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BUS RAPID TRANSIT VEHICLE CHARACTERISTICS

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BUS RAPID TRANSIT

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This report focuses on vehicle issues related to BRT systems. The characteristics of BRT systems described in this report are developed based on existing or planned BRT systems. Information on the vendors' offerings is based on information from the existing BRT transit agencies, industry publications, including the year 2000 edition of *Jane's Transit Systems*, and follow-up interviews with a few of the vendors offering products that appear to be aligned with BRT needs. The report will be updated as necessary, to reflect emerging BRT vehicle concepts.

Based on broad BRT system goals, this report first identifies those goals as well as the desirable characteristics of BRT systems. Second, the report summarizes those characteristics against the backdrop of transit agencies, who are either proposing BRT systems in their community, or have an operational system. Finally, the report draws conclusions that will affect and determine BRT vehicle attributes and features. In addition, the extent to which those desirable characteristics are available from bus vendors is examined. Also, conclusions are drawn concerning the near-term design of BRT systems, and approaches for procuring BRT vehicles. The results are based on interviews with nine transit agencies and four potential BRT vehicle vendors.

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1.0 Introduction

The Federal Transit Administration (FTA) in cooperation with communities across the nation, is pursuing a Bus Rapid Transit (BRT) Demonstration program. BRT refers to a flexible form of rapid transit that combines advanced bus technologies and innovative bus operations and management techniques into an integrated system that can provide enhanced transportation services equivalent to light rail rapid transit systems. The BRT program goal is to increase the level and quality of bus service through the integration of vehicles, facilities, services and intelligent transportation systems (ITS). As a result, bus service can become a more viable mobility option.

While this report seeks to provide a better understanding of the unique vehicle-related issues and challenges of implementing BRT systems, there are other critical issues regarding BRT service implementation such as financing approaches, land use issues and planning implications which are beyond the scope of this report.

1.1 Background

Communities have been looking for new and innovative approaches to address increasing urban congestion and associated pollution while providing efficient and effective transportation options. Adding more highways is expensive and disruptive; and is not always an environmentally sound approach. However, light rail rapid transit systems, of interest to many communities, require a significant initial capital investment, and may not be an effective solution for all urban transportation problems. Transit buses provide an essential transportation service in metropolitan areas, but are often viewed as slow and unreliable.

One innovative approach is the use of buses rather than light and/or heavy rail, in an integrated, well-defined system with design features similar to light rail rapid transit systems. Some of the features of these Bus Rapid Transit, or BRT Systems that may be similar to light rail rapid transit systems include:

- Dedicated right-of-way
- Limited stops with fast travel between stops
- Rapid loading and unloading of vehicles on platforms and using multiple entryways
- Simplified, fast fare collection
- Communications and safety systems

There are a few forward-looking, successful BRT-like systems, both in the U.S. and abroad, that have combined modern bus technology with 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 pioneering systems, such as the system in Curitiba Brazil, have shown that these systems are capable of providing heavily-used, high capacity rapid transit at a reduced cost.

With this in mind, a BRT Demonstration Program was established by FTA and funded by Congress in the Transportation Efficiency Act for the 21st Century of 1998 ("TEA 21") with FTA named as the lead agency. The purpose of the program is to demonstrate BRT capabilities in transit across the U.S. Through a competitive process, seventeen sites were selected to participate in the program, with eleven of these sites awarded FTA grants for a BRT demonstration. A BRT Consortium was formed to help exchange ideas and experiences in BRT systems development among the participants. Membership in the Consortium will expand as interest in BRT increases.

It seems that no two existing BRT systems are alike. Each is designed and/or implemented to meet the needs and fit the environment of a particular community, and each has a unique set of characteristics. Many of the potential BRT characteristics and features are not, however, unique to BRT systems. Many of these elements could also enhance more traditional bus service.

1.2 SCOPE

This report focuses on vehicle issues related to BRT systems. The characteristics of BRT systems described in this report are developed based on existing or planned BRT systems. Information on the vendors' offerings is based on information from the existing BRT transit agencies, industry publications, including the year 2000 edition of *Jane's Transit Systems*, and follow-up interviews with a few of the vendors offering products that appear to be aligned with BRT needs. The report will be updated as necessary, to reflect emerging BRT vehicle concepts.

1.3 REPORT CONTENTS

Based on broad BRT system goals, this report first identifies those goals as well as the desirable characteristics of BRT systems. Second, the report summarizes those characteristics against the backdrop of transit agencies, who are either proposing BRT systems in their community, or have an operational system. Finally, the report draws conclusions that will affect and determine BRT vehicle attributes and features. In addition, the extent to which those desirable characteristics are available from bus vendors is examined. Also, conclusions are drawn concerning the near-term design of BRT systems, and approaches for procuring BRT vehicles. The results are based on interviews with nine transit agencies and four potential BRT vehicle vendors. Table 4-1, Detailed Implications for BRT Vehicles, provides a concise summary of potential BRT vehicle attributes for each of the BRT system characteristics. Results of the interviews with the selected transit agencies are contained in Appendix A, and the questionnaire used in those meetings is in Appendix B. Appendix C contains the results of the meetings with selected potential BRT vehicle vendors.

