, and the Metro Liner, a 60-foot bus that the LA Metropolitan Transit Authority bills as "the most advanced transit vehicle ever introduced in North America... the biggest leap in style and appearance our industry has seen in 30 years."[39] During preliminary studies, Los Angeles' MTA projected 22,000 daily boardings on the 14-mile corridor by 2020. The Orange Line averaged 21,828 daily weekday boardings in May 2006, nearly meeting this prediction 14 years ahead of schedule.[40]

Above: The Metro Liner used on Los Angeles' Orange Line bus rapid transit corridor. Photo: Deniz Durmas/Los Angeles MTA.

Below: The success of the "BRT-lite" Metro Rapid service is proof that relatively modest improvements in bus service can result in significant ridership gains.

BRT and Transit-Oriented Development

In addition to providing commuters with an effective alternative to driving, a cross-corridor transit system like bus rapid transit could afford municipalities the opportunity to pursue transit-oriented development (TOD). TOD is a land-use strategy whereby residential, office, and retail development is concentrated around transit stations. The term also refers to the developments themselves. TODs are typically mixed-use, walkable developments with higher-than average density. Compact development oriented around transit stations has been proven to increase transit ridership and increase real estate values around the station.[41]

A comprehensive assessment of TOD as practiced in the United States identified many other benefits.[42] Transit-oriented developments tend to command higher rents than comparable developments not close to transit, yet are also natural locations for affordable housing as residents of TODs do not need to own as many automobiles or use them as often as non-TOD residents. TOD is therefore a strategy that can both revitalize struggling neighborhoods and attract development. Because transit-oriented developments are denser and create less car use than non-TODs, a land-use strategy focusing on TODs preserves open space and reduces the cost of infrastructure such as roads and sewage lines. Reduced car use means reduced traffic congestion and air pollution.

Proponents of TOD do not claim that these benefits magically appear through the creation of a transit stop; rather, they accrue from the synergy between transit access, mixed-use development, and density. Maximizing these benefits requires careful design; there is no "one-size-fits-all" TOD blueprint. Project for Public Spaces is one internationally known nonprofit which focuses on what it calls "placemaking," for example. In addition, some private developers specialize in building TODs.

In poor market conditions, development is less likely to occur. But when market demand exists, land-use regulations and developer incentives can focus growth around transit stations. For example, New Jersey's Transit Village Initiative provides funding and technical assistance to 19 designated "transit village" municipalities which engage in TOD around NJ Transit rail and bus stations (see left). Boston's TOD-supportive policies include a cap on downtown parking, a requirement that plans for large developments include transportation mitigation, and increased police presence around transit stations considered unsafe.[44] In many municipalities, zoning regulations must be tweaked to allow for mixed-use developments.

It has been argued that developers shy away from bus transit-oriented development because of buses' lack of permanence—unlike a rail line, a bus route can be easily changed, hurting busi-

TOD in Action: Rahway, N. J.

Rahway, N.J., was one beneficiary of New Jersey's Transit Village Initiative, which provides $3 million in small grants and technical assistance to municipalities with a proven interest in transit-oriented development.

Rahway certainly fits the bill. A $13 million renovation of the NJ Transit rail station and the construction of an adjacent plaza transformed it into a community gathering place. Rahway's sustained efforts to revitalize downtown and its commitment to transit-oriented planning have paid off. Between 1999 and 2003, $103 million of construction activity occurred within a half-mile of the train station, and the development hasn't stopped since then.[43] Projects currently being built near the train station include condominiums, offices, small and large shops, and hotels.

nesses built to take advantage of proximity to transit. This criticism is not particularly relevant to high-end, capital-intensive bus rapid transit systems. BRT may be cheaper to implement than rail, but it still represents a sizeable investment, particularly when dedicated busways are involved. A review of the academic and government literature on bus rapid transit and transit-oriented development concluded that "the argument that fixed rail infrastructure has more magnitude and permanence compared to busways is weak."[45]

In Ottawa, transit-oriented development centered around BRT has been wildly successful. Strong land-use controls have concentrated commercial development around Ottawa's Transitway.[46] Between 1988 and 1991 alone a billion Canadian dollars of development was built or in the process of being built along the Transitway. Stations anchor office parks, shopping malls, and mixed-use developments; one station is even directly connected to a hospital.

