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Advanced Network Planning for Bus Rapid Transit

The "Quickway" Model as a Modal Alternative to "Light Rail Lite"

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13. ABSTRACT

Transit planning in the United States has tended toward viewing BRT as an analogue to light rail transit, with similar operating patterns. This model, referred to as "Light Rail Lite," is compared to international best practices, which have often favored the development of a grade-separated bus infrastructure ("Quickways") that in turn supports a varied mix of all-stops, express, and branching services. This model, dubbed the Quickway model, evolved out of the practical necessity of cities to meet ambitious ridership or mode split targets. The two models are contrasted along the key dimensions of BRT service, and significant differences are identified. Three international case studies—Ottawa, Bogotá, and Brisbane—are reviewed for their particular application of this model and of the results they have obtained. Four domestic cities are compared to these international examples: Eugene, Oregon, and Los Angeles are profiled for their adoption of the Light Rail Lite model, and two other cities, Pittsburgh and Miami, are profiled for their BRT implementations which share elements in common with the Quickway model. A set of lessons is drawn from this comparison, including a review of those conditions which may favor the adoption of either model or light rail in any given urban context. Recommendations are offered at the level of the Federal Government, Metropolitan Planning Organizations, and planning and engineering firms, for the proper planning and evaluation of Quickway-based alternatives. An appendix introduces a fifth domestic case study, a Quickway-based planning effort sponsored by a nonprofit organization for the San Diego region, and the preliminary results of this effort are reviewed.

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1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

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1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

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1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
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1 meter (m)	=	3.3 feet (ft)
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1 kilometer (km)	=	0.6 mile (mi)

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1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

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1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

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1 liter (l)	=	1.06 quarts (qt)
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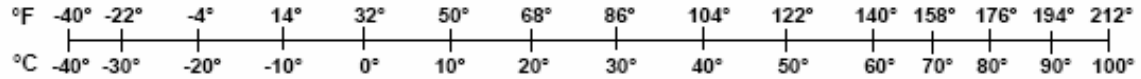

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Foreword

Bus Rapid Transit (BRT) has become, in the space of less than a decade, a fixed and growing part of the American transit landscape, with numerous projects being planned, developed, built, and operated in cities large and small. However, in the process of this widespread adaptation, there has been considerable confusion as to what exactly BRT is, what it could be, and how best to take advantage of this mode in regional transportation strategies. All too often, in too many American metro areas, BRT is seen as the "consolation prize," if that, in the intense competition of local cities and neighborhoods to be the focus of the next light rail line or other transit improvement. Likewise, some of the support—perhaps too much of the support—for BRT comes from those who view BRT as "light rail on the cheap," as a means to placate transit advocates without spending too much money.

In contrast, those cities internationally that represent the most impressive BRT implementations—measured in terms of ridership gains or modal split, if nothing else—did not approach BRT as an "on the cheap" approach to service, nor was their goal that of mimicking a light or heavy rail plan. Rather, these cities invested considerable sums in the development of a mostly grade-separated infrastructure that could support a range of services, some resembling light rail, others express, limited-stop, branching, direct, or even streetcar lines in terms of station spacing, frequencies, travel speed, and route behavior.

This report focuses on what it was these cities did that make their experience of BRT not merely different from that of most American cities, but one which is arguably superior to anything yet attempted in this country. Along the way, these cities put to rest many misconceptions of BRT—that it is an "intermediate capacity" mode (all three cities routinely move as many or more people than any light rail line in the U.S.), that it is a stepping stone to light rail (some BRT systems clearly are, but the international examples go beyond the limitations of light rail in significant ways), that its capacity to promote, attract, or support Transit-Oriented Development (TOD) is limited (all of these cities have impressive and growing amounts of investment made around BRT stations), or that bus-based systems are limited in their ability to attract choice riders from their cars (it turns out that people value significant time savings and convenience more than they value vehicle type).

This report introduces new terminology to the discussion of BRT, the key term of which is Quickway, which is defined as a primarily grade-separated (that is, fully segregated) busway capable of supporting express and all-stops operations. Functionally, a busway is a Quickway if a bus can traverse its length without being stopped or slowed by auto traffic, pedestrians, or buses which are loading or discharging passengers. Quickways, it is argued, are not merely a step in the gradation of bus-based infrastructure; their particular characteristics change the operating logic, the cost logic, and the market responsiveness of transit operations in significant ways, and can help American cities achieve a "phase shift" in the role that transit plays in their functioning.

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Still, there are many people whose unique contributions need to be mentioned. Foremost among them is Chuck Morison of the National Transit Institute, whose tireless work promoting BRT not only brought this mode—or collection of modes—to attention in many cities across the land, but who also brought me into contact with two of the foremost practitioners of BRT planning on the planet, Sam Zimmerman of the World Bank, and John Bonsall of McCormick Rankin International, both of whom made immeasurable contributions to my understanding, however, limited, of this field.

Likewise, my colleagues in Australia, chief among them Barry Gyte of GCI Pty Ltd., Brian Bothwell of Brisbane City Services, Professor David Hensher of the University of Sydney, and Professor Graham Currie of Monash University, have all deeply enriched my understanding of the potential of BRT to meet regional goals, and have made various contributions to this study. Special thanks is also offered to Jurgen Pasieczny, Ray Donato, and the staff of TransLink, overseers of the Brisbane Busway projects, for their support and insight; to Lyall Kennedy of New South Wales Ministry of Transport; and to Professor Phil Charles of the University of Queensland and Phil Sayeg of Transport Roundtable Australasia, whose Smart Urban Transport Conferences first brought global attention to the Quickway model of BRT.

The contributions made by the staff and management of TransMilenio in Bogotá are considerable; their achievements are nothing short of miraculous in producing a rapid transit system of impressive growth, speed, popularity, and impact. I would especially like to acknowledge Ing. Liliana Pereira for all of her contributions to my understanding of the TransMilenio and of the many planning decisions that were made in support of that system.

Many people contributed their thoughts and knowledge to this study, in addition to the people mentioned above. Roderick Diaz, now of the Los Angeles County Metropolitan Transportation Authority, and a former classmate of mine at MIT, has done much to advance the domestic understanding of BRT, including many of the concepts dealt with in this report; he was also instrumental in providing background information on Los Angeles, as was Leon Bukhin and Rex Gephart, both of the MTA. In Miami, I would like to thank David Fialkoff of Miami-Dade Transit for his contributions. In Pittsburgh, both Rich Feder and David Wohlwill of the Port Authority of Allegheny County provided insight and data as to their busway network. In Eugene, Graham Carey of Lane Transit District has been not merely a source of data, but a source of inspiration as he dealt over the years with the difficulties of implementing the EmX.

At MIT, Nigel Wilson, Joe Sussman, Fred Salvucci, and Ralph Gakenheimer all played a major role in developing my understanding of the behavior of public transit systems.

To the staff of the National Bus Rapid Transit Institute at the Center for Urban Transportation Research at the University of South Florida I extend my thanks for their support and encouragement in formalizing my thoughts about BRT. In particular, I would like to thank Alasdair Cain who helped shepherd this project from the idea stage to the final product you are now reading.

Finally, I would like to acknowledge the role that many of my clients have played in creating the opportunities through which I was able to explore the practical application of the ideas embedded in this report. Anthony Beckford and Sarah Blanchard of Sarasota County Area Transit; Jacob Snow, Tina Quigley, and Mark Wells of the Regional Transportation Commission of Southern Nevada (as well as the entire staff of that agency); and Carolyn Chase, Craig Jones, and the entire board of Move San Diego, Inc. all have believed in the goals of creating regionally effective transit systems and encouraged me to search for solutions beyond those of the ordinary.

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Executive Summary

The Quickway Model as a New Mode

Planning for Bus Rapid Transit (BRT) in the United States is dominated by the "Light Rail Lite" model, in which a bus service is configured to behave in ways that resemble traditional light rail systems. This model is typified by having a single "BRT" route serve a corridor, enjoying at least some measure of transit priority (ranging from signal priority systems to dedicated busways), stopping at widely-spaced stops or stations, and using distinct branding for the service thus provided. It has been widely embraced because it permits cities to offer a service level which approaches that of light rail, but at reduced capital investment.

Some of the more outstanding models of BRT implementation internationally follow a different model. They focus on the creation of grade-separated bus guideways, or *Quickways*, that then support not just a "light rail-like" service, but a variety of express and branching services that extend the benefits of the infrastructure far beyond the immediate service areas.

Figure ES.1. Quickway station in Brisbane, Australia, showing tunnel segment in background. Grade separation is at the heart of the Quickway model; it supports express operations and fundamentally reduces the relative operating cost of services.

The "Quickway Model" is not merely a step on the continuum of the Light Rail Lite mode, but represents a fundamentally distinct *mode* of transit, much in the same way that streetcar and heavy rail are two distinct modes of rail transit. The Quickway model imposes its own planning, cost, and operating logic, leading to fundamentally different transit networks than does the more traditional Light Rail Lite model. Bus Rapid Transit, therefore, may be understood not as a *mode* of transit, but as comprised of at least these two distinct modes.

The Quickway model emerged internationally from the specific need of different cities to meet ambitious ridership or mode share targets. It has its origins in the pioneering work of Ottawa, Ontario, and its Transitway system and has been further developed, in different ways, by both Bogotá's TransMilenio system and Brisbane, Australia's Busway network. All three cities demonstrate the role of strategy and targets in favoring the Quickway model.

This report presents case studies of these three cities, and then contrasts their experience with that of four American cities which have developed BRT systems, two of which explicitly follow the Light Rail Lite model and the other two representing the closest American cities have come to implementing the Quickway model.

This report also introduces new terminology to the discussion of BRT systems. Busways are described as comprising *T-Ways*, which are characterized by grade-crossings, and *Quickways*¸ which are grade-separated facilities that permit express (limited or nonstop) operations. BRT systems that operated exclusively within a busway infrastructure are described as *internalized* systems, and those that branch off that infrastructure are, appropriately enough, described as *externalized* systems.

The Quickway Model

The essential focus of the Quickway model is that of creating a primarily grade-separated infrastructure which then permits the cost-effective operation of a range of transit services, many of which may not be identified during the infrastructure planning stage. Stations, too, play a central role as the primary means of branding the system, integrating it into surrounding land uses, and permitting high-volume operations.

The Quickway model differs from the Light Rail Lite model in virtually every strategic element of the service.

Running ways. The Quickway model focuses on the creation of grade-separated running ways, or Quickways, with passing facilities at stations, in order to permit a range of services, many of which will branch off from the originating corridor. The investment in grade-separation permits much higher operating speeds (especially at high bus volumes) than would be possible with at-grade busways, reducing the travel time needed to produce any given service, changing in fundamental ways the cost basis of operating such services: as operating costs go down (due to shorter round-trip times) and revenues increase (due to the increase in ridership associated with reduced travel time), a *virtuous circle* is created.

Stations. Quickway stations tend to be designed for higher passenger and bus volumes than equivalent Light Rail Lite stations, and they are often located off automotive corridors. They mostly employ grade-separated pedestrian crossings to minimize potential conflicts with bus operations.

Vehicles. The Light Rail Lite model often leads to the use of specialty BRT vehicles which more closely mimic light rail vehicles in terms of design and passenger comfort. As implemented to date, the Quickway model has been based either on standard transit buses or, in the case of Bogotá, high-floor transit buses with wide, level-boarding doors, but which otherwise are standard articulated transit buses.

Intelligent Transportation Systems. Most implementations of Light Rail Lite depend on advanced signaling systems to give transit vehicles some measure of priority at intersections; these systems are not required for Quickways. Advanced passenger information systems may be deployed, but have not proven essential to Quickway operations.

Fare collection. Most implementations of Light Rail Lite employ off-board fare collection as a means of minimizing vehicle dwell times; Only Bogotá among the Quickway examples relies on this technique (but in doing so more resembles heavy-rail systems by using stored-fare media and a barrier system); other Quickway cities rely on grade separation to reduce total travel time.

Service patterns. Quickway-based cities use the infrastructure to create a range of services which take people directly to major employment sites, often eliminating intervening stops and transfers in the process. The Light Rail Lite model generally produces single routes per corridor serviced, imposes additional modal transfers, requires all vehicles to stop at all stations, and in a number of cases delivers people not to employment sites but to a rail station for an additional modal transfer.

Identity and branding. Quickway-based systems are more likely to brand the infrastructure (the Quickways themselves and the stations that serve them) than any particular service using them (with the exception of fully-internalized systems such as TransMilenio); in contrast, most Light Rail Lite implementations of BRT focus on branding the vehicles and the particular routes they serve.

Strategic Intent. The primary intent of the Quickway model is to change the under-

lying economic performance of transit services and hence permit a significant "ramping-up" of service in order to meet ambitious mode-split or ridership targets. They meet these targets by then being able to cost-effectively deploy services which connect more places together (improved network structure), reduce travel time while improving reliability (improving system performance), all while paying attention to the many other aspects of service which together influence a person's disposition to use transit (improving the customer experience).

International Case Studies

Three international cities represent the state of the practice in implementing the Quickway model.

Ottawa: Transitway. Ottawa, Ontario, has developed a network of grade-separated Quickways—the Transitway—which it uses to operate a range of local, branching, and express services. Ottawa developed its Transitway as a cost-effective means of meeting ambitious mode-split targets which were dictated by its long-range land use plan and adopted transportation policies.

Figure ES.2. Bogota's *TransMilenio* system makes use of grade separation and station passing facilities to move passenger loads typically associated with heavy rail systems—at a fraction of both the capital and operating costs of heavy rail.

Ottawa's Transitway system has been limited by at-grade operation using bus lanes through its relatively dense downtown core. Its stations, which do provide some measure of protection from the harsh winter elements, are nonetheless Spartan in design and materials. Nonetheless, the Transitway at its busiest point matches the highest-volume light rail line in Canada or the U.S. and gives Ottawa the highest per-capita transit mode share of any mid-sized city in Canada or the U.S.

Bogotá: TransMilenio. Bogotá's TransMilenio network was not originally conceived of using the Quickway model, but planners backed into a version of the model while attempting to overcome the limitations of the Light Rail Lite model to meet crushing passenger demand. Though TransMilenio's busways are only partially grade-separated, grade-crossings are still relatively minimal for an urban system, and the system was designed to support both passenger and vehicle volumes normally associated with high-volume heavy rail systems.

While much attention world-wide has been paid to Bogotá's BRT infrastructure (busways and stations), its service plan is a primary contributor to its success. An extensive series of express and "super express" routes link different groups of stations based on actual origin-destination travel patterns. The network is fed, in turn, by an extensive feeder network of traditional collector buses operating in traditional bus mode.

Brisbane: Busways. Brisbane, Australia, along with Bogotá, represents the state of the art in Quickway implementation. It has been developing a network of Quickways—the Busway network—which includes extensive tunneling and bridging in order to maintain full grade separation, even through the busy Central Business District. Unlike the other two international cities, Brisbane also has an extensive electrified commuter rail network that behaves, in

practice, like a hybrid heavy rail system. The Busway strategy has allowed Brisbane to reverse declining transit ridership and register impressive system-wide gains; its Busway, at its busiest point, is now moving significantly more peak-hour passengers than any light rail line in North America.

Busway stations in Brisbane are an outstanding element of the system and are considered its primary branding focus. They integrate in many cases into surrounding land uses and can comfortably handle heavy passenger loads while providing effective protection from the elements. The extensive network of branching and express services that use the Busways create significant travel time savings for many passengers and in fact give buses a sustainable competitive advantage over all other modes of transport for a key set of regional trips.

"Light Rail Lite": Eugene and Los Angeles

Two American cities were chosen for their implementation of the Light Rail Lite model: Eugene, Oregon, and Los Angeles, California. In both cases, planning began and ended with this model. In the case of Eugene, that decision was consonant with projected levels of passenger demand; in the case of Los Angeles, that decision may have precluded a more effective solution in the Orange Line corridor.

Eugene, Oregon: EmX. The Emerald Express is Eugene, Oregon's new BRT service, the first segment of which, the Green Line, opened in early 2007. It connects the downtowns of the two primary cities in Lane County, Eugene and Springfield. This BRT service features specialty vehicles and a range of running ways, including an innovative "trackway" as well as on-street operations. Passenger acceptance has been high, with significant gains in corridor ridership, though some of this increase may be due to fare-free operation for the present.

Los Angeles: Metro Rapid and the Orange Line. Los Angeles has implemented BRT at the two poles of the Light Rail Lite model: Metro Rapid, which some consider "BRT Lite," and the Orange Line, a full attempt to replicate light rail service using rubber-tired vehicles. Metro Rapid relies primarily on vehicle branding, simplified route design (with widely-spaced stops), and signal priority measures to reduce vehicle run times. It has been credited with measurable ridership increases in the 16 bus corridors in which it operates.

The Orange Line, in contrast, uses specialty vehicles (some of which are also used for Metro Rapid service) on a dedicated T-Way serving specialty stations along a 14 mile corridor. The history of that corridor was one of many failed attempts to create some form of rapid transit and much political posturing. BRT—and the Light Rail Lite model in particular—was dictated not by planning or *transit* strategic concerns, but out of political expedience: the desire to "get something built" within a given pot of money. It has proven highly successful at attracting riders, greatly exceeding projections, but as a result is also running into capacity and operational limitations which have planners scrambling for solutions.

Beyond "Light Rail Lite": Pittsburgh and Miami

Pittsburgh and Miami together offer the closest American equivalent to the Quickway model. Each, however, falls short on certain key dimensions, limiting the ability of these implementations to influence further Quickway adoption within the U.S.

Pittsburgh: Busways. Pittsburgh is by far the American city that comes closest to the Quickway model in terms of its physical infrastructure and service plan. Its three Busways are largely grade-separated and support a range of services, and have proven highly cost-effective compared to

other transit services (including its light rail system). The lack of infrastructure in the downtown and a conservative approach to route planning have limited the further effectiveness of the network, and Busway stations are not nearly to the standard established by Brisbane, creating both operational issues and lowered perceptions of the system.

Miami-Dade: South Miami-Dade Busway. The South Miami-Dade Busway is a T-Way facility that connects far suburbs to the terminus of Miami's single heavy rail line. Even with these limitations, it supports a range of services that more closely resembles the Quickway model, and has attracted healthy ridership in a cost-effective manner (though with noted operational issues). Its success begs the question of how well an improved infrastructure could attract additional ridership (and provide even greater operational cost benefits).

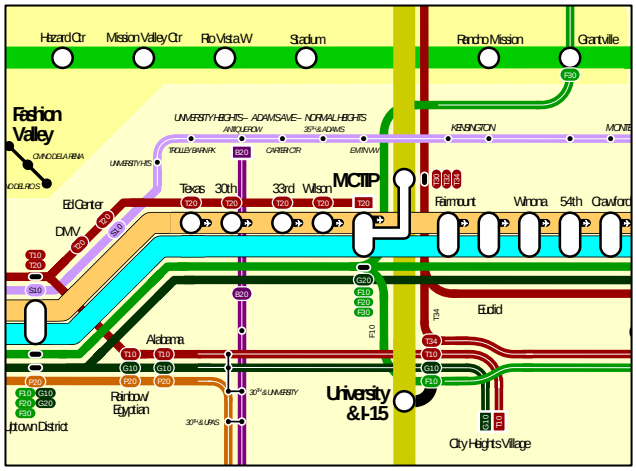

Figure ES.3. Segment of draft route structure for the San Diego *FAST* Plan showing express, all-stops, and branching services in both Quickway infrastructure (solid lines) and arterial operations (striped lines).

An appendix to this study reports on a Quickway plan developed for the San Diego region, the preliminary findings for which are encouraging for the application of this model in an American context. The *FAST* Plan, sponsored by Move San Diego, Inc., a nonprofit organization, specifically built off the experience of cities such as Brisbane and Ottawa, and identified new innovations that would make the model more closely match the trip patterns of a American sunbelt city.

Conclusions

Several conclusions may be drawn from this initial review of the Quickway model as a modal alternative to Light Rail Lite.

The role of passenger demand. The Quickway model is appropriate in contexts where sufficient passenger demand may be created to justify the investment in grade-separation. In many cases, this demand is generated off-corridor, and is captured through careful service planning. Properly planned, the Quickway model can push transit over a "tipping point" in which passenger demand rises significantly not just for Quickway-based services, but for all transit services.

The role of existing services. The Quickway model has proven especially useful for transit agencies that already operate a variety of express services. In all cases, it implies network-level analysis, not merely the kind of corridor-level analysis typical to the Light Rail Lite model, and implies a greater degree of service redesign if all of the benefits of the infrastructure are to be realized.

The role of strategy. In contrast to the Light Rail Lite model—which is a *service strategy*—the Quickway model is an *infrastructure strategy.* The cities that have adopted it have looked to create an underlying infrastructure which can best support the organic and evolving deployment of a range of transit services, but nonetheless confer the benefits of fixed infrastructure. More to the point, Quickway infrastructure is inherently *scalable*, meaning that it can effectively support a very wide range of

passenger demand. In contrast, most Light Rail Lite implementations have limited scalability; if ridership grows *too much,* then operations are compromised and service begins to break down.

The role of targets. In every case, the Quickway model was adopted (or backed-into) as a strategic response to the need of the cities to achieve measurable ridership or mode share targets. In contrast, targets as such are generally not a major factor in Light Rail Lite planning.

The role of growth. For transit to shape urban form, there must be growth or investment at a scale that can respond to transit infrastructure and services. The Quickway model appears most valuable in moderate- to high-growth cities, as it can respond to such growth in a way that begins to shape market demand.

The role of branding. Light Rail Lite depends on branding of the route and vehicle (and infrastructure, although to a slightly lesser extent). The Quickway model tends to put much more emphasis on branding of the infrastructure, and in the best practices example treats stations as the primary branding vehicle, raising the profile of the system significantly.

The role of models and understanding. Most cities learn from other cities when attempting to implement a new transit mode. The importance of such city models is therefore paramount, as is knowledge of the elements that contribute to the success of that model.

The match between models and urban form. When is Light Rail Lite, Light Rail itself, or the Quickway model most appropriate for a city? This study identifies a number of factors, including:

- The corridor type;
- Residential and employment density and the location of demand;
- Dispersion of origins;
- Corridor conditions;
- Total demand;
- Demand for express services;
- Passenger volumes;
- Internalized vs. externalized systems;
- Hybrid service opportunities; and
- The role of the corridor in the network.

These factors together suggest the need for further consideration by the Federal Transit Administration in terms of how it can best support the Quickway model where it comes closest to meeting adopted strategic goals.

Recommendations for Practice

For the Quickway model to make a contribution to transit planning in the United States, a number of recommendations are proposed.

At the Federal level, interest in the Quickway model should be driven by that model's demonstrated ability to cost-effectively attract and carry massive ridership. The Federal Transit Administration in particular can encourage the appropriate exploration of this mode in several notable ways:

- Recognition of the Quickway model as a distinct *mode*;
- Support for network-level planning;
- Support for improved alternatives development;
- Flexible funding criteria;
- Additional technical study;
- Improved operating cost modeling; and
- A more competitive alternatives generation process, including the adoption of mode split targets.

Metropolitan Planning Organizations (MPOs) and public transit agencies can undertake a number of steps as well:

- Develop mode-split targets;
- Improve network-level analysis and planning;
- Learn from and about the Quickway model; and
- Embrace high-level market research.

Planning and engineering firms—who perform the bulk of the alternatives development and analytical work in this country—can and should become more familiar with the Quickway model as a means of helping regions meet their long-range goals:

- Become familiar with the Quickway model; and
- Explore Quickway service planning concepts.

In short, the effective implementation of the Quickway model calls for a number of elements:

- The adoption of targets;
- Embracing an infrastructure strategy;
- Understanding the role of infrastructure in supporting regional growth;
- Understanding the role of stations in branding Quickway infrastructure;
- Understanding the limitations of current ridership modeling; and
- Improving the state of practice of network planning.

Quickways are not merely a graduated step-up in BRT-supportive infrastructure; they imply their own logic on system design and operations and make possible services that otherwise would not be cost-justifiable. They should be treated as a distinct mode, particularly for network and corridor-level planning, and one with great potential for helping American cities achieve phase shifts in the role that transit plays in their daily lives and long-range growth.

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1. Introduction: A New Model, a New Mode

Bus Rapid Transit (BRT) has come to mean many things to many people within the United States. At one extreme lie "Rapid Bus" schemes such as Los Angeles's *Metro Rapid* network, consisting of a number of bus routes that feature simplified routing, lengthy stop spacing (just under one mile), mild signal priority measures in many corridors, and special system branding. At the other extreme lie dedicated guideway systems, such as Los Angeles's *Orange Line*, a bus route that mimics a light rail line by operating in a dedicated right-of-way and connecting specialty-built stations typically spaced at about one mile apart. Like Metro Rapid, the Orange Line enjoys signal priority measures at street crossings; unlike many rail systems, it does not enjoy signal override.

A common feature of the range of most BRT applications in the United States is that the route and the underlying alignment or guideway are essentially one and the same. The Orange Line, for example, is a single route operating in a dedicated busway; every bus stops at every busway station, and every busway station is served by every bus. To be sure, there are some notable exceptions to this rule (such as Pittsburgh's busways), but the vast number of BRT projects in the US follow this model.

The service model that dominates BRT planning in the United States may described as that of "Light Rail Lite," in that BRT is intended, at some level, to mimic the kind of service that light rail (LRT) typically provides: compared to a bus in mixed traffic, light rail is often deployed so that it operates, if not entirely in its own right of way, at least separated from auto traffic, connecting enhanced stops or stations typically spaced one-half to one-mile apart (closer in urban centers, occasionally farther apart in outlying areas) with a generally higher-speed operation. The Light Rail Lite model of BRT has found favor not because of any innate interest in the bus per se (it is relatively common to see people clamoring for rail systems for rail's sake, but rarely buses for bus's sake), but as a cheaper means of introducing a light rail-like service (or what some have dubbed "*Like* Rail Transit"); it has sometimes been described as "light rail on the cheap."

Both LRT and Light Rail Lite models may be compared to pearls on a string, in that a corridor is conceived as a string of stations that are all linked by a single transit service. This image of "rapid transit" is a classic one and hence is relatively easy to conceive and communicate.

Though most current applications of BRT in the United States follow the Light Rail Lite model, some of the outstanding examples of BRT systems internationally follow a *different* network model. This other model involves the creation of relatively high-speed guideways or *Quickways* that support not just an "all-stops" or Light Rail Lite route but also a range of other routes, some or many of which may bypass individual stations through the use of passing lanes. Some of these other routes may branch off of the core or central guideway to serve locations along other corridors or alignments. These Quickways often take advantage

of grade separation to minimize travel times and permit high-volume operations. This model, which may be called the Quickway model, differs fundamentally from the Light Rail Lite model in that it focuses planning attention on creating an underlying infrastructure to support a range of services, some of which may enter or leave that infrastructure.

The differences between the two models are sufficient to suggest that Quickway-based systems be understood as a distinct *mode* of transit, not merely a variant on the continuum of the Light Rail Lite *mode* of Bus Rapid Transit as currently understood in the United States.[1] That is to say, just as rail transit is not a single mode but rather a collection of modes (including heavy rail, light rail, commuter rail, and streetcar), Bus Rapid Transit itself comprises at least two distinct modes, each of which implies its own planning and service logic.

As the review of international practice will suggest, the Quickway mode of BRT emerges as a preferred or desirable alternative following a planning process that is focused on deploying a *network* of services to achieve specific and ambitious ridership *targets*. The Quickway model evolved from a sophisticated understanding of the relationship among a set of variables—the cost of operating buses (and under what conditions), the factors that drive modal choice, the role that station design, location, and amenity play in driving choice, the willingness of passengers to transfer (and under what conditions), and the relationship between and among different services in an overall transit network.

Three outstanding examples of the Quickway model internationally are located in three vastly different cities on three different continents. The model originated with the pioneering work of John Bonsall in Ottawa, Ontario, capital of Canada, a generally well-planned metro area whose population passed the million mark in the 1990s. Ottawa has developed what it calls the Transitway, a network of mostly grade-separated roadways used by a variety of transit services in the region. Ottawa's Transitway differs from virtually all US BRT systems in its use of grade separation, its service plan, and the quality of the stations that serve the corridors.[2]

Bogotá, Colombia, is the capital of a South American republic long associated with social strife and generally unsafe conditions, in addition to the problems of urban poverty and rapid growth exacerbated by a steady stream of refugees from poor and less-safe rural provinces. A city of maybe perhaps 7 million residents (in a metro area that exceeds 8 million), Bogotá is actually in the throes of an urban renaissance variously noted even in the American media.[3] This renaissance has, as one of its core elements, the development of the TransMilenio BRT system. This system was not directly inspired by Ottawa, but rather evolved into the Quickway model following an original attempt to plan a Light Rail Lite form of BRT for the city, as a means of overcoming the limitations of that model.

The other notable city sits half a world away from Bogotá. Brisbane, Australia, is the capital of Queensland, a state which is enjoying relatively high inmigration from other parts of Australia due, in part, to a healthy economy and perceived high quality of life. Brisbane is a city of about 1.6 million residents, within a metro area of about 2.25 million residents. Brisbane—which was directly inspired by Ottawa—has been developing a network of grade-separated Quick-

ways (the Busway system) which together support literally dozens of bus routes operating in all-stops, branching, and express modes.

Though there are significant differences in the underlying approach to developing BRT in the three cities, what they share in common is a *service plan* which differs sharply from the Light Rail Lite model. It is the purpose of this study to identify the features that distinguish these international cities' approach to BRT, to compare them with recent and relevant BRT projects in the United States, and to then discuss issues relating to the applicability of this model to cities in the U.S. A central theme of this discussion is the role of *strategy* in general and *strategic goals* in particular, as the Quickway model as implemented has consistently reflected the need to meet *targets*.

This report is structured in four primary sections. The first introduces the theme and sets the stage for the analysis that follows. The second focuses on the three international examples of Quickway-based BRT systems, describing key features of these systems and highlighting major issues with their development. The third section looks at four American cities with notable BRT systems, and compares these cities with the international case studies. These four American cities are themselves divided into two groups: those that are unabashed implementation of the Light Rail Lite model, and the two that come closest to the Quickway model. The final section highlights key points that emerge from the preceding analysis in terms of the applicability of the Quickway model to US cities. An appendix looks at a planning process currently underway in San Diego to develop a Quickway infrastructure for that region, and reviews some key initial findings of that process.

The report follows a case study methodology, in which each city's BRT system is reviewed according to the key characteristics of BRT systems which have been commonly advanced world-wide.[4] The importance of each of these elements to the overall functioning of the system is discussed, as well as the interrelationship among these elements.

This study introduces or reinforces several new terms to the discussion of transit systems in the hopes of highlighting the distinction among differing elements that are often called by the same name; as transportation professionals and the broader public become more familiar with the distinctions, their ability to promote more effective solutions will be heightened. Among the terms used in this report are the following.

T-Way. It is common to use the expression "busway" to describe any running surface dedicated for use by buses. In practice, though, there is a world of practical difference between an at-grade busway such as the Los Angeles Orange Line and a grade-separated busway such as Brisbane's Southeast Busway. The term "T-Way" is proposed for an at-grade busway, or one whose operations are determined by grade

Figure 1.1
Sydney's T-Way network operates mostly at grade.

crossings. The term "T-Way" is taken from Sydney, Australia's busway network (Figure 1.1), which operates mostly at grade.

T-Ways are an example of a "Category B," or "Longitudinally Physically Separated" right-of-way, to use Vuchic's framework.[5] In such a right-of-way, transit vehicles are separated longitudinally from other vehicles (traffic), but there are at-grade crossings from automobiles and/or pedestrians.

Figure 1.2 Brisbane's Southeast Busway is an example of a Quickway—a transitway that enjoys the benefits of grade separation and passing lanes at stations.

Quickway. In contrast to a T-Way, which is an at-grade facility, a Quickway is a grade-separated busway, such as those found in Brisbane (Figure 1.2) and Ottawa,[6] that allows for buses to pass at stations (to support express routes). Quickways offer not merely faster travel times than T-Ways, but generally offer much higher capacity, fewer traffic impacts, and produce markedly greater operating cost benefits. They are also far more expensive to build.

Quickways are an example of a "Category A," or "Fully Controlled" right-of-way; access to the facility is fully controlled, and cross traffic is eliminated through grade-separation or, in limited circumstances, signal override at grade crossings.

Internalized Networks are rapid transit systems that operate exclusively within specialty guideways, be they T-Ways or Quickways. Examples of such systems are Bogotá's TransMilenio and Los Angeles's Orange Line. Such systems tend to use specialty vehicles that are unique to the network. Prior studies of BRT have suggested the notion of "open" or "closed" systems to describe BRT infrastructure which is *open* to "any" operator or vehicle, or is operated with only a specific set of vehicles by operators specifically contracted or otherwise entitled to operate them; the concepts of "internalized" and "externalized" networks as introduced here are intended to focus entirely and specifically on the issue of whether buses operate only within dedicated guideways, or whether they branch out of them.

Externalized Networks are those that permit or even depend on "standard" transit vehicles to enter and/or leave the guideway system to serve origins and destinations off-corridor. Such systems rely more on the branding of the infrastructure than of the services running on the guideways. Examples of externalized networks are the South Miami-Dade Busway as well as Brisbane's, Ottawa's, and Pittsburgh's busway systems.