2.0 Bus Rapid Transit Characteristics

The following section is divided into three broad sub-sections: BRT System Goals, BRT System Characteristics and BRT Service Types. Each sub-section attempts to present a detailed definition for each sub-section. First, Section 2.1 defines nine goals of BRT systems. Second, Section 2.2 categorizes various BRT system characteristics (i.e., Rail Like Image, Level Boarding, Vehicle Tracking) into six broad categories: Roadway Operations, Operations Management, Rapid Load & Unload, Rapid Fare Collection, System Image and Low Environmental Impact. Finally, Section 2.3 explains the three types of BRT services that are either operational or in the planning stages: Express Service, Urban Shuttle and Local Service.

2.1 BRT System Goals

The goals for a BRT system are based on the goals of other rapid transit systems. A key word is "rapid"; the service must be geared to providing reduced door-to-door travel times to riders compared to today's bus systems. However, there are other BRT service goals that, taken together, can provide a meaningful rapid transit service that improves on today's bus services, such as:

- **Shorter trip times between origin and destination**—Fewer stops, faster travel, less congestion.
- **Short wait between vehicles**—More frequent service, even spacing between vehicles.
- **Integrated**—Convenient to parking, other transportation modes including neighborhood bus service and bicycle access.
- **Accessible**—Ease of access for physically challenged and elderly.
- **Distinctive**—Modern, distinctive design for vehicles and stations.
- **Easy to use**—Easy and rapid embarkation and debarkation; Simple fare collection; Clear signing including indication of routing.
- **Welcoming**—Comfortable vehicle interior designed for both seating and standing; Clean; Affordable service--in line with other transit services.
- **Low environmental impact**—Low-emission and low-noise transit vehicles.
- **Incremental development**—Service can grow to meet rising demand and to accommodate new technologies.

2.2 BRT SYSTEM CHARACTERISTICS

There are many transit system characteristics that meet the above goals that are not unique to BRT systems. Many of the desirable BRT technologies have also been applied to standard bus systems to help make them more efficient. A BRT system is not defined by one technology or feature, but by a combination of technologies and features that, taken together, make it an effective transportation system for the environment in which it operates.

Given the BRT system goals, a set of BRT characteristics were developed based on the research team's knowledge and review of the BRT literature, discussions with FTA staff, interviews with managers from transit agencies developing BRT systems, and discussions with bus vendors. BRT characteristics are classified into Roadway Operations, Operations Management, Rapid Load & Unload, Rapid Fare Collection, System Image, and Low Environmental Impact. A description of each characteristic, its potential benefits, and any potential implementation issues are described below.

2.2.1 Roadway Operations

Roadway Operations refers to the operation of BRT vehicles on the roadway and supporting infrastructure that affects BRT operation. The infrastructure includes the roadway itself as well as any BRT-related enhancements such as signal prioritization. The possible operational configurations of BRT systems include dedicated lanes, semi-dedicated lanes, and mixed traffic operations, on both expressways and corridors/streets.

- **Dedicated Lanes**—These are lanes dedicated for transit use only, not necessarily just bus use. These lanes allow a BRT system to operate in a similar mode to rail systems within a dedicated roadway. The cost of implementing dedicated lanes in an urban area can be very expensive unless unused right-of-ways are used such as abandoned rail lines. For example, in its South Busway, Pittsburgh buses share the roadway with light rail vehicles for a short distance; in fact, the busway was originally a rail-only line. There is a requirement that emergency vehicles be able to operate on or access the dedicated lanes in case of emergency. Operating speeds along these dedicated lanes depend on the quality of the roadway and the vehicle capabilities.
- **Semi-Dedicated Lanes**—These are lanes that are primarily dedicated to transit, but because of the topology, the lanes must be shared with non-transit vehicles. Depending on the roadway configuration and the level of restrictions regarding the lane use, these lanes can allow faster travel for BRT vehicles. Costs for providing semi-dedicated lanes is less than for dedicated lanes; it may mean designating an existing roadway lane or shoulder for transit use or widening an existing roadway to include semi-dedicated lanes.

Examples are center-city bus and light rail lanes that cars and trucks must use to make left-hand turns (if in the center of the roadway) or right-hand turns (when the transit lane is on the right-hand side of the road). Examples are the proposed Boston Silver Line on Washington Street, some HOV lanes, and shoulders on Minneapolis freeways that are designated for bus use only when congestion is encountered.

