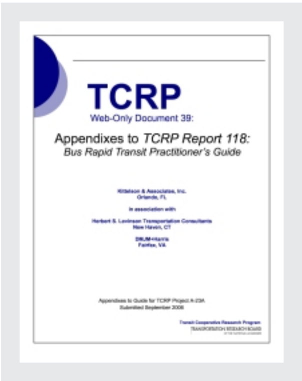
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Appendixes to *TCRP Report 118:*
*Bus Rapid Transit Practitioner's Guide*

# Appendixes to TCRP Report 118: Bus Rapid Transit Practitioner's Guide

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Appendix A and Appendix B were developed by Sam Zimmerman, Terri Morrell, and Maureen Araujo.

Appendix C was developed by Kelly Blume and Patrick McMahon.

# CONTENTS

# APPENDIX A AGENCY BRT RIDERSHIP SURVEY

A survey of BRT travel demand modelers was conducted.

An integral part of the BRT demand forecasting research in TCRP Project A-23A was exploring how contemporary demand modelers forecast BRT demand in terms relative to demand for both local bus and rail-based modes (including LRT). To this end, a survey was conducted through telephone and Internet interviews with travel demand modelers in North American cities that have BRT and rail transit systems to assess how they treat BRT in modeling exercises.

A structured survey instrument was designed by the A-23A project team to compare contemporary treatment of local bus, BRT, and LRT. Topics in the survey included:

- How the respective region's travel models are structured and calibrated?
- What results were obtained?
- How has actual BRT performance compared to forecasts?
- What on-board, origin-destination, or other data have been collected to use to assess what works?

## AGENCIES SURVEYED

The following agencies (MPOs and transit operators) were contacted for interviews:

- Alameda-Contra Costa (AC) Transit (Oakland, California)
- City of Ottawa
- Dallas Area Rapid Transit
- Denver Regional Council of Governments
- Denver Regional Transportation District (RTD)
- Greater Cleveland Regional Transit Authority, Main Office
- Houston-Galveston Area Council
- Houston METRO
- Los Angeles County Metropolitan Transit Agency
- Massachusetts Bay Transportation Authority (MBTA), Central Transportation Planning Staff
- Metropolitan Transportation Commission (MTC, San Francisco)
- Miami Dade MPO
- Miami Dade Transit Agency (MDTA)
- North Central Texas Council of Governments (NCTCOG)
- Northeast Ohio Area-wide Coordinating Agency (Cleveland)
- Port Authority of Allegheny County (PAT)
- Regional Transportation Commission of Southern Nevada / Clark County Transit Agency (Las Vegas)
- Southern California Association of Governments (SCAG, Los Angeles)
- Southwestern Pennsylvania Commission (SPC, Pittsburgh)
- TransLink (Vancouver, BC)

## SURVEY QUESTIONS

Two basic questions were asked regarding demand model structure and calibration. They were as follows:

I. How is demand being forecast for your transit system for long-range and project planning (as opposed to operation planning) purposes?

1. If a traditional four-step modeling process is used for all trip purposes, is there special treatment for rail-based rapid transit modes?
   a. If yes, is this special treatment in the mode choice model (e.g., using different modal constants)?
   b. If yes, is this special treatment also used in assignment (i.e., using different boarding penalties)?
   c. If yes, is this special treatment also used in distribution (i.e., using a "log-sum" variable to reflect travel production to attraction travel impedance (generalized cost))?

How has BRT travel demand been forecast?

2. If a modal bias constant is used in the mode choice model and the constant for rail is different from the one used for "bus," what do you use for BRT?
3. If bias constants are used, do(es) the difference(s) between/among bias constants vary by trip purpose?

What have been the results of BRT ridership forecasts?

II. What have actual BRT ridership results been?

1. How has implementation of BRT affected travel (transit, highway) demand in the respective corridor(s)?
2. Were travel demand increases in line with expectations based on past results reflecting changes in the local bus system, i.e., improvements in travel times and frequency?
3. Was there a higher amount of unexpected growth in non-peak, non-work trips than peak work trips (based on previous experience with bus system changes)?

## SURVEY RESPONSES

Responses to the survey questions are summarized below. Some of the agencies contacted did not respond to every question, and some agencies did not respond to the survey at all. Full responses to each of the questions from each of the responding agencies are in the last section of this Appendix.

### *Questions Concerning How the Respective Region's Travel Models Are Structured and Calibrated and What Results Were Obtained*

All of the responding agencies use a version of the four-step modeling process for long-range and project planning. Responses to the questions regarding special treatment for rail-based transit modes, however, revealed a wide variation in modeling practices. The variations are summarized in Exhibit A-1 and are further described below.

**EXHIBIT A-1 Mode Choice Modeling Summary**

| Responding Agencies | Uses Modal Constant for Rail Different from Bus Modes | Uses Same Modal Constant for Rail & BRT Different from Local Bus | Uses One Generic Transit Mode Constant for All Modes | Uses Impedance Function, etc. for Rail Different from All Bus Modes | Uses Same Impedance Function for Rail & BRT Different from Local Bus |
|---|---|---|---|---|---|
| Oakland - AC Transit | | X | | | X |
| San Francisco - MTC | X | | | X | |
| Denver - RTD | | | X | X | |
| Houston - METRO | X (new) | | X (current) | | |
| Houston - H-GAC | | X | | | X |
| Boston - CTPS | | X | | | |
| Dallas - NCTCOG | | X | | | X |
| Pittsburgh - PAT | | X | | | |
| Pittsburgh - SPC | | X | | | |
| L.A. - SCAG | | X | | | |
| Vancouver - TransLink | | | X | | |

NOTE: AC Transit = Alameda-Contra Costa Transit, MTC = Metropolitan Transportation Commission, RTD = Regional Transportation District, H-GAC = Houston-Galveston Area Council, CTPS = Central Transportation Planning Staff, NCTCOG = North Central Texas Council of Governments, PAT = Port Authority of Allegheny County, SPC = Southwestern Pennsylvania Commission, and SCAG = Southern California Association of Governments.

The modeling structure and calibration for each agency in Exhibit A-1 are summarized below in groups. Where more than one approach applies to a given agency (e.g., they use different modal constants and impedance [generalized cost] functions), they are placed in the single group that best characterizes the particular set of modeling tools.

Agencies that use one generic transit constant for all modes in mode choice modeling include the following:

- The Metropolitan Transit Authority of Harris County, Texas (Houston METRO) model currently uses the same constants and time parameters for LRT as for local bus, and the assignments vary only by trip purpose. LRT is treated the same as local bus; METRO is, however, moving toward using unique constants in the rail nest for assignment purposes. Survey data suggests that the use of special rail bias constants is valid, but this has not been factored into the models yet. No special treatment is made in trip distribution.
- TransLink typically had no special treatments for rail-based modes of travel in the mode choice model but did in transit assignment. The TransLink bias constant used in the mode split model is the same for all transit sub-modes (i.e., bus and rail), and the mode choice model only deals with transit trips as a whole. The allocation to transit sub-modes is handled during the transit assignment process where different impedance functions are utilized. All things being equal, in typical analysis, TransLink applies a factor to give a slight reduction to the wait time for rail (1/2 headway × 0.8) options and a slight penalty to the bus mode (1/2 headway × 1.2). In recent work for the Northeast Sector Rapid Transit

project, however, they conducted an analysis on BRT in which they endeavored to eliminate even that bias on the assumption that investment in high-grade BRT (assumed guided light transit [GLT]) would receive the same level of priority and investment as rail modes.

Some agencies use the same bias constant for rail and BRT.

Agencies that use the same mode-specific constant for rail and BRT, a constant that is different from local bus, include the following:

- The Boston Central Transportation Planning Staff (CTPS) mode choice model (a nested logit model) focuses on whether the mode is accessed by walking or driving. However, local bus paths (but not BRT) are assessed a 10-minute penalty consistent with recent FTA modeling direction, compared to the rapid transit modes. The model set is applied for the Silver Line the same as for LRT. The bias constant is only rail/BRT versus local bus, not rail versus local bus and BRT.
- The current Southern California Association of Governments (SCAG) model separates the transit mode into four sub-modes: walk to local transit, auto to local transit, walk to express transit, and auto to express transit. Rail lines are treated as express transit and Metro Rapid Bus lines are treated as local transit. The impedance (generalized cost) functions were estimated based on a 1991 origin-destination survey and some transit on-board surveys of later date. Mode constants were determined based on year 2000 model validation. SCAG's web site (www.scag.ca.gov) contains the complete report of year 2000 model validation and summary. Transit assignments were done for each mode separately using corresponding trip tables from mode choice. Log sums from mode choice model were used in home-based work (HBW) trip distribution. SCAG's constants were adjusted for each transit sub-mode based on model validation.
- Southwestern Pennsylvania Commission (SPC) uses the same bias constants for all premium service, which includes LRT and BRT. Premium includes fixed guideway (LRT, BRT, and commuter rail) for any portion of the person trip. BRT includes all bus routes that use a busway for all or any portion of the trip. Local transit includes all other bus modes and Pittsburgh's inclined planes. SPC builds transit skims for up to three possible paths: walk to premium, walk to local, and auto access. Any transit mode can have auto access. Different modal constants are used for the above three categories as well as by trip purpose (home-base work, home-base other, and non-home base). All modes have a minimum initial or transfer wait time of four minutes except for rail (LRT, commuter rail, inclined rail), which has no minimum. The process is used for mode choice and transit assignment. The transit paths from the mode choice model are saved for use in transit assignment. Distribution is based on highway impedance (generalized cost).
- Port Authority of Allegheny County (PAT) does not use modal constants or boarding penalties to differentiate BRT from rail, and no special distribution treatment is used. BRT is considered a guideway mode because this system's busways are more similar to LRT than local bus. No special efforts are made for BRT--it is treated just like any rail line in an analysis. The strength of BRT--its train-like qualities--is also its weakness when doing an analysis. Keeping track of BRT riders is more complicated than with other fixed guideway modes. This is seen as a process detail, not a basic behavioral issue.

- The Houston-Galveston Area Council (H-GAC) mode choice model uses different mode choice coefficients and mode-specific constants for each mode.
- Alameda-Contra Costa Transit District (AC Transit) has no separate sub-modes in their models. They have mode-of-access only in their home-based work mode choice models. AC Transit uses composite impedance (generalized cost) for the home-based work trip distribution (gravity) model, stratified by household income quartile. Their "gray area" is deciding if BRT is a premium service or a simple bus service, and if so, how to treat it.
  - A Major Investment Study (MIS) evaluated three modal alternatives as well as various alignment alternatives. The modes evaluated included Express (enhanced) Bus (a "minimal" BRT-like service similar to the existing 72R Rapid Bus Route), BRT, and LRT. For purposes of the MIS, Express Bus (assumed to be a higher mode than Local Bus) was used as base to develop a refined application of the Express Bus mode for BRT.
  - This was done by adjusting the mode's parameters creating improved travel time (Express Bus assumes running speed to be a fraction of auto speed because bus and autos share the roadway, whereas BRT enjoys congestion-free, fixed speeds on dedicated guideways) and shorter dwell times (due to fare collection enhancement and level boarding) for BRT.
  - For the MIS (a proposed BRT line), the AC Transit model was refined to improve assignment results (i.e., split into smaller zones) and calibrated. Modal constants were reviewed because it was observed that "Express Bus" actually had a smaller modal constant than Local Bus (perhaps an artifact of earlier base model calibration). For this reason, Local Bus was selected as the base mode for BRT. This produced unrealistic BRT assignments due to high sensitivity of the model to headways (BRT attracting walk access ridership from distant parallel routes over 0.75 miles away). A manual process was used to reassign these "unreasonable" assignments.

Agencies that use the same impedance (generalized cost) function for rail and BRT that is different from local bus include the following:

Some agencies use the same impedance function for rail and BRT.

- North Central Texas Council of Governments (NCTCOG) had unique rail bias constants in some of their earlier TransCAD testing but found that the model validation "station RMSE" results looked better when they switched to an alternative means of representing the fact that "rail stations offer patrons a much better environment than the typical bus stop." For both transit skimming and transit assignment, NCTCOG has a lower wait time factor applied to the wait times at rail stations for walk-to-rail and drive-to-rail travel (for purposes of getting on rail).
  - For both transit skimming and assignment, NCTCOG also uses a "transit pulse time" approach in which the bus-to-rail and rail-to-bus transfers are assumed to not exceed a calibrated wait time value. For mode choice, the wait time (and transfer wait time) coefficients for bus and rail are the same. NCTCOG's trip distribution does not include transit travel times because their trip distribution calibration work was

based on a 1996 household survey that took place before light rail was in operation. It was noted that NCTCOG will seriously re-investigate this in 2009+, when they have the results of the 2007/2008 survey available.

> While NCTCOG does not technically have a "bias constant" for rail, NCTCOG does allow bus-rail and rail-bus pulse times, as well as lower weight times applied to the initial waits at rail stations. They do not consider their current express bus services on freeways and HOV lanes as "BRT," but reserve the title "BRT" for facilities in which the bus operations include "very special" buses that run at least partially on special bus guideways.

> "Real" BRT alternatives are treated in demand modeling with the same "pulse" and "lower weight time for first wait" treatment that are used for rail options. NCTCOG does not know if this is "correct," since they do not have any "real" BRT in their region.

