An Assessment of the Balanced Transportation Analyzer’s Move NY Revenue Projections

Final Report

Presented to:

Blue Marble Project and the Move NY Campaign

HNTB Corporation
December 3, 2013
Move NY gratefully acknowledges the generous support of Alan Bell of Bell Urban, LLC for providing the funding that made this report possible.
**Table of Contents**

Section 1. Purpose ...................................................................................................................................... 4  
Section 2. Cordon Tolling Overview ..................................................................................................... 5  
Section 3. Summary of Work to Date ................................................................................................... 7  
Section 4. General Comments on BTA ................................................................................................. 8  
Section 5. Data Validation ...................................................................................................................... 11  
Section 6. Review of Key Results ......................................................................................................... 14  
  Revenue....................................................................................................................................................... 14  
  Traffic Volumes and Speeds.................................................................................................................... 16  
  County & Borough Incidence of Tolls.................................................................................................. 17  
  Benefit-Cost Calculations....................................................................................................................... 18  
Section 7. Alternative Scenarios Analysis ........................................................................................... 19  
Section 8. Sensitivity Analysis ................................................................................................................ 22  
Section 9. Comparison with Other Cordon Tolling Experiences ................................................ 29  
Section 10. Recommendations & Areas for Further Study .................................................................... 31  
Appendix A Correspondence with Prof. Kenneth Small................................................................ 34  
Appendix B Estimating a Reasonable Range of Non-Revenue Percentages................................. 37  

**Index of Figures**

Figure 1 – Overview of Move NY Baseline Proposal............................................................................... 6  
Figure 2 – Data Validation Outline........................................................................................................ 13  
Figure 3 – Revenue Components of Move NY Baseline Plan (in millions of dollars) .................... 15  
Figure 4 – Historical Growth of E-ZPass Usage on TBTA Crossings, 2003-2012 .......................... 39  

**Index of Tables**

Table 1 – Scenario Description Summary............................................................................................ 20  
Table 2 – Comparison of Alternative Scenarios (in annual millions of dollars) .................................. 21  
Table 3 – Sensitivity Analysis Results .................................................................................................... 25  
Table 4 – Comparison of Extreme Optimism and Extreme Pessimism Scenarios ......................... 28  
Table 5 – Cordon Tolling Comparison .................................................................................................. 30
Section 1. Purpose

The purpose of this study was to provide an in-depth review of the Balanced Transportation Analyzer (BTA), a detailed spreadsheet model designed to forecast the traffic and revenue impacts of various proposed cordon tolling schemes for Manhattan. This review, performed at the request of Move NY and the Blue Marble Project, involved an evaluation of the following:

- **Soundness.** A sound model is one in which the internal calculations are performed accurately and for which all cell references are linked correctly. Stated another way, a sound model must have all of its internal “plumbing” connected properly. HNTB reviewed hundreds of key linkages within the model to ensure the model’s soundness.

- **Robustness.** A robust model is a model that is able to evaluate a wide range of scenarios without crashing or yielding irrational answers. HNTB performed numerous “stress tests” on the BTA to assess its ability to handle significant changes in a wide array of key inputs.

- **Reasonableness.** A reasonable model is a model whose high-level results are consistent with what one observes in the real world. To evaluate the model’s reasonableness, HNTB continually posed the following three questions during its analysis: First, do the model's most fundamental outputs—namely, change in average vehicle speed and increase in net revenue—make sense under a given set of assumptions? Second, do the fundamental outputs change in a reasonable way when key assumptions are varied? And third, if the changes do not appear to be intuitive, is there a reasonable explanation based on a more detailed review of the model's internal function?

The model's soundness was evaluated through a detailed review of the model's structure, its key formulas, and the relationships among the various tabs that comprise the model. Both soundness and robustness were tested through an evaluation of various scenarios and through sensitivity analysis. Finally, the model's reasonableness was tested through a detailed look at the BTA's projections of key results. This included a review of the model's forecasts of revenue, of projected traffic volumes and speeds, of county and borough incidence of tolls, and of benefit-cost calculations.

This assessment of the BTA proceeds in the following manner:

- Section 2 provides an overview of the proposed cordon tolling program.
- Section 3 provides a summary of the work that HNTB performed during the course of the study.
- Section 4 summarizes HNTB’s general comments on the BTA.
- Section 5 documents HNTB’s validation of traffic data employed by the BTA.
- Section 6 contains an assessment of the BTA’s projections of key results.
• Section 7 provides an analysis of alternative scenarios as defined and requested by Move NY.
• Section 8 contains a sensitivity analysis of selected variables to evaluate their impact on key model results.
• Section 9 provides a brief comparison of the BTA’s Baseline forecasts with cordon tolling experiences in other cities.
• Section 10 provides a series of recommendations and areas for further study.

Section 2. Cordon Tolling Overview

The BTA is designed to forecast the traffic and revenue impacts of various cordon tolling proposals for Midtown and Lower Manhattan. Though the specifics of the various proposals vary, they generally contain the following basic elements:

• The imposition of a cordon toll for all automobiles (not including taxis) driven into Manhattan’s Central Business District (CBD). The CBD is defined as all points on Manhattan south of 60th Street.
• The imposition of a surcharge on all medallion taxis operating south of 96th St. These surcharges include a per-trip (or “drop”) charge, a surcharge on the per-mile rate, and a surcharge on the wait time rate.
• A reduction in tolls on six “Outer-Borough” bridges.¹

The BTA operates on the premise that the revenue to be generated by the cordon tolling program (unless designated otherwise) will be poured back into the transportation system. The investments may be differentiated between the roadway network and the transit network. The model makes further estimates regarding the extent to which the transit investments could in turn improve service and attract more users.

Figure 1 provides an overview of the layout of the proposed cordon tolling program. It should be noted that the BTA, while equipped to evaluate the program outlined in Figure 1, is actually capable of assessing a broad array of toll and fare scenarios. For example, it enables the user to charge taxis a cordon toll as opposed to a CBD surcharge. It allows the user to evaluate various toll discount levels on the Outer-Borough bridges and various levels of tolls on the Queensboro Bridge upper roadway. Moreover, the BTA is flexible and allows for cordon tolls to vary by time of day as well as by type of day (i.e. weekdays vs. weekends). It also allows for the cordon toll to be differentiated between automobiles vs. commercial vehicles. In short, the BTA has built-in versatility to allow it to do more than is documented in this memorandum.

¹ The Move NY baseline plan calls for a toll reduction on the Bronx Whitestone, the Cross Bay, the Marine Parkway, the Throgs Neck, the Triborough, and the Verrazano Narrows bridges.
All vehicles (except medallion taxis) entering CBD (south of 60th St.) pay round trip cordon toll of $10.66.

Vehicles entering Manhattan via Queensboro Bridge Upper Roadway pay $2.83 to enter.

Medallion Taxis operating south of 96th St. are assessed a surcharge.

Holland and Lincoln Tunnel tolls are not changed.

Outer-Borough Bridges receive toll discounts of 48% (E-ZPass) & 33% (Cash/License Plate).
Section 3. Summary of Work to Date

HNTB’s approach to reviewing the BTA involved five basic steps.

- **Step 1** was to learn the model’s structure. The BTA is an Excel-based model with 62 unique worksheets (or “tabs”), most of which are interconnected. HNTB took a significant amount of time to understand both the fundamental components of the model and the relationships among these components. This process was aided by a conference call at the beginning of the project, in which Mr. Charles Komanoff, the developer of the BTA, provided an overview of the model’s structure and purpose.

- **Step 2** was to study the model’s mechanics. This involved looking at each tab and reviewing how it functioned.

- **Step 3** was to identify the key assumptions and to examine how the model’s key results responded to changes in these key assumptions.

- **Step 4** was to conduct an ongoing dialog with Mr. Komanoff in order to ask questions and provide feedback. This interaction was critical in order to (a) improve HNTB’s understanding of the model, and (b) provide Mr. Komanoff with a stream of information that could support the ongoing process of revising and updating the model. Over the course of the study, the dialog between HNTB and Mr. Komanoff resulted in six unique updates to the BTA. Each update was made by Mr. Komanoff and was reviewed by HNTB.

- **Step 5** was to repeat Steps 2 through 4 as necessary to test and confirm the validity of any changes made to the BTA.

The modifications made to the BTA over the course of the study included the following:

- Some errant cross-references within the model were identified and corrected. Examples of such corrections included cell references pertaining to volumes on the upper roadway of the Queensboro Bridge (QBB) and cell references between the “MTA Crossings” and the “User Inputs” tab.

- The methodology for estimating the reduction of traffic on the QBB upper roadway was changed. Previously, the model used a fixed percentage; this was changed to a formula-driven percentage based on the proposed toll rate and the assumed toll elasticity of demand. This change provided more realistic results, since the actual traffic reduction would be dependent on the magnitude of the toll rate and the responsiveness of drivers to that toll rate.

- Some minor discrepancies concerning bus revenue calculations were fixed. Previously, some calculations were based on 2012 actual numbers while others were based on 2013 projected numbers. All calculations were subsequently changed to be based on 2013 projections for consistency purposes.
• Several points of annotation and documentation were updated and clarified. For example, the new BTA more clearly documents the rationale for estimating the share of George Washington Bridge traffic that ultimately enters the Central Business District (CBD), defined as the section of Manhattan south of 60th Street (encompassing Midtown and Lower Manhattan).

• Many parts of the taxi tab were overhauled. The new version accomplishes the following:
  o It accounts for an apparent change in the existing fare structure, as posted on the New York City Taxi & Limousine Commission’s website.
  o It clarifies the geographical breakdown of Medallion taxi trips (e.g. the distinction between intra-CBD trips, trips between the CBD and points north of 96th Street, and trips completely outside the CBD).
  o It revises formulae used to convert speeds and travel times into taxi fares. Prior to the revision, the formulas tended to underestimate the number of miles driven when the taxi was traveling at speeds greater than 6 mph.
  o It provides a more consistent treatment of fare-trips versus person-trips. Prior to the revision, the model didn’t properly account for the fact that the average occupancy in an automobile was different than the average occupancy in a taxi.