- **Mixed Traffic Expressway Operation**—This refers to express buses that operate partly on existing expressways, preferably in the HOV lanes. The service could include toll booth bypass lanes and ramp metering bypass lanes. Buses could operate at speeds up to 65 mph. The Pittsburgh north line offers this service.
- **Mixed Traffic Corridor & Street Operations**—This refers to BRT vehicles operating on local streets. Several approaches can be used to speed up bus service for relatively low costs. They include:
  - ***Signal Prioritization***—Sensors or other communications technologies notify the signal controller that a bus is approaching; the signal is then either held green an extra few seconds to let a bus through, or the signal changes from red to green a few seconds earlier.
  - ***Signal Preemption***—Sensors or other communications technologies notify the signal controller that a bus is approaching; the signal then changes to, or holds green until a bus is through the intersection.
  - ***Queue jumper lanes***—At intersections, a bus is given an exclusive lane (far right or far left). When a bus approaches the congested intersection, it has its own (presumably uncongested) lane so it is able to bypass the traffic waiting in the other lanes. The bus is then given a green light a few seconds before the other traffic lanes allowing the bus to get in front of the other traffic.
  - ***Pullout Right-of-Way***—Buses are given the right-of-way when pulling out from the curb. This was recently enacted as law in Alameda County, California. Special signs on the back of buses along with a public education campaign will help ensure its effectiveness.

2.2.2 Operations Management

The following are characteristics that define how a transit agency could manage BRT operations.

- **Vehicle Tracking**—A variety of location and positioning technologies can be used for tracking purposes. The mostly widely used today, Global Positioning Satellite (GPS)-based Automatic Vehicle Location (AVL) systems, allows bus location to be transmitted to a central control facility. Another approach deployed in L.A. uses vehicle-mounted transducers detected by loop detectors installed in the roadway, with the bus number transmitted back to central control over traffic control communications lines. This information can be used to provide exact bus location to emergency response teams in cases of emergency and may also be used to pinpoint the location of each bus on a system map so that traffic problems and headways can be tracked, and corrective actions taken, if necessary. For example, if two buses are running too close together, central control personnel can contact the bus drivers by radio and have them take action to correct the problem. Development of this capability, including the central geo-tracking capability, can be costly. In addition, transit agencies can collect point of sale information for planning and scheduling of BRT vehicles through passenger counters which are typically integrated with an AVL system or fare collection system.

- **High Capacity Vehicles**—Articulated buses provide up to 50 percent more rider capacity per bus. While this is not a defining feature for BRT, it can be important particularly for BRT systems in high-ridership corridors. Articulated buses also have a distinctive look and if they are used only on the BRT line, and can help define the BRT service.
- **Central Security Tracking**—The system allows transit agencies to use voice radio and/or silent alarms to notify central control if there are incidents. Some agencies may provide a screen messaging system with buttons for the driver to push to transmit pre-defined emergency messages, and displays for communications with the drivers.
- **Passenger Information**—Provides information to passengers regarding the arrival of the next BRT vehicle or status of system delays or changes. Information can be provided at BRT stops and stations through passenger information displays and on the vehicle via an LED display. Also, next stop annunciators on the BRT vehicle provide passengers with consistent information. The systems are normally tied to vehicle tracking.
- **Dependable Service**—Includes acquiring buses that are very reliable, properly maintaining vehicles and equipment, and operational attention to schedules and headways. Dependable service also includes ensuring short headways on key BRT lines so that the riders know that their wait will be relatively short.
- **Flexible Service**—Defines the extent to which the BRT service can change to accommodate phased growth and service changes, both planned and unplanned.

2.2.3 Rapid Load and Unload

The ability to rapidly get riders on and off the bus is key to reducing the travel time on a BRT route. Some of the BRT characteristics that help accomplish this are level boarding, through raised platforms, or low floor buses, and better access onto and off of vehicles.

- **Level Boarding**—Entry from a curb can be speeded if low floor buses are used. Level boarding reduces the size of the step that must be taken to enter the bus, and thus reduces boarding time and also eases boarding for physically challenged and elderly passengers. In addition, kneeling buses can be used to further provide a more level boarding. BRT vehicles designed to be compatible with station platforms allow riders to enter and exit on the level with the bus floor, speeding loading. Platforms allow wheelchairs to load directly into the bus, assuming the bus can come within a few inches of the platform. A ramp extension or the Precision Docking feature can more easily enable wheelchair loading.
- **Ease of Access**—There are two methods to improve the ease of access on to a BRT vehicle: larger or wider doors and an increased number of doors. Commercially available doors can be ordered that are wider than standard doors—up to 42 inches in width. These doors allow people to enter and exit simultaneously through the same door. A 40-foot bus typically has two doors, and a single articulated bus has three. The three doors allow even faster loading of people. At least one transit agency wants to add two additional doors on the left side of the bus for loading and unloading from a central platform.

2.2.4 Rapid Fare Collection

Rapid fare collection can also help reduce the amount of time it takes to get riders onto the bus. There are two approaches.