> However, NCTCOG felt this was the "right thing to do" in their planning-level work for BRT, so that they would not bias the results against BRT (when compared to rail). Further, if the end result was that BRT service was identified in the community as the preferred service for more detailed analysis, they would have had to re-examine whether BRT truly deserves the same treatment as rail services. While NCTCOG has no unique rail/BRT bias constants in their model, they apply "pulse" and initial wait weighting assumptions equally to all trip purposes.

Agencies that use an impedance (generalized cost) function for rail that is different from that for all bus modes, local and premium (e.g., BRT), include the following:

- Denver Regional Transportation District (RTD)/Denver Regional Council of Governments (DRCOG) models do not use a nested model for mode choice, and bias constants have not been used under any of the model versions/platforms. The older MINUTP-platform model that was used to support FasTracks and the West Corridor EIS planning treated rail and "premium bus" the same in path-building, with a less onerous penalty (1/2 that for regular bus). The perceived transfer time penalty approach was not used for the more recent West Corridor "New Starts" modeling; however, rail in-vehicle travel times were reduced by 35% compared to all bus times before transit path building and carried through to mode choice. The travel time reduction was implemented to achieve a reasonable assignment model validation by mode. The latest TransCAD-platform model is being used to support both the US 36 and I-70 East Corridor EISs.

> DRCOG's TransCAD model factors rail in-vehicle time in both mode choice and path building differently than for all bus modes. RTD/DRCOG's model validations under the newer TransCAD platform have consistently over-predicted express bus demand versus LRT in corridor(s) where they both operate. The belief is that similarly weighting in-vehicle travel time for "premium" bus would have been counterproductive. It is not clear whether BRT and "express bus" are treated differently. There is no special treatment applied in the distribution model and no mode-specific "bias" constants are used in the mode choice model.

- The San Francisco Bay Area Metropolitan Transportation Commission (MTC) uses a nested logit structure for their Home Based Work model. The transit nest is first separated into Drive Access and Non-Drive Access. For Drive Access, the next tier includes Kiss & Ride and Park & Ride access modes, but access links are included only to Bay Area Rapid Transit (BART) stations and not other transit systems. For the Non-Drive access mode, the next tier includes Local Bus, Express Bus, and BART.
  - In the MTC models, existing long-distance express bus service between the East Bay and downtown San Francisco is treated as an "Express Bus mode." This service has limited stops and segments on freeway HOV lanes (not available over the San Francisco Bay Bridge) and uses enhanced, over-the-road coaches. There are separate mode choice models for HBW trips and non-HBW trips.

### *Questions Concerning Results of BRT Implementation*

Most of the responding agencies have experienced increased ridership in BRT corridors. However, most of the agencies did not have detailed before-after study data available. These include AC Transit, DRCOG/Denver RTD, SCAG, SPC, San Francisco Bay Area (MTC), and Miami-Dade Transit Authority (MDTA).

There is a lack of detailed before-and-after documentation of BRT ridership impacts for some systems.

Exhibit A-2 shows which agencies specifically reported ridership increases with the implementation of BRT. Specific data from these agencies are summarized below.

**EXHIBIT A-2 Summary BRT Implementation Comparison**

| Responding Agencies | Transit Ridership/Mode Share Increased Where BRT Was Implemented | Specific Evidence of Increased Ridership in Both Non-Peak and Non-Work Trips |
|---|---|---|
| Boston - MBTA | X | X |
| Miami - MDTA | X | X |
| Pittsburgh - PAT | X | |
| L.A. - MTA | X | X |
| Las Vegas - RTC | X | |
| San Francisco - MTC | X | X |
| Pittsburgh - SPC | X | |
| Vancouver - TransLink | X | X |

NOTE: MBTA = Massachusetts Bay Transportation Authority, MDTA = Miami-Dade Transit Agency, PAT = Port Authority of Allegheny County, MTA = Metropolitan Transportation Authority, RTC = Regional Transportation Commission of Southern Nevada/Clark County Transit Agency, MTC = Metropolitan Transportation Commission, and SPC = Southwestern Pennsylvania Commission.

Transit ridership/mode share increases where BRT was implemented were reported as follows:

- Boston Central Transportation Planning Staff (CTPS) reported that the Silver Line BRT serves over 14,000 passengers per day, which is over 100% greater than with the previous local bus service. CTPS reported that forecast travel demand for the Silver Line BRT route was "pretty accurate." However, the forecasts were done only a couple of years before service began. It might have been different if the forecasts were more long range.

- Los Angeles County Metropolitan Transit Authority (MTA) reported that their Metro Rapid Bus Service, which is synonymous in L.A. with BRT, will eventually include 28 lines, covering 450 miles by 2008. Corridor ridership on the first two corridors (Ventura and Wilshire/Whittier corridors) is up 40% (65,000 to 85,000/day and 10,000-12,000 to 17,000/day, respectively). MTA attributes this simply to faster, more reliable service. The first two corridors were successful enough that 26 additional corridors were approved. Of those, nine more have already been implemented. The 11 existing lines have many elements of BRT (special livery/buses, stations, ITS) but do not have dedicated lanes, high capacity buses (although new buses are coming soon), or prepaid fares.

  > Another corridor in Los Angeles, known as the "Orange Line," opened in 2005. This line is 12 miles along an old railroad line and is a full-featured BRT with more rail-like attributes. The new 60-foot buses run on compressed natural gas. All the buses that run on BRT lines of any kind (dedicated ROW or Metro Rapid Bus and 45-foot or 60-foot) have low noise, low emissions, low floors, a nicer interior, a unique look/image, and, in general, offer riders a better experience than the current local bus system.

  > MTA offered the most specific statistics regarding the results of implementing their BRT-like service. MTA reported that, based on previous experience with bus improvements, ridership was much higher than expected on the first two corridors, but less than expected on the next nine corridors. This is partly because system-wide bus ridership (1 million riders) declined five percent overall. However, the average increase for all BRT corridors but one was between 23 and 24 percent. The excluded one increased 17 percent. Average running times for all nine corridors decreased by about 20 percent.

- Miami-Dade Transit Agency (MDTA) reported that implementation of BRT resulted in near doubling of bus ridership for corridor routes, increasing the total from 8,000 per day before BRT implementation to 14,000-15,000 several years after implementation of BRT along the U.S. 1 Corridor. There was only a modest increase in average travel speeds with introduction of the South Dade Busway, but significant improvements in reliability and increases in service.
- Pittsburgh's Port Authority of Allegheny County (PAT) reported that travel demand has significantly increased in the corridors where BRT was implemented. The Southwestern Pennsylvania Commission (SPC) attributes most of the increases in ridership in virtually all BRT corridors to the provision of new or expanded park-and-ride facilities. Ridership on the West Busway, however, is significantly lower than predicted (one-third) in the EIS for the project for a variety of reasons.
- Las Vegas Regional Transportation Commission of Southern Nevada/Clark County Transit Agency (RTC) reported that their new MAX BRT system has increased in ridership in the North Las Vegas Boulevard Corridor over 30% only six months after opening.
- San Francisco Bay Area Metropolitan Transportation Commission (MTC) reported that it has only been a year since "BRT Lite" (Rapid Bus) was implemented on San Pablo Boulevard running north from downtown Oakland. This is not full-blown BRT service. However, a survey of Rapid

Bus riders suggests that new transit riders account for over 30% of the total on the new line.

- Vancouver's TransLink has typically seen ridership increases of 25-30% in corridors with BRT. The most comprehensive analysis of this is in a study of the #98 B-Line. TransLink found that demand increases are a result of complex factors including service levels, reliability, branding and marketing of service, integration with other transit services (a significant factor in some, but not all of their BRT services), fleet quality attributes, and on-street enhancements. Research suggests that frequency, travel time, and reliability are the dominant factors causing the increases.

Ridership increases in non-peak and non-work trips were reported as follows:

- For various reasons, none of the respondents specifically answered this question. In several cases the data were not available, and in other cases an analysis was not done. However, some comments are interesting, if not valuable, to the issues addressed here:
  - Boston Central Transportation Planning Staff (CTPS) reported that growth occurred at the rate expected. In fact, the proportional increases in the off-peak weekend travel were higher than in the weekday peak.
  - In a BRT case study done by the University of South Florida's Center for Urban Transportation Research (CUTR) for the Federal Transit Administration, MDTA reported that increases in ridership due to implementation of the South Dade Busway were much greater on weekends (150% after seven years) than during the week (+70%).
  - Vancouver TransLink's "B" Line services have attracted significant off-peak and reverse peak ridership. This was by design as B-Line routes were developed in corridors that have potential to attract these types of trips. Supporting this has been the service design change whereby connecting routes have been improved to enhance the attractiveness of connecting to B-Line. Typically, TransLink has eliminated some or all competing express routes in the corridor, but have kept local services. In the cases of #98 B-Line and #97 B-Line, they also modified existing routes to act as feeders.

BRT implementation based on issues other than ridership forecasting was reported as follows:

The traditional four-step travel demand model has not been universally applied to BRT projects. There has been some use of elasticity approaches.

- The survey discussed above was intended to summarize BRT ridership forecasting practice during alternatives analyses. It should be noted that there was little if any traditional four-step model-based travel demand forecasting used in the planning done for many BRT projects, particularly the less elaborate applications where Alternatives Analyses were not necessary. In many cases, the projects resulted from a unique opportunity (e.g., reconstruction of a major arterial such as in Las Vegas) or a political mandate (MTA Rapid Bus). In most of these cases, however, simple elasticity-based approaches, borrowed from the service planning "tool box," were used in service planning and financial (budgeting) analyses. For example:
  - Los Angeles County Metropolitan Transit Authority (MTA) did not forecast demand for the initial Metro Rapid Bus routes. System development resulted from a mayoral directive following a popular

referendum passed in November 1999 that explicitly forbid further expansion of the L.A. subway system.

> Regional Transportation Commission of Southern Nevada/Clark County Transit Agency (RTC) (both the transit operator and the MPO) did not develop the original MAX line through the normal major investment planning process; therefore, no pre-implementation ridership forecasts were developed. The Nevada Department of Transportation (NDOT) approached them because they had excess ROW on an arterial corridor rehabilitation project that they wanted to dedicate to use as an exclusive bus lane. This gave them an "opportunity" to develop BRT on what happened to be their most productive transit corridor. However, they are now pursuing development of additional BRT lines through the standard planning process.

> The Miami-Dade Transit Agency (MDTA) did not run a traditional four-step travel model in planning for initial segment of the South Dade Busway. A major investment had been part of the region's Metro Rail plan for a considerable period, and the Agency took advantage of an offer by the State DOT to fund construction of the busway out of "flexible" funds.

## SUMMARY OF SURVEY FINDINGS

The issue of the appropriate and fair assessment of the attributes of the different modes must be addressed in any objective alternatives analysis. Alternatives analysis evaluation criteria typically include ridership and revenue, congestion and pollution reductions, and the effects on land use and economic development. These criteria are all driven by ridership forecasts. If the attributes of rail alternatives (assumed to include comfort, convenience, and speed) are given bonuses over other rapid transit modes in the transportation demand models, then the alternatives analyses would be considered biased toward rail alternatives. The survey explored this topic and has identified that, in many cases, there is a bias in favor of rail alternatives over all bus alternatives regardless of their nature:

1. In a number of cases, "premium" or rapid transit modes including LRT and BRT are not differentiated from local bus at all. In a third set of instances, non-rail premium modes have not yet been evaluated by the demand forecasting models as they were never seriously considered.
2. In some metropolitan area—even where BRT alternatives are identical to LRT with respect to the number and quality of stations, their locations, the quality of the vehicles in terms of aesthetics, noise, floor level, etc., the existence of a dedicated running way, off-board fare collection, and service plan, etc.—the models will forecast a significantly higher ridership for rail compared to BRT, all else (e.g., land use, population and employment, origin-to-destination fares, and travel times) being equal.
3. In a very few places, BRT, LRT, and other rapid transit modes are treated identically in travel forecasting.

Half of the respondents surveyed did nothing special for any rapid transit mode (Case Number 1) compared to the basic local bus system in forecasting ridership.

In Case Number 2, special treatment only for rail rapid modes is provided for in a variety of ways:

- BRT is often treated as conventional local bus, while LRT is uniquely treated as "premium" service in all coefficients and constants in the respective impedance (generalized cost) function. For example, the SCAG model treats rail as express transit and Metro Rapid Bus as local transit, despite the unexpectedly positive experience with Rapid Bus.
- MTC's nested logit structures separate transit into drive access and non–drive access. For drive access, the next tier in the nested logit model includes kiss-and-ride and park-and-ride modes, but auto access links are included only to BART (rail) stations and not other transit nodes. For the non–drive access mode, the next tier includes local bus, express bus, and BART. All modes and sub-modes have different modal specific constants.

Only two respondents treat BRT in essentially the same special way they treat LRT and rail-based rapid transit modes (Case Number 3). For example:

- SPC specially models all bus routes that use a busway for any portion of the person trip as BRT, a mode identical to LRT in terms of impedance function coefficients and constants. (LRT, however, is not given the minimum initial or transfer wait time that SPC applies to all other modes.)

