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Development of Bus Rapid Transit Information Clearinghouse

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Development of Bus Rapid Transit Information Clearinghouse

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Final Report for Task Orders 4407 and 5602

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ABSTRACT

This report documents the development of the bus rapid transit information clearinghouse, which is a web-based informational tool on bus rapid transit systems. It may be accessed at the following website address: http://path.berkeley.edu/informationclearinghouse/. This web-based tool provides users with a comprehensive and organized first-stop way of performing bus rapid transit-related research and investigations. The initial version of the BRT Information Clearinghouse has three primary elements consisting of the *Planning Support Tool*, the *Publications Database*, and *BRT Resources*. The *Planning Support Tool* provides users directly with or pointers to information resources by walking users through the scope of a given situation and the nature of the issues being addressed to arrive at a set of resources to provide the necessary support. The *Publications Database* provides access to fully abstracted records of published and/or otherwise publicly available materials from professional journals, technical and trade magazines, academic publications, conference proceedings, technical reports, government documents, and links to related websites. Direct links to the documents (in PDF) are provided where available. In *BRT Resources* users will find access portals to BRT-related information including links for site-specific BRT systems around the world, BRT-focused websites, organizations, search engines and research databases, and technical information, assistance and training. We designed and administered a survey to transit industry professionals to review the Information Clearinghouse prior to its official release. Survey responses show that, overall, the Information Clearinghouse fills a gap in the set of informational tools that currently exist in the arena of bus rapid transit systems and that the Information Clearinghouse website is a valuable and useful part of this informational tool collection.

Key Words: bus rapid transit, information clearinghouse, web-based tool, resources

EXECUTIVE SUMMARY

This report constitutes the final deliverable for PATH Project Task Orders 5602 and 4407 under contract 65A0161 — "Development of Bus Rapid Transit Information Clearinghouse". This report documents the development of the bus rapid transit information clearinghouse, which is a web-based informational tool on bus rapid transit systems. It may be accessed at the following website address: http://path.berkeley.edu/informationclearinghouse/. This web-based tool provides users with a comprehensive and organized first-stop way of performing bus rapid transit-related research and investigations. The initial version of the BRT Information Clearinghouse has three primary elements consisting of the *Planning Support Tool*, the *Publications Database*, and *BRT Resources*.

The *Planning Support Tool* provides users directly with or pointers to information resources by walking users through the scope of a given situation and the nature of the issues being addressed to arrive at a set of resources to provide the necessary support. A set of synthesized reports covering a broad spectrum of subject areas within the bus rapid transit systems domain was developed according to the following framework:

- Overview / What is BRT?
  - Introduction
  - What is BRT?
  - Where has BRT been implemented?
  - Has it been successful?
  - Benefits of BRT
- Planning and Development Process for Federally Funded Projects
- Institutional Arrangements for Planning, Developing, and Operating BRT
- BRT Economics and Finance
- Elements of BRT
  - General
  - Running Ways
  - Stations
  - Vehicles
  - ITS Applications
  - Fare Collection
  - Service Patterns
  - Identity and Branding
- BRT System Integration: Putting BRT Systems Together
  - BRT Service Integration
  - Integration of BRT Elements
  - Interactions and Tradeoffs
- Land Use and BRT
- BRT Planning Tools and Methodologies
  - Introduction
  - Tools
  - References
- Design Specifications
- Operations Planning

- Case Studies
    - Introduction
    - Background
    - Summary of Characteristics of BRT
    - Elements of BRT
    - Performance of BRT in Selected Case Study Cities
    - Benefits of BRT in Selected Case Study Cities
    - Costs of BRT in Selected Case Study Cities

For the BRT *Publications/Bibliographic Database*, a BRT-focused searchable database was created that consisted of fully abstracted records/citations of published and/or otherwise publicly available materials from professional journals, technical and trade magazines, academic publications, conference proceedings, technical reports, government documents, and links to related websites. The database is searchable on any of the following fields:

- Bus Rapid Transit Topic
- Author
- Title
- Year of Publication
- Date Added to Online Database

Each search returns records ─ if there are any ─ with the title, author(s), and year of publication fields. Subsequent clicking on any such record returns the complete set of fields for each such record, that is, supplements the above list of searchable fields with the following:

- Source/publisher
- Abstract
- Direct links to the PDF documents where available
- Link(s) to Related Website(s)

For the *BRT Resources* section of the website, an extensive set of resources encompassing 1) existing BRT programs, 2) BRT-focused websites, 3) public transportation organizations, and 4) search tools, technical information, and training, was provided via access portals for users interested in a wide variety of aspects of Bus Rapid Transit.

We designed and administered a survey to forty-five transit industry professionals, including representatives from transit agencies and transit industry consultant firms to review the Information Clearinghouse prior to its official release. Survey responses show that, overall, the Information Clearinghouse fills a gap in the set of informational tools that currently exist in the arena of bus rapid transit systems and that the Information Clearinghouse website is a valuable and useful part of this informational tool collection. Approximately 80%, 100%, and two-thirds of all, transit agency, and consultant firm respondents, respectively, rate the Clearinghouse's overall organization either at least "Good" or "Very Good". From the perspective of the Planning Support Tool, approximately 90%, 100%, and 85% of all, transit agency, and consultant firm respondents, respectively, rate its top level headings as clearly expressed and self-explanatory. Moreover, between 95% and 100% of each of these three respondent groupings also rated the Planning Support Tool's overall organizational structure as either "Fine as is" or "OK for the most part". Eighty percent of all respondents rated the information within each level of the Planning Support Tool as useful or mostly useful. For transit agency and consultant firm respondents, respectively, the percentages were 60% and 85%. There were also consistent findings in that the overwhelming majority of responses ─ approximately 94% for all respondents, 100% for transit agency respondents, and 86% for consultant firm respondents ─ found the Information Clearinghouse would be either "Very easy" or "Generally easy" for someone new to BRT to navigate. For the seasoned BRT practitioner, 60%, 75%, and 43% of all, transit agency, and consultant firm respondents, respectively, found the website either "Completely appropriate" or "Mostly appropriate". Revisions in the content of the Information Clearinghouse have been made where appropriate and necessary based on the survey responses.

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1.0 INTRODUCTION

This report constitutes part of the Final Deliverable for PATH Project Task Orders 5602 and 4407 under contract 65A0161 — "Development of Bus Rapid Transit Information Clearinghouse". The primary component of the Final Deliverable is Version 1 of the Bus Rapid Transit Information Clearinghouse website, which can be accessed at the following URL: http://path.berkeley.edu/informationclearinghouse/. This web-based tool on bus rapid transit (BRT) provides users with a comprehensive and organized first-stop way of performing bus rapid transit-related research and investigations, including, for example, issues related to how they fit within the overall transportation planning process, their costs and benefits, and where they are implemented.

The initial version of the BRT Information Clearinghouse has three primary elements consisting of the *Planning Support Tool*, the *Publications Database*, and *BRT Resources*. The *Planning Support Tool* provides users directly with or pointers to information resources by walking users through the scope of a given situation and the nature of the issues being addressed to arrive at a set of resources to provide the necessary support. The *Publications Database* provides access to fully abstracted records of published and/or otherwise publicly available materials from professional journals, technical and trade magazines, academic publications, conference proceedings, technical reports, government documents, and links to related websites. Direct links to the documents (in PDF) are provided where available. In *BRT Resources* users will find access portals to BRT-related information including links for site-specific BRT systems around the world, BRT-focused websites, organizations, search engines and research databases, and technical information, assistance and training.

The remainder of this section discusses the motivation for, objectives of, and a summary of the contents for the remainder of this final report.

1.1 Motivation and Objectives

There are currently numerous available websites that deal in one way or another with BRT-related issues, though generally fill specific needs and offer particular services to their users. For example, the following four BRT-related websites provide information that.

- http://www.busrapidtransit.net/ (Bus Rapid Transit Central)
- http://www.calstart.org/programs/brt/ (WestStart-CALSTART, in partnership with the Federal Transit Administration (FTA) BRT newslane newsletter)
- http://www.apta.com/research/info/briefings/briefing_2.cfm (APTA's Transit Resource Guide on BRT)
- http://www.fta.dot.gov/2381_ENG_HTML.htm (FTA's web site on BRT information)

However, someone interested in a certain aspect of BRT, especially someone relatively new to the field, is likely faced with the question "Where do I begin looking for the information I want?" or is required to do a lot of online navigating until the information he/she wants is finally located or both. Our objective in developing the BRT Information Clearinghouse is to provide — by means of expert-based content — a single online address for well organized information related to BRT together with knowledge-based information to support intended users —

primarily transit industry professionals — in the planning for and implementation of bus rapid transit systems. Moreover, the Clearinghouse is intended to serve as an electronic portal to BRT-related information via links to site-specific BRT systems around the world.

1.2 Contents of the Report

This is the first of five sections. Section 2 talks about the structural framework for the information clearinghouse and Section 3 discusses the content of the information clearinghouse; the testing and review of the website based on the design and administration of a survey of transportation-industry professionals is presented in Section 4. Finally, conclusions and next steps are presented in Section 5.

2.0 STRUCTURAL FRAMEWORK FOR INFORMATION CLEARINGHOUSE

The development of the structural framework for the BRT Information Clearinghouse was conducted by the development team via an iterative process. We used a 'Top-Down' approach commencing with three primary tool components, which were originally described in the project's scope of work:

- Planning Support Tool
- Publications/Bibliographic Database
- BRT Resources

Within the Planning Support Tool, the task at hand was to develop synthesized reports covering a broad spectrum of subject areas within the bus rapid transit systems domain. The team developed the following framework for the *Planning Support Tool*:

- Overview / What is BRT?
    - Introduction
    - What is BRT?
    - Where has BRT been implemented?
    - Has it been successful?
    - Benefits of BRT
- Planning and Development Process for Federally Funded Projects
- Institutional Arrangements for Planning, Developing, and Operating BRT
- BRT Economics and Finance
- Elements of BRT
    - General
    - Running Ways
    - Stations
    - Vehicles
    - ITS Applications
    - Fare Collection
    - Service Patterns
    - Identity and Branding
- BRT System Integration: Putting BRT Systems Together
    - BRT Service Integration

    - Integration of BRT Elements
    - Interactions and Tradeoffs
- Land Use and BRT
- BRT Planning Tools and Methodologies
    - Introduction
    - Tools
    - References
- Design Specifications
- Operations Planning
- Case Studies
    - Introduction
    - Background
    - Summary of Characteristics of BRT
    - Elements of BRT
    - Performance of BRT in Selected Case Study Cities
    - Benefits of BRT in Selected Case Study Cities
    - Costs of BRT in Selected Case Study Cities

For the BRT *Publications/Bibliographic Database*, the task at hand was to create a BRT-focused database consisting of fully abstracted records/citations of published and/or otherwise publicly available materials from professional journals, technical and trade magazines, academic publications, conference proceedings, technical reports, government documents, and links to related websites. The database is searchable on any of the following fields:

- Bus Rapid Transit Topic
- Author
- Title
- Year of Publication
- Date Added to Online Database

The list of Bus Rapid Transit topics available for the user to select exactly matches the structure of the Planning Support Tool, that is, consists of

- Overview / What is BRT?
- Planning and Development Process for Federally Funded Projects
- Institutional Arrangements for Planning, Developing, and Operating BRT
- BRT Economics and Finance
- Elements of BRT
- BRT System Integration: Putting BRT Systems Together
- Land Use and BRT
- BRT Planning Tools and Methodologies
- Design Specifications
- Operations Planning
- Case Studies

Each search returns records ─ if there are any ─ with the title, author(s), and year of publication fields. Subsequent clicking on any such record returns the complete set of fields for each such record, that is, supplements the above list of searchable fields with the following:

- Source/publisher
- Abstract
- PDF Available to Download
- Link(s) to Related Website(s)

For the *BRT Resources* section of the website, the task at hand was to offer in an organized and structured fashion an extensive set of valuable resources for users interested in a wide variety of aspects of Bus Rapid Transit. These resources encompass the following categories:

- Existing BRT programs
- BRT Focused Websites
- Organizations
- Search Tools, Technical Information, and Training

In addition to these three core elements of the tool, that is, the *Planning Support Tool*, the *Publications/Bibliographic Database*, and the *BRT Resources* section, there are the following sections:

- ITS Resources
- About the Clearinghouse
- Home
- Site Map
- Search

3.0 CONTENT WRITTEN FOR THE CLEARINGHOUSE

In this chapter, we provide the content for the BRT Information Clearinghouse contained in the Planning Support Tool, BRT Resources, and ITS Resources sections.

3.1 Planning Support Tool

The Planning Support Tool consists of the following major components, the text for which is presented in the remaining part of Section 3.1[1].

- Overview / What is BRT?
- Planning and Development Process for Federally Funded Projects
- Institutional Arrangements for Planning, Developing, and Operating BRT
- BRT Economics and Finance
- Elements of BRT
- BRT System Integration: Putting BRT Systems Together
- Land Use and BRT
- BRT Planning Tools and Methodologies
- Design Specifications
- Operations Planning
- Case Studies

[1] The headings for each of these major components appears in larger font size in the text below – 16 point – similar to how it appears on the website to better inform and alert the reader about the start of a new part.

General

It is perhaps fair to say that no two Bus Rapid Transit (BRT) systems in operation around world are identical. The one common feature; however, is that each system comprises a series of basic elements. The difference in each system being the choice of option for each element, with some options being far more advanced than others. These elements also form the basic structure of any rapid transit service, including light rail or commuter rail. The major advantage of Bus Rapid Transit over fixed-guideway forms of transit is its flexibility and ability to be implemented in almost any operating environment, as well as tailored to suit all budgets. The elements that comprise any rapid transit system are listed as follows:

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

When planning and designing BRT systems one generally tries to provide an improvement over the local bus system on the network, so that forms the starting point and options to provide a greater overall level of service for passengers are identified. A choice of options exists for each element ranging from the highly sophisticated to what would be included in a typical local bus system. In this paper, the options available for each of the above elements when planning and designing BRT systems are discussed. This section offers a general discussion of each BRT element. For more site-specific examples, see the "Elements of BRT" subsection within Case Studies.

OVERVIEW / WHAT IS BRT?

Introduction

The worldwide recognition that Curitiba, Brazil has received for its innovative urban planning and related "Surface Metro" bus rapid transit system has induced many elected officials and urban transport planners in the United States to begin considering "BRT" (Bus or Rubber-Tired Rapid Transit) as a potential solution to their respective urban transportation problems. The discussion below begins with a definition of BRT developed for the Transit Cooperative Research Project (A-23), BRT Implementation Guidelines. We then proceed with some basic information on BRT successes, costs and benefits.

What is BRT?

BRT is a flexible, rubber tired form of rapid transit that combines stations, vehicles, services, running way, and ITS (Intelligent Transportation Systems) elements into a permanently integrated system with a quality image and a unique identity. BRT applications are designed to be appropriate to the market they serve and their physical surroundings and can be incrementally implemented in a variety of environments, from rights-of-way totally dedicated to transit (surface, elevated, underground) to mixed traffic on streets and highways.

Where has BRT been implemented?

BRT has been implemented all over the world. In North America, the best examples of BRT applications include: Boston (Silver Line), Pittsburgh (South, MLK/East and Airport/West Corridors), Miami (South Dade/US-1), Los Angeles (El Monte/I-10, various Metro Rapid Bus lines, Honolulu (City Express!), the soon to be opened S an Fernando Valley Orange Line, Las Vegas (Las Vegas Blvd MAX.), Houston (Transitways), Ottawa, Ontario (OC The Transitway), the Vancouver (Line 98B) and York, Ontario (VIVA). The best examples of BRT outside the U.S. are in Curitiba and Sao Paulo Brazil, Quito, Ecuador, Leon, Mexico and Bogotá, Columbia, ; Sidney, Adelaide and Brisbane, Australia; Paris, Nancy and Rouen, , France and Amsterdam and Eindhoven, Holland.

Has it been successful?

In virtually every fully integrated, full-feature BRT application to date, there has been the same customer, community and developer acceptance observed with the implementation of any high-quality rapid transit mode such as LRT. Increases in ridership attributed to BRT have ranged as high as 100% or more over the initial application period. For example, transit ridership in Miami-Dade's South US-1 Corridor has increased from approximately 7,000 daily trips in 1996 before the Miami South Dade Busway opened, to over 14,000 per day today. In Boston, ridership on the Silver Line Phase I corridor doubled to more than 15,000 trips per day in the first 2 years of operation, and many (over 30%) of the BRT riders were former Orange Line subway passengers. Implementation of Metro Rapid Bus in L.A.'s Wilshire-Whittier and Ventura Blvd. Corridors has resulted in increases of, respectively, 20% and 50% in total corridor bus ridership. Over one third of the new trips on the Metro Rapid Bus services were made by travelers that did not previously use transit at all before the lines opened. In the Wilshire-

Whittier Corridor, over 60,000 trips per day are currently made on the Metro Rapid Bus. AC Transit (East Bay in San Francisco Bay Area) experienced a 35% increase in ridership on its San Pablo Blvd Rapid Bus line after one year of operation, and 12% of it riders were former BART passengers.

Experience in places as diverse as Ottawa, Pittsburgh and Brisbane and Bogotá has also demonstrated that when BRT is implemented as part of a comprehensive urban development strategy, it can have a profound impact on land use. For example, since the Martin Luther King East Busway in Pittsburgh opened in the mid-eighties, there has been over $300M in new development in the vicinity of its stations. In Ottawa, the number was over $750m after approximately 10 years of operation, while in Boston; over $700m of development and redevelopment have clustered around its stations.

There is growing interest in BRT worldwide because it can provide attractive, cost-effective rapid transit at capital and operating/maintenance costs extremely competitive with other rapid transit modes. Before making a decision to proceed with any rapid transit investment, a detailed, objective analysis of all reasonable alternatives, including BRT should be made for the respective application.

Benefits of BRT

BRT is the most flexible rapid transit mode. BRT services can be precisely tailored so that BRT vehicles rather than BRT customers transfer. BRT vehicles can be steered or guided mechanically or electronically and can travel in general traffic on any street or highway. They can also be operated at high speeds safely and reliably on their own dedicated transit ways, without interference from other vehicles.

To guarantee the minimum running way cross section, the highest safety and the best ride quality, BRT vehicles can also be guided mechanically like a rail transit vehicle, or electronically. Mechanically guided BRT vehicles have been operating for almost twenty years in Essen Germany and Adelaide Australia, and electronically guided BRT operates in Las Vegas, Nevada, Rouen and Clermont-Ferrand, France and Eindhoven, Netherlands.

BRT generally has modest implementation costs. Though desirable, it is not necessary to construct a fully dedicated transit over the entire distance of a busy corridor to guarantee a high level of speed, safety and reliability. For example, West Busway BRT users in Pittsburgh enjoy a congestion-free ride at all times of day, over the full 20+ mile distance between the Airport and downtown Pittsburgh --- though only the first approximately eight miles from downtown Pittsburgh Westward are covered by the West or Airport Busway. I-279 is almost always free flowing over the rest of the distance, meaning that airport passengers and workers have a reliably high speed ride of up to 20 miles long over a corridor that include only eight miles of exclusive rapid transit BRT running way.

Running ways are also invariably cheaper to construct from scratch than rail based modes per unit length because they are simpler. Their construction can be competitively procured from a much larger number of local firms than other forms of rapid transit. BRT also does not require elaborate purpose-built signal or power supply systems, and implementation of BRT rarely means construction of totally new, expensive operating and maintenance yards and shops. Even sophisticated, electronically guided BRT vehicles can be maintained and stored off-line where convenient, e.g., at an existing bus operating and maintenance facility.

BRT vehicles can be conventional, low floor, low noise and low emission buses with a variety of propulsion systems, including conventional clean diesel, CNG spark ignition, hybrid clean diesel, CNG or gasoline or electric trolley. With seating and door configurations optimally suited to the nature of the given market, they can be painted in special livery with special graphics to provide a system identity consistent with the rest of the given line's stations, running ways, etc. At the other end of the spectrum, manufacturers around the world are producing special rubber tired, steered or guided rapid transit vehicles.

Irrespective of whether they are conventional buses or purpose built BRT vehicles like NABI's MetroBus, or New Flyer's Irisbus's Civis vehicles or Bombardier's GLT, BRT vehicles are Invero, specialized BRT vehicles are usually significantly less expensive than other rapid transit vehicles, even adjusted for capacity and service life, for a variety of factors, including component economies of scale, competition, and lower structural strength requirements.

Only after an application specific analysis that covers the entire transit system, including rapid transit and feeders, can the determination of which rapid transit alternative is the least expensive to implement be made.

At the demand volumes found in most U.S. corridors, BRT can be the least expensive rapid transit mode to *operate and maintain*. In the demand volumes found in most US corridor applications, the major operating and cost difference between any form of rapid transit and local bus service is operating speed, not the size of the basic service unit. For example, all things being equal, local buses going 12 miles per hour in mixed traffic, stopping at every street corner, are one half as productive as BRT vehicles or LRT trains making limited stops on a dedicated transit guideway where they might average 24 miles per hour.