- **Vehicle-Based Fare Collection**—If fare is collected on the bus, then one approach for speeding up the process is to use passes, tokens, tickets or automated fare collection (AFC) techniques which helps reduce the time consuming use of exact change. AFC systems can use either stored value farecards or smart cards that can be read by a card reader located on the bus. Another approach used in some parts of the world is to collect the fare after the riders have boarded the bus, which usually requires a separate fare collection person on each bus.
- **Station-Based Fare Collection**—This approach is commonly used on light rail rapid transit systems. The fare is paid before the rider enters the vehicle. This could include the purchase of tickets or the use of stored value or smart cards. The rider is given a "proof-of-payment". In most cases, the honor system is used along with inspectors that occasionally ride the buses and ask to see the rider's proof-of-payment with stiff fines for non-payment. Another approach is to have gates through which only paid riders may pass; riders then load onto the buses from these "paid fare" areas.

2.2.5 System Image

A key aspect of BRT for many transit agencies is the image of this new system. These agencies want the system to stand apart from regular bus service and be more rail-like than bus-like. This image will help raise the public perception of the service and therefore help raise its ridership. A distinct image for BRT systems can be achieved through the operation of the system, through the appearance of the vehicles, and through the appearance of the busway.

- **Rail-Like Operation**—To be rail-like, the service offered by the BRT must be dependable. System users must feel confident that buses will come as scheduled with dependable headway maintenance. Less frequent stops are also a part of a rail-like image. A local bus service that stops every block, offers substantially slower service than rail transit systems that have stops every half-mile to a mile. Rail-like systems typically offer more frequent service (shorter headways) so that wait time is minimal.
- **Rail-Like Image**—To the extent possible, transit agencies want BRT buses to appear more rail-like. In the extreme, this could include longer, sleeker appearance, with a modern front and side appearance. For most bus vendors, this kind of vehicle would require custom design and much higher costs. However, a special BRT vehicle image can be achieved with less radical redesign such as low floor buses, articulated buses and unique exterior achieved with special paint or wrap treatment. Other factors affecting the overall vehicle image include on-board passenger information, displays and stop annunciation, comfortable interior, safe environment, smooth quiet ride, and low emissions vehicles.

  For systems to be promoted as new and modern transportation system, they should incorporate new and modern features, amenities or linkages. Features such as system information readily available from the internet, information kiosks, or automated call-in messaging, including real time schedule and routing, and linkages with community attractions and employment centers, activities, etc. could enhance the attractiveness of the service to the public. Linkages with other new mobility options, such as station cars, or transit focused development centers, could also enhance the modern system image of BRT.
- **Smooth & Quiet Operation**—BRT vehicles could incorporate technologies such low-noise propulsion or advanced suspension suspensions which provide a smoother and quieter ride, compared to conventional bus technologies. Such technologies could also further enhance the image of BRT systems as beneficial to communities.

2.2.6 Low Environmental Impact

Considering the public's demand for low emissions buses, and increasingly stringent emissions standards implemented or planned for transit buses, BRT provides an excellent opportunity to implement low emissions vehicle technologies in transit. These technologies are consistent with the modern system image for BRT and may better fit the community that they will serve.

The transit industry, largely in response to tightening transit bus emissions standards, has been at the forefront in implementing clean fuel technologies, and continues to pursue these technologies. Several clean fuels, such as natural gas, propane, alcohol fuels, biofuels, and battery electric, hybrid electric and fuel cell propulsion technologies, have been adopted or demonstrated for transit buses. Buses powered by alternative fuels, mainly compressed and liquefied natural gas, account for approximately 20-percent of all new bus orders, and hybrid-electric vehicles are now emerging in transit fleets. Lightweight chassis buses are also being explored as a way to improve vehicle efficiency and thereby decrease emissions. Each technology is at various stages of maturity and offers varying degrees of emissions benefits, at a range of costs, reliability and performance.

- **Alternative Fuels**—Compressed and liquefied natural gas (CNG and LNG), propane (LPG), alcohol fuels (ethanol and methanol), and biodiesel fuels have all been explored for transit with varying success. Natural gas fuels are the predominate alternative to diesel for transit buses with some limited use of propane and biodiesel fuels. All alternative fuels require special fueling infrastructure and in some cases maintenance and storage facility modifications.
- **Electric Drive Technologies**—Battery-powered, hybrid-electric drive, fuel cell, and externally-powered electric vehicles (e.g., electric trolley buses) offer substantial emissions benefits and quieter operation compared to diesel transit buses. Battery powered electric vehicles utilize batteries to store energy on-board the vehicle. They are very effective in certain applications, particularly smaller buses. Limitations for application in BRT include range and passenger carrying capacity. Hybrid-electric powered buses utilize a small engine coupled with an electric motor and batteries. They can greatly reduce vehicle emissions without costly infrastructure changes. They are beginning to emerge in transit fleets, with orders for diesel hybrid-electric powered buses currently numbering in the hundreds. Small numbers of fuel cell powered buses are planned for demonstration. Although a promising technology, they are undergoing further development and are extremely costly. Externally-powered electric buses draw propulsion power from overhead catenary wires. Some can operate "off-wire" for short

distances, thereby increasing their flexibility. A new approach is having the power source embedded in the roadway.