2. The Quickway Model

2.1 Introduction

The Quickway model of BRT differs from the Light Rail Lite model by its essential focus: the role that infrastructure, namely rights-of-way and stations, plays in the system. The Light Rail Lite model of BRT is generally concerned with duplicating the service pattern of LRT; the underlying right-of-way may involve any degree of transit priority, from signal priority measures or even the simple ability to stop a bus in a travel lane, on up to grade separation at key choke points, but such infrastructure is justified primarily in terms of supporting the LRT-like level of service.

Quickway-based systems focus instead on creating a dedicated and primarily grade-separated right-if-way to permit a *range* of transit services to travel through a corridor at the highest practicable speed. It is expected that such services will evolve and change over time, and only a handful or even just one of these services will resemble an equivalent LRT service.

BRT systems are commonly described in terms of a set of elements, or at least a range of considerations for a number of standard elements. These include:[7]

- Running Ways;
- Stations;
- Vehicles;
- Intelligent Transportation Systems;
- Fare Collection;
- Service Patterns; and,
- Identity and Branding.

Quickway-based BRT systems differ from the more common Light Rail Lite model in a number of key fashions; however, since neither is a fixed model, there is considerable room on both sides for variance. Still, a comparison of BRT implementations in different cities yields the following insights.

2.2 Running Ways

For the Quickway-based model, the running way is the key variable, the *strategic choice* that in turn shapes and enables service choices. Quickway-based systems focus considerable capital resources on creating a mostly grade-separated infrastructure (Quickways) to support a range of transit services. These Quickways almost always feature passing lanes at stations to permit some routes to bypass intervening stations. In cases where full grade-separation is not possible, sufficient right-of-way is still provided (often, as is the case with TransMilenio, two travel lanes in each direction) to maintain high capacities and still permit passing at stations. The importance of the grade separation lies in its impact in terms of both ridership (revenues) and operating costs (public subsidies); because significantly faster services may usually be provided at less cost than slower services

(this will be explored in greater detail below), a transit agency is able to provide more service per available dollar; likewise, because faster services generally attract a higher ridership, these services generate more farebox revenue. The double-play of lower costs and higher revenues can be used to drive a "virtuous circle" and lead to a phase-shift in the role of transit in a given area (there is evidence that this is occurring in two of the international case studies discussed in this report).

Full or even partial grade separation is rarely a component of the Light Rail Lite model, as projected ridership along a single route may not justify the scale of cost (or, more often, push planners or decision-makers to favor a rail mode for the corridor, given the scale of investment). Many applications of BRT in the United States anticipate operation within a major arterial, either in a dedicated bus lane or relying almost entirely on signal priority measures to help buses compensate for the effects of road congestion and signal-induced delay. Where dedicated right of way is provided, it may not necessarily include passing lanes at stations, forcing all buses either to stop or await a stopped bus before proceeding, and even when passing lanes are provided, frequent and complex grade crossings significantly slow services, even with signal priority.

2.3 Stations

Since the Quickway-based model focuses on creating exclusive and primarily grade-separated right-of-way, stations are a major component, and in some systems are quite elaborate and generously sized (such as with Brisbane). Quickway stations almost always include passing lanes for vehicles not stopping, and also include separated crossways for pedestrians (typically, pedestrian bridges) to reduce conflicts with buses that are not stopping and permit higher bus operating speeds through stations.

Stations may take a large variety of forms for the Light Rail Lite model, ranging from simple signs (such as those found at some stops of Los Angeles's Metro Rapid) to light rail-like stations, generally comparable to stations commonly used in Quickway-based systems.

2.4 Vehicles

Cities with Quickway-based systems, such as Brisbane and Ottawa, tend not to use specialty "BRT" vehicles, but rather run their traditional transit buses through their Quickways. In the case of Bogotá, TransMilenio does use specialty articulated vehicles, outfitted with extra-wide high doorways designed for platform loading, but otherwise are configured internally much like traditional transit buses.

Figure 2.1
Gillig 35' transit bus in "BRT treatment" (top) and "regular" treatment (bottom). The primary difference is in the shape of the vehicle's front end and custom paint scheme. Other physical differences are due to the use of a hybrid electric drive train (top).

Many cities implementing Light Rail Lite versions of BRT are choosing specialty buses that cost considerably more than standard transit vehicles. These buses are purportedly designed to provide a higher degree of passenger comfort, level low-floor boarding, and a more appealing exterior. Some bus manufacturers offer their standard buses in a "BRT treatment," often implying design cues that add visual interest to the exterior. As a result, the meaning of "BRT" has become even more diluted, as some transit operators have been observed to say, "let's run the BRT on this [non-BRT] route."

2.5 Intelligent Transportation Systems

Quickway-based systems, in practice, have rarely had to rely on advanced ITS systems (such as advanced signaling systems), as physical infrastructure generally provides many of the benefits that such systems are otherwise called upon to provide. Advanced passenger information systems may be a part of Quickway-based systems, though the improved schedule adherence of Quickway-based systems may somewhat obviate the need for live, as opposed to scheduled, information.

ITS systems become of greater importance to most Light Rail Lite implementations of BRT, as these systems generally must contend with traffic signals and automotive flows that affect vehicle travel time.

2.6 Fare Collection

Quickway-based systems may or may not use off-board fare collection or various smart media; the use of such systems may confer benefits, but is again not central to the model.

Light Rail Lite-based systems must often rely on advanced fare collection systems (primarily, the use of off-board collection) as a means of reducing vehicle dwell times. Given the delays that otherwise may be expected due to at-grade operations, reduced dwell time is one of the primary means by which Light Rail Lite systems are able to gain travel time savings (the other four are through the use of wider station spacing, queue-jumping infrastructure, more direct routing, and traffic signal priority systems).

Quickway-based systems, in contrast, gain substantial travel time savings by the elimination of most or all traffic signals and traffic queuing and by reducing the number of stops that most routes make. While reductions to dwell time could further improve operations, the gains created by grade separation are significantly greater and hence may have overshadowed the benefits that off-board fare collection could bestow.

2.7 Service Patterns

Quickway-based systems are characterized by a rich mixture of services taking advantage of a high-speed guideway (the Quickway) in order to deliver transit

services to a wide swath of a metro area. They typically feature a "spine" service which is otherwise comparable to the Light Rail Lite service, but also feature various express, semi-express, branching, and direct (point-to-point) routes.

A key feature of the service patterns of cities such as Brisbane, Ottawa, and Bogotá is that the infrastructure is designed to support services which deliver passengers directly to major employment sites and other key trip generators. Though transfers are facilitated by these networks, the operational goal is to deliver as many riders as possible to their destinations as directly as possible, bypassing intervening stops and eliminating many transfers.

The Light Rail Lite service pattern is typically just that: a single route mimicking a light rail service along a given alignment. This route may or may not serve key trip generators, and it may be conceived as an extension to a more capital-intensive transit mode, albeit with a forced transfer where it meets that mode (as is the case, for example, with both Los Angeles's Orange Line and the South Miami-Dade Busway, both of which terminate at a heavy rail station).

2.8 Identity and Branding

Branding has been identified as a common feature of BRT systems, but it is in *how* and *what* is branded that the distinction between the Quickway and Light Rail Lite models becomes clear.

Figure 2.2
Logo for Brisbane's Busway network.

Quickway-based systems, generally speaking, are as likely or more likely to brand the *infrastructure* as they are the transit services that use that infrastructure. Both Ottawa and Brisbane, for example, have special logos for their Transitways and Busways (respectively); the various routes that use these guideways are not necessarily branded any differently from traditional transit services. Brisbane, in particular, uses station architecture as an element of branding and identity; as one Brisbane planner explained, it's hard to give a special identity to what is essentially just a two-lane road (the Quickway itself), so the stations become the opportunity to give a "corporate architecture" to the system. The message may be understood as "*any* service that uses the Quickway is, by definition, faster than surface services."

The Light Rail Lite model generally focuses on branding not just the stations or right of way but the vehicles as well, given that they need to be distinguished from traditional bus services even more than with the Quickway model (as in most cases they are more likely to operate adjacent to or within traffic). The message may be understood as "*this* service is faster than other transit services."

Figure 2.3
Original branding for LA's Metro Rapid bus service.

2.9 Strategic Intent

To sum up, the Quickway model may be characterized therefore as:

1. Created around a dedicated, often grade-separated right-of-way;
2. Employing major stations along that right-of-way, and occasionally off that right-of-way as well, which incorporate passing facilities so that some routes may bypass individual stations;
3. Less dependent on advanced transit vehicles;
4. Less dependent on advanced signaling and traffic management systems, as well as advanced passenger information systems;
5. Benefiting from advanced or off-board fare collection, but less dependent on it to achieve travel time savings;
6. Employing a robust and multi-route service pattern, designed to deliver the largest number of passengers to key destinations with a minimum of transfers; and
7. Focusing branding and identify more on the *infrastructure* and less on the *vehicles*.

Beyond these *elements* of service lies the *strategic intent* of creating Quickway-based networks. The Quickway model is designed to change the *economic performance* of transit services by focusing on those elements that *generate costs* and those that *generate revenues*. It is precisely because the Quickway model responds to these "cost and revenue drivers" that the model is not only relevant to the U.S., it holds out at least the promise of effecting a major change in the role of transit in many American cities.

To understand better the impact of Quickway infrastructure on costs and revenues, it is necessary to explore in greater detail the relationship between operating characteristics and operating costs.

Throughout the United States, transit systems routinely maintain distinct capital and operating budgets; what's more, federal funding for capital purchases (such as for new vehicles or the New Starts and Small Starts capital programs) is generally divorced from operating funding. As a result, some agencies with limited dedicated local funding sources find themselves "capital rich but operating poor," as one transit agency general manager once lamented. In addition, while the public officials who generally sit on transit agency boards may favor capital projects for political reasons, the political payback for funding operations may be more limited.

Most, if not all, US transit agencies rely on *accounting models* to allocate costs to routes. While these models vary by agency, it is common to have models that assign some costs based on in-service hours (to account for drivers) and others based on mileage traveled (to account for fuel, tires, oil, and maintenance, which together can be considerable). While this might be a useful and even appropriate way to allocate costs *when all bus routes behave approximately the same*, it can distort the actual costs of operating truly rapid BRT services; to begin with, a bus operating at higher speeds with fewer stops will generate less wear-and-tear than a bus going stop-and-go in an urban low-speed environment (implying reduced maintenance costs per mile traveled); then too, at higher speeds, the vehicle is gener-

ally operating more efficiently. Of even greater impact, high speed operations may allow a transit operator to produce a given service frequency with fewer vehicles, as each vehicle is able to complete a round trip in less time.

Economists generally distinguish *accounting* models from *production function* models. Accounting models seek to allocate costs for accounting purposes, which is fair, but they rarely identify the *drivers* of such cost. It may be that, on average, a transit bus costs, say, $60/hour to operate, but that doesn't tell us what specific dimensions of service generate those costs or, of greater importance, what the additional or *marginal* cost would be of adding (or removing) new services.

A production function model is one that identifies the *attributes* of a service that generate costs. For example, using the above example, *operating speed* is one such attribute; as speed increases, some costs generally go down (such as fuel required per mile of travel, maintenance required per mile of travel). As certain thresholds are crossed, the number of vehicles that must be in service to produce a given route schedule is reduced, leading to a further reduction in labor costs. So from an economics perspective, a transit agency that seeks to systematically reduce the time it takes to produce a given round trip is one that will be lowering its operating costs.

The above facts are salient in the discussion of the relative performance of BRT vs. LRT systems. Common pronouncements will often claim that LRT systems are more cost effective than BRT systems at relatively modest ridership thresholds because of the need to operate more buses to match the seating (or gross) capacity of a three- or four-car LRT train. This argument was advanced, for example, by former California State Senator James Mills, who is widely credited with being the father of modern light rail in the United States:

> The belief that buses on guideways are cheaper to operate than light rail trains is false. To carry 400 riders at rush hour requires five or six buses with five or six drivers. One light rail train would do that with only one driver, and most of the cost of transit operations is labor.[8]

The Senator was correct that "most of the cost of transit operations is labor," but with LRT systems, most labor costs are for maintenance; a review of the operating budget of one LRT operator suggests that driver costs may account for only 13% of gross costs, so while driver costs on the bus side would indeed be higher, the scale of difference would be far less than the ratio of drivers (and the cost of adding a car to a train, rather than being trivial, can be nearly that of operating a bus with driver). More to the point, though, a thoughtful BRT service plan (based on the Quickway model) would not have each of those five or six buses operating identically, but would involve some mixture of express, all-stops, and short-lined service, thereby reducing total vehicle in-service time and freeing up resources to be used on other routes. In addition, in the off-peak, demand may only require one or two buses, at substantially lower cost than that of operating a train.

Also, and this leads to the other side of the equation, that of revenues, there are known attributes of service that attract ridership to a transit service; they generally fall into three groups:[9]

1. *Network structure*, which defines the places that are connected by a transit system, the location of access/egress points, and the directness of such connections;
2. *System performance*, which is a function of waiting time, access time, in-vehicle travel time, capacity, and overall system reliability; and
3. *Customer experience*, which consists of many different attributes or stages in a transit *service encounter* and the various degrees of perceived risk or benefit involved in each stage; issues of identity and self-validation are also important to this dimension.

By and large, Quickway-based systems generally offer higher service frequencies and shorter travel times than many other modes (figure 2.4), and more advanced systems also eliminate many interim transfers, or locate such transfers in stations (as opposed to making them on-street), typically along the same platform.[10] So, returning to the LRT example, one would not expect the same level of ridership for a train that operated every 15 minutes versus a bus that operated every 3 minutes, *everything else being equal*. Likewise, given a 30 minute train trip or a 20 minute bus trip, assuming equivalent reliability and service frequencies, the faster trip would be likely to attract a larger share of riders. So the combination of higher base frequencies and shorter travel times would induce higher ridership on the bus-based system, further offsetting the difference in operating costs.

Figure 2.4
AM route schedule for spine services on Brisbane's Southeast Busway, showing the extraordinarily high frequencies on this corridor. Express services, not included in this schedule, offer faster connections from outer stations to destinations in the central business district.

Route Number	111	133	162	111	133	162	160	111	162	133	111	162	133	160	111	133	133	160	111	162	111	133	111	162	160	133	111
	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am
Eight Mile Plains Station	7:25		7:27	7:30		7:32		7:35	7:37		7:40	7:42			7:45				7:50	7:55	7:55		8:00	8:02			8:05
Garden City Bus Depot	|		|	|		|	7:33	|	|		|	|		7:43	|			7:53	|	|	|		|	|	8:03		|
Upper Mt Gravatt (Garden City) Stn	7:27		7:29	7:32		7:35	7:35	7:37	7:40		7:42	7:45		7:45	7:47			7:55	7:52	7:58	7:57		8:02	8:05	8:05		8:07
Griffith University Station	7:30	7:31	|	7:35	7:36	|	7:38	7:40	|	7:42	7:45	|	7:47	7:48	7:50	7:52	7:57	7:58	7:55	|	8:00	8:02	8:05	|	8:08	8:07	8:10
Holland Park West Station	7:32	7:33	|	7:37	7:38	|	7:40	7:42	|	7:44	7:47	|	7:49	7:50	7:52	7:54	7:59	8:00	7:57	|	8:02	8:04	8:07	|	8:10	8:09	8:12
Greenslopes Station	7:35	7:36	|	7:40	7:41	|	7:43	7:45	|	7:47	7:50	|	7:52	7:53	7:55	7:57	8:02	8:03	8:00	|	8:05	8:07	8:10	|	8:13	8:12	8:15
Buranda Station	7:37	7:38	|	7:42	7:43	|	7:45	7:47	|	7:49	7:52	|	7:54	7:55	7:57	7:59	8:04	8:05	8:02	|	8:07	8:09	8:12	|	8:15	8:14	8:17
Mater Hill Station	7:39	|	|	7:44	|	|	7:47	7:49	|	|	7:54	|	|	7:57	7:59	|	|	8:07	8:04	|	8:09	|	8:14	|	8:17	|	8:19
South Bank Station	7:41	|	|	7:46	|	|	7:49	7:51	|	|	7:56	|	|	7:59	8:01	|	|	8:09	8:06	|	8:11	|	8:16	|	8:19	|	8:21
Cultural Centre Station	7:43	|	|	7:48	|	|	7:51	7:53	|	|	7:58	|	|	8:01	8:03	|	|	8:11	8:08	|	8:13	|	8:18	|	8:21	|	8:23
Queen Street Bus Station	7:46	|	|	7:50	|	|	7:54	7:56	|	|	8:00	|	|	8:04	8:06	|	|	8:14	8:11	|	8:16	|	8:20	|	8:24	|	8:26
Elizabeth St far side Albert St		7:46	|		7:51	|			|	7:57		|	8:02			8:07	8:12			|		8:17		|		8:22	
Parliament - Margaret St Stop 94		|	7:42		|	7:48			7:53	|		7:58	|		|	|			8:11			|		8:20		|	
Riverside (Creek St) - Stop 148		7:49	7:48		7:54	7:54			7:59	8:00		8:04	8:05			8:10	8:15			8:17		8:20		8:26		8:25	

Route Number	133	111	162	133	160	111	133	111	162	133	160	111	133	111	133	160	111	133	111	160	111	133	133	111	133	160	133
	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am	am
Eight Mile Plains Station		8:10	8:12			8:15		8:20	8:22			8:25		8:30			8:35		8:40		8:45			8:50			
Garden City Bus Depot		|	|		8:13	|		|	|		8:23	|		|	8:33		|	8:43	|			|		8:53	
Upper Mt Gravatt (Garden City) Stn		8:12	8:15		8:15	8:17		8:22	8:25		8:25	8:27		8:32		8:35	8:37		8:42	8:45	8:47			8:52		8:55	
Griffith University Station	8:12	8:15	|	8:17	8:18	8:20	8:22	8:25	|	8:27	8:28	8:30	8:32	8:35	8:37	8:38	8:40	8:42	8:45	8:48	8:50	8:47	8:51	8:55	8:55	8:58	8:59
Holland Park West Station	8:14	8:17	|	8:19	8:20	8:22	8:24	8:27	|	8:29	8:30	8:32	8:34	8:37	8:39	8:40	8:42	8:44	8:47	8:50	8:52	8:49	8:53	8:57	8:57	9:00	9:01
Greenslopes Station	8:17	8:20	|	8:22	8:23	8:25	8:27	8:30	|	8:32	8:33	8:35	8:37	8:40	8:42	8:43	8:45	8:47	8:50	8:53	8:55	8:52	8:56	9:00	9:00	9:03	9:04
Buranda Station	8:19	8:22	|	8:24	8:25	8:27	8:29	8:32	|	8:34	8:35	8:37	8:39	8:42	8:44	8:45	8:47	8:49	8:52	8:55	8:57	8:54	8:58	9:02	9:02	9:05	9:06
Mater Hill Station	|	8:24	|	|	8:27	8:29	|	8:34	|	|	8:37	8:39	|	8:44	|	8:47	8:49	|	8:54	8:57	8:59	|	|	9:04	|	9:07	|
South Bank Station	|	8:26	|	|	8:29	8:31	|	8:36	|	|	8:39	8:41	|	8:46	|	8:49	8:51	|	8:56	8:59	9:01	|	|	9:06	|	9:09	|
Cultural Centre Station	|	8:28	|	|	8:31	8:33	|	8:38	|	|	8:41	8:43	|	8:48	|	8:51	8:53	|	8:58	9:01	9:03	|	|	9:08	|	9:11	|
Queen Street Bus Station	|	8:31	|	|	8:34	8:36	|	8:40	|	|	8:44	8:46	|	8:51	|	8:54	8:56	|	9:01	9:04	9:06	|	|	9:11	|	9:14	|
Elizabeth St far side Albert St	8:27		|	8:32			8:37		|	8:42			8:47		8:52			8:56				9:01	9:05		9:09		9:13
Parliament - Margaret St Stop 94	|		8:30	|			|		8:40	|			|	|			|			|	|		|		|
Riverside (Creek St) - Stop 148	8:30		8:36	8:35			8:40		8:46	8:45			8:50		8:55			8:59				9:04	9:08		9:12		9:16

This issue is of extreme importance in the development of Quickway-based alternatives for an Alternatives Analysis program; the relative operating cost-performance of a Quickway-based alternative is based on a somewhat nuanced

service plan that seeks to move as many riders as possible to express services, and that seeks to eliminate transfers whenever feasible—precisely opposite the planning logic of the Light Rail Lite model.

So, again, this leads to the fundamental strategic intent of a Quickway-based system: the creation of an infrastructure that significantly lowers the net costs of providing transit services while at the same time attracting a larger market (more riders). While it should be obvious that the conditions where this could occur (to the point where the capital costs are justified) are likely present in a limited set of corridors in any given urban area, they do highlight a rather paradoxical fact of the model: in contrast to popular notions (fueled by conceptions of the Light Rail Lite model) that hold that BRT is an "intermediate" capacity mode or a stepping-stone on the way to light rail, the Quickway-based model both relies on and, properly planned and configured, generates *higher* ridership than is *typically* found in US light rail implementations. If it's a stepping stone, it's a stepping stone to heavy rail or metro systems, but likely not light rail.[11]

The next section of this report will review the experience of three global cities, Ottawa, Bogotá, and Brisbane, with their BRT systems. While the three cities—and the three systems—are different, they each illustrate many key features of a Quickway-based approach to BRT systems planning, and will serve as a point of contrast for comparing American approaches to BRT.

3. The Quickway Model: International Case Studies

3.1 Ottawa, Ontario: The Transitway

3.1.1 Transitway: Background

Ottawa, Ontario, is the capital of Canada and its fourth-largest metropolitan region (behind Toronto, Montreal, and Vancouver) with a 2005 metro population of approximately 1.15 million residents.[12] Ottawa is noted for its Transitway system, a network of mostly grade-separated roadways that serve as the backbone of its transit system. Ottawa is widely regarded as having by far the highest per capita transit use of any mid-sized city in North America (approximately 120 annual transit trips per capita, equating to an equivalent mode split for transit of 20% of daily trips).[13]

Though other cities had developed busways, or even grade-separated busways before Ottawa, it was Ottawa that assembled the elements that together make up the Quickway model of BRT. The system was not conceived *in toto,* but rather evolved as the considered response to a long series of decisions and challenges. Before discussing the elements of the system, it is worth looking at the background of the system.

In the early 1970s, public sentiment in Ottawa was reportedly aligned against a road expansion approach to dealing with growth and congestion. The 1974 Official Plan, developed by the then-regional government, contained deliberate policy language favoring public transportation above all forms of road construction and widening, and that further, as a result, set out ambitious and calculated mode share objectives for transit investments and services on a corridor-by-corridor basis.

These mode-share objectives were the salient and overriding "push" that led to the development of the Quickway model. The 1974 Official Plan was, above all else, a land use plan, directing which areas were to be the targets of growth and development. Since road development was to be limited, it then fell to transit to meet the projected demand for movement to, from, through, and within the region and its associated land uses. These targets then became the basis for planning; it was not enough that any particular transit alternative demonstrate its cost-efficiency relative to other alternatives (as is often the case in traditional Alternatives Analyses conducted in the U.S.); if the alternative(s) did not meet the mode share goals, then it would need to be revised, revamped, or replaced until it did.

The pressure to meet modal targets forced Ottawa area planners to confront the limitations of a surface-based transit system; clearly, some form of rapid transit would be needed, and for transit to be rapid, it would need to be grade-separated. Ottawa was at this time operating express buses on freeways, so there

was some appreciation of the costs and benefits of higher-speed transit operations.

Ottawa originally conceived of its "transitways" as mode-undefined grade-separated corridors that linked downtown with other principal destinations and that offered access to a large share of the bedroom communities in the region. These transitways were evaluated in terms of costs, ease of construction (regardless of mode), ability to serve land uses, and connection with other alignments, without reference to any particular technology As such, these transitways were conceived as mode-neutral; they could be either light rail or busway corridors.

Ottawa planners, when looking at transitways from a bus perspective, understood from the start that the transitways could support a range of services; the fact that they already operated multiple service types (feeder, mainline, express, and limited stop routes) meant they already had a more nuanced understanding of the behavior of such service types. More to the point, they also recognized that a grade-separated Quickway infrastructure would favor a restructuring of the entire transit system into an integrated network of services.

The alternatives analysis performed by Ottawa planners was undertaken at the *system level*, in which an optimized light rail-based transitway system was compared against an optimized bus-based system. This study determined that the bus-based system would have a large set of advantages over a rail-based system:

1. It would be cheaper to both build and operate;
2. It met mode share objectives more effectively than LRT, primarily because of the reduced need for transfers on the bus network;
3. It was stageable, meaning both that the benefits of investment could be spread around the region (a political reality) and that the system could be implemented much sooner, as transit services could operate over existing roadways while dedicated infrastructure was being built on a prioritized, as-needed basis; and
4. It offered riders a higher level of service, with shorter wait times and more express choices.

3.1.2 Transitway: Strategic Elements

The elements that make up Ottawa's Transitway system were, generally speaking, not copied from other cities, but evolved out of Ottawa's need to achieve certain targets and goals. They set the pattern that would be picked up later by Brisbane with its Busway system.

Running Ways. While Ottawa's transitways were originally conceived as mode-neutral, the system-wide alternatives analysis recommended that the transitways be configured to serve a bus-based system. Thus was the Transitway—the name formally adopted for the infrastructure—born. The first sections opened in 1983; by 2004 some 28 miles of Transitway had been constructed, and plans continue to call for further expansion of the system.

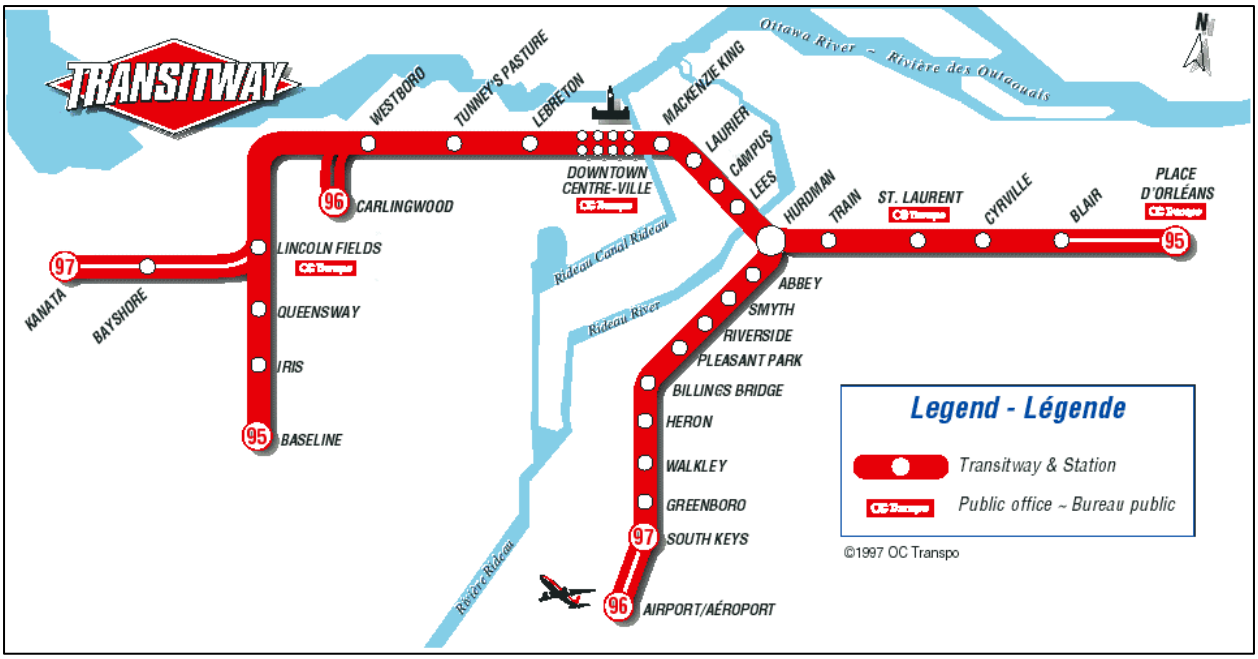

Figure 3.1
Map of Transitway corridors.

Ottawa's Transitways were designed to be compatible with both rail and bus technologies, in terms of basic geometries. However, these geometries were not optimized for light rail (in constrained environments), as doing so would have imposed significant additional construction costs on the system.

The Transitways do not continue through Ottawa's downtown. Rather, buses travel along transit lanes on surface streets (Figure 3.3). This routing followed the strategic decision to not attempt grade-separation through the downtown given the very significant costs involved. A downtown twin-bore tunnel plan was developed, however, to demonstrate the feasibility and identify the costs and issues involved in creating such grade-separation. This tunnel plan assumed traditional diesel bus operations; should Ottawa decide to revisit the bus tunnel concept, some cost savings might accrue should the tunnel be redesigned for hybrid electric vehicles (given the potential for operation in electric mode through a tunnel).

Figure 3.2
Bus leaving station along Transitway. Note access ramp ahead of bus on right.

Concerns about bus volumes downtown have played a role in Ottawa's recent interest in developing light rail infrastructure. A starter light rail line (using self-propelled units) of approximately five miles along an existing rail track was inaugurated in 2001. More recently, a more detailed plan for light rail expansion

was first abandoned then readopted; meanwhile, the completion of the Transitway network remains a regional priority.[14]

Ottawa's Transitways are generally designed to support bus operations of 45-50 mph between stations and 30 mph within stations. Stations are spaced at approximately one mile intervals.

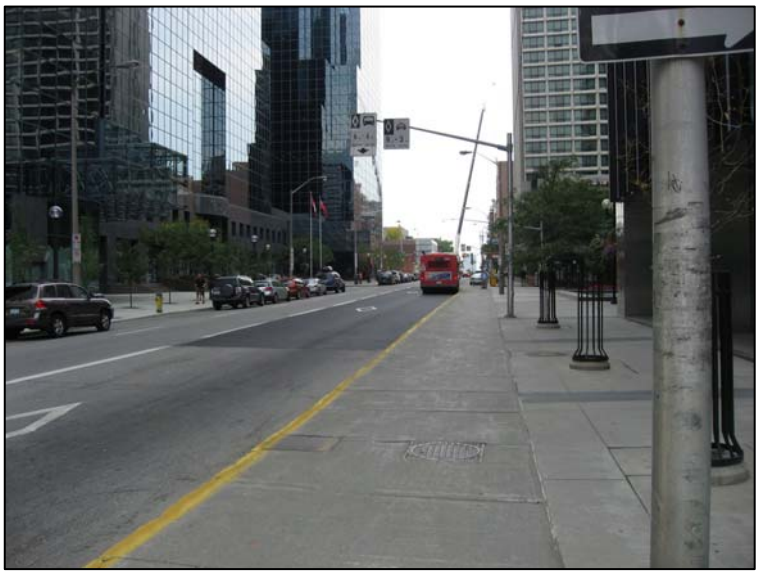

Figure 3.3
Bus in transit lane through Ottawa's downtown.

Stations. Ottawa's Transitway strategy emphasized the importance of both running ways and stations in terms of implementing a vision of rapid transit. Planners report that they understood that stations needed to be special, that they needed to be the equivalent of a light rail station. In this sense, the choice of buses for the Transitway was not viewed as a *cost-cutting* move, but as more *cost-efficient* than a rail alternative. There would still be equal attention to the quality of infrastructure.

Though original plans for stations proved too ambitious, the OC Transpo Board rejected the revised station concepts as second-class; political support for quality stations was strong, as it was understood that stations would project the system's image in the community.

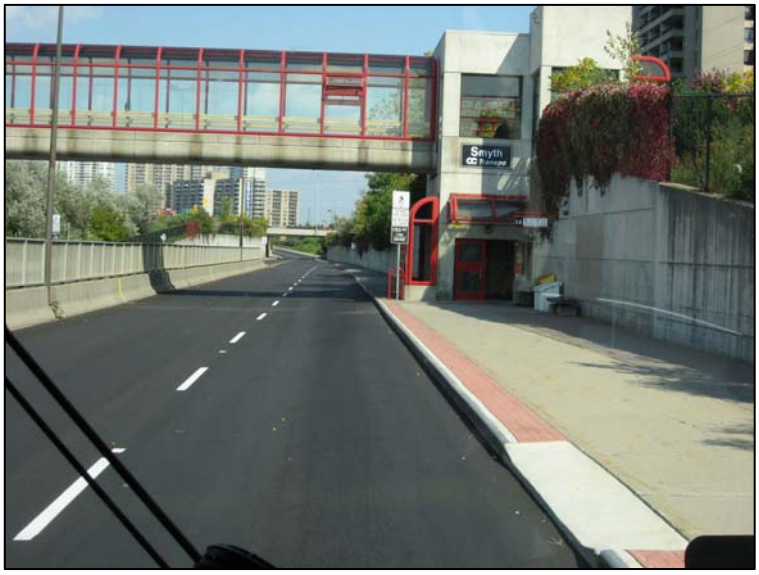

Figure 3.4
Minimal Station on Transitway.

Stations on the Transitway are designed with Ottawa's frigid winter climate in mind. They feature a significant degree of enclosure to protect waiting passengers from the harsh elements, and feature common design elements (red metal, glass, and raw concrete form the primary palette). Stations vary in size depending on passenger demand.

Vehicles. Ottawa's Transitway was conceived as an infrastructure that would permit the more efficient operation of the existing transit fleet. As such, no special vehicles were anticipated. Over time, passenger volumes led to the addition of articulated, low-floor buses to the fleet. Though not all of these operate on the Transitway, they all share certain operational policies, which are discussed under the heading of Fare Collection.