As with other issues of including LRT and BRT in transit systems, the use of mode-specific bias constants in modeling for LRT versus BRT and local bus varied among respondents:

- Houston METRO noted that they do not use specific rail constants to represent LRT, but their goal is to move toward having unique constants in the rail nest for assignment purposes. Their survey data suggest that use of a rail bias is valid. Houston METRO models BRT, BRT-like services, and LRT using the same constants as were calibrated from actual data for their "Park and Ride" commuter express routes which feature high-quality, frequent service operating on "transitways"/HOV lanes with terminals in an extensive system of park-and-ride lots.
- PAT does not use a unique "rail"–only modal constant. BRT is considered a guideway mode because the "ridership response to bus services on the PAT system's busways are more like they would be to LRT than local bus service." No special efforts are made for BRT--it is treated just like rail in any analysis.
- SCAG uses the same bias constants for all premium service, which includes LRT and presumably BRT.
- CTPS notes that it is currently deciding whether BRT is a premium mode or a conventional local bus service, but, in the meantime, the Silver Line was modeled using the same parameters as LRT.
- NCTCOG reserves the title "BRT" for routes where "very special" buses run at least partially on special bus guideways. Such a "real" BRT service is provided the same "pulse" and "lower weight time for first wait" treatment as rail service. This has been done at the planning level (none is currently in operation), so that there is no bias against BRT when compared to rail. The result of this modeling practice is that the BRT alternative was identified in the community as the preferred service for more detailed analysis. NCTCOG is re-examining whether BRT truly deserves the same treatment as rail services.

## DETAILED SURVEY RESPONSES

### Questions Concerning Demand Modeling

**QUESTION 1: How is demand being forecast for your transit system for long-range and project planning (as opposed to operation planning) purposes?**

| Agency | Response |
|---|---|
| Alameda County Transit (California) | We use our own trip-based travel demand forecasting model system. |
| City of Ottawa | No response. |
| Dallas Area Rapid Transit | No response. |
| Denver Regional Council of Governments | No response. |
| Denver Regional Transportation District (RTD) | The DRCOG/Denver-RTD Model is in transition and different model specifications and software platforms have been used for different projects. All model versions use a four-step process. |
| Greater Cleveland Regional Transit Authority | No response. |
| Houston-Galveston Area Council | No response. |
| Houston METRO | A traditional four-step modeling process is used. Current practice relative to "bias constants"/ LRT-BRT treatment is described below. An indication of where Houston hopes to go is also suggested. As background (from *Houston-Galveston Areawide Council Transportation Modeling System Overview and Summary, H-GAC website*), "the trip-based models that are currently under construction for the Houston-Galveston Areawide Council (H-GAC) represent advanced modeling practices…The models take advantage of market segmentation techniques throughout the model chain, consider all modes of transport in both trip distribution and nested logit mode choice models differentiated between toll, HOV, local bus, express bus, and rail transit…" |
| Los Angeles County Metropolitan Transit Authority | Demand was not forecasted for initial BRT routes because the challenge was/is just to have better and faster service with the same fares. |
| Boston Central Transportation Planning Staff (CTPS) - Serves MPO and MBTA | For project and system level, CTPS uses the same model set used for all modes – the regional model with all modes (bus, LRT, commuter rail, BRT, and boat) represented—and the same methods. The gray area is deciding if BRT is a premium service or a simple bus service. For the Silver Line, the model is calibrated the same as for LRT. This is a nested logit model where the modes are differentiated by access—whether the rider gets to the mode by walking or driving. In the mode choice model, BRT just fits in. |
| San Francisco Bay Area Metropolitan Transportation Commission (MTC) | No response. |
| Miami Dade MPO | No response. |
| Miami Dade Transit Agency | MDTA did not prepare ridership forecasts for the South Dade Busway. They referred the interviewers to the MPO for answers to modeling questions. |
| North Central Texas Council of Governments (NCTCOG) | MPO has a TransCAD-based four-step model system in place. Please see this site for basic documentation: http://www.nctcog.org/trans/program_areas/travel_forecasting.html |
| Northeast Ohio Areawide Coordinating Agency (Cleveland) | No response. |
| Port Authority of Allegheny County (PAT) (Pittsburgh ) | For long range system planning and projects, the regional model is used. For operations, a pivot point process is used. |

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|---|---|
| Regional Transportation Commission of Southern Nevada / Clark County Transit Agency (Las Vegas) | Ms. Duval will refer the modeling questions to other staff in her agency. They are both the transit operator and the MPO. However, the original MAX line was not developed through the normal planning process and no pre implementation forecasts were done. NDOT approached them because they had excess ROW on a corridor project that they wanted to dedicate to use as an exclusive bus lane. This gave them an "opportunity" to develop BRT on what happened to be their most productive transit corridor. They are now pursuing development of additional BRT lines through the standard planning process. She will provide ridership for existing service and pre-implementation bus ridership and forecast for the proposed corridors. |
| Southern California Association of Governments (SCAG) (Los Angeles) | SCAG maintains a Regional Travel Demand Model which follows the traditional four-step modeling process with feedback loops from trip assignment to trip generation, trip distribution, and mode choice for convergence. |
| Southwestern Pennsylvania Commission | Traditional four-step process is used for long range and project planning. This model is not used for operations planning by SPC. |
| TransLink (Vancouver) | A traditional four-step modeling process is used. Brian Mills indicated that the modeling was done 10 years ago, and that extensive modeling was involved. He also said that the corridor has just undergone an investment-grade study for conversion to LRT. For long-range and project planning we use the EMME/2 model, with the four-step modeling procedure implemented in EMME/2. We model four trip purposes:<br>– Work<br>– Post Secondary<br>– Grade School<br>– Other<br>and four modes of travel:<br>– Auto Driver<br>– Auto Passenger<br>– Transit<br>– Walk/Bike |

**QUESTION 2: If a traditional four-stop modeling process is used for all trips' purposes, is there special treatment for rail-based rapid transit modes?**

**If yes, is this special treatment in the mode choice model (i.e., using different modal constants)?**

**If yes, is this special treatment in assignment (i.e., using different boarding penalties)?**

**If yes, is this special treatment in distribution (i.e., using a "log-sum" variable to reflect travel production to attraction travel impedance)?**

| Agency | Response |
|---|---|
| Alameda County Transit (California) | There are no separate sub-modes in our models. We only have mode-of-access in our home-based work mode choice models.<br>No.<br>No, although we do use composite impedance for our home-based work trip distribution (gravity) model, stratified by household income quartile. |
| City of Ottawa | No response. |
| Dallas Area Rapid Transit | No response. |
| Denver Regional Council of Governments | No response. |

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|---|---|
| Denver Regional Transportation District (RTD) | Mode choice does not use a nested model. No bias constants are used for any of the model versions/platforms. The older MINUTP-platform model was used for FasTracks and the West Corridor EIS and New Starts. For the FasTracks and the West Corridor EIS, a perceived transfer time penalty is used in transit path building, with rail and premium bus treated equally with a less onerous penalty (1/2 that for regular bus). The perceived transfer time penalty approach was not used for the most recent West Corridor New Starts modeling (transfer time penalties removed/no replacement) due to concern about maintaining consistency in treatment of mode choice and path building by the model. However, actual rail travel time was reduced by 35% before transit path building and carried through to mode choice. The reduction was necessary to achieve reasonable model validation by mode, but consistency was maintained in transit path building and mode choice.<br><br>The newer TransCAD-platform model is being used for the US 36 and I-70 East Corridor EISs. The TransCAD model uses a weight for both mode choice and path building. The weight is applied to perceived in-vehicle travel time. It is set at about 70% *(ask Greg Erhardt for exact value)* and applies to rail only. RTD/DRCOG model validation under the newer TransCAD platform has consistently identified over prediction for express bus versus under prediction of rail, so similarly weighting in-vehicle travel time for premium bus was viewed as counter productive.<br><br>There is no special treatment applied to distribution. "Bias constants" are not used. |
| Greater Cleveland Regional Transit Authority, Main Office | No response. |
| Houston-Galveston Area Council | No response. |
| Houston METRO | No, but survey data suggests that there should be. For LRT we do not use specific rail constraints. The model uses the same constraints as local bus.<br><br>Houston METRO's goal is to move toward having unique constants in the rail nest for assignments. Survey data suggests that use of rail bias is valid, but this hasn't been factored into the models yet because we have two New Starts packages pending and FTA hasn't been convinced that the bias is necessary. Currently, the assignments vary only by trip purpose, but otherwise LRTs are the same as local bus. Constants for travel time are modeled in. No special treatment is made in distribution. |
| Los Angeles County Metropolitan Transit Authority | Not applicable. |
| Boston CTPS | No. The differentiation is whether the mode is accessed by walking or driving. It is the same for all modes. Except for bus, it is the same for each sub mode. Buses (but not BRT) are assessed a 10 minute penalty that corrects for a recent FTA modeling directive. The log-sum variable is used, but BRT does not get special treatment. |
| San Francisco Bay Area Metro. Transportation Commission (MTC) | No response. |
| Miami Dade MPO | No response. |
| Miami Dade Transit Agency | No response. |

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|---|---|
| North Central Texas Council of Governments (NCTCOG) | No. We actually did have rail bias constants in some of our earlier TransCAD testing, but found that our model validation "station RMSE" results actually looked better when we switched to an alternative means (see next item) of representing the fact that rail stations offer patrons a much better environment than your typical bus stop. Yes. For both transit skimming and transit assignment, we have a lower weight time factor applied to the wait times at rail stations for walk-to-rail and drive-to-rail travel (for purposes of getting on rail). For both transit skimming and assignment, we also use a "transit pulse time" approach in which the bus-to-rail and rail-to-bus transfers are assumed to not exceed a calibrated wait time value. For mode choice, the wait time (and transfer wait time) coefficients for bus and rail are the same. [Note: please call me, if this is unclear as to what I am trying to say]. No. Our trip distribution does not include transit travel times, primarily because our trip distribution calibration work was based on a 1996 household survey that took place before light rail was in operation—I am sure we will seriously re-investigate this in 2009+, when we have the results of the 2007/2008 survey available. |
| Northeast Ohio Areawide Coordinating Agency (Cleveland) | No response. |
| Port Authority of Allegheny County (PAT) (Pittsburgh) | Modal constants are not used. No boarding penalties are used. No special treatment is used. |
| Regional Transportation Commission of Southern Nevada / Clark County Transit Agency (Las Vegas) | Current SCAG model separates transit mode into four submodes: walk to local transit, auto to local transit, walk to express transit, and auto to express transit. Rails are treated as express transit and Rapid bus are treated as local transit. The utility functions were estimated based on 1991 OD survey and some transit on-board surveys of later date. Mode constants were determined based on year 2000 model validation. SCAG's web site www.scag.ca.gov contains the complete report of year 2000 model validation and summary. Transit assignments were done for each mode separately using corresponding trip tables from mode choice. Log sums from mode choice model were used in HBW trip distribution. |
| Southern California Association of Governments (SCAG) (Los Angeles) | No response. |
| Southwestern Pennsylvania Commission | Yes. Transit skims are built for up to three possible paths. These are walk to premium, walk to local, and auto access. Premium includes fixed guideway (LRT, BRT, and commuter rail) for any portion of the person trip. BRT includes all bus routes which use a busway for any, or the entire, portion of the trip. Local includes all other bus modes, and Pittsburgh's inclines. Auto access can include any transit mode. Different modal constants are used for the above three categories as well as trip purpose (home-base work, home-base other, and non-home base). All modes have a minimum initial or transfer wait time of 4 minutes except for rail (LRT, commuter rail, inclines) which has no minimum. The process is used for mode choice and transit assignment. The transit paths from the mode choice model are saved for use in transit assignment. Distribution is based on highway impedances. |

| | |
|---|---|
| TransLink (Vancouver) | In the past we have typically had special treatments for rail-based modes of travel, in which rail receives a modal advantage using a wait time factor. In recent work for the Northeast Sector Rapid Transit project we conducted analysis on BRT in which we endeavored to eliminate the biases on the assumption that investment in high-grade BRT (we actually assumed guided light transit or GLT) would receive the same level of priority and investment as rail modes. Because BRT/GLT was assumed to use existing roadways for segments, its operating speed would be limited by the posted speed limit in these segments. This is accounted for in the recent analysis. Links to this research are:<br>♦ http://www.translink.bc.ca/files/pdf/plan_proj/area_plans/northeast_sector/summary.pdf<br>♦ http://www.translink.bc.ca/files/pdf/plan_proj/area_plans/northeast_sector/executive_summary.pdf<br>♦ http://www.translink.bc.ca/files/pdf/plan_proj/area_plans/northeast_sector/final_technical_report.pdf<br>The mode choice model only deals with transit trips as a whole. The allocation to transit sub-modes is handled during the transit assignment process. All things being equal we use the same wait time for rail-based modes, but in typical analysis we would apply a wait time factor give a slight reduction to the wait time for rail (1/2 headway * 0.8) and a slight penalty to the bus mode (1/2 headway * 1.2). In the Northeast Sector analysis described above the modes were treated the same. There is no special treatment for rail-based transit modes in the trip distribution stage. |