More evidence for bus transit-oriented development comes from Pittsburgh's busway system. A 1996 analysis of Pittsburgh's 9.1-mile East Busway found that between 1983 (when the busway opened) and 1996, 59 new developments (including retail, office, residential, and medical complexes) valued at $302 million had been built within a 6-minute walk of busway stations.[47] This was despite terrain constraints which limited development opportunities, despite declining population in the communities adjacent to the busway, and despite the absence of Ottawa-style land-use planning. The Port Authority of Allegheny County estimates that another $203 million in development occurred between 1996 and 2004.[48]

These are not the only successes. Areas as far-flung and different as Seoul, Korea; Curitiba, Brazil; and Boulder, Colorado have had success with bus-centered TOD.[50] It can happen here as well. At a recent land use charette, the Regional Plan Association identified several spots in the Rockland half of the Tappan Zee corridor that could support transit-oriented development, including Nanuet, Airmont and Montebello, and Suffern. The Westchester Department of Planning has identified Tarrytown, White Plains, and Port Chester as areas primed for downtown density increases. [51]

The success of transit-oriented developments depends on multiple factors, including political leadership, government incentives, land-use regulations, the strength of the real estate market, and the level of traffic congestion in the area (which affects demand for transit-oriented living). But it cannot be overemphasized that one of the most critical factors is the effectiveness of the transit system. Only when a transit system effectively connects places does access to transit—the heart of the TOD concept—become a valued commodity. And so the question of which transit mode can best support TOD is inextricably linked to the question of which transit mode is best suited to the development and commuting patterns of a given area.

TOD in Action: Curitiba, Brazil

Curitiba was one of the first cities to demonstrate BRT's potential to shape urban form. Zoning regulations have concentrated high-rise development around the city's five major BRT corridors, and the municipal planning authority has allowed large retail centers to be built only along these corridors.[49]

Below: Shopping Curitiba, the largest mall in the city, is easily accessible by bus.

Conclusion: The Future of the Tappan Zee/I-287 Corridor

What will the Tappan Zee corridor look like in 2020 and beyond? The answer to that question will depend in part on what solutions are chosen now for the area's traffic problems. If nothing is done, or if the chosen remedy fails to take cars off the road, the future of the corridor will be one of congestion and of all the ills that come with it: lost economic opportunities, increased air pollution, and lowered quality of life for commuters stuck in the stress and delay of traffic. Without mass transit investment, future growth will necessarily be auto-dependent sprawl development that will only worsen traffic problems.

But a future which includes effective mass transit can be a very different one. In this future, transit connects people's homes and their workplaces. In this future, drivers on I-287 always have a congestion-free option, whether that is to ride mass transit or to pay for access to an HOT lane. In this future, transit-oriented development reinforces the transit system, allowing for sustainable growth that doesn't come with the economic, environmental, and health costs of congestion.

This future, however, can only occur if mass transit is effective—that is, if it takes people from where they are to where they want to go, and if it does so quickly, conveniently, and affordably. In the I-287 corridor, commuters are traveling from suburb to suburb, from east to west, from many origin points to many destinations. They represent a dispersed travel market that requires a flexible transit system.

Full corridor bus rapid transit is the alternative being studied which can offer the most flexibility. With an intelligent service plan, BRT can provide convenient one-seat rides between more destinations than light rail or commuter rail can, and can provide fast, congestion-free service by running on dedicated rights-of-way. It has the ridership capacity and magnitude of investment to induce transit-oriented development, and is more cost-effective than any other alternative.

In the keynote address at "Finding Transit that Fits in the Tappan Zee Corridor," Scenic Hudson president Ned Sullivan talked of the open space that was forever lost after the Tappan Zee Bridge opened up the region that is now the I-287 corridor to sprawl. While the completion of the new Tappan Zee Bridge will not cause as rapid or drastic a shift in urban form as the old, it represents the single largest opportunity to shape the corridor in the foreseeable future. Effective transit and a land-use vision that embraces transit-oriented development will ensure that the new bridge leaves a more sustainable legacy than the old.

What's Next?

The NYS Department of Transportation and the rest of the Tappan Zee environmental review study team is currently working on the Draft Environmental Impact Statement, in which it will examine all of the transit alternatives in further detail. The DEIS is expected to be released in Spring 2008. After a period for public comment, the project team will begin work on the Final Environmental Impact Statement and produce a Record of Decision—the selected alternative. Construction of a new bridge or the rehabilitation of the existing bridge may begin as early as 2010, and is expected to take five years.

Public involvement will continue throughout the process. The project team is required by law to hold public hearings after the release of the DEIS, and will likely hold additional informational meetings. Groups like the Tri-State Transportation Campaign will work to ensure that the process is as transparent as possible, that all alternatives are given a fair analysis, and that corridor stakeholders are fully involved and informed.

The official website of the Tappan Zee Bridge/I-287 Environmental Review is **http://www.tzbsite.com**. It includes announcements of future public meetings and a library of study documents, published reports (including the Alternatives Analysis), and materials distributed at past public meetings.

The Tri-State Transportation Campaign is a 501(c)(3) non-profit organization working towards a more balanced, transit-friendly, and equitable transportation system in New York, New Jersey, and Connecticut.

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