One other factor that led Ottawa planners to discount the role of specialty vehicles (or a special livery for Transitway services) was the general lack of stigma attached to the bus. Transit ridership in Ottawa traditionally attracted a range of users from most socio-economic groups; hence, it was not viewed as necessary to *distinguish* BRT services (that is, services enjoying the advantages of the Quickway infrastructure) from other transit services. Then, too, a large share of routes, and virtually all buses at some point, use at least some part of the Transitway infrastructure, diluting the potential impact of vehicle branding.

Figure 3.5
Major station along Transitway.

Intelligent Transportation Systems. Ottawa makes use of real-time service control and passenger information systems; however, neither is central to Transitway operations. Service control technology is useful at a network level to improve and monitor bus operations as a whole, but is not specific per se to the Transitway. Passenger information systems are seen as useful to customers, particularly for lower-frequency express routes that use the Transitway. Other routes are so frequent—some feature two- or three-minute headways—that live information is of little consequence.

Fare Collection. Ottawa has typically relied on traditional fare collection strategies (farebox and passes). However, interest in reducing vehicle dwell times at stations led to the adoption of a policy for articulated buses that permits holders of prepaid fare media to board through any of the doors on the vehicle (through the honor system); only those paying the driver are required to board through the front door. It is reported that boarding time has, as a result, been reduced to an average of one second per passenger on 3-door articulated buses. The policy on multiple-door boarding applies to articulated vehicles anywhere they travel, including routes off the Transitway.

Figure 3.6
Articulated bus at Transitway station.

Transitway stations do not currently feature fare machines.

Service Patterns. OC Transpo, the agency responsible for bus operations (and for the operation of the Transitway and O-Train systems), operates four kinds of service on (and off) the Transitway system.

- *BRT Spine Services* are all-stops routes that run entirely on the Transitways, providing a very high-frequency core "Light Rail Lite" service (but at much higher frequencies than would be typical for most light rail systems). Four such routes—the 94, 95, 96, and 97—connect different corridors with the downtown spine.
- *Mainline routes* travel across the region and may use portions of the Transitway for part of their route. An example would be the 101 and 102.
- *Local feeder buses* connect neighborhoods with Transitway stations. Some offer connecting service in non-peak hours (during peak hours, Express services operate as local feeders, then continue through the Transitway to or from downtown), whereas others operate all day.

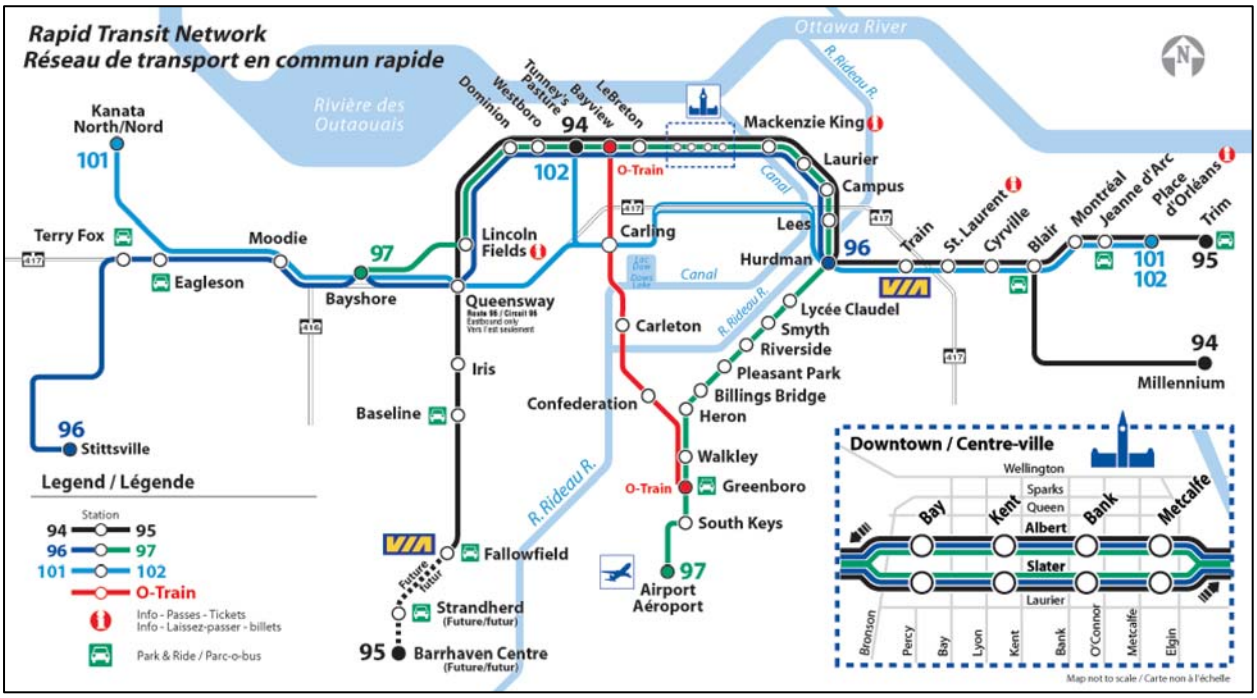

Figure 3.7 Ottawa Rapid Transit Network showing Transitway spine services (94, 95, 96, and 97), two mainline routes (101 and 102), and the O-Train light rail.

- *Express and Limited Stop services* are the fourth kind of service using the Transitways. Express services target the outer parts of the region; they begin at the periphery as a local bus in feeder mode until they reach the entry Transitway station, then operate mostly nonstop until they reach downtown Ottawa; they then mostly travel through the other side of downtown to serve other corridors. Limited Stop services serve closer-in neighborhoods; they behave like Express services, except they are more likely to stop at more stations along the Busway, given the greater likelihood of people traveling the shorter distances to these stations.

Ottawa makes extensive use of interlining to maximize service efficiencies. The Quickway infrastructure of the Transitway makes it feasible to do extensive interlining, as travel time among points along the infrastructure is minimal.

Identity and Branding. Given the importance of the Transitway in meeting numerical mode split targets, attention was paid to station design and to the

branding of the overall infrastructure. As such, it is the Transitway that is branded, not the buses using it or the particular services that operate through it.

It is worth observing that OC Transpo in recent years seems to have been pulling back from promoting Transitway as a brand; with the inclusion of the light rail O-Train in the mix, OC Transpo (see, for example, figure 3.7, the rapid transit network map) has described the "Rapid Transit Network" in which the O-Train is specifically identified but the Transitways are not. This may have been in response to political pressure to promote a light rail plan for the region.

Figure 3.8
Transitway logo.

3.1.3 Ottawa and the Quickway Model

Ottawa represents the birthplace of the Quickway model, in that the key elements of that model came together with the Transitway project:

1. The development of a network of mostly- or entirely-grade separated rights-of-way designed to directly target key destinations, provide access to a large number of residential zones, and minimize travel times among these various origins and destinations;
2. The elaboration of a service plan that include both Light Rail Lite elements (a spine service and feeders) and Quickway-specific services (branching express and limited-stop services, as well as right-of-way to support mainline cross haul services), much of which has been optimized through interlining to reduce overall system operation costs;
3. A focus on developing significant stations, which were seen from the start as projecting the image of the infrastructure (and its many services) to the communities, and which were designed as rapid transit facilities (as opposed to glorified bus stops) with significant passenger amenity;
4. A staged infrastructure development plan that allowed services to be implemented before the completion of the underlying Quickway infrastructure, and which in fact was able mostly to target elements and pieces of infrastructure where and when they would produce the greatest network benefits; and
5. Continued elaboration and refinement of the original service plan, matching capacity and routes to actual travel demand.

The combination of fixed infrastructure but variable service plan has been identified as one of the major strengths of Ottawa's approach, particularly in terms of its impact on transit-oriented development:

> One of the major advantages of a busway compared to an LRT system is that it gives the benefits of a *fixed* infrastructure without the drawbacks of a fixed guideway. The presence of a fixed rapid transit infrastructure gives developers and the public the confidence that a

> high level of service will be always be provided to the stations, so that stations can act as a catalyst for promoting transit-friendly patterns of development. The lack of a fixed guideway allows incredible flexibility of operation. The new Transitway station at Place d'Orleans is a prime example of how a busway station will be able to influence growth decades before a separated right-of-way is built to it.[15]

The success of Ottawa's strategy—as a strategy—is made clear by transit mode splits in the region. Ottawa ranks first among similar-sized cities in North America in transit mode split (20.1%), placing it ahead of Canadian cities such as Calgary (13.2%) and Vancouver (11.5%).[16] Actual Transitway bus ridership is approximately 200,000 trips/day, with peak loading of 10,000 passengers per hour at the peak locations in the peak direction.[17]

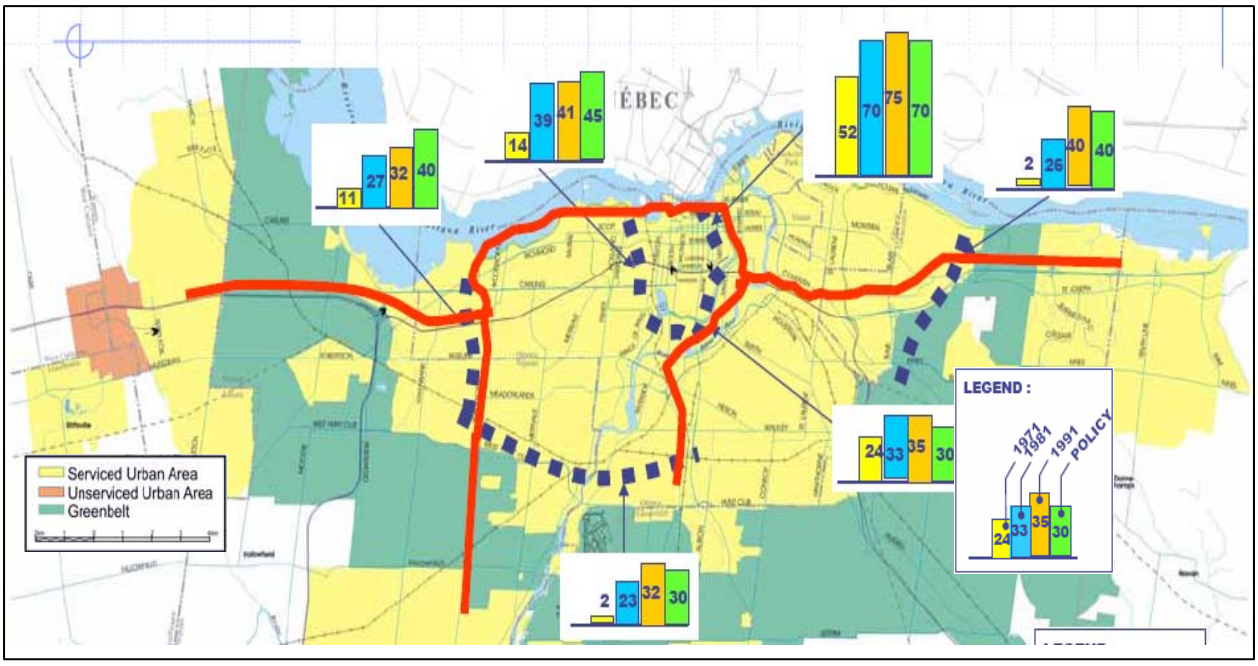

Figure 3.9
Targeted vs. actual transit mode split at screenlines.
Source: John Bonsall

Ottawa is also facing major challenges with its Transitway system, principal of which is the impact of surface bus operations through the downtown. This "weak link" in the system has spurred wholesale questioning of the entire system and has led to political calls for its replacement by light rail (though no published technical studies have demonstrated the cost effectiveness or positive ridership impacts of such a replacement). It may also be worth asking whether the stations, though clearly designed to a standard superior to that of many other transit facilities, are perceived as desirable by users and potential users of the transit system (passengers are still exposed to potentially harsh weather when accessing vehicles, and the hard materials, such as exposed concrete, do little to create a warm and welcoming environment).

Though Ottawa's is often cited as an example of a successful transit project (let alone successful transit strategy), few cities have attempted to copy Ottawa's approach to developing a Quickway network. Indeed, the primary example globally to date is Brisbane, though a BRT network for suburban Toronto is being planned which generally follows the Quickway model. The question as to why this model has not been more widely replicated or studied for application, particularly in the United States, will follow a review of BRT projects in the U.S.

3.2 Bogotá, Colombia: TransMilenio

3.2.1 TransMilenio: Background

Bogotá is the capital of the Republic of Colombia and its largest city, with a population that varying estimates place close to eight million residents, with significant in-migration from the rest of the country. Bogotá is justly famous for its BRT system, TransMilenio, which was the subject of an extensive technical study, published in 2006 by the National Bus Rapid Transit Institute, which reviewed the applicability of the TransMilenio experience to the United States.[18] Rather than repeat the information contained in that report, the current study will focus on TransMilenio as an expression of a *model* of BRT planning rather than as merely a set of choices along a continuum of BRT elements. That is to say, it is not just that TransMilenio represents an appropriate set of choices, but that some of these choices *determined* what TransMilenio could *achieve* as a BRT system.

3.2.2 TransMilenio: Strategic Elements

The *elements* that together make up TransMilenio have been effectively catalogued. They are recapped here in brief form in order to highlight aspects relevant to the Quickway model.[19]

Running Ways. TransMilenio is actually composed of two separate networks of service that interface only at terminal stations: a *feeder* network, composed primarily of transit buses that operate in mixed traffic at the periphery of the metro area and that deliver passengers to one of the system's seven terminal stations (and a small set of in-line stations); and the *mainline* network, which is served by specialty articulated transit vehicles operating exclusively in dedicated busways which to date have been built in over half a dozen corridors. These busways, which depending on the corridor may be at grade or extensively grade-separated, are composed of either one or two transit travel lanes per direction; in cases where only a single travel lane is provided, passing lanes are nonetheless provided at stations.

It is worth noting that grade separation plays only a partial role in the system, found primarily in those corridors that are built within major express roads. Just the same, other corridors nevertheless mostly feature limited grade crossings, conferring at least some of the benefits of grade separation and providing significant travel time benefits.

It is also worth noting that the mainline (trunk) network of TransMilenio may be characterized as both a "closed" system (meaning that only designated operators may use the infrastructure for specific routes) and an "internalized" system, meaning that all trunk transit services operate internally to the infrastructure (guideways). Red mainline TransMilenio buses do not operate outside of busways specially developed for them; in contrast, the green feeder buses operate entirely *outside* of the busway infrastructure, except at the transfer stations. This stands in contrast to *externalized* systems such as Brisbane's (which will be discussed shortly) and Ottawa's.

Figure 3.10
Grade-separated interchange at juncture of two TransMilenio corridors.

Stations. Stations along the TransMilenio system are, generally speaking, in median locations, with vehicle doors opening on the left. Much like Curitiba's famed BRT system, stations have automated sliding glass doors which are activated by the bus driver along with bus doors. Fare prepayment (using proof-of-payment entry) and level boarding together help minimize dwell times.

Stations have designated platforms, with specific routes assigned to specific platforms on a permanent basis.

Stations are built using a modular architecture. A typical module has two bus platforms on either side. Stations that require more platforms employ additional modules, separated from the other modules with sufficient space for buses to be able to merge to the station lane from an outer lane and dock level with the station; the modules are bridged, so that passengers may easily walk from one set of platforms to another. Because within station modules the two bus platforms are closely spaced, buses seeking to access the second platform must first clear the first platform, which may be occupied by another bus. As a result, TransMilenio planners report that the second platform within each module only gives approximately a 30% capacity boost to the module. A single-platform module has a capacity for 60 buses an hour per direction; with two platforms, that increases to about 80.

Figure 3.11
Grade-separation along TransMilenio corridor.

A key feature of stations is their spacing. Like Curitiba's "Surface

Subway" system, TransMilenio spaces its stations, as a general rule, every 500 meters, or just under 1/3 mile. The reasons for such spacing are described as practical: prior to TransMilenio, the custom among bus riders in Bogotá was (and still is) to flag down buses at any point along their routes; the custom of walking along an arterial to access a bus stop was not well-established. Planners of TransMilenio decided on 500 meters as the preferred station spacing through little more than the educated guess that people would not be willing to walk more than about 3 minutes (250 meters) to get to a station once they reached a major arterial.

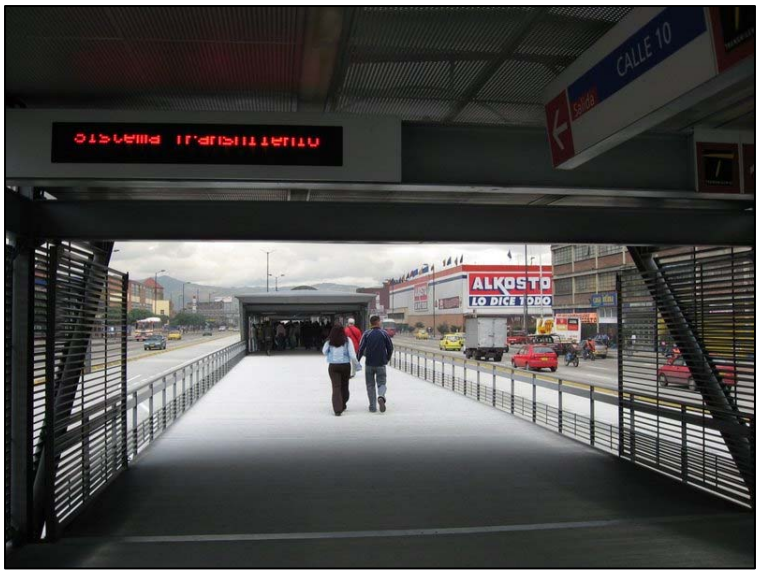

Figure 3.12
"Bridge" section connecting two modules of a TransMilenio station. Separated modules allow for buses to align themselves to station platforms for level boarding.

The concern with customer behavior was also reflected in the decision to use high-floor level-boarding, as opposed to low-floor, buses. With a low-floor system, planners were concerned that passengers would still attempt to flag down buses between stations in an attempt to board; with level-boarding from high-platform stations, passengers would instinctively understand the need to board vehicles at stations. Such concerns, though they may seem anachronistic today, were well-founded, as TransMilenio was preceded by a busway in which many of these problems emerged.

Phase III of TransMilenio expansion, which was launched in November, 2006, will include the development of an underground "Central Station" at a point in which principal corridors meet up. This station will feature tunnel access from the different corridors (grade separation) and a massive "Transit-Oriented Development" project built on top of the station.

Vehicles. The mainline network of TransMilenio is operated entirely by specially-designed high-floored level-boarding articulated buses. The choice of these buses followed an economic analysis which compared capital, operating, and maintenance costs, as well as capacity, of such buses with the biarticulated buses used in Curitiba and other Brazilian cities. This analysis purportedly demonstrated that articulated buses would be sufficient to meet capacity needs at

Figure 3.13
Underground walkway leading to station. Since most TransMilenio stations are located in the medians of major arterials, grade-separated crossways are required to handle the sheer volume of pedestrian movements, which would otherwise severely impact road operations.

an overall lower cost than biarticulated vehicles, at least for quite a number of years. Should demand continue to rise in the busiest corridor, even with the opening in Phase III of a parallel corridor, then the issue of biarticulated vehicles may be reviewed anew.

Intelligent Transportation Systems. ITS systems play an important role in the management of the TransMilenio system. While traffic signals at intersections along trunk corridors have optimized timing for signal progression, the sheer volume and frequency of buses preclude the use of signal priority with any degree of effectiveness.

Fare Collection. TransMilenio relies on fare prepayment, using contact-less smartcard technology, in order to simplify fare collection and speed boardings at stations. All stations feature barriers and require payment prior to entry.

Service Patterns. The service plan for TransMilenio is one of its outstanding features and indeed represents arguably the greatest innovation in the service. The service plan has permitted some corridors on the TransMilenio system to move passenger loads normally thought of as the exclusive domain of heavy rail systems, and several *times* more than is observed in the most heavily utilized light rail systems in North America.

The service plan for Bogotá was initially inspired by that of Curitiba. Curitiba's RIT (Integrated Transport Network as rendered in Portuguese) system featured BRT corridors which operated only all-stop service (essentially, the Light Rail Lite model) using bi-articulated buses stopping at stations generally spaced every 500 meters. At varying distances, generally 3-5 km., major transfer facilities, known as Integration Terminals (Figure 3.15), were located. The BRT network operated in five radial corridors, supplemented by a network of Speedy buses (the *ligeirinhos*) which connected the Integration Terminals with a generally non-stop service operating in mixed traffic (much of it along a network of one-way express roads); major trip generators off-corridor were also served by the Speedy network which, like the BRT lines, used modular "boarding tubes" for stations. As the system further developed, Speedy routes were extended to additional places, tying in certain neighborhoods into the "rapid" component of the rapid transit system.

Figure 3.14
TransMilenio bus. The use of level-boarding high-floor buses precludes boarding between stations—a strategic decision that was successful in shaping passenger behavior.

According to TransMilenio planners, the initial concept for Bogotá was to largely import the Curitiba service plan and apply it to Bogotá. However, planners reached a major hurdle in that sufficient land did not exist for integration terminals in Bogotá, or, more to the point, creating such terminals at an appropriate scale would have required excessive rebuilding of the major through-roads within which TransMilenio busways were built (unlike Curitiba, which generally relied on a "trinary" road system for its major corridors, pushing major

traffic flows to two "outer" roads, Bogotá's busways were located within the major traffic arterials), at tremendous expense and disruption. As a result, planners were forced to consider how else to provide an express network in the absence of major transfer facilities.

The breakthrough in planning seems to have occurred when it became obvious that demand for service would be enough to support express services connecting different groups of stations. An extensive origin/destination survey along the key corridors was conducted, and the result of this exercise was the identification not of a single set of parallel express routes, but of a network of express routes, each linking a group of stations that the O/D analysis had identified as generating sufficient demand for such services.

Figure 3.15 "Integration Terminal" or transfer center in Curitiba. These terminals typically cover an entire city block and feature extensive passenger facilities for BRT and local buses in addition to a range of retail shops.

The power of this express network becomes apparent when one considers that both all-stops and express services were devised that "turn the corner" from one corridor to another, permitting travel along different corridors without the need for transfer.

In the network map (Figure 3.16) representing the system as it was approximately 3-4 years into service, it becomes obvious that between any two stations, there may be multiple options for making the trip. As an example, for travel between the *Calle 57* station on Avenida Caracas and the *Escuela Militar* station on Calle 80, one could ride the No. 1 All-stops, stopping at five intervening stations (but avoiding a transfer at *Calle 76*), or one could ride the Express No. 40, making only one intervening stop (and also avoiding a transfer). For travel between the *Tercer Milenio* station along Avenida Caracas and *Minuto de Dios* along Calle 80, it's more complicated; one may take the No.1 and make 20 intervening stops, or one can take the Express No. 30 five stops to *Calle 72*, then transfer to the Express No. 20 for a nonstop run to *Minuto de Dios*.

This combination of express and local services, some branching, was the key to providing the capacity required within the limitations of the infrastructure. According to planners, origin/destination data is collected and reviewed three times a year, and express routes adjusted, based on observed demand among different groups of stations.

Figure 3.16 TransMilenio network map ca. 2003, announcing "new map, new services." All-stop routes are indicated by colored lines, whereas express routes are implied by alternative gray lines.

Yet even this attention to moving passengers off all-stops service and onto express services was still insufficient to meet increasing passenger demand. As a result, a Super-Express service was initiated, providing a one-way service in the peak direction during the peak hours (and in one case, all-day). These routes are designed to transport people from the terminal stations to the central employment corridor along Avenida Caracas in the heart of the city, a primary destination for most passengers, without stopping at any intervening stations. In order to free up capacity for people boarding at non-terminal stations (*within* the actual corridors), some Express routes were redesigned so that they begin or end not at the terminal station but at the penultimate station (and hence do not fill up immediately), channeling passengers at the terminal stations thereby onto the more efficient Super Express routes.

As of the most recent major route restructuring (April 2006), the total number of Express and Super-Express routes was 55, of which 26 are symmetrical (two-way operation) and 29 asymmetrical (generally, one-way service).

Though the TransMilenio system is designed to reduce the need for transfers, planners estimate that up to 50% of TransMilenio's riders use feeder buses to access the system, with 60% of all riders boarding at one of the terminal (portal) stations. Though on the one hand this illustrates the limitations of a system that by itself does not reach into the far suburbs where large numbers of lower-income households are located, it also illustrates a fact of the system that is commonly repeated among not just local planners but people "on the street" in

Figure 3.17
Following the completion of Phase II of TransMilenio expansion in 2006, multiple corridors are now in operation. The service map, though, is unable to illustrate the routes operating on the infrastructure, such is the current complexity of the system.

Bogotá: TransMilenio has improved access to better-paying jobs for lower income residents of the city's periphery.

Approximately 70% of all demand is generated by the central section of the city (where much employment is concentrated), namely the Avenida Caracas corridor between *Calle 100* and *Tercer Milenio*. Even with the extensive network of express and branching services, about 28% of all trips on TransMilenio involve a transfer.[20]

Identity and Branding. TransMilenio employs a distinct logo which is used on promotional materials, buses, and stations, though in common practice, the red TransMilenio vehicles stand out and are visually distinct from other buses (the green feeder buses less so). Of greater interest, the author, in his two visits to Bogotá and in discussions with *Bogotanos* both within and outside Colombia, has never heard anyone refer to TransMilenio as "the bus"; it was always referred to as the *TransMilenio*.

It is worth noting that, in contrast to both the Ottawa and Brisbane models, the TransMilenio *identity*, which certainly applies to stations, is mostly visible as relates to vehicles. This is a stronger possibility with internalized systems. It is also worth noting that, even though significant right-of-way is devoted to TransMilenio, that right-of-way is not itself the focus of specific brand-related imagery or identity, perhaps in great part because it is generally located within existing roadways.

Figure 3.18
TransMilenio pylon at Calle 19 station.

3.2.3 TransMilenio and the Quickway Model

In the introduction to this report, it was suggested that BRT systems were outgrowths of one of two distinct visions or core strategies: a "Quickway" model that emphasized the development of infrastructure in order to support a network of services, and a "Light Rail Lite" model that emphasized the emulation of a light rail-like service using buses (one would guess, primarily, on cost grounds). While Bogotá clearly has elements of both—its implementation of a core "Light Rail Lite" service ranks among the most successful and copied examples of its kind (for example, Indonesia's TransJakarta busways are based almost entirely on this aspect of the Bogotá system, as are the BRT systems implemented in Mexico City and the Mexican city of Leon)—it will be argued here that Bogotá's implementation of Quickway concepts is at least as important to the success of the system and its ability to move passenger volumes normally seen only on the busiest metro systems. In fact, TransMilenio "backed into" a Quickway model as it was forced to deal with meeting capacity targets far in excess of anything that the Light Rail Lite (or, for that matter, LRT) model could achieve.

Bogotá has devoted considerable resources to developing the T-Way and Quickway infrastructure of TransMilenio. While grade separation is generally a function of the arterial on which it operates (for example, the Autopista Norte enjoys full grade separation, whereas some other corridors have only infrequent at-grade crossings), some grade separation is being built, at considerable expense, in the core of the system (to create a Central Station) and at certain major intersections. More to the point, Bogotá has attempted to mitigate where feasible the lack of complete grade separation through strategies that minimize dwell times, optimize traffic signals, and by providing passing lanes either along the length of the busway or at least by stations, in addition to designing modular stations that permit at least some segment of buses to enter and leave their platforms directly.

On the service end, Bogotá has realized that express overlays are the key to moving large volumes of people. Whereas the T-Ways of Curitiba are limited to moving approximately 12-13,000 passengers an hour in the peak direction at the peak location, Bogotá is routinely moving well over 40,000 passengers. The key not just to moving these passenger flows, but doing so economically, is an express network that permits vehicles to produce more round trips per service hour through shorter end-to-end travel times. Since service planning follows demand, it also follows that routes will turn from one corridor onto another, without forcing the transfer, if demand warrants.

Bogotá represents the implementation of Quickway concepts within an i*nternalized* system and may justifiably be considered an example of Global Best Practice; of equal importance, and the subject of the next section, is an example of an *externalized* system: Brisbane's Busway system.

3.3 Brisbane, Queensland, Australia: Busway

Brisbane is the capital of the Australian state of Queensland and is the home of approximately 1.6 million residents in a metro area of approximately 2.25 million residents. It is the fastest growing region in Australia, with an expanding economy and major investments underway in preparing the region to be more globally competitive in the future.[21]

One of the central features of Brisbane's current growth is its development of a network of grade-separated Quickways, known simply as the Busway. In its development of its Quickways, Brisbane demonstrates the predominance of the *infrastructure-oriented* strategy over the *service-oriented* strategy for BRT development—namely, that it was concerned first and foremost with creating an infrastructure that could then be used in ways partially unforeseen, as opposed to the *service-oriented* strategy which assumes the development of a particular route, and then seeks how to best "right size" the investment needed to produce that route.

Brisbane has been served for many decades by a legacy electrified commuter rail system. This system is configured in some respects more like light rail, in that stations are relatively closely spaced (perhaps every mile). The State, through Queensland Railroads, operates this Citytrain network, with a well-established institutional and bureaucratic structure. Four corridors radiate out of the CBD, which then split into seven primary corridors.

Absolute data on system ridership is hard to obtain, as it is not available publicly, but anecdotal evidence suggests that the system is well-used, particularly by commuters to downtown employment as well as those going to other activities. Still, Brisbane transit planners noted that, while the trains seemed to serve the areas surrounding stations fairly well, they were struggling to attract a larger set of riders from zones between rail lines. They also noted that the size of these "wedges" grew as one left downtown, with large areas of the city essentially without effective (or time-competitive) access to the rail system. They further noted that, though the rail system enjoyed full grade separation through the core of Brisbane (operating mostly through a subway in the CBD and the adjacent urban neighborhood of

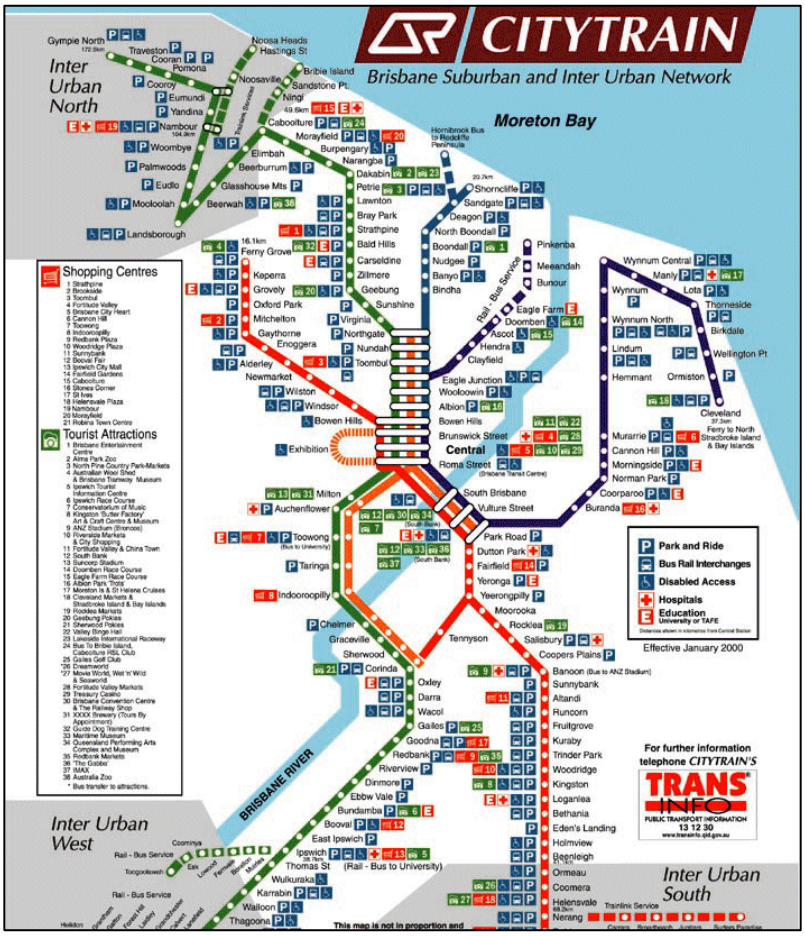

Figure 3.19
Brisbane's Citytrain operates an extensive electrified commuter rail service that runs through a subway in the central core.

Fortitude Valley), stations were not necessarily within comfortable walking distance (during Brisbane's tropical summers, even short walks can be taxing) of many of the job sites.

The inspiration for the Busway system is largely credited to former Lord Mayor Jim Soorley, who apparently was looking for means to help transform Brisbane from a somewhat sleepy and unsophisticated town into a truly competitive city. A private bus operator who had toured Ottawa's Transitway system shared his observations of the efficiencies of that system with the Lord Mayor, who saw in the concept something that could be implemented in a relatively short time (as opposed to working through the State bureaucracy) and that would accomplish his goal of providing more and better transit (Brisbane area planners note that the goal was always expressed in terms of transit, not in terms of any particular mode).