**QUESTION 3: If a bias constant is used in the mode choice model (and or other mode(s)) is different for rail from the one used for "bus," what do you use for BRT?**

| Agency | Response |
|---|---|
| Alameda County Transit (California) | No. |
| City of Ottawa | No response. |
| Dallas Area Rapid Transit | No response. |
| Denver Regional Council of Governments | No response. |
| Denver Regional Transportation District (RTD) | "Bias constants" are not used. |
| Greater Cleveland Regional Transit Authority | No response. |
| Houston-Galveston Area Council | No response. |
| Houston METRO | During alternatives analysis for LRT and BRT-like service, BRT was modeled using the same constants as the commuter premium bus service, which takes commuters from park and rides and uses HOV lanes.<br><br>As stated before, LRT is modeled using local bus constants. |
| Los Angeles County Metropolitan Transit Authority | Not applicable. |
| (Boston) CTPS | The bias constant is only rail versus bus, not rail versus BRT. |
| S.F. Bay Area Metro. Transportation Commission (MTC) | No response. |
| Miami Dade MPO | No response. |
| Miami Dade Transit Agency | No response. |

| | |
|---|---|
| North Central Texas Council of Governments (NCTCOG) | Although we don't technically have a "bias constant" for rail it is true that we do allow bus-rail and rail-bus pulse times, as well as lower weight times applied to the first waits at rail stations. We do not consider our current express bus services on freeways and HOV lanes as "BRT," but reserve the title "BRT" for facilities in which the bus operations are "very special" buses that run at least partially on special bus guideways. Such a "real" BRT is provided the same "pulse" and "lower weight time for first wait" treatment as we do for rail service. We don't know if this is right, since we do not have any "real" BRT in our region. However, we felt this was the "right thing to do" in our planning-level work for BRT, so that we would not bias the results against BRT (when compared to rail). Note: if the end result was that BRT service was identified in the community as the preferred service for more detailed analysis, we would have had to re-examine whether BRT truly deserves the same treatment as rail services. |
| Northeast Ohio Areawide Coordinating Agency (Cleveland) | No response. |
| Port Authority of Allegheny County (PAT) (Pittsburgh) | A bias constant is not used. BRT is considered a guideway mode because this system's busways are more similar to trains than LRT. No special efforts are made for BRT—it is treated just like any rail line in an analysis. When passengers are not transferring, like on trains, it is easy to count them. It is harder for buses. The strength of BRT—its train-like qualities—is also its weakness when doing an analysis. Keeping track of BRT riders is more complicated than with other fixed guideway modes. This is a technical issue, not a process issue. The analysis process remains the same. |
| Regional Transportation Commission of Southern Nevada / Clark County Transit Agency (Las Vegas) | No response. |
| Southern California Association of Governments (SCAG) (Los Angeles) | Constants were adjusted for each transit submode based on model validation. |
| Southwestern Pennsylvania Commission | The same bias constants are used for all premium service which includes LRT and BRT. |
| TransLink (Vancouver) | The bias used in the mode split equations is the same for all transit sub-modes. As mentioned in II.a, transit is modelled as a whole during the mode choice stage. |

**QUESTION 4: If bias constants are used, do(es) the difference(s) between/among bias constants vary by trip purpose?**

| Agency | Response |
|---|---|
| Alameda County Transit (California) | Not applicable. |
| City of Ottawa | No response. |
| Dallas Area Rapid Transit | No response. |
| Denver Regional Council of Governments | No response. |
| Denver Regional Transportation District (RTD) | "Bias constants" are not used. |
| Greater Cleveland Regional Transit Authority | No response. |

| | |
|---|---|
| Houston-Galveston Area Council | No response. |
| Houston Metro | As stated above, during alternatives analysis for LRT and BRT-like service, BRT was modeled using the same constants as the commuter premium bus service, which takes commuters from park and rides and uses HOV lanes.<br><br>As stated before, LRT is modeled using local bus constants. |
| Los Angeles County Metropolitan Transit Authority | Not applicable. |
| Boston CTPS | Yes, but it is not specific to BRT. |
| S.F. Bay Metro Transportation Commission (MTC) | No response. |
| Miami Dade MPO | No response. |
| Miami Dade Transit Authority | No response. |
| North Central Texas Council of Governments (NCTCOG) | No rail/BRT bias constants in our model. However, we do apply our "pulse time" assumptions equally to all trip purposes. |
| Northeast Ohio Areawide Coordinating Agency (Cleveland) | No response. |
| Port Authority of Allegheny County (PAT) (Boston) | The modeling system does differentiate between work and non-work trips. |
| Regional Transportation Commission of Southern Nevada / Clark County Transit Agency (Las Vegas) | No response. |
| Southern California Association of Governments (SCAG) (Los Angeles) | Constants were adjusted for each trip purpose based on model validation. |
| Southwestern Pennsylvania Commission | Yes. |
| TransLink (Vancouver) | A bias constant is used to calibrate transit mode choice by comparing the generalized cost of travel between auto and transit. This bias does vary by trip purpose as the propensity to take transit will be different for the different modes of travel. |

## QUESTIONS CONCERNING RESULTS OF BRT IMPLEMENTATION

**QUESTION 1: How has implementation of BRT affected travel demand in the respective corridor(s)?**

| Agency | Response |
|---|---|
| Alameda County Transit (California) | Not available |
| City of Ottawa | No response. |
| Dallas Area Rapid Transit | No response. |
| Denver Regional Council of Governments | No response. |
| Denver Regional Transportation District (RTD) | RTD does not consider the 16th Street Mall Shuttle as BRT due to low speeds and frequent stops. They believe that the North I-25 Corridor bus/HOV lanes (Downtown Express) would be the closest they have to BRT. RTD staff could examine the Downtown Express NEPA documentation for bus ridership forecasts and compare those against observed bus ridership. However, it is possible that such a comparison would be "apples to oranges" because it is likely that forecasts for the NEPA document were made for the corridor as a facility, but observed ridership is counted by route. |
| Greater Cleveland Regional Transit Authority | No response. |
| Houston-Galveston Area Council | No response. |
| Houston METRO | Five "Signature Service" routes are also planned. These will be similar to the AC Transit Rapid Bus in the Bay area, or the Silver Line in Boston. They will not be on a guideway, but will have signal priority. It will have upgraded shelters, and buses of a different design (CIVIS 3-door), off-board fare collection. Constants for travel time were modeled in, and bus capacity assumptions were fitted to smooth peak loads (58 seats with a 90-person crush load). The first "Signature Service" BRT-like route is proposed to open in 2008. |
| Los Angeles County Metropolitan Transit Authority | (Metro Rapid Bus Service, synonymous in LA with BRT, will include 28 lines covering 450 miles by 2008. LA does not have actual BRT, thus LA was not included in the BRT consortium. The 11 existing lines have special attributes, but do not have dedicated lanes, high capacity buses (although new buses are coming soon), or prepaid fares. The planned 29th corridor is 12 miles along an old railroad line and will be more of a true BRT with more rail-like attributes. The new 60-foot buses will run on compressed natural gas. All the buses—45-foot and 60-foot—will have low noise, short dwell times, a better look/image, big windows, and in general, offer riders a good experience.)<br><br>Ridership on the first two corridors (Venture and Wilshire corridors) is up 40% (65k to 85k/day and 10-12k to 17k/day). This is based simply on faster service. These corridors were successful enough that 27 additional corridors were approved. Of those, 9 more have been implemented. |
| Boston CTPS | BRT shows 14K passengers per day, which is greater than with the previous bus service (doesn't remember the rider numbers for bus service). |
| S.F. Bay Metro. Transportation Commission I (MTC) | No response. |
| Miami Dade MPO | No response. |
| Miami Dade Transit Agency | Implementation of the BRT service resulted in near doubling of bus ridership for corridor feeder routes, increasing from 8K per day before BRT implementation to 14K–15K after implementation of BRT along the US 1 Corridor. They provided detailed current ridership data. |

| | |
|---|---|
| North Central Texas Council of Governments (NCTCOG) | We don't consider an express bus service as "real" BRT. |
| Northeast Ohio Areawide Coordinating Agency (Cleveland) | No response. |
| Port Authority of Allegheny County (PAT) (Boston) | As with any fixed guideway mode, travel demand has generally increased. |
| Regional Transportation Commission of Southern Nevada / Clark County Transit Agency (Las Vegas) | It has produced increases. Actual data will be provided (see above). |
| Southern California Association of Governments (SCAG) (Los Angeles) | SCAG has not performed an independent assessment of the performance of BRT. |
| Southwestern Pennsylvania Commission | Based on model simulations for corridor planning, corridor travel demand has increased with implementation of BRT. But most of the increase can be attributed to additional park and ride facilities. |
| TransLink (Vancouver) | We have typically seen ridership increases in corridors with BRT. The most comprehensive analysis of this is in a study of the #98 B-Line (http://www.itsbc.ca/pdf/98BLine_BRT_Evaluation_Study.PDF). |

**QUESTION 2: Were travel demand increases in line with expectations based on past results due to changes in the local bus system with respect to improvements in travel times and frequency?**

| Agency | Response |
|---|---|
| Alameda County Transit (California) | Not available |
| City of Ottawa | No response. |
| Dallas Area Rapid Transit | No response. |
| Denver Regional Council of Governments | RTD does not the 16th Street Mall Shuttle as BRT due to low speeds and frequent stops. They believe that the North I-25 Corridor Express Bus would be the closest they have to BRT. They could dig back in archives for 10-year old forecasts on that if we want the data. They said however, that there will also be difficulty in assembling actual ridership data because of how they collect data. Some broad assumptions could be made to derive what we need, but it would be of limited accuracy. |
| Denver Regional Transportation District (RTD) | No response. |
| Greater Cleveland Regional Transit Authority | No response. |
| Houston-Galveston Area Council | No response. |

| | |
|---|---|
| Houston METRO | The opening year for LRT is 80% of the 2020 forecasts with 33% of survey respondents saying they are NEW to transit. This is a 7.5-mile line with two major activity centers. The 2025 Metro Solutions plan showed a preference for LRT because of the type of network it would provide.<br><br>Houston METRO has not assessed the commuter bus forecasts with actual data. All of the routes are in place. No "gut" feeling as to whether the forecasts were in line with expectations. If necessary, will go into the records to get the data. |
| Los Angeles County Metropolitan Transit Authority | Ridership was much higher than expected on the first two corridors, but less than expected on the next nine corridors. However, this is partly because system wide bus ridership (1 million riders) declined 5% overall. Still all but one corridor increased 23 to 24%. The other increased 17%. Running time for all nine corridors increased by more than 20%.<br><br>Eventually, 20% more capacity will be added because of the increased speed—not because of higher capacity buses—which is a cost-free improvement. |
| Boston CTPS | Forecast travel demand was "pretty accurate." However, the forecasts were done only a couple of years before service was implemented. It might have been different if the forecasts were more long range. |
| S.F. Bay Metro. Transportation Commission (MTC) | No response. |
| Miami Dade MPO | No response. |
| Miami Dade Transit Agency | They didn't really have expectations relative to impact/increases. |
| North Central Texas Council of Governments (NCTCOG) | From a qualitative standpoint, we have been generally satisfied as regards the "believability" of our bus and rail transit ridership forecasts with our TransCAD-based Dallas-Fort Worth regional travel model. |
| Northeast Ohio Area-wide Coordinating Agency (Cleveland) | No response. |
| Port Authority of Allegheny County (PAT) (Boston) | As with any fixed guideway mode, travel demand has generally increased. |
| Regional Transportation Commission of Southern Nevada / Clark County Transit Agency (Las Vegas) | There were no quantified "expectations." |
| Southern California Association of Governments (SCAG) (Los Angeles) | SCAG has not performed an independent assessment of the performance of BRT. |
| Southwestern Pennsylvania Commission | This has not been specifically evaluated by SPC. |
| TransLink (Vancouver) | Demand increased are a result of complex factors including service levels, reliability, branding and marketing of service, integration with other transit services (a significant factor in some, but not all of our BRT services), fleet attributes and on-street enhancements. Research suggests frequency, travel time and reliability are the dominant factors. |

| **QUESTION 3: Was there a higher amount of unexpected growth in non-peak, non-work trips than peak work trips (based on previous experience with bus system changes)?** | |
|---|---|
| **Agency** | **Response** |
| Alameda County Transit (California) | Not available |
| City of Ottawa | No response. |
| Dallas Area Rapid Transit | No response. |
| Denver Regional Council of Governments | No response. |
| Denver Regional Transportation District (RTD) | RTD does not the 16th Street Mall Shuttle as BRT due to low speeds and frequent stops. They believe that the North I-25 Corridor Express Bus would be the closest they have to BRT. They could dig back in archives for 10-year old forecasts on that if we want the data. They said however, that there will also be difficulty in assembling actual ridership data because of how they collect data. Some broad assumptions could be made to derive what we need, but it would be of limited accuracy. |
| Greater Cleveland Regional Transit Authority | No response. |
| Houston-Galveston Area Council | No response. |
| Houston METRO | As stated above, the opening year for LRT is 80% of the 2020 forecasts with 33% of survey respondents saying they are NEW to transit. This is a 7.5-mile line with two major activity centers. The 2025 Metro Solutions plan showed a preference for LRT because of the type of network it would provide.<br><br>Houston METRO has not assessed the commuter bus forecasts with actual data. All of the routes are in place. No "gut" feeling as to whether the forecasts were in line with expectations. If necessary, will go into the records to get the data. |
| Los Angeles County Metropolitan Transit Agency | In Los Angeles, these data are unreliable. |
| Boston CTPS | Growth happened as expected. Phase 2 of the Silver Line opened on December 17, 2004. |
| S.F. Bay Metro. Transportation Commission (MTC) | No response. |
| Miami Dade MPO | No response. |
| Miami Dade Transit Authority | As above, they didn't really have expectations relative to impact/increases. |
| North Central Texas Council of Governments (NCTCOG) | The relative rail ridership increases in home-based work (HBW) versus home-based non-work (HNW) versus non–home-based (NHB) trips seems generally believable. |
| Northeast Ohio Areawide Coordinating Agency (Cleveland) | No response. |
| Port Authority of Allegheny County (PAT) (Pittsburgh | As with any fixed guideway mode, travel demand has generally increased. |
| Regional Transportation Commission of Southern Nevada / Clark County Transit Agency (Las Vegas) | As above, there were no quantified "expectations." |

| | |
|---|---|
| Southern California Association of Governments (SCAG) (Los Angeles) | SCAG has not performed an independent assessment of the performance of BRT. |
| Southwestern Pennsylvania Commission | This has not been specifically evaluated by SPC |
| TransLink (Vancouver) | Yes, the B-Line services have attracted significant off-peak and reverse peak ridership. This has been by design as B-Line routes have been developed in corridors that have potential to attract these types of trips. Supporting this has been the design change whereby connecting routes have been improved to enhance the attractiveness of connecting to B-Line. We typically have eliminated some or all competing express routes in the corridor, but have kept local services. In the cases of #98 B-Line and #97 B-Line we also modified existing routes to act as feeders. |