The latest version of the BTA (dated October 8, 2013) incorporates all changes resulting from HNTB’s research and analysis. The net result of all the changes was a projected reduction in annual net revenue\(^2\) of about $30 million (or roughly 2%) compared to the July 15th version that was current when HNTB’s study began.

Section 4. General Comments on BTA

HNTB offers the following comments as a general assessment of the BTA, following a detailed review and exploration of the model.

• Comprehensive. The BTA encompasses the full spectrum of transportation alternatives. Its analysis explores virtually all transportation options—pedestrian, bicycle, bus, subway, train, taxi, and automobile. It provides a detailed assessment of the interactions among the motorized modes of transport, and it even takes some initial steps toward quantifying the relationship between reduced automobile use and increased walking and bicycling.

\(^2\) “Net revenue” is defined as gross revenue less the capital and operations costs associated with enacting a cordon tolling program. A more detailed discussion of the various components of the net revenue calculation is provided in Section 7 and Section 8.
• **Dynamic.** The BTA explicitly recognizes the dynamic nature of transportation in the following ways:
  
  o *It recognizes the relationships between cost and usage.* Through its exhaustive use of elasticities of demand, the model assesses the extent to which cost increases can dissuade travelers from using a particular mode of travel. In the same way, the model also assesses the potential of both cost decreases and travel time improvements to attract travelers to a particular mode of travel.
  
  o *It recognizes the relationships among the various modes.* For example, it considers how changes in service levels on the subway may attract users that currently use private automobiles. Similarly, it considers how price increases on the road (such as would result from the addition of a cordon toll) may encourage drivers to shift to alternative modes of travel (such as taxi or subway).
  
  o *It recognizes the relationship between investment and usage.* The proposed imposition of a cordon toll is not simply about generating revenue; rather, it is about providing a funding source for a wide array of transportation improvements. At a high level, the BTA captures the impact that transportation investments can have in attracting users by improving the level of service.
  
  o *It is iterative in nature.* The model considers the “ripple effects” of isolated changes to the transportation system. For example, it recognizes that a cordon toll will cause some drivers to shift to other modes, such as taxi or transit. However, it also recognizes that this shift will have two distinct impacts. First, it will slightly degrade the service of the alternative mode, since these modes (all else being equal) will need to handle more travelers with the same resources. Second, it will slightly improve the level of service on the roadway, since the overall volume has declined as a result of the shift. These two impacts will combine to yield a “rebound” of travelers onto the road, to take advantage of the comparatively better service on the road. The model iteratively tracks the shifting of travelers among the various modes until a new equilibrium converges.

• **Transparent.** The values of all key variables used in the model are either sourced or are explicitly stated as being assumptions. Unlike many transportation models, the BTA is not a “black box” whose inner workings are opaque. By virtue of being an Excel-based model, the reviewer is free to review and assess all calculations. Though some calculations may be complex and difficult to follow, they are not cloaked in any way.

• **Broad-based.** Because it is so broad in its scope, the BTA has natural limits on the extent to which results hinge on any one particular variable. As such, there is little opportunity for someone to manipulate the results simply by substituting one or two erroneous (or deliberately skewed) assumptions.
• **Realistic.** The anticipated response of the transportation system to the proposed imposition of a cordon toll is reasonable. To illustrate, HNTB compared the existing number of inbound cordon crossings with the number of crossings that would be expected in the Baseline scenario. Here is what the model indicated:
  
  - Existing number of crossings (annually) – 223.3 million
  - Forecast number of crossings with cordon toll – 183.1 million
  - Forecast reduction = 1 – (183.1/223.3) = **18%**

In other words, the Baseline model predicts an 18% reduction in auto cordon crossings as a result of adding a cordon toll. This level of reduction is similar to what an existing toll facility with an elasticity of demand of approximately -0.20 would expect if it doubled the toll rates\(^3\). In other words, the model expects a fair amount of diversion off the roads, but it is a level that is consistent with what one would expect to follow the imposition of a new, significant toll.

The following disadvantages of the model were identified:

• **Occasionally fragile.** The model proved to be fairly robust, yielding reasonable results over a range of inputs. (This will be discussed in more detail in the section on Sensitivity Analysis.) However, HNTB found that some variables would cause the model to crash if their values exceeded certain threshold values. One example can be found on the “Sub v. Bus” tab, cell H55, which contains an assumed value for the standard deviation of the total transit trip cost. If this assumed value falls below 4%, the model crashes.

• **Slightly cumbersome.** While virtually all assumptions are identified and documented, they are not necessarily easy to test. The “Assumptions” tab provides a helpful summary of many of the model’s most important assumptions. However, the assumptions are not sourced in this tab. Instead, the “Assumptions” tab merely references values from other worksheets. Therefore, in order to test an assumption listed in the “Assumptions” tab, one must go to the source worksheet and perform any modifications at that location. For example, the “Assumptions” tab (cell G207) identifies that the price elasticity of demand for auto work-trips as -0.40. However, to test how the model would respond to a change in this assumption, it is necessary to look at this cell and identify the location from which it is drawn. In this instance, one must go to the “Elasticity” tab and perform a test on the value contained in cell G66.

---

\(^3\) Elasticity is defined as the percent change in demand divided by the percent change in price. A facility with an elasticity value of -0.20 indicates that it would expect a 20% reduction in demand in response to a 100% increase in the toll rate. In HNTB’s experience, most toll facilities in the Northeast have toll elasticities of demand in the range of -0.10 to -0.30.
In short, the model’s fairly decentralized structure does not lend itself toward quick and easy stress testing of selected assumptions. Moreover, though the “Assumptions” tab does summarize many assumptions, it does not summarize all of the assumptions in the model. A thorough testing of the model requires a detailed review of all worksheets in order to identify assumptions that may need to be evaluated.

HNTB has had extensive discussions with Mr. Komanoff (the developer of the BTA) regarding the “Assumptions” tab. Mr. Komanoff readily acknowledges that the tab is due for an overhaul.

Section 5. Data Validation

HNTB was tasked with validating the key traffic data employed by the BTA. To this end, HNTB reviewed the motor vehicle volumes that provide the foundation for much of the model’s analysis. These foundational volumes are summarized in Figure 2. In reviewing and validating these volumes, HNTB notes the following:

- HNTB cross-referenced the volumes in the BTA with the volumes noted in the report entitled *HUB Bound Travel Data 2011*. The BTA’s references to this report appear to be accurate; no citation errors were discovered.

- The BTA takes great pains to distinguish between trips that pass thru the CBD and trips that are destined for the CBD. For trips destined for the CBD, it further distinguishes between work trips and non-work trips. It is HNTB’s opinion that these distinctions were made accurately and consistently. This careful accounting is important for the following reasons:
  - First, each time a driver making a round trip thru the CBD is tolled off the roadway, two potential cordon trips are affected. In this way, drivers making thru trips have a disproportionate impact on traffic and revenue.
  - Secondly, drivers that make thru trips have different baseline costs. Thru trips have higher fuel costs, while trips destined for the CBD have much higher parking costs. The impact of the parking costs means that, at present, the average total cost of a thru trip is cheaper than the average total cost of a trip destined for the CBD.
  - Third, drivers that make thru trips (i.e. that pass through the CBD in both directions) will experience a greater impact from a cordon toll. They will essentially pay the cordon toll twice per round trip, whereas trips that are destined for the

---

4 This report, cited in the BTA, was published by the New York Metropolitan Transportation Council in February 2013.
CBD will only pay once per round trip. As a result, the implementation of cordon tolling will render a thru trip more expensive than a trip destined for the CBD—the inverse of the current situation.

- Fourth, drivers making thru trips have a different toll elasticity of demand than drivers making trips destined for the CBD. The careful trip differentiation made by the BTA enables the analyst to properly apply the appropriate values of elasticity.

- The assumptions employed by the BTA to provide a more detailed breakdown of the Hub-bound volumes appear to be defensible. Where possible, the assumptions were tied to specific sources (e.g. Schaller’s report entitled Necessity or Choice?). In other cases, where publicly available data was not available, the BTA based its assumptions on the analyst’s judgment. HNTB has reviewed these assumptions and is satisfied with their reasonableness.

In short, HNTB concludes based on its review that the volumes as summarized in Figure 2 and employed by the BTA are valid and serve as a reasonable foundation for the model’s calculations and analysis.
Figure 2 – Data Validation Outline

Trips Not Entering CBD

Auto & Taxi Trips on CBD Upper Roadway NOT Entering CBD: 18,800

Assumptions: 5% of trips entering Manhattan via the CBD Upper Roadway do not enter the CBD (Koenigoff Assumption)

Auto Work, Auto Non-Work, Auto Thru, & Taxi Entries: 701,000

Auto & Taxi Trips Entering Corridor: 682,300

Auto Work, Auto Non-Work, & Auto Thru Entries to CBD: 613,500

Auto Entries passing thru CBD (34% of total, per Schaller): 208,500

Auto Work & Auto Non-Work destined for CBD: 404,800

Total Hub-Round Trips as Defined by MMTF: 757,000

Truck Entries (Koenigoff Assumption): 45,000

Bus Entries (as defined by MMTF in Hub-Round): 10,900

Bus Entries passing thru CBD (10% of total, Koenigoff estimate): 1,090

Bus Entries – Round Trip thru CBD (90% - Koenigoff Assumption): 9,810

Total CBD Entries

***For every one of these drivers that is rolled off the roadway, 2 auto entries to the CBD are lost
Section 6. Review of Key Results

Move NY requested HNTB to provide feedback on selected key results provided by the BTA. This section will provide high-level comments on these results. Subsequent sections will explore some of the key results (particularly “Revenue” and “Traffic Volumes and Speeds”) in more detail.