The basic unit of capacity for BRT, an individual vehicle of 40 to 82 feet long, is smaller than for many LRT consists. This means that the number of BRT consists and drivers required to carry a given number of passengers past a point can be higher than with rail rapid transit, all thing being equal; however, BRT line-haul services can be integrated with collection/distribution, meaning that the additional "overhead" costs of having separate rapid transit, feeder and circulator services can be eliminated. Also, the marginal costs of maintenance of way, signals and power for BRT are either non-existent or low. BRT vehicle maintenance costs are also relatively low (adjusted for capacity), and implementation of BRT usually does not mean manning a wholly new maintenance and operations base. BRT vehicle operations and maintenance can usually be competitively procured from any number of local transit providers.

All things (e.g., fare collection, degree of ROW dedication, number of stops) being equal, LRT will only have lower operating and maintenance costs than BRT per unit ridership if transit volumes are high enough so that savings in line haul vehicle operating personnel (i.e., drivers) offset LRT's higher fixed maintenance and operating costs.

As is the case for all planning parameters, only after an application specific analysis that covers the entire transit system, including rapid transit and feeders, can a determination be made as to which rapid transit alternative is least expensive to operate (on a per passenger mile (Km) or passenger trip basis) be made.

BRT has been very successful in attracting new ridership to public transportation. In virtually every fully integrated, full-feature BRT application to date, there has been the same customer, community and developer acceptance observed with the implementation of any high-quality rapid transit mode such as LRT. Increases in ridership attributed to BRT have ranged as high as 100% or more over periods as short as one year. For example, transit ridership in Miami-Dade's South US-1 Corridor has increased from approx. 7,000 daily trips in 1996 before the Miami South Dade Busway opened, to over 15,000 per day today.

Implementation of Metro Rapid Bus in L.A.'s Wilshire-Whittier and Ventura Blvd Corridors has resulted in increases of, respectively, 20% and 50% in total corridor bus ridership. In the Wilshire-Whittier Corridor, over 60,000 trips per day use Metro Rapid Bus, while in the Ventura Blvd Corridor, over 10,000 use it. It has been estimated that about 33% if the trips on Metro Rapid Bus are being made by riders totally new to transit.

Conclusion

BRT has tremendous potential for incremental development, getting rapid transit operating as rapidly as possible with the least amount of funds while preserving options for latter expansion and upgrading. BRT's flexibility gives it a unique ability to be implemented incrementally. Where a particular application would be in the continuum for each BRT element illustrated in the table below is dependant on the parameters of the application environment in terms of: 1) the nature of current and future land use and demographic (population, employment, densities) characteristics; 2) current and expected future transit markets, such as origin to destination patterns, expected rapid transit ridership, both total and maximum load point volumes; 3) right of way (stations and running way) availability and characteristics (e.g., width, length, number and types of intersections, traffic volumes and ownership); and 4) availability of capital, operating and maintenance funds.

Table 1 Bus Rapid Transit Element Continuum

SERVICES	STATIONS	VEHICLES	RUNNING WAY	SYSTEMS
PRIMARILY LOCAL	SIMPLE STOPS	NO SPECIAL TREATMENT	MIXED TRAFFIC	RADIOS, ON-BOARD FARE COLLECTION
MIXED LIMITED STOP, LOCAL	SUPER STOPS	SPECIAL SIGNAGE	DEDICATED ARTERIAL CURB LANES, COMPETING TURNS ALLOWED	AVL FOR SCHEDULE ADHERENCE
ALL-STOP (LOCAL), MIXED LOCAL/EXPRESS	ON-LINE, OFF-LINE STATIONS, SIGNIFCANT PARKING FOR TRANSIT PATRONS	DEDICATED VEHICLES, SPECIAL LIVERY	DEDICATED FWY MEDIAN LANES, MERGE/WEAVE ACCESS/EGRESS	ITS PASSENGER INFORMATION, FARE COLLECTION
POINT-TO-POINT EXPRESS	TRANSFER/ TRANSIT CENTERS	DEDICATED VEHICLES, UNIQUELY SPEC.'ED, (E.G., DOUBLE-ARTIC.'S, HYBRID PROPULSION)	FULLY DEDICATED LANES, EXCLUSIVE FWY ACCESS/EGRESS	ITS VEHICLE PRIORITY
	INTR'MODAL TRANSFER/ TRANSIT CENTER	MECHNICAL OR ELECTRONIC GUIDANCE	PARTIAL GRADE SEPARATION	ITS VEHICLE LATERAL GUIDANCE
		FULLY ELECTRIC PROPULSION SYSTEM	FULL GRADE-SEPARATION, CURBED/ STRIPED/CABLED FOR GUIDANCE	ITS AUTOMATION, ELECTRIC POWER SYSTEM
			OVERHEAD POWER CONTACT SYSTEM	

PLANNING AND DEVELOPMENT PROCESS FOR FEDERALLY FUNDED PROJECTS

In most corridor applications, all things being equal (e.g., extent, quality of components, amenities), a BRT line will cost less than an LRT line. That having been said, BRT can represent a substantial investment in both capital and operating and maintenance costs. Accordingly, one should take the decision to invest in BRT seriously, and follow the same basic planning and project planning process as one might use for any rapid transit investment, irrespective of whether requesting Federal funding assistance is being contemplated.

The description below is a broad outline. It does not go into detail on planning and analysis legislation, regulations, methodologies, organizations, public involvement, the environmental review process under the National Environmental Policy Act (NEPA). The best place to obtain detailed information and guidance on the Federal New Starts planning and project development process is from the Federal Transit Administration. Having enunciated and gotten policy official endorsement of goals, objectives and criteria, transportation planners will begin the rapid transit planning and project development process (i.e., “New Start planning and project development process) with an in-depth analysis of the characteristics and causes of current and potential future transportation and transportation related problems in a given corridor. This corridor (or corridors) will have been identified by the ongoing systems planning process as needing a rapid transit investment of some kind. This analysis, know as an “alternatives analysis” will focus on multi-modal (transit and highway) demand, supply condition and performance in the corridor or corridors in question. It will also cover transportation-related environmental, social, economic development and land use related challenges and issues.

After a complete analysis of the current and projected future (i.e. analysis of a no project or “do-nothing” alternative) situation, alternative rapid transit and/or multi-modal solutions can be identified. The first alternatives(s) to be identified will be one or more modest investment alternatives also referred to as “TSM” or base-case alternatives. These will include both additions of new capacity and services as well as operational improvements.

Based on the results of analysis of the “TSM” alternatives, one or more rapid transit alternatives are identified and analyzed. Where a modest BRT investment is being contemplated, there may be only one rapid transit “build” alternative, while where a more expensive (e.g., in excess of $75m) BRT and other rail-based alternatives are being examined, less expensive rapid transit alternatives will be examined as well.

Following the open, objective analysis of the full range of alternatives in terms of the goals, objectives and criteria enunciated at the beginning of the planning process, policy officials will select the single rapid transit alternative to take into more detailed planning, engineering and design. This alternative will be defined in terms of basic mode, and general alignment. The next step in the process, preliminary engineering, further defines the alternative selected at the conclusion of alternatives analysis to a level of detail normally requiring completion of 30% of all engineering and design activities.

At the conclusion of preliminary engineering, the environmental review process under NEPA will have been completed and the scope and cost of the project will be known with a level of confidence that will permit commitment to construction of the project by the various funding partners, including the Federal Transit Administration. The Federal commitment will reflect a rigorous cost-effectiveness analysis utilizing the results of both the alternatives analysis and preliminary engineering processes.

The recently enacted Federal Surface Transportation legislation: "Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users" (SAFETEA-LU) requires a less-rigorous alternatives analysis and FTA evaluation process for project where less than $75m of Federal funds are being requested, under a new "Small Start" transit capital assistance program; however, the basic process described above and illustrated below will be the same as for major "New Start" projects.

Establish Goals and Objectives;
Transportation, Related Quality of Life

↓

Evaluate Current Problems,
Future Challenges

↓

Identify Investment

↓

Evaluate Alternatives

↓

Decision on Mode and General Alignment

FIGURE 1 Alternatives Analysis Process

AA

↓

Preliminary Engineering

↓

Identify Investment

↓

Final Engineering

↓

Construction

↓

In service

FIGURE 2 Alternatives Analysis (AA) In the Over-All Planning and Project Development Continuum

INSTITUTIONAL ARRANGEMENTS FOR PLANNING, DEVELOPING, AND OPERATING BRT

The implementation of bus rapid transit, like any other rapid transit service, must proceed through the customary planning and project development process beginning with an Alternatives Analysis at the end of which a Locally Preferred Alternative is selected. The next stage in the process consists of Preliminary Engineering followed by Final Engineering, Construction and then Operations. However, due to its inherently flexible nature that permits incremental deployment phasing over time ─ a unique characteristic of BRT ─ bus rapid transit can undergo additional planning scrutiny to determine what BRT elements will be included and their deployment sequencing in phases/stages over time. Of course, after the Alternatives Analysis portion of the Project Development Process, a parallel operations planning process usually gets underway that includes designing routes and stations, setting timetables, scheduling vehicles, and assigning crews.

The planning, development, and operations activities occur in a context of stakeholder participation at various organizational levels. During each stage of the BRT implementation process, questions and issues will inevitably arise concerning the effects of actions taken or policy decisions made. These questions and issues need to be considered and effective arrangements made that address them to successfully implement a bus rapid transit system.

Bus rapid transit systems will not necessarily experience the same set of institutional and/or policy issues because each BRT deployment will be affected by local and regional factors. Moreover, even when the same issues arise in different settings, there will likely be local and regional site-specific differences. The importance of identifying and working out such issues should not be underestimated as they do contribute to the overall success of implementing bus rapid transit systems in terms of how transit operations and quality of service for passengers are enhanced.

It is rarely the case that a transit agency can develop a bus rapid transit system without the coordination and cooperation of multiple agencies and often overlapping governmental jurisdictions. Even if this were possible, there is benefit in seeking the cooperation and support of other agencies. However, the multi-jurisdictional and/or multi-stakeholder aspects can make the process of decision-making and implementation more complex as each stakeholder usually brings its own philosophies, priorities, and agendas to the table.

When planning for the deployment of bus rapid transit systems, there are, at a minimum, two distinct types of stakeholders with primary roles. One is the local and/or regional transit agency whose interest lies foremost in reducing its own costs while also enhancing the quality of transportation services that it delivers to its passengers. The other primary stakeholder is the local and/or regional highway and traffic department along the route the transit agency's bus runs and this latter stakeholder could include multiple operators depending on whether the bus runs through multiple political jurisdictions. Other stakeholders might also include the regional metropolitan planning organization, the state department of transportation, federal transportation agencies, e.g., Federal Transit Administration and Federal Highway Administration, various local public officials and/or decision makers, and the general public. The significance of these stakeholders' roles and influence depends on local and regional conditions encompassing the bus route/traffic corridor where the bus rapid transit system is to be implemented.

Typically a transit agency will interface with other government agencies during regular service discussions however theses interfaces become more critical with the development of a BRT system; it is typical for a transit agency to need to coordinate with an organization it had not worked with prior to the BRT project. These agreements should set out agency and staff responsibilities giving particular attention to the clarification of roles. Achieving consensus, let alone agreement, among all affected stakeholders, whether political jurisdictions or other transportation organizations may at times prove to be a challenging and possibly difficult task. To have a system that works effectively requires the transit agency to achieve agreement with localities and other agencies on infrastructure, operations, and assignment of responsibilities. However, the primary objectives of transit agencies, to provide high-level, high-quality service for their customers at minimum cost, may conflict with the objectives of highway and traffic agencies whose performance is often judged more on enhancing vehicle-moving than people-moving capacity. These often-competing objectives can complicate the implementation of bus rapid transit strategies and may require significant coordination and cooperation if multiple transportation and traffic agencies are involved.

The number and complexity of the agreements will depend upon the type of facility and the governmental organization in the area. There are generally a number of elements of the system that are out of the control of the transit agency. Cooperation of these agencies is critical to the successful introduction and operation of a BRT system. In these cases it is necessary to define and codify these responsibilities. Inter-governmental agreements will be required with a number of different agencies covering items such as right of use (how long, conditions for extension or termination of agreement, state in which the facility is returned to the appropriate agency, legal responsibility, watering maintenance of landscaping, maintenance of running ways, trash collection, graffiti removal, advertising, enforcement, signal timing, lighting). In some cases local or state laws may be enacted, repealed or modified to implement various BRT elements or practices, such as the use of the BRT facility by emergency service vehicles.

The following examples illustrate a variety of contexts in which institutional concerns and policy issues may arise:

Introduction of New Technologies

Institutionally, there may be concerns over the use of new technologies regarding their complexity and reliability. Moreover, there will need to be coordination on the selection and implementation of new technologies determining whether or not they should be selected to meet the needs of multiple stakeholders and how this could complicate BRT deployment. Insufficient understanding of the "state of the art" of technologies and how they can be used in BRT operations also needs to be recognized and addressed.

Intra-Organizational Adaptation to Implementing Bus Rapid Transit

Institutional issues may arise not only between organizations such as transit agencies, individual cities and/or counties, and traffic operators, but also internally within individual organizations. Concerns over preferences in funding and use of scarce resources, the delegation of potentially added responsibilities for staff may result in intra-organizational resistance and morale issues. Unless there are additional funding sources available, increased spending on one route will usually mean decreased funding on others.

Bus rapid transit systems may require additional resources to support the service offered. Additional operations, new technologies, retrofitted/new vehicles, and new infrastructure will likely require training and maintenance. Achieving agreement on roles and responsibilities may be difficult if employees are merely required to shoulder additional duties and responsibilities for BRT without additional compensation or support.

Many agencies will need additional time to identify and integrate best industry practices for BRT. Even then, identifying and attempting to accommodate an agency's departments' needs may cause internal discord. As new strategies may affect the duties of staff, it is vital that they are consulted and strategies are selected with staff concerns in mind.

The Political Arena

At each stage in the process of implementing BRT, decision-making stakeholders are involved in a variety of ways that impact the specific deployment path a particular bus rapid transit system will take. The decision-makers are by definition major players in the political arena that govern the local jurisdictions in which the BRT would operate. The commitment to BRT by such major players is of crucial importance to its success.

To establish and sustain a high level of interest and commitment to BRT will likely require a political champion. Whether it is an individual or organizational entity, a political champion would aid in coalition building and sustaining interest in BRT when interest could expand and diminish over time. The strength and capability of a political champion would help determine if the project can withstand voices of opposition arising from various quarters, for example, the local business community or local residents. However, gaining the support of such championing decision-makers often first requires proof of the operational and quality-of-service benefits of BRT; however political support is usually required first to perform the testing that could result in quantifiable and demonstrable benefits. Here we encounter the well-known chicken-or-the-egg dilemma. At this time with already successful bus rapid transit systems implemented internationally as well as in the U.S., one way out of this dilemma is to cite BRT benefits arising from these other locations especially others in U.S. communities with similarities to the site in question so that valid comparisons may be made.

Public Relations and Marketing

The ultimate success of any new product, no matter how good its potential may be, depends largely on how information about it _both benefits and costs _ is communicated. To gain support for BRT, it needs to be properly "sold" to stakeholders including bus passengers, employees, motorists, the general public, as well as decision-makers. However, selling BRT requires setting expectations. Setting high, yet realistic expectations will be crucial for the long-term success of the system. Failure to produce what was proposed could lead to public disappointment and tarnish the sponsoring agency's name and reputation, resulting in BRT being untouchable for some period of time.

One issue that may arise from poorly executed public relations, marketing, and educational campaigns are motorists' complaints and backlash who perceive that transit is getting special, and undeserved, treatment, causing roadway delays and raise "tax-equity" issues upon seeing such a system installed for buses, such as with transit signal priority systems.

It would also be important to educate the public and passing motorists on new interactions they may have with bus rapid transit systems. Moreover, the transit agency needs to take into account its current performance, both actual and perceived by the public. Before taking on the additional responsibilities of a BRT, an agency must ensure its current operations are performing satisfactorily. Otherwise, the agency may face political and public opposition if it is perceived the agency is overextending itself beyond its capabilities.

Labor and Human Factors

Transit agencies must consider the effects different aspects of BRT, such as the use of new technological systems, on its staff, especially bus drivers and maintenance workers. BRT may raise concerns over additional work and responsibilities, changing role of drivers, especially without assurances of additional staff, resources, and/or pay, use of Automated Vehicle Location (AVL) systems for monitoring schedule adherence and different responsibilities between BRT and non-BRT routes.

For example, for collision warning systems or precision docking systems, bus drivers would have a direct and likely the closest connection of all agency employees with such systems implemented as part of a BRT. How would such employees embrace such new systems? Would it mean any change in the definition of their job? The specifics of the bus rapid transit system will determine the extent to which bus drivers need to interact with the system, that is, how much attention drivers must pay to activate and/or monitor the system. With everything the bus driver currently needs to do as part of his/her job, giving the driver additional tasks related to the operation of a new technology would likely lead to a preference for either no or only minimal driver interaction.

Drivers may also need to switch between BRT and non-BRT routes and equipped buses over the course of relatively short time periods, possibly even the same day. Thus, training for new driving conditions and situations and the ability to smoothly switch between BRT and non-BRT routes/vehicles could concern drivers as well as transit agency management, especially in the instance where drivers have more than simply minimal interaction with the system.

Planning and Land Use

Large-scale public transportation projects often influence travel patterns and surrounding land use. Bus rapid transit, intended to replicate high-level transit service, may raise concerns over how it fits into a region's overall transportation plans and how it will affect local land use. Many BRT projects intend to strengthen and encourage higher land uses. Project sponsors will need to educate and address public concerns regarding the potential impacts of BRT on the physical environment. The public's fear of change and the "unknown" often leads to resistance and opposition toward many such projects. Finally, a BRT system's inherent flexibility, may, in fact, be a disadvantage if potential developers perceive this as a lack of permanence and show reluctance to invest along BRT corridors.

The Physical Environment

The physical presence of a BRT system may also raise institutional challenges. Many project areas, especially in older city centers, may simply lack the physical space to easily accommodate certain BRT implementation strategies. Bus rapid transit projects may also find themselves competing with other interests for high value real estate, which may not only inflate costs, but also complicate institutional dealings. Thus, availability and acquisition of right-of-way or physical space may be an issue.

Image is also a strong marketing tool for BRT. While station area improvements are a popular BRT strategy, these improvements are typically being inserted into the existing urban design. Organizations may find it a challenge to reach agreement or consensus to develop station improvements that promote a strong image, while being acceptable to numerous local interests.

BRT ECONOMICS AND FINANCE

Implementation of a BRT system requires a clear understanding of the benefits and costs, sources of funding and the various mechanisms that can be deployed to finance, develop and operate the system.

Typically the total overall capital and operating costs for BRT systems are less than similar rail-based systems. As there are few BRT systems in the US there is a concern amongst some practitioners that BRT will not attract the level of ridership of a typical rail-based system and therefore may prove to be less cost effective (cost per rider). However, because BRT is more competitive at lower passenger volumes, the per boarding passenger costs cab range from less than half to about 90% of the costs of a similar rail-based system. Consideration also needs to be given to duration and the degree of exclusivity of the BRT system. Service that is offered for limited periods of the day and that are able to operate at higher speeds on dedicated rights of way are going to have a different operating cost than regular transit service. Thought should also be given to the increases in operating cost of some of the components of the BRT system. While the higher speed of operation and the bypassing of congestion will reduce the vehicle operating cost, additional costs include maintaining right of way, stations; fare collection systems which the agency may not presently occur will need to be accounted for. Fare policy towards BRT systems vary considerably. Some systems consider BRT as an extension of their regular service whilst others see BRT as a premium service where a higher fare is appropriate.

Funding sources for BRT projects include most of the traditional transit funding sources. To date most US BRT systems have been extensively publicly funded from discretionary grants at the federal level, supplemented with a variety of state and local funding sources. At the federal level these grants include Urbanized Area Formula Funds (Section 5307), Capital Investment Grants Program (Section 5309), Surface Transportation Program (STP) and/or Congestion Management and Air Quality (CMAQ) aid. At the state level General Revenue or Dedicated Tax Revenue could be used. Local public funding sources include Dedicated Tax Revenue and General Fund aid. As BRT is essentially a road based mode funding from highway and other non-transit sources may be applied. There are also a number of private and non-traditional funding/financing sources which may be used to match or supplement federal or state funds allotments. These include Transfer and Leaseback, Joint Development, Value Capture, Tolls, Debt Financing and various Design/Build options.

ELEMENTS OF BRT

General

It is perhaps fair to say that no two Bus Rapid Transit (BRT) systems in operation around world are identical. The one common feature; however, is that each system comprises a series of basic elements. The difference in each system being the choice of option for each element, with some options being far more advanced than others. These elements also form the basic structure of any rapid transit service, including light rail or commuter rail. The major advantage of Bus Rapid Transit over fixed-guideway forms of transit is its flexibility and ability to be implemented in almost any operating environment, as well as tailored to suit all budgets. The elements that comprise any rapid transit system are listed as follows:

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

When planning and designing BRT systems one generally tries to provide an improvement over the local bus system on the network, so that forms the starting point and options to provide a greater overall level of service for passengers are identified. A choice of options exists for each element ranging from the highly sophisticated to what would be included in a typical local bus system. In this paper, the options available for each of the above elements when planning and designing BRT systems are discussed. This section offers a general discussion of each BRT element. For more site-specific examples, see the "Elements of BRT" subsection within Case Studies.