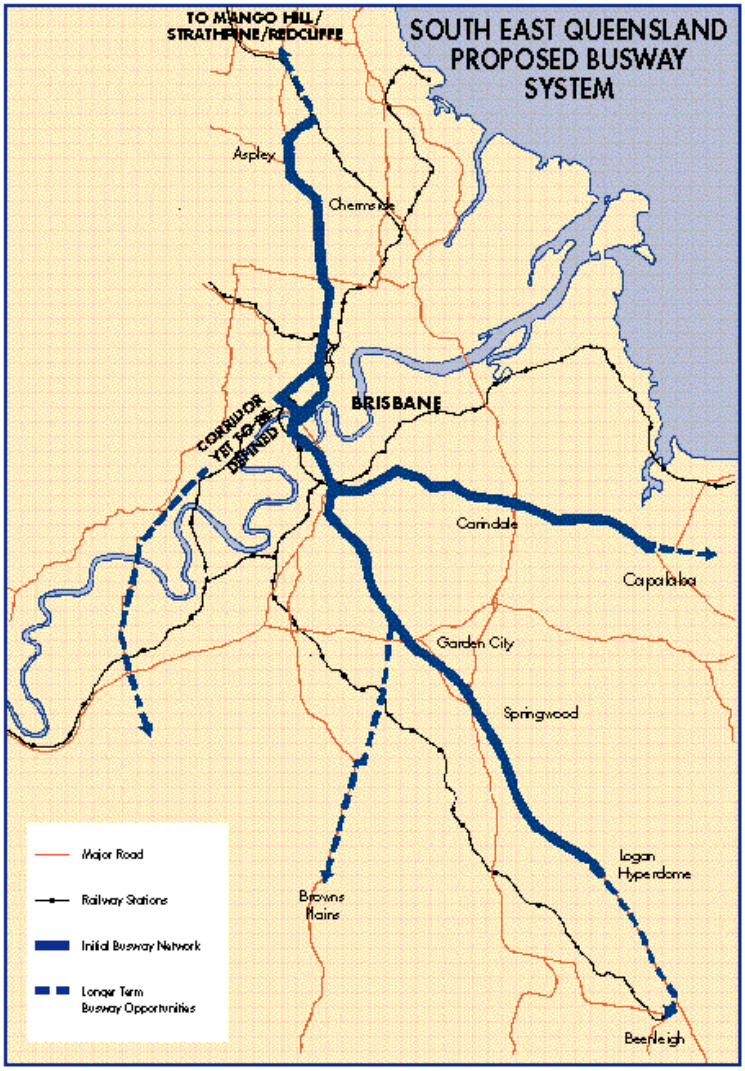

Figure 3.20
The original plan for Brisbane's Busway system was developed in the 1990s. Subsequent planning led to the addition of a western spur to the Eastern Busway crossing the river the University of Queensland Campus. The first Busway, the Southeast, was built from the core just past Garden City, with an off-Busway station in Springwood.

Though initial planning for the Brisbane busway network (it was conceived from the beginning as an infrastructure network comprised of four initial Quickways, with future expansion possibilities) was directly influenced by Ottawa's Transitways—the people who had been involved in developing Ottawa's system did the original planning on the Brisbane system—these plans began to change and evolve as they were applied to Brisbane's specific context.

There were a number of key differences between Brisbane and Ottawa which began to influence Quickway planning in Brisbane:

1. In Ottawa, the Transitways are the regional rapid transit system; in Brisbane, that role was played by the Citytrain network. The new busways would need to position themselves as competitive with—or even superior to—that network if they were to overcome any stigma from being bus-based.[22]
2. Brisbane already had an underground bus station built beneath the Queen Street pedestrian mall, the "heart" of the city; this infrastructure meant that busway services feeding the CBD could enjoy some degree of grade separation, as well as staging areas, in the heart of the CBD.

3. Ottawa had a fairly strong land planning regimen compared to Brisbane. Notions of closer transit/land use coordination had apparently been floated in Brisbane in the mid-90s, but attracted little political support. This paradoxically favored a Quickway-based approach to Brisbane's transport network: if it wasn't feasible to bring more people to transit infrastructure (via transit-oriented development), then a Quickway network made it easier to bring transit out to the zones where people already were.

Brisbane had also, prior to the development of the first Busway, developed a "two-tiered" bus network. The first tier was made up of traditional city bus service, with routes that generally extended as far as 10 km (6 miles) from the center. Transit planners recognized, however, that beyond this distance, this model of bus service generally broke down: land uses didn't favor close bus stop spacing, and excessive travel times along routes meant that few commuters were attracted to these routes from beyond the 10 km range.

Planners at first considered increasing bus stop spacing within the urbanized area (that is, the area within about 10 km of the city center), but realized the difficulty involved in removing bus stops that people had come to rely on (anyone who has attempted to remove bus stops and then dealt with public backlash will be familiar with the problem). The solution was to overlay a new kind of service, CityXpress, which was built around a service standard that called for bus stops in the periphery to be widely spaced (800-1000 km, or 0.5-0.6 miles); within the urbanized area, buses would stop only at selected bus stops spaced approximately every 2 km (about every mile and a half). CityXpress was generally an all-day service; "Rockets" were developed as a peak-only service that would serve the same outer-area stops as CityXpress, but would then travel directly into the CBD.

Figure 3.21
The emerging Southbank district, with the Southbank Parklands and Brisbane River, is now served by both rail and Busway stations.

The first of the Busways to be built was the Southeast Busway, which traversed four principal zones of the city:

- The Southbank district (Figure 3.21), which, following the development of the extensive Southbank Parklands, was emerging as a major urban neighborhood and regional recreational draw;
- The Mater Hill hospital district;
- The Woolloongabba cricket grounds (and surrounding zone); and

- The Southeast Motorway corridor, a mostly residential zone but with major educational and shopping facilities located along its length.

When the Southeast Busway was first under development, the service plan emphasized spine (all-stops) service, with various express and branching services mostly at the peak hour. Though such a plan was undoubtedly the most *efficient* use of bus resources, Brisbane planners opted for a more extensive plan, essentially rerouting existing CityXpress services so that they operated on the Busway. As one planner explained,[23]

> We took the view that the CityXpress services were full when they arrived at the Busway—so if you have a full bus, why on earth would you ask people to transfer to a new bus that does the same journey you'd otherwise do?

The performance of the Southeast Busway has exceeded even optimistic projections. Corridor ridership has gone up 124% overall since the opening of the facility, with even more impressive gains on Sunday (215%) and Saturday (176%), and the economic performance has been equally strong; planners believe that it exceeds 90% farebox recovery on the "premium" network (made up of CityXpress; "BUZ" routes, which are described below; and Rockets). Some routes are believed to generate a profit, which is then used to cross-subsidize the system (which include school services and relatively poorly performing "community routes").

One difficulty in identifying the actual cost performance of the system is the Byzantine funding structure employed by the State of Queensland. Funding for City bus services comes from TransLink, an arm of the State Government, but costs and revenues are functionally split. When the City of Brisbane wishes to implement a new set of services, for example, that together cost $14 million a year to operate, it must request from TransLink the *entire* (gross) cost of providing those services. Farebox revenues are returned to TransLink, but through a separate channel, divorced from the original funding request. This structure makes it difficult for both the City and the State to readily and systematically understand the cost effectiveness of individual routes and make adjustments accordingly; it may also limit the amount of new services developed, even if such services could actually produce an operating profit.

A related issue is the limited availability of new buses. Again, bus purchases are funded through a separate process, so rising demand for new services—which might otherwise convince state officials that investment in additional new buses is warranted—may not necessarily get acted upon in the fastest light. Officials from Brisbane were known to have been scouring Australia for additional buses; in the end, the State Government agreed to expand the capacity of the bus assembly plant in the state to help meet the demand for new vehicles.[24]

The opening of the Southeast Busway was notable in that it helped turn around what had been declining transit ridership in Brisbane; in the year before it opened, annual ridership had declined by 800,000 fares; after its first year of operations, annual regional ridership had climbed by 866,556, erasing the previ-

ous year's loss.[25] In the past three years, overall transit ridership city-wide has climbed between 30-40%, depending on the source cited, with annual growth rates ranging from 10-12%. Peak ridership on the Southeast Busway (peak hour/peak direction) is now reported at over 15,000 passengers, which is approximately 50% above the highest confirmable ridership observed on any light rail line in North America and close to the ridership on the busiest metro line in Washington, D.C.

Brisbane opened the Inner Northern Busway to service in 2006 and the Green Bridge (later renamed the Eleanor Schonell Bridge) in 2007. This bridge, which spans the Brisbane River, connects the University of Queensland main campus with what will be the Boggo Road Busway, a short extension of the planned Eastern Busway, branching off from the Southeast Busway just north of the Buranda station. An Inner Northern Connector, linking the Queen Street underground bus station with the Inner Northern Busway via the Roma Street Transportation Terminal, is under construction and should open for revenue service in 2008; the Boggo Road Busway between the Southeast Busway and the Green Bridge has been fast-tracked and should open by 2009, and preferred plans have been published for the Eastern and Northern Busways.

Figure 3.22
A section of the Inner Northern Busway running through a golf course. The screen structure is designed to prevent errant golf balls from interfering with bus operations.

It is of especial interest that, as the magnitude of the success of the Busway system is more fully appreciated, planning on the new Busways has moved in a new direction. When the Eastern and Northern Busways were given the green light to go into project development in 2002, they were roughly budgeted at $400 million Australian for both projects;[26] the latest plans, which have emerged as the *preferred* alternatives, are pegged at several times that amount, if not more. Design compromises that otherwise might have been made (for example, serious consideration was given to operating much of the Eastern Busway as a surface T-Way) have been jettisoned in favor of plans that rely extensively on tunneling to produce high-speed Quickways capable of significantly reducing transit travel times in their respective corridors, in addition to supporting a larger share of "transit-oriented development."

3.3.1 Brisbane's Busways: Strategic Elements

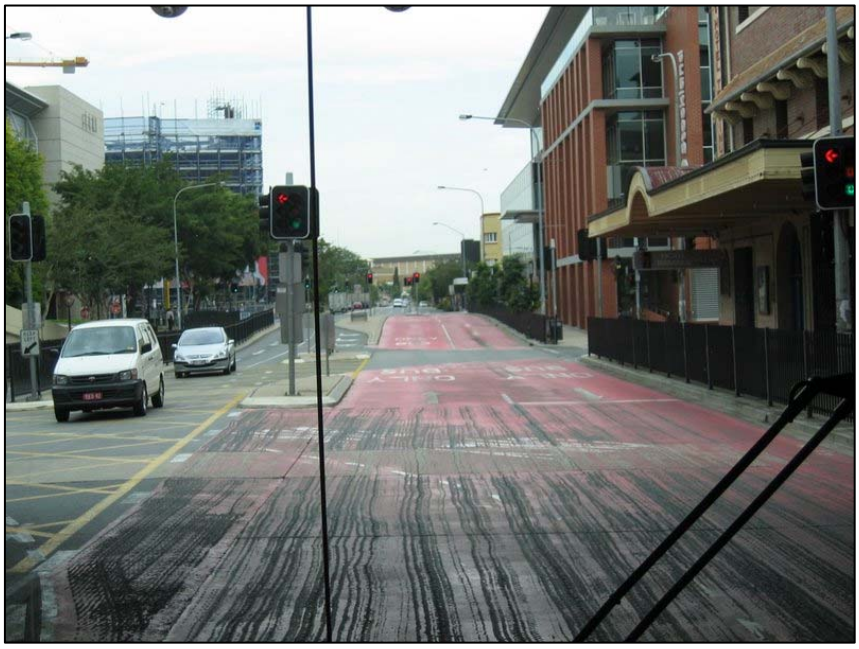

Figure 3.23
T-Way by entrance (off to left) to Southeast Busway.

Brisbane is, along with Ottawa, the classic example of the Quickway model in operation. More so than Ottawa, it has developed, and continues to develop, grade separated infrastructure in the central business district, and hence will serve as the most advanced example of this model for the foreseeable future.

Running Ways. At the heart of the Brisbane system are its Quickways, which operate fully grade-separated along their lengths. Currently, however, there is a gap between the terminus of the Southeast Busway at Melbourne Street in South Brisbane and the beginning of the Queen Street bus tunnel just east of William Street. Connecting the two is a T-Way section with one Busway station—the Cultural Center Station. Brisbane planners have discussed the possibility of replacing the current T-Way with a Quickway linkage, sending a bus-only bridge over the Brisbane River and building a new station at the Cultural Center to enable full grade-separation. To date, though, this plan has yet to be formally adopted or funded. Also, a modest middle segment of the proposed Eastern Busway is currently designated as a T-Way; even so, pedestrian crossings will be made in an overhead structure to minimize conflicts and maximize bus through-speeds.

Figure 3.24
Tunnel segment along the Southeast Busway. Planned new busways will rely heavily on tunneling to create full grade-separation.

Brisbane's Busways all are two lane roads with pull-off lanes at stations. They are designed to support 80 kph (50 mph) travel speeds, though there are reports that bus drivers have been able to exceed these speeds at certain points. The Southeast Busway, which runs for 16 km (10 miles), features approximately 1.6 km (1 mile) of underground sections (both bored and cut & cover tunnels) and about 2 km (1.25

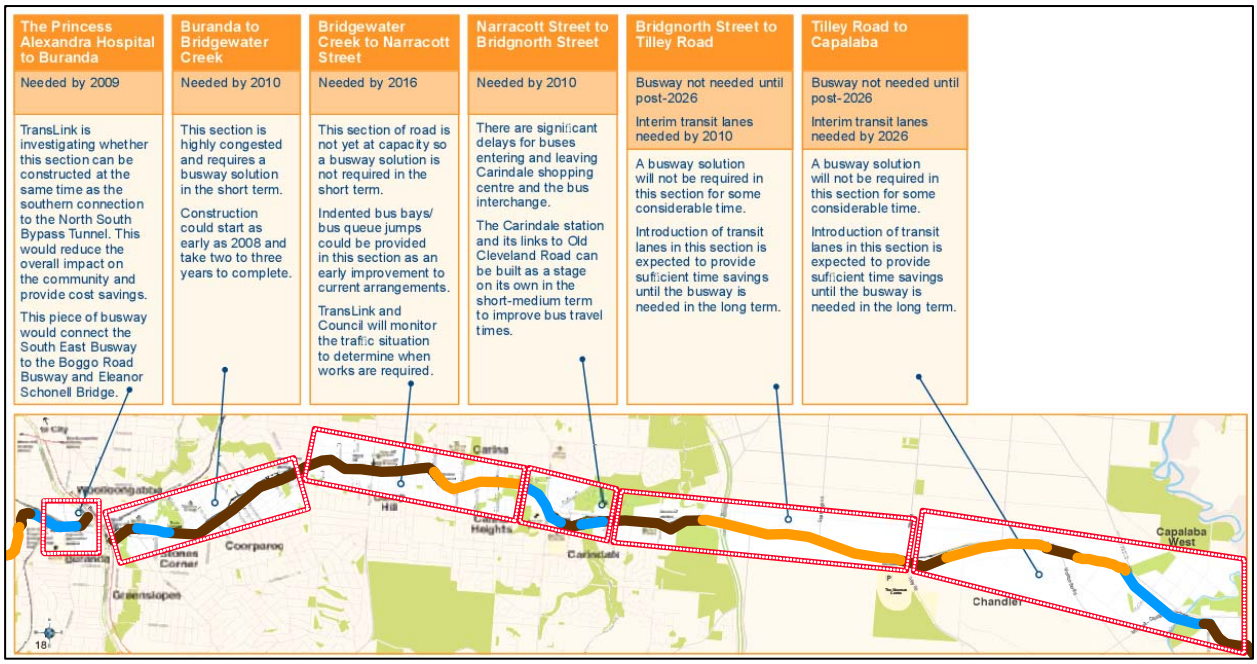

Figure 3.25
The staging plan for the Eastern Busway reflects the fact that not all pieces of infrastructure need to be built at once or even contiguously in order to provide effective Quickway-style service. In the case above, the target dates for segment completion reflect when such segments are fully warranted. In some cases, interim measures, such as at-grade bus lanes, can provide sufficient capacity and reliability for a number of years.

miles) of elevated or bridge sections. Travel time by express bus from the farthest station to the CBD is reported to be 18 minutes; travel by auto from the adjacent freeway is said to be about 40 minutes during the AM peak.

Though Brisbane has designed its Busways so that they *could* be converted to light rail should demand warrant, in practice the geometry of the busways is such that light rail would not be able operate at the same speed as the buses.

The Preferred Plan for the Eastern Busway calls for a facility that, at its western end (where it approaches and meets the Southeast Busway), is almost completely underground for the final 2-3 km. Though the cost of the entire Busway clearly exceeds the budget that had been allocated for it, analysis suggested that components of the facility would not be required until beyond the 20 year planning horizon that guides investments; in other words, rather than building the entire facility within the established budget (and needing to make major design compromises along the way), planners have instead suggested a staging plan in which different segments are constructed when warranted (Figure 3.25).

Brisbane's Busways are also used by emergency vehicles; it is not uncommon to see police or ambulances take advantage of the right-or-way when necessary. Busway planning stresses locating facilities so that emergency service facilities (for example, hospitals) are directly connected.

Given the tight tolerances to which the Busways are built—there are stretches with relatively narrow lanes and minimal shoulders—only professional drivers are allowed to operate on the facility, and then they must be specifically trained in using the Busway. Brisbane planners therefore report an unusually high reliability record, which is especially enviable given the number and length of tunnel segments in the system.

Figure 3.26
Typical station platform along Southeast Busway.

Stations. Sations are the most visible element of Brisbane's Busways, and are considered by planners as critical to the system's success. Typical stations feature linear platforms with four bus bays; platforms are generally 5 meters (16.4 feet) deep and 55 meters (181 feet) long, are screened on the sides and covered on top (Figure 3.26). High quality materials are in evidence throughout, as well as a high standard of design; Brisbane planners are proud to point to design details, such as flush bolts and recessed lighting, that add to the feeling of being a "first class" "rapid transit" station. Indeed, planners report that the overriding design goal was that of being perceived, not as a bus stop, but as a rapid transit station.

Figure 3.27
Original (left) and rebuilt (right) Cultural Center Station. In addition to providing passing lanes, the rebuilt station features improved platforms and shelters.

Most buses that enter stations stop at the lead stop, but when bus traffic is heavy, they may stop at any of the stops along the platforms. In practice, this likely induces at least some measure of rider anxiety (it did with the author), as riders seek to determine where they need to be to catch and board their desired bus.

Figure 3.28
Elevated walkway over Cultural Center Station, connecting the Cultural Center with the Brisbane Museum and Science Center. The elevators and walkway also serve an underground parking garage.

All stations along the Busways feature through lanes for express buses. When the system first opened, the Cultural Center station—which technically is not on one of Busways, but which links the Southeast Busway with the CBD—was built with a single lane in each direction, which had been expected to be sufficient over a multi-year time horizon; however, demand for transit services was so strong that the station became a choke point in the system (figure 3.27). Within five years of opening, the station needed to be rebuilt, colonizing right-of-way that had been previously reserved for a companion light rail (in streetcar mode) line that had been planned to connect the West End with the CBD and Fortitude Valley (this line has recently been authorized to begin development, though it is unclear how it will share right-of-way with the T-Way along Melbourne Street).

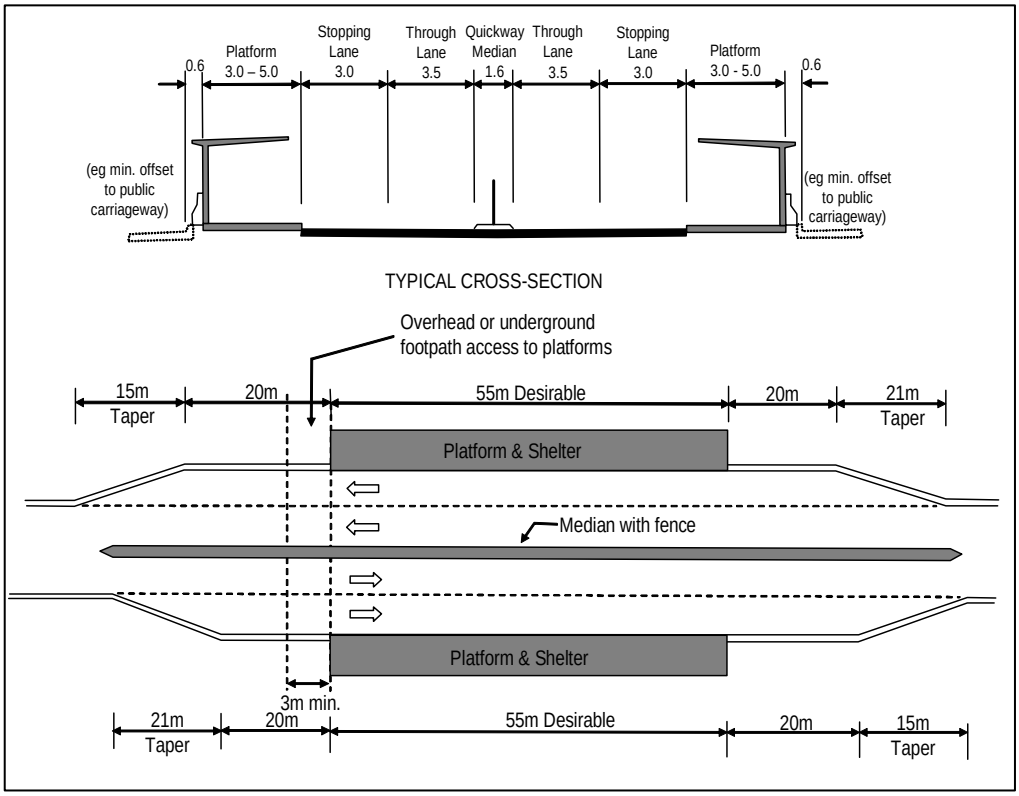

Figure 3.29
Typical Busway station schematic, showing approximate dimensions of the station (except for the stair/elevator towers) in meters.

The Cultural Center station also serves as an important "lynch pin" of the system; two-thirds of all buses in Brisbane pass through there, and it has become an important transfer site. The station also represents an especially fine example of transit/land use integration; a wide elevated walkway connects the station with the Brisbane Museum, Brisbane Science Center, and State Library on the north, and the Brisbane Cultural Center and Southbank parklands on the south (figure 3.28).

Figure 3.30
Standard architectural elements of Brisbane's Busway stations are the stair/elevator towers and the arched pedestrian bridges. These are provided even where other structures bridge the Busway, as can be seen in this photo. The deep, covered platforms also help give an architectural identity to stations.

Stations are barrier-free, and are monitored by closed-circuit video cameras.

Stations along most of the Busways feature a standard "corporate" architecture to give a consistent identity to the system (stations along the Inner Northern Busway, which were planned/designed by a different team than was involved with the Southeast, Northern, and Eastern Busways, are visibly different in architectural treatment). The most striking of the elements are the elevator/stair towers and arched pedestrian bridges found at most stations. For stations to be built along the Eastern Busway, the decision has been made to maintain the same corporate architecture, but permit variations in the color of materials so as to better blend into surrounding communities. Attention to station design is especially justified because, with so much of the proposed running way underground, sta-

Figure 3.31
The Cultural Center Station, following its remake in 2004.

tions become the most visible component of the Busway.

While the Queen Street underground bus station was conceived independently of and prior to the Busway system, it has nonetheless helped contribute to the perception and success of the system by providing a means for large numbers of buses to provide direct connections into a major transit hub in the heart of the CBD. While the design standards of this station were not as advanced as those later adopted for the Busway system, they still create a different experience than that of waiting for a bus on the street (figure 3.33). The Inner Northern Busway connector, currently under construction, will link this station underground with a new station adjacent to the Brisbane City Hall by King George Square and a retrofitted set of platforms at the Roma Street Train Station, a major hub for local and interregional train services in South East Queensland. The new underground bus station at King George Square is designed to service up to 300 buses an hour during the peak periods. A 32-story office building has been proposed for a location across the street from this station; the new Busway station has been cited as a factor in the choice of location for the project.[27]

Figure 3.32
Standard livery bus at Wooloongabba Busway station. Note the live bus arrival information displays.

Vehicles. Brisbane uses its Busways as a means of deploying its bus fleet efficiently and effectively; it does not as of yet operate specialty vehicles, nor does it brand vehicles that use the Busway. Given the level of demand for Busway services, consideration is being made to introducing articulated or even bi-articulated vehicles along popular routes; press reports mention the European Megabus as the vehicle being reviewed for introduction.[28]

Figure 3.33
Queuing lines painted on floor by a bus bay at the Queen Street Bus Station. Retail shops and fast food eateries are part of the complex.

Intelligent Transportation Systems. While the Busways avoid the need for advanced traffic signaling systems, the transit network as a whole relies on corridors beyond the Busways, necessitating so-

phisticated traffic signaling systems on certain key arterials. The Busway also uses advanced passenger information systems, with live displays at stations. This is seen as necessary in a system that operates a plethora of routes at high frequencies, so that passengers know when to begin "staging themselves" to catch their bus. This is especially important in that system maps are largely not up to the same level of design and usability as other aspects of the Busway system.

Fare Collection. To date, fare collection is still handled on board buses, though there has been some experimentation with fare pre-payment.[29] Passengers may purchase a fare from the driver (who makes change), use a multi-day or monthly pass, or use on-board fare validation for prepaid fare media. There is no question that the use of on-board fare payment adds to vehicle dwell time, but these losses are more than adequately offset by time savings elsewhere in the system. Still, high and increasing demand will likely lead to broader application of various pre-paid fare schemes.

Service Patterns. As described earlier, Brisbane operates a rich mixture of services that use its Busways.

- *Spine*, or all-stops services, ply each corridor at relatively high frequencies;
- *CityXpress* services generally operate off-corridor in an on-street mode, then enter the Busway at various ramps provided for that purpose along the length of the Busways. CityXpress vehicles then stop at the first Busway station they encounter (usually located by the point of entry) to allow for transfers to the Spine or other services, but then proceed generally non-stop inbound until they reach the "inner core" of stations, bypassing most suburban stops.
- *Rockets* behave similarly to CityXpress services, except that they leave the Busway near the Woolloongabba station (which is itself located on a short spur from the Southeast Busway), enter the Southeast Motorway to access the CBD more directly, and then travel to the major office buildings on the southeast side of the CBD.

Some CityXpress routes have been split into two as ridership has increased; along the originating corridor, the original route now only serves the outer stops before proceeding non-stop to the Busway, while the new route is a shortlined version, serving only those stops closest to the Busway. As a result, people living farther out have an even faster journey; and people who live closer in can find seats (or at least standing room).

The operational flexibility of the Busway has been a key to its success. The service pattern is seen by planners as deliberately tailoring different services to different market segments, and the Busway allows them to provide the benefits of a fixed infrastructure (stable station locations, for example) while permitting continued evolution and refinement of services. What's more, it is acknowledged that the service plan *could not have been anticipated* when the infrastructure itself was being planned:[30]

> When busways were first planned, current operating plans couldn't have been foreseen… At the time, no one really comprehended what a busway could deliver.

Key to the increasing ridership on the system is its ability to deliver those elements of service that actually drive mode choice: frequency, speed, and reliability:[31]

> Our experience is that we don't hear people clamoring to convert bus service to LRT because of the high frequency we can offer compared to LRT—so in the peak, LRT may offer a higher caliber of ride, but reliability and frequency score higher than comfort in all the market research we've done here in Brisbane. So we're offering the reliability and frequency, which is what really matters when people make their choices.

Indeed, ridership response to service improvements on the Busway can exceed the ability of the system to respond quickly enough:[32]

> We get overcrowding and leave people behind, so we get the funding to increase service to every 10 minutes, which attracts more riders, so that in 3 weeks we're back to the same crowding. In some corridors, we're up to 1-2 minute service, which people then see.

The City of Brisbane has also responded to increased demand for transit by identifying a set of core bus routes that together serve the principal corridors in the City. It then upgraded the frequencies on these routes to "peak frequencies, all day and into the evening," with a maximum headway generally of 15 minutes (some services operate more frequently). It then designated these routes as the BUZ network—the Brisbane Urban Zone—and produced specialized, "subway-style" maps of this network (Figure 3.34). The BUZ network comprises CityXpress, local, and Busway Spine services; though each is a different service, together they make for a specialized network.

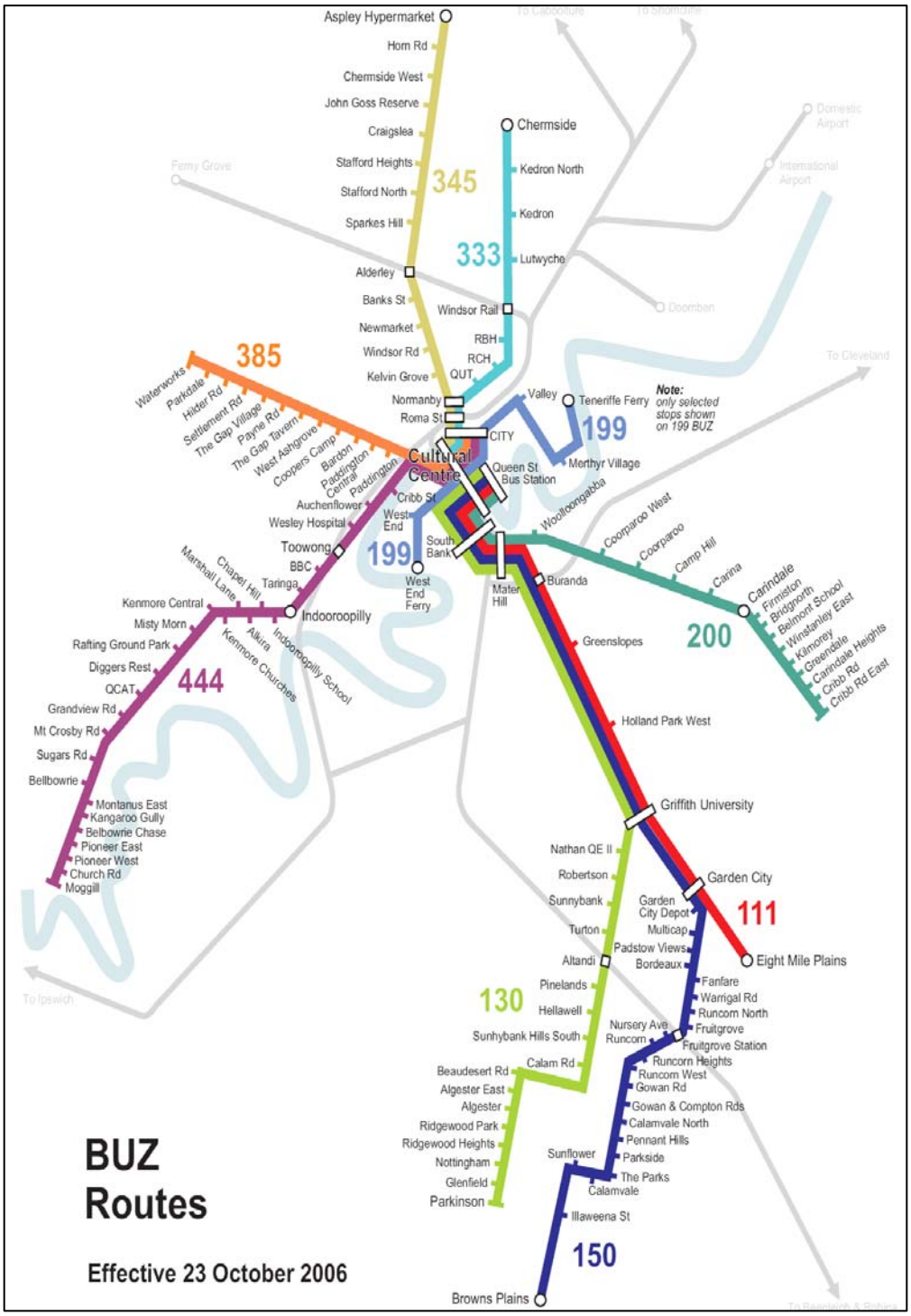

Figure 3.34
Brisbane's BUZ Network is defined by relatively high frequencies all day and into the mid/late evening. It includes "city bus" service such as the 199; "spine services" such as the 333, 444, and the Southeast Busway running 111, and CityXpress services such as the 130, 150, and 200.

Branding and Identity. Branding and identity are key features of Brisbane's Busway system, and reflect the fact that the decision to embrace Quickways was driven by an *infrastructure strategy*—namely, that the development of a network of grade-separated Quickways would permit a range of evolving transit services to be offered. As a consequence, and unlike most US BRT implementations, the buses that use the Quickways are not themselves "branded"—they're just Bris-

bane's "regular" transit vehicles; it is the infrastructure, and in particular the stations, that are the focus of the branding and image effort. As one local planner noted, it is hard to brand or give a special identity to what is essentially a two-lane road (without resorting to specialized running ways, such as the O-Bahn guided busway in Adelaide), but stations *can* stand out and hence create an identify for the system.[33]

Figure 3.35
Entrance to the Eight Mile Plains Station at the southern terminus of the Southeast Busway. The consistent station architecture, as well as the scale of the architectural elements, conveys a degree of importance and centrality to the Busway system.

3.3.2 Brisbane's Busways and the Quickway Model

More than any other city, Brisbane has made the Quickway model central to its growth strategy, and has taken the notion of creating a grade separated infrastructure farther than other comparable cities. Though Ottawa, for example, has a more extensive Quickway network, and has seen land uses respond over time to its Transitway, Brisbane is creating grade separation through its CBD, enhancing capacity, reducing travel times, and aiming to attract a higher ridership, or at least an accelerated growth in per capita ridership.

There are a number of key ways in which Brisbane's implementation of the Quickway model differs from Bogotá's.

1. *Brisbane's is an externalized system;* though there are routes that essentially operate only within the infrastructure (the so-called Spine Service), most routes travel out of the system to serve other corridors. In fact, as most buses in the system use the Quickway infrastructure at some point in their journey, it makes little sense to brand these vehicles as different or special.