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# APPENDIX B BRT RIDERSHIP FORECASTING RESEARCH

## INTRODUCTION

Ridership forecasting is an integral part of transportation planning for rail and BRT. Realistic estimates of BRT (and rail) ridership are essential for selecting and sizing facilities, preparing service plans, estimating capital and operating costs, quantifying benefits, and assessing cost-effectiveness. Moreover, ridership influences almost every public transportation objective, including congestion relief, economic development, and environmental enhancement. These objectives relate directly to the ability of a given transit investment to attract new riders.

This appendix reviews four basic methods of forecasting ridership for bus and rail rapid transit. It reviews the basic research that addresses the relative attractiveness of bus versus rail rapid transit and gives guidelines for improving BRT modal split parameters. Its basic purpose is to help practitioner's perform more realistic and objective assessments of modal options.

Four research efforts were reviewed related to forecasting BRT vs. rail ridership and modal split parameters.

Four seminal studies relating rapid transit characteristics to ridership suggest that the modal bias constants for bus and rail rapid transit are similar when the features that both modes provide are essentially the same.

The first study, *Demand Model Estimation and Validation* (Reference B1), by the Nobel Prize–winning economist Daniel McFadden and his student at the University of California at Berkeley, Antti Talvitie, et al., developed the mathematical basis for subsequent statistical analyses of travel demand/choice models. Though the research covered mode choice as a general issue, it drew inferences as to the impact of the unique characteristics of different transit technologies on mode choice in addition to the logistic model formation.

The second study, *Comparing Ridership Attraction of Rail and Bus* (Reference B2), by Moshe Ben-Akiva and then-student Takayuki Morikawa, built on the ground-breaking work by McFadden. The researchers applied discrete travel choice analysis techniques to different corridors in the same metropolitan area. Travelers in Boston and Washington, D.C., had a relatively high-quality bus choice (e.g., express bus on median-separated HOV lanes) in one corridor and a rail transit choice in another. By statistically analyzing the differences among mode choice model parameters, they were able to draw conclusions about the way in which travelers would respond to high-quality bus alternatives such as BRT in competition with driving when compared to their response to transit when the choice was rail transit.

The third study, *The Demand Performance of Bus Rapid Transit* (Reference B3), by Graham Currie of Australia's Monash University, conducted a worldwide survey of travel analysis and modeling efforts similar to that done by Ben-Akiva and Morikawa. It, too, drew inferences as to how travelers respond to high-quality bus systems like BRT and noted the implications for travel demand forecasting.

The fourth study, *Easy to Use Public Transport - How to Use a New System* (Reference B4), by Katrin Dziekan of the Royal Institute of Technology in Stockholm, focused on the effects of passenger information and knowledge aspects of public transportation on system attractiveness. The study surveyed new residents of the Stockholm Region and asked how they learned the basic information necessary to use the system (where to access it, where it goes, when to get it, how to pay, etc.) and their modal preferences.

These four studies are discussed in detail below. Each discussion is organized around the following:

- An introduction and problem;
- A description of the methodology used;
- The results of the research as described by the researcher; and
- The researcher's conclusions.

The Conclusions section for each study summarizes the conclusions of the researcher and discusses implications for BRT ridership attraction.

## RESEARCH REVIEWED

### Demand Model Estimation and Validation (McFadden et al.)

*Introduction*

As part of the USDOT-financed Bay Area Rapid Transit System (BART) Impact Study, Daniel McFadden of the University of California at Berkeley used home interview survey results before and after the opening of BART, which opened in 1974, to develop a new understanding of how individuals make travel choices. He found that "discrete-choice" models that replicate the behavior of individuals are far better at predicting the traveler response to changes in the transportation system (e.g., the introduction of a new transit system) than the aggregate models formerly used in transportation planning.

Aggregate models are simple statistical correlations of data collected for traffic analysis units or "zones" without a structure that replicates the real behavior of individual travelers. As such, aggregate models require more data to develop and are inherently less stable over time and, thus, are less accurate as forecasting tools.

The study used models developed using individual travel data collected before BART was built to predict behavior after BART opened. It compared predicted behavior with actual behavior to see how well the models did and, thus, how stable they were over time. Many different model structures and their parameters were compared and validated, and this process is detailed in the paper. The study found that mode-choice models are stable over time and transferable from one place to another if they are properly structured and calibrated to match real, disaggregate, or individual choice behavior.

In comparing the differences between the results of models developed with pre- and post-BART data, McFadden found the following:

- When quantifiable service and performance characteristics (travel time, cost, transfers, etc.) are equal for both transit modes, there is no evidence that riders will more readily choose rail transit compared to driving than they would a (quality) bus choice.
- To ensure better forecasting accuracy, comfort and convenience and other attitudinal variables could be accounted for when developing generic mode choice models (i.e., models that are the same regardless of transit mode).

### *Methodology*

The validation of the models calibrated with pre-BART data against post-BART data was done in two ways. First, actual post-BART modal shares were compared with the modal shares that the pre-BART sample predicted. Then, the parameters of models estimated using post-BART data were compared with the parameters of the model estimated with pre-BART data.

In the multinomial logit models used in the study and now the standard for mode split models worldwide, the ratio of the probabilities of choosing any two alternatives is independent of the attributes of other alternatives. This facilitates model development and model application in forecasting, particularly in the situation where a new modal alternative is added. The pre-BART models were calibrated with a sample of workers making travel-to-work choices before BART was introduced. In effect, the available mode choices were auto/drive alone, carpool, bus with walk access, and bus with auto access. Forecasting was performed on a sample of people taken after BART with an expanded choice set including BART with walk access, BART with auto-access, and BART with bus-access. In an attempt to forecast the new mode's effects, post-BART alternative-specific effects for BART alternatives were explored, using subjective judgments on the similarities of the unobserved attributes of the modal alternatives.

Because transferability of models of travel behavior must be observed to validate the underlying basis of the theory, McFadden worked to resolve several issues including acquisition of data, data consistency, and development and evaluation of alternative model specifications that could be estimated with all the data sets. The generic specification of in-vehicle time was uniformly rejected.

It is generally agreed that genericity would be a desirable property of a model, but such a model would come about only after comfort and convenience and other attitudinal variables were accounted for. Thus, the non-generic in-vehicle time coefficients account for some unobserved attributes that are dissimilar between modes. McFadden asserted that non-genericity would disappear with the inclusion of attitudinal variables in models.

### *Results*

Specification tests:

- *Tests of non-genericity.* Similar attributes of bus and BART (e.g., various travel times) had equal coefficients. "Many of the attributes of transit use that are considered onerous, such as lack of comfort and the possibility of crime, do not vary substantially with length of time spent in-vehicles and are captured by the alternative-specific dummy variables rather than the in-vehicle time coefficient."
- *Tests of non-linearity.* The hypothesis tested was that walk time in excess of 7.5 minutes to the first transit mode used has the same coefficient as other walk times, based on the assumption that the value of walk time is much higher for long walks to the first transit mode than for short walks. Waiting time in excess of 8 minutes and transit and auto in-vehicle times in excess of 30 minutes were also tested. The tests indicated that the assumptions of linear relations between representative impedance (generalized cost) and time are not unduly restrictive.
- *Tests of taste variation.* This test showed that the estimated values of time and headways were higher for urban residents than suburban residents, except

for the value of transit in-vehicle time. It also demonstrated that models allowing for differences between urban and suburban residents are better.

### *Transferability of the Models*

Regarding the transferability of transportation choice models within regions, in time, and between cities, McFadden states, "The single and most important conclusion regarding transferability of mode choice models can be simple stated: If the transferability of models is judged using statistical criteria, there is little ground to claim that the extant work-trip mode-choice models are transferable." However, he follows this statement with recommendations regarding improved model specification, including expanding the list of variables and choice sets and developing a better understanding of how "travel needs are intertwined with the everyday patterns of the life of households." McFadden stated that it was clear that any research in the matter of model transferability within regions or taste variation between different market segments must start with "meticulously collected and collated data."

### *Conclusions*

For the purposes of this BRT research, McFadden's most important conclusion was that tests of non-genericity regarding traveler perceptions demonstrated that, "the hypothesis is accepted that the coefficients of bus and BART on-vehicle times are equal and that the coefficients of bus and BART walk times are equal… Bus and BART transfer-wait times are equal."

In tests of transferability (within regions), McFadden's conclusion is that because "most of the … tests reject the null hypothesis of equal coefficients for different market segments, it is of interest to learn if the rejection is due to differences in tastes with regard to the system attributes… The result [is] that the urban and suburban dwellers indeed value the system attributes differently. They have different values of time. [However,] similar tests … for both urban and suburban dwellers and CBD and non-CBD workers using Washington data accepted the null hypothesis of no taste deviations between these groups."

The McFadden research concluded that, if system components are similar, BRT and rail systems are likely to have the same ridership attraction.

*The implications here are that all things (travel times, costs, transfer requirements, system "quality") being equal, rail and bus-based rapid transit systems are likely to have the same ridership attraction.*

This conclusion was born out in a subsequent paper published by McFadden in the University of California research journal *Access* in the spring of 2002 in an article titled "The Path to Discrete Choice Models." In the article, McFadden recounted the historic research for which he had received the Nobel Prize for Economics in 2002.

In that article, he said that, "The official forecast of BART patronage in 1973 foresaw it carrying about 15% of all work trips. This forecast was based very loosely on gravity model calculations.... Based on our survey [presumably pre-BART], we forecast that BART would carry 6.3% of work trips. In 1975, BART was carrying 6.2% of work trips. Thus, we turned out to be spot on. In another word, accurate."

Thus, a model calibrated on modal preferences (transit versus driving) revealed pre-BART was used to develop mode choice models that extremely accurately predicted the behavior of potential customers of the new BART model.

McFadden also said that "We overestimated bus use in the presence of the BART system," implying that in the unlikely event that BART (or other rail-based alternative) and a bus alternative were indeed in direct competition, then, all else being equal, the forecasting model would have to reflect a preference expressed for BART.

### Comparing Ridership Attraction of Rail and Bus (Ben-Akiva and Morikawa)

#### *Introduction*

Many analysts and elected officials perceive that there is a preference for rail transit over "bus" alternatives even when all measurable attributes are the same, regardless of the amenities/level of service (LOS) proved by the "bus" option.

To explore the validity of this view and expand on the initial work of McFadden, Moshe Ben-Akiva and Takayuki Morikawa conducted a study in 1990 at the behest of FTA using 1980 Census data for Washington, D.C., and stated preference survey data for Boston from the mid-1980s.

The study concluded that, when quantifiable service characteristics (travel time, cost, transfers, etc.) are equal, there is no evident preference for rail transit over quality bus alternatives for CBD-oriented work trips. A bias does occur, however, when rail offers a higher quality service. The study findings indicate that there is no justification for introduction of rail preference bias if measured in terms of time and costs (or vice versa in the situation where there is a quality bus alternative).

The Ben-Akiva and Morikawa research found that a rail bias exists in comparison to BRT only if rail provides a higher-quality experience.

The issue of the relative attractiveness of rail and bus transit to potential customers is often framed in a discussion of qualitative attributes such as comfort and convenience; however, most mode choice models explicitly treat LOS variables such as in-vehicle travel time, out-of-vehicle travel time, travel cost, and the number of transfers. Alternative-specific constants are used to account for qualitative factors affecting mode choice (e.g., reliability, information availability, safety from accidents, security from crime, and availability by time of day).