Running Ways

By virtue of BRT vehicles being rubber tired and steered (as well as guided in some cases), BRT services can operate in a variety of physical environments, ranging from mixed traffic to dedicated curbside or offset lanes, median arterial busways and bus-only transitways that may be at the surface, elevated or in tunnels. Most corridor applications utilize a combination of the above due to neighborhood and street/highway system conditions and constraints. Typical bus lanes are 11 to 12 feet (approx 3 meters) wide and depending on the applicable municipal standards or policies may have a different color wearing-course than the remainder of the street. Red and Green are two colors used to distinguish the bus lanes from those lanes available to general traffic. Almost all cities have different policies with regards to the use of bus lanes. For example, some bus lanes operate 24-hours per day, while some may be only dedicated to a particular peak period and then allow all traffic to use the lane in off-peak periods.

Some configurations of running ways may include provisions for optical, magnetic or mechanical guidance for the vehicles. These are introduced to yield benefits in terms of

the travel speeds and safety and perhaps most important, facilitates precision docking at stops. The cost of these measures varies depending on what is selected.
The most expensive form of running way, but also potentially most beneficial in terms of user benefits is the bus-only transitway, whether at grade, elevated or in a tunnel. These options require the construction of costly new infrastructure, which will include land acquisition costs; therefore, feasibility has to be examined very closely. Clearly, there needs to be economic justification for such an undertaking. The benefits of such a route, however, can be very significant to the user. Given its separation from general traffic, BRT services on fully dedicated and grade separated transitways are not subject to the same level of delay and traffic interference as regular bus services, and therefore could be equated to a light rail (LRT) project in terms of operating speeds, reliability and safety.
A lower cost alternative is the provision of a dedicated bus lane or busway on an existing street. In this instance, existing road space is allocated to BRT services within the dedicated lane. Pavement markings and signage are provided to distinguish the lane from general traffic. This is an option where space, traffic, parking and access conditions permit the provision of a dedicated lane. Anecdotal evidence suggests that the provision of a dedicated, on-street bus lane can be advantageous, as car drivers and passengers sitting in traffic are first hand witnesses to buses moving quickly through traffic, thus encouraging greater levels of mode change.

One of the greatest challenges to the success of such a running way is the enforcement of the bus-only rule. On occasion, drivers will use the bus lane to avoid heavy congestion. Enforcement can be supported through the use of physical barriers, roving police officers or traffic agents, appropriate signage, the use of buses with on board cameras equipped with license recognition software, and other options. Drivers in every city act very differently. In some cities drivers obey the rules and regulations presented to them and with little enforcement will observe the regulations, while in other places little will deter drivers from trying to gain an advantage on the road.

Most BRT systems display a range of running way configurations over a corridor or route, depending on the streets used, the areas served and space available at any given location.

The running way does not only refer to the actual surface treatment but also the intersection control along the route. In the vast majority of cases worldwide the running way is on a shared surface with other vehicles, and while maybe on a dedicated bus lane or HOV lane, the vehicle can still encounter traffic related delays at intersections. BRT schemes usually include some form of prioritization for BRT vehicles over general traffic. This can be done in a variety of manners, including vehicle detection/signal priority or some other method. These will be discussed further under the ITS heading.

Stations

The stations commonly used for BRT schemes vary from system to system; however, they are generally of a more advanced nature that those typically used on bus transit routes. They can combine state of the art passenger information technology, with the comfort and convenience of rail stations, along with improved safety and fare collection systems.

The planning and design of stations is a combination of factors all of which have an important role in the overall success of the scheme. These factors are summarized as follows:

- Station Spacing;
- Platform location in the running way cross-section;
- Platform Length; and,
- Station Design Features.

Station Spacing is a fundamental input to the planning process for BRT services and systems. BRT stations are typically spaced from as little as 1,000 feet (approximately 300 meters) in CBDs to as much as 10,000 feet (3,000 meters) in low density suburbs to allow fast operating speeds without sacrificing ease of access.

Spacing varies greatly depending on the form of running way to be used and development demand densities. For on-street running, it may be prudent to provide stations more closely spaced than on an exclusive bus-only road. However, the essential inputs to this feature of the design, other than passenger demand, are how riders reach the station and the delay incurred as a result of the number of stops to be made. It is important not to make so many stops that rapid transit operating speeds and reliability become difficult to achieve.

Station Platform Location in the running way cross-section is closely related to available right of way and adjacent land uses and other BRT element designs. For example, for central median stations can save space on dedicated busways (e.g., Bogota, Quito), but vehicle door configurations (e.g., doors on both sides or on the one side consistent with the direction of operation) must permit boarding on the side of the vehicle opposite sidewalks. It is most advantageous to provide stations at locations that will facilitate easy interchanges to/from other bus routes, other modes and direct, safe walking access to large trip generators such as colleges or retail districts.

Most BRT stations are located at the far side of signalized intersections to take advantage of progressively synchronized signals and/or transit signal priority.

Station/Platform Length depends on the volume of buses through a station, the number of distinct routes it serves and the number of people boarding and alighting. In some locations these parameters will combine to require space for a minimum of 2 or 3 buses plus clearance for pull in/pull out. Where an articulated fleet is utilized, this translates into a total of 150 to 250 feet; however, in some instances (e.g., end of the line terminal where many routes, including local and BRT services, converge or diverge) it may be necessary to provide even more space for larger vehicle and passenger volumes.

Design Features provided for stations can be totally different for stations along a single route, depending on available space and the number of people boarding and alighting. For example, larger stations at route termini might include a range of passenger services, such as coffee stands, ATMs, dry-cleaning services and other items that would be of use to passengers. All stations should be well-lit and include facilities to protect the passengers from inclement weather, i.e. a roof and wall to deflect wind. In climates that are particularly inclement, the shelters could be heated and even air conditioned. Stations should provide a significant amount of passenger information, including time to next bus etc., either through posted schedules and/or shown electronically via a VMS system. Efficient forms of fare payment could also be used at major stations to expedite the boarding process, for example honor-fare ticket vending machines, magnetic card vending machines or smart card vending and or value updating machines.

Vehicles

Standard diesel buses, both 40 foot and 60 foot are widely used for BRT operations. There is however a trend toward innovations in vehicle design in terms of (1) "clean" propulsion systems (e.g., diesels with self regenerating after-burners using low sulfur diesel fuel; diesel/CNG/gasoline - electric hybrids; compressed natural gas [CNG] fueled spark ignition engines) (2) dual-mode (diesel-electric) vehicles that permit on-wire operation through tunnels, regular diesel operation elsewhere; (3) 100% low-floor buses with inordinately wide stairwells; (4) buses with more and wider doors; and (5) use of distinctive BRT vehicles with unique styling and operational features such as the ability to dock close enough to station platform edges to permit level, no-step boarding and alighting.

Examples of innovative vehicle designs include:

- Los Angeles' low-floor, CNG powered 60 foot low floor NABI "Metroliners").
- Boston's planned multi-door Neoplan dual-mode diesel-electric and CNG buses.
- Curitiba, Brazil and Utrecht, Holland's 80 foot long+ double articulated buses with 5 sets of doors
- Rouen's Iris Civis bus – a "new design" diesel-electric specialized BRT vehicle with a train like look, four doors in 60 feet, optical guidance, and a minimum 34-inch (about .87 meters) wide aisle end to end. A 34 inch aisle width compares to the 22-30 inch minimum width between wheel wells found on most other 100% low floor vehicles, including those operated by NYCT.
- Bogotá's high-platform Volvo and Marco Polo vehicles with multiple left-side doors that serve stations which universally have center island platforms.

ITS Applications

Applications of ITS technologies in BRT systems begin with those that are operations-oriented such as 1) fleet management, including automatic vehicle location (AVL) systems, automatic passenger counters, and surveillance systems through the use of remote sensing and close circuit TV, and 2) electronic fare payment systems and passenger-oriented, namely passenger information systems either on-board the bus or at stations/stops. AVL systems automatically determine and track the real-time geospatial location of a bus. Several different technologies may be used to perform AVL, such as GPS, ground-based radio, signpost and odometer, dead-reckoning, and combinations of these. Automatic passenger counters are devices that count passengers automatically as they board and alight transit vehicles, typically buses. Most common technologies include treadle mats or infrared beams. Electronic fare payment systems provide an electronic means of collecting and processing fares. Passengers can use a magnetic stripe card, smart card, or credit card instead of tokens or cash to pay for transit trips. Smart cards have the ability to store monetary value and other information on an embedded integrated circuit or micro-chip.

There are several additional technological systems that may be involved in the implementation of bus rapid transit systems and are at different stages of research, development, and deployment. They include collision warning systems, transit signal priority systems, and vehicle assist and automation systems such as precision docking, automatic steering control systems, and automatic speed and spacing control systems.

Collision Warning Systems

Collision warning systems could augment the driver's normal driving and could provide alerts to hazards of which he may be unaware, and could also help out in conditions in which the driver is distracted or less than fully alert, e.g., due to fatigue. Such systems may take the form of forward, rear, and side hazard warnings and can be delivered to the driver by either auditory, haptic, or visual cues. The driver retains responsibility for corrective actions based on the warnings provided. Technologies that may be used in these systems include radar, ultrasound or laser sensors and threat assessment software and the driver interface. Benefit opportunities include a reduced risk of property damage, injuries, and fatalities; reduced liability and vehicle repair expenses; improved vehicle utilization, and improved rider/passenger perception of bus performance. The primary incremental cost generator is for the installation of warning systems on vehicles.

Transit Signal Priority Systems

ITS can help provide priorities for buses at intersections, freeway ramps, toll plazas, and bridge or tunnel approaches. Transit signal priority systems in their simplest form makes it possible for a bus approaching an intersection during the final seconds of the green signal cycle to be detected and to request an extension of the green cycle so that the bus can pass through before the signal turns red, thereby saving the bus and its passengers the red cycle time. This tends to provide some ancillary time saving benefits to the other vehicles traveling in the same direction as the bus, while increasing the time delays to the crossing traffic. Technologies that may be utilized include vehicle detection, identification, and location systems to identify a bus and communicate to a roadside signal controller cabinet, Global Positioning Systems (GPS), Differential GPS, dead-reckoning for vehicle positioning, and wireless communication. Benefit opportunities include reduced travel time for passengers, higher utilization of the bus fleet, improved schedule adherence (assuming a schedule-based operational policy), and improved service effectiveness in terms of passengers per revenue hour or mile). Incremental cost generators include vehicle and roadside equipment such as vehicle detection systems, signal controllers, and wireless communication systems, and added delays to cross street traffic.

Vehicle Assist and Automation Systems

Vehicle Assist Systems technologies are those that help the driver maintain lateral control of the bus such as Precision Docking and Vehicle Guidance. Vehicle Automation Systems technologies are those that provide both longitudinal and lateral control of the movement of the transit vehicle, for a potentially driverless vehicle or automated section of a route such as Platooning and Automated Vehicle Operations.

Precision Docking Systems

Precision docking systems involves the low-speed positioning of buses relative to the curb or loading platform at bus stops and/or stations under the direct bus driver supervision. The lateral position of the bus is precisely controlled with 1to 2 cm. tolerances. Technologies that may be utilized include roadway magnetic marker sensors or visual/optical sensing systems with an electronically-controlled steering actuator. The benefit opportunities associated with precision docking include reduced bus dwell times, saving times for both passengers and fleer operators; a safer and easier boarding and alighting for handicapped/disabled passengers; less wear and tear on bus tires resulting from scuffing at curbs; reduced level of driver stress; and enhanced comfort for passengers. Incremental cost generators include electronically-controlled steering actuator, lateral-position sensing system, and reference markings at bus stops/ stations.

Automatic Steering Systems

Automatic steering systems enable buses to stay centered in their traveling lane. Typical technologies include roadway magnetic marker sensors, vision/optical sensing systems with an electronically-controlled steering actuator. Benefit opportunities include the ability to operate buses in narrower lanes, thereby saving rights-of-way (ROW) and construction costs, enabling operations in locations that would be too narrow for conventional buses, a smoother lateral ride quality, and reduced driver stress. Incremental cost generators include electronically-controlled steering actuator, lateral position sensing system, and reference markings along the vehicle lanes.

Automatic Speed and Spacing Control Systems

Automatic speed and spacing control systems have vehicle speed under automatic control rather than under manual or driver control. Vehicles can be operated very close together due to the spacing control. Typical technologies include forward ranging sensors such as radar or laser systems, electronic control of the engine and brakes, and vehicle-to-vehicle data communication systems. Benefit opportunities include an enhanced bus capacity using bus platoons (from close spacing), smooth ride quality for passengers, and a reduction in fuel consumption and level of emissions. Incremental cost generators include sensing and communication devices and electronic brake control actuators.

Fare Collection

One of the central strategies to reducing the dwell time on a route is to reduce the time for passengers to board through the utilization of a fare collection technology that facilitates speedy boarding. Dwell time can comprise up to or even over 25% of the end to end travel time, thus the reduction of this component will be of major benefit to the both bus users and operating company. Several alternative fare collection systems exist, from the relatively low-tech using exact change to highly advance smartcard technologies.

The three primary attributes of a fare collection system are as follows:

- *Fare Collection Process* – i.e. how the fare is physically paid, processed and verified. This element can have an impact on the dwell time and reliability of the service. It also influences the fare evasion and enforcement procedures and has operating and capital cost impacts.
- *Fare Media* – The choice of fare media is based on the collection process prescribed for a service. Cash or paper media are among the simplest and most traditional forms of fare media available, however, while inexpensive to implement, can be among the slowest to process impacting on the dwell time and reliability of the service. Magnetic strip media (for example the MetroCard) are another popular form of fare media. These cards store information as to the number of trips available, based on a monetary or time-based system (or both). There is an increased expense in the implementation of this form of media as electronic readers are required.
- *Smart Cards* – these support faster and more flexible fare collection systems. They can you either contactless or proximity systems. These are generally the most expensive form of fare media in terms of the media itself as well as the technology required to operate the system.

There are 4 basic forms of fare payment systems utilized in transit networks; the following discusses these four systems:

On-Board Payment – This system involves a transaction (using whichever fare media) at a system adjacent to the drivers' position. It requires the passengers to board at a single location and pay as they enter. This can result in increased dwell times, which when combined with the door and internal layout of the bus can result is significant delays, particularly at high boarding and alighting points on the route. The advantage, however, is that there is negligible fare evasion as a result of each passenger passing the driver.

Conductor Validated Payment – This system requires that a driver and a separate conductor be employed on each bus, whereby passengers can either buy a ticket or have a pre-paid ticket validated. While this system has higher operating cost, in terms of the labor requirements, it has the advantage of allowing for the speedier boardings and minimal dwell-times.

Barrier Enforced Payment – This system requires the provision of turnstiles or ticket agents to allow access to a secure location whereby passengers can board a bus without having to pay either on entry or on-board the vehicle. Essentially the fare-control area operates similar to a subway platform; however, this would be the most expensive option of the above in terms of capital and operating costs. Ticketing machines as well as the barriers, including the maintenance cost can be prohibitive to the provision of such a system. The system can be used in entry control or in entry and exit control in the case of a distance based fare structure.

Proof of Payment System – This requires the rider to carry a valid (usually by time and day) ticket or pass when on the vehicle. The riders are subject to a random check of tickets/passes by roving inspectors. The advantage of such a system is that it supports the use of multiple door boardings and thus lower dwell times. There is however, a greater chance of fare evasion.

The fare structure is also an important consideration under this element.

Flat fares impose the same cost per ride regardless of time of day or length of trip. This is the most straightforward and minimizes the responsibilities of the operator and potential level of confusion for riders. It also therefore speeds up boarding times.

Differentiated fares are charged depending on time of day, length of trip and type of customer. This type of system can lead to greater levels of confusion for riders and increased dwell times for bus operators (assuming the ticket is purchased on-board) as well as increased levels of validation for inspectors if applicable. An additional cost may the requirement to provide machines to track the locations where passengers board and then alight the vehicle, so that the correct fare is applied.

Service Patterns

BRT service patterns, based on the nature of the given corridor's transit market, determine the types of running way and vehicles utilized. Many systems provide an "overlay" of peak-only express or limited stop services on top of an all-day, all-stops local route. They also utilize "feeder" bus lines intersecting BRT routes at selected stations. Services on most systems extend beyond the limits of transitways or dedicated bus lanes – an important advantage of BRT. However, because of door arrangements, platform heights and/or propulsion systems, BRT systems in Jakarta, Bogotá, Curitiba, and Quito operate only within the limits of the special running ways. Some systems (e.g., Ottawa, Brisbane, Pittsburgh and Miami) feature line haul routes operating on transit ways that are integrated with off-line, off-transitway feeders at the trip production (home) end and distributors at the attraction or non-home end.

BRT operating headways should be less than 10 minutes where feasible and should be in operation all-day to minimize potential confusion for riders.

Identity and Branding

The provision of a distinctive, unique and highly visible branding/identity should be considered essential for any BRT system. This identity should be incorporated into all elements of the system particularly in terms of the running ways, stations and the BRT vehicles selected. Surveys have revealed this to be particularly appealing to users and helps create a strong image for the system. They should convey a greater level of service to other local and limited-stop services on the bus network for a corridor or area.

Brand identity is incorporated through the use of names, logos, color schemes, graphics, design of physical elements and marketing materials. The choice of a brand is unique to each market and therefore must be tailored to that specific situation. The choice of the identity for a system usually begins with a large research effort to understand the needs and tastes of the target riders. Implementation of the branding involves incorporating the chosen motif into the physical elements of the service.

BRT SYSTEM INTEGRATION: PUTTING BRT SYSTEMS TOGETHER

BRT Service Integration

Integration and connectivity are of great importance to a BRT system as the BRT system relies on the regular service to provide additional connections. In many ways the introduction of BRT has raised some of the same concerns that light rail systems encountered when they were first introduced into a community. In the initial stages of the introduction of the BRT system it is likely that additional transfers will be required between the regular service and BRT. As transferring imposes a penalty on the passenger, system expansion should endeavor to minimize the number of transfers required to reach a desired destination.

Since BRT is likely to use specially identified and designed vehicles, opportunities for interlining the BRT service with other bus services may be constrained. Clearly the existing network will need to be restructured to minimize over-coverage of an area.

The following is a discussion of the some of the key service integration considerations:

- Service differentiation: Most new BRT systems will endeavor to capture the imagination of the traveling public with speed, convenience and directness of the service. Differentiating the BRT service from the regular service as a separate but different brand raises many challenges. In some service applications the new BRT may offer only subtle differences with the regular service that may be difficult for passengers to discern. Separation of the brands is important so that the differences can be exploited from a marketing stand point.
- Scheduling: Regular transit service is timetable based where as the BRT system may be headway based. The BRT
- Rolling stock: The vehicles used in the BRT service could vary from newer standard vehicles with a particular branding to specifically designed low floor extra long vehicles with doors on both sides. These two types of vehicle may have different performance characteristics which affect the maneuvering space needed at the approach to the stations etc.
- Infrastructural compatibility: Station platforms may be specifically designed to accommodate the BRT vehicle. To ensure level boarding the platform may be raised and railing that opens to align with the door positions may be installed. A regular bus may have two or three steps at the door way which will result in passengers stepping up out the bus. The high platform may prohibit the use of the wheel chair ramp, which would need to be lowered to a certain height before the ramp is extended.
- Operator selection, training, uniforms and labor agreements: In order to create the best first impression of the new service, the transit agency may prefer to have their most talented and personable operators on the new BRT system. However the selection and training of the operators may be subject to existing labor contracts.

Additional issues with interlining of BRT vehicles with regular routes include fares, labor agreements, service frequency and hours, operator relief's, breaks, contingency planning, vehicle maintenance and spares, spares ratio, operating policies including securement of wheel chairs, and bicycle accommodations.

Integration of BRT Elements

One of the principal benefits of BRT is the ability to combine discrete BRT elements into a cohesive system. The selection of the particular elements will depend on the operating, environmental, political landscape, passenger needs and/or other factors. Agencies will generally endeavor to maximize the service benefit they receive from the amount funds invested. There may be unique opportunities where BRT elements can be introduced as part of a larger project undertaken by another agency, for example the city upgrading their traffic controllers may provide for the introduction of transit signal priority. Elements of the BRT system may be added incrementally as funding or staff support is available.

In order to distinguish the BRT service from regular bus service, the BRT must have a sufficient number of unique elements. At the basis level this may mean some service improvements and branding. As more elements are added careful consideration needs to be given to maximizing the investment already made, for example, a real time passenger information system may be added at marginal cost when an AVL system is already available. Also certain elements need to be combined in order to operate efficiently. An example would be fare collection and multi-doored vehicles. The benefits of a vehicle with multi doors are that passengers can enter and depart through any door. If the fare collection system requires passengers to file pass the driver then only one door can be used for boarding.

Interactions and Tradeoffs

A systems approach needs to be taken in the planning for and implementation of bus rapid transit systems that considers technology aspects, design attributes, operational and service plans, and institutional and policy issues. These four areas need to be integrated to understand their interactions. In this way, a much more complete and accurate depiction of the system with both its benefits and costs may be derived. We provide here a few examples to illustrate this point.