Revenue

The BTA takes a comprehensive approach to calculating gross revenue. It identifies seven basic sources of revenue that would be generated as part of the proposed cordon tolling program:

- Cordon Toll. The Move NY cordon tolling plan assesses a $10.66 toll to all automobile trips entering the CBD. Automobiles without a transponder are assessed a surcharge of $4.34. Trucks and buses are tolled as well, though at a higher rate. The revenue generated by these trips accounts for most revenue forecasted by the BTA.
- Toll on non-CBD Inbound Trips via QBB Upper Roadway. Vehicles crossing into Manhattan via the upper roadway of the Queensboro Bridge are assessed a toll under the Move NY cordon tolling plan, even though they do not directly enter the CBD. Since these trips are currently untolled, this represents a new source of revenue.
- Greater Use of Outer-Borough Bridges. The Move NY cordon tolling plan calls for tolls on the Outer-Borough bridges to be reduced by an average of 44%. The BTA quantifies the effect of this policy in two ways. It calculates the lost revenue resulting from the fact that all existing vehicles will pay a lower toll, and it calculates new revenue resulting from the expectation that some new trips will be attracted to the bridges because of the reduced toll rate. The second component is represented by this line item.
- More Transit Riders. The combined effects of imposing a roadway toll and of improving transit service will result in growth in transit usage. This increase in usage will translate into greater farebox revenue.
- New Taxi Surcharge. An additional surcharge would be assessed on all taxi rides operating in Manhattan south of 96th Street.
- Ravitch Surcharge. A surcharge of 50¢ (sometimes referred to as the “Ravitch” surcharge) is assessed by New York State on all NYC medallion taxi fares. As the number of taxi rides increases, the quantity of revenue generated by the Ravitch surcharge will also increase.

---

5 These include the Verrazano Bridge, the two Triborough Bridges, the Bronx Whitestone Bridge, the Throgs Neck Bridge, the Marine Parkway Bridge, and the Cross Bay Bridge. These bridges are operated by the MTA/TBTA; none of them feed directly into the CBD.
- **Parking Exemption.** The cordon tolling program calls for eliminating the partial sales tax exemption currently enjoyed by Manhattan residents that park on a monthly basis within the CBD. This would result in additional sales tax revenue.

Figure 3 depicts the relative contributions of each of the seven revenue components noted above for the Move NY baseline plan.

**Figure 3 – Revenue Components of Move NY Baseline Plan (in millions of dollars)**

As Figure 3 illustrates, the cordon toll is expected to generate over $1.6 billion in revenue; this comprises nearly 75% of all revenue expected from the Move NY baseline plan. However, two other non-cordon toll elements are also expected to generate significant revenue:

- A surge in transit usage is expected to generate over a quarter billion annually. Two factors are expected to contribute to the surge: (1) a shift from automobile drivers who wish to avoid the cordon toll; and, (2) an attraction of users who are drawn to transit because of improved service. The improved service is the anticipated result of investing a portion of the cordon toll revenue into transit.

- The new medallion taxi surcharge is expected to generate $230 million. This revenue source, resulting from a surcharge on both wait time and miles driven, is expected to come primarily from Manhattanites.

The one area in which the BTA doesn’t provide a great detail of detail regarding revenue collection is in the area of video customers. The model proceeds on the assumption that (a) video
transactions (i.e. transactions that do not involve an E-ZPass) comprise approximately 12% of all toll transactions, (b) a small fraction will be non-revenue customers (e.g. emergency vehicles) and scofflaws, and (c) all video customers will be assessed a surcharge of $4.34 per transaction. In HNTB’s estimation, the model slightly understates the likely percentage of non-revenue customers. Additionally, the model does not consider two other components of revenue from video customers: late fees (from video customers that do not respond to bills in a timely manner) and fines (from video customers whose bills ultimately get forwarded to Collections). While a planning-level model is likely acceptable with the assumptions currently in place, a more detailed look at revenue collection from video customers will likely be needed in the future.

Traffic Volumes and Speeds

The BTA employs a direct methodology for estimating the relationship between traffic volumes and average vehicular speeds within the CBD. The methodology was drawn from the book Urban Transportation Economics by Prof. Ken Small, a recognized expert in transportation economics from the University of California-Irvine. It builds on the following formula, drawn from Figure 3.5 of the text:

\[
\frac{60}{S} = 2.48 + 0.254 \times \left( \frac{V}{V_K} \right)^{4.08}
\]

where:
- \(S\) = the average CBD speed in miles per hour over a given period of time
- \(V\) = vehicle-miles traveled in the CBD over a given period of time
- \(V_K\) = a constant for the CBD, roughly approximating the capacity of the CBD in terms of vehicle-miles traveled

The BTA then solves for \(S\) algebraically:

\[
S = \frac{24.2}{1 + 0.1 \times \left( \frac{V}{V_K} \right)^{4.08}}
\]

Based on the knowledge that the average speed in the CBD during the overnight hours (when the expression \(V/V_K\) would be minimized) is approximately 22 miles per hour, the BTA modifies this expression as follows:

\[
S = \frac{22}{1 + 0.1 \times \left( \frac{V}{V_K} \right)^{4.08}}
\]

Please see Appendix B for more details.
The model then solves for $V_k$ as follows:

- As noted elsewhere in the model, the Baseline VMT in the Central Business District during the hours of 6am-6pm is approximately 168,000 VMT per hour.
- Based on other sources, the average traffic speed in the CBD during the hours of 6am-6pm is approximately 9 mph.
- Substituting 9 mph for “S” and 168,000 for hourly VMT, $V_k$ is calculated to be 87,150.

Once $V_k$ is determined, it is possible to estimate the CBD speed associated with any scenario once the associated hourly VMT has been calculated.

This calculation is fundamental to the model. For any pricing structure inputted into the BTA, there is an initial response (i.e. diversion of automobiles from the roadway to avoid the toll) which reduces traffic in the CBD. This reduction in traffic naturally yields improved speeds. These reduced speeds are then referenced against a time elasticity of demand, and a “rebound” effect is calculated by which some vehicles are drawn back to the roadway. This results in an oscillation which eventually converges after a number of iterations (the model allows 10).

After reviewing the methodology and finding it reasonable, HNTB sought to confirm the approach by corresponding directly with Professor Small. Transcripts of the e-mail correspondence between HNTB and Prof. Small may be found in Appendix A. The conclusion drawn by HNTB is that the BTA’s approach to correlating traffic volumes with vehicle speeds is reasonable and yields plausible results. Section 7 and Section 8 will both take a closer look at vehicle speeds in the context of a sensitivity analysis.

**County & Borough Incidence of Tolls**

The BTA estimates the share of toll incidence for Manhattan and the surrounding areas that will bear the financial burden of the cordon toll. The share of cordon incidence as quantified by the BTA goes beyond the financial burden of the cordon toll itself and also includes the impacts of the medallion taxi surcharge, outer-borough bridge toll relief, reduced bus fares for subway “deserts,” and the elimination of the partial tax exemption currently offered to Manhattan monthly garage parkers. This is done on a county-by-county basis for all 12 counties within the MTA taxing district (all of which are in New York State) as well as New Jersey, Connecticut and “other.” The result is an aggregate “bottom line” calculation of the net cordon incidence for each county as summarized by the BTA.

This comprehensive look at incidence illustrates the significant impact of the non-cordon elements of the Move NY baseline plan. If one looks solely at the cordon toll itself, then Manhattanites bear only 6.3% of the incidence. But when one factors in all other elements of the plan, this share rises to 24.9%. In other words, the non-cordon toll elements of the Move NY base-
line plan shift a greater portion of the financial burden to Manhattan while providing relief to the other four boroughs (and to Nassau county as well).

The share of cordon incidence is derived by the BTA, in large part, using a combination of demographic data extracted from Census data and supplemented by well-documented assumptions from subject matter experts such as Mr. Charles Komanoff and Mr. Sam Schwartz.

The BTA’s estimates of county and borough share of cordon incidence seem to provide a sound, robust, and reasonable approximation of the net financial impacts resulting from the implementation of the Move NY baseline plan. HNTB’s only recommendation for this portion of the BTA would be to update the demographic data used by the BTA (primarily drawn from a 2007 update to 2000 U.S. Census data) with the most recent data currently available from the year 2010 U.S. Census. It is also possible that some of the existing toll facilities in the region (e.g. MTA Bridges and Tunnels, Port Authority of New York & New Jersey) have conducted origin-destination studies in the past that may provide some helpful demographic data.

Benefit-Cost Calculations

HNTB also reviewed the BTA’s estimates of benefit-cost calculations. Functionally, these calculations are sound; however, HNTB is concerned with how the BTA distinguishes between “benefits” and “costs.” For example, one of HNTB’s concerns is that the BTA does not distinguish whom the “benefits” and “costs” apply to. As a result, some costs may be double-counted, inadvertently understating cordon tolling’s net benefits.

Consider the following: The BTA currently counts both “User Fees” and “Toll & Fare Administration” as costs. This may not be appropriate. The “User Fees” actually go to the entity that is implementing Cordon Pricing; the entity then uses these fees to support the associated “Toll & Fare Admin” costs. In doing this, the BTA may be overstating (or double counting) the costs as viewed by the entity implementing Cordon Pricing. This is because both the revenue generated by the entity (classed “User Fees”) and the money used to operate the Cordon Toll (classed “Toll & Fare Admin”) are counted as costs by the BTA.

HNTB recommends that the BTA employ either (or both) of the following accounting perspectives when considering costs and benefits:

- First, from the perspective of the traveling public, consider the “costs” to be the changes in user fees. The “benefits” fall into the various categories identified and quantified in the BTA (saved time, wellness, etc.).

---

7 Some updated demographic data may be found at the following website: http://longisland.newsday.com/templates/simpleDB/?pid=197
• Second, from the perspective of the Operating Entity (or collection of entities), consider the “costs” as the sum total of the various investments (Transit System, Transit Service, and/or Roads and Bridges) as well as all associated capital and operational costs (e.g. Toll & Fare Admin). The “benefits” are comprised of the various revenue sources (e.g. the cordon toll revenue, revenue from the medallion taxi surcharge, etc.) less any revenue losses associated with toll reductions on the outer-borough bridges. By definition, the ratio of benefits to costs from the perspective of the Operating Entity will be 1.0, as long as all net revenues are funneled into transportation system investments.