The validity of using different mode-specific constants in travel forecasting is difficult to evaluate because:

- Available data are not comparable from one line to another. There is a scarcity of travel behavior data from regions, let alone corridors, where the two transit modes exist and compete. Usually, there is one or the other.
- It is difficult to isolate what the specific constant is capturing. They are designed/calibrated to capture various effects in different applications, effects that may include situational constraints or socio-economic variations that are beyond variations in identified service attributes.

#### *Methodology*

To overcome the difficulties of data limitations and to capture the situational constraints and taste variations, the researchers analyzed two types of disaggregate travel and socio-economic data: revealed preference (RP) and stated preference (SP). "RP data are based on actual traveler behavior while SP data are collected by asking travelers for their preferences under hypothetical scenarios."

The RP survey data utilized in the study was 1980 census journey-to-work information used by the Metropolitan Washington Council of Governments in their travel modeling efforts. The data set treated four different modes: rapid transit, commuter rail, express bus, and local bus. Three market segments were analyzed: households with 0, 1, and 2+ cars. The LOS attributes for all transit modes included transit running time, walking and wait time, and transfer time. As expected, out-of-vehicle time was perceived to be significantly more onerous than in-vehicle time for all modes. To assist in estimating the relative attraction of bus and rail, "corridor types" and transit scenarios were developed that made direct comparison possible.

While the RP analysis focused on travel times and costs, the SP analysis included some qualitative attributes. The SP data were collected for a metropolitan transit agency as part of a study of the relative preferences for bus and light rail services in Boston's southwest corridor. The qualitative attributes, which were presented in six variations, included wait time, travel time reliability, and in-vehicle ride time (including transfer points), and respondents were asked to rank their preferences.

### *Results*

Analysis of the Washington revealed preference survey data showed that:

- There is an overall preference for MetroRail over local bus services.
- When the bus choice is express bus on an HOV lane, its attractiveness compared to driving is higher than local bus.
- For some classes of travelers (e.g., zero-car and one-car households), the relative preference for MetroRail relative to express bus vanishes or is significantly reduced.

Analysis of the Boston SP survey data showed:

- No modal preference bias exists for the MBTA rail (Green Line LRT) over express bus services operating on the Massachusetts Turnpike Toll Road.
- There is a strong aversion to transfers in general and to bus-rail and rail-bus transfers in particular.

### *Conclusions*

The Ben-Akiva and Morikawa research concluded that transit ridership is most dependent on running times, service frequency, and number of transfers.

The principal conclusion of this study is that, all measurable LOS parameters (travel times and costs) being equal, rail and bus services that have similar service attributes have the same ridership attraction. The most important determinants of transit ridership are running times, service frequency as it affects waiting times, and the number of transfers. "…In order to increase ridership on public transit, the service should be designed to have favorable levels of passenger convenience. Whether it is a rail system or bus system should not be of great importance."

## The Demand Performance of Bus Rapid Transit (Currie)

### *Introduction*

Graham Currie reviewed a number of studies that used empirical data to analyze how transit passengers value trip attributes for on-street/local bus, BRT, light rail, and heavy rail systems. The paper uses a total trip (origin to destination) approach to examine the attractiveness of BRT systems to passengers when compared to the other transit modes. The analysis concluded that BRT systems should be able to generate ridership equal to rail when the total trip attributes of both alternatives (travel times and costs, ride quality, minimal transfers, quality of stations and facilities, etc.) are the same.

Currie theorizes that if there are any mode-specific parameters, they should be of two kinds, constant (e.g., a constant reflecting general perceptions of system route and network knowledge) versus variable (e.g., one with time reflecting ride quality), because "these may be potential weaknesses in the design of BRT compared to rail based systems."

Historically, the issue of differences between rail and bus ridership attraction has been framed in a discussion of qualitative attributes; however, transit trip attribute research has found that the key inputs to disaggregate transport models (travel demand forecasts) include "mode neutral" attributes such as access walk, egress walk, wait time, fare, and in-vehicle travel time. These components make up "generalized cost."

Currie states, "It is a central premise of this paper that the patronage performance of BRT can best be understood through measurement of how passengers value trip attributes specific to BRT systems. A comparison of how perceived BRT attribute values compare against those of other transit modes will be indicative of their relative patronage performance." Therefore, Currie also accounts for "transit mode-specific trip attributes" such as the perceived travel impedance (generalized cost) of the need to transfer from one transit vehicle to another and other factors perceived to vary with transit mode. These include ride quality and comfort, quality of stations/stops, knowledge of transit stop locations, and knowledge of transit route and network design.

The validity of specific constants is difficult to evaluate because:

- No evidence of transfer penalty research on BRT systems was identified.
- A high variation in the approaches used to measure transfer penalties was identified.
- There is a limited number and quality of empirical measures for mode-specific factor measurement.

### *Methodology*

To measure how passengers value trip attributes specific to BRT systems and to compare how perceived BRT attribute values compare against those of other transit modes, Currie divided trip attributes reflected in empirical data into transit mode-neutral and transit mode-specific elements based on the degree to which passengers might value the attributes differently for alternative public transport modes. The mode-neutral attributes are common conventions used in mode choice modeling (walk/wait time, fare, and in-vehicle travel time) and examples are found in research literature. Mode-specific trip attributes include transfer penalties and mode-specific factors (MSF).

The Currie research distinguished mode-specific attributes from mode-neutral attributes.

Mode-specific factors are the user-perceived attractiveness of one transit mode compared to another excluding the influence of continuous mode-neutral attributes and transfer times. Currie reviewed a range of studies comparing implicit user preference for heavy rail, light rail, or BRT relative to on-street/local bus. Preference was measured as a constant and expressed in minutes of equivalent in-vehicle travel time. Currie also presented a typology of modal attributes, which the MSF represents, which were ride quality, passenger amenities, and knowledge/understanding of the service offered. The factors vary with travel distance.

### *Results*

Currie found that local bus–to–local bus transfers generally have much higher transfer penalties compared to rail modes (about 3 to 1) but that the penalties are much lower for bus alternatives that have higher quality interchange facilities (stations, platforms, sheltered walks). There is no empirical evidence regarding BRT systems per se, but if the station environments are the same as for LRT or other rail systems, the author suggests that the ridership response should be similar.

Currie also found evidence suggesting that LRT and BRT should have a similar ridership response and that BRT may sometimes perform better than heavy rail. "BRT should perform as well as rail with the other factors identified, depending on the scale of the BRT system and the quality of its stations and facilities."

### *Conclusions*

The principal conclusion is that performance of all transit modes should be measured in terms of ride quality, perceptions of the attributes of the transit path (e.g., times and costs), and network knowledge (e.g., access locations, schedules). The perceived valuation of these trip attributes has a major influence on the passenger demand--especially transfer penalties and mode-specific factors that vary between transit modes.

The Currie research recommends a consistent approach to measuring transfer penalties across transit modes.

Currie recommends adoption of a consistent approach to measure transfer penalties across transit modes, which would allow a more objective comparison among them in terms of ridership attraction. In addition, he offers "useful pointers" for BRT design to achieve higher patronage levels:

- Minimize transfers.
- Emulate the quality of heavy and light rail stations and interchange facilities.
- Match the profile, scale, and simplicity of heavy rail systems (perceived as easy to use and understand).
- Match heavy and light rail service frequency, travel speeds, and service coverage.

If these pointers are followed, Currie finds that "…the evidence available suggests that passengers will perceive the quality of travel by BRT in much the same way they do heavy and light rail...."

## Easy to Use Public Transport – How to Learn a New System (Katrin Dziekan)

### *Introduction*

The Dziekan research focused on the influence of transit information on ridership.

This study focused on the role played by information and knowledge of the public transportation system in its use. The study's central approach was to explore the role of "mental representation and cognitive mapping" of the attributes of the public transportation system by potential customers in their use. Dziekan was clearly interested in a broader issue than the relative attractiveness of bus-based versus rail-based rapid transit systems and did not use a standard mode choice model formulation as the basis for her research. Her conclusions on the differences among the modes echo what Currie found as a perceived difference between bus and rail, and her research is included here for that reason.

Dziekan cites her central research issue as "the need to reveal how spatial knowledge is structured and processed [and] how data learned through different medias and at different scales is integrated and used in wayfinding practice... (for public transport)." In other words, what are the features of the public transportation system that make it easy to use for new potential riders? How important a role does wayfinding play in the decision to use transit and riders' modal preferences?

Though the impact of spatial and other information on the ease of wayfinding has been frequently studied for highway systems, little work has been done to date on that subject for public transportation. By addressing this issue in structured research, Dziekan was able to make suggestions for improving public transportation's ease of use and, hence, attractiveness to the occasional passengers who make up such a large percentage of total ridership in many places and could add significantly to patronage in others.

### *Methodology*

A survey was undertaken of 31 new residents of Stockholm in 2002. These "new residents" were foreign exchange students at the researcher's university who had arrived only three months before. All had used the different parts of the public transportation system.

The 45- to 60-minute survey asked a variety of questions of the following types:

1. Personal characteristics.
2. How they would explain the overall public transport system to a newly arrived student.
3. What difficulties they had found in using the system to date.
4. How they would travel between several origin and destination pairs specified in the survey.
5. Parts of the public transportation system they liked most, least, and why.

### *Results*

Getting oriented to the system is an essential first step in a system's use. Comprehensive, easy-to-use maps are critical to that objective, as are public transportation nodes that serve as "reference" points. It was found that students that had used the public transportation system frequently in their hometown were better able to use the one new to them in Stockholm.

The places in the system that caused the most difficulty to new users were transfer points--places where the system converged and diverged, which were few and well illustrated on the subway and many and hard-to-understand on the bus system. Real-time subway train arrival information was also seen to be a great advantage.

The respondents had a clear preference for the subway over the bus system (65% versus 23%). Dziekan says that "apart from speed, accessibility, and frequency, a lot of ease-of-use arguments were pointed out as to why Tbana (subway) is the favorite PT system…. Only a few lines, not complicated, and good overview…. The (subway) signs are all over the city and one could ask anybody on the street for the next subway station…. You do not have to think on Tbana (subway); you already know how it works."

Dziekan's suggestions for improving bus systems include:

- Design of "good" maps for bus systems
- Better design of bus stations to present a "trustful" and stable image

### *Conclusions*

The most interesting conclusion relative to BRT is that a special class of customers preferred a subway system to the local bus system by a wide margin for reasons that essentially disappear when forecasting the comparative ridership of similarly configured LRT and BRT alternatives. If BRT systems have the same or better speeds (which is a function of running way dedication, stop spacing, and dwell times, not mode); accessibility (a function of station locations and design); service frequency (a function of policy); the exact same stations, terminals, and passenger information (e.g., maps); and an easy-to-understand route structure (as with LRT)—then there should be no differences in customer preference related to "ease of use" and, hence, ridership potential.

One of the more interesting things about Dziekan's research is that it utilized a survey limited to newly arrived university students from out of town. On the one hand, university students could be thought of as higher-than-average intelligence and thus capable of overcoming path-finding information impediments to transit use. On the other hand, being from out of town, they had much less exposure to the public transportation system than even uneducated long-time residents of Stockholm.

## SUMMARY AND CONCLUSIONS OF REVIEWED RESEARCH

The implication of the past research reviewed is that, if there are differences between potential travelers' perceptions of similarly configured bus- and rail-based rapid transit systems with same quality features, they are small and should probably not be accounted for in the ridership forecasting done to support objective alternatives analyses. That having been said, virtually all of the research implied measurable differences in people's preferences for generic rapid transit modes, both rail and rubber-tired bus-based, and basic local bus systems versus driving. Even there, the differences were found to be relatively small, with mode choice decisions overwhelmingly focused on critical time and cost parameters.

An overall conclusion is that, if rail and BRT alternatives have similar features and provide similar levels of service, the impedance functions and bias constants in travel demand modeling should be the same.

If rail and BRT alternatives would have the same station locations, amenities, vehicle quality, span of service, level of running way dedication (hence, reliability), and fare collection approach (hence, convenience), the impedance (generalized cost) functions and modal constants should basically the same. If one (e.g., BRT) was better than the other in these respects, it would be the more favorable, depending on the characteristics of the rail-based and BRT systems.

These preferences related to the informational advantages of the unique identity of a system with simple route structures and schedules, the better waiting and transferring environments of stations as opposed to bus or street-car stops, and comfort/ride quality of better, more modern vehicles and exclusive transit running ways.

The main point is that these latter differences are far greater between basic local bus systems and generic rapid transit than they are between, for example, light rail and bus rapid transit running in the exact same environment with the exact same station and running way configurations, basic route pattern, and schedule.

There are some shortcomings in the research assessed. The major shortcoming is that for a number of reasons (age being one of them), virtually none of the studies examined a situation where there was a true, full-featured BRT system in place.

In McFadden's case, the pre-BART alternative was an express system running largely in mixed traffic across the San Francisco Bay Bridge into the Trans Bay Terminal. It had running way advantages on the bridge (by-pass around toll booths), some suburban type buses, and an attractive CBD terminal, but none of the other features that have, together, become part of the definition of BRT. The Boston and Washington cases studied by Ben-Akiva had the same disadvantages.

The other concern is that both the McFadden et al. and Ben-Akiva and Morikawa studies and some of the papers cited in Currie's work only addressed work trips. The informational advantage of rail-based systems and the fact that some people find them "fun" to ride may make more than a slight difference for non-work trips that are more variable in frequency, time of day, and orientation. These differences should be explored.