Design attributes are directly linked with operational and service plans and resulting benefits especially in terms of new ridership. For example, to reduce route travel time along a bus rapid transit corridor, fewer BRT stops/stations may be designated than would normally be used if that corridor were used for conventional local bus service. However, the further apart consecutive stops/stations are placed, the further customers would need to walk to access the stop/station. Clearly, a transit agency would plan the location of each stop/station to balance the competing objectives of reducing total travel time and attracting new riders. Having the stops spaced further apart contributes to reducing overall travel time because there would be fewer number of stops for the bus to provide boarding and alighting, however, having to walk further to access the bus may discourage potential riders from using this BRT service that may have been attracted to the new service because of the reduced travel time. In Los Angeles, MTA's Metro Rapid along Wilshire Boulevard originally sited stations approximately 75% to 80% of a mile apart. Overall travel time along the Wilshire corridor has been reduced by 25% and there has been an increase in ridership by approximately 25% with 33% of these being riders new to transit. However, based on public opinion about the Metro Rapid service, MTA is planning on inserting a few additional Metro Rapid stops/stations. The number and location have to be selected carefully as adding stops will attract new riders because of the reduced distance people have to walk to the stop, however, it will increase overall travel time, which itself would be a disincentive to attracting new riders.

Another interaction is among design attributes, service plans, and institutional concerns. In order to provide more rail-like level of service, an exclusive or at least near-exclusive right-of-way may be sought. Moreover, at BRT stops/stations the use of queue jumpers and/or bus bulbs may also be considered. The use of these design attributes in order to improve the level of service may, however, conflict with concerns of the local business community over its opposition to the removal of or restrictions placed on parking space availability that may be necessary to accommodate such operational and service plans for BRT.

A third example to illustrate the importance of integrating these issues brings together technological aspects, operational plans, and institutional concerns. Again, on Los Angeles' Wilshire Boulevard Metro Rapid service, MTA implemented in 2000 various bus rapid transit features as elements of its Metro Rapid service including transit signal priority along the heavily traveled Wilshire-Whittier Boulevard corridor. This corridor traverses the cities of Santa Monica, Beverly Hills, and Montebello in addition to the city of Los Angeles and each of these municipalities controls signal operation within their respective jurisdictions. Moreover, along the corridor, the municipal boundaries are such that the city of L.A is interspersed among the other three municipalities in a non-contiguous fashion. Thus for the Wilshire-Whittier corridor, MTA and the four traffic signal operators, that is, the local municipalities, are the primary stakeholders. Initially, transit signal priority was implemented only within the city of Los Angeles as the other cities wanted demonstrative proof of transit signal priorities' benefits before relinquishing control over the operation of traffic signals in their jurisdictions. To date, transit signal priority still remains implemented only in the city of Los Angeles while negotiations between MTA and the other jurisdictions continue.

LAND USE AND BRT

There is little doubt that transit shaped the urban form of our major cities. During the early stages of a cities development transit provided a way where workers could live outside of the central area and travel to jobs at a minimum cost. Developers saw value in the increased exposure provided by transit thus orientating their building to maximize the buildings visibility. The advent of the motor coach, while providing the flexibility in service users requested, denigrated the influence that transit has had in modern times in influencing land development.

Anecdotally most transit planners believe that fixed guideway systems have a positive impact on land use, particularly around the station areas, where as bus based systems have at best a neutral impact. Bus based systems have been shown to be beneficial impact at a community level however property adjacent to stops/station are considered less desirable. Proponents of fixed rail systems point to the lack of permanence of bus based modes as the principal reason why they have not been able to impact/ direct land use. In reality bus based systems are constrained by the available road network and are more permanent then some opponents would care to concede.

One of the biggest concerns of communities developing BRT systems is convincing the development community that BRT will provide the benefits that they associate with fixed guideway modes The advent of BRT systems has challenged premise. The new BRT systems that have chosen to incorporate a fixed guideway element have demonstrated that bus based transit systems can have a positive impact on urban form and land values. Although the BRT concept is new and few systems are in operation there is a growing body of evidence that suggests that BRT systems can support existing land users and promote higher density residential, office and commercial land use, particularly around the BRT stations. North American examples of this trend include Boston where $1,250 million, Pittsburgh $302 million and Ottawa $675 million of new or improved development respectively has occurred. The continuing development of more BRT systems will provide further evidence of this effect; however, as land use improvements tend to lag transit investment, examples of this trend may take a while to be realized.

Some BRT systems have benefited by initially developing a number of key stations where land use development potential exists and linking them with transit facilities which incrementally increase to fully exclusive busways. In this way they could make strategic infrastructural investments at specific locations with out the need to improve the whole corridor to the same level

The symbiotic relationship between land use and transit is well documented. Carefully crafted land use policies, can direct land development in a manner which increases real estate values but also provides the ridership needed to sustain a BRT system. Land uses that mix residential and commercial development can encourage balanced use of the BRT system. Unfortunately since the advent of the private auto mobile transit planning has largely been reactive. The transit planner has sought to supply service to suburban development in the most efficient manner possible.

BRT PLANNING TOOLS AND METHODOLOGIES

Introduction

This section of the BRT Information Clearinghouse explores the various sketch planning tools available for the development of a bus rapid transit system project.
The concept of using rubber-tired vehicles to provide rapid transit is not new as there have been major plans in the United States put forth since the 1930s and that Chicago was the first such investigation (See References 1-4 at end of document). During the 1960s and 1970s, pioneering research and planning studies were also performed (See References 5-10). In the mid- to late-1970s in the U.S., the focus in transit planning shifted away from bus use and moved toward high-occupancy-vehicle (HOV) and light-rail transit (LRT). Consistent with this trend in the 60s and 70s away from BRT in the U.S., the oldest rapid bus systems in operation were implemented twenty to thirty years ago in locations around the world, outside the U.S., including 1) Runcorn, United Kingdom, 1973; 2) Curitiba, Brazil, 1974; 3) Ottawa, Ontario, Canada, 1983; and 4) Adelaide, Australia, 1986 (See BRT Resources) . It is only over the last half-dozen or so years that bus rapid transit systems have grown in popularity and been put into operation in the United States beginning in 1998 when the FTA formed the BRT Consortium to demonstrate the effectiveness of BRT and to encourage BRT deployment and the implementation in 2000 of the Los Angeles Metro Rapid service along the Wilshire-Whittier Boulevard and Ventura Boulevard corridors.

Tools

Generally, the methodological approaches taken and the planning tools used in the study of bus rapid transit systems for purposes of ridership forecasting, operations/maintenance costing, etc., would ordinarily be no different than those employed to study other transit travel mode alternatives, such as light or heavy rail transit in the overall larger context of transit planning and project development , beginning with the execution of the Alternatives Analysis Process. Examples of the types of models/tools employed include transit network models, travel demand models, and simulation models.
There has been, however, until recently, a shortage of information about bus rapid transit, especially in the area of the potential benefits and costs. In response to this information deficit, BRT-specific approaches and tools are being developed at the national as well as the state level to support BRT planning and analysis. A number of these additional tools are described below.

- FTA's ITS Enhanced Bus Rapid Transit – BRT uses Intelligent Transportation Systems technology, modern land use planning, and transportation policies to support new concepts for rapid transit systems based on bus-like vehicles. The success of some of these implemented BRT systems have shown that they are capable of providing heavily-used high capacity rapid transit at a reduced cost. This research explores the relationship between BRT and ITS technologies to determine the best set of ITS enhancements to optimize overall BRT performance. Specifically, this research recommends appropriate sets of ITS technologies for various BRT operational scenarios.

- FTA's Characteristics of Bus Rapid Transit for Decision Making - A compendium of information describing BRT experience to date, including physical, operational, service, cost, and performance characteristics. CBRT serves as a first cut, "sketch planning" tool and as a source of reasonability-checking information for detailed planning.
- FTA's ITS & BRT Assessment Tool (IBAT) - Intelligent Transportation Systems (ITS) play a key role in the operation of BRT systems. Collectively, ITS are an integral part of BRT system characteristics and enable BRT to provide higher quality of service in terms of safety, speed, comfort, and convenience. Thus it is important to understand which ITS technologies that are relevant to BRT. It is also critically important to be able to test the various requirements for an integrated BRT system. As a follow-on to its ITS Enhanced BRT and Characteristics of BRT for Decision Making, FTA has proceeded with the development of the ITS-BRT Assessment Tool or IBAT, an analytic tool that allows for quick, flexible, and customizable estimation of the impacts of various ITS packages on BRT system performance. The tool allows users to quantify corridor-level travel time savings, link delay, and system capacity through multiple refinements of ITS packages.
- National BRT Institute's (NBRTI) web-based image and video library This resource, originally prepared under the Transit Cooperative Research Program/s BRT Guidelines project A-23, is a compendium of hundreds of BRT images and video clips from around the world. The intent of the on-line database is to assist planners in preparing presentations, videos and reports for a host of communications and planning purposes.
- TCRP Project A-23, BRT Case Study Synthesis and BRT Implementation Guidelines, TCRP Report 90, Volumes I (Case Studies) and II (Implementation Guidelines) The focus of these two documents is on BRT planning and implementation from both the perspective of each individual element of BRT and from the perspective of packaging. It is not a prescription but a practical "how to do it" guide.
- TCRP Project A-23A, BRT Practitioner's Guide A logical extension of the BRT Implementation Guidelines. This document will focus on a number of important planning activities such as ridership forecasting and traffic operations analysis as well as the determination of the relative cost effectiveness of various BRT treatments.
- BRT Case Study Evaluations An extension of the 26 BRT case-studies documented and synthesized by TCRP Project A-23, a large number of BRT case study evaluations are in the process of being documented by CUTR and other institutions under the auspices of FTA.
- The Institute for Transportation and Development Policy has produced BRT Planning Guidelines, which is oriented to BRT systems in developing countries. These guidelines are much more policy and process oriented then TCRP Guidelines which focuses on specific elements of BRT.
- FTA's BRT Evaluation Guidelines This document presents guidelines for planning, implementation, and reporting the findings of an evaluation of a BRT implementation site selected for the FTA BRT Demonstration Program. The

document will provide a common framework and methodology for developing and then executing the evaluation of individual BRT demonstrations.

There are other resources of value to BRT planners and developers. Some uniquely deal with BRT, but others deal with individual BRT issues and elements (e.g., bus technology, ITS, traffic engineering for transit, service planning, fare collection planning for transit oriented development or TOD), while others may deal with issues of relevance to BRT, but were originally prepared for LRT – e.g., improving the safety of street-operations.

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(See Publications for complete citations for these references)

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DESIGN SPECIFICATIONS

For many communities the concept of BRT is new. With out appropriate design criteria it is difficult for community to determine the likely costs and impacts associated with a BRT system. As BRT systems are relatively new there is not the body of knowledge to guide the prospective BRT community in the design of a BRT system. Most designers have relied on rail based design standards. At the sketch planning level this may be an appropriate choice however unless the agency is considering expanding to a rail based system this may result in an overestimate of the geometric needs which could result increased anticipated land impacts.

Also as a number of BRT implementations include dedicated facilitates, used by professional driver, standard roadway design requirements may be inappropriate.
At a minimum the design criteria should consider the vertical and horizontal geometry, vehicle dimensions, station requirements, and lane widths, vehicle speeds.
Design standards and allowable practices do vary from region to region: the final criteria will be determined by the officiating jurisdiction however, it is desirable that the designer have some basis to evaluate the design. A consistent set of design standards also aids comparison of alternatives. Also during the early stages of the project development it is unlikely that a vehicle will have been selected .As the size and operating characteristics play an important role in the design, the use of generic measures is appropriate.

OPERATIONS PLANNING

This section of the site addresses the issue of operational planning. The term operational planning is used to describe the activities that occur before service introduction therefore discriminating between service planning which focuses on setting frequency and schedule. Critical activities that need to be addressed before service introduction include contingency planning in which agency staff responses to critical events are established, driver selection and training, support and supervisory staff training.

The level of contingency peculiar to the BRT system will depend on the number of elements that differ from the regular service. If the BRT system operates as an enhanced express service than existing contingency planning will be sufficient, however if dedicated barrier separated rights of way are used then additional measures must be considered. These events could include access for emergency services, recovery of and rerouting around a disabled vehicle and maintenance operations. The temporary rerouting of service will require a significant passenger information element, which will ensure that passengers are able to access and egress the system with the minimum of discomfort. Issues such as curb height at the alternative loading area may impact service particular if the BRT service has been designed for level boarding with out wheelchair lifts.

The process of selecting and training drivers will generally need to be negotiated with the labor union. While agency management may want there best and most personable operators on the new service, existing labor agreements may preclude driver selection on anything other than seniority.

Route supervisors are generally the first responder in the event of an incident. Procedures for addressing all likely incidents need to be developed.

CASE STUDIES

Introduction

The case studies considered for the Planning Support Tool are summarized in the following list, which is consistent with and primarily based on the those described in the TCRP Report 90, Volume 1 Case Studies, in Bus Rapid Transit as well as the included in the Characteristics of Bus Rapid Transit for Decision Making document prepared for the Federal Transit Administration. The case studies presented represent both national and international experience with the planning, design and implementation of Bus Rapid Transit.

- United States and Canada
  - Boston, Massachusetts (Silverline)
  - Chicago, Illinois
  - Cleveland, Ohio (Euclid Ave.)
  - Eugene, Oregon (EmX)
  - Hartford, Connecticut (Hartford-New Britain Busway)
  - Honolulu, Hawaii (CityExpress!, CountryExpress!)
  - Houston, Texas
  - Los Angeles, California (Metro Rapid Wilshire/Ventura Boulevards, I-10 El Monte Busway, I-110 Harbor Transitway, Metro Orange Line)
  - Miami, Florida (South Miami-Dade Busway)
  - Oakland, California (The Rapid)
  - Orlando, Florida (Lymmo)
  - Ottawa, Ontario, Canada (Transitway)
  - Phoenix, Arizona (Rapid)
  - Pittsburgh, Pennsylvania (Martin Luther King Jr., East Busway)
  - Seattle, Washington (Bus Tunnel)
  - Las Vegas, Nevada (MAX)
- Australia
  - Adelaide (O-Bahn Busway)
  - Sydney
  - Brisbane
- Europe
  - Leeds, UK
  - Runcorn, UK
  - Rouen, France
  - Paris, France
  - London, UK
- South America
  - Bogotá, Colombia
  - Curitiba, Brazil
  - Quito, Ecuador

Background

In this section, short descriptions of background material are presented to show the range of environments in which bus rapid transit systems have been implemented in numerous cities around the world.

United States and Canada

Boston, Massachusetts

There was a need to provide better transit access and more capacity to the growing South Piers redevelopment area and Logan International Airport. BRT was perceived as providing operational and service flexibility and related benefits rather than merely cost advantages over other rail-based rapid modes. A limited amount of bus subway (tunnel) construction provides a one-seat ride to major activity centers such as Logan Airport from a variety of locations in the western and south-west portions of the City of Boston as well as providing another link among the City's multi-lined rapid transit system.

Cleveland, Ohio

Rail transit on the Euclid Avenue corridor has been proposed for more than a half century, but numerous rail-based rapid transit plans were never realized because of the cost involved and the declining commercial activity in the corridor. BRT was perceived to be more cost-effective and affordable, and was seen as a tool for encouraging redevelopment.

Eugene, Oregon

A BRT system was seen as an environmentally responsive way of alleviating traffic congestion without making costly highway improvements in that rapidly growing medium-sized community.

Hartford, Connecticut

A BRT line was found to be a more cost-effective, less environmentally intrusive alternative for improving mobility than either LRT or a major freeway reconstruction, and more compatible with community planning goals.

Houston, Texas

The HOV, park and ride, and commuter express bus system makes effective use of HOV lanes in radial freeway corridors thereby reducing peak-hour traffic congestion. It originated after voters rejected a referendum dealing with bond sales for rail transit yet the region still needed a high-performance rapid transit system as an alternative to pervasive traffic congestion.

Las Vegas, Nevada

The MAX line, opened in July 2005, is the first U.S. BRT system to have all six major elements of BRT, including dedicated lanes, attractive stations, specialized, guided BRT vehicles, off-board fare collection, real time passenger information and signal priority. BRT was found to be much easier and less expensive to implement than any other rapid transit alternative in the fastest growing city in the U.S., allowing much more system to be built for the same money.

Los Angeles, California

Long delays and cost overruns led to a county referendum prohibiting future subway construction. BRT was seen as a cost-effective alternative to improving transit service in major travel corridors. It was also considered to be a strategy for offsetting a 12% decline in bus speeds in recent years.

Miami, Florida

The State of Florida Department of Transportation examined alternative ways of providing high performance public transportation on an abandoned railroad right-of-way in a highly congested, growing suburban corridor. This led to the decision to build an at-grade 8-mile busway serving the terminal Metrorail station at Dadeland south. This busway functions as an extension of the Metrorail system and is now being extended to Florida City, another 8 miles further south.

Ottawa, Ontario, Canada

The region's land use and transportation policy gave public transportation projects priority over all forms of road construction or widening. Busway technology was selected because it was cheaper to build and operate than an LRT alternative, allowing much more system to be built and operated for the same amount of money. A 1976 study found that a bus-based system could be built for half the capital costs of rail transit and would cost 20% less to operate. It also offered a higher level of service; greater staging flexibility met the capacity requirement of 15,000 passengers per hour in the peak direction and had similar environmental impacts when compared to the rail option. BRT was also seen as a growth management tool.

Pittsburgh, Pennsylvania

Busways were found easier to implement, politically viable, and affordable relative to major highway construction or rail transit. They would benefit riders that traveled beyond the limits of the guideways. The Port Authority of Allegheny County was also able to make use of an extensive network of railroad rights-of-way to implement dedicated busways.

Seattle, Washington

In the early 1980's, a then federal policy of "no new rail starts" required Metro to explore bus alternatives for improving mobility and addressing pervasive congestion in this rapidly growing city. The bus tunnel was selected for its ability to remove the huge number of buses crowding downtown streets while, in conjunction with that Region's extensive HOV system, providing a high-speed, reliable one seat ride from many locations to the CBD.

Australia

Adelaide

Mercedes Benz Company's "O Bahn" mechanically guided bus system was found to have significantly lower initial costs than light rail and reduced the need for transferring in a low-density corridor. The O-Bahn technology was selected to reduce the cross section of a completely elevated guideway necessitated by soil conditions and a constrained right-of-way.

Brisbane

The Southeast Busway was designed to increase transit level of service in a low-density corridor, promote transit-oriented development, and make use of existing HOV lanes on the Southeast Motorway heading toward the "Gold Coast" beach area.

Sydney

A suburban BRT link was built to provide better transit service to low density areas with minimum transfer and walk times.

Europe

Leeds (UK)

The Guided Bus technology provides self-enforcing (cars and truck cannot physically operate on the tracks) queue bypasses for buses at congested locations.

London (UK)

For the past several years, London has implemented a 67-corridor "Quality Bus Corridor" program. This program represents a strategy to improve all aspects of bus operation and the customer experience in the respective corridors, end-to-end. Since 1999, there has been an increase in bus riderhip of over 40% to the highest point since 1968. In large measure, the increase has been due to the implementation of a variety of corridor "BRT Light" schemes, featuring red-paved dedicated arterial bus lanes, off-board fare collection, signal priority, real-time passenger information and an extensive fleet of 60 ft.(18 meter) three double-stream door, low floor ”bendy” (articulated) buses.

Runcorn (UK)

A “Figure 8”, partially grade-separated Busway was an integral part of the New Town’s basic lay-out from its beginning. It is the spine around which the community has been laid-out.

Rouen (France)

After bid for a second light rail line came in significantly over available funds, local authorities re-advertised a competition to build-operate-and-maintain a rapid transit line for which BRT was an option. The winning bid (less than half the cost of the best LRT proposal) resulted in construction of a BRT system application (TEOR), featuring modern, optically-guided vehicles, off-board fare collection, signal priority, real-time passenger information on-board and at stations and a significant proportion of running on dedicated, specially colored running ways. Fare collection and station designs are the same as for the initial LRT line.

Paris (France)

A number of segments of “semi-rapid” transit have been built as part of a belt-line around Paris. The Val de Marne BRT line is a full-featured BRT application, with operation on dedicated busways, off-board fare collection, 100% low-floor articulated vehicles and real time passenger information. Stations are identical to those used for most of the LRT segments of the transit belt-line.

South America

In South America, there has been an urgent need to improve travel conditions in congested cities with populations that are growing exponentially. There generally has been neither time nor resources to build rail transit. Busways in the center of wide arterial streets emerged as a means of increasing bus performance and capacity.

Bogotá (Colombia)

After many false starts with rail-based rapid transit, the TransMilenio four-lane median busway system was built after a three-year period to provide affordable bus rapid transit services. It uses physically separated four lane median bus lanes to service center high platforms, no gap boarding/alighting island stations. With over one million riders per day on less than 30 miles, and at least one line carrying more than 30,000 trips per hour past the maximum load point in the peak direction, TransMilenio is the busiest BRT system in the world.

Curitiba (Brazil)

Rapid transit was seen as essential to the organized, efficient growth of this rapidly expanding city. Median busways were affordable and more flexible than rail, and have been an integral part of a "structural axis" along which development has been and continues to be encouraged.

Quito (Ecuador)

Given the explosive growth of the city over the past 30 years, improved public transport became a political imperative. After a number of abortive (insufficient funds) attempts to implement a rail system in the city, the decision was made to pursue BRT. Electric trolley buses were selected for the lines serving the city's colonial core because of the view that an increased number of diesel buses would detract from its historic heritage.