Section 7. Alternative Scenarios Analysis

HNTB’s review included an assessment of four scenarios, all of them built on the idea of charging all vehicle trips into and out of the Manhattan CBD at the same rate as is now charged on the MTA/TBTA East River tunnels, and simultaneously reducing round-trip tolls on the MTA/TBTA “major bridges” by $5.00. The first scenario was created by Move NY. The other three scenarios were transmitted to HNTB by Move NY and reflect variations offered for analysis by one of the regional transportation bodies.

• Scenario 1 – The current version of the BTA defines this as the “Gridlock Sam Fair Plan.” The key components of this plan (which is referred to in this memorandum as the “Move NY baseline plan”) are as follows:
  o a $10.66 round-trip toll for all automobiles crossing the cordon line at 60th St. or via an East River bridge8;
  o a $4.34 round-trip surcharge for the subset of those crossings in which automobiles pay via video tolling (as opposed to E-ZPass)9;
  o a $5.00 reduction to the current toll rates on the major MTA/TBTA bridges; and,
  o a surcharge to the portions of medallion taxi trips that take place south of 96th Street.10 This surcharge is assessed in lieu of tolling medallion taxi trips that cross into the CBD.

• Scenario 2 – This scenario is identical to Scenario 1, except that it doubles the percentage of non-revenue crossings into the CBD from its assumed baseline value of 2.5%, to 5.0%.

• Scenario 3 – This scenario is identical to Scenario 2, but it assumes that half of all toll revenues from the 60th St. cordon are sequestered by the City of New York.

8 This rate was selected in order to correspond to the current toll levels on the major MTA/TBTA bridges, which include the Bronx Whitestone, Throgs Neck, Triborough, and Verrazano Narrows bridges. The round-trip fare for each of these bridges for E-ZPass customers is $10.66.
9 The proposed surcharge corresponds to the existing differential between the round-trip cash rate ($15.00) and the round-trip E-ZPass rate ($10.66) on the major MTA/TBTA bridges.
10 The proposed medallion taxi surcharge on weekday trips has three components—a flat $0.50 surcharge on all fare-trips, a 15% surcharge on the current per-mile rate, and a 20% surcharge on the current wait time rate. The weekend surcharge for all three components is half of the weekday surcharge.
• **Scenario 4** – This scenario builds on Scenario 3 by adding an additional sequestration of $200 million to be dedicated to fund ongoing maintenance of the East River bridges.

Table 1 provides a quick comparison of these scenarios.

**Table 1 – Scenario Description Summary**

<table>
<thead>
<tr>
<th></th>
<th>Sc. 1</th>
<th>Sc. 2</th>
<th>Sc. 3</th>
<th>Sc. 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Revenue %</td>
<td>2.5%</td>
<td>5.0%</td>
<td>5.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Annual Revenue Sequestered by City of New York</td>
<td>$0</td>
<td>$0</td>
<td>50% of 60th St. toll revenue</td>
<td>50% of 60th St. toll revenue, plus $200M for E. River Bridges</td>
</tr>
</tbody>
</table>

The results of the analysis of the four alternative scenarios are summarized in Table 2. The table has four parts:

- **The top portion of the chart summarizes the various revenue components of each scenario.** It identifies the additional revenue that may be expected through the creation of a cordon toll.
- **The second portion identifies the various costs that would be associated with the cordon tolling.**
- **The third portion summarizes what is done with the “net revenue”—that is, the gross revenues minus the costs.** The chart identifies how the net revenue was allocated among four major categories—transit system capital improvements, transit system operating enhancements, investment in roads and bridges, and other miscellaneous revenue expenditures.
- **Finally, the bottom portion summarizes the expected increase in average CBD vehicle speeds resulting from reduced traffic (due to imposition of the cordon toll).**
Table 2 – Comparison of Alternative Scenarios (in annual millions of dollars)

<table>
<thead>
<tr>
<th>Scenario 1 Baseline</th>
<th>Scenario 2 5.0% NR</th>
<th>Scenario 3 Sc2+50% Seqr.</th>
<th>Scenario 4 Sc3+$200M Br.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revenues</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero Out Manhattanites’ Parking Rebate</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
</tr>
<tr>
<td>More Taxi Trips Paying “Ravitch” Surcharge</td>
<td>$5</td>
<td>$5</td>
<td>$0</td>
</tr>
<tr>
<td>New Medallion Taxi Surcharge</td>
<td>$230</td>
<td>$230</td>
<td>$225</td>
</tr>
<tr>
<td>More Transit Riders</td>
<td>$265</td>
<td>$250</td>
<td>$110</td>
</tr>
<tr>
<td>Greater Use of Outer-Borough Bridges</td>
<td>$80</td>
<td>$80</td>
<td>$80</td>
</tr>
<tr>
<td>Toll on non-CBD inbound trips via QBB Upper Roadway</td>
<td>$20</td>
<td>$20</td>
<td>$20</td>
</tr>
<tr>
<td>Cordon Toll</td>
<td>$1,650</td>
<td>$1,580</td>
<td>$1,680</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td>$2,260</td>
<td>$2,175</td>
<td>$2,125</td>
</tr>
<tr>
<td><strong>Costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cordon Toll Revenue Appropriated by NYC</td>
<td>$0</td>
<td>$0</td>
<td>$840</td>
</tr>
<tr>
<td>Outer-Borough Toll Relief</td>
<td>$585</td>
<td>$585</td>
<td>$585</td>
</tr>
<tr>
<td>Toll &amp; Fare Admin</td>
<td>$165</td>
<td>$165</td>
<td>$175</td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
<td>$750</td>
<td>$750</td>
<td>$1,600</td>
</tr>
<tr>
<td><strong>Net Revenue Available for Improvements</strong></td>
<td>$1,510</td>
<td>$1,425</td>
<td>$525</td>
</tr>
<tr>
<td>Revenues Invested in System Improvements (Capital)</td>
<td>$805</td>
<td>$755</td>
<td>$240</td>
</tr>
<tr>
<td>Revenues Spent on Service Enhancements (Operating)</td>
<td>$240</td>
<td>$225</td>
<td>$70</td>
</tr>
<tr>
<td>Revenues Spent on Roads and Bridges</td>
<td>$350</td>
<td>$330</td>
<td>$100</td>
</tr>
<tr>
<td>Misc. (Transit Fare Adjustments, Taxi Driver Fund)*</td>
<td>$115</td>
<td>$115</td>
<td>$115</td>
</tr>
<tr>
<td><strong>CBD Speed Gain</strong></td>
<td>20.7%</td>
<td>19.6%</td>
<td>13.3%</td>
</tr>
</tbody>
</table>

*This line item has two major components. The first is $25 million in funds set aside for a taxi drivers’ health fund. The second is $90 million in lost revenue associated with a transit policy that would offer a $1.00 fare for buses serving residents who live more than one-third of a mile from the nearest subway stop.

The following observations may be drawn from Table 2:

- Scenario 1 is expected to yield nearly $1.5 billion in net revenue and is expected to provide nearly a 21% improvement in average speeds in the CBD.\(^\text{11}\)
- Scenario 2 doubles the expected number of drivers from whom no revenue will be collected. The expected result would be a decline in net revenue of $85 million. Most of this would be attributable to a decline in cordon toll revenue of $70 million. The other

\(^{11}\) Speed improvement is calculated based on this formula:
\[\text{% speed improvement} = \left(\frac{\text{average speed in CBD with cordon toll}}{\text{average speed under existing conditions}}\right) - 1\]

In the baseline condition, the existing average speed is 9.00 mph while the forecasted average speed is 10.86 mph. This equates to an improvement of \([\left(10.86/9.00\right)-1]\), or about 21%.
A decline of $15 million is due to a smaller gain in transit ridership. This relative decrease in transit ridership is the result of having less net revenue available to invest in transit.

- Scenario 3 involves a sequestering of half of all cordon toll revenue by the City of New York. This means that, of the expected $1,680 million in cordon toll revenue, half (or $840 million) is sequestered by NYC. This leaves much less net revenue available for investment in the transit system and roadway network.

- The expected improvement in average speed in the CBD for Scenario 3 is lower than for Scenario 2. The primary reason for this is that Scenario 3 spends nearly 70% less on transit improvements. This means that the improvements to transit service are marginal and are therefore less effective at luring drivers out of their cars and into transit. As a result, more cars remain on the road, reducing the traffic benefit.

- Scenario 4 adds another $200 million to the total that is sequestered by the City of New York. The result is still less money available to invest in transit. The decline in revenue associated with “More Transit Riders” can be attributed to this relative decline in investment. And, since fewer drivers are shifting into transit, the speed gain in the CBD is also reduced.

To summarize, the analysis of alternative scenarios indicated that the policies associated with the imposition of a cordon toll would yield gross revenues of over $2 billion per year. After accounting for the associated costs (most of which is the cost to reduce tolls on the four major MTA/TBTA bridges by $5.00 per round trip), the net revenue is in the vicinity of $1.4-$1.5 billion. If all of this net revenue is spent on transit improvements as well as on regional roads and bridges, then the model expects average speeds within the CBD to improve by about 20%. But if half (or more) of the revenue is sequestered for other purposes, then the expected improvement to speeds in the CBD will diminish by nearly half.

Section 8. Sensitivity Analysis

One major purpose of the study was to identify key variables to which the model is sensitive and to evaluate whether the model responds in a reasonable way. To this end, HNTB identified five sets of variables which appeared to be key drivers of net revenue.