- **Lightweight Chassis Design—**Lightweight materials, such as composite bus structures can significantly reduce the weight of transit buses by as much as 25-percent, increasing overall bus fuel efficiency, and may also offer increased durability. They could enhance the ability of clean fuel technology buses to meet axle weight requirements.

2.3 BRT SERVICE TYPES

Because of BRT flexibility, existing and planned BRT systems do not all share a common set of operational characteristics. It appears that BRT systems can be operated to offer at least three variations of BRT services, and still fall within the broad BRT definition: Express BRT Service, Urban Shuttle BRT Service and Local Collector/Distributor BRT Service. Within a given category of service, not all BRT systems share a common set of characteristics. Also, a BRT system may plan to have a single vehicle offer two types of service. For example, Local Collector/Distributor BRT vehicles could also be expected to operate on express lanes; or express buses may be expected to also operate on downtown streets.

2.3.1 Express BRT Service

The Express BRT Service is geared toward the rapid rail type of service—higher speed, either dedicated lanes or operation on HOV lanes on expressways, large capacity, less frequent stops, and ability to load/unload passengers rapidly. This service could connect an urban area to its suburbs, airport, transit hub or other urban areas. Riders access the service through park-and-ride lots or connections to other transportation services such as collector/distributor buses. Many of the U.S. BRT systems are built around express bus service. Characteristics of the Express BRT Service include the following:

- **Roadway Operations**—Dedicated or semi-dedicted lanes, such as sharing HOV lanes. Mixed expressway and traffic/street operations would be less likely. IVI technologies such as lane keeping and lane change warning systems may improve safety.
- **Operations Management**—On-board radio with two-way transmission to central control, articulated buses for higher capacity and dependable/proven technologies. Passenger information system highly desirable for rail-like operation.
- **Rapid Load & Unload**—Doors compatible with station platform heights, increased number of doors.
- **Rapid Fare Collection**—Station-based fare collection more likely via proof-of-payment. If vehicle-based, electronic fare payment is likely.

- **System Image**—Rail-like operation, rail-like image and a smooth and quiet operation.
- **Low Environmental Impact**—Low emission vehicle potentially with a lightweight chassis design.

2.3.2 Urban Shuttle BRT Service

The Urban Shuttle BRT Service is geared more toward operation in heavily congested areas, such as downtown. The system may have semi-dedicated lanes, similar to a light rail right-of-way (R.O.W), that may be shared with vehicles turning left or right; or the lane may actually be shared with light rail vehicles. Desirable characteristics include flexibility to operate in tight spaces (e.g., articulated buses), large capacity, rapid passenger loading and unloading, and precision docking capability at platforms. Riders access the service by walking or biking to the stop, or by connection to an express service. Higher vehicle speeds is not a primary goal for these systems, however, like all BRT systems, reduction in door-to-door travel time is a goal. Characteristics of the Urban Shuttle BRT service include:

- **Roadway Operations**—Semi-dedicaed lanes more likely with lane change/lateral warning system. However, dedicated lanes may be possible if right-of-way is available. Mixed traffic corridor and street operations are likely as well. A signal priority system would be highly desirable.
- **Operations Management**—On board AVL with radio transmission to central control, articulated buses for higher capacity, flexible vehicle design that could operate as an express vehicle. Passenger information system likely.
- **Rapid Load & Unload**—Level boarding through low floor buses or kneeling buses. Less likely to have more doors due to vehicle-based fare collection strategy.
- **Rapid Fare Collection**—More likely to be vehicle based with electronic fare payment system. Station-based less likely.
- **System Image**—Rail-like operation, rail-like image through distinctive stops that stand out from regular bus service and a smooth and quiet operation.
- **Low Environmental Impact**—Low emission vehicles or electric drive technologies for operating in downtown areas.

2.3.3 Local Collector/Distributor BRT Service

The Local Collector/Distributor BRT Service is not in itself a BRT service, however this type of service can be coupled with the Urban Shuttle or Express BRT service, providing a means of access to these service. The Local Collector/Distributor BRT Service will complement the other BRT service and provide improved access to transportation for riders in dispersed areas.

Desirable characteristics typically include smaller size buses, signal priority, low floor for easy entry from the curb, and AVL vehicle tracking to provide waiting riders with arrival information. Desirable characteristics typically do not include large capacity, high speed, rapid loading/unloading, or dedicated lanes. This is essentially the regular bus service offered in many cities today but with a few extra features. Buses operating on BRT Express or Urban Shuttle Service may also be required to perform a dual function including the collector/distributor part, making vehicle selection for these types of BRT service more challenging. Some characteristics of the Local Collector/Distributor BRT Service include:

- **Roadway Operations**—Most likely seen operating in mixed traffic corridors and streets. Possibility of using expressway operations at time, but less likely.
- **Operations Management**—On-board AVL highly desirable for tracking purposes. Smaller vehicles that could also operate as an urban shuttle. Articulated vehicle unlikely.
- **Rapid Load & Unload**—Curb entry likely with low floor vehicles.
- **Rapid Fare Collection**—Vehicle-based fare collection system through electronic payment system desirable.
- **System Image**—Rail-like image desireable that is tied to other transit systems or BRT services.
- **Low Environmental Impact**—Low emission vehicles can be important.