Summary of Characteristics of BRT

Across the case studies there is a wide range of BRT services and facilities that reflect specific community needs and resources. The principal features by system discussed above, and geographic area are summarized in Table 2.

Table 2 Number of Facilities with Specific Features

Feature	US / Canada	Australia / Europe	South America	Total	% of Total Number of Systems
Dedicated Running Ways	14	8	6	28	90
Stations	14	7	3	24	77
Distinctive Vehicles	9	5	3	17	55
Off-Vehicle Fare Collection	2	3	3	8	26
ITS	9	4	3	16	52
Frequent All-Day Service	13	8	6	27	87
Total Systems Surveyed	**16**	**9**	**6**	**31**	**100**

Over 90% of the systems profiled have some type of exclusive running ways, either a bus-only road or bus lane. More than 85% provide frequent all-day service, and 75% have serious "stations" rather than simple stops. In contrast, only about 55 percent have distinctive vehicles (in design/type/livery) and roughly 50% feature some type of ITS application. Only 8 systems of the list surveyed above, roughly 26%, have off-board fare collection.

It should be noted that the percentage of systems with an increasing number of BRT elements is going up as the more recent applications, e.g., Las Vegas MAX and San Pablo Blvd Rapid Bus (Oakland, California) are much more complete systems.

Six existing systems (Bogotá's TransMilenio, Curitiba, Rouen, Paris, London and Quito's Trolebus) have all six basic BRT elements; while several other systems have four of the six primary elements. Systems under development in Boston, Cleveland, and Eugene will also have all six BRT elements, while Las Vegas MAX, opened in July 2004, also has all six.

Currently in North America, only Ottawa and Las Vegas have off-board fare collection; however, Boston's Silver Line Phase 2 will also have this feature.

Currently within the United States and Canada, 14 of 16 systems have dedicated running ways (bus lanes or busways), 13 have stations, 11 have all-day service, seven feature ITS elements, and two systems have off-board fare collection.

As a final summary note, a TCRP survey, done in 2000/2001 covered the first increment of a number of systems that have added features and evolved over time. For example, the system in Los Angeles is as of this writing, in the process of adding specialized BRT vehicles to the fleet operating its various Metro Rapid Bus Routes, while Boston is beginning installation of its Smart-Card based fare collection system that should enable much more efficient boarding on the first Phase of its Silver BRT line (Phase II subway stations have fare gates controlling access to station platforms.)

Elements of BRT

This subsection focuses on site-specific examples for each BRT element. For a more general description, see Elements of BRT within the Planning Support Tool.

Running Ways

BRT running ways include operations in mixed traffic, median arterial busways, contra-flow freeway bus lanes, normal-flow freeway HOV lanes, and busways on separate rights of way and bus tunnels. These running way features are summarized by geographic region in Table 3.

There is considerable variation among BRT facilities from region to region. Independent busways dominate North American and Australian practice, while arterial median busways are used throughout South America. Arterial street bus operations are found in two of the three European case studies. Reserved freeway lanes for buses and carpools are found only in the United States.

Table 3 Types of Facility by Region

	US/ Canada	Australia / NZ	Europe	South America	Total
Arterial Street					
Mixed Traffic	7	-	-		5
Queue Bypass	0	-	1 (1)		1
Curb Bus Lanes	3		1 (2)		3
Median Busway	2 (3)			8	10
Freeways/Separate R/W					
Contra-flow Lanes	3				3
HOV Lanes	3				3
Busways	7	3 (1)	1		11
Bus Tunnels	2				
TOTAL	**24**	**3**	**3**	**8**	**38**

(1) Includes O-Bahn and bus tunnel as part of one busway
(2) Optically Guided Bus
(3) Once system includes an electronically guided vehicle

While Brisbane's SE busway and Pittsburgh's West Busway have several tunnel sections, a bus "subway" with five on-line underground stations exists in Seattle. A 1.2 mile subway is being constructed in downtown Boston that will have three underground stations. This represents an important advance in BRT development, bringing a key running way feature of rail transit to bus operations, complete grade separation in a busy CBD to BRT.

Bus-only roads (busways) exist in Miami, Ottawa, Pittsburgh, Runcorn, Sydney and Brisbane. A busway on a rail right-of-way is under construction in Hartford.

Curb bus lanes traditionally have been the main type of bus priority treatment both in North America and Europe, although they were not reported in the case studies. Despite their advantages in bringing buses curbside and their minimum impact on street traffic flow they are often avoided because of their uncertain availability and conflicts with deliveries. This is certainly the case in South America where arterial median busways predominate.

Several systems in the United States and Canada (Honolulu, Los Angeles, and Vancouver) operate largely in mixed traffic. In the case of Los Angeles, this is an interim operation, and after a demonstration on Wilshire Blvd., more bus-only lanes will be selectively incorporated in the future.

Running ways are generally radial, extending to or through the city center. However, Vancouver's Broadway-Lougheed Line provides cross-town service and is anchored by the University of British Columbia on the west. Sydney's northwest suburbs busway is a circumferential facility.

Bus lanes are typically 11 to 12 feet wide. Shoulders are provided along busways where space exists. At busway stations, roadways are typically widened to about 50 feet to allow for express bus or skip-stop passing. Busway envelopes (widths) are about 30 to 50 feet between stations. At stations, the total envelope (4 travel lanes, plus station side platforms) can be as wide as 75 feet. For example:

- The Hartford-New Britain Busway will provide a 50-foot envelope at "staggered" or offset side platform stations.
- The South Miami-Dade Busway provides a 52-foot roadway at stations plus station platforms.
- Ottawa's Transitways provides two 13-foot lanes plus 8-foot shoulders. There is a 75-foot envelope at stations.
- Curitiba's arterial median busways have 23-foot roadways. The overall envelope – including stations and service roads is 72 to 85 feet wide.

Stations

Spacing

Station spacing along freeways and busways ranges upward from about 2,200 feet along Boston's Silver Line to several miles along the Adelaide O-Bahn and the El Monte Busway in Los Angeles. The South Miami-Dade Busway has a spacing of almost 2,900 feet, the Pittsburgh busways average 4,200 feet, the Brisbane busway averages 5,540 feet, the Ottawa Transitway system averages 6,900 feet, and LA's El Monte Busway along Interstate 10 exceeds 21,000 feet between on-line stations, though there are end-to-end expresses.

BRT station spacing along arterial streets ranges upward from about 1,000 feet in Porto Alegre, 1,200 feet in Cleveland and 1,400 feet in Curitiba to over 4,000 feet along Vancouver's "B" Lines and Los Angeles' Metro Rapid service.

This spacing, ranging from approximately 1,000 feet in urban areas to 5,280 feet in suburban areas, is similar to LRT and Metro practice. (NYC Transit limited service has an average stop spacing of 2,000-2,500 feet.)

Locations

Stations are placed curbside when buses operate in mixed traffic, as in Los Angeles and Vancouver. Stations are typically located on the outside of the roadway along arterial medians and busways. However the Bogotá system, a section of the Quito Trolebus, and Curitiba's "direct" service have center island platforms with commensurate use of left-side doors on buses.

Passing Capabilities

Two-way busways widen from two to four lanes to enable express buses to pass vehicles making stops. In situations where stations are staggered on either side of intersections, busways typically widen to a total of three lanes. The median arterial busways in South American cities also provide passing lanes for buses; usually station platforms are offset to minimize the busway envelope, thereby resulting in lane changes (shifts) by buses. Bogotá's median busway has continuous express (passing lanes). Cleveland will operate express buses on parallel streets, thereby obviating the need for passing lanes at median busway stations.

The Brisbane and Ottawa busways have barriers between opposing directions of travel at stations to prevent at-grade pedestrian crossings. Pittsburgh has barriers as well as raised curbs with designated crosswalks. Miami merely designates desired crossing locations, as will the new Hartford-New Britain Busway.

Platform Length

Station platform length varies depending upon bus volumes and the lengths of the vehicles operated. Stations typically accommodate two to three buses, although busy stations may accommodate four to five vehicles. Boston's Silver Line, for example, will have 220-foot long platforms that can simultaneously handle three 60-foot articulated buses. Where the service plan has more than one route serving a particular station, platform lengths will be longer. Because of the number of routes serving each station and the enormous passenger volumes it carries, Bogotá's TransMilenio busway has platforms up to 500 feet long.

End of the line BRT stations, where many routes converge and diverge, including local buses, may have many additional bus docking positions.

Platform Height

Most new BRT stations have low platforms, since many will be served by low-floor buses. However, three systems in South America – Bogotá's TransMilenio, Quito's Trolebus, and Curitiba's systems have high platforms to allow no-gap, level boarding and alighting of passengers from high floor vehicles. Guided vehicles such as the Civis vehicle used in Rouen and Las Vegas, or buses with at-grade access ramps that automatically drop down at stations, e.g., Quito and Curitiba, are required for floor-to-platform boarding and alighting.

Fare Collection

Bogotá, Curitiba and Quito have fare gates controlling access to "high" station platforms similar to those found on metro rail systems. The station fare collection mechanism function essentially like those for rail rapid transit lines, with access allowed for people paying exact cash fare in Curitiba and by smart card in Bogotá. Prepayment along with multi-door use of buses reduces dwell times, to as low as 20 seconds per stop in Curitiba and Bogotá for some high volume stations.

In Rouen, the barrier-free honor fare system, similar to that used in many European cities' bus or LRT systems, facilitates multiple door boarding. In other cities with high BRT passenger volumes (e.g. Ottawa) the use of fare passes allows at least two-stream boarding through all doors. Las Vegas is the first BRT system in North America to utilize an honor-fare system featuring ticket vending machines at stations and on-board time and date validation enforced by roving inspectors. Most American LRT systems use honor fare systems including Hudson-Bergen LRT in New Jersey.

Station Design Features

Stations along the case study systems provide a broad spectrum of features and amenities, depending on location, climate, type of facility, and available space. Some are simple, attractive canopies as along Miami's Busway or Los Angeles' Metro Rapid Lines. Others, like those along Brisbane's South East Busway provide distinct and architecturally distinguished designs, as well as a full range of pedestrian facilities and conveniences. The "high platform" stations in Bogotá, Curitiba and Quito contain extensive space for fare payment. Curitiba's tube stations have become an internationally-recognized symbol. LACMTA's Metro Rapid Bus, AC Transit's San Pablo Blvd Rapid Bus and Las Vegas Max stations feature real-time bus arrival information.

Overhead pedestrian walks connect opposite sides of stations in Brisbane and Ottawa, as well as busy stations in Pittsburgh. In some situations, access to both platforms is provided from roadway crossings over the busway.

Vehicles

Body Style

Vehicle body styles range from the standard (40-ft) bus to articulated (60-ft) buses, and in one case: Curitiba, bi-articulated buses. Some double-deck buses operate in Leeds, and Houston's BRT service uses over-the-road intercity coaches and articulated buses with a suburban seating configuration. It is significant to note that almost every city cited in the

U.S. and Canada, except Los Angeles and Vancouver, even a region as small as Eugene operate or will operate articulated vehicles in BRT service. Rouen, Boston, Los Angeles, Las Vegas and Cleveland operate or plan to operate specialized BRT vehicles rather than conventional buses.

Propulsion

Standard diesel buses predominate; however, there is a trend in North America towards vehicles with "green" propulsion systems, such as CNG-fueled spark ignition engines, e.g., Los Angeles, and hybrid diesel-electric vehicles, e.g., Seattle, Eugene and Cleveland. Boston will operate dual-mode full performance diesel and electric trolley (Silver Line Phases II and III) diesel and already operates CNG buses (Phase I). The Iris Civis vehicle used in Rouen, France and in Las Vegas is a specialized diesel-electric vehicle with train-like features and optical guidance.

Floor Height

An increasing number of systems operate 100% or partially low-floor (under 15 inches or 38 cm) vehicles to make passenger boarding and alighting easier. Buses in Bogotá, Curitiba, and Quito have platform high boarding and alighting. While these vehicles reduce passenger service times, their operation is limited to the BRT lines with high platform stations, and the vehicles cannot operate elsewhere. This dramatically reduces their operating flexibility.

Doors Sizes and Numbers

The need for better door arrangements on buses used for BRT services is increasingly recognized. Existing door arrangements have been a major constraint to shortening dwell times on many North American bus systems. Many articulated buses used for BRT lines in North America (e.g., Ottawa, Los Angeles, Boston, Vancouver) have three double-stream doors. In Europe 100% low floor vehicles with three double and one single stream doors are not uncommon (e.g., Rouen). The double articulated buses used in Curitiba have five sets of doors, four double and one single stream. Doors are generally located on the right side for North American and French systems and on the left side for buses operating in Australia and Great Britain. Although a vehicle with doors on both sides has been developed by different manufacturers, e.g. Neoplan and New Flyer, neither of which has gone through Altoona testing nor are currently available for use. The New Flyer will only be available in 2006 at the earliest and the NABI in 2007. The "direct buses" in Curitiba, which operate along one-way arterials with center platform stations, have left side doors as do buses operating in Bogotá and in Leon in Mexico. Some of the buses operating in Sao Paulo have doors on both sides to better serve various platform arrangements.

Design Features

The most successful BRT systems have vehicles used only for BRT services with unique identities. Bogotá, Curitiba and Los Angeles use red buses for their BRT services. Honolulu, Quito and Vancouver have distinctively striped buses. Rouen's and Las Vegas' Civis vehicles have modernistic rail-like styling and a futuristic appearance, and could serve as prototypes for future BRT vehicle designs. Las Vegas' and Rouen's Irisbus 100% low floor Civis vehicle buses have a 34-inch (86 cm) wide aisle, end to end, compared to typically 27-inch (69 cm) on the NYC Transit's low floor buses.

Intelligent Transportation Systems

The applications of ITS cover:

- Automatic vehicle location systems (AVL),
- Passenger information systems (e.g. automated station announcements on vehicles, real time information at stations), and
- Transit signal preference/priorities.

BRT systems having centralized AVL systems include Boston, Los Angeles, Vancouver, Brisbane, Sydney and Bogotá.

Systems with real-time passenger information systems include Boston, Las Vegas MAX, AC Transit Rapid Bus, Ottawa, Pittsburgh (some buses), Vancouver, Brisbane, Los Angeles' Metro Rapid Bus, and Curitiba.

Systems having transit signal timing priorities or special bus phases include Cleveland, Los Angeles, Vancouver, Boston, Las Vegas, Oakland and Rouen. The Metro Rapid lines in Los Angeles, for example, can get up to 10 seconds of additional green time when buses arrive at a signalized intersection. However, at major crossroads, advancing or extending the green time for buses is permitted only every other cycle. Bus signal preemption along South Miami-Dade Busway was removed because of a small increase in accidents. The Brazilian cities of Porto Alegre and Sao Paolo have automated bus platoon dispatching systems that are used to increase bus and passenger throughput.

The system by which alternating 2-3 bus "platoons or virtual trains" serve different station sets along a line (e.g., "A" stops and "B" stops) was developed in Brazil and is known as the Commonor system. This is one of the techniques used to provide the capacity needed to carry the enormous volumes found on many South American BRT systems (e.g., Porto Alegre, Sao Paulo).

Service Patterns

The specific service patterns reflect the types of running ways and vehicles utilized. Most systems provide express or limited stop services overlaid an all-stop (or local) service that operates like an LRT line. Some also have feeder bus lines that serve selected stations.

Busways – either along separate rights-of-way or within street medians – can have basic “all stop” service with an overlay of express operations during peak periods. In a few cases, such as Cleveland and Curitiba, the express service is or will be provided along nearby parallel streets. BRT operations in mixed traffic – as in Honolulu, Los Angeles and Vancouver provide limited stop service. Local bus service is also operated along the streets, as part of the normal transit service. Rouen’s BRT system also provides limited stop service along arterial streets.

The bus tunnels in Boston and Seattle are located in downtown areas. All buses make all stops in the tunnels.

The BRT system in Leeds provides all-stop service while Quito’s Trolebus service also stops at all stations. In Leeds the all-stop patterns are necessary because of curb-based mechanical guidance systems and the trolley-supplied power system, both of which make passing around stopped vehicles difficult or impossible.

Buses using median expressway lanes in Charlotte and Houston’s HOV lanes also operate, for the most part, in an express mode with no intermediate stops. However, in Houston there are a number of routes that exit the HOV lanes on dedicated bus ramps, enter transit centers or park-and-ride lots to drop off or pick up passengers, and then re-enter the HOV lanes.

In most systems the BRT service extends beyond the limits of busways or bus lanes. This flexibility is an important advantage of BRT as compared to rail transit. However, three BRT systems in South America operate only within the limits of the special running way, mainly due to door arrangements, station platform heights, and/or propulsion systems. These systems, including Bogotá’s TransMilenio, Curitiba’s median bus service, and Quito’s Trolebus actually function as though they were rail rapid transit lines.

Performance of BRT in Selected Cities

Performance varies widely reflecting factors such as facility location, size of the urban area, and the type of facility (e.g. off-street or arterial).

Weekday Riders

The weekday ridership reported for existing systems in North America and Australia, ranged from about 1,000 riders in Charlotte, up to 40,000 or more in Los Angeles, Seattle, and Adelaide. Specific ridership figures are shown in Table 4.

Table 4 Daily Ridership Figures for Selected BRT Systems

Bus Subways (Tunnel)	Seattle	46,000
Busways	Ottawa (Multiple Routes)	200,000
	Brisbane	50,000
	Pittsburgh	48,000
	Adelaide	30,000
	L.A. I-10 El Monte Busway	18,000
	Miami	13,000
	L.A. I-110 Harbor Transitway	9,400
Arterial Streets	L.A. Metro Rapid (Wilshire)	55,000
	Vancouver	25,000-30,000
	L.A. Metro Rapid (Ventura)	10,000
	Boston Silver line Phase I	15,000

Daily ridership in South American cities is substantially higher. Reported values for specific facilities range from 150,000 in Quito and 230,000 in Sao Paulo to over 1 million daily trips in Bogotá. Reported system riders also exceed 1,000,000 in Belo Horizonte, Curitiba and Porto Alegre in Brazil.

Peak-Hour Bus Flows

Where there are no intermediate stops, peak-hour, peak direction bus flows on dedicated freeway lanes can exceed 650 buses per hour (e.g. on the New Jersey approach to the Lincoln Tunnel and the Port Authority of NY/NJ Midtown Bus Terminal.) Ottawa's Transitway system reports bus volumes of 180 to 200 buses per hour per direction along downtown bus lanes. These volumes result from high use of fare passes, an honor fare system on the Busway All-Stop routes, and use of multi-door articulated buses. Over 140 buses per hour use the busiest section of Brisbane's Southeast busway.

Peak-hour flows of over 100 buses per hour are found in New York City's Long Island and Gowanus Expressway Contra-flow bus lanes. Most other BRT facilities in the United States and Australia have fewer than 100 buses per hour. Flows of about 50 to 70 buses per hour are typical.

The South American arterial median bus lanes that have passing capabilities at stations, with a service plan featuring a variety of locals and expresses in each corridor, carry as many as 300 buses per hour one-way at the maximum load-point. These systems often use "platoons" of 2-3 buses moving, in essence, as a train through the system.

Peak-Hour Peak-Direction Riders

Peak-hour passenger volumes carried past the maximum load points exceed 25,000 on the approach to the Lincoln Tunnel in New York, on Bogotá's TransMilenio four-lane busway, and along the Farrapos Busway in Porto Alegre. Peak-hour flows approach 20,000 on median busways in Sao Paulo and Porto Alegre. Ridership in Quito, Ottawa and Curitiba are in the 8,000-12,000 range. Brisbane's South East Busway carries 9,500 people one-way in approximately 150 buses during the peak hour. Its capacity has been estimated at 11,000 persons per hour. The ridership seen in the international case studies equal or exceed the number of LRT and metro passengers carried in most U.S. and Canadian cities.

Speeds

BRT operating speeds depend upon the type of running way and service pattern. Where buses run non-stop on reserved freeway lanes, revenue speeds of 40 to 50 mph are common. When the service patterns include stops on reserved or dedicated lanes, speeds generally average 18 (e.g., Bogotá) to 30 mph (Pittsburgh), depending on stop spacing and dwell times. Because of the importance of stop spacing and running way top speeds, BRT speeds are comparable to LRT speeds for the same type of operating environment even though the acceleration rate of contemporary buses are somewhat lower than LRT vehicles. The slower speeds recorded along Miami's busway reflect stops and traffic signal delays at signalized intersections along the busway.

Average speeds for BRT operations along arterial streets in the United States and Canada range from 8 to 14 mph in New York City, 15 mph along Wilshire Boulevard and 19 mph along Ventura Boulevard in Los Angeles.

"Express" operations along Curitiba's one-way streets and Bogotá's TransMilenio busway are approximately 18-20 mph. Buses making all-stops along median busways in South America average 11 to 14 mph. These speeds are low when compared to BRT operations on dedicated busways in the United States and Canada. However they represent dramatic improvements over local bus speeds, and are often faster than auto speeds.

Benefits of BRT in Selected Cities

Bus rapid transit systems have achieved important benefits in terms of travel time savings, increased ridership, land development impacts and improved safety.