2. *Brisbane's Quickways avoid running in the center of arterials or freeways*—at least, in the central urbanized area. This is a major distinction between the two systems, and one that represented a deliberate choice for Brisbane planners. Freeway-based operations posed a number of strategic hazards:

- They would create pressure to open up the facilities to automobiles (for example, the El Monte Busway in Los Angeles was eventually opened to carpools), which would then create safety concerns at stations and reduce the reliability of the system (maintaining exceptionally high reliability was seen as key for attracting and retaining transit riders).;
- They would locate stations farther away from actual land uses, forcing potential users to walk longer distances on isolated bridges over freeways, reducing the attractiveness of the system;

- Additional noise and isolation would make stations less attractive, and tighter spaces would preclude full stations (with passing lanes and generous passenger platforms); and
- In the end, it would impose greater costs and engineering challenges to get transit vehicles in and out of the facility without getting caught in intervening traffic.

The southern segment of the Southeast Busway was therefore built adjacent to the Southeast Motorway in mostly unused right-of-way; at key points, it deviates slightly to permit better station integration into major trip generators.

Future Busway alignments—notably, the Northern and Eastern Busways—are located along major arterials. Current plans call for extensive use of tunneling (both cut-and-cover and bored tunnels), especially in the inner sections; some median operations are suggested at the farther ends, with tunnel or bridge sections leading to stations located off-arterial (figure 3.36; unlike "Texas Ts," these stations are served by separate connectors at both ends to permit more of a straight-line movement).

Figure 3.36
Plans for Brisbane's Eastern busway in the easternmost section propose running in the median of a surface arterial, but locating stations off-corridor to better integrate with land uses and provide a better station environment.

3. *Brisbane is chasing a different target.* In the case of Bogotá, latent demand for transit services among transit-dependents represented not a goal to be reached but almost a threat that needed to be accommodated…or else. Crushing demand forced Bogotá's service planners to restructure routes and upgrade planned infrastructure; it also implied an internalized system.[34] Demand was always taken as a given; the planning challenge was how to meet it cost-effectively using a fleet of articulated buses.

In Brisbane, the challenge was more about meeting mode share targets, which forced Brisbane planners to consider a range of design and planning elements in terms of their potential appeal to a largely choice market. Though the decision to pursue a Quickway strategy was made at the political level for strategic/political reasons, it fell to planners the task of using that infrastructure to help meet ambitious targets for moving people in and out of Brisbane's already dense urban center (figure 3.37; plans for the CBD call for major increases in both employment and residential density, without expanding the CBD's footprint).

4. *Brisbane's land use environment is less concentrated.* Since, outside of the portal stations, TransMilenio serves a mostly walk-up market, close-spaced stations provide dense corridor coverage; in contrast, Brisbane's Busways are not within dense urban arterials, and as an externalized system, rely on branching services to bring people in from areas beyond surrounding stations (which average mile spacing outside of the CBD).

5. *Brisbane did not, until now, need to worry about capacity constraints.* TransMilenio has focused on systematically reducing bus dwell time through a variety of measures; these are central to achieving capacity goals. No such pressure had existed until now in Brisbane, where the emphasis has been on run times and frequencies, though such pressures are now emerging as ridership continues its double-digit growth.

Figure 3.37
Adelaide Street in Brisbane's Central Business District (CBD). The bus mall component of this street will be replaced by the new underground Inner Northern Busway link under construction, while service along the surface will eventually be taken up by a streetcar line. Plans for the CBD call for a doubling of employment and residential densities—remarkable targets given the existing density levels. Major issues with the plan include that of striking the right balance between pedestrian facilities and room for autos.

Brisbane demonstrates the power of the Quickway model to produce major and sustained benefits when implemented fully.

1. By providing or developing grade separation not just on the periphery but in the core of a region, the benefits of travel time savings are maximized (both in terms of attracting riders and reducing operating costs).

2. The greater the degree of grade separation, particularly as one moves into the core, the greater the overall operational savings, as even minor time savings are shared by a larger and larger subset of vehicles. These operational savings allow for increased frequencies or service extensions, that themselves create the conditions spoken of earlier where service frequency improvements have not lessened crowding but instead have attracted even more riders.

3. Time savings attract new riders; when those time savings become significant (that is, when potential users see a benefit relative to driving), large-scale modal shift may occur. The 30-40% increase in total transit ridership observed in Brisbane in the past three years may be understood in this context.

4. Travel time savings also begin to justify more express services, as the cost of providing them, and the potential ridership, tend to move in complementary directions. The result is a virtuous circle.

5. The emphasis placed on station design appears to have paid off in customer acceptance. Brisbane planners report unusually high levels of transfer within Busway stations, suggesting that customers find the burden of transferring significantly reduced within a station environment (and between relatively high frequency services). Stations are also the principal means for branding the infrastructure and creating the kind of "corporate identity" that communicates the relative importance and centrality of the system for the metro area.

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4. "Light Rail Lite": Eugene and Los Angeles

Of the four American cities reviewed in this report, two operate what are unabashedly implementations of the Light Rail Lite model of BRT: Eugene, Oregon, and Los Angeles, California. In one respect, they sit at opposite ends of the scale: Eugene is perhaps the smallest metro area in the United States to have implemented a "true" BRT project, while Los Angeles forms part of the nation's second largest metropolitan area. In both cases, BRT thinking began and ended with the Light Rail Lite model, though the applicability of the Quickway model was raised unsuccessfully by external planners working on LA's Orange Line. Both systems are considered successful at the *project* level, though questions must be asked in particular about the success of LA's program at the *strategic* level.

4.1 Eugene/Sprinfield, Oregon: EmX (Emerald Express)

4.1.1 Description

Eugene, Oregon, together with its twin city of Springfield, is a small metropolitan area approximately two hours south of Portland; Lane County, where both cities are located, had just under 325,000 residents in the 2000 census. Its BRT system, currently a single line, opened in early 2007. The system is known as the Emerald Express, or EmX, which was also the name of the original transit service first operated by the Lane Transit District.[35]

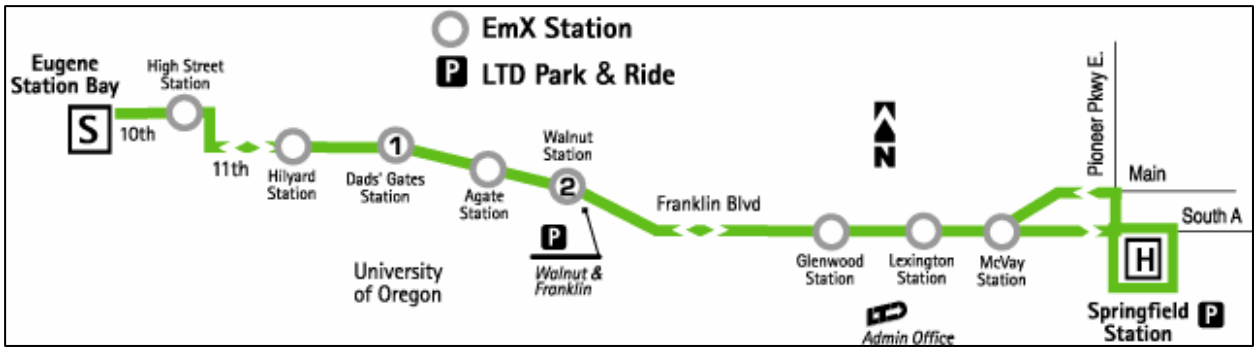


Figure 4.1
Service map of EmX Green Line.

EmX was conceived of directly along the lines of the Light Rail Lite model. The first line of EmX, the Green Line, connects the two major transit hubs of the region, located respectively in downtown Eugene and downtown Springfield. This four mile line, serving eight intermediate stations, was built at a capital cost of $6 million a mile including vehicles; close to 80% of the costs were provided by the Federal Government.

The Green Line replaced a local bus service that previously operated in the corridor. EmX relies on a combination of mostly dedicated right-of-way and signal priority to reduce travel time on the corridor from 22 minutes to 16 minutes;

in addition, some intervening bus stops were removed. This necessarily entailed extensive work with the community, which was ultimately successful.

Ridership on the new service has increased rapidly. During its first week of operations, ridership had climbed by 40%; within a few months, it was up 80%, though some of the increase in ridership may be due to the fact that fares on the line are now free; fares are not planned to be introduced until 2010. According to system planners, ridership now reaches 500 passengers an hour at the peak hour, which is accommodated with a 10 minute frequency produced by only four buses.

4.1.2 Comparison to the Quickway Model

The Green Line is a model expression of the Light Rail Lite model, in that it represents the very strengths of that model: producing a rail-like customer experience while adapting to difficult and varied corridor conditions.

Running Ways. The Green Line operates in a combination of on-street, transit lane, and at-grade T-Way environments. Among the issues dictating the choice of running way were right of way availability and corridor conditions.

Where T-Ways are provided, they were designed to an unusual standard: as two "tracks," separated by a grassy strip, with hard curbs set just 10.5 feet apart. This design was chosen to highlight the "rail-like" nature of the service and distinguish it from more lanes of asphalt or concrete. It has the practical implication, though, of creating certain operational challenges: driver response to this unusual guideway ranges from caution (and hence slower travel speeds) to behavior that has been compared to that of driving in a video game.

Figure 4.2
Section of T-Way running in special "trackway". The use of such trackway is purely cosmetic: it establishes that the EmX is more of a "like rail" system than a typical bus. Note that the inbound lanes must deviate around a mature tree. Environmental concerns in Eugene are paramount.
Source: Graham Carey, Lane Transit District

There is also one stretch of the corridor where only a single two-way lane is available for transit vehicles. While the current service plan is able to effectively mitigate the impacts of a single lane, there is some concern that future system development, if met with strong ridership response, may turn this stretch into a bottleneck.

Finally, environmental concerns in Eugene—noted for its impassioned environmental community—make it extremely difficult to remove mature trees for any reason (figure 4.2), dictating the need, at times, for vehicle guideways to "swerve" around trees that in other cities would have been removed (and hopefully replaced).

Figure 4.3
Simple station along EmX Green line.
Source: Mark Wells, RTC of Southern Nevada

Figure 4.4
Major station along EmX Green line.
Source: Mark Wells, RTC of Southern Nevada

Stations. Stations along the EmX are attractively designed and able to support level boarding with the vehicles. Some are quite simple, whether others have more elaborate shelter structures. Some stations feature waist-high screens separating the station from the bus running way so as to enhance passenger safety (figure 4.3); openings are located to coincide with doors on the EmX vehicles. Some stations are located curbside, whereas others are located in the medians, and hence may board passengers either on the right or left side of the vehicles. Traditional transit buses therefore cannot use some of the stations along the corridor. Stations do not appear designed for heavy bus volumes, and bus passing, though possible at certain curbside stations, was not a design consideration.

Vehicles. The EmX uses a specialty articulated BRT vehicle with doors on both sides of the vehicle. Though active vehicle guidance is not utilized, drivers are able to position vehicles so that level boarding at stations is supported. Vehicles employ a continuously variable transmission to enable smooth acceleration and deceleration, purportedly increasing passenger comfort.

Intelligent Transportation Systems. EmX depends on a signal priority system to help maintain system reliability and help reduce travel times. While there were initial problems with the system, these issues have been resolved.

Fare Collection. Fare collection is at the present not an element of the system, as fares are not charged. This has helped reduce the risk for new users to "try out" the system, as well as reduce dwell times and even the risk to passengers of missing a bus as they attempt to purchase a fare from a fare machine.

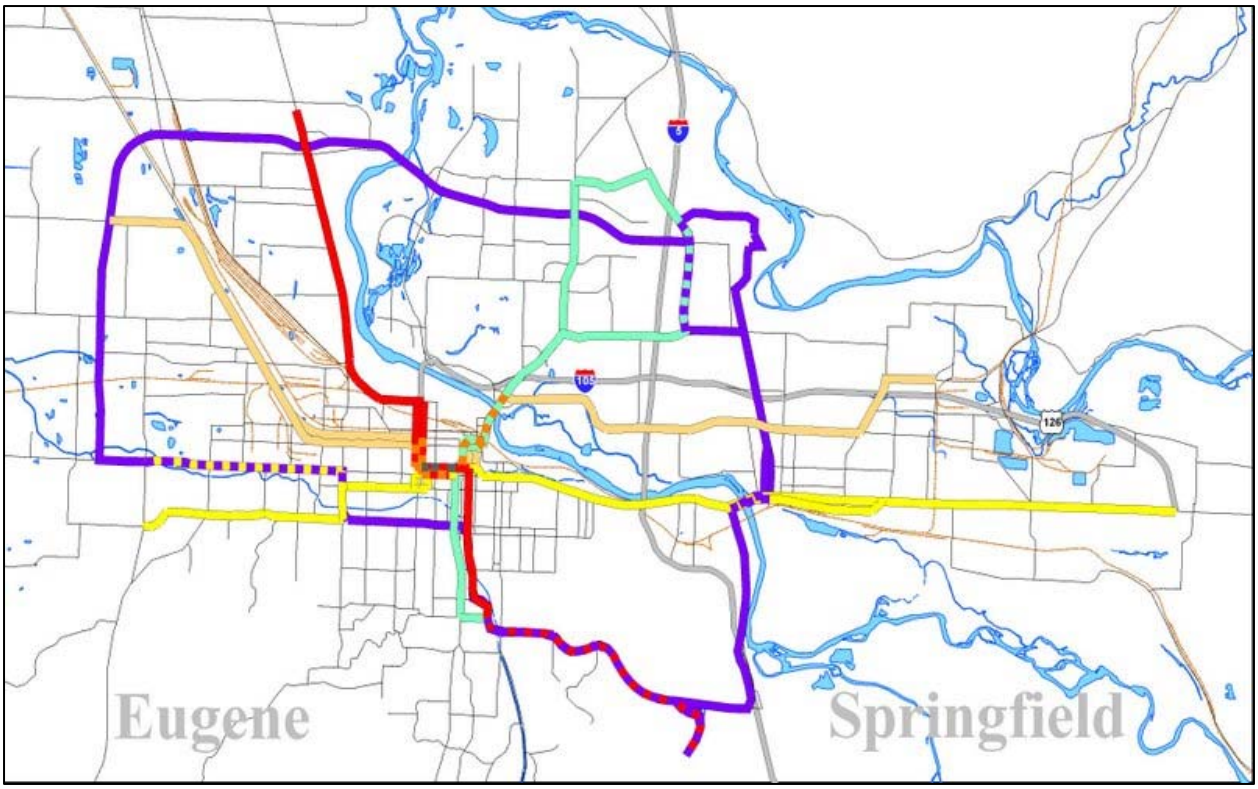


Figure 4.5
Current plans for Eugene anticipate a set of radial lines feeding out of the region's two principal centers and a circumferential line linking the outskirts.

Service Patterns. The Green Line is the first line of what is planned to be a 60 mile system of lines. Though it was originally hoped to complete the system by 2020, planners currently hope to extend the system an average of two miles a year, giving a 30 year time horizon for the project.

Each line in the EmX system is conceived of as a light rail-like service replacing existing bus service. At full build-out, six lines are anticipated. At its busiest point, three lines are expected to operate in one segment of the system.

The service pattern for Eugene/Springfield reflects the conditions unique to that community:

- sufficient ridership demand for a core or spine service, but insufficient to support a network of express services; and
- a public constituency interested in light rail, but aware that the community could not afford it; planners describe it in terms of "the community pretty much wanted light rail, but got 'like rail'."

Identity and Branding. EmX features a strong identity and branding; its logo is used extensively, buses are painted with a special livery, and indeed, are sufficiently distinct from traditional buses to alone warrant notice, and T-Way segments

Figure 4.6
EmX branded bus on the Green Line
Source: Mark Wells, RTC of Southern Nevada.

are configured as trackways, further highlighting the difference between EmX and local bus services.

4.1.3 Conclusions: Eugene/Springfield's EmX

Ridership potential was the singular motive behind the selection of the Light Rail Lite model; or rather, that model was by default the only one to have been considered precisely because existing or potential ridership demand was never as high enough to support a web of express services (though physical choke points on the network might necessitate a creative planning response to support even a Light Rail Lite service). Eugene, therefore, represents the opposite extreme from Bogotá, which was "forced" into a Quickway model by the sheer need to meet passenger demand with a bus system operating in a compromised infrastructure, or Brisbane, which needed to attract a large share of the demand that would be generated as the city grew. In the case of Eugene, it is the lack of demand, or rather, the lack of demand for which express services could be cost-effectively supplied, that drives the appeal of the Light Rail Lite model.

This is not to categorically dismiss the Quickway model as having any potential for a region the size of Eugene/Springfield, but the very real capital costs involved in creating a grade-separated infrastructure would pose a significant challenge for a smaller community that otherwise is not facing even greater expenses in order to keep its transportation system functioning.[36]

4.2 Los Angeles: Metro Rapid and the Orange Line

Los Angeles has not just one but two distinct implementations of BRT: Metro Rapid, a rapid bus network operating on multiple corridors, and the Orange Line, a T-Way-based BRT route serving the San Fernando Valley. They represent two different approaches to the Light Rail Lite Model (in fact, they arguably represent its two extremes), as well as illustrate how that model can come to dominate planning even when conditions might otherwise favor the Quickway model.[37]

4.2.1 Metro Rapid: Description

Metro Rapid is a network of rapid buses that represent the most minimal implementation of BRT concepts; it is often referred to as "BRT Lite." The program, which will eventually feature single routes operating in 28 corridors and covering 450 route miles, had its genesis in the confluence of three currents:

- Planners within the Los Angeles County Metropolitan Transportation Authority (MTA) had been looking for means to speed bus services along congested arterials;
- The then-mayor of Los Angeles, along with other local elected officials, had recently traveled to Curitiba to inspect its BRT system at the instigation of Martha Welborne, a local architect; and

- The Federal Transit Administration had launched a new and still loosely-defined BRT program and was looking for city partners.

Metro Rapid was developed and launched within only a six month time window, relatively unheard of for major transit initiatives. Planners decided on several basic principles to guide the development of this "overlay" network of services:

1. *Route design* – routes were to be kept as simple and straight-line as possible, in order to facilitate ease of understanding;
2. *Transit priority* – traffic signal priority measures were to be employed wherever possible to help buses avoid excessive signal delay;
3. *Branding* – system branding would be important in order to differentiate the service in the eyes of the public;
4. *Frequency* – headway-based schedules would be employed, rather than timetable-based. Service would be operated frequently enough so that riders could just show up at a station without excessive wait times or the need to consult a timetable;
5. *Boarding* – level boarding vehicles would be used, to minimize dwell times;
6. *Stations* – special bus stops, highlighting the rapid and frequent nature of the service, would be employed; and
7. *Station spacing* – bus stops would be widely separated, close to one mile apart.

The first two routes chosen to demo the project represented two corridor extremes. Wilshire Boulevard is arguably one of the longest, densest urban corridors in the United States; the Metro Red Line subway runs underneath it from downtown as far as Western Avenue. Wilshire also intersects many of LA's major north/south arterials, and hence provides a lot of connectivity options.

The other corridor selected, Ventura Boulevard, is bisected by relatively few major arterials, sitting as it does at the southern end of the San Fernando Valley.

The pilot program proved successful; bus travel times were reduced by about 25% in the corridors, with overall ridership rising by substantial amounts in both corridors. Though Metro Rapid had not been planned with the *intention* of raising ridership, this result was welcomed, though it meant that additional buses needed to be identified and put into service, particularly on the Wilshire corridor.

The success of the Metro Rapid pilot project led to the expansion of that program. Changes in the program were made, though, in keeping with practical and political concerns.

1. Along the new corridors, certain existing bus stops were designated as Metro Rapid stops. The cost and difficulty of building dedicated Metro Rapid bus stops led to this decision.
2. Specialty BRT vehicles, chosen originally for the Orange Line, were also introduced into the Metro Rapid program.
3. The system was rebranded, with a new color scheme and a new tagline: "Metro Rapid: Fast, Frequent, Fabulous."

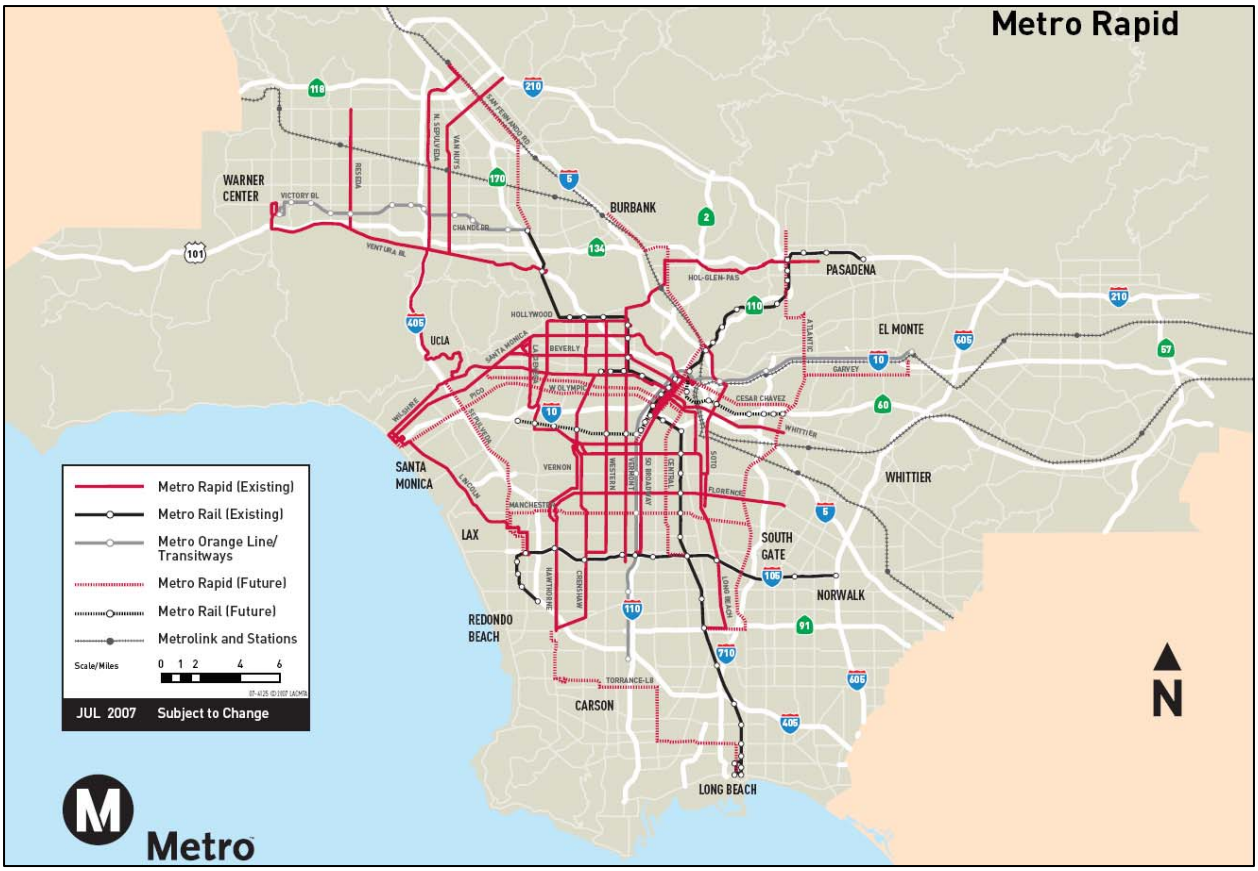


Figure 4.7
Map showing existing and planned Metro Rapid Routes, along with LA's rapid transit (rail and busway) infrastructure.

To date 16 lines are operating. One new line was considered unsuccessful and terminated: Beverly Boulevard. Its failure was attributed to the mismatch among trip patterns/trip lengths, service frequencies, and the relative competitiveness of traditional bus services. Otherwise, ridership gains across corridors range from 4-5% up to 40%, with an average of 15-20%. Average speed improvements for all 16 corridors average 26%.

One interesting development in Metro Rapid—one that hearkens to the Quickway model—is the recent introduction of a "super express" service in the Wilshire corridor. Dubbed "Metro Express," this service stops, on average, only every four or five Metro Rapid stops. Metro Express came about because of issues with overcrowding on Metro Rapid services in

Figure 4.8
On board Metro Rapid. Fast, frequent...but fabulous?

that corridor (as Figure 4.8 attests) and the discovery that many people were making longer trips in that corridor. Planners reasoned that the cost of moving these people would be cheaper if they could bypass stops and essentially recycle the buses in less time, in essence making the same discovery that drove service planning in Bogotá for the TransMilenio system.

4.2.2 The Orange Line: Description

The Orange Line is Los Angeles's first dedicated BRT T-Way. It roughly parallels Ventura Boulevard, operating in what had been an abandoned railroad corridor. It operates primarily as a feeder to the terminal station on the Metro Red Line subway. While it is often viewed as a success on many levels (ridership has significantly exceeded projections, and the system's modest capital costs compared to light rail has given more legitimacy to BRT as an effective mode in Los Angeles), it may also be understood as a lesson in opportunities lost as well as the role of vision and strategy in devising effective regional transportation solutions.

The Orange Line is a 14 mile route that opened for service in October of 2005. By August of 2007, daily ridership averaged 23,814 passengers,[38] significantly exceeding the far-more-expensive Gold Line light rail and attracting a ridership that had been projected for fifteen years after project opening.

The Orange Line was built in an abandoned rail right-of-way that had long been recognized for its potential utility as a transit corridor. Virtually every mode of rapid transit had been considered for this corridor since the 1970s, including light rail, heavy rail, DMU, and monorail. When a public referendum halted funding for the subway program, light rail was seriously explored for the corridor, but opponents of the project succeeded in passing a state law prohibiting anything other than a deep bore subway from being built, essentially creating an untenable situation.

When Bus Rapid Transit emerged at the political level as an option for Los Angeles, it was proposed again for the corridor. In this case, leadership and conceptualization came from the political side, and state funding was quickly obtained for building a BRT line. The funding determined the project, and the political desire to develop something quickly and expeditiously strongly favored a single-route, Light Rail Lite model for the corridor. Though consultants involved in the design of the facility and route were familiar with the Quickway model and had even suggested it for the corridor (especially given its *scalability*, the ability of the infrastructure to function effectively at a wide range of passenger demand), both the municipal and regional agencies and political representatives favored a quick and simple project. As one project consultant put it:

> So without a constituency for branching lines, little staff interest, politicians satisfied they have a line there, and agency hostility, no one's pushing for a branch line structure.[39]

4.2.3 Comparison to the Quickway Model

Though Metro Rapid and the Orange Line are separate projects, they will be treated here together in comparison to the Quickway Model, as they reflect many of the same planning assumptions.

Running Ways. Metro Rapid operates along major arterials in Los Angeles, many of which experience congestion during all or most of the day. It derives its time benefits primarily through the combination of distant station spacing and traffic signal priority measures. Together, these deliver major travel time benefits relative to traditional bus service, but the service is not time competitive with the subway, for example.

The Orange Line, in contrast, is a dedicated T-Way with no traffic queuing. It, too, relies on traffic signal priority measures at intersections, though planners have suggested that these measures are less effective here than along many Metro Rapid routes (though fewer major arterials cross the Orange Line, the ones that do carry major traffic flows and are less amenable to major changes in cycle timing).

Why was the Orange Line designed as a T-Way and not as a Quickway? In the long history of transit planning for the corridor, different modal alternatives were considered, each with its champions or detractors. When finally a BRT solution was suggested, it was seen as being relatively simple to implement, relatively low-impact, and feasible. An appropriation was secured from the state government; according to planners associated with project, the Orange Line was designed to the budget available. Grade separation *may* have been more cost-effective, but it would have required a different planning approach and focus, and most certainly would have had higher up-front costs.

Figure 4.9
Buses on the Orange Line.

Stations. Metro Rapid employs special stops only along its pilot corridors of Wilshire and Ventura Boulevards. These stations were designed to be distinct from regular bus stops; among their distinction is the lack of seats (lean rails are employed instead), since the high frequency of the system meant that passengers would not need to wait very long.

Metro Rapid stations feature "Next Bus" displays which, naturally enough, give the projected arrival time of the next bus based on its actual location. One issue facing this system, though, is that the current implementation of the technology will not be able to distinguish between a Metro Rapid bus and a Metro Express bus, leading undoubtedly to some degree of customer confusion and frustration.

Figure 4.10
Metro Rapid "station" by the terminus of the Metro Red Line subway at Wishire & Western.

The Orange Line, in contrast, features specialty stations along its length. While such stations are attractive, their platforms are smaller than those of Brisbane (as should be expected, given the difference in number of bus operations) and shelter structures are not contiguous. Given the width of the busway corridor, which is attractively landscaped, and the use of at-grade crossings, stations are only peripherally integrated into surrounding land uses, but many of those land uses are auto-oriented. Stations feature step-up boarding to low-floor vehicles, but are not level loading as are those in Eugene. Some stations are equipped with passing lanes, whereas others are not.

Vehicles. The Orange Line employs specialty articulated BRT vehicles, some of which have been placed into service on Metro Rapid routes (Figure 4.12).

Capacity issues with the Orange Line[40] have led the MTA to order new vehicles which exceed the 60 foot length of the existing articulated vehicles, necessitating a special waiver from Caltrans.[41] Though the new vehicles are only five feet longer, they provide three more rows of seats and a 20% boost in total passenger capacity (Figure 4.13).

Figure 4.11
Orange Line bus at West Hollywood Station.
Source: Cian Ginty.

Intelligent Transportation Systems. Both Metro Rapid and the Orange line rely on advanced traffic signal priority measures, as well as live passenger "next bus" information. Traf-

fic signal priority measures in fact represent the major construction component of the Metro Rapid program.

Three issues have tested the limit of current implementations of ITS technologies.

Figure 4.12
Specialty BRT vehicle used on both Orange Line and some Metro Rapid routes. This bus is painted in the Metro Rapid livery.

1. Traffic signal priority systems begin to lose effectiveness when bus headways get shorter than three minutes. This has been observed on the busiest corridors of Metro Rapid, which achieves a peak frequency of a bus every two minutes.

2. The same systems have less flexibility when dealing with major cross-arterials. This has been an issue on the Orange Line, where some intersections have as many as 18 different signal phases, limiting the range of signal priority measures and essentially losing effectiveness at peak periods when headways dip below four minutes. As a result, bus bunching has been observed at peak hours on the Orange Line.[42]

Figure 4.13
New 65-foot "Metro Liner" buses for Metro Orange Line.

3. As previously noted, the passenger information system currently employed cannot distinguish between Metro Rapid and Rapid Express buses, leading to potential customer confusion.

Fare Collection. The Orange Line relies on off-board fare collection to minimize dwell times. Fare machines are located at stations. As with Metro rail lines, the honor system is employed, with roving fare inspectors to ensure compliance.

Metro Rapid buses require on-board fare payment (or use of pre-purchased passes), identical to city bus services.

Service Patterns. Both Metro Rapid and the Orange Line are built around the one corridor/one route approach which typifies the Light Rail Lite model. In neither case did ridership patterns (origins to destinations) play a role in service planning, for one of several reasons.

1. Having multiple routes interlined into one corridor was viewed as potentially confusing to riders, particularly new riders.
2. For the Orange Line, LA City traffic engineers were concerned that multiple routes would overwhelm the traffic signal priority system, triggering a breakdown in automotive flows across the busway.

3. The goal in both projects was to develop service, not specifically to attract new riders.

The Orange Line, in particular, was the product of a long history of planning for rapid transit in the corridor in which rail had been the preferred mode. Local politics placed the corridor in an untenable position: on the one hand, one voter-passed measure blocked the use of certain tax streams to build more rail lines in Los Angeles; on the other hand, the State Legislature passed a measure which stipulated that only a subway could be built in the corridor.

Figure 4.14
Orange Line service map.

When local elected officials pushed for a BRT line in the corridor, a state appropriation was quickly granted ($300 million for two corridors). As one planner described it, the pot of money designed the corridor. It was not a case of "what's the best solution for the corridor, " it was more "let's just get *something* built."

External planners working on the Orange Line corridor recognized the potential value of the corridor as a Quickway, or even as a T-Way supporting a modified Quickway service pattern, but these notions were rejected on several grounds:

- Most people, ranging from agency planning staffs to elected officials, were not familiar with the practical and operating costs and benefits of a Brisbane-style network, and hence did not recognize either the opportunity or the benefits of such an approach;
- Of the many different agencies which are involved in planning, designing, and operating transportation services in the LA area, not all were involved early enough in the project to participate in the learning phases or to buy into other aspects of the project;
- No constituency emerged that was clamoring for anything other than a core service along the corridor, again likely because few would have understood the possibilities or the benefits of alternative approaches; and
- Many elected officials were satisfied that they were getting a line, and were not themselves as focused on what may have been perceived as "staff's job."

As a consequence, people within the San Fernando Valley that wish to access their jobs in Los Angeles's CBD and do so by transit may need to take a city bus service down to the Orange Line, ride the Orange Line (stopping at every station)

to the end of the line, transfer to the Metro Red Line subway (stopping at every station), and possibly needing to transfer within the CBD to either a DASH bus or the Metro Blue Line light rail.