3.0 Survey of Transit Agencies Planning BRT Systems

In this section, the characteristics of planned BRT systems are described based upon surveys and interviews conducted with agencies planning BRT systems. For this report, the study team visited nine transit agencies that were representative of the types of BRT systems planned under the FTA-sponsored demonstration program. Visiting all of the transit agencies planning BRT systems under the FTA-sponsored demonstration program was beyond the scope of this effort.

First, the BRT characteristics of the surveyed agencies are compared to the BRT System Goals defined in Section 2.1 BRT System Goals of this report. Second, the responses of the agencies are compared to the BRT System Characteristics defined in Section 2.2. Third, a summary of the BRT service types planned by the interviewed agencies is provided. Finally, conclusions are developed regarding the predominant BRT System Characteristics that seem to be core to the BRT System Goals. Appendix A contains the detailed results of the meetings held with the selected transit agencies.

3.1 BRT SYSTEM GOALS

- **Shorter Trip Times**—Shorter trip times are a primary goal for all of the interviewed agencies, and will primarily be accomplished through Roadway Operations, Rapid Load and Unload of passengers and Rapid Fare Collection.
- **Shorter Wait Between Vehicles—**Detailed statistics were not available from the agencies. However, the majority of the agencies either offer or plan to offer a service that includes frequent (e.g., 5 to 10 minutes at peak) headway to minimize passenger wait times.
- **Integrated**—All of the agencies plan to make BRT as accessible as possible by having the BRT service intersect with other bus routes or approach other transportation modes such as inter-city bus terminals or airports. Park and ride lots are also in the plans for a few of the agencies.
- **Accessible**—All of the agencies planned to be in compliance with the Americans with Disabilities Act. Beyond ADA compliance, a few of the agencies were planning to have raised platform stations that would provide more accessibility for handicapped persons.
- **Distinctive**—All but one of the agencies either have or are planning on having a distinctive appearance for their BRT system. This is being achieved using unique paint (6 agencies), unique buses (1 agency is using low floor articulated buses only for BRT), or by using busways (5 agencies are using busways and special colors; 3 more are using

unique stops). Only one agency does not plan any unique identification for its BRT service.

- **Easy to Use**—Ease of use relates to rapid loading and unloading through wider doors or more rapid fare collection; low floor buses or platform loading; and "Next Arrival" displays. All of the agencies are using at least one of these characteristics.
- **Welcoming**—This translates into comfortable, clean and affordable. Complete data were not available on this category during the study. However, most agencies seemed to feel that these categories are an important part of the BRT system image. One aspect of Welcoming is low noise. In this category, only the three agencies that plan on electric-powered systems would expect to have lower noise.
- **Low Environmental Impact**—All of the agencies either have or plan to have low emission buses for BRT: CNG fuel, clean diesel, electric trolley bus or hybrid vehicles.
- **Incremental Development**—Many of the agencies are planning for incremental developments. Most of the agencies that are planning incremental development will be operating BRT vehicles on Mixed Traffic Expressway Operations or Mixed Traffic Corridor & Street Operations.

3.2 BRT System Characteristics

The following section summarizes the responses of the agencies specific to the BRT system characteristics defined in Section 2.2. The summary provides a detailed description of how the surveyed agencies will be addressing the 20 BRT system characteristics described in Section 2.0 through their BRT systems, specifically their vehicles. None of the surveyed agencies plans to incorporate all of the 20 BRT system characteristics. However, each agency is planning a combination of these characteristics that, taken together, make up their unique BRT system. A summary of the surveyed agencies responses is provided in Table 3-1 Agency BRT System Characteristics Summary. The table quantifies which surveyed agencies will be implementing which BRT System Characteristic.

3.2.1 Roadway Operations

- **Dedicated Lanes**—Five agencies indicated they would have dedicated lanes for BRT vehicles. Some of the agencies indicated the need for Lane Assist and Lateral Control devices to insure the safety of vehicles and the occupants.
- **Semi-Dedicated Lanes**—Three agencies indicated they would operate on Semi-Dedicated Lanes. Two of the agencies will operate on Dedicated Lanes as well. One

agency is currently testing the use of a Lateral Warning System, and another has indicated interest for such a system.

- **Mixed Traffic Expressway Operations**—One agency will be operating in Mixed Traffic Expressway Operation. However, there was no indication about using a Lateral Warning System or Lane Assist technology.
- **Mixed Traffic Corridor & Street Operations**—Four agencies will operate in Mixed Traffic Corridor & Street Operations. One agency, Los Angeles, is currently operating and has seen significant benefits in its BRT service. Los Angeles has an extensive Signal Priority System in place. One other agency indicated the need for such a system.