Travel Time Savings

Travel time reductions resulting from the introduction of BRT services have exceeded 40% compared to the former local bus routes. Bus operations in exclusive freeway lanes or busways have achieved savings of 47% in Houston, 44% in Pittsburgh, 38% in Los Angeles (compared to former limited stop service), and 32% in Adelaide, compared to local bus routes. Seattle's bus tunnel has achieved a 33% reduction in bus travel times for the CBD portion of the express bus routes that use it.

The Metro Rapid BRT line on San Pablo Blvd. in Oakland, California (San Francisco Bay Area) has reduced travel times by 17% compared to the former limited stop bus route operating in the corridor.

BRT services along arterial have achieved savings of 23% to 28% in Los Angeles compared to the former limited stop bus service, 29% in Porto Alegre, and 32% in Bogotá compared to the fastest alternative bus services. The time savings in Los Angeles and Oakland are impressive in that buses operate in mixed traffic. They have been achieved by increasing the spacing between stops, by using a signal priority system and by using low floor vehicles.

Total time savings range from 5 minutes with Seattle Bus tunnel to over 20 minutes along Pittsburgh's East and West Busways. Most facilities achieve time savings of 2 to 3 minutes per mile.

Busways and reserved bus lanes on freeways that bypass traffic backup on approaches to river crossings save up to 7.5 minutes per mile. Busways on partially grade separated rights of way generally save two to 3 minutes per mile over the previous bus service. BRT lines on arterial streets typically save 1 to 2 minutes per mile. The savings are greatest where the previous bus routes experienced major congestion.

Ridership Increases

Some evidence suggests that many of the new riders of BRT services were previously motorists and that improved bus service results in more frequent travel. In Houston, for example, up to 30% of the riders did not make the trip before, and up to 72% were diverted from automobiles. In Los Angeles the Metro Rapid Bus service, which operates in mixed traffic, had a roughly 33% increase in riders. The increase was made up of customers totally new to transit, riders diverted from other corridors, and existing transit users that rode transit more often. In Vancouver, 20% of new riders previously used automobiles, 5% represented new trips, and 75% were diverted from other bus lines.

Ridership on Las Vegas MAX, increased more than 20% compared to the former local bus service – after only two months of operation, while ridership on Boston's Silver Line's Phase I was up over 100% in less than 2 years. In Oakland and Berkeley, California, ridership is up over 30% on San Pablo Boulevard with the implementation of Rapid Bus service compared to the former limited bus route after a little over one year of operation.

Adelaide's Guided Busway reported a 76% gain in ridership at a time when overall system ridership declined by 28%. Brisbane's South East Busway reported over a 40%

gain in riders during the first six months of service and a reduction of 375,000 auto trips annually. More recent ridership data is summarized in Table 5 below.

Table 5 BRT Ridership Effects

City/System	% Ridership Gain in Corridor	% of Ridership New Transit Trips
Los Angeles	+40% (3 Yrs.)	>30%
Miami	+85% (5 Yrs.)	>50%
Brisbane	+60% (2 Yrs.)	> 45%
Vancouver, BC	+30% (2 Yrs.)	>25%
Boston	+100% (18 months)	>30%
Oakland	(12 months)	>30%

Table 6 reflects results of the MBTA's Silver Line, illustrates the ability of new BRT lines to effectively "compete" with other types of rapid transit, in this case conventional subways. It also shows BRT's ability to "induce" totally new trips not here-to-fore thought possible or desirable by potential travelers.

Table 6 Boston Silver Line Phase I: Before/After Ridership Data

Prior Mode	Percent
Bus	67%
Subway	32%
Auto	4%
Did Not Make Trip	25%
Other	20%

It should be noted that this does not add to 100% as some respondents picked two or more modes in some instances.

Similar results were obtained by the San Pablo Rapid Bus Line in Oakland, California shown in Table 7.

Table 7 San Pablo Blvd Rapid Bus: Before/After Ridership Data

Prior Mode	Percent
Bus	55.2%
BART	12.9%
Auto	18.9%
Did Not Make Trip	8.7%
Other (e.g., taxi)	4.2%

Many of the "previously not made" trips shown in the above before/after tables were made in the off-peak for non-work purposes. This is further reinforced by the ridership growth data that appears in Table 8 below for the South Miami-Dade Busway.

Table 8 Growth in Ridership over Time, South Miami-Dade Busway

	1st Qtr. 1996	3rd Qtr. 2003	% change
Avg. Weekday	7,600	13,000	+70%
Avg. Weekend (Sat. and Sun.)	6,000	15,000	+150%

Clearly, as fast as typical weekday ridership, dominated by work trips was growing, off-peak (e.g., weekend) transit travel was growing even more dramatically.

Operating and Environmental Benefits

The travel time savings associated with buses operating on their own rights-of-way have also achieved cost savings as well as safety and environmental benefits.

- Ottawa's Transitway requires 150 fewer buses than if the Transitway system did not exist, resulting in savings of roughly $49 million in vehicle costs and $19 million in annual operating costs.
- Seattle's bus tunnel has reduced surface street bus volumes by 20%. Buses using the tunnel also had 40% fewer accidents than in mixed-traffic operations.
- Bogotá's TransMilenio Busway had 93 percent fewer fatalities. In addition a 40% decrease in pollutant emissions was recorded during the first five months of operation.
- Curitiba uses 30% less fuel per capita for transportation than other major Brazilian cities. This has been attributed in part to the success of the BRT system.

Land Development Benefits

Like rapid rail transit modes, BRT stations can provide a focal point for transit-oriented development (TOD). Reported land development benefits are shown in Table 9. Ottawa reported over $675 million (m) in new construction around transitway stations. Pittsburgh reported $302 million in new or improved developments along the East Busway stations. Property values located near Brisbane's South East Busway grew two to three times as fast as those located at greater distances. These impacts are similar to those experienced along rail transit lines.

In Boston, a recent study reported over $500 m (now $700 m) in new development and redevelopment along the Silver Line since construction first began.

In several of the case studies, local governments implemented land use planning policies that encourage development near BRT facilities. In the Ottawa-Carleton region, major activities such as regional shopping centers are required to locate near the Transitway. In Curitiba, the arterial median busways are integral parts of the structural axes along which high-density development has been fostered.

Table 9 Benefits, Selected BRT Systems

LAND DEVELOPMENT BENEFITS	
Pittsburgh East Busway	59 new developments within a 1,500-ft. radius of station. $302 m in land development benefits of which $275 m was new construction. 80% is clustered at station.
Ottawa Transitway System	$1 billion ($C) in new construction at Transitway Stations
Adelaide Guided Busway	Tea Tree Gully area is emerging into an urban village.
Brisbane South East Busway	Up to 20% gain in property values near Busway. Property values in areas within 6 miles of station grew 2 to 3 times faster than those at greater distances
Boston Silver Line	Over $700 m in new development and redevelopment since construction began
OTHER BENEFITS	
Ottawa Transitway	150 fewer buses, with $58 million ($C) savings in vehicle costs and $28 million ($C) in operating costs
Seattle Bus Tunnel	20% reductions in surface street bus volumes. 40% fewer accidents on tunnel bus routes.
Bogotá TransMilenio Median Busway	93% fewer fatalities. 40% drop in pollutant emissions.
Curitiba Median Busway	30% less fuel consumption per capita

Costs of BRT in Selected Cities

Costs for BRT systems vary widely depending on the BRT elements being implemented (running ways, vehicles, etc.) and the location, type and complexity of construction. A comparison of the costs shows the following:

- Costs for bus tunnels range from about $200 to $300 million per mile, including stations.
- Costs for busways on their own rights of way display a wide range, depending upon the year built and ease of construction. The values cited range from about $6 to $7 million in Los Angeles, Miami, and Pittsburgh (South Busway), to about $20 million per mile for the East Busway in Pittsburgh and the recently completed South East Busway in Brisbane. The high cost of Pittsburgh's West Busway - about $53 million per mile – was due to the hilly terrain traversed, a major tunnel

rehabilitation, and an expensive freeway interchange at the outer terminus of the busway.

- Costs for arterial street median busways have been reported as about $1.5 million per mile in Curitiba, $5-8 million per mile in Bogotá and Quito, and an estimated $29 million per mile in Cleveland.
- Costs for mixed traffic operation have generally been less than BRT systems with dedicated running ways. The costs reported for guided bus systems include $2.4 million per mile of guideway in Leeds, $7 million per mile in Rouen, and less than $5 million per mile in Las Vegas. Table 10 below summarizes the full implementation costs, including ITS and vehicles, for some recent BRT systems.

Table 10 Full Implementation Cost per Mile for recent BRT Services

City – System	Capital Costs ($ million) /Mi.)*
LA Metro Rapid Bus (Wilshire)	$2
Las Vegas Max	$3
Rouen TEOR	$11
Boston Silver Line Phase I	$20
LA Metro Rapid Bus (Ventura)	$22

- Information on busway maintenance costs was only available for Pittsburgh's East Busway. These costs averaged $110,000 per mile per year for seven miles.
- Operating costs for BRT service are influenced by wage rates and work rules, fuel and electricity costs, operating speeds and ridership. The comparisons in Table 10 suggest that BRT can cost less per passenger trip and per mile than light rail transit, depending on the situation.

3.2 BRT Resources

The BRT Resources component of the website consists of the following major components, the text for which is presented in the remaining part of Section 3.2.

- General
- Existing BRT Programs
- BRT Focused Websites
- Organizations
- Search Tools, Technical Information, and Training

GENERAL

The Information Clearinghouse offers in an organized and structured fashion an extensive set of valuable resources for users interested in a wide variety of aspects of Bus Rapid Transit. These resources encompass existing BRT programs, BRT-related organizations, ongoing research activities, technical assistance, education, and training, and others. The following links are organized by category.

EXISTING BRT PROGRAMS

Here's a list of agency websites in North America, Australia, and Europe that have BRT systems either in operation or in development, planning, or construction stages.

Adelaide Metro in South Australia/O-Bahn

Alameda-Contra Costa Transit District (AC Transit) in Oakland/San Pablo Rapid

TransMilenio in Bogota, Columbia

Charlotte Area Transit System (CATS), North Carolina

Chicago Transit Authority (CTA)/X49 Western Ave. Express

CT Transit in Hartford, Connecticut/CT Busway

Greater Cleveland Regional Transit Authority (GCRTA)/Euclid Corridor Silverline

Hampton Roads Transit/Oceanfront Bus Rapid Transit System

Lane Transit District (LTD) in Lane County, Oregon/EmX

Los Angeles Metro/Orange Line

Los Angeles Metro/Metro Rapid

Lynx in Central Florida/Orlando Lymmo

Massachusetts Bay Transportation Authority (MBTA)/Silverline

Miami-Dade County Transit/South Miami-Dade Busway

OC Transpo/The Transitway in Ottawa, Ontario,Canada

Oahu Transit Services/CityExpress! & CountryExpress!

Port Authority of Allegheny County in Pittsburgh/Busways

Regional Transportation Commission in southern Nevada/Las Vegas MAX

Santa Clara Valley Transportation Authority (VTA)/Rapid 522

Roads and Traffic Authority (RTA) and Department of Transport (DOT)/Sydney, Australia/Liverpool-Parramatta Transitway

Valley Metro in Phoenix/Rapid

Greater Vancouver Transportation Authority (Translink)/B Line

York Region Transit (YRT) in Toronto/Viva

BRT Focused Websites

American Public Transportation Association (APTA) Transit BRT Resource Guide

Bus Rapid Transit Central

Bus Rapid Transit Policy Center (Breakthrough Technologies Institute)

California BRT Resources

Federal Transit Administration (FTA) — Bus Rapid Transit

Federal Transit Administration's Bus Rapid Transit Exchange

Metro-Magazine

National Bus Rapid Transit Institute (NBRTI)

WestStart-CALSTART (including BRT newsLane)

Sustainable Urban Transport Programme (SUTP)

Organizations

American Planning Association

American Public Transportation Association (APTA)

Federal Transit Administration

Institute for Transportation & Development Policy

National Transit Institute — Advanced Technologies

Transportation Research Board (TRB)

SEARCH TOOLS, TECHNICAL INFORMATION, AND TRAINING

ITS Resources

This collection of websites gives users access to search tools and research databases to acquire information about intelligent transportation systems overall, and about bus rapid transit systems in particular.

National Transit Institute BRT Course

Glossary of Bus Rapid Transit Terms (in Appendix B of CBRT)

Photo Gallery of BRT Systems in Appendix D of CBRT)

BRT Planning Tools and Methodologies

This section is part of the Planning Support Tool and provides users with additional BRT-focused planning tools and methodologies.

3.3 ITS Resources

INTELLIGENT TRANSPORTATION SYSTEMS (ITS) RESOURCES

The following list of websites provides users with various online tools to acquire information about intelligent transportation systems overall, as well as for BRT-related investigations, indicated by an "*".

Bureau of Transportation Statistics (BTS) Transit Data Library

Caltrans-PATH Database* (A bibliographic database containing fully abstracted citations for intelligent transportation systems publications and Web documents)

ITS Benefits Database

ITS Costs Database

ITS Deployment Tracking Database

ITS Decision Web Tool at California PATH* (Reports to help planners and implementers in decision-making and planning. Reports are available on transportation goals, performance measures, assessing benefits and costs, decision analysis and planning, environmental impact assessment, evaluations and program assessments as well as ITS projects occurring around the country)

ITS Deployment Analysis System (IDAS) (Software developed by FHWA that can be used in planning for ITS deployments.)

ITS Electronic Documents Library (EDL)

ITS/Operations Resource Guide 2005 (one stop shopping for documents, videos, websites, training courses, software tools)

Lessons Learned Knowledge Resource

Major ITS Organizations in U.S. and Internationally

National ITS Architecture

National Transit Database (NTD)

National Transportation Library

Technology Overview

TRB E-Newsletter*

TRB Online Publications*

TRB Research in Progress (RIP)*

TRB TRIS Online*

Transit ITS Impacts Matrix* (Single source that shows the impacts of ITS for transit.)

US DOT ITS Standards

3.4 About the Clearinghouse

The About the Clearinghouse section of the website consists of the following major components, the text for which is presented in the remaining part of Section 3.4.

- Mission Statement
- Sponsors and Partners
- BRT Focused Websites

MISSION STATEMENT

There are currently numerous available websites that deal in one way or another with BRT-related issues. However, someone interested in a certain aspect of BRT, especially someone relatively new to the field, is likely faced with the question "Where do I begin looking for the information I want?" or is required to do a lot of online navigating until the information he/she wants is finally located or both. Our objective in developing the BRT Information Clearinghouse is to provide a single online address for well organized information related to BRT together with knowledge-based information to support intended users — primarily transit industry professionals — in the planning for and implementation of bus rapid transit systems. Moreover, the Clearinghouse is intended to serve as an electronic portal to BRT-related information via links to site-specific BRT systems around the world.

SPONSORS AND PARTNERS

The BRT Information Clearinghouse is based at the PATH Program — a collaboration between the California Department of Transportation (Caltrans), the University of California, other public and private academic institutions, and private industry. PATH's mission is to apply advanced technology systems to increase highway capacity and safety, and to reduce traffic congestion, air pollution, and energy consumption.

The California Department of Transportation (Caltrans), and its Division of Research and Innovation is a key collaborator in developing innovative concepts and in providing funding for design and evaluation of innovative technologies and services. Caltrans is responsible for planning, designing, constructing, operating and maintaining California's State Highway System. While continuing to play the role as the owner and operator of the State Highway System, Caltrans is also involved in inter-city passenger rail service, mass transit and aeronautics. Caltrans is a leader in promoting the use of alternative modes of transportation. In addition, Caltrans deals with complex issues such as land use, goods movement, environmental standards and the formation of partnerships between private industry, local, State and Federal agencies. Caltrans has over 22,000 employees with an annual operating budget of over nine billion dollars. Headquartered in Sacramento, Caltrans has 12 district offices situated across the State in Eureka, Redding, Marysville, Oakland, San Luis Obispo, Fresno, Los Angeles, San Bernardino, Bishop, Stockton, San Diego and Irvine. Caltrans' mission is to improve mobility across California.

The National BRT Institute, a collaborative enterprise between the PATH Program at the University of California at Berkeley and the Center for Urban Transportation Research (CUTR) at the University of Florida, facilitates the sharing of knowledge and innovation for increasing speed, efficiency, and reliability of high-capacity bus service through the implementation of BRT systems in the United States.

CONTACT US

For inquiries about our site, please e-mail us at
BRT-InformationClearinghouse@path.berkeley.edu

4.0 TESTING AND REVIEW OF WEB TOOL

Prior to releasing Version 1 of the Bus Rapid Transit Information Clearinghouse, the team believed it would be important and practical to solicit information from members of the public transportation profession concerning their reaction to and opinion of the Information Clearinghouse website. Responses to the survey would serve as a basis for revising the Information Clearinghouse prior to its official Version 1 release. The remainder of this section discusses the survey, its participants, and its responses.

4.1 Internet Survey

The team selected to use an internet or web-based survey so as to make the entire process as simple and convenient as possible for potential participants. Based on recommendations from colleagues, we used a commercial web-based product called *Survey Monkey*, which can be found at the web site http://www.surveymonkey.com. Survey Monkey requires only that the specific survey questions be input into the system during the design phase. No programming is necessary on the part of the user as that is all performed “behind the scenes” and built into the structural architecture of the site. Participants taking the survey only have to answer the questions and click “Done” when they are done because upon completing the survey, all responses are saved and accessible to the project team for subsequent analysis.

4.2 Identifying Participants and Survey Administration

The team identified names of potential participants based on their knowledge of and experience in the public transportation field. A request to participate in the survey was e-mailed to each of these potential participants. Participation in the survey was completely voluntary and anonymous with no attribution of responses to specific individuals or organizations to encourage more frankness in responses and protect participants' confidentiality. The complete list of potential participants is contained in Appendix A. Table 11 shows the breakdown by organizational type. The request to participate is provided in Appendix B and the survey is contained in Appendix C.

Table 11 Breakdown by Organizational Type

Organizational Type	Percentage
Transit Agency	40.0%
Other Public (Planning Agency, Department of Transportation, University)	22.2%
Other Non-Profit	4.4%
Private/Consulting Firm	33.4%

4.3 Survey Responses

The survey was administered to 45 potential participants with each participant given two weeks to complete the survey. We received three Internet notices indicating that the e-mail addresses used were no longer valid and such messages could, therefore, not be delivered. Essentially, then, there were 42 valid e-mail addresses corresponding to potential participants. There were 17 responses for a response rate of 40.5%. One follow-up e-mail that requested survey participation was sent out several days prior to the deadline for survey completion.

Questions 1 through 7 deal with using the Information Clearinghouse site and site ratings relative to particular criteria and responses are shown in Figures 1 through 7, respectively. Moreover, in these figures we depict responses for all users, for transit agency responses, and consultation firm responses since these two latter groups comprise approximately three-quarters of the potential participant sample as well as three-quarters of the survey respondents (See Figure 13).

Question 1: “How would you rate the overall organization of the Clearinghouse site from the perspective of the top-level topic headings, i.e., ‘Planning Support Tool’, ‘Publications’, ‘BRT Resources’, etc.” Responses are shown in Figure 3

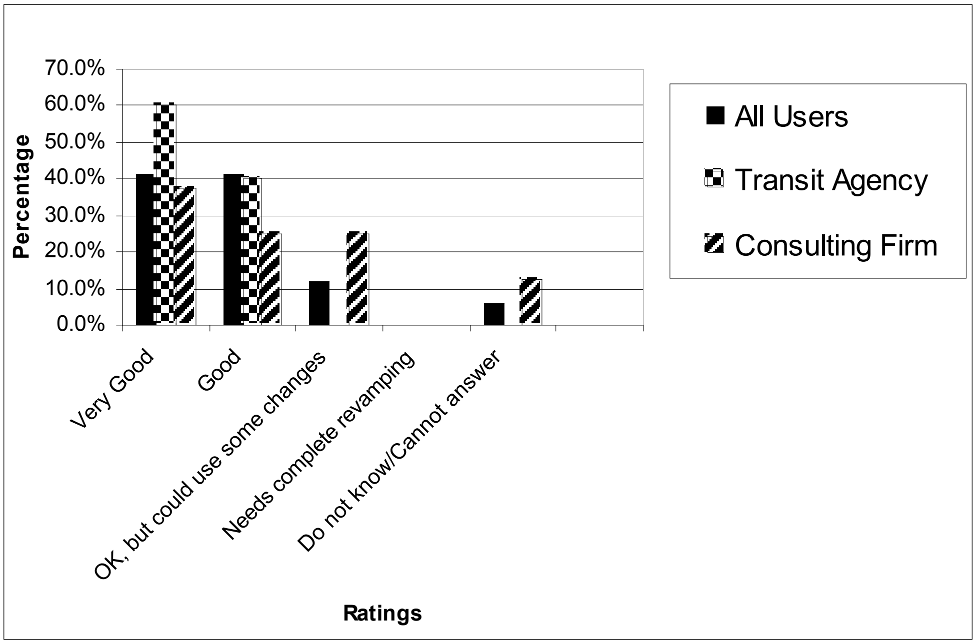

FIGURE 3 Overall Site Organization Based on Top-Level Headings

From Figure 3, we observe that approximately 80% of all respondents, while 100% of transit agency respondents and approximately two-thirds of consultation firm respondents rate the Clearinghouse’s organization from the perspective of the top-level headings either “Good” or “Very Good”. However, 11.8% of all respondents and 25% of consultant firm respondents indicated that the organization is “OK, but could use some changes”. The only suggestion made by any respondent rating the organization as “OK, but could use some changes” was “The Elements category needs to broken down; it returns 148 entries”, which refers to the number of entries being returned by the Publications Library from the “Elements of BRT” topic and indicates that subdividing this topic further should be considered.