- **Transit Volume with respect to Transit Time.** This variable (in the Elasticities tab) relates the anticipated percent change in transit usage to the anticipated percent change in the transit travel time. It is a negative value, meaning that a decrease in transit time is expected to yield an increase in transit volume. The baseline values for this variable were
-0.50 for weekday trips and -0.55 for weekend trips. HNTB evaluated how the net revenue would change if these values changed by ±30%.12

- **Auto Volume with respect to Auto Cost.** This variable (also in the Elasticities tab) relates the anticipated percent change auto usage to the anticipated percent change in the auto cost. It is a negative value, meaning that an increase in auto cost is expected to yield a decrease in auto volume. The baseline values for this variable were -0.40 for weekday trips and -0.60 for weekend trips. As with the first variable listed above, HNTB evaluated how the net revenue would change if these values changed by ±30%.

- **Percentage of Non-Revenue Vehicles.** This variable estimates the percentage of auto trips passing through the cordon tolling points that will not end up paying the toll. There are essentially three components to this percentage: (1) Authorized vehicles (e.g. law enforcement, emergency vehicles, government vehicles, etc.); (2) non E-ZPass drivers who cannot be properly identified, either because no good images were taken of the license plate or because no valid data could be gathered from the Department of Motor Vehicles; and (3) drivers who simply refuse to pay the billing notices. The baseline value for this variable was 2.5%. Based on HNTB’s observations of agencies that have deployed video tolling, we believe a more reasonable range of values would be from a low of 3.2% to a high of 7.2%. A more detailed explanation of the derivation of these values can be found in Appendix B.

- **Estimated Percent Change in Subway Trip Duration per First $100M/Year.** This variable was used to help quantify the benefit of investing a portion of the projected net revenue into the subway system. The baseline assumption used by the BTA was 1.2%, meaning that the first $100 million invested in the subway system each year would be expected to yield an average 1.2% reduction in travel times on the subway.13 This would in turn tend to attract more users from other modes into the subway system. HNTB considered two extremes in its sensitivity analysis—one in which subway investments yielded no reduction in subway trip duration, and one in which subway investments yielded a 2.4% reduction in subway duration.

---

12 Adjusting by -30% (i.e., multiplying by 0.7) would yield elasticities of -0.350 on weekdays and -0.385 on weekends. A multiple of +30% (multiplying by 1.3) would yield elasticities of -0.650 on weekdays and -0.715 on weekends.
13 This assumption was derived mathematically by Mr. Komanoff, based on figures drawn from an MTA report entitled **2010 NYC Transit Service Reductions**. The report suggested that trip durations would increase (worsen) by about 3-4% per $100 million that is disinvested in the subway system. Mr. Komanoff assumed that the same would be true in reverse—that is, that a comparable investment in the subway system would yield a reduction in trip durations. To be conservative, Mr. Komanoff reduced the anticipated improvement by a factor of 3, yielding 1.2%.
Optimistic and Pessimistic Operating Cost Scenarios. The BTA makes some high-level estimates for the costs of operating and administering video tolling. The Baseline model assumes three key operational costs—a 15¢ cost per E-ZPass transaction, a 50¢ cost per video transaction, and a $20 Million annual administrative cost. It is HNTB’s estimate that the E-ZPass cost and the administrative cost is at the high end of what would be expected, while the video cost is at the low end of what would be expected. Therefore, two scenarios were constructed for evaluation.

- **Optimistic:** E-ZPass cost = 10¢ per transaction, video cost = 50¢ per transaction, administrative cost = $10 million annually.
- **Pessimistic:** E-ZPass cost = 15¢ per transaction, video cost = $1.00 per transaction, administrative cost = $20 million annually.

The sensitivity analysis performed by HNTB is summarized in Table 3 on the following page.

---

14 The E-ZPass and video transaction costs were adapted from figures from a 2007 NY Daily News article. The administrative costs were assumed by Mr. Komanoff, intended to cover (as cited in the model) “office space, computer, legal, administration and other costs not included in the per-transaction cost figures.”
## Table 3 – Sensitivity Analysis Results

<table>
<thead>
<tr>
<th>Move NY Elasticity</th>
<th>Transit Time Elasticity</th>
<th>Driving Cost Elasticity</th>
<th>Non-Revenue Share</th>
<th>Subway Trip Time Reduction</th>
<th>Toll Price &amp; Cost Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base-line x 1.3</td>
<td>x 1.3</td>
<td>x 1.3</td>
<td>NR = 3.2%</td>
<td>2.4% per $100M</td>
<td>2.4% per $100M</td>
</tr>
<tr>
<td></td>
<td>x 0.7</td>
<td>x 0.7</td>
<td>NR = 7.2%</td>
<td>0.0% per $100M</td>
<td></td>
</tr>
<tr>
<td>Revenues</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero Out Manhattanites' Parking Rebate</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
</tr>
<tr>
<td>More Taxi Trips Paying &quot;Ravitch&quot; Surcharge</td>
<td>$5</td>
<td>$5</td>
<td>$0</td>
<td>$5</td>
<td>$5</td>
</tr>
<tr>
<td>New Medallion-Taxi Surcharge</td>
<td>$230</td>
<td>$235</td>
<td>$225</td>
<td>$230</td>
<td>$230</td>
</tr>
<tr>
<td>More Transit Riders</td>
<td>$265</td>
<td>$350</td>
<td>$190</td>
<td>$270</td>
<td>$260</td>
</tr>
<tr>
<td>Greater Use of Outer-Borough Bridges</td>
<td>$80</td>
<td>$80</td>
<td>$80</td>
<td>$100</td>
<td>$80</td>
</tr>
<tr>
<td>Toll on non-CBD inbound trips via QBB Upper Roadway</td>
<td>$20</td>
<td>$20</td>
<td>$20</td>
<td>$20</td>
<td>$20</td>
</tr>
<tr>
<td>Cordon Toll</td>
<td>$1,650</td>
<td>$1,590</td>
<td>$1,700</td>
<td>$1,580</td>
<td>$1,720</td>
</tr>
<tr>
<td>Total Revenue</td>
<td>$2,260</td>
<td>$2,290</td>
<td>$2,225</td>
<td>$2,220</td>
<td>$2,310</td>
</tr>
<tr>
<td>Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cordon Toll Revenue Appropriated by NYC</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Outer-Borough Toll Relief</td>
<td>$585</td>
<td>$585</td>
<td>$585</td>
<td>$585</td>
<td>$585</td>
</tr>
<tr>
<td>Toll &amp; Fare Admin</td>
<td>$165</td>
<td>$160</td>
<td>$170</td>
<td>$160</td>
<td>$170</td>
</tr>
<tr>
<td>Total Costs</td>
<td>$750</td>
<td>$745</td>
<td>$755</td>
<td>$745</td>
<td>$755</td>
</tr>
<tr>
<td>Net Revenue Available for Investment</td>
<td>$1,510</td>
<td>$1,545</td>
<td>$1,470</td>
<td>$1,475</td>
<td>$1,555</td>
</tr>
<tr>
<td>Revenues Invested in System Improvements (Capital)</td>
<td>$805</td>
<td>$825</td>
<td>$780</td>
<td>$785</td>
<td>$830</td>
</tr>
<tr>
<td>Revenues Spent on Service Enhancements (Operating)</td>
<td>$240</td>
<td>$250</td>
<td>$235</td>
<td>$235</td>
<td>$260</td>
</tr>
<tr>
<td>Revenues Spent on Roads and Bridges</td>
<td>$350</td>
<td>$355</td>
<td>$340</td>
<td>$340</td>
<td>$350</td>
</tr>
<tr>
<td>Misc. (Transit Fare Adjustments, Taxi Driver Fund)</td>
<td>$115</td>
<td>$115</td>
<td>$115</td>
<td>$115</td>
<td>$115</td>
</tr>
<tr>
<td>CBD Speed Gain</td>
<td>20.7%</td>
<td>24.3%</td>
<td>17.6%</td>
<td>23.4%</td>
<td>18.0%</td>
</tr>
</tbody>
</table>
The following observations may be drawn from Table 3:

**Transit Time Elasticity**

- Greater transit time elasticity yields a higher expectation of net revenue ($1,545M vs. $1,470M).
- The scenario with a greater transit time elasticity yielded $15M more in taxi-related revenue and $160M more due to a higher number of transit riders. This was partly offset by $110M less in cordon toll revenue.
- The scenario with greater time elasticity yielded a greater gain in CBD speeds (24.3% vs. 17.6%). This is because this scenario involves more people switching from auto to transit, which in turn reduces the volume of traffic on the roadways and thus improves traffic flow.

**Driving Cost Elasticity**

- The scenario with a higher driving cost elasticity yielded less net revenue ($1,475M vs. $1,555M). This is because, for a given toll rate, a greater proportion of people will refrain from driving in order to avoid the added cost. Since fewer drivers pass through the cordon, less cordon toll revenue is generated.
- The relative drop in cordon toll revenue is only partially offset by slight growth in revenue from increased transit usage and increased taxi usage.
- The scenario with greater driving cost elasticity yielded a greater gain in CBD speeds (23.4% vs. 18.0%). The reason is simple—if fewer drivers are passing through the cordon, then fewer drivers are operating within the CBD. This in turn yields less congestion and higher travel speeds.

**Non-Revenue Share**

- Both scenarios yielded less net revenue than the Baseline scenario. That is because the baseline assumption of non-revenue vehicles (2.5%) was lower than HNTB’s most optimistic assumption about non-revenue usage (3.2%).
- Overall, the pessimistic scenario (non-revenue = 7.2% of all traffic) generated $135 million less than the pessimistic scenario (3.2%). Clearly, this is a sensitive variable that has a very direct impact on net revenue.
- Two categories are most affected by the change in assumption about non-revenue vehicles.
  - The first is the “Cordon Toll revenue” category. As the number of non-paying vehicles increases, the amount of revenue declines.
  - The second is the “Toll and Fare Admin” category. Since the “pessimistic” category involves a greater number of cash-paying vehicles, and since cash-paying vehicles cost more to process than E-ZPass customers, the administrative costs are
higher in the “pessimistic” scenario. This is the purpose of the toll surcharge for cash-paying trips—to offset the increased administrative costs associated with identifying license plates, tracking down drivers, sending bills and processing payments.