3.2.2 Operations Management

- **Vehicle Tracking**—Seven agencies indicate they plan to use a vehicle tracking system. Six will use AVL technology while one, Los Angeles, will be a transponder-based system. Three of the agencies indicated the use of Passenger Counters.
- **High Capacity Vehicles**—Four agencies indicate they plan to purchase High Capacity Vehicles, generally to be accomplished through the use of articulated buses.
- **Central Security Tracking**—Three agencies plan on a distributed type of central security tracking. In most cases, agencies will include in-vehicle cameras and microphones that will eventually be linked backed to a central office.
- **Passenger Information**—Six agencies plan to disseminate transit traveler information to riders. A majority will use "Next Stop" annunciators and arrival information. One agency will have in-vehicle LED units.
- **Dependable Service**—Two agencies specified they want dependable service. This is not to say that the other seven do not want dependable service, it's certain that they do. One agency specified the use of vehicles that are not considered to be "alternative fuels" while the other was planning to use on-board vehicle diagnostics to monitor the mechanical system of their vehicles to address maintenance problems in a proactive manner.
- **Flexible Service**—Three agencies will have a flexible service system; where the BRT vehicle can be used for other purposes, if needed. This also includes the ability for other vehicles to be used as part of the BRT service if needed.

3.2.3 Rapid Load & Unload

- **Level Boarding**—Eight agencies will have some type of level boarding. In most cases this will be accomplished through low-floor buses and stations that are at curb height. Some agencies will use standard floor buses and raised platform stations. In both cases, there is the need for a precision docking system that will place the BRT vehicle in the same position, both longitudinally and latitudinally, from the curb or platform.

- **Ease of Access**—Two transit agencies indicated the use of improved Ease of Access through the use larger/wider doors or an increased number of doors.

3.2.4 Rapid Fare Collection

- **Vehicle-Based**—Three agencies plan to use a vehicle-based electronic fare payment system. The electronic fare payment system will mostly consist of mag-stripe cards rather than contactless cards. While this may seem as a low-tech solution, most of these agencies are currently only accepting either cash, tokens, or passes.

- **Station-Based**—One of the transit agencies plan to have a station-based fare collection system.

3.2.5 System Image

- **Rail-Like Operation**—Three agencies will have operations that are rail-like. For each of these agencies the BRT service is being used as an alternative to light rail. Thus, the BRT service is being designed, in essence, like a light rail system.

- **Rail-Like Image**—All nine agencies wanted to portray some type of rail-like image. This is to be accomplished generally through unique paint schemes, low floor and articulated buses with a comfortable interior.

- **Smooth & Quiet Operation—**Two agencies specified the need for smooth and quiet operation. One has specified low-noise propulsion technology while the other did not specify a means with which to achieve a smooth and quiet operation.

3.2.6 Low Environmental Impact

- **Alternative Fuels**—Six agencies plan to use alternatively fueled vehicles (not electrically powered). In most cases, Compressed Natural Gas will be used.

- **Electric Drive Technologies—**Three agencies will use electric drive technologies. In both cases this will be through the use of overhead catenary wires to supply electrical power.

- **Lightweight Chassis Design**—One agency specified the use of a light-weight chassis design.

Table 3-1 Agency BRT System Characteristics Summary

	Alameda County	Allegheny County Port Authority	Charlotte Transit Authority	Cleveland Regional Transit Authority	Hartford Transit Authority	Lane Transit District	Los Angeles Transit Authority	Massachusetts Bay Transportation Authority	Valley Transportation Authority	Sum
Roadway Operations										
Dedicated Lanes		X	X		X	X		X		5
Semi-Dedicated Lanes		X		X				X		3
Mixed Traffic Expressway Operations			X							1
Mixed Traffic Corridor & Street Operations	X			X			X		X	4
Operations Management										
Vehicle Tracking	X		X	X	X		X	X	X	7
High Capacity Vehicles		X		X				X	X	4
Central Security Tracking			X			X			X	3
Passenger Information	X			X		X	X	X	X	6
Dependable Service	X				X					2
Flexible Service	X	X					X			3
Rapid Load & Unload										
Level Boarding	X	X	X	X		X	X	X	X	8
Ease of Access						X	X			2
Rapid Fare Collection										
Vehicle-Based		X			X		X			3
Station-Based				X						1
System Image										
Rail-Like Operation				X		X		X		3
Rail-Like Image	X	X	X	X	X	X	X	X	X	9
Smooth & Quiet Operation				X		X				2
Low Environmental Impact										
Alternative Fuel			X	X	X	X	X	X		6
Electric Drive technologies				X		X		X		3
Lighweight Chassis Design			X							1

3.3 BRT SERVICE TYPES

Findings from the nine agencies participating in this study show the following types of BRT service planned. Table 3-2 BRT Service Type by Agency, summarizes the BRT Service Type by agency.