The essential issue is how to estimate BRT ridership vis-à-vis estimating ridership for other modal alternatives during alternatives analyses and other planning studies. This is an extremely important issue. Transit's critical objectives are to decrease emissions, fuel consumption, accidents, etc., and to foster more efficient and sustainable urban development. All of these results depend on a given transit investment alternative's ability to attract new riders to public transportation in addition to providing a better level of access and mobility for existing users. This research supports the conclusion that BRT has the ability to do both.

The disaggregate, discrete choice research on travel behavior indicates that, in their mode choice decision-making, potential transit customers perceive the travel time and cost attributes of premium, high-quality bus alternatives in essentially the same way they view the attributes of similarly configured rail rapid transit systems. Where the system content and quality of system elements and performance factors like time and travel cost are the same for BRT and LRT, they are likely to attract similar levels of ridership.

A comparison of actual ridership on several BRT systems (See Chapter 3) found that BRT has attracted new riders beyond those anticipated from increases in travel speed and frequency. Moreover, fully integrated BRT systems have attracted high-income riders with access to autos, and have even attracted rail rapid transit riders residing within their service areas.

The implication of the past research reviewed is that, if there are differences between potential travelers' perceptions of similarly configured bus- and rail-based rapid transit systems, they are small and should probably not be accounted for in the ridership forecasting in alternatives analyses. That having been said, virtually all of the research implied measurable differences in people's preferences for generic rapid transit modes, both rail and rubber-tired bus-based, and basic local bus systems versus driving. In alternatives analysis modeling, the mode choice model modal constant used to estimate ridership for BRT would fall somewhere in between that obtained from a valid calibration for the existing local bus system and that obtained for a rail-based system. Where in the continuum BRT falls would depend on the nature of the respective systems. This practice contrasts with much current modeling experience.

## RECOMMENDED FURTHER RESEARCH

A research framework for further assessment of BRT modeling guidelines is proposed.

Additional research is desirable to provide further guidelines on the attractiveness of BRT. It is desirable to validate the basic assumptions by repeating the work of McFadden et al., Ben-Akiva and Morikawa, and others, using revealed preference (as in "What did you do?") and stated preference (as in "What would you do?") data sets that explicitly reflect the presence of local bus and BRT choices in the same or different parts of the same region.

The steps in this research would be as follows:

1. Select a metropolitan area that:
   - has implemented a full-featured BRT line / system;
   - has a statistically valid and complete, relatively recent, home-based origin-destination survey available reflecting the "before" situation (Census journey-to-work data could be utilized); and
   - has the results of a statistically valid on-board survey available.

2. Do statistically valid home-based origin-destination and on-board surveys reflecting the situation at least one year after the BRT line opens.
3. Statistically estimate a series of different mode choice models using discrete choice analysis methods (e.g., generic models with no mode differentiation, non-generic models with different coefficients and constants by mode) for both the before and after situations.
4. Compare the calibration results statistically for BRT versus the conventional local bus system.
5. Do essentially the same thing in corridors in the same metropolitan area (if at all possible--possibly in Los Angeles) before and after LRT was implemented as well.
6. Compare the calibration results statistically for BRT versus LRT versus the conventional local bus system.
7. Report on the findings and update the guidelines with more precise recommendations.

More stated preference surveys related to BRT are desirable.

A similar approach could be utilized with the results of properly designed and executed stated preference surveys. These would be particularly helpful because many trips (e.g., mid-day lunch time trips to a shopping mall not previously accessible) made on new BRT (and LRT) systems were not made before at all by any motorized mode. Stated preference surveys could address the effect of system characteristics on them as well as trips actually taken.

Properly structured stated preference surveys could also be best used to judge the value placed on the various elements of BRT (e.g., station amenities, rail-like vehicles, all-day frequent service, a unique identity, etc.) in affecting mode selection decisions.

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# APPENDIX C DEVELOPER SURVEY RESPONSES RELATED TO BRT - BOSTON AND OTTAWA

## DEVELOPER SURVEY QUESTIONS

The questions asked of each developer in Ottawa are those listed below. Similar questions were asked of each Boston developer; the Boston questions were tailored to reflect the Silver Line, competing transit modes in Boston, and Boston's TOD incentives and requirements.

The questions from the developer survey of BRT land development impacts are presented.

1a. Please rate the following factors with respect to their influence on your decision to develop a transit-oriented development (TOD) project near the Transitway.

(Please rate each factor from 1 to 5, with 1 being the most important. Please provide any specific comments below.)

| | | | | | | |
|---|---|---|---|---|---|---|
| Supportive zoning/codes: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Agency support/assistance: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Public support for TOD project: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Streamlined development process: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Funding assistance/grants: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Reduced parking requirements: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Existing TOD projects nearby: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Market study/market history: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Land availability/cost: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Experienced agency/partners: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Proximity to Transitway: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Frequency of bus service on Transitway | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Transitway image: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Transitway station amenities: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Transitway vehicle type: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Transitway running way type: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Transitway ridership: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Pedestrian connections to transit: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Community amenities: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Environmental issues: | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |
| Other (Please provide details below.): | 1 | 2 | 3 | 4 | 5 | DON'T KNOW |

1b. Would the importance of the factors listed above be different for a development near rail-based transit?

YES ☐ NO ☐

2. Did you participate in an agency-sponsored TOD program?

YES ☐ NO ☐

If YES, how important were the program's incentives/requirements to the outcome and success of your project?

3a. Did you consider other sites for this project?

YES ☐ NO ☐

If YES, why did you choose the Transitway site over alternative sites for this project?

3b. What value is added to the project by being located adjacent to the Transitway (improved market, lower parking demands, etc.)? How does this relate to the benefits from proximity to rail? To local bus routes?

4. What uses (e.g., residential) are elements of your project? To what extent is the project built out, leased, and occupied? How does your project compare with others in the neighborhood that are not in close proximity to the Transitway (e.g., as dense, as fully occupied, as profitable)?

5a. Were you involved in initial Transitway alignment and station location decision-making?

YES ☐ NO ☐

5b. Have you been involved in the decision-making for any other transit lines?

YES ☐ NO ☐

6a. How satisfied are your tenants with the development (e.g., parking, accessibility, and market strength)? If you have completed a tenant survey on this subject, please enclose a copy when returning this survey.

6b. How satisfied are your tenants with the Transitway service (e.g., frequency of service, station amenities, locations served, etc.)? If you have completed a tenant survey on this subject, please enclose a copy when returning this survey.

7. Do you plan to develop other TOD projects near the Transitway? Why or why not?

8. Do you use images of the Transitway in your marketing materials? If so, please enclose copies when returning this survey.

9. How would the following assumptions about Transitway service have impacted your decision to build near the Transitway?

(Please rate the assumptions on a scale of 1 to 5, with 1 meaning a very positive impact and 5 meaning a very negative impact. Please provide any specific comments below.)

a. Walking distance between the project and the station is doubled.

1 2 3 4 5 DON'T KNOW

b. Transit stations are not sheltered.

1 2 3 4 5 DON'T KNOW

c. A much bigger shelter is provided at the station.

1 2 3 4 5 DON'T KNOW

d. Projected Transitway ridership is cut in half.

1 2 3 4 5 DON'T KNOW

e. Twice as many buses arrive per hour.

1 2 3 4 5 DON'T KNOW

f. Buses share the roadway with automobiles.

1 2 3 4 5 DON'T KNOW

g. The Transitway buses look different from regular buses.

1 2 3 4 5 DON'T KNOW

h. Real-time bus information is provided at the station.

1 2 3 4 5 DON'T KNOW

10a. If not already addressed above, does your project include fewer parking spaces or greater density as a result of your proximity to the Transitway?

YES ☐ NO ☐

10b. Is this as a result of City requirements/allowances for TOD sites or is it market-driven?

City requirements ☐ Market-driven ☐

11. Are you as confident of the transit agency's long-term commitment to the Transitway service in this corridor as you would be if this were a rail corridor?

## DEVELOPER SURVEY RESULTS - BOSTON

### Developer #1

More detailed responses to the developer surveys are presented in this appendix.

Developer #1, the non-profit development corporation, stated that the largest factor in site selection was land availability and cost. Reduced parking requirements and agency support were identified as other important influences. Being close to the Silver Line was believed to provide better transportation access and reduce the need for a car, which is important for the corporation's client base. Developer #1 felt that the provision of real-time information would be the most influential design factor, with reduced headways being the second most influential and transit shelters being the least important.

Developer #1 has not used the Silver Line in any marketing materials. Unlike many of the other developers surveyed, Developer #1 stated that they had been involved in alignment and station decision-making.

Developer #1 reported that their projects are relatively successful and their tenants are happy with the Silver Line service. Because of their ongoing efforts to redevelop the Dudley Square/Roxbury community, they intend to take on more projects in that area. They also report being confident of MBTA's commitment to the corridor.

### Developers #2 through #6

Boston's South End has seen the most significant levels of Silver Line TOD, and five individuals involved with development projects in that neighborhood returned surveys. Responses from the Washington Gateway Main Street program are mixed in with the developers' responses.

The most common responses regarding the factors influencing their decision to develop the projects were proximity to the Silver Line, experienced agencies/partners, and public support. Other responses included supportive zoning codes, land availability and cost, agency support/assistance, frequency of service, the Silver Line's image, and market studies. BRT ridership and parking requirements were listed as having the least influence, with environmental issues, community amenities, a streamlined process, and funding assistance also having little impact. Every developer stated that his/her decision-making factors would have been different for a rail project, but no one provided any further detail on that point.

As mentioned above, the City of Boston does not have a formal TOD program and, as such, none of the projects participated in one.

According to one developer, reconstruction of Washington Street, widening of sidewalks, and installation of other pedestrian amenities put in as part of the Silver

Line project had as much of an influence as the transit itself and had been a major selling point.

Only one developer mentioned that they had considered other sites. The South End portion of the Washington Street corridor was selected due to its proximity to downtown. All of the developers said that the Silver Line added value to the site, with several mentioning that they did not think the benefits were as good as rail and that the frequency of stops reduced the importance of being located right at a BRT station. One developer mentioned that it allowed them to lower their parking ratio while another felt that parking demand and ownership among tenants had remained just as high as a non-BRT site.

When asked about the influence of changes to the service, doubling the number of buses on the route was seen as having the most positive potential impact, followed by providing real-time bus information (something for which there are facilities but that has reportedly been unreliable) and larger shelters. Accordingly, the removal of shelters was listed as the most negative potential impact, with bus appearance, non-exclusive lanes, reduced ridership, and increased walking distance all seen as having a moderate impact on the decision to build near the line.

None of the developers stated that they use images of the Silver Line in their marketing materials, but the project team noticed a link to the Silver Line on the web site of one of the developments.

While the MBTA and the Main Street program coordinated what they felt to be an extensive public outreach process for the redesign of the street and planning of the Silver Line, none of the individual survey respondents mentioned having been involved in the planning process for the Silver Line or any other transit project.

Each of the developers stated that their projects are largely residential, with some ground floor retail and with two of the five projects described as more dense than projects off of the Silver Line. Every one of the developers mentioned that the projects in the corridor are all occupied and have been received well by their tenants on all accounts, with two of the five developers planning to do more projects in the Silver Line corridor.

Two of the five developers mentioned that their projects had fewer parking spaces or more density as a result of project location, with one stating that this was market-driven and the other mentioning a combination of government and market influences. For the projects without reduced parking, two mentioned the City as being the driving force and one mentioned market factors as the cause.

There were also mixed feelings about the MBTA's commitment to the corridor, with two confident of the commitment but three unsure. There were worries about the third phase connecting Washington Street to the Waterfront and a feeling that the lower capital investment in the project makes it less important to the MBTA.

### Developers #7 through #9

Developers #7 and #8 have built or are planning to build in the South Boston Waterfront. The South Boston Waterfront has for decades been an area of maritime uses and surface parking lots, separated from downtown Boston by the Central Artery and the Fort Point Channel. The opening of the Silver Line has connected the waterfront to the downtown and, in conjunction with the opening of the Moakley Federal Courthouse and the Boston Convention Center, it is intended to spur the development of a dense mixed-use area, in some ways creating a new downtown. However, the private development has not occurred as quickly as expected and so Phase II of the Silver Line opened with new stations in December but with two of the largest parcels yet to be sold to developers, let alone built and opened, although plans for the site have been developed. Representatives for the current property owners completed surveys to the best of their abilities, but the projects are still in a conceptual stage and each has owned the property for several decades, so many of the questions are not applicable or not yet answerable.

Developer #9 is a state-created quasi-governmental agency that owns property in the South Boston Waterfront. As part of the approval process for development on their site, Developer #9 agreed to pay $12 million towards the acquisition of the Silver Line vehicles and up to $20 million in operating expenses over the next decade.

Neither Developer #7 nor Developer #8 are developing property as part of an official TOD program, although the Silver Line has factored into the development of both, and some of their property was provided to MBTA for the development of the Silver Line tunnel and a station. Developer #8 said that the most influential development factor was the land availability, with public support, a streamlined process, and market studies being the next most influential and BRT's image being the least influential.