Questions 2: “Overall, how would you rate the web site in terms of its visual appearance?” Responses are shown in Figure 4. Responses are shown in Figure 4.

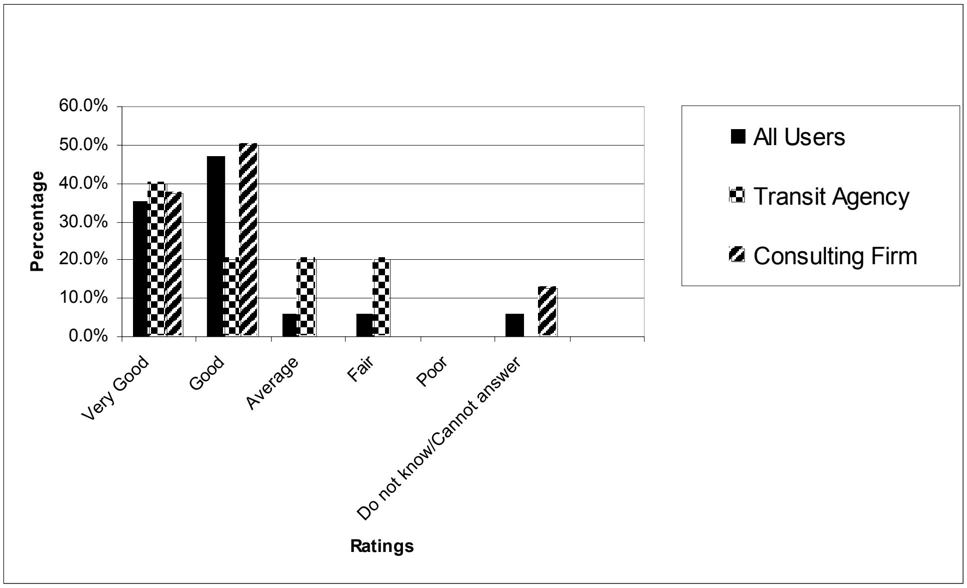

FIGURE 4 Overall Visual Appearance of Website

From Figure 4, more than 80% of all respondents rated the visual appearance of the website as either “Good” or “Very Good”, while nearly 90% of consultant firm and only 60% of transit agency respondents rated the site as either “Good” or “Very Good”.

Question 3: “Are the topic headings in the Planning Support Tool, such as ‘Overview / What is BRT?’, ‘BRT Economics and Finance’, ‘Case Studies’, etc., clearly stated, i.e., are they self-explanatory?” Responses are shown in Figure 5.

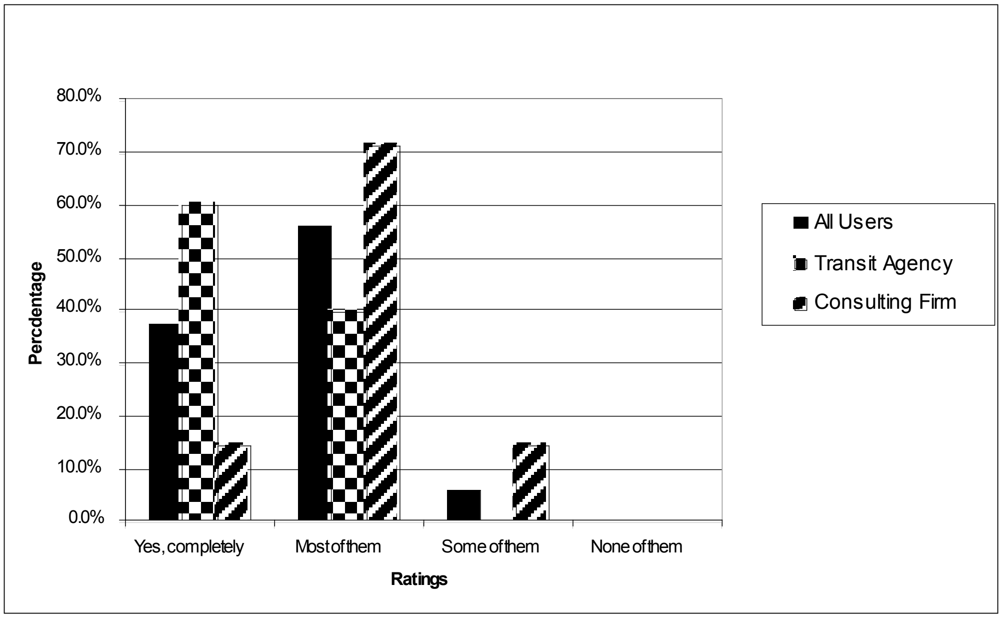

FIGURE 5 Clarity of Planning Support Tool’s Topic Headings

From Figure 5, we observe that nearly 90% of all respondents, while 100% of transit agency respondents and approximately 85% of consultation firm respondents rate the Planning Support Tool’s topic headings as either “completely” or “most of them” self-explanatory. Approximately, 14.3% of consultation firm respondents indicated that only “some of them” were self-explanatory, however, none of these respondents provided any supplementary comments. The only added suggestions made were from two “most of them” respondents and were: “Needs to drill down on the details a little more”, and “Design Specs and Operations Planning are probably the most vague”.

Question 4: “What is your view of the organizational structure of the Planning Support Tool”. Responses are pictured in Figure 6.

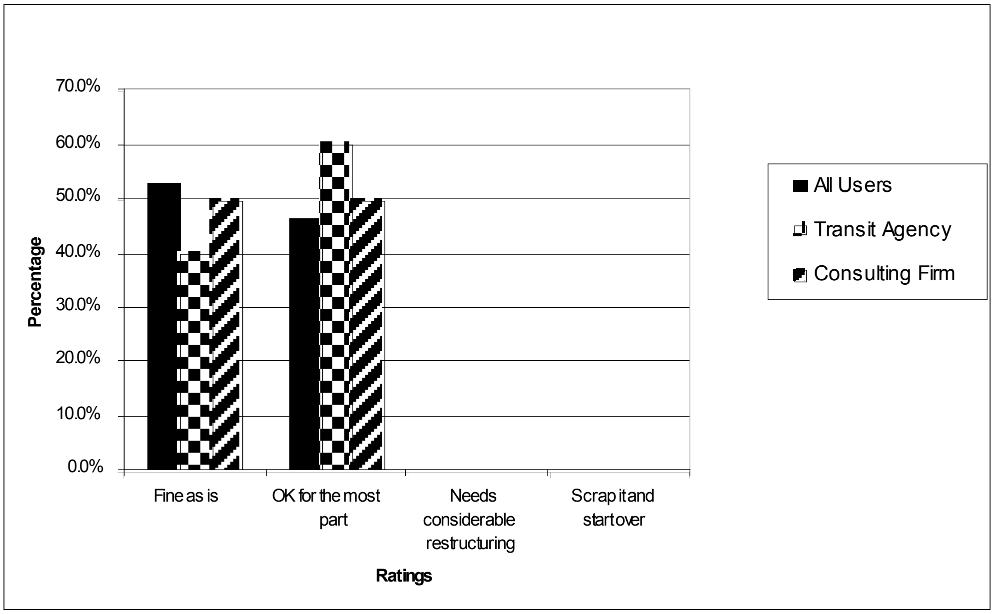

FIGURE 6 Organizational Structure of Planning Support Tool

From Figure 6, we observe that nearly 94% of all respondents, while 100% of each transit agency and consultation firm respondents rate the organizational structure of the Planning Support Tool as either “Fine as is” or “OK for the most part”. There were only a few suggestions made by those respondents rating the organization as “OK for the most part”, as follows:

- “Some elements need to be re-ordered. Elements of BRT should definitely come after What is BRT?”
- “Consider the audience. The tool may not be read by elected officials or professionals with BRT experience.”
- “It more like a list of things that one should consider, I do not see much structure in the list... I would follow the planning process in listing the topics.”

Regarding the first comment, “Elements of BRT” already does come after “Overview / What is BRT?” in the content of the website. The third comment is particularly relevant because the team did account for the transportation ‘planning process’ when developing the organizational structure of the Planning Support Tool. Of particular relevance to the transportation planning process is the “Planning and Development Process for (Federally Funded) BRT Projects” component of the “Planning and Development Tool” (Also see Section 3.1 of this report).

There was also a comment by one of the “Fine as is” respondents, as follows: “It seems very logical, one topic leading to the next”.

Question 5: “In the Planning Support Tool is the information within each level useful?”. Responses are pictured in Figure 7.

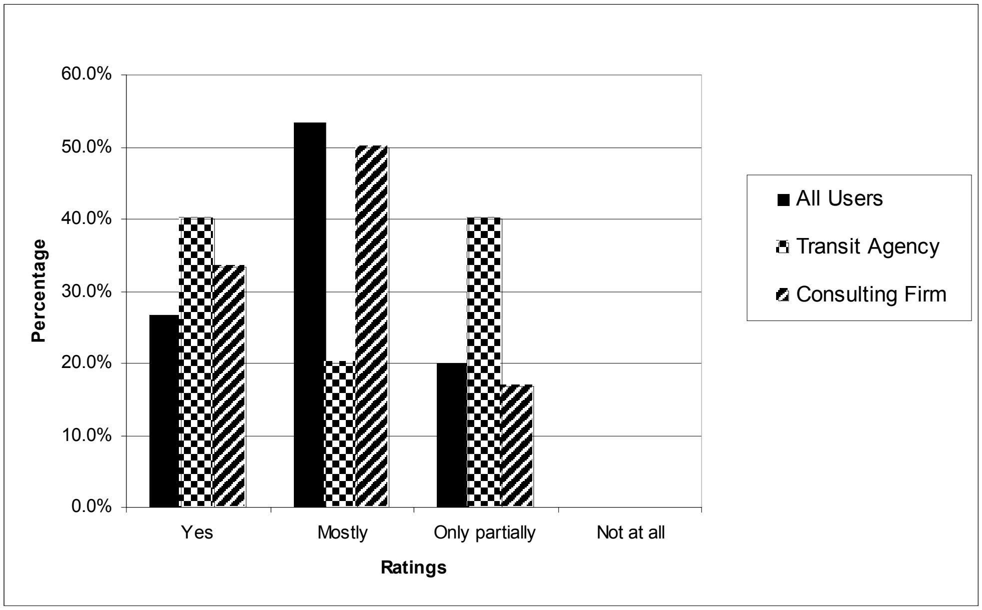

FIGURE 7 Usefulness of Information in Planning Support Tool

From Figure 7, we observe that 80% of all respondents, while only 60% of transit agency respondents and approximately 85% of consultation firm respondents rate the information within each level of the Planning Support Tool as useful or mostly useful. Twenty percent of all users rate such information as “Only partially” useful, while 40% of transit agency respondents and 16.7% of consultation firm respondents indicated that such information is “Only partially” useful. The only suggestion made by any respondent rating the information “Only partially” useful was the following:

> “Institutional part is too verbose for my taste. Plus, I disagree with some part of the Land use discussion. BRT flexibility does NOT mean that it can be uprooted and rerouted. BRT’s route is permanent just like any other rapid transit route. BRT flexibility means something different. 1.) BRT is flexible in the sense that it can be deployed in section in space and time. 2.) Also, it is not necessary to have every elements of it at its final stage before operation can start. 3.) It is also flexible in its operation, such as coordination with local and feeder routes, and the BRT operation frequency.”

The respondent’s remark about BRT’s flexibility appears to refer to the discussion in the Institutional Arrangements for Planning, Developing, and Operating Bus Rapid Transit” component of the Planning Support Tool, under the sub-heading of “Planning and Land Use”. In particular, it refers to the authors’ statement:

"Finally, a BRT system's inherent flexibility, may, in fact, be a disadvantage if potential developers perceive this as a lack of permanence and show reluctance to invest along BRT corridors."

This respondent's concern can be addressed by inserting "— incorrectly —" immediately after the word "perceive" in the statement above.

Question 6: "How easy do you think it would be for someone new to BRT to navigate the site to find information she/he needs?" Responses are shown in Figure 8.

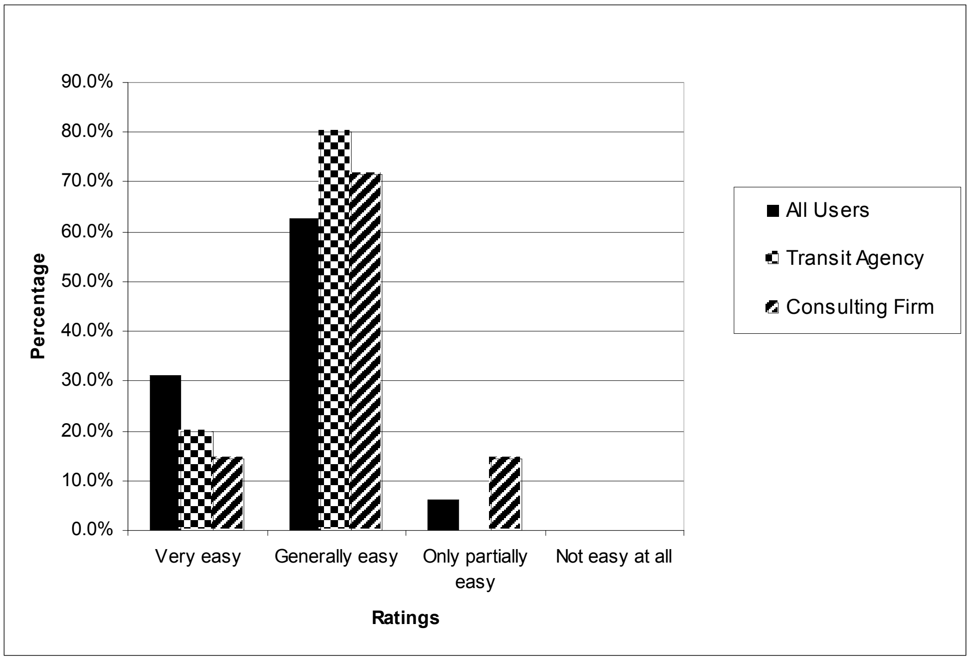

FIGURE 8 Ease of Navigation for Someone New to BRT

From Figure 8 we observe consistent findings in that the overwhelming majority of responses ─ 93.7 for all users, 100% for transit agency respondents, and 85.7% for consultant firm respondents ─ found that the Clearinghouse would be either "Very easy" or "Generally easy" for someone new to BRT to navigate.

Question 7: “Overall, how appropriate is the information for the seasoned BRT practitioner, i.e., is the information too basic for such a BRT-experienced person?” Responses are shown in Figure 9.

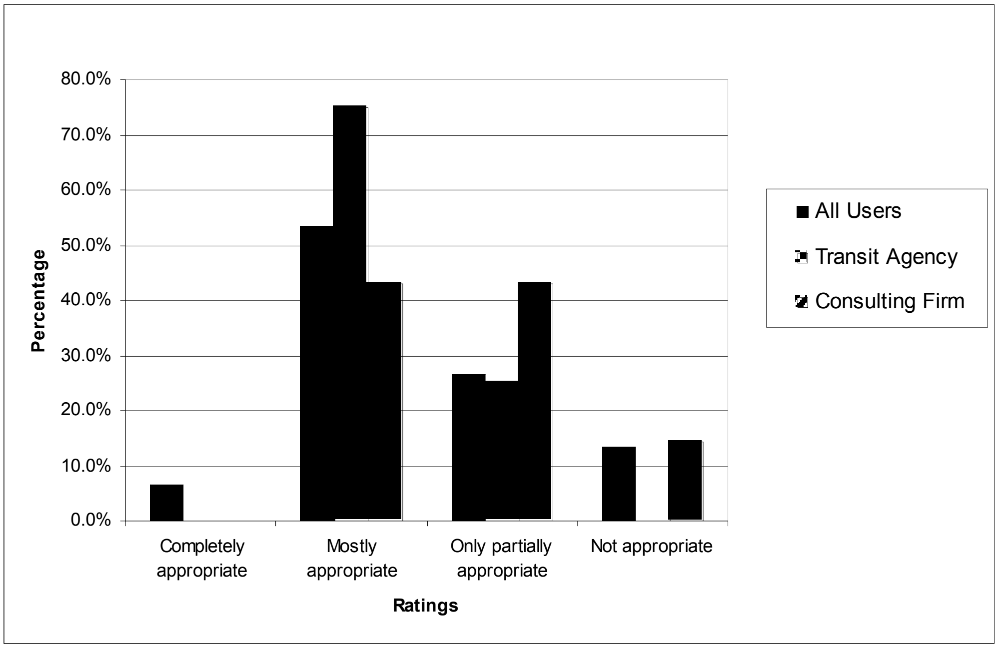

FIGURE 9 Appropriateness of Information for the Seasoned BRT Practitioner

Figure 9 shows that all users, transit agency respondents, and consultant firm respondents, 60%, 75%, and 43%, respectively, found the website either “Completely appropriate” or “Mostly appropriate” for the experienced BRT practitioner. However, 26.7%, 25%, and 42.9% of all users, transit agency respondents, and consultant firm respondents, respectively, found the information “Only partially appropriate” for the seasoned BRT practitioner. Approximately 13 to 14 percent of all users and of consulting firm respondents found the website “Not appropriate” for the experienced BRT practitioner.

There were only two comments from respondents answering this question with the rating of “Only partially appropriate”:

> “While there is a lot of useful information to the practitioner, the seasoned practitioner might want to see some summaries of quantitative information made readily available without having to go to the individual publications. Currently there is only a high level summary and links to documents.”

> “I think for the “seasoned” BRT practitioner, a lot of what is mentioned is known information. I would want a lot more data on real experiences with BRT in other systems/countries that are relevant to mine. For example, if I am planning a BRT to Washington Dulles, I would want similar information on a system like this: dedicated ROW, alternative to LRT, etc. Now, looking at data from Bogota, Columbia wouldn't be

relevant since in the DC area 90% of the people own a car and in Bogota 9% own a car. In DC, we're trying to make the BRT much more attractive, an alternative, to the vehicle. In Bogota, they have no other option. So, it's important that the data be relevant to my system."

However, the following comments were provided from respondents answering this question "Mostly appropriate":

"I would not worry about this. Experience person just skips to what he/she wants."

"Most is too basic for the expert in their area of expertise. But, most experts won't be experts in all areas on the site."

"Some information is basic for a seasoned practitioner; however the structure allow skipping this info easily."

Questions 8 through 11 deal with background information on the users to help the team discover correlations among users to particular site ratings.

Question 8: "How familiar are you with using the Internet for information gathering?" Responses are shown in Figure 10.

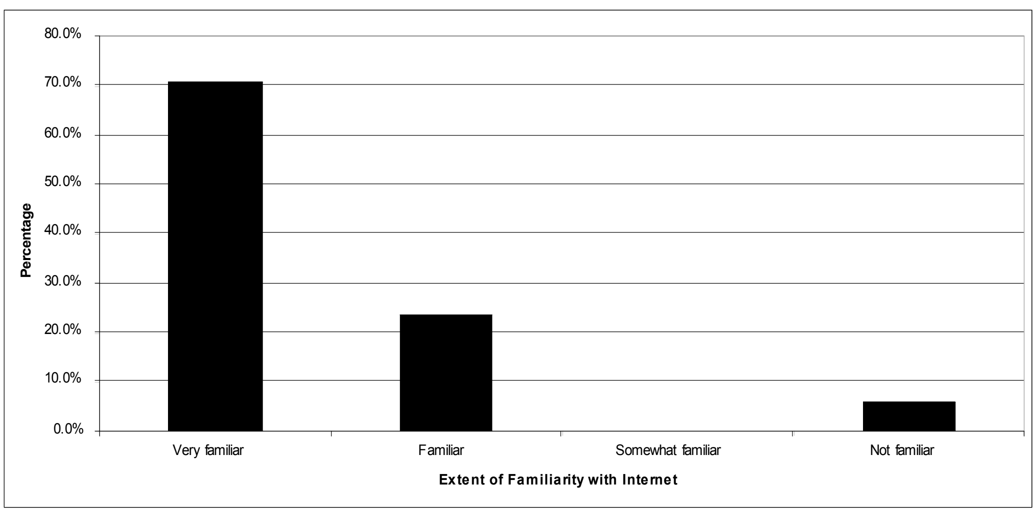

FIGURE 10 Extent of Familiarity with Internet

From Figure 10, we see that approximately 95% of all users are either "Very familiar" or "Familiar" with using the Internet to gather information.