The Orange Line was also clearly designed as a suburban feeder service, with 3,200 free parking spaces provided in five park-and-ride lots, as well as bicycle and pedestrian access to stations.[43]

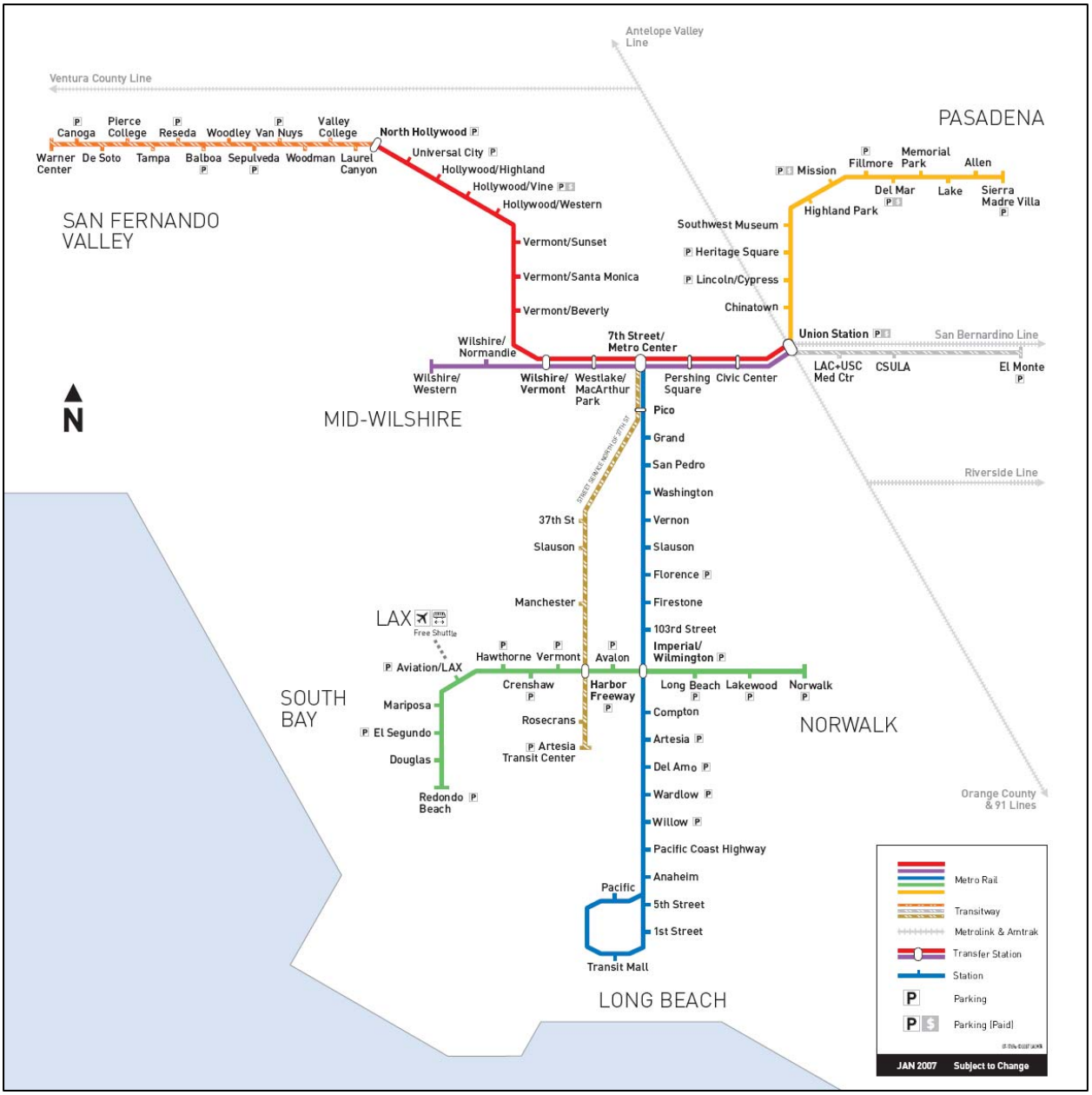


Figure 4.15
Los Angeles rapid transit map

Identity and Branding. Identity and branding were always central to both efforts. Both have branded their services and given them a special identity, and the Orange Line in particular enjoys the benefits of being branded as a rapid transit line alongside LA's major rail lines (the Red, Blue, Green, and Gold). The Orange

Line shows up on the LA rail rapid transit system map (Figure 4.15), though it is identified as a "Transitway" line instead of a "rail" line.

With Metro Rapid, the branding of vehicles was key to making the system stand out from other bus services. As the image in Figure 4.16 suggests, even an effectively branded on-street bus stop can easily get caught up in the confusion of "street furniture" that lines the side of many arterials. Though much of the Metro Rapid fleet is made up of the same *kind* of buses used in regular service, the buses operate under a different livery and are easily noticeable.

Figure 4.16
Metro Rapid stop along Wilshire Boulevard.

4.2.4 Conclusions: Los Angeles's Metro Rapid and Orange Line

Transit planning in Los Angeles has had to contend with a difficult political context and a history of "grand projects" (such as the LA Rail Plan that led to the development of the Red Line subway) that often failed to deliver on their promises, often at greater cost than advertised.[44] The frustration or desire to "just do something" was clearly an impetus for LA to embrace not just BRT, but the Light Rail Lite model of BRT—it was easy to understand, comparable to rail, relatively easy to implement, and could always be justified with the reasoning that, if it proves successful, it can be converted to rail "some day."

Unfortunately, the LA experience also points to the dangers of transit development without clear strategy or situation-driven goals—transit projects may be successful *as projects,* but they produce only marginal benefits that by themselves do little to advance broader goals. Brisbane's Busway strategy has been catalytic in producing a major change in the role that public transport plays in that city (if the dramatic increase in public transit ridership system-wide is any measure); Bogotá's TransMilenio has reshaped much of the city and been part of a measurable and notable improvement in regional quality of life.

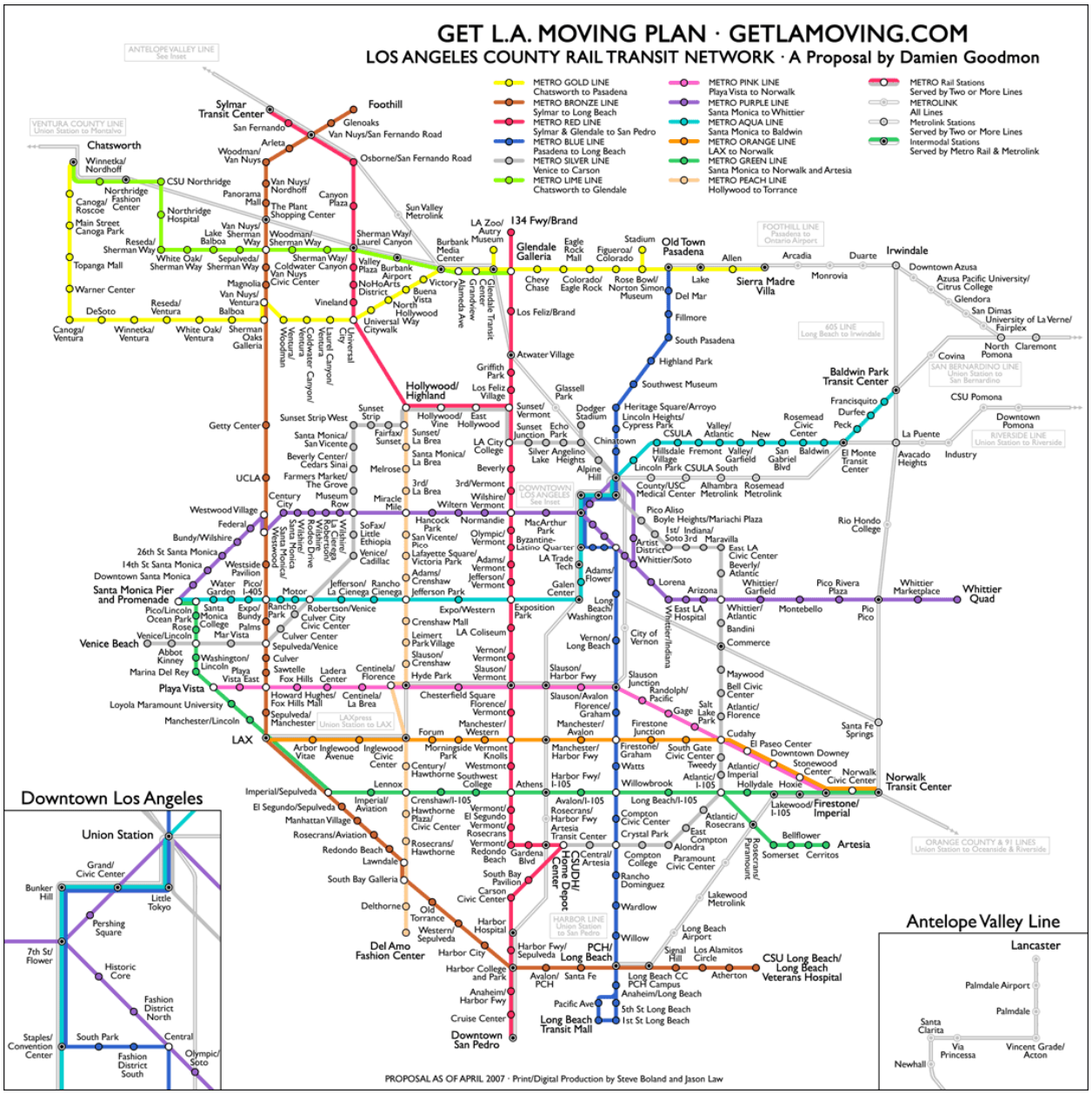
Circumstances in LA are forcing transit to begin to innovate beyond the Light Rail Lite model, however; the recent development of Metro Express as a skip-stop service overlaid over Metro Rapid is evidence of this, as is renewed

interest in the potential of grade separation for future busways (and possibly portions of the existing Orange Line) in the San Fernando Valley.[45] And LA-area transit planners may be right that "keeping routes simple" is the key to attracting and retaining riders, although both Bogotá and Brisbane have managed to achieve impressive ridership growth with networks that are anything but simple (in part by operating an easy-to-understand "spine service" in addition to their more complex express networks).

LA's interpretation of the Light Rail Lite model should not be rejected out of hand, however, as it has indeed demonstrated the existence of a market that would respond to improvements in transit quality of service as well as the effectiveness of measures to speed buses (and hence reduce corridor operating costs); it has also demonstrated that BRT is indeed a viable mode, even in the supposedly car-worshipping world of Angelinos.

For LA to achieve a phase shift in the role of transit, however, a broad range of interested parties will need to learn about the experience of cities that have embraced the Quickway model and how they have been able to deploy networks which better match market demand and the generators of that demand.[46] This will be difficult in a city that for many years has thought in terms of grand metro rail schemes, both official and unofficial; several "rail fantasy maps" have recently appeared online,[47] as LA-area transit advocates attempt to devise the kind

Figure 4.17
Numan Parada of the LA Transit Coalition developed this "Fantasy Map" for Los Angeles rail transit.



of network of rapid transit services that best match their understanding of movement patterns in that region. These maps are universally based on the rail model of service, even though LA is hardly configured the way successful rail cities are typically configured; still, each has great merit from the point of view of understanding how LA actually *works* as a city, for at least some of its denizens.

Figure 4.18
Damien Goodman's "fantasy rail plan" for LA more closely follows its grid street network than does Numan Parada's proposal.

5. Beyond "Light Rail Lite": Pittsburgh and Miami

Pittsburgh and Miami together offer the closest American equivalent to the Quickway model employed internationally. Both cities have developed bus guideways—in the case of Pittsburgh, three busways that near Quickway standards, in the case of Miami-Dade County, a T-Way—that serve a combination of service types. Each, however, also must contend with limitations that prevent the full benefits of the Quickway model from contributing to their respective regions.

5.1 Pittsburgh: Busways

5.1.1 Description

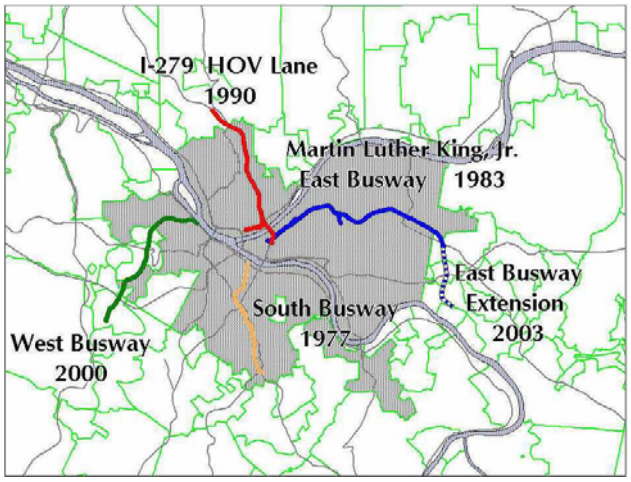


Figure 5.1 Pittsburgh's busway system.

Pittsburgh is the American city that comes closest to the Quickway model in terms of its physical infrastructure and service plan. Still, the differences between Pittsburgh and the international examples are noteworthy, and help illustrate the challenges of pursuing a Quickway-based model for BRT development in the United States.

Pittsburgh currently operates three near-Quickways:[48]

- the *South Busway*, which when it opened in 1977 was the first dedicated non-freeway based busway to open in the U.S.;
- the *Martin Luther King, Jr., East Busway*, which opened in 1983; and
- the *West Busway* (airport link), which opened in 2000.

Table 5.1 provides comparative data on these three busways.[49]

While all three busways provide grade-separation, design speeds vary; the South Busway in particular shares a tunnel with light rail trains, necessitating more cautious operating speeds. Pittsburgh's 25-mile light rail network is more extensive than its busways (that is, it's longer than all busways combined and serves more stations), and it operates in a subway through the downtown, enhancing travel times as well as the customer experience, but still attracts far fewer riders.

As indicated in Table 5.1, a large number of bus routes use the three busways. Both the East and the West Busways support a spine, or all-stops service that operates exclusively on the facility (except for downtown, where all buses must operate on surface streets); the South Busway has no dedicated all-stops route, but is served by routes that continue beyond the last station to serve destinations beyond the busway. Just over half of all busway users ride an all-stops service (the numbers for each busway are remarkably consistent, and range between 51 and 53%).[50]

Figure 5.2
Pittsburgh's South Busway shares part of its right-of-way with a light rail line.

In terms of cost performance, the busways in Pittsburgh are reported to be highly efficient. Data for the South and East Busways shows an average Operations and Maintenance cost per rider ranging from $0.95 (the latter) to $1.03 (the former), which is less than half that of the rest of the bus system ($2.55 per rider) and less than a third that of the light rail system ($3.22 per rider).

Facility	Construction Cost	Year Opened	Length (miles)	Stations/ Stops	Routes Using	Daily Trips	Travel Time Savings	Average Daily Ridership
South Busway	$27 m	1977	4.3	9	16	552	20-30 mins.	11,000
MLK, Jr., East Busway	$115 m	1983	6.8	9+1	34	943	25-34 mins.	~ 30,000
East Busway extension	$68 m	2003	2.3				6-15 mins.	
West Busway	$258 m	2000	5.0	6	11	413	20 mins.	9,500

Table 5.1
Pittsburgh's busways.

Though Pittsburgh as a metro area is relatively static as far as population is concerned, the busways have attracted various amounts of development. While it is difficult to determine how much of that development was *because* of the busways, the total amount and scale of development has been impressive. In the period 1993-1996, some $302 million in development (divided among 54 projects) occurred within 1500 feet of the Eastern Busway corridor; in the seven years since, an additional $203 million occurred.[51]

5.1.2 Comparison to the Quickway Model

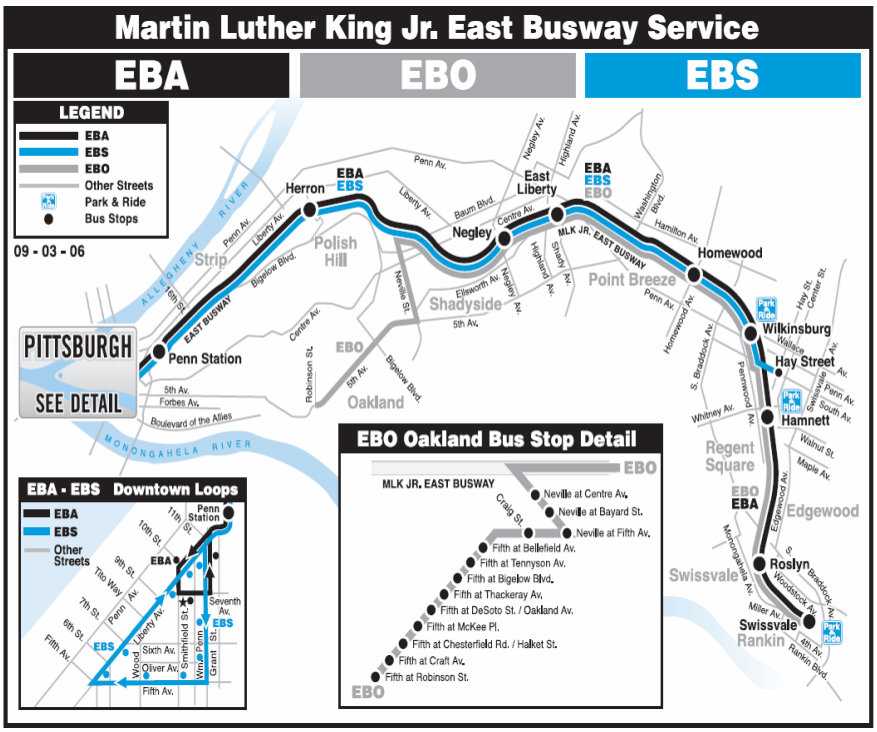


Figure 5.3
Spine services on the Martin Luther King Jr. East Busway.

Pittsburgh's busways are clearly successful on many levels, yet they have not stimulated much in the way of interest in copying or modeling them within the United States (virtually all recent BRT projects, even at the scale of Los Angeles's Orange Line, have been based on an Light Rail Lite model operating mostly if not entirely at grade). Pittsburgh area planners concede that buses are seen as second class compared to their LRT system, which operates in a subway in the downtown, and communities along the Eastern Busway have clamored at times for their busway to be converted to light rail.[52]

Running Ways. Pittsburgh's busways are fully grade separated from other traffic (except for a section of the South Busway that shares a guideway with the light rail); however, busway infrastructure is not carried into and through the downtown; on the east side, the busway terminates at the Pennsylvania Station, which is at the eastern edge of downtown; on the western end, the West Busway currently terminates by the south bank of the Ohio River.

What are the consequences of not continuing dedicated bus infrastructure into the downtown? Pittsburgh planners have identified bottlenecks that limit capacity and add to bus travel times. However, the light rail system does travel through a downtown subway serving underground stations (as opposed to on-street bus stops). The significance of the impact of surface bus operations in the downtown can best be illustrated by comparing the PM peak travel time of the all-stop route EBS on the MLK, Jr East Busway, as illustrated in the route map (figure 5.3). The travel time required for a bus to complete a one-way loop in the downtown section—20 minutes—is identical to the amount of

Figure 5.4
"Station" on the South Busway. Stations on more recently built busways feature a higher standard of design and shelter.

time it takes to then traverse the entire busway, stopping at every station, until the terminus at Swissvale.

Stations. Stations on the original South Busway were extremely basic (figure 5.4); later busways feature improved stations (figure 5.5), but these are still modest in dimensions, design, and materials compared to Brisbane. All stations rely on at-grade pedestrian crossings, unlike in Brisbane, where such crossings are made using pedestrian bridges, or Bogotá, which relies on elevated structures or underground tunnels outside of the CBD. It would be fair to say that stations on Pittsburgh's busway are treated more as enhanced bus stops (some even feature "bus stop" signs) than as the "rapid transit" stations envisioned for Brisbane. Like in Brisbane, stations are not barrier-separated, and fares are paid onboard vehicles.

Figure 5.5
Busway station on the Dr. Martin Luther King, Jr., Eastern Busway.

Vehicles. Pittsburgh operates its traditional transit fleet through the busways; like Brisbane, it uses the busways to provide travel time benefits to an existing bus system, and hasn't yet seen the need to "upgrade" spine services to larger or more specialty vehicles (such as that used by Los Angeles for its Orange Line).

Intelligent Transportation Systems. Since Pittsburgh's busways are grade separated, there has been little need for advanced traffic signaling systems as part of the infrastructure. Live passenger information is not employed, either.

Fare Collection. Like Brisbane, Pittsburgh does not employ any special fare collection scheme exclusively for its busways.

Service Patterns. Pittsburgh's service pattern reflects that of a Quickway infrastructure, with all-stops, branching, and express services all taking advantage of the busway infrastructure. Given Pittsburgh's unusually difficult topography—

Figure 5.6
Left, bus riders wait on street in downtown Pittsburgh (this location lacked a shelter); *Right*, light rail riders wait in a spacious underground metro station.

with two large rivers coming together to form a third, and steep hills and valleys, places that may seem close on a map may be far apart in practice—it may be that the busway infrastructure, however useful, is still insufficient to provide adequate connectivity to the metro area. More to the point, Pittsburgh's route structure has changed only modestly over time, and more aggressive proposals to improve on that route structure—for example, through larger reliance on interlining—have largely been rejected. A recent budget crisis has led to some reduction in transit services, affecting especially a number of lower-ridership express routes.

Identity and Branding. Pittsburgh has done relatively little to create a busway brand or focus strategically on creating a specific system image. The busways when first conceived and as originally developed were seen in very practical terms—they were designed to reduce bus travel times, and at this they succeeded remarkably. But little if any thought went into viewing or positioning them as a distinct brand or mode of service. Stations are still indicated with regular "Bus Stop" signs, and were hardly conceived of as rapid transit stations on the level of a light rail station (or beyond).

5.1.3 Conclusions: Pittsburgh's Busways

Figure 5.7
Platform on the MLK, Jr., Eastern Busway.

Pittsburgh's busway system is without question the closest to a global Quickway model in the United States. That it has not had more of an impact in promoting this model may be due to several factors.

1. *Identity/branding.* The lack of a strong, "high class" identity or image reduces the busways to private roads supporting a traditional bus network. The customer experience of using the busway is not very different from that of boarding a bus along any other (little-traveled) roadway.

2. *Infrastructure.* The lack of dedicated infrastructure in the central business district cancels out a portion of the travel time benefits of the busways and is generally uncompetitive with the light rail system, which enjoys subway operations in the center.

3. *Routing.* Relatively inflexible route planning has limited the potential for evolving more market-responsive routes or taking greater advantage of the efficiencies of interlining.

4. *Stagnant growth.* The relatively declining share of transit use in Pittsburgh—the result of a generally stagnant population but increased suburbanization of residents and employment—and the relative extensiveness of the transit system make it difficult to achieve attention for "breakthrough" service, or to significantly attract new ridership.

5. *Station design and configuration.* Stations, which are the means of accessing the system and its most public face, are as yet exceedingly basic in design and amenities, and hence do little to promote the system and its attributes.

5.2 Miami: South Miami-Dade Busway

5.2.1 Description

The South Miami-Dade Busway is an approximately 13-mile long T-Way, or at-grade busway, running parallel (and adjacent to) US 1, a multilane express arterial. The Busway begins at the Dadeland South Metrorail Station, and terminates at SW 344th Street. The first segment, terminating at SW 112th Avenue, began service in 1997; the extension to SW 264th Street opened for service in 2005. A final segment, terminating at SW 344th Street in Florida City, opened for service in late 2007.[53]

The Busway operates primarily as a feeder to the Metrorail heavy-rail system which serves the central Miami area. For those traveling to worksites in downtown Miami, an automated people mover connects with the Metrorail at the Brickell and Government Center stations, located seven and eight stops respectively from the Dadeland South station.

Busway services are considered generally economical to operate; staff at the Miami-Dade County Transit Agency report that Busway services are much cheaper per boarding, in terms of public subsidy, than the Metrorail it feeds. No data could be ascertained, though, to compare trip lengths or discretionary ridership.

Park-and-Ride facilities are located at several stations along the Busway. The three inmost stations report parking utilization rates approaching 100%, but the two farthest lots (which are both smaller) report much lower utilization rates (43.7% and 11.1%),[54] indicating the likelihood that auto travel to the inbound stations is probably seen as preferable/faster than parking at the farther stations.

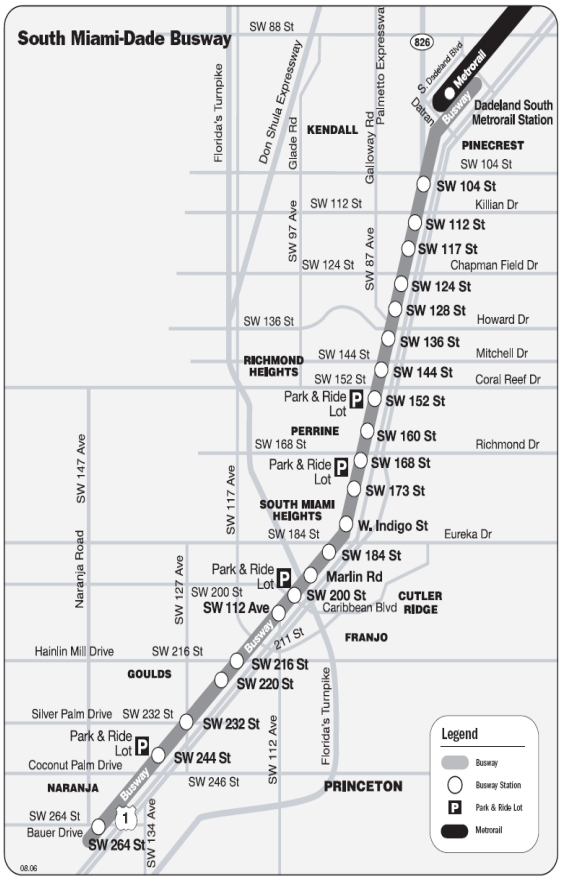


Figure 5.8
South Miami-Dade Busway Diagram.

5.2.2 Comparison to the Quickway Model

At least superficially, the South Miami-Dade Busway appears to implement many of the concepts of the Quickway Model; at the same time, other elements are missing, and they may as a result have a significant impact on the overall impact of the Busway.

Running Ways. The South Miami-Dade Busway is a T-Way operating parallel to a major traffic artery. As such, it passes through many signalized intersections. Signal-induced delay is a major factor in vehicle travel time along the Busway; effective travel speeds along the Busway are under 20 mph. Even comparing the Busway Flyer with the Busway Local service on the stretch between SW 200th St and the terminus at Dadeland South Metrorail Station shows a scheduled time savings of only 2 minutes (25 vs. 27 minutes), even though the Flyer service only makes two stops in comparison to the fourteen stops made by the Local service.

Figure 5.9
Station along South Miami-Dade Busway.

The location of the Busway, running parallel to a busy arterial, is one that generates numerous conflicts with cross traffic, including cars blocking the busway as they queue to enter or cross U.S. 1 (figure 5.10).

Of greater importance, the Busway terminates at the Metrorail station; all services feed the Metrorail, forcing a transfer to an all-stops service that itself may require an additional transfer at the destination end of a trip.

Stations. Busway stations provide some protection from the elements, but are generally not integrated into surrounding land uses. Pedestrian crossings are made at-grade. It is unknown how the stations rate aesthetically with the targeted market for Busway services.

Vehicles. Most Busway services use standard transit vehicles; Flyer services

Figure 5.10
Operational issues observed on busway. *Left*, queued cars blocking busway (which has green light); *Right*, apparently unauthorized vehicles driving on busway.

use on-the-road coaches, which are typically used for commuter services and are reported to be popular with riders. Two routes still operate minibuses. While some routes are named for the Busway, both MAX and Flyer designations are also used for equivalent limited-stop services in other corridors.

Intelligent Transportation Systems. The Miami-Dade County Transit Agency is only now in the process of outfitting intersections with transit signal priority measures, using loop detectors to determinate the presence of a bus. It is hoped that such a system will enhance system reliability and in particular reduce bus bunching, which is reported to be a problem in the northern (original) section of the Busway.

Fare Collection. No special fare collection measures are yet employed on the Busway.

Service Patterns. The service pattern on the Busway is clearly consistent with a Quickway model, though the efficacy of that pattern (and the ability to extend it to other routes) is hampered by the generally slow operating speeds dictated by the many at-grade crossings along the alignment. The service pattern in also limited by the fact that the Busway serves as a feeder to another transit service—Metrorail—which, as an all-stops service, doesn't take full advantage of its grade separation.

Figure 5.11
Busway terminus at Dadeland South Metrorail station (notice train waiting above).

A total of nine bus routes use the South Miami-Dade Busway, all with a terminus at the Dadeland South Metrorail Station. Three of these are Busway-specific routes, whereas the others use the Busway for a portion of their journey before branching out onto other arterials.[55]

The three Busway-specific routes (Figure 5.7) are emblematic of three kinds of services normally found in Quickway-based BRT systems: all-stops, express, and super-express.

- Route 31, *Busway Local*, is an all-stops service along the length of the *original* Busway; it does not continue along the recently-opened extension to SW 264th Street, but rather travels off-corridor to serve the South Dade Government Center.
- Route 34, *Busway Flyer*, is a very limited-stop "super-express" service that connects key points in Florida City before entering the Busway, where it stops at only six of the twenty-one intervening stations before arriving at the Dadeland South station, including the four park-and-ride stations. The *Busway Flyer* operates only during peak hours, at approximately every 20 minutes. The *Flyer* also differs from the other bus services using the Busway in that it uses commuter coaches

as opposed to more typical transit buses. To manage or limit crowding, *Flyer* service has a higher fare and certain service rules (for example, on the inbound journey, no alightings are permitted except at the terminal station; on the outbound journey, no boardings are permitted except at the Metrorail, or originating, station); limited stops help improve travel times, but only marginally, given the role of signal delays on the system.

- Route 38, *Busway MAX*, is a semi-express or "skip-stop" service that, like the Busway Flyer, begins off-corridor in Florida City, then enters the Busway, stopping at all stations (except for the innermost seven stations during peak hours only). Interestingly, this route deviates from the Busway near its former terminus in order to serve a major trip generator off-corridor (the Southland Mall). *MAX* services operate 24 hours and use typical 40′ transit buses.

Non Busway-specific services include routes #1, 52, 65, 136, 252, and 287.

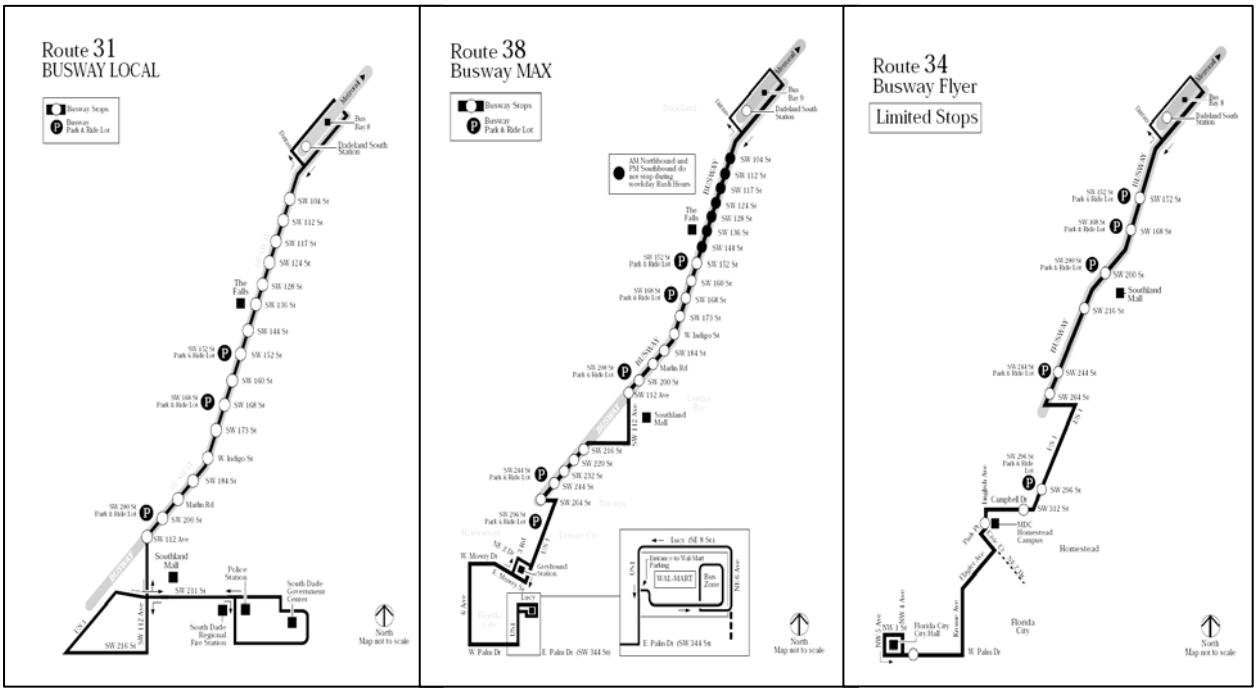


Figure 5.12
Busway-specific routes.

A good illustration of the flexibility of bus-based rapid transit infrastructure is the experience of the Miami-Dade County Transit Agency during the first year of Busway operations. There was concern among planners as to whether or not the Busway would be successful (particularly as scheduled travel times along the Busway were in fact no better than those of the route that previously ran along the parallel US 1 highway), so in an attempt to maintain relatively high frequencies at relatively modest operating costs, minibuses were employed on most routes.[56] Within a year, ridership response was robust enough to lead to a shift to standard sized buses on most routes. Articulated buses were introduced for MAX service, but these were eventually abandoned in favor of standard transit buses, but at a higher frequency.

Identity and Branding. While the Busway is certainly named, publicity and informational materials reviewed for this study did not stress any particular brand identity for the Busway or Busway services.