Subway Trip Time Reduction

- The difference between the two extremes was about $140 million per year in net revenue. If we double the expected reduction in subway trip time, net revenue jumps to $1,580 million from the baseline value of $1,510 million. Conversely, if we eliminate the expected reduction in subway trip time, net revenue tumbles to $1,440 million.
- The scenario that doubled the expected reduction in subway trip time had much lower cordon toll revenue compared to the scenario that eliminated the expected reduction ($1,470 million vs. $1,790). However, this difference was more than covered by a large jump in revenue due to more transit riders ($500 million vs. $75 million).
- In other words, the model suggests the following: If subway improvements reduce trip times, then large numbers of users will shift to the subway system. The increase in transit revenue yielded by this influx will more than outweigh any decline in cordon toll revenue resulting from drivers shifting from auto to transit.
- One implicit assumption is that the transit system improvements will not only speed up service but will also be able to accommodate the influx of transit users. Evaluating the level of investment required to both handle more users and provide improved service is an area in which the BTA could benefit from further quantification and refinement.

Toll Price and Cost Scenarios

These two scenarios did not materially affect gross revenue; they only impacted the estimated costs. The only significant difference between the two scenarios was in the “Toll and Fare Admin” category, for which the costs associated with the pessimistic scenario were $80 million more than the costs associated with the optimistic scenario.

To complete the sensitivity analysis, HNTB performed an assessment of two extreme conditions based on the five scenarios discussed above.

- **Extreme optimism.** This scenario assumed a high value of transit time elasticity (baseline +30%), a low value for driving cost elasticity (baseline -30%), an optimistic non-revenue share (3.2%), a high estimate of subway trip time reduction (2.4% per first $100 million of investment), and an optimistic operating cost scenario.
- **Extreme pessimism.** This scenario assumed a low value of transit time elasticity (baseline -30%), a high value for driving cost elasticity (baseline +30%), a pessimistic non-revenue share (7.2%), a pessimistic operating cost scenario, and an assumption that subway investments will have no impact on subway trip time reduction.
Table 4 summarizes the results of this assessment, comparing the “extreme optimism” and “extreme pessimism” scenarios with the Baseline scenario noted in Table 2.

<table>
<thead>
<tr>
<th>Revenues</th>
<th>Baseline</th>
<th>Extreme Optimism</th>
<th>Extreme Pessimism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Out Manhattanites’ Parking Rebate</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
</tr>
<tr>
<td>More Taxi Trips Paying “Ravitch” Surcharge</td>
<td>$5</td>
<td>$10</td>
<td>$0</td>
</tr>
<tr>
<td>New Medallion-Taxi Surcharge</td>
<td>$230</td>
<td>$230</td>
<td>$225</td>
</tr>
<tr>
<td>More Transit Riders</td>
<td>$265</td>
<td>$695</td>
<td>$65</td>
</tr>
<tr>
<td>Greater Use of Outer-Borough Bridges</td>
<td>$80</td>
<td>$60</td>
<td>$100</td>
</tr>
<tr>
<td>Toll on non-CBD inbound trips via QBB Upper Roadway</td>
<td>$20</td>
<td>$20</td>
<td>$20</td>
</tr>
<tr>
<td>Cordon Toll</td>
<td>$1,650</td>
<td>$1,360</td>
<td>$1,580</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td><strong>$2,260</strong></td>
<td><strong>$2,385</strong></td>
<td><strong>$2,000</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Costs</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cordon Toll Revenue Appropriated by NYC</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Outer-Borough Toll Relief</td>
<td>$585</td>
<td>$585</td>
<td>$585</td>
</tr>
<tr>
<td>Toll &amp; Fare Admin</td>
<td>$165</td>
<td>$110</td>
<td>$220</td>
</tr>
<tr>
<td><strong>Total Costs</strong></td>
<td><strong>$750</strong></td>
<td><strong>$695</strong></td>
<td><strong>$805</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Net Revenue Available for Investment</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues Invested in System Improvements (Capital)</td>
<td>$805</td>
<td>$900</td>
<td>$625</td>
</tr>
<tr>
<td>Revenues Spent on Service Enhancements (Operating)</td>
<td>$240</td>
<td>$270</td>
<td>$185</td>
</tr>
<tr>
<td>Revenues Spent on Roads and Bridges</td>
<td>$350</td>
<td>$385</td>
<td>$270</td>
</tr>
<tr>
<td>Misc. (Transit Fare Adjustments, Taxi Driver Fund)</td>
<td>$115</td>
<td>$115</td>
<td>$115</td>
</tr>
<tr>
<td><strong>CBD Speed Gain</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20.7%</td>
<td>39.3%</td>
<td>13.4%</td>
</tr>
</tbody>
</table>

The following observations may be drawn from Table 4:

- The “Extreme Optimism” scenario yields an increase of $180 million in net revenue compared to the Baseline. The “Extreme Pessimism” scenario yields a decrease in net revenue of $315 million. Comparing the two results, the “downside potential” is about 75% greater than the upside.
- In comparison to the Baseline, the “Extreme Optimism” scenario actually yields about $300 million less cordon toll revenue. However, this loss is more than covered by an anticipated revenue increase of $430 million from more transit riders.
- The “Extreme Pessimism” scenario yields more cordon toll revenue than the “Extreme Optimism” scenario ($1,580 million vs. $1,360 million). However, the “Extreme Pessimism” scenario involves a minimal shift of people into transit. Therefore, relatively little revenue is generated from the addition of more transit riders.
• The “Extreme Optimism” scenario appears to involve a significant shift from auto to transit. This shift results in fewer vehicles on the road, which in turn means that average speeds in the CBD are expected to increase significantly. This is suggested by the near-doubling in the CBD speed gain (39.3% for “Extreme Optimism,” compared to 20.7% in the Baseline condition).

• Conversely, the “Extreme Pessimism” scenario appears to involve a minimal shift from auto to transit. Consequently, more vehicles are on the road by comparison, resulting in a more modest improvement in CBD speeds (just 13.4%).

In sum, HNTB evaluated a variety of variables to which the BTA’s forecasts for speed gain and net revenue were sensitive. A reasonable range of the values for these variables were identified and subsequently tested. The resultant forecasts appeared to be reasonable and consistent. Even the most pessimistic set of assumptions still generated over $1 billion in net revenue.

Section 9. Comparison with Other Cordon Tolling Experiences

Cordon tolling is not currently deployed in any US cities. However, it has been in place for nearly four decades in Singapore and for several years in two European cities. A very high-level summary of the experiences of three cities that have deployed cordon tolling is provided below.¹⁵

**London.** The cordon tolling program in London was instituted in 2003 and applies to an area of approximately 8 square miles, centered on the downtown area. In terms of geographic size, it is nearly identical to the Manhattan CBD. The current toll is £10 (about $16) and is assessed between 7am and 6pm. The toll is only collected on non-holiday weekdays. Unlike the proposed cordon toll for Manhattan, the London program does not employ transponders. Rather, cameras are used to capture license plates. If a driver doesn’t render payment electronically by midnight on the day of travel, a third party tracks down vehicle owners via the Driver and Vehicle Licensing Agency (DVLA) and sends a bill accompanied by a late fee.

**Singapore.** The city of Singapore first implemented cordon tolling in 1975. It was initially launched as an area licensing plan. Drivers were required to purchase a $3 pass in advance and to display the pass on the windshield in order to enter the Central Business District, which covers an area of about 3 square miles. Collecting the fees and monitoring conformance was cost-

---

¹⁵ Data provided in this section is drawn from three sources: Wikipedia; an FHWA document entitled *Congestion Pricing: A Primer* (available at [http://ops.fhwa.dot.gov/publications/congestionpricing/](http://ops.fhwa.dot.gov/publications/congestionpricing/)); and a presentation entitled *Congestion Pricing: Singapore, London, and Stockholm* by the Sustainable Urban Transport Project. A handful of other, smaller cities in Europe have also implemented cordon pricing schemes. HNTB did not review any first-hand data. This section is simply provided as a cursory check to see whether the predictions of the BTA are consistent with experiences elsewhere.
ly and manpower-intensive. Therefore, in 1998, the city converted to an “Electronic Road Pricing” program, or ERP. Now, all vehicles that wish to enter the CBD must be fitted with an in-vehicle transponder mounted on the windshield. The transponder is read by an overhead gantry at all entry points to the CBD; the assessed toll varies by location and by time of day. There are approximately 80 toll gantries in Singapore.

**Stockholm.** The city of Stockholm held a 7-month trial of cordon tolling from January through July 2006. Cordon tolling was implemented permanently in August 2007. Vehicles are charged upon entry to the Stockholm City Center, which covers an area of roughly 14 square miles. Similar to London, the cordon toll operates from 6:30am to 6:30pm on non-holiday weekdays. The amount of the toll varies by time of day, ranging from roughly $1.50 to $3.50 (in US dollars). Vehicles that must enter the CBD multiple times throughout the day are charged a maximum toll of about $9.50. As in London, all charges are identified via license plate number recognition. However, unlike in London, the driver isn’t responsible for contacting the agency to render payment. Instead, customers are sent monthly bills which they are expected to pay within one month.

Table 5 summarizes the experiences of the three cities with respect to traffic reduction and speed improvement with the CBD. The figures are compared with the Baseline forecasts from the BTA.