Question 9: "How familiar are you with BRT systems?" Responses are shown in Figure 11

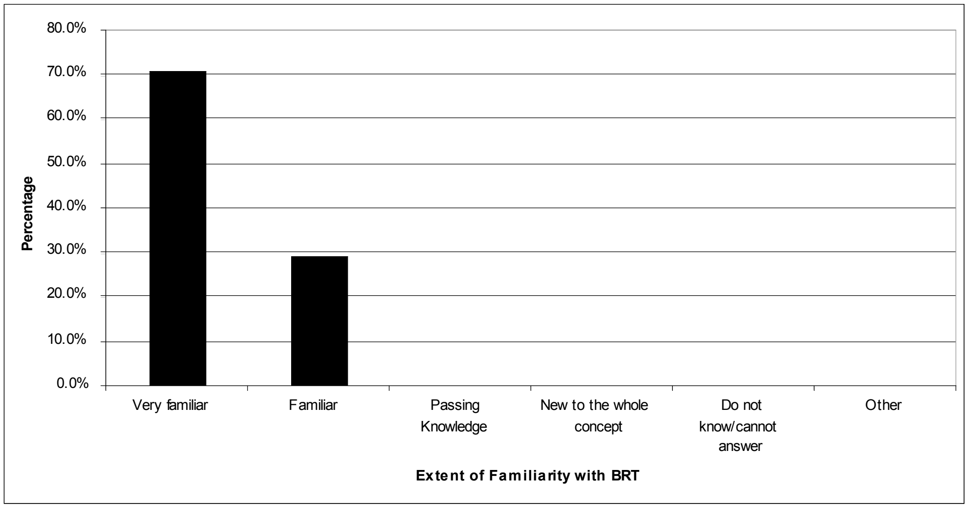

FIGURE 11 Extent of Familiarity with BRT

From Figure 11, we see that 100% of respondents are either "Very familiar" or "Familiar" with BRT systems.

Question 10: "How do you usually get information about BRT?" Responses are shown in Figure 12.

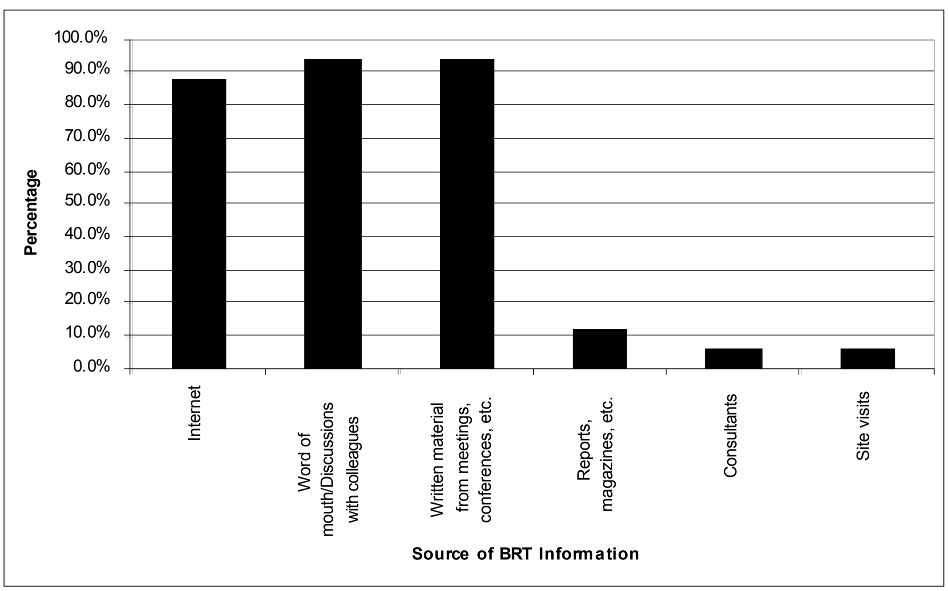

FIGURE 12 Sources of Information on BRT

In response to the question about the means of acquiring information about BRT, approximately 90% use the Internet while nearly 95% get such information from discussions with colleagues and from written material from meetings and conferences. A much smaller percentage gets information about BRT from reading reports or magazines (11.8%), consultants (5.9%), and site visits (5.9%). These percentages do not sum to 100% because a single respondent was asked to select all answer options that applied.

Question 11: "What type of organization/company do your work for?" Responses are shown in Figure 13.

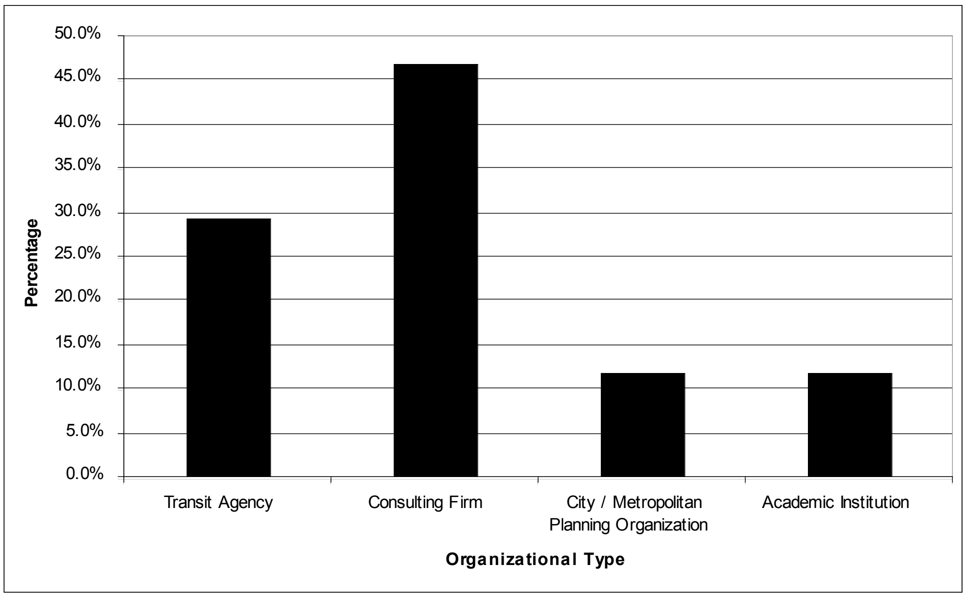

FIGURE 13 Respondents' Organizational Type

From Figure 13, we see that approximately 30% of respondents were from transit agencies, while 47% of respondents were from consultant firms. This differs from the corresponding distribution among the sample of potential participants that we requested to take the survey, that is, 40% and 33.4% of the sample, respectively, were from transit agencies and consulting firms. We had a larger response rate from consultant firm participants than from transit agency representatives.

Questions 12 and 13 deal with the future direction for the Information Clearinghouse site.

Question 12: Overall, how useful an informational tool do you think the BRT Information Clearinghouse will be to users assuming it is revised based on your comments? Responses are shown in Figure 14.

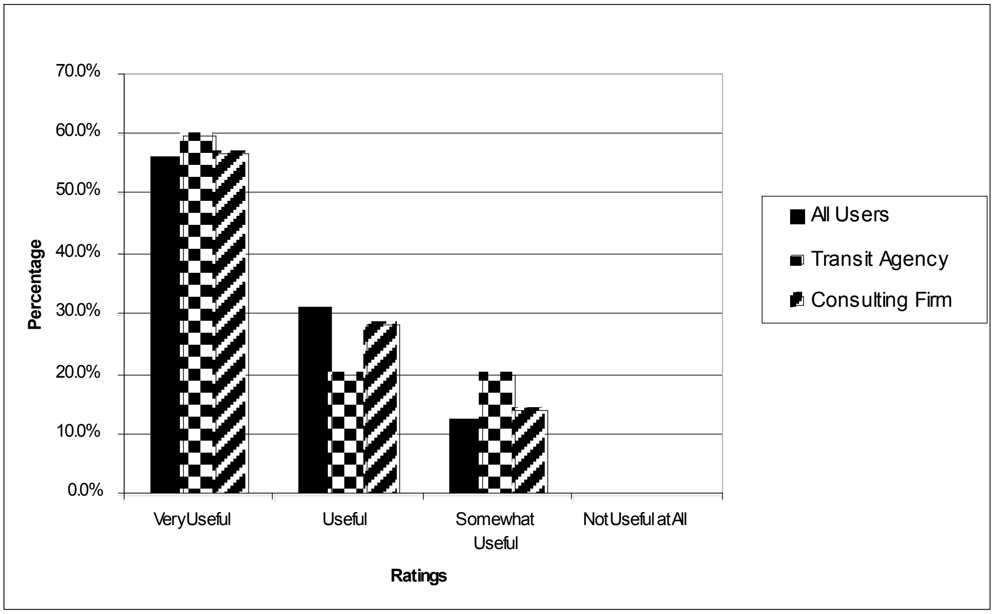

FIGURE 14 Overall Site Usefulness

From Figure 14, we observe that a consistently high percentage of each group: all users, transit agency, consultant firm respondents – between 80% and 88% – rate the BRT Information Clearinghouse either "Very useful" or "Useful".

In Question 13, participants were asked to rate the importance of three potential new features for the next iteration of the Clearinghouse, including 1) adding a 'Keyword' field to the Publications Database, 2) an expert system tool to help users determine what BRT system technologies and services might be appropriate for their particular setting, and 3) a case-based reasoning tool to help users assess the benefits of BRT services. Responses are summarized in Table 12.

TABLE 12 User Ratings for Additional of New Features to Information Clearinghouse

Potential New Features to Add	Very Important	Important	Somewhat Important	Not Important	Do Not Know / Cannot Answer
'Keyword' field to Publications Database	59%	35%	6%	0%	0%
Expert System Tool	29%	35%	18%	12%	6%
Case-Based Reasoning Tool	29%	24%	29%	0%	18%

Adding the 'Keyword' field to the Publications Database was considered either "Very Important" or "Important" by approximately 95% of respondents. Approximately two-thirds of respondents thought that the expert system tool would be "Very Important" or "Important", whereas just 53% of respondents thought that the case-based reasoning tool would be an important feature to add.

In Question 14, respondents were asked to suggest other features that they would like to see added to the functionality of the BRT Information Clearinghouse beyond regular website maintenance and adding documents to the Publications Database. The following list summarizes these suggestions:

- An update/news page on new developments including highlights of success stories
- Upcoming meetings
- Maps of BRT systems
- Information on buses and the bus manufacturing industry
- Contact information for systems and responsible personnel
- Pictures and video
- Regular updates on BRT systems experience
- Links to BRT-related conferences and meetings

In Question 15, we gave respondents another opportunity to provide comments or suggestions regarding the BRT Information Clearinghouse. The following list summarizes these comments:

- Contrast BRT with LRT, especially in terms of costs
- Additional cost information on the components beyond conventional bus service operation that is special to bus rapid transit system operation.
- Under identity, the most important point is that the agency has one chance to deploy a successful BRT. With the first implementation the agency has to establish a reputation for BRT as a higher level of service. A failed BRT looses the chance to establish a brand that means something better. Passengers will forget and forgive a failed attempt.

5.0 CONCLUSIONS AND NEXT STEPS

Based on the comments from survey respondents, we infer that the BRT Information Clearinghouse has definitely filled a gap in the set of informational tools that currently exist in the arena of bus rapid transit systems; moreover, the Information Clearinghouse website is a valuable and useful part of this informational tool collection. Based on these received comments, we have made revisions to the website where appropriate and necessary.

The team has already started discussing potential next steps with the National BRT Institute and the Federal Transit Administration in terms of future funding opportunities long-term housing opportunities. In 2006 there will be two BRT-related conferences, each of which provides an occasion for promoting and marketing the BRT Information Clearinghouse. In May 2006, APTA will hold its Bus and Paratransit Conference in Orange County, California and we have submitted an abstract describing the Information Clearinghouse and requesting participation in the conference. In August in Toronto, Canada, there will be a BRT Conference sponsored by the

Bus Transit Committee of the Transportation Research Board. The project team has discussed potential participation at that conference through a hands-on poster session type of demonstration that would be available over several hours during which those attending the conference could actually sit and access the database. We will meet with the Conference Planning Sub-Committee at the TRB Annual Meeting in January to demonstrate the Clearinghouse and further discuss demonstration opportunities at the August Conference.

The Information Clearinghouse will, naturally, require regular maintenance including tasks such as 1) adding records to the Publications Database, 2) obtaining from publicly available website locations additional downloadable PDF versions of cited publications, 3) adding to the BRT Resources page transit agency websites that have BRT systems either in operation or in development, planning, or construction stages, and 4) getting on other BRT-related websites via links, and 5) monitoring for website obsolescence by using a tool that can determine those web addresses that no longer produce a valid site, that is, returns "The page cannot be found".

APPENDIX A

List of Potential Survey Participants

Name	Organizational Affiliation
Craig Amundsen	URS Corp.
Michael Baltes	Mitretek
Larry Blackstad	Hennepin County, Minnesota
Tunde Balvanyos	Pace Bus (Chicago)
Billy Charlton	San Francisco County Transportation Authority
Rosemary Covington	Parsons Brinkerhoff
Jim Cunradi	AC Transit
Russ Chisholm	Transportation Management & Design
Georges Darido	Booz Allen Hamilton
John Dockendorf	Pennsylvania Department of Transportation
Ron Drolet	British Columbia Transit (CN)
Larry Englisher	TranSystems, Inc.
Richard Feder	Port Authority of Allegheny County (PA)
David Fialkoff	Miami-Dade Transit Authority
Rex Gephart	Los Angeles Metropolitan Transportation Authority
Leon Goodman	Parsons Transportation Group
Matthew Hardy	Mitretek
Cyndi Harper	Metro Transit (Twin Cities, Minnesota)
Brendon Hemily	Symatico.ca
Rachel Hiatt	San Francisco County Transportation Authority
Dennis Hinebaugh	Center for Urban Transportation Research
Aaron Isaacs	Metro Transit (Twin Cities, Minnesota)
Doug Jamison	Lynx Transit (Orlando)
Gwen Johnson	City of Charlotte Department of Transportation (NC)
Doug Kimsey	Metropolitan Transportation Commission (SFBA)
Roland King	---------------
Rob Klein	Montgomery County, Maryland
Peter Koonce	Kittleson & Associates
Herb Levinson	Levinson Consulting
Eric Lindstrom	Kittleson & Associates
John Muth	City of Charlotte Department of Transportation (NC)
Ted Orosz	New York City Transit
Tim Papandreou	Los Angeles Metropolitan Transportation Authority
Dave Phillips	TranSystems
Jack Reilly	Capital District Transportation Authority (NY)
Scott Rutherford	University of Washington
Kevin St. Jacques	Wilbur Smith, Inc.
Michael Sanders	Connecticut Department of Transportation
Carol Schweiger	TranSystems
Hak C. Shin	Jackson State University (MS)
Doug Skorupski	Booz Allen Hamilton
Stan Teply	University of Alberta (CN)
Cheryl Thole	Center for Urban Transportation Research
David Tomzik	Pace Bus (Chicago)
David Wohlwill	Port Authority of Allegheny County (PA)

APPENDIX B

Request to Participate

Dear Mr./Ms. Potential Participant,

The PATH Program at the University of California, Berkeley in partnership with the California Department of Transportation (Caltrans) and the National Bus Rapid Transit Institute has just finished developing a web-based tool called the *Bus Rapid Transit Information Clearinghouse*. Development team members include Graham Carey of Lane Transit District in Eugene, Oregon and Sam Zimmerman* & Ian McNamara of DMJM+Harris. Before Version 1 is released we would very much appreciate if you could take some time to review and critique the site and provide us with your feedback. We have developed a very short internet-based survey that will assist you in answering our questions. Your individual responses are completely anonymous and there is nothing to e-mail back as your responses will automatically be saved. If possible, please complete the survey by December 15, 2005. If you have questions or problems, contact me at 415-250-5415 or mamiller@path.berkeley.edu.

The link to the BRT Information Clearinghouse is:
http://path.berkeley.edu/informationclearinghouse

The link to the survey is:
http://www.surveymonkey.com/s.asp?u=786871517678

On behalf of the entire development team, thank you very much for your participation.

Mark Miller
BRT Information Clearinghouse Project Manager
California PATH Program

*Sam Zimmerman left DMJM+Harris in September and is now at the World Bank.

APPENDIX C

Bus Rapid Transit Information Clearinghouse Survey

Exit this survey>>

1.0 Introduction

There are currently numerous web-sites available with information on bus rapid transit (BRT) systems. While such sites are valuable, they tend to be somewhat narrowly focused since each performs particular functions and offers specific services; moreover, they are generally only partially linked with each other. Our objective in producing the BRT Information Clearinghouse has been to take a more systematic and organized approach to the compilation and delivery of BRT-related information in order to provide comprehensive and knowledge-based information to assist intended users – the general transportation community with particular emphasis on the public transportation community – at any level of familiarity with BRT in the planning for and operation of bus rapid transit systems. In this way, we hope to fill an existing gap in the current set of web-based BRT information offerings. The BRT Information Clearinghouse does not intend to be the single-source for all BRT-related information as we believe that such a single source is not feasible. It does, however, intend to be a **single-access point** for as comprehensive an amount of BRT-related information as possible, a significant amount of which is housed locally on the Clearinghouse.

Please let us know what you think about the BRT Information Clearinghouse web site by answering the following questions. Click "Next" to get started with the survey. If you'd like to leave the survey at any time, just click "Exit this survey", which appears in the upper right hand corner. Your answers will be saved until you return to complete the survey. However, if you do exit and resume the survey at a later time, you do need to use the **same computer** to resume where you left off.

Next>>

Exit this survey>>

2.0 Site Use

1. How would you rate the overall organization of the Clearinghouse site from the perspective of the top-level topic headings, i.e., 'Planning Support Tool', 'Publications', 'BRT Resources', etc. (If you have additional comments, insert them in the text box below)

- ☐ Very good
- ☐ Good
- ☐ OK, but could use some changes
- ☐ Needs complete revamping
- ☐ Do not know / cannot answer
- ☐ Place additional comments here

2. Overall, how would you rate the web site in terms of its visual appearance?

- ☐ Very good
- ☐ Good
- ☐ Average
- ☐ Fair
- ☐ Poor
- ☐ Do not know / cannot answer

3. Are the topic headings in the Planning Support Tool, such as 'Overview / What is BRT?', 'BRT Economics and Finance', 'Case Studies', etc., clearly stated, i.e., are they self-explanatory? (If you have additional comments, please insert them in the text box below)

- ☐ Yes, completely
- ☐ Most of them
- ☐ Some of them
- ☐ None of them
- ☐ Place additional comments here

4. What is your view of the organizational structure of the Planning Support Tool (If you have additional comments, please insert them in the text box below)

- ☐ Fine as is
- ☐ OK for the most part
- ☐ Needs considerable restructuring
- ☐ Scrap it and start over
- ☐ Place additional comments here

Exit this survey>>

5. In the Planning Support Tool is the information within each level useful? (If you have additional comments, please insert them in the text box below)

☐ Yes
☐ Mostly
☐ Only partially
☐ Not at all
☐ Place additional comments here

6. How easy do you think it would be for someone new to BRT to navigate the site to find information she/he needs? (If you have additional comments, please insert them in the text box below)

☐ Very easy
☐ Generally easy
☐ Only partially easy
☐ Not easy at all
☐ Place additional comments here

7. Overall, how appropriate is the information for the seasoned BRT practitioner, i.e., is the information too basic for such a BRT-experienced person? (If you have additional comments, please insert them in the text box below)

☐ Completely appropriate
☐ Mostly appropriate
☐ Only partially appropriate
☐ Not appropriate
☐ Place additional comments here

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Exit this survey>>

3.0 Background Information

8. How familiar are you with using the Internet for information gathering?

- ☐ Very familiar
- ☐ Familiar
- ☐ Somewhat familiar
- ☐ Not familiar
- ☐ Do not know / cannot answer
- ☐ Other (please specify)

9. How familiar are you with BRT systems?

- ☐ Very familiar
- ☐ Familiar
- ☐ Passing knowledge
- ☐ New to the whole concept
- ☐ Do not know / cannot answer
- ☐ Other (please specify)

10. How do you usually get information about BRT? (Check all that apply)

- ☐ Internet
- ☐ Word of mouth / Discussions with colleagues
- ☐ Written material from meetings, conferences, etc.
- ☐ All the above
- ☐ Other (please specify)

11. What type of organization/company do your work for?

- ☐ Transit agency
- ☐ Consulting firm
- ☐ Regional/metropolitan planning organization
- ☐ Academic institution
- ☐ Other (please specify)

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Exit this survey>>

4.0 Future Directions

12. Overall, how useful an informational tool do you think the BRT Information Clearinghouse will be to users assuming it is revised based on your comments? Please let us know how we can improve it. (If you have additional comments, insert them in the text box below)

- ☐ Very useful
- ☐ Useful
- ☐ Somewhat useful
- ☐ Not useful at all
- ☐ Place additional comments on how we can improve the tool here

13. The following features may be added to the BRT Information Clearinghouse in the near future. Please rate their importance.

	Very Important	Important	Somewhat Important	Not Important	Do Not Know/Cannot Answer
'Keyword' field to Publications Database	☐	☐	☐	☐	☐
Expert System Tool to help users determine what BRT system technologies and services might be appropriate for their setting	☐	☐	☐	☐	☐
Case-Based Reasoning Tool to help users assess the benefits of BRT services	☐	☐	☐	☐	☐

<<Prev Next>>

Exit this survey>>

14. Beyond regular maintenance of the web site to keep information current and to add items such as more documents to the Publications Library, what other features would you like to see added to the BRT Information Clearinghouse?

15. If you have any other comments or suggestions regarding the BRT Information Clearinghouse, please provide them here.

On behalf of the entire Development Team, thank you for reviewing the BRT Information Clearinghouse and giving us your comments. We very much appreciate your feedback.

Mark Miller
BRT Information Clearinghouse Project Manager
California PATH Program

<<Prev Done>>