5.2.3 Conclusions: South Miami-Dade Busway

The South Miami-Dade Busway by all accounts is a successful BRT project; for a modest capital cost, transit ridership in the corridor has risen 184% in nine years.[57] Just the same, it deviates from the Quickway model along four salient aspects:

1. *Destinations.* The Busway does not itself deliver riders to major employment sites, but instead feeds a modal transfer to an elevated rail system that itself only partially delivers riders to an end-destination. The benefits of express or super-express service are therefore limited, as transit riders are still generally forced to transfer to an all-stops mode.
2. *Land Use.* It features limited integration into surrounding land uses or, perhaps more appropriately, surrounding land uses are not configured to optimize the value of Busway stations. This is probably a common issue in far-suburban locations, regardless of mode.
3. *Grade Crossings.* As an at-grade T-Way operating parallel to a major surface highway, cross traffic poses both significant travel delays as well as issues for operational safety. Travel times on the Busway, while faster than many on-street bus services, are still relatively slow, and stations are often not optimally located.
4. *Demand.* The combination of the three factors above serves to depress potential demand, making additional branching or express service non-viable. An infrastructure that could support significantly faster through-speeds along with direct links to principal work centers would likely create significant additional market demand (and lower the cost of providing the linkages), opening up the potential for a richer and denser mixture of services.

6. Conclusions

The preceding review of BRT planning in seven cities highlights the conditions that together lead to effective implementation of the Quickway model, as well as those conditions that lead one to the Light Rail Lite model. In some cases, the factors are positive, meaning they represent choices or options; in other cases, they are passive, representing conditions which dictate one option or another (such as relatively low passenger demand and limited capital resources driving Eugene's choice of model).

6.1 The Role of Passenger Demand

Overall passenger demand is or should be the primary criterion driving the choice of BRT model. In the case of Eugene, ridership demand even under the best of conditions is insufficient to justify much more than a relatively frequent Light Rail Lite service. In the case of Bogotá, ridership demand literally required Quickway services in order to avoid the collapse of the system. In the middle, Brisbane is within the "sweet spot"—while demand immediately surrounding the corridor could easily have been met with just a Light Rail Lite service, the strategic decision to embrace the Quickway model permitted the operation of a much denser web of services which both responded to market demand and generated new demand; the recent and dramatic growth in public transit ridership in that city is a testament to the power of the Quickway model to push transit services over a "tipping point," changing significantly the "value equation" for potential customers.

6.2 The Role of Existing Services

What role do existing transit services play in shaping a Quickway service? To what extent should services using a Quickway *supplement* or *replace* such services?

In the case of both Ottawa and Brisbane, complex transit systems, consisting of overlapping networks of service, were in place before planning for Quickways was undertaken. In the case of Ottawa, the infrastructure was seen as a catalyst for systematic, network-level analysis to devise the most *efficient* transit network possible. In the case of Brisbane, the infrastructure led less to a redesign of the transit network, but rather was seized opportunistically to re-route a range of pre-existing services so as to either make those services faster or, at least, collect them so that inter-route transfers could take place within a station environment. The end result appears less *efficient* than Ottawa's system but clearly is *effective* on both a patronage (ridership) and cost recovery basis.

The Bogotá case is strikingly different, but its genesis was also strikingly different. Unlike Ottawa, which was seeking to meet mode-split targets, or Brisbane, which "stumbled' into Quickways for political reasons but then discovered

their utility for meeting mode-split targets, Bogotá developed TransMilenio specifically to replace existing transit services, which were seen as chaotic and generating many negative externalities (such as air pollution and traffic congestion).

For most transit agencies, the development of a Quickway infrastructure *should* lead to network-level analysis of existing transit routes, especially if that infrastructure is targeted at key employment sites and serving a major regional role (in comparison, the South Miami-Dade Busway is limited to a single corridor where it feeds a line-haul heavy rail system). Since Quickway infrastructure can significantly alter the cost-performance of bus services (by reducing travel time, reducing the effects of "stop-and-go" wear-and-tear on buses, and raising additional farebox revenue due to the increased attractiveness of services to potential riders), such network-level analysis is both warranted and justified.

A related issue, particularly in the U.S. context, is the extent and degree to which an *infrastructure project* like a Quickway should or must necessarily involve the introduction of completely new services. Under current FTA practices for both New Starts and Small Starts projects, such projects, particularly if branded as "BRT," must include a specifically "branded" higher-frequency (minimum headways of 10 minutes peak and 15 minutes off-peak) BRT service. While such a requirement is a natural outgrowth of the Light Rail Lite model, it imposes a unique and unnecessary burden on Quickway projects; many corridors might be ideal for the development of a Quickway infrastructure that allows services to speed their way to many connecting corridors, but otherwise may not generate sufficient ridership in their immediate catchment area to justify a stand-alone higher-frequency all-stops service—or if they do, only enough to support such a service, and not other routes that would branch off the corridor.

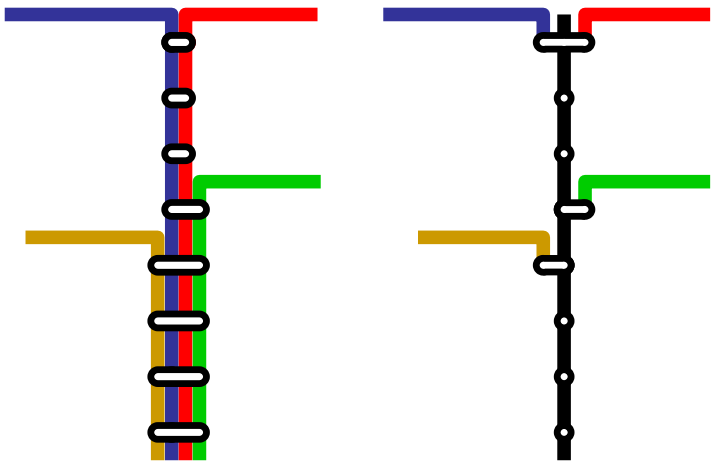


Figure 6.1
Network types.

This situation places some transit agencies in a bind; they may look to a Quickway solution in a major corridor in order to improve operating efficiency and increase ridership, but the requirement that they add a new route, with its attendant costs, may make the project (which otherwise could demonstrate cost-effectiveness on a system-wide basis) untenable.

This problem is illustrated in Figure 6.1. The network depicted on the left may represent a smaller city's implementation of a Quickway infrastructure, in which otherwise lower-frequency routes combine to create a high frequency corridor. The map on the right represents the traditional approach to BRT development in the U.S., in which the infrastructure, if there is to be any, is expected to have a high-frequency spine service, the operating cost of which may no longer

make through-routing of connecting services feasible. The result may be "easier" for a casual or first-time user, but in the end such a system imposes transfer penalties (such transfers rarely take place on the same platform) which will ultimately depress ridership compared to the faster, one-seat ride of the network on the left.

6.3 The Role of Strategy

Strategy, or more particularly strategic vision, was integral to Ottawa, Bogotá. and Brisbane. In these cases, *regional strategies* were developed that described how an infrastructure could be deployed that could then support an evolving set of services that together could meet numeric targets for transit system performance. Corridors were analyzed not so much as independent entities, as they typically are in the U.S. Federal New Starts Program, but in terms of their role within the broader network strategy.

The presence of a strategic vision is hardly "fluff;" rather, it is the key to politically generating buy-in to certain projects, or at least to the understanding of what these projects *need to achieve.* The experience of the Orange Line in Los Angeles is especially instructive in this regard; the absence of a coherent (and achievable) regional infrastructure strategy—linked to the lack of clear targets as to what transit would need to achieve in order to meet a broader set of regional goals—meant that virtually all aspects of the Orange Line's design and operating plan were up for grabs. Since it didn't *matter* if potential ridership was lost, the argument in favor of many design decisions was weakened and often lost. That the infrastructure is capable of supporting a more intense service plan is probably due more to the thoughtfulness of project staff than to any specific political or managerial dictate. And while the Orange Line may rightly be held up as an example of a successful *project*—for it is—and even one worthy of emulation—for it is that, too—it must also be understood as a much weaker example of *strategy*, one whose marginal contribution to regional goals may be insufficient in the end (though to be fair, to the extent it demonstrates latent demand for quality transit services, even those provided by BRT, it will indeed serve an important strategic purpose).

6.4 The Role of Targets

The most outstanding attribute all three global examples of the Quickway model share is how they all evolved out of the necessity of meeting ridership or mode split targets which were exogenous to the transit planning process itself. In the case of both Ottawa and Brisbane, these targets emerged from regional land use plans: if growth were to take place in certain zones, and only limited improvements were to be made in the road network serving these zones, then transit would need to achieve relatively high mode splits if the land use plans were to work. In the case of Bogotá, existing and latent demand for transit services was exceedingly high, and would overwhelm the ability of a BRT system modeled

after Curitiba's to meet without significant and sustained innovation intended to continuously increase the carrying capacity of individual corridors.

In none of the domestic examples of BRT were ridership targets a major—or even minor—factor in planning. This is not to say that ridership projections were not made; they clearly were. But in no case did targets actually serve the role of pushing system design to *need to* achieve anything. It is this lack of hard and meaningful targets on the domestic level and the absolute role of them on the international level that most stands out from this study, and it was in the response to these targets that the Quickway model emerged in the first place.

6.5 The Role of Growth

Both Brisbane and Bogotá are rapidly growing cities (Ottawa's growth, while solid, is more moderate); as growing cities, transit is able to shape trip patterns and land uses to a greater and greater degree. University of California professor Robert Cervero has previously observed that transit can shape urban form only to the extent that an urban area is growing or at least attracting significant and ongoing investment,[58] and while Pittsburgh has been successful at diversifying its economy and attracting some share of investment, it has largely over the decades lost population and ceased to be a growth center. It is perhaps for this reason that its busway system has not been the model for other American cities the way Bogotá's system in particular has served as the dominant model for cities throughout the Third World.

6.6 The Role of Branding

The Light Rail Lite model of BRT, because it tends to emphasize a bus operating in a surface treatment, depends heavily on *bus branding* to distinguish the service from standard "city bus" services. The Quickway model, however, suggests a different priority: that of branding the *infrastructure*, precisely because, in externalized systems, buses using that infrastructure may otherwise be traveling on traditional arterials in traditional bus mode. Brisbane especially has placed great emphasis not merely on branding the infrastructure with a standard logo, but with using station architecture, in particular, to establish the identity of the system. In fact, they go beyond mere *design cues* to focus on creating stations which many planners in the US would consider too lavish, certainly by the standards of typical bus stops. Again, this was a deliberate strategic decision: since the vehicles couldn't or wouldn't be distinguished from the rest of the bus fleet, stations would need to establish the tone and image of the system, and communicate the *importance* of the system to the general public.

6.7 The Role of Models and Understanding

Most cities do not develop unique responses to their transit challenges in a vacuum. One theme that emerges from this study is the role that *models from other cities* play in stimulating thought and consideration for a particular strategy in any given city; the better understood these models (particularly in terms of their specific elements), the more they were able to stimulate further innovation, as a response to the conditions in the new city. Bogotá turned to BRT because the Mayor was concerned that the Metro scheme otherwise under development would not provide sufficient system-wide benefits soon enough for the amount of money it would cost (let alone whether Bogotá could actually raise the massive amounts of capital that would have been required), so he reached to Curitiba as a model for what Bogotá could do (and then promptly reinvented BRT service in an attempt to make the model "fit" the situation of Bogotá). Los Angeles, too, reached to Curitiba, but came up with a spectacularly different application of what they learned and understood than did Bogotá. Brisbane only developed its Busway strategy after seeing it in operation in Ottawa. The list goes on.

For the Quickway model to be better understood and appreciated in the United States, more people at more levels will either need to learn about examples such as Brisbane or Ottawa or wait for an American city to successfully follow through on the full implementation of the strategy (though Pittsburgh comes close, its station strategy and CBD strategy, along with relatively conservative service planning, limit the ability of the model to produce the greatest results, and hence limit its appeal to other cities).

6.8 The Match between Models and Urban Form

When is the Light Rail Lite model more appropriate than the Quickway model? When is light rail itself more appropriate than BRT, given the choice of the Light Rail Lite model? And what conditions favor the Quickway model?

The preceding review of cities large and small offers clues for answering these questions.

1. *Corridor type.* The Light Rail Lite model is most appropriate in contexts where relatively dense corridors exist with relatively short trip lengths, and where most trips begin and end on the corridor. The service pattern thus produced matches many likely trips, and often can be produced in a cost-effective manner.

2. *Density.* If the above conditions exist but densities run high and right of way is available, rail solutions can become preferable. Rail solutions are especially preferable to BRT where at-grade operations are required and large volumes of passengers need to be transported crossing other arterials. We learn from LA that signal priority systems are most effective when bus headways are at least three-four minutes; an articulated bus every three minutes can only provide an effective throughput of under 2,000 passengers an hour per direction (and that's assuming 65′ vehicles, which are still technically illegal in most locales). Though some cities achieve much higher volumes on their at-grade BRT

systems (Curitiba is reported to move over 12,000 passengers per hour using biarticulated buses), they rely less on true traffic signal priority, employ dedicated lanes or T-Way configurations, and/or are willing to degrade the performance of traffic in favor of buses. If, however, grade separation is possible and significant demand for transit is located beyond potential station locations, then the Quickway model could be preferable to most rail alternatives.

3. *Dispersion of origins.* The Quickway model is most appropriate when the opportunity exists to deliver people directly and rapidly to major destinations from generally dispersed origins. Given that most American cities can be described in terms of "dispersed origins to multiple destinations," the Quickway model likely has widespread applicability to US urban areas.

4. *Corridor conditions.* Quickways are preferred over freeway-based solutions for BRT when located in zones that generate potential ridership (and hence can support stations) and when the highest degree of reliability is required (particularly noteworthy if the "wedge" of land being served by branching services is capable of generating significant ridership).

5. *Total demand.* Quickways are generally only warranted in environments capable of generating a large number of bus trips, at least during the peak period. Unlike Light Rail Lite or rail lines, which could in a large metro area conceivably be justified in a plethora of corridors, cities that develop Quickways can focus these investments more tightly and then rely on T-Way or even simpler transit priority measures on corridors that feed the Quickways.

6. *Demand for express services.* Quickways are also warranted in metro areas that would gain from express and super express services that will want to stop at multiple destinations.

7. *Volume.* Quickways should also be explored in corridors with existing significant transit volumes, as Quickways have the potential to dramatically lower operating costs (by speeding services). *With Quickway infrastructure, the capital investment is intended to produce an ongoing revenue benefit.* This benefit results from both lower operating costs and increased ridership (hence fares). Analysis of Quickway alternatives must take this dynamic into account.

8. *Internalized vs. Externalized systems.* Within the Quickway model, the choice of externalized or internalized operating schemes is a function of the ability to provide adequate specialized infrastructure (i.e., rights of way and specially branded vehicles). In the case of Brisbane, this would not have been possible, given the multitude of corridors that feed into their Busways; in the case of Bogotá, it represented a deliberate strategy that understood the role of infrastructure in meeting practical needs for high capacity and operational efficiency.

9. *Hybrid service opportunities.* It is indeed possible to create hybridized internalized/externalized transit networks. Brisbane, for example, has built a Busway-style station in Springwood, several kilometers to the south of the terminus of the Southeast Busway, extending the brand image and service pattern beyond the core infrastructure. Particularly in cities where buses are viewed as "second class," it may make sense to use specialty vehicles for services that rely in great part on the Quickway infrastructure, and develop Quickway-like stations or stops off-corridor in order to distinguish the services from more tradi-

tional services. Other buses could still share the same Quickway infrastructure, but would be perceived as opportunistic as opposed to strategic uses of the Quickways.

10. *Role of corridor in network.* Light Rail Lite, much as Light Rail, is manifestly a *corridor* strategy, and so may prove useful in single corridors in a metro area. The three international cities reviewed here that adopted the Quickway model saw it as an *infrastructure strategy* that could then support a high-capacity and cost-effective service plan. In other words, the infrastructure could support a network plan in which much of the ridership along any one Quickway might actually be attracted far off the alignment itself. This is why, for cities interested in exploring the Quickway model, the first step must be that of developing and testing a Quickway network plan, much as was done for Ottawa, Brisbane, and Bogotá, identifying the set of infrastructure projects that together could achieve whatever numerical goals (e.g., ridership, mode share, or economic performance) needed to be achieved.

This is not to say that the Federal Alternatives Analysis process, with its emphasis on corridor-level analysis, would need to be abandoned. Rather, the fact of an integrated network strategy would permit in any one corridor a more appropriate review of a properly configured Quickway alternative compared to other alternatives; since the infrastructure strategy would almost certainly identify the larger set of corridors that would be expected to feed services into any one Quickway project, the AA process would have an effective starting point for comparing the overall performance of the project to competing alternatives.

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7. Recommendations for Practice

The Quickway model has clearly produced benefits for cities such as Ottawa and Brisbane that resemble, in many ways, their U.S. counterparts; even Bogotá's experience is of value to U.S. cities. But for these benefits to be realized, different actors involved in planning major transit projects will need to familiarize themselves with the dimensions of this new mode and make adjustments to existing planning policies and processes.

7.1 Federal Level

Planning for major transit capital projects in the United States is often driven by the requirements for funding under the Federal Transit Administration's New Starts program (and its relatively new sibling, the Small Starts program). The FTA can encourage the exploration of Quickway concepts (and, in the light of international experience with the model, *should* encourage such exploration) in many notable ways.

1. *Recognition of mode.* Quickways should be identified as a distinct *mode* of transit, essentially distinct from the Light Rail Lite model of BRT. As a distinct mode, however, proper attention could and should be paid to Quickways in the Alternatives Analysis (AA) process.

This point bears emphasizing. Quickway infrastructure is typically far more expensive than surface BRT treatments, be they in mixed traffic or segregated T-Ways; on the other hand, the potential travel time savings and increase in corridor carrying capacity imply opportunities for a multi-layered route structure that typically goes beyond the more basic route-level planning associated with more traditional modal alternatives. As a result, a properly-developed Quickway alternative should be significantly different than a "BRT" alternative derived from the Light Rail Lite model.

2. *Support for network-level planning.* Network-level planning should be encouraged in metro areas large enough to support a reasonably high level of transit service. Currently, FTA involvement in transit planning is focused almost entirely at the corridor level; as a result, many regions pay short shrift to system-wide planning, instead allowing the corridor-level AA process to dictate actual modal alternatives. The foreign example of Ottawa is an example of why this makes good planning and funding sense: had the FTA's New Starts process been applied to Ottawa, it is almost a certainty that a properly qualified LRT alternative could have emerged in any one of its principal Transitway corridors. However, because Ottawa conducted a systematic network analysis, it was able to identify and specify the ways that a Quickway infrastructure could support a redesign of its bus network (less likely under a purely corridor-level analysis), and hence could therefore demonstrate significant *network* benefits to a Quickway strategy.

3. *Support for improved alternatives development.* The FTA should support demonstration projects for Quickway alternatives development. Since few transit planners in the United States are familiar with the dimensions of the Quickway model (Pittsburgh's busways, as an example, come close to the model, but fall short at the level of station branding and network design), the FTA can play a major role in helping willing regions explore the concept in a meaningful way.

4. *Flexible funding criteria.* Funding criteria should embrace network-level improvements. Current transit infrastructure funding programs emphasize corridor-level projects, which is appropriate to rail systems but not to bus-based rapid transit systems. Cities such as Brisbane and Ottawa have developed phased infrastructure plans in which different pieces of a network may be built at different times, prioritized by the immediate benefit they offer the system. One corridor, for example, may consist of "permanent" and "temporary" capital improvements, with some elements vital in the short term and others not required for decades. To the extent Federal funding policy discounts or limits funding for such strategies, it misses the opportunity to achieve potentially higher returns on its capital investments at less general risk than most New Starts projects.

5. *Additional technical study.* The FTA might wish to sponsor and publish further technical study of the Quickway model. In particular, a more in-depth comparative study of the Ottawa and Brisbane systems could shed additional light on the most effective planning methodologies and processes for Quickway system development. This study should aim at a domestic process for Quickway Alternatives development as an input into corridor-level Alternatives Analysis projects, let alone network-level analysis.

6. *Improved operating cost modeling.* The FTA might wish to further support research into proper cost-modeling for Quickway-based systems, as well as sponsor market research to identify market responsiveness to Quickway infrastructure and services. Such research would be most valuable if it is able to suggest coefficients appropriate to the specific analysis of Quickway alternatives in regional modal split models (such as modal utility, in-station transfer penalties, and network-level impacts on individual trip mode choice[59]).

7. *A more competitive alternatives generation process, including the adoption of mode split targets.* As a means of further improving the development of alternatives for the AA process, the FTA might consider the development of a process for supporting the *competitive development* of such alternatives. Since the Quickway model evolved from the attempt of different cities to meet specific targets in the most cost-effective means possible, it stands to reason that a competitive AA process could also lead competing teams to innovate and sharpen the alternatives they develop. Such a process would almost certainly lead to the development of new Quickway-based proposals in at least some U.S. cities.

7.2 Metropolitan Planning Organizations (MPOs) and Public Transit Agencies

MPOs and transit agencies involved in the development of transit infrastructure projects can benefit from an improved understanding of the Quickway model

and a deeper knowledge of how to exploit the model's features for their respective regions.

1. *Develop mode-split targets.* MPOs should consider the development of transit mode split targets as a function of land use plans. These targets should organize and focus long-range transit planning, and would also serve the needed use of testing and identifying limitations in their Regional Travel Model (the experience of several cities is that these models may inaccurately underproject transit's potential to attract new riders to an extent not warranted by actual data[60]). Mode split targets are most effective when applied at screen lines and when driven by either projected demand for transit or (more likely) by the projected deficiencies in the automotive system's ability to provide connectivity within acceptable standards.

2. *Improve network-level analysis and planning.* MPOs and transit agencies should improve their ability to conduct network-level analysis in which network alternatives are developed and studied in some detail. This kind of analysis could be incorporated into the processes for developing Regional Transportation Plans, though they would tend to be more complex and systematic than the processes used to screen proposed projects in an RTP.

3. *Learn from and about the Quickway model.* MPOs and transit agencies should familiarize themselves and their key constituents/stakeholders with the dimensions and requirements of successful Quickway-based systems so as to better support the alternatives development process.

4. *Embrace high-level market research.* MPOs and transit agencies should also consider contracting for specific market research to test public acceptance of and reaction to Quickway concepts and infrastructure as a means both of driving system design and gauging potential ridership.

7.3 Planning and Engineering Firms

Though they belong to the private sector, planning and engineering firms set the basic tone for the planning of transit infrastructure projects in the United States, particularly at the level of alternatives development to feed into the Alternatives Analysis process. To better understand and take advantage of the Quickway model, such firms should consider the following.

1. *Become familiar with the Quickway model.* Firms should familiarize themselves with the Quickway model, particularly with the specific technical issues involved in the design of Quickway infrastructure, the role and importance of stations, issues regarding ongoing operating costs of vehicles and infrastructure, and issues related to ridership demand and customer acceptance issues.

2. *Explore Quickway Service planning concepts.* Firms should become more expert in the kinds of service planning that characterize the international Quickway examples cited in this report. Of particular note, the use by these systems of overlapping networks made up of multiple service types is a central concern, as is that of matching origins with likely destinations.

7.4 Final Thoughts

To sum up the preceding points, the effective implementation of the Quickway model calls for the following steps or elements.

1. *Targets.* The adoption of targets, whether for ridership or mode share, is a powerful inducement to focus planning efforts on devising the most effective service plan, and hence lead to the appropriate specification of infrastructure. It takes considerable work to design an effective service plan, which may be one reason why such plans have been few and far between.

2. *Infrastructure strategy.* Quickways represent an *infrastructure strategy*, and hence are less likely to prove useful if developed solely on a corridor-by-corridor basis. This is not to say that the Alternative Analysis process need be bypassed, but rather that an integrated regional application of a Quickway model will yield precisely those corridors where Quickway infrastructure can support the kind of service plan that can generate the ridership that can justify the investment (and it is *these* proposed corridors that can be then tested in an AA process).

3. *Regional growth.* Quickways can begin to shape an urban area only to the extent that they provide a perceived and significant benefit, and that the region as a whole is growing. The Light Rail Lite model may be more appropriate in environments where capital investment cannot be justified at the scale necessary to produce benefits, however valuable those benefits may be.

4. *Stations as branding.* The Quickway Model benefits from branding, but such branding is more focused on the infrastructure than on the services. Station design and configuration in particular are the key means for establishing a brand identity and system image.

5. *Modeling challenge.* When devising and assessing the performance of Quickway alternatives, it may be necessary to go beyond ridership projections, as few models are able to capture some of the potential benefits of such alternatives without specific and expensive dedicated market research. Other evaluative measures, such as projected travel time savings and impacts on operation and maintenance costs, should also be employed as significant measure of user and system benefits.

6. *Network planning.* While Quickways are compatible with corridor-level Alternatives Analyses, the development of *competitive* Quickway alternatives should follow a network-level analytical process; corridor-specific Alternatives Analyses can then examine how the infrastructure proposed for that corridor compares to other alternatives.

Quickways are not merely a graduated step-up in BRT-supportive infrastructure, nor are they a precursor or stepping stone to light rail systems; they imply their own logic on system design and operations and make possible services that otherwise would not be cost-justifiable. They should be treated as a distinct mode, particularly for network and corridor-level planning, and one with great potential for helping American cities achieve phase shifts in the role that transit plays in their daily lives and long-range growth.

Appendix

Application of the Quickway Model to an American City: San Diego and the *FAST* Plan

Can the Quickway model be applied fully within the United States? Given that there are no full-fledged examples of this mode within the U.S., the first question is whether such a model could be designed, configured, and priced to match an American city—its trip patterns, urban form, physical and topographical constraints, and reasonably expected transit capital and operating resources.

Many modal innovations in public transit arise not from within the industry itself (or its governmental counterparts), but from private individuals and organizations that become familiar with such innovations internationally and then work toward raising the possibilities for domestic application. Examples of this include former California State Senator James Mills, often credited with being the "father of light rail" in the U.S., and Los Angeles-area architect Martha Welborne, who played a major role in bringing the concept of Bus Rapid Transit to fruition in the U.S.

Move San Diego, Inc., is a non-profit organization that emerged from a set of agreements between San Diego's land development and environmental communities, dedicated to the promotion and wide scale adoption of alternatives to private passenger automobiles within San Diego County. This County, with a population slightly above three million residents, borders on the Mexican city of Tijuana, with its two million residents, creating the largest binational city on the planet.

Move San Diego assembled an international team of transit planning experts to develop a new regional public transit plan, building off the Global Best Practices discussed earlier in this report. This team included several of the professionals responsible for planning and developing both Brisbane's and Ottawa's Quickway systems, as well as an engineering firm with extensive domestic experience in designing bus facilities in the U.S. The author served as project leader.[61]

The team began by reviewing a major market research study commissioned by the former Metropolitan Transit Development Board (MTDB) in 1999, which was conducted by Cambridge Systematics, Inc., with the assistance of The Mission Group. This study identified six primary market segments in the San Diego region, each of which was found to respond to a different set of cues when it came to mode choice. However, a number of overall generalizations were drawn from this study.

1. *Speed.* Transit services would need to be significant faster if they were to appeal to four of the six market segments. San Diegans across the board valued their time more so than had been expected.

2. *Experience.* Special attention would need to be paid to upgrading the customer experience associated with transit services.

3. *Walking.* Station location mattered more than had previously been thought, with much of the market responding to even minor improvements in walking distance.

4. *Coverage.* The decision to use transit was not only a function of the viability of transit for that particular trip, but of subsequent trips that that person might wish to make (that is, system extensiveness counted).

Following this review, the team reviewed origin/destination data for the region, focusing on its major employment centers. Maps were drawn depicting these desire lines, using a projected data set supplied by the San Diego Association of Governments (SANDAG). These maps confirmed that movement patterns in San Diego were highly dispersed, and could be characterized as a "dispersed origins to multiple destinations" network problem.

These maps were also compared with existing transit services, both bus and light rail. Both networks were found to provide some but nonetheless limited opportunities to attract significant additional ridership. It was further found, though, that many bus routes could be re-routed in such a manner that they could better serve commute trips, should the appropriate infrastructure be provided.[62]

The team then set about attempting to identify whether a Quickway infrastructure could be configured to support the trip patterns identified above. An "urban spine" was identified, running from Kearny Mesa in the north to Downtown in the south, via Mission Valley and Hillcrest, that linked many of the principal employment sites and other key destinations in the central region. From Kearny Mesa, a branch to the North County coastal region emerged, serving the Golden Triangle region; another branch moved along the I-15 corridor northward, where it would take advantage of the managed lanes then under development in that zone; and a connecting alignment along the north provided direct service into the heart of Sorrento Mesa, San Diego's major high tech zone.

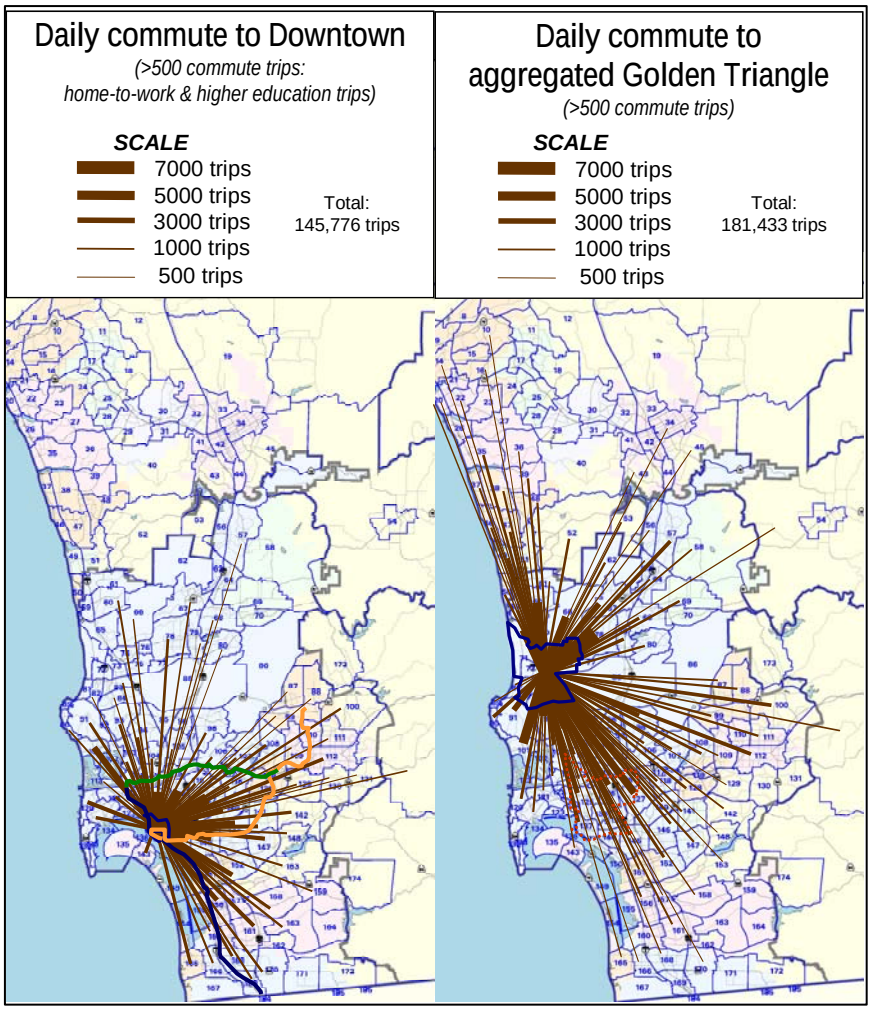


Figure A.1
Trip pattern analysis to two regional job centers. Downtown map (left) shows existing light rail lines superimposed.

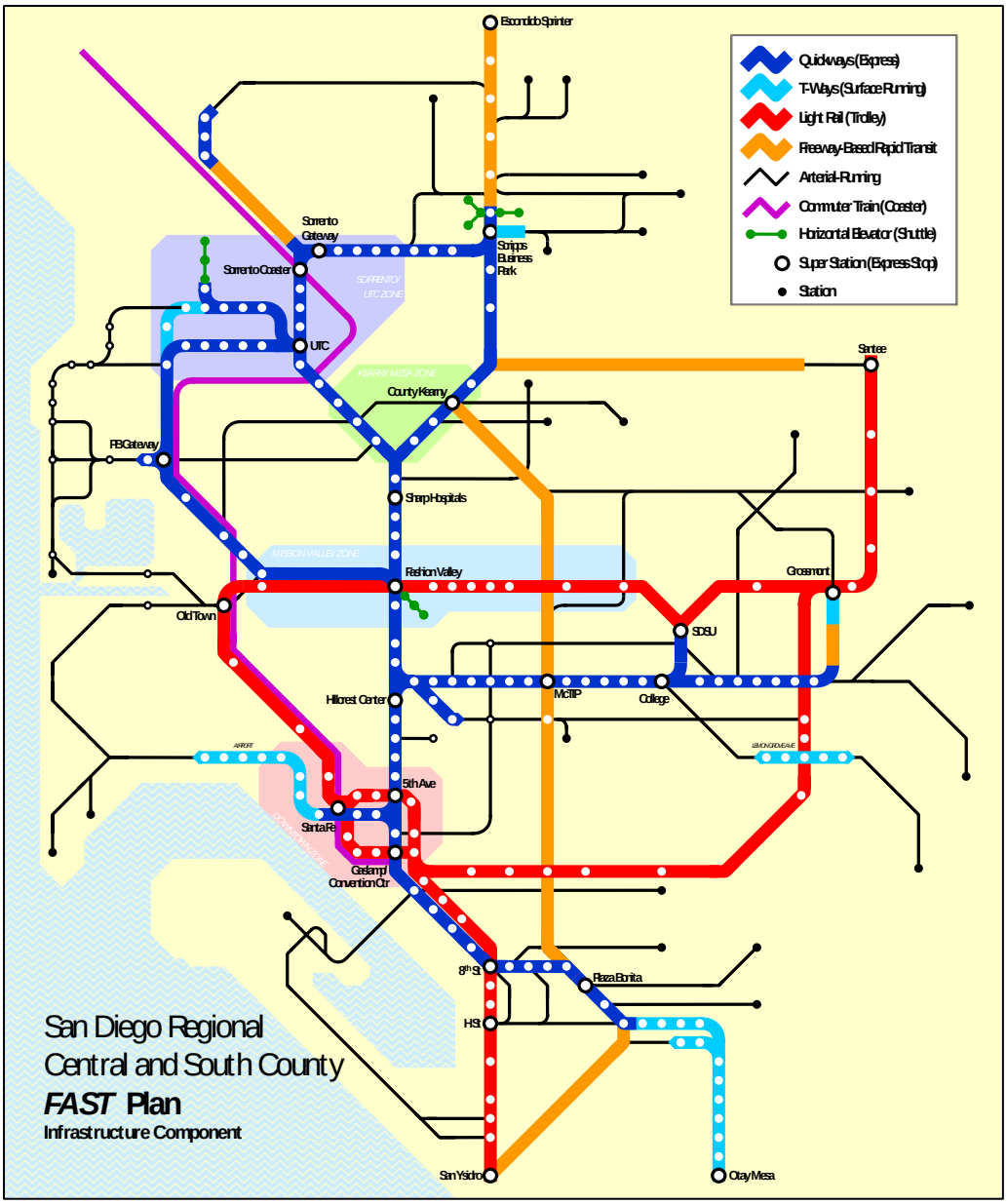


Figure A.2
The infrastructure map of the *FAST* Plan as of late 2007, showing proposed Quickway and related bus and rail infrastructure. The Quickway section running north/south from Kearny Mesa to Downtown (just north of the Sharp Hospitals station to the Gaslamp/ Convention Center station) becomes the central spine of the system.