**Table 5 – Cordon Tolling Comparison**

<table>
<thead>
<tr>
<th></th>
<th>London</th>
<th>Singapore</th>
<th>Stockholm</th>
<th>Manhattan (Move NY baseline forecast)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td>8 sq. mi.</td>
<td>3 sq. mi.</td>
<td>14 sq. mi.</td>
<td>8 sq. mi.</td>
</tr>
<tr>
<td><strong>Traffic Change in CBD</strong></td>
<td>-16%</td>
<td>-13%</td>
<td>-22%</td>
<td>-16.5% (entering vehicles) -8.3% (VMT)</td>
</tr>
<tr>
<td><strong>Speed Improvement</strong></td>
<td>+22%</td>
<td>+20%</td>
<td>+25%</td>
<td>+21%</td>
</tr>
<tr>
<td><strong>Net Revenue</strong></td>
<td>~$144M (2006/7)</td>
<td>n/a</td>
<td>n/a</td>
<td>$1,505M</td>
</tr>
</tbody>
</table>

Three important observations may be drawn from Table 5:

- The traffic-related forecasts for the Manhattan cordon toll (e.g. traffic reduction and speed improvement) are consistent with the observed changes at the three other cities. The revenue forecasts are more difficult to judge because current and comparable data is much harder to find.

- The BTA’s projected reduction in VMT (-8.3%) is only half as great as the projected reduction in entering vehicles (-16.5%). This is because only about 55% of the VMT within the CBD is generated by vehicles that enter the CBD from outside the cordon. The re-
remaining VMT is generated by *intra-cordon* trips—that is, trips whose start and end points both lie entirely within the CBD. While cordon VMT from entering vehicles is projected to decline by about 17%, cordon VMT generated by intra-cordon trips is actually projected to increase by about 2%. The BTA predicts that the improvement in average speeds within the cordon will actually encourage new automobile trips that don’t have to cross the cordon line.

- The projected improvement in speeds within the CBD (+21%) is greater than the projected reduction in VMT within the CBD (-8.3%). This is the nature of roadway capacity. When a facility is congested, even a modest improvement can yield a disproportionate benefit to traffic operations. The same effect can be seen in reverse: When a facility is congested, even a small impediment to traffic flow can yield near-gridlock conditions.

**Section 10. Recommendations & Areas for Further Study**

Based on its extensive review of the Balanced Transportation Analyzer, HNTB makes the following recommendations:

- Clarify the “Assumptions” tab to better facilitate testing the sensitivity of the model to critical assumptions. Future modifications to the “Assumptions” tab should include the following:
  - Ensure that all critical assumptions—that is, assumptions to which the models’ results are sensitive—are listed in the Assumptions tab. The current listing of assumptions is extensive but not comprehensive.
  - Clearly identify the location within the model where each assumption may be found. Adding a hyperlink to the appropriate tab would be helpful.
  - If possible (that is, if the architecture of the calculations enables it), enable the user of the model to test assumptions within the Assumptions tab. This will not be possible for all assumptions, given that some assumptions are calculated as opposed to simply being stated.

- The model should be scanned to identify the most commonly-used variables that can cause the model to crash. Once they are identified, Excel provides some options to help avoid a subsequent crash:
  - The first (and most obvious) approach is to simply add some highlighted text in a blank cell adjacent to the variable, warning the user to restrict entries to a specified range of values.
  - A second approach is to go to the “Data” tab, the “Data Tools” group, the “Data Validation” button, and the “Data Validation” option. This option opens up three possible tabs, the second of which is labeled “Input Message.” This tab allows the designer to create a warning message that pops up whenever a specified cell is selected. So if the user selected a cell whose value could potentially
cause the model to crash, a customized message could be designed to open up, warning the user to restrict entries to a specified range of values.

- A third approach is to create two cells for each variable that can potentially cause the model to crash. The first cell would be the cell in which the user is prompted to enter the appropriate assumption. The second cell would be the cell that feeds the model’s calculations. This second cell would be designed with an “IF” statement that examines the value in the first cell. If the value inputted by the user were to be outside of the prescribed range, then the value feeding the model calculations could default to a pre-determined minimum or maximum value.

- NOTE: The “Data Validation” option (“Settings” tab) provides the modeler with the ability to restrict selected cells to a specified range of values. However, this restriction does not operate until after the value is entered. As a result, the model crashes before the model delivers a message to the user stating that the value is out of range. Therefore, this option is of limited value in avoiding model crashes.

- The non-revenue percentage should be shifted from the “User Inputs” tab to the “Assumptions” tab. This variable is an assumption that should be verified and tested. Unlike a toll rate, it is not a variable that can be determined independently.

- The non-revenue percentage should be increased above its Baseline value of 2.5%. Based on HNTB’s experience with toll agencies (as discussed in detail in Appendix B), a good place to start would be to set it equal to approximately 32% of the non E-ZPass share of automobile traffic. HNTB’s optimistic estimate of a non-revenue percentage would be 3.2% for the opening year.

- It may be appropriate to consider an alternative that requires all automobiles crossing the cordon to have an E-ZPass, similar to the system that is in place in Singapore. This would greatly reduce the operating costs of the system (since E-ZPass tolls are much cheaper to collect than video tolls), and it would also eliminate revenue leakage from video customers that either cannot be identified or who refuse to pay the bill.

- If video tolling is advanced, certain details will need to be considered as part of a more detailed financial analysis. These will include:
  - Taking a closer look at the anticipated percentage of E-ZPass traffic that will be expected in the opening year.
  - Examining the expected frequency with which video customers will travel.
  - Identifying how video bills will be handled (e.g. monthly billing).
Determining whether fees (in addition to the $4.34 round-trip video surcharge prescribed by the Move NY baseline plan) will be added to the video bills to help cover the additional cost of handling.

Conducting a technology scan to consider the performance of video toll collection equipment in highly congested, slow-speed and stop-and-go conditions.

Seeking further information on the quality of registered motorist databases in the region.

Estimating the impact of existing or potential future applicable legislation to support enforcement of non-payments, both within New York, in neighboring states, and in the states of registration of motorists using the program.

- An important step in refining the BTA would be to meet with transit operations experts to consider the kinds of improvements that would be needed to ensure the transit system is able to do the following: (1) handle the influx of users that would likely result from the imposition of a cordon toll, and (2) provide improved service to existing transit customers. These improvements should be quantified in terms of costs, and these costs should in turn be cross-referenced to the proposed transit system improvements embedded in the BTA model.

- At present, the BTA allows the user to allocate net revenue to three major types of improvements: (1) investment in transit system improvement and expansion, (2) transit service enhancements, and (3) road and bridge upgrades and improvements. At present, the BTA has a feedback mechanism that estimates the extent to which transit ridership may be boosted (and transit revenue increased) by the proposed level of transit investment. However, no feedback mechanism exists to estimate the extent to which road and bridge investment could boost automobile usage (with an accompanying gain in cordon toll revenue). Introducing such a feedback loop is another way in which the BTA may be refined in order to capture the potential benefits associated with road and bridge improvements.
Appendix A  Correspondence with Prof. Kenneth Small

On Friday, October 4, 2013, Todd Pendleton of HNTB sent the following e-mail to Prof. Kenneth Small of the University of California – Irvine.

Hello Prof. Small-

My name is Todd Pendleton, and I work for HNTB Corporation. We are currently under contract to the “Blue Marble Project” (New York) to review a detailed spreadsheet model called the Balanced Transportation Analyzer. I believe that you helped contribute to the development of this model by providing guidance to Charles Komanoff back in 2009. We’ve been corresponding with Charles throughout the course of our review; Charles suggested that we reach out to you.

**Bottom Line**: We’d like your thoughts on Charles’ methodology for estimating average speeds within the Manhattan Central Business District (CBD).

The latest version of this model is attached to this e-mail. The tab of primary interest (highlighted in yellow) is entitled Speed-Vol., Cordon. You’ll notice a familiar formula in line 21 of this tab, drawn from your book *Urban Transportation Economics*. (As a side note, I used that book as a text during my graduate studies in Transportation at MIT back in 1996-1998.)

The model uses this formula:

\[
60/S = 2.48 + 0.254 \times (V/V_K)^{4.08} \]  
\text{(hopefully the formatting gets conveyed via e-mail)}

Komanoff solves for \(S\) algebraically:

\[
S = \frac{24.2}{1 + 0.1 \times (V/V_K)^{4.08}}
\]

He subsequently simplifies this expression, as described in the spreadsheet. I believe the change reflects the fact that “Graveyard” speeds (during which \(V/V_K\) would be minimized) seem to average about 22 mph. Therefore,

\[
S = 22 / [1 + 0.1 \times (V/V_K)^{4.08}]
\]

The model then solves for \(V_K\) as follows:

- In other portions of the model, Komanoff calculates the baseline vehicle-miles traveled (VMT) in the Central Business District (CBD) during the hours of 6am-6pm. This hourly value is approximately 168k VMT.
- From other sources, he notes that the average traffic speed in the CBD is approximately 9 mph.
- Substituting 9 mph for “\(S\)” and 168k for hourly VMT, he comes up with \(V_K = 87,150\)
Once $V_K$ is determined, the model can calculate the expected CBD speed associated with any scenario once the associated hourly VMT has been calculated.

This calculation is fairly fundamental to the model. It is an iterative model. When a new pricing structure is assumed, there is an initial response which reduces traffic in the CBD. This reduction in traffic naturally yields improved speeds. These reduced speeds are then referenced against a time elasticity of demand, and a “rebound” effect is calculated by which some vehicles are drawn back to the CBD. This results in an oscillation which eventually converges after about 10 iterations.

Here are our questions:

- Are you in general agreement with the validity of this approach of translating VMT within a CBD into an average speed?
- According to Charles, you last reviewed this methodology in early 2009. Are you aware of any research over the past 4+ years that would have bearing on this topic?

We would welcome any feedback and insight you are willing to offer. Thanks very much for your time. Please let us know if you have any questions.

Have a good weekend.

Todd

---

**Todd A. Pendleton, P.E.**

**HNTB Corporation**

340 County Rd., Suite 6C

Westbrook, ME 04092

Ph: 207.228.0899

Fax: 207.228.0909

---

On Tuesday, October 8, 2013, Prof. Small sent the following reply:

---

Dear Todd,

Thanks for the opportunity to see how Charles’ spreadsheet has developed. I am still in general agreement with this methodology, and with the specific formula he uses and the way he has adjusted parameters to match known speeds in Manhattan.