All three developers purchased their sites years ago, long before the current Silver Line planning process began. They all acknowledged that proximity to BRT brings a variety of important benefits, most importantly reduced parking demand and connections to downtown and the rest of the region via the other MBTA lines.

Only one developer answered the questions regarding the influence of different aspects of BRT, with increased bus frequency seen as the most positive potential development followed by real-time information and with a lack of shelters seen as the most negative.

None of the projects discussed are at a point where marketing materials have been developed, but they all anticipate utilizing the Silver Line in future marketing.

Developer #8 and Developer #9 were heavily involved in alignment and station decisions, while the real estate broker working with the Developer #7 was unsure of how involved they had been in the early stages of the Silver Line planning.

All three projects are expected to include a wide mix of residential, commercial, office, retail, and civic spaces, although the details are still being developed and they are not nearly at a point where their success, or that of the Silver Line's Phase II, can be evaluated.

Each developer stated that the Silver Line had both reduced the parking demands for and increased the density of their projects and that this had come as a result of both public agency involvement and confidence from the development community that the Silver Line will be a viable transit service to downtown.

Located primarily underground, this segment has been constructed to allow for future conversion to rail, and that has provided some added confidence on behalf of the developers. However, they are all somewhat concerned about the potential for the Silver Line's Phase III. Their concern is less with the need to connect to the Washington Street corridor than the need to connect with the other MBTA lines, providing one-transfer access to the entire metropolitan area. If these connections are not made in Phase III, then it will be a significant challenge to the waterfront development projects.

## DEVELOPER SURVEY RESULTS - OTTAWA

Six developers responded to the survey. These developers include a federal government agency, commercial developers, residential developers, and mixed-use project developers.

### Developer #1

Developer #1 is a federal agency that owns a large government office complex at one of the Transitway stations. The complex was established in the 1950s, and BRT service first became available in 1983. The area has seen sporadic development since the 1950s, although the survey respondent indicated the office complex is "still in its early stages of development." The survey respondent indicated that the existing transit system is not the only consideration for future development: Several of the buildings require refurbishment, and several of the government offices are seeking to expand. City staff indicated, as described earlier, that Developer #1 is developing a master plan to intensify development at the station.

The survey respondent declined to provide any additional information, citing confidentiality concerns that seemed to be associated with providing details about a federal office complex to researchers associated with a foreign government.

### Developer #2

Developer #2 owns and manages a large shopping center in addition to other commercial properties. Discussion with the survey respondent focused on the shopping center, which was built in 1973. The shopping center was expanded later to include a third floor.

In 1996, the west side of Ottawa experienced sharp growth due as a result of an information technologies boom. According to the survey respondent, the City wanted a regional Transitway connection (i.e., a new station) on the west side. Developer #1's shopping center was a logical choice for this connection. While a number of local bus lines already served the area (mostly on one side of the shopping center), the Transitway connection provided access to a high-quality regional line and brought more order to the configuration of existing local bus lines. Incentives that encouraged expansion of the existing shopping center rather than construction of new development at another site including adjusted parking ratio requirements. This was important, but not critical; also important was the potential increase in site traffic resulting from the regional connection designation.

To support the new Transitway station, a new access to the shopping center was constructed. The survey respondent estimated that 5 to 6 percent of shoppers (i.e., Transitway users) enter the shopping center via that access. This percentage is small because the shopping center is accessed primarily by automobile. However, the survey respondent believes that transit ridership and the station amenities that make transit more comfortable, convenient, clean, and safe are very important for the following reasons:

- A customer whose transit trip is pleasant will use transit again. Good transit service encourages customers who do not have a car to come to the shopping center and provides an attractive alternative means of access for customers who do have a car. "Transit makes access easier." This increases tenant satisfaction.
- Transit is important for shopping center employees, too. Many of the retail staff are young and do not own a car. This also increases tenant satisfaction.

- The shopping center site is almost completely built out in terms of development intensity. The only undeveloped property at the shopping center is a 1.7-acre parcel targeted for office development. Developer #1 exchanged a 0.8-acre parcel of land for this 1.7-acre parcel, which was previously owned by the City. Proximity to the Transitway was "important" in deciding what to do with this parcel.
- Considerable growth is projected for the next 10 years. The survey respondent believes that transit access is a part of any long-term vision.

The City's reputation is perceived as "quite good" (both inside and outside Ottawa) regarding its commitment to the Transitway and transit quality. Transitway access is "an amenity" for the shopping center, so the Transitway is shown on shopping center directories and on the shopping center's web site.

Unlike other developers surveyed, Developer #2 looks at BRT and LRT differently. Developer #2 believes that BRT has an advantage over LRT regarding the transit connection at the *other* end of a customer's trip. That is, BRT is more likely to allow a customer to make a transfer-free transit trip from his or her home to the shopping center. LRT, in contrast, may require a transfer from a local feeder bus route or a connection at a park-and-ride lot. The transfer is likely to dissuade potential ridership.

The survey respondent indicated that Transitway influences on vacancy rates and other measures of development success are hard to evaluate, particularly when sites have a history of success. Thus, no quantitative data are available on these subjects.

### Developer #3

Developer #3 is a multi-use development that includes a shopping center, a convention center, a hotel, an office building, and a theater. The development is located in the center of downtown Ottawa between two of the busiest Transitway stations. The stations were not constructed when the development was built in 1983, so only local bus routes served the area. The Transitway stations were planned around the development because the development was already established as a substantial attractor of trips.

A significant expansion of the convention center, expanded retail space, and a new hotel are currently planned. This is occurring more because of the number of proximate uses within walking distance than because of the access and mobility provided by the Transitway. Nevertheless, the development serves a "significant" volume of transit users. A shopper survey indicated that 49 percent of shoppers (many of whom also work in the vicinity) arrive using OC Transpo transit services and 7 percent arrive using Société de transport de l'Outaouais (STO) transit services. (STO is the transit agency serving the Gatineau metropolitan area, which is located north of Ottawa.) One factor driving this high modal share for transit is high parking fees in downtown Ottawa.

Although the development pre-dates the Transitway and, thus, the City's Mixed-Use Center requirements did not affect the development, the development is obligated to keep its common areas open 21.5 hours to match the Transitway's service span. This requires the center to provide weather refuge and security even when the development's business tenants are not open for business. The proposed retail expansion is anticipated to create complicated access and aesthetical challenges, such as a need for more doors to handle peak-hour pedestrian traffic (currently 130,000 per day at all doors). The retail businesses that will compose the expansion are seeking space at the development because they want to capture this high existing volume of pedestrian traffic.

The survey respondent indicated that the Transitway service currently provided meets rider demand. Although no tenant surveys have been conducted on this subject (or other relevant subjects), the survey respondent does not think that service enhancements will result in significant ridership increases.

Developer #3 does not use images of the Transitway in marketing materials because of difficulties in obtaining adequately attractive images. The survey respondent indicated that station improvements might increase customer satisfaction but would probably not increase ridership since most customers come downtown to work, not to shop.

### Developer #4

Developer #4 develops and manages “power centers” and “lifestyle centers” including a shopping center at a Transitway station. The survey respondent indicated that, because such projects are auto-oriented, they do not seek out sites with proximity to a Transitway or LRT station. Transit stations are incorporated into site design, but amenities such as the type of shelter at the station and TOD incentives such as parking credits are not factors in site development decisions. (Regarding parking, city codes usually require construction of more parking than Developer #4’s sites need.)

Developer #4 has coordinated with the City of Ottawa in advance on development of portions of the Transitway and the LRT line, but such coordination generally focuses on the amount of right-of-way that must be deeded over to rapid transit lines. Of great concern to the survey respondent is how far in advance of transit line development this transfer of right-of-way must occur. Deeding over land that will not see transit service for many years is frustrating to the developer because it disrupts site plan layout and because sometimes more land is deeded than turns out to be necessary (up to 30 to 35 feet, for example). This concern is independent of whether a BRT line or an LRT line is to be constructed.

Developer #4’s marketing materials show Transitway and LRT stations on maps and site plans, but no additional detail is provided about transit service. Few comments have been received from tenants of Developer #4’s properties regarding transit service. The only negative comment received within the past six years stated that bus stops in front of stores encourage transit riders to congregate inside the stores to avoid inclement weather--not to make purchases.

No mode share information is available for Developer #4’s shopping center or other properties. Developer #4 has not quantified the effects of Transitway (or LRT) proximity on sales, vacancy rate, or other measures of development success.

### Developer #5

Developer #5 was described by the City of Ottawa as “Ottawa’s largest homebuilder,” but Developer #5 is also involved in commercial development as well. The survey respondent believes that Ottawa has a greater commitment to the LRT line than to the Transitway now, but the modes impact Developer #5’s development decisions in the same way. The most significant impacts of LRT and the Transitway were stated to be the following:

- *Required right-of-way dedications.* The amount of right-of-way that must be dedicated to the rapid transit network is “high” and comes from “very conservative” design standards. The survey respondent cited that the right-of-way dedicated may be 150 to 200 feet wide. Right-of-way must also be dedicated for transit projects that are up to 20 years away from construction.

- *Restrictions on where specific types of development can occur within the city*. The survey respondent felt that developers are "forced" to build near existing and future rapid transit lines.

The impacts listed above are highly objectionable to the survey respondent, and he therefore does not see TOD as an attractive development form. He stated that proximity to rapid transit is not a factor in site selection and that no potential benefits of TOD are great enough to balance out lost right-of-way.

The survey respondent stated that his tenants do not currently use transit and would not be inclined to use it given Ottawa's climate. Transit is thus not a part of his projects' marketing materials. No data on vacancy rates or tenant satisfaction is available to compare Developer #5's projects located near to and far from rapid transit lines.

### Developer #6

Developer #6 develops mixed-use projects. Developer #6 formally filled out the survey form; the survey respondents representing other Ottawa developers preferred to discuss their projects and their viewpoints over the phone. Developer #6 tailored their responses to a mixed-use development located on the LRT line but indicated that a project on the Transitway would be evaluated in a similar manner. Developer #6 was not involved in initial LRT alignment and station location decisions.

When asked about the importance of factors that influenced Developer #6's decision to build projects such as a mixed-use development at one of the LRT stations, the survey respondent gave the lowest possible rating to Reduced Parking Requirements, Proximity to Transitway/LRT, Frequency of Service on Transitway/LRT, Transitway/LRT Running Way Type, Transitway/LRT Ridership, and Pedestrian Connections to Transit. No factors on the survey form received the highest possible rating. The breakdown of factor importance ratings is shown in Exhibit C-1.

The survey respondent indicated that the ratings in Exhibit C-1 would be different for a development near a regular (local) bus route. The key components of value added by building near LRT were access and less need for parking (which is market-driven because reduced parking is not formally an incentive associated with Mixed-Use Centers). Developer #6 did not participate in an agency-sponsored TOD program for its mixed-use development, nor did they consider other sites. Developer #6 could not identify a comparable mixed-use site not in proximity to LRT or the Transitway, so no data were provided to look at differences in lease rates and density that may result from proximity to the rapid transit network.

When asked if different assumptions about LRT service would have impacted the decision to construct the mixed-use development, the survey respondent indicated that no assumption included in the survey form would have very strong or very weak impacts. The breakdown of ratings is shown in Exhibit C-2.

**EXHIBIT C-1 TOD Factors Important to Developer #6**

| Importance Rating* | TOD Factors |
|---|---|
| 1 | None |
| 2 | ▪ Agency Support/Assistance<br>▪ Market Study/Market History<br>▪ Experienced Agency/Partners<br>▪ Transitway/LRT Station Amenities<br>▪ Environmental Issues |
| 3 | ▪ Supportive Zoning/Codes<br>▪ Streamlined Development Process<br>▪ Funding Assistance/Grants<br>▪ Existing TOD Projects Nearby<br>▪ Land Availability/Cost |
| 4 | ▪ Public Support for TOD Project<br>▪ Transitway/LRT Image<br>▪ Transitway/LRT Vehicle Type |
| 5 | ▪ Reduced Parking Requirements<br>▪ Proximity to Transitway/LRT<br>▪ Frequency of Service on Transitway/LRT<br>▪ Transitway/LRT Running Way Type<br>▪ Transitway/LRT Ridership<br>▪ Pedestrian Connections to Transit |

* A rating of 1 means "most important" and a rating of 5 means "least important."

**EXHIBIT C-2 Impact of Changes to TOD Factors (from Developer #6's Perspective)**

| Impact Rating* | TOD Factors |
|---|---|
| 1 | None |
| 2 | ▪ Transit stations are not sheltered<br>▪ A much bigger shelter is provided at the station |
| 3 | ▪ Projected ridership is cut in half |
| 4 | ▪ Walking distance between the project and station is doubled<br>▪ Twice as many buses arrive per hour<br>▪ Buses share the roadway with automobiles<br>▪ Real-time bus information is provided at the station |
| 5 | None |

* A rating of 1 means "a very strong impact" and a rating of 5 means "no impact."

Tenants of Developer #6's mixed-use development are "very satisfied" with the development (in terms of parking, accessibility, market strength, and so on). They are less satisfied with LRT service (in terms of frequency of service, station amenities, locations served, and so on). Developer #6 uses an LRT map in its marketing materials. According to the survey respondent, Developer #6 has no immediate plans to develop other TOD projects near LRT or the Transitway.