Capital cost and feasibility analysis was performed on an earlier draft of this plan; notable posterior changes include the extension of infrastructure through Mid-City (east of the McTIP station), the rerouting of the South Bay Quickway through National City, and the reconfiguration of infrastructure in the Golden Triangle. These changes would be expected to increase the total capital cost of the Plan.

A coastal alignment was also identified from the Golden Triangle/UCSD area south to Mission Valley, whose purpose was primarily to connect into the various beach communities (La Jolla, Pacific Beach, Mission Beach, and Ocean Beach); a branch through Mid-City provided service into this population-dense heart of the metro area; and a branch south/southeast to the international border provided connectivity into the rapidly developing southeast suburbs.

Given the highly-developed nature of some of these alignments, grade separation would require extensive tunneling (both cut-and-cover and bored segments) in certain locations; in other locations, it would be relatively easy to provide or colonize surface alignments that were free of cross-traffic. A first draft of the infrastructure plan was analyzed by the team's engineers for basic feasibility,

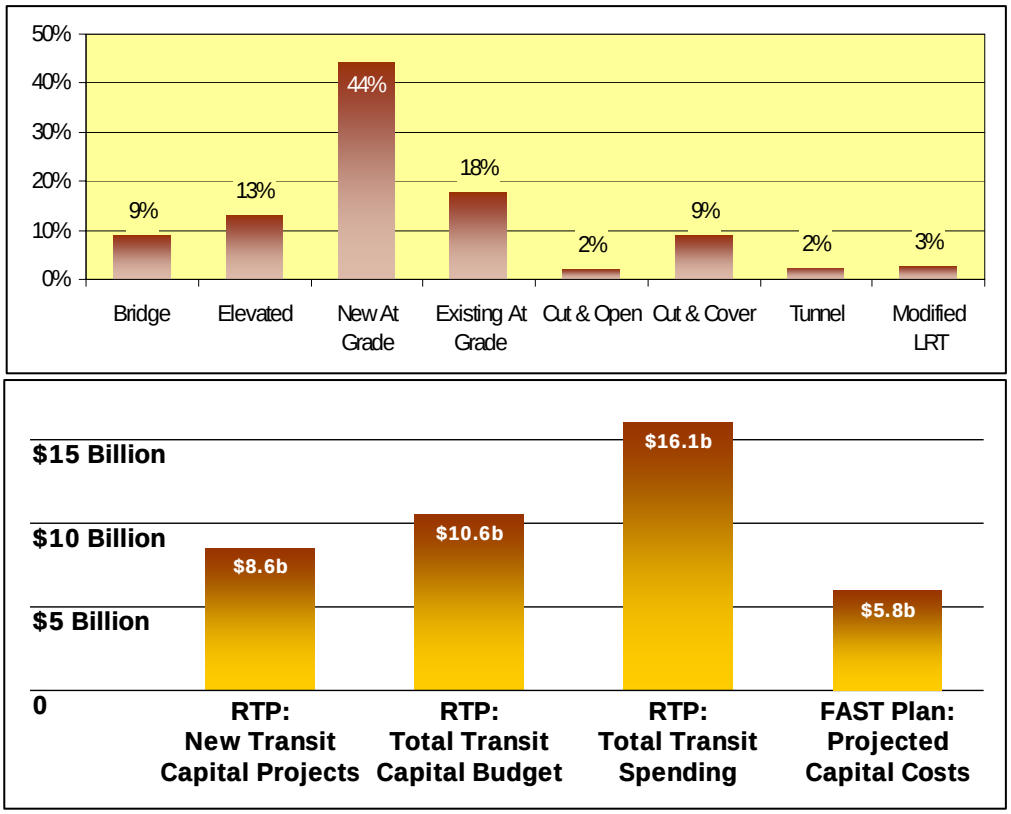


Figure A.3
Above, Infrastructure components of the first draft of the *FAST* Plan as a percent of total guideway length. *Below*, Projected capital costs compared to transit projects in the 2003 Regional Transportation Plan. Subsequent changes to the plan will have significantly increased the percent of infrastructure in cut & cover tunnels (and hence costs). These changes were made, though, in response to encouraging signs of potential ridership gains and operating efficiencies.

and a conservative cost model, with healthy contingencies, was developed for purposes of deriving a total price tag for the project.[63]

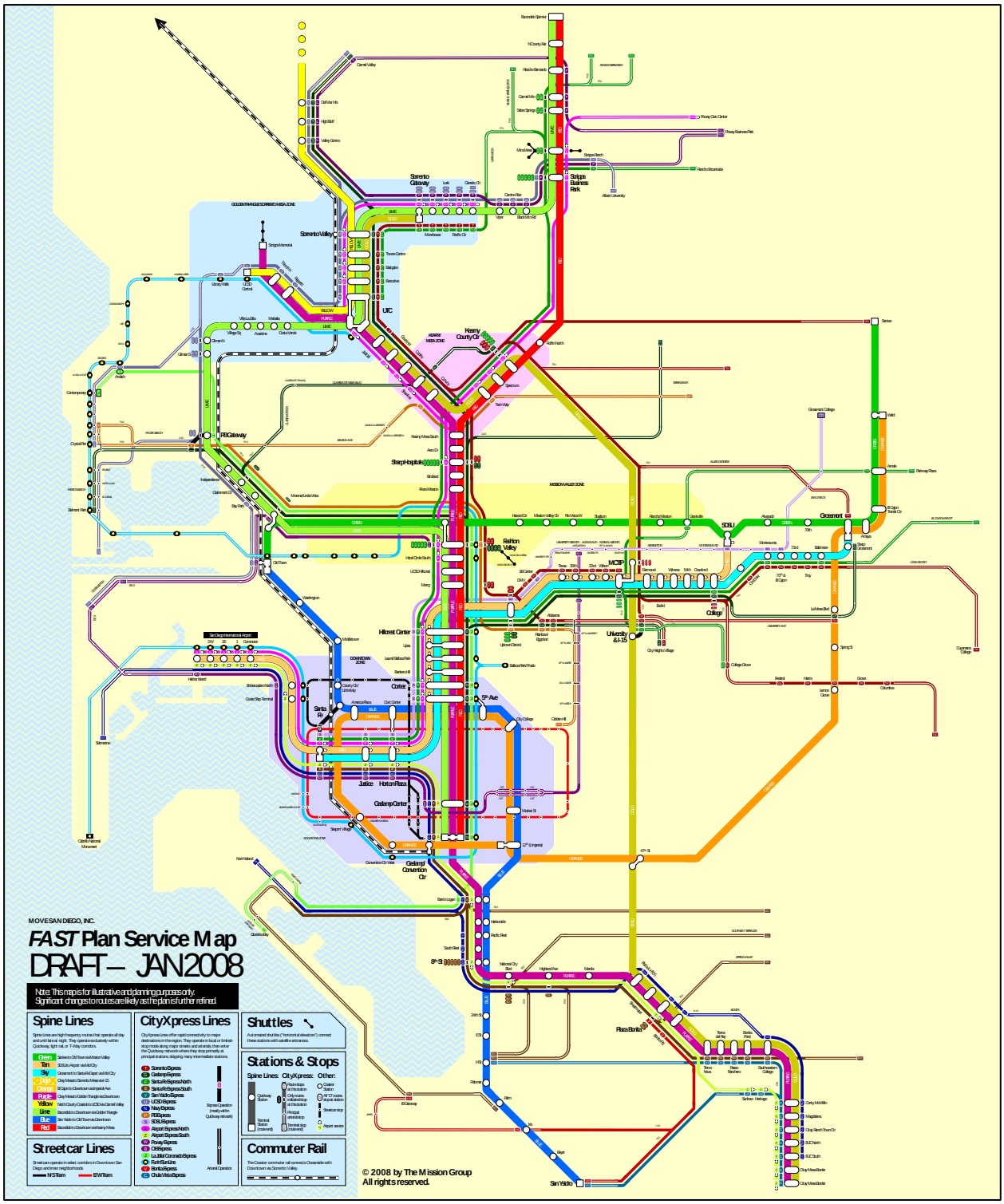
The first draft's total capital cost was projected at $5.8 billion[64] (in 2006 dollars); which fit well within the 2003 Regional Transportation Plan's $8.6 billion in new transit capital projects; subsequent work on the plan has added, extended, or modified a number of segments, likely raising the total price by $1-2 billion, but significantly extending the reach of the network and potentially adding significant value to the plan.

The current plan covers only Central and South County, Move San Diego is planning to conduct a North County planning exercise to determine whether the plan's elements can work as well in the different environment of North County. Still, the plan, dubbed the *FAST* Plan (Financially Affordable, Saves Time), has passed the first test for capital affordability.

The infrastructure component of the *FAST* Plan was complemented by a service plan composed of a number of distinct route types:

1. *Spine routes*, an *internalized* network operating entirely within Quickway or T-Way infrastructure, operating in all-stops mode. These "core lines" include the existing light rail lines. Seven BRT Spine Lines complement the three LRT Spine Lines in the total network.

2. *CityXpress Routes*, and *externalized* network which mostly begin as local or limited-stop routes along arterials, then enter the Quickway infrastructure and operate in limited-stop mode until reaching a major destination zone.


MOVESANDIEGO, INC.
FAST Plan Service Map
DRAFT – JAN2008
Note: This map is for illustrative and planning purposes only. Significant changes to routes are likely as the plan is further refined.
Spine Lines
Green Santee to Old Town via Mission Valley
Tan SDIA to Airport via Mid City
Sky Grossmont to Santa Fe Depot via Mid City
Blue Clay Mesa/Genesis/Miramar 15
Orange El Cajon to Downtown via Imperial Ave
Purple Clay Mesa to Golden Triangle via Downtown
Yellow North County Coastal to LJCD via Carmel Valley
Lime Sorrento to Downtown via Golden Triangle
Blue San Ysidro to Old Town via Downtown
Red Sorrento to Downtown via Kearny Mesa
Streetcar Lines
Streetcars operate in select corridors in Downtown San Diego and inner neighborhoods.
NS Tram
EW Tram
CityXpress Lines
CityXpress Lines offer rapid connectivity to major destinations in the region. They operate in local or limited-stop mode along major streets and arterials, then enter the Quickway network where they stop primarily at principal stations, skipping many intermediate stations.
1 Sorrento Express
2 Gaslamp Express
3 Santa Fe Express North
4 Santa Fe Express South
5 San Ysidro Express
6 LCDD Express
7 Navy Express
8 PB Express
9 SDIA Express
A Airport Express North
B Airport Express South
C Poway Express
D Otay Express
E La Jolla Colonnade Express
F Point Loma Express
G Bonita Express
H Chula Vista Express
Express Operation (mostly within Quickway network)
Airport Operation
Shuttles
Automated shuttles ("horizontal elevators") connect these stations with satellite entrances.
Stations & Stops
Spine Lines:
Terminal Station (inclusive)
CityXpress:
Drop-stops at Transition
Only stops outside stop at Transition
Drop-off and stop
Terminal stop (inclusive)
Other:
Cluster Station
All 12 routes stop at station
Elevator stop
Airport service
Commuter Rail
The Coaster commuter rail connects Oceanside with Downtown via Sorrento Valley.
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Sorrento Gateway
Sorrento Valley
UTC
Kearny County Ctr
PB Gateway
Sharp Hospital
Rancho Bernardo
Scripps Business Park
Rancho Penasquitos
Carmel Valley
Del Mar Hts
Rancho Santa Fe
Poway Ctr
Poway Business Park
Mira Mesa
Scripps Ranch
Alliant University
Scripps Memorial
Library Walk
LCDD Central
Villa La Jolla
Mobile
Austine
Clairemont
Balboa
Cortemporo
Cyclotron
Balboa Park
Mission Valley
Fashion Valley
Hotel Circle South
LCDD Rental
Mary
Old Town
Washington
Hillcrest Center
Uptown
Laurel Balboa Park
Balboa Hill
Middleton
Cortez
County Ctr Little Italy
America Plaza
Civic Center
Santa Fe
Cruise Ship Terminal
Harbor Island
Shelter Island
Sunset
Cabrillo National Monument
Justice
Horton Plaza
Gaslamp Center
Seaport Village
Gaslamp Convention Ctr
Convention Ctr Hotel
Barrio Logan
Chollas Way
Nestor
Imperial Beach
Tech Way
Spectrum
Mission Valley Ctr
Rio Vista W
Qualcomm
Rancho Mission
Grantville
SDSU
Alvarado
Grossmont
Grossmont College
Amaya
Rancheria Park
El Cajon Transit Ctr
Montezuma
Third
Fairmount
Texas
30th
32nd
Villa
Sixth
Crawford
MCIP
College
University & I-15
City Heights Village
College Grove
Rolando
Hamilton
Lemon Grove
Chollas
Spring St
Cuyamaca College
Harbor Drive
Harbor Bayshore
Upscale District
Nature Walk Preab
Cedar
5th Ave
City College
Golden Hill
Market St
12th & Imperial
6th St
National City Blvd
Highland Ave
Mesa
Plaza Bonita
Terra Nova
Rancho Penasquitos
Sabre Springs
Sabre Heights
Carmel Mtn Ranch
Mira Mesa
Miramar
Miramar Ranch
Scripps Ranch
Alliant
Rancho Bernardo
Poway
Sorrento Valley
Sorrento Mesa
Pacific Rim
Sorrento Mesa
Pacific Rim
Sorrento Valley
Carmel Valley
Del Mar Hts
Rancho Santa Fe
Poway Ctr
Poway Business Park
Mira Mesa
Scripps Ranch
Rancho Bernardo
Alliant University
Sorrento Gateway
Sorrento Valley
UTC
Kearny County Ctr
PB Gateway
Sharp Hospital
Rancho Bernardo
Scripps Business Park
Rancho Penasquitos
Carmel Valley
Del Mar Hts
Rancho Santa Fe
Poway Ctr
Poway Business Park
Mira Mesa
Scripps Ranch
Alliant University
Scripps Memorial
Library Walk
LCDD Central
Balboa Park
Mission Valley
Fashion Valley
Old Town
Washington
Hillcrest Center
Cortez
Santa Fe
Harbor Island
Shelter Island
Sunset
Cabrillo National Monument
Justice
Horton Plaza
Gaslamp Center
Seaport Village
Gaslamp Convention Ctr

fied route structure" has long been considered a desirable element of BRT planning, in Quickway planning it becomes less of a concern: Spine services provide the "easy to understand" introduction to services for new riders, but the more complex CityXpress services provide the daily travel time savings and flexibility that retains riders.

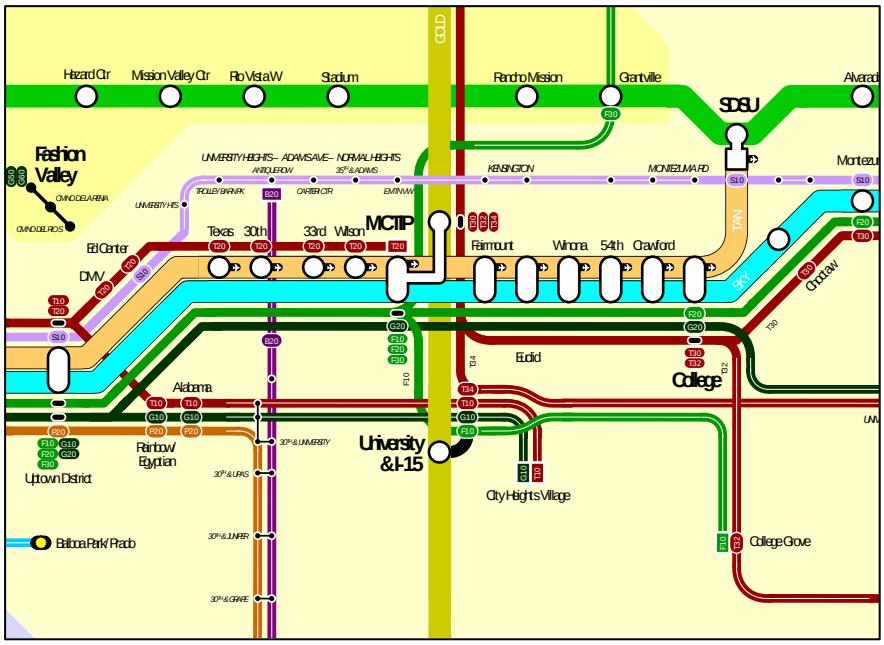

Figure A.5
Zoomed-in view of section of draft route map, showing Spine Lines (thicker lines) and CityXpress routes. CityXpress routes operating along arterials are depicted by a thin white line in the middle of the colored line; when operating in express mode, the lines are solid. CityXpress routes are further grouped by destination: all T routes serve the Sorrento Mesa technology center, all G routes terminate at the Gaslamp station, all S routes serve San Diego State University, and all F routes terminate at the Santa Fe Depot downtown.

In the draft *FAST* Plan map, most zones of the Central/South County are served by CityXpress routes which operate in arterials, then use (primarily) the Quickway network to connect to the principal employment zones and other major destinations. Spine services provide all-day high-frequency connectivity along Quickways, and specialized lines serve airport trips and the tourism market. The *FAST* Plan anticipates further refinement of the transit route network as modeled data is reviewed.

Stations for the *FAST* Plan were initially modeled along the lines of Busway stations in Brisbane, but a new station type—the Super Station—emerged in the planning process. These are spaced along Quickways on *average* every three to five miles, which serve all routes passing through, including CityXpress and Spine Lines. These are where many transfers would be expected to take place. They are mostly located at very major destinations, though there are a few exceptions.

Super Stations work especially with CityXpress routes to create a unique regional rapid network in which many if not most CityXpress routes intersect most other such routes, providing very extensive regional coverage in an express framework—something that would prove impracticable with the existing light rail network.

The *FAST* Plan has been going through continuous refinement since the initial infrastructure draft was produced in the Spring of 2006. In the Fall of 2007, an operational analysis was conducted of the second draft service network to ascertain ridership and operating cost impacts of the plan.

This analysis was performed using 2003 and 2030 trip tables supplied by SANDAG, though only transit trip tables (as opposed to total trip tables) were available in time for the analysis. The major impact of this limitation was to depress likely ridership among trip pairs that currently have poor transit connectivity (and that would enjoy competitive transit connectivity in the new plan), so the operational analysis was designed more to help guide continued service re-

finement and ascertain a lower bound on the *FAST* Plan's operating performance.

The operational analysis generally confirmed the viability and efficiency of the Quickway model as applied in the *FAST* Plan to San Diego. The analysis projected a nearly trebling of transit use (again, this projection was made using only an incomplete data set), though with a per-passenger operating subsidy significantly less than that of the current bus system and also less than that of the current light rail system. Certain Quickway segments (namely, the Quickway connecting Downtown with Mission Valley, and the "Broadway Extension" downtown) were projected to carry the highest ridership of any transit infrastructure in the County. What's more, these projections were made on a network that was not yet optimized (for frequency, service span, and routing); such refinements would be expected to significantly reduce projected operating subsidies, further highlighting the ability of a Quickway infrastructure to change the operating cost structure of transit services.

Move San Diego is continuing to refine and update the *FAST* Plan, even as discussions have begun with and among regional leadership regarding plan adoption. Still, the *FAST* Plan, having been developed by a team with international experience in Quickway design and implementation, and vetted by an engineering firm familiar with U.S. requirements, is a domestic proof-of-concept that the Quickway model may indeed be cost-effectively applied to American cities with the potential for significant, positive impacts.

Notes

[1] While it is true that the Quickway model relies on buses, it is as much a distinct mode as Light Rail Lite is from "city bus" service in that the interaction between infrastructure and services implies a distinct approach to planning and operations.

[2] Pittsburgh's Busways come the closest to this model within the U.S., but differ primarily in the attention paid to station design, pedestrian crossings, the provision of downtown infrastructure, and in the extensive use of interlining to gain operational efficiencies, a key virtue of Quickway-based systems.

[3] See, for example, Gabrielle Birkner, "Answers to City's Traffic Woes Could Arrive Via Bogotá," *New York Sun*, October 12, 2006.

[4] See especially Roderick B. Diaz, editor, *Characteristic of Bus Rapid Transit for Decision-Making*, U.S. Federal Transit Administration, 2004.

[5] V R Vuchic, *Urban Public Transportation: Systems and Technology* (Prentice Hall: Englewood Cliffs, NJ), 1981.

[6] Pittsburgh's Busways would not qualify as full Quickways under this definition, as pedestrians cross at-grade within many stations, limiting top speeds through these stations.

[7] This framework, published in the previously cited CBRT document, is also discussed clearly in Mark A. Miller, Graham Carey, Ian McNamara, and Sam Zimmerman, "Development of Bus Rapid Transit Information Clearinghouse," California PATH Research Report (Berkeley: Institute of Transportation Studies, University of California, Berkeley), May 2006.

[8] James Mills, letter to the editor, *San Diego Union-Tribune,* March 15, 2001.

[9] The author developed this framework for a long-range strategy study undertaken for the San Diego Metropolitan Transit Development Board (MTDB) in 1999. It was subsequently published in William Lieberman, David Schumacher, Alan Hoffman, and Chris Wornum, "Creating a new century of transit opportunity: strategic planning for transit," *Transportation Research Record 1747*, 2001, pp. 60-67.

[10] The elimination, or reduction, of transfers is a major benefit of the Quickway model. The literature on modal choice generally finds a fairly significant penalty that potential customers assign to transfers; some regional travel models assign a specific penalty for the fact of a transfer, others instead weight average transfer waiting time. Still, the elimination of a transfer can have as dramatic a positive impact on ridership as many far more expensive measures.

In addition, the environment in which a transfer is made, and the ease of such transfer, may also be a factor having some influence on a person's ultimate choice of mode.

[11] Both Brisbane and Bogotá have documented peak ridership exceeding that of any light rail system in North America, and Ottawa matches that of the highest-volume light rail system.

[12] Source: www.ottawakiosk.com/people.html. Accessed on September 9, 2007.

[13] For this and other data/background on the Ottawa system, the author is indebted to Mr. John Bonsall, former General Manager of the OC Transpo system in Ottawa.

See also John Bonsall, "Implementing BRT: The Results," presentation to the TRB/APTA 2004 Bus Rapid Transit Conference.

[14] A review of newspaper articles from Ottawa and discussions with planners familiar with the on-again, off-again light rail plan suggest that, unlike the original planning efforts which led to the development of the Transitway system, recent planning has been driven less by the need to achieve targets and far more by political concerns.

[15] Colin Leech, head of OC Transpo's long-range planning section, quoted in Robert Cervero, *The Transit Metropolis: A Global Inquiry* (Washington, D.C.: Island Press), 1998.

[16] As reported by Tommy Au, David Nguyen, and Demetri Prevatt, "16th Avenue North: The People's Corridor," 16corridor.com/case.html. Accessed on September 9, 2007. The discussion on transit mode share has generated a variety of points of view, some of which claim that Calgary, for example, has been enjoying much higher rates of increase in transit use than Ottawa, which otherwise has seen its mode share remain fairly stagnant. Still, it cannot be disputed that Ottawa has been able to maintain impressive levels of transit use at least in part due to the provision of extensive and rapid transit connections, and that Calgary's growth, though impressive, still places it at a level significantly below Ottawa.

[17] John Bonsall, op. cit.

[18] Alasdair Cain, Georges Darido, Michael R. Baltes, Pilar Rodriguez, and Johan C. Barrios, *Applicability of Bogotá's TransMilenio BRT System to the United States*, Final Report (Tampa: National Bus Rapid Transit Institute, Center for Urban Transportation Studies, University of South Florida), May 2006.

[19] The author wishes to acknowledge the major contribution made by Ing. Liliana Pereira and the entire planning staff at TransMilenio to this section. Additional sources reviewed include Instituto de Desarrollo Urbano, "Plan Marco Sistema: TransMilenio," November, 2003; and Liliana Pereira, "Rediseño de Servicios Troncales para la Fase 2 del Sistema TransMilenio," Alcaldía Mayor de Bogotá, undated,

[20] The phenomenon of "new" transfers was also observed in Brisbane; as transit networks make primary travel easier, through higher frequencies, more direct routes, and faster travel times, and particularly as transfers take place within stations, more passengers are willing to make new transit trips that involve transfers, particularly for suburb-to-suburb trips.

[21] The author wishes to acknowledge the major contribution that three individuals made to this section: Barry Gyte of GCI Pty, Ltd., the Australian firm that is contracted to the Queensland Department of Transportation for planning and developing much of the Busway system; Mr. Brian Bothwell, Bus Services Manager for the City of Brisbane, who supplied much in the way of background and data; and Mr. John Bonsall of McCormick-Rankin International, who developed the initial Busway plans for Brisbane.

[22] A very small but vocal local group, the "Smogbusters," agitated loudly for the abandonment of busway concepts in favor of light rail. The very real success of the Busways has made much of this opposition moot.

[23] From an interview with Brian Bothwell, Bus Services Manager for the City of Brisbane, February 7, 2007.

[24] "Another report into Brisbane's public buses has found services are overcrowded and hundreds of passengers are being left behind. The demand for bus services in Brisbane is growing at a rate of 12 percent each year." from "Brisbane Council Bus Services Fail to Meet the Grade," *Australasian Bus and Coach*, January 23, 2007

[25] Lachlan Heywood and Chris Jones, "City on Board for New Busways," *Brisbane Courier-Mail,* April 29, 2002.

[26] Lachlan Heywood and Chris Jones, *op. cit.*

[27] "DA Lodged for 32-Storey Office Tower in Brisbane CBD," *Brisbane Business Review*, August 10, 2006.

[28] A recent newspaper article alleges that the Southeast Busway is "approaching gridlock" under the existing operating plan. Edmund Bourke, "Busway Approaching Gridlock," *Brisbane Sunday Courier*, September 30, 2007.

[29] Ibid.

[30] From an interview with Brian Bothwell, Bus Services Manager for the City of Brisbane, February 7, 2007.

[31] Ibid.

[32] Ibid.

[33] The author especially cites the observations offered in various interviews with Barry Gyte of GCI Pty, Ltd., who is in charge of the planning for the Northern and Eastern Busways.

[34] It also implied a feeder system exogenous to the internalized network as the only means of managing capacity at terminals and literally getting buses to fit into surrounding communities.

[35] The author wishes to thank Graham Carey, BRT Project Manager of Lane Transit District, for his input into this section.

[36] It is a legitimate question whether smaller communities necessarily require fully grade-separated Quickways to support a Quickway service model. Planners in Sarasota, Florida, for example, have been exploring the potential of a T-Way infrastructure to support what is essentially a modified Quickway operating plan.

[37] The author wishes to thank both Rex Gephardt, Project Manager for the Metro Rapid system, and Roderick Diaz, a consultant who worked extensively with Orange Line planning, for their input to this section. Also of great use was Roderick Diaz, "Metro Orange Line Benefits from Worldwide BRT Design Principles," *BRT NewsLane* (WestStart/Calstart), vol. 4, no. 5, p. 2.

[38] Source: www.mta.net/news_info/ridership_avg.htm. Accessed on September 16, 2007.

[39] Interview with Roderick Diaz, August 10, 2007.

[40] Reports suggest that it was nearing its engineered capacity within two years of opening, with ridership levels that were not expected for fifteen years. See Racher Uranga, "Busway so Popular, It's Nearing Capacity," *LA Daily News*, June 10, 2006.

[41] Rong-Gong Lin II, "MTA Super Sizes Bus Service," *Los Angeles Times,* August 25, 2007.

[42] Interview with Leon Bukhin, Systems Engineering Project Manager for the Los Angeles County Metropolitan Transportation Authority, November 14, 2007.

[43] Source: "Metro joins elected officials in dedication of new 14-mile Metro Orange Line," MTA Press Release, October 28, 2005.

[44] This theme is explored in great detail by Martin Wachs, "The Evolution of Transportation Policy in Los Angeles," in Edward Soja and Allan Scott, eds., *The City: Los Angeles and Urban Theory at the End of the Twentieth Century* (UC Press), 1996.

[45] Interview with Leon Bukhin, *op. cit.*

[46] The importance of other cities modeling transit solutions is apparently a major theme in LA. Jonathon Richmond, in his doctoral dissertation at MIT, suggested that LA's pursuit of the Blue Line light rail was a direct response to San Diego's being able to "whip out" a light rail line previously; LA's Metro Rapid is also widely credited to have been inspired by a tour of Curitiba's BRT system.

[47] Tony Barboza, "Fantasy Maps Re-Imagine Public Transit," *Los Angeles Times,* May 1, 2007.

[48] Again, what prevents Pittsburgh's busways from being formally classified as Quickways is their reliance on at-grade pedestrian crossings within stations, imposing significantly reduced operating speeds on express buses traveling through stations.

[49] Source: "Quick Facts" for Busways, on www.portauthority.org.

[50] Data supplied by David Wohlwill, Lead Transit Planner for the Port Authority of Allegheny County.

[51] David Wohlwill, "Transit-Oriented Development in a Changing Urban Corridor," presentation to the Rail~Volution conference, Chicago, November 7, 2006.

[52] See, for example, Brandon Keat, "Group claims public transit is unequal," *Pittsburgh Tribune-Review*, December 9, 2000.

[53] Federal Transit Administration, "Bus Rapid Transit Demonstration Program: Miami-Dade Transit Agency—The South Miami-Dade Busway," undated; Miami-Dade County Government, "South Miami-Dade Busway," at www.miamidade.gov/transit/south_miamidade_busway.asp.

[54] Miami-Dade Country Transit, "Ridership Technical Report: Budget & Performance Reporting," May 2007.

[55] The Busway-specific routes had until recently branched out to serve destinations off-corridor beyond its southern terminus. Following the recent completion of the extension of the Busway into Florida City, these routes no longer operate on regular surface roads.

[56] As a contracted service, minibuses were available to the agency at a cheaper per-hour operating cost than standard transit buses.

[57] Isabel Patron, "South Dade Busway Design," presentation to the South Miami-Dade Busway 2006 Design Conference.

[58] Robert Cervero, *The Transit Metropolis: A Global Inquiry* (Washington, D.C.: Island Press), 1998.

[59] Specifically, to measure the influence of a transit network's overall characteristic on individual trip choices. Does the presence of a dense web of rapid transit services help shape the individual's choice of transit for any given trip?

[60] A common theme among planners associated with the Quickway model is that regional travel models become less and less useful or accurate for predicting ridership on services which differ fundamentally from existing services (particularly when travel time savings change the fundamental competitive position of transit relative to the automobile); their strength is in projecting marginal changes, not wholesale changes. As a result, some cities interested in exploring the Quickway model have contracted for specific market research to gauge public acceptance of the concepts and elements and better project potential ridership.

[61] Alan Hoffman of The Mission Group. Other team members included Barry Gyte of GCI Pty. Ltd, which is responsible for the planning and development of Brisbane's Eastern and Northern Busways and Brian Bothwell of Brisbane City Enterprises; as well as the staff of McCormick Rankin International of Toronto, Canada, and Wendel-Duchscherer Architects & Engineers of Buffalo, New York.

[62] At about this time, the Metropolitan Transit Service (MTS), the agency that took over from the now-defunct MTDB, was undergoing a Comprehensive Operations Analysis that led to similar findings.

[63] This capital cost model was applied to the then-recently-completed Mission Valley East light rail project, where it was found to significantly over-project the cost of that project, even including ancillary elements. The run-up in construction costs over the past several years has probably rendered even this cost model outdated at the present; still, the relative cost performance of the Quickway component of the *FAST* Plan remains attractive compared to other modal alternatives.

[64] It should be noted that, although most corridors and stations were located in public rights of way, there are segments which were located on private land; cost for land acquisition was not specifically factored in to the capital cost projections, though was assumed to be covered by the contingency.