I am not aware of any newer research that would make me think this methodology is no longer appropriate.
There is some newer research on "hypercongestion", showing that in circumstances where traffic flows within a CBD can interfere strongly with each other (e.g. by blocking intersections), traffic can flow at very slow speeds for extended times until the system clears. There are some papers that provide quantitative estimates, including one by myself and Xuehao Chu (Journal of Transportation Economics and Policy, 2003), and two or three papers by Carlos Daganzo and colleagues in Transportation Research part B. But that subject is in its infancy and leads to inherently dynamic models, which would not fit well within a feasible calculation strategy such as Charles is undertaking. So, I would not recommend trying to adopt the hypercongestion approach at this stage.

Best wishes.

Ken Small

*****************************************************************************
Prof. Kenneth A. Small
Department of Economics
3151 Social Science Plaza A
University of California
Irvine, CA 92697-5100
voice: +1-949-824-5658
fax: +1-949-824-2182
email: ksmall@uci.edu
*****************************************************************************

This correspondence makes it clear that Prof. Small approves of Komanoff's approach to defining the relationship between vehicle-miles traveled (VMT) and average speed within the CBD. Given Prof. Small's breadth of experience in the realm of modeling transportation networks, HNTB is inclined to accept Small's approval as a subject matter expert.
Appendix B  Estimating a Reasonable Range of Non-Revenue Percentages

The current plan for the deployment of cordon tolling is to install gantries over all roadways that run into the Central Business District, defined as Manhattan south of 60th Street. These gantries will be equipped with two general types of toll collection equipment.

- The first type will be automatic vehicle identification equipment matching the E-ZPass standard that will identify (for toll processing) all vehicles properly equipped with a valid E-ZPass. It is expected that at least 80% of all transactions crossing the cordon line will have a valid E-ZPass.

- The second type will be a video image capture system (typically a set of cameras) that will capture a license plate image of all vehicles that are not identified with a valid E-ZPass. If the image is sufficient and a license plate is present and readable, the image will yield a plate state of registration, a plate type, and an alphanumeric value that can be cross-referenced with the appropriate database, such as a Department of Motor Vehicles. Once the vehicle’s registered owner is identified, the owner can be sent a bill.

Several toll agencies, including the Miami-Dade Expressway in Florida and E-470 in Denver, employ video tolling as part of an overall program of all-electronic tolling. Other agencies, including the New York State Thruway Authority, are considering making a transition to video tolling for all customers that are currently paying cash. Experience has shown that video tolling is subject to a significant amount of gross revenue loss that is commonly referred to as “leakage.” There are four common contributors to leakage:

- **Factor #1 – Non-Usable Images.** Many images are not readable, either because of poor visibility (e.g. rain or snow), because the plate is obscured by another vehicle or some element of the vehicle itself, because the plate is obscured by dirt or mud or damage, or because the plate is improperly mounted (or not mounted at all).

- **Factor #2 – Invalid DMV Records.** In some instances, even if the image is usable to identify the plate number, the plate number cannot be traced to a valid record at the corresponding Department of Motor Vehicles (DMV). This could be due to the use of temporary plates or due to the failure to identify the appropriate plate type. It could also be due to the fact that some jurisdictions do not freely share DMV data with other states. Additionally, rental vehicles can pose a challenge in terms of properly identifying the owner if the issuing agency does not have specific connections to rental databases.

---

16 A “valid” E-ZPass is one that is properly mounted, in working order, and tied to an account that has sufficient funds.

17 Many states have multiple types of license plates, and the same plate number can be used on multiple plates. If the appropriate plate type is not identified, and if a particular number shows up on multiple plates, then the owner cannot be properly identified.
Factor #3 – Invalid Addresses. Even if the DMV is able to provide an address for billing, the address may not be current or valid. Experience has shown that 5-10% of all initial bills are eventually returned as undeliverable.

Factor #4 – Refusal to Pay. Experience has also shown that not everyone who receives a bill will ultimately pay that bill. Estimates of actual payment rates range from as high at 90% to as low as 54%. A number of variables affect the payment rate, including (but not limited to) whether fees and or fines are appended to the bills, the extent to which toll authorities have legal recourse to compel payment (e.g. through enacting registration holds until delinquent bills are paid), and the extent to which regional agreements are in place to collect revenue from out-of-state vehicles.

Based on HNTB’s work in previous studies for agencies considering a conversion to video tolling, we conclude that a reasonable estimate of the combined effects of Factors 1 through 3 is a loss of 25%. In other words, of the non E-ZPass vehicles that pass through a given gantry, 75% will yield a plate image that ultimately leads to a bill delivered to the proper address. When this value is multiplied by the response rate, we can estimate the overall percentage of users that are expected to pay their bills.

- As noted above, a low-end response rate is 54%. If we multiply this value by 75% (accounting for the fact that only 75% of all users ever receive a bill), then the net “low-end” response rate is 0.75 * 0.54 = 40%. The non-revenue percentage would therefore be (1-40%), or 60%.

- Also as noted above, a high-end response rate is 90%. Again multiplying this value by 75%, calculate a net “high-end” response rate of 0.75 * 0.90 = 68%. The non-revenue percentage would therefore be (1-68%), or 32%.

These percentages all represent a share of non E-ZPass traffic. In other words, these figures suggest that a minimum of 32% of all non E-ZPass trips will yield no revenue, while a maximum of 60% of all non E-ZPass trips will yield no revenue. However, these figures must be multiplied by the share of non E-ZPass traffic in order to estimate the non-revenue share of overall traffic.

The baseline BTA model assumes the following:

- The existing share of E-ZPass transactions is 80%.

- The conversion to video tolling will cause the share of E-ZPass usage to grow by 8%. This is because of the assumption that many non E-ZPass customers will shift to E-ZPass in order to avoid the proposed video surcharge of $4.34.

- Therefore, the baseline share of E-ZPass traffic is expected to be 88%.

In order to properly estimate share of non-revenue traffic after implementation of a cordon tolling program, it is critical to properly estimate the share of E-ZPass traffic at implementation.
It is HNTB’s opinion that the BTA’s estimate of an 88% share is close but should be reconsidered in the following manner:

- According to the TBTA report entitled *History and Projection of Traffic, Toll Revenues and Expenses*\(^{18}\), average E-ZPass usage on the nine crossings operated by the TBTA was 81.0% in 2012.\(^{19}\) Given the proximity of these crossings to Manhattan, this figure represents a reasonable estimate of the likely level of E-ZPass usage for vehicles entering the CBD.
- Figure 4 illustrates how E-ZPass usage has grown at the TBTA crossings over the past decade. As the superimposed best-fit linear regression illustrates, the E-ZPass market share has grown an average of 1.16% over this time.

**Figure 4 – Historical Growth of E-ZPass Usage on TBTA Crossings, 2003-2012**

![E-ZPass Market Share at TBTA Crossings](image)

\[
y = 0.0116x + 0.6777 \\
R^2 = 0.9103
\]

- The TBTA report notes that “Based on customer acceptance of the technology, TBTA expects that the E-ZPass share of total transactions will continue to increase over time.”\(^{20}\) Therefore, it is reasonable to expect that the market share will continue to rise up to the time at which cordon tolling could be implemented.
- Knowing that the data in Figure 4 is already 1 year old, and assuming that cordon tolling is still about 5 years from full deployment, it is necessary to project the existing share of 81.0% forward to 6 years in the future. The estimated “baseline” E-ZPass usage may be calculated as follows:

\[
\text{Baseline E-ZPass Usage} = 81.0\% + 6 \times 1.16\% = 88.0\%
\]

\(^{18}\) This report was prepared for the TBTA by Stantec (April 26, 2013).
\(^{19}\) Ibid, pg. E-9.
\(^{20}\) Ibid.
In other words, the baseline share of E-ZPass usage at the time of cordon tolling implementa-
tion is likely to be about 88%.

The next question to address is: To what extent is the share of E-ZPass usage likely to grow
upon conversion to video tolling? In HNTB’s experience, two factors militate against assuming a
large surge into E-ZPass:

- First, many veterans in the toll industry believe that 90% represents a reasonable cap on
  the achievable level of E-ZPass usage. Experience has shown that there is a share of
drivers that will simply not convert to E-ZPass under any circumstances, either because
they are unbanked or because of privacy concerns.
- Second, virtually no agencies that have actually implemented video tolling have actually
  observed a surge in E-ZPass market share.

Therefore, HNTB considered two “extremes” in its analysis—one in which the E-ZPass market
share does not grow at all (with the share of E-ZPass usage remaining at the baseline projected
rate of 88%), and one in which the E-ZPass market share grows by a modest rate of 2% (thus
yielding an overall share of 90%). Viewed another way, we estimated that non E-ZPass vehicles
would comprise a low-end market share of (100%-90%) = 10%, and a high-end market share of
(100%-88%) = 12%.

In order to estimate the low-end and high-end percentages of non-revenue vehicles, HNTB
made this final calculation:

- **Low-end non-revenue percentage.** We took the low-end estimate of a non-
  revenue percentage (32%) and multiplied by the low-end estimate of the non E-ZPass
  market share (10%) to yield a low-end non-revenue percentage of 3.2%.
- **High-end non-revenue percentage.** We took the high-end estimate of a non-
  revenue percentage (60%) and multiplied by the high-end estimate of the non E-ZPass
  market share (12%) to yield a low-end non-revenue percentage of 7.2%.

These two estimates of non-revenue percentages formed the basis of the sensitivity analysis
performed in Section 8. Please note that even the low-end non-revenue percentage (3.2%) is
slightly greater than the baseline estimated share of non-revenue (2.5%). In other words, it is
HNTB’s opinion that the baseline BTA model slightly underestimates the share of traffic that
will not generate any revenue under a video tolling system.

This analysis has focused on estimating non-revenue usage as a function of video customers. It is
ture that, to some extent, a small share of E-ZPass users (e.g. vehicles operated by the entity
that will implement cordon tolling, emergency vehicles, etc.). However, experience has shown
that this share tends to be *de minimis* relative to the non-revenue share of video customers.