- **Express BRT Service**—Six agencies are planning on express bus service; Three of those agencies assume that the express buses will also provide either downtown street operation or local neighborhood operation.
- **Urban Shuttle BRT Service**—Two of the agencies interviewed are planning an exclusive downtown shuttle bus type of service.
- **Local Collection/Distributer BRT Service**—Two of the agencies assume that the local collector/distributor (C/D) bus service will be part of BRT. One assumes that there will be different C/D buses, but they will have AVL, and their schedules will be linked to express bus operation—neither the express buses nor local buses have any special color or designation. The other agency is essentially operating what it calls its "BRT service" as a local bus.

Table 3-2 BRT Service Type by Agency

BRT Service Type	Alameda County	Allegheny County Port Authority	Charlotte Transit Authority	Cleveland Regional Transit Authority	Hartford Transit Authority	Lane Transit District	Los Angeles Transit Authority	Massachusetts Bay Transportation Authority	Valley Transportation Authority	Sum
Express BRT Service	X	X	X		X	X	X			6
Urban Shuttle BRT Service				X				X		2
Local Collector/Distributor BRT Service					X				X	2

3.4 BRT CHARACTERISTICS CONCLUSIONS

The nine overall goals of the BRT system concept are based upon the assumption that the system should move more passengers than traditional bus service. This was seen with all of the agencies that were interviewed. The BRT systems want to move more people by reducing trip time, reducing the wait time at stops and stations, having a service that is unique and distinctive, ensure that BRT is welcoming and has a low environmental impact on the surrounding communities. Some of the BRT System Characteristics will greatly impact transit agencies meeting the goals of a BRT system. However, not all of the BRT System Characteristics will meet each of the BRT system goals. For example, for a shorter trip time, the roadway operations, such as using dedicated lanes or HOV lanes will determine the greatest amount time-savings. Below is a summary of the highlights of some of those comparisons that were revealed in the agency interviews. A more detailed breakdown relating the nine BRT System Goals to the BRT System Characteristics is provided at the end of this section in Table 3-3 Comparison of BRT System Goals to BRT System Characteristics. The analysis is based upon the transit agency interviews.

- **Shorter Trip Times**—Generally accomplished through Roadway Operations, Operations Management, Rapid Load & Unload and Rapid Fare Collection. For example, the roadway should be designed to give the BRT buses an advantage, particularly during congestion. Approaches can vary from queue-jumper lanes at congested intersections to dedicated lanes for buses. Signal priority helps speed bus trips when traffic is freely flowing; however, it is not clear how much advantage signal priority offers during heavy congestion.
- **Shorter Wait**—There were two major methods to reduce wait at stops: Rapid Load & Unload and Rapid Fare Collection. Most of the agencies planned to use level boarding with a few proposing some type of electronic payment system.
- **Distinctive**—A distinctive operation will be accomplished through Roadway Operations (utilizing Dedicated or Semi-Dedicated Lanes), Rapid Fare Collection, System Image and a Low Environmental Impact. All of the agencies wanted a rail-like appearance and many planned to use some type of alternatively fueled vehicle.
- **Welcoming**—A welcoming system was accomplished through Operations Management (High Capacity Vehicle, Passenger Information), Rapid Load & Unload and the System Image.
- **Low Environmental Impact—**The goal of low environmental impact will primarily be met through the use alternatively fueled vehicles (CNG predominantly). However, two of the agencies plan to utilize vehicles with electric drive technologies.

Table 3-3 Comparison of BRT System Goals to BRT System Characteristics

	BRT System Goals								
	Shorter Trip Times	Shorter Wait	Integrated	Accessible	Distinctive	Easy to Use	Welcoming	Low Environmental Impact	Incremental Development
Roadway Operations									
Dedicated Lanes	✓				✓				
Semi-Dedicated Lanes	✓		✓		✓				
Mixed Traffic Expressway Operations	✓								✓
Mixed Traffic Corridor & Street Operations	✓		✓				✓		✓
Operations Management									
Vehicle Tracking	✓	✓	✓				✓		
High Capacity Vehicles	✓						✓		
Central Security Tracking							✓		
Passenger Information						✓	✓		
Dependable Service						✓	✓		
Flexible Service			✓			✓			✓
Rapid Load & Unload									
Level Boarding	✓	✓		✓	✓	✓	✓		
Ease of Access	✓	✓		✓		✓	✓		
Rapid Fare Collection									
Vehicle-Based	✓				✓	✓			
Station-Based	✓	✓			✓	✓			
System Image									
Rail-Like Operation					✓		✓		✓
Rail-Like Image			✓		✓		✓		
Smooth & Quiet Operation					✓		✓	✓	
Low Environmental Impact									
Alternative Fuel					✓			✓	
Electric Drive technologies					✓			✓	
Lighweight Chassis Design					✓			✓	

4.0 BRT Vehicle Implications

The following sections provide a summary of detailed implications for BRT vehicles based upon given system characteristics. The design of the BRT vehicle (or those features that are necessary) will have a direct impact on the cost of the vehicle. Also, the cost of the vehicle, or the funds available to purchase a vehicle, will have a direct impact on the design (or features that can be added) of the vehicle. Table 4-1 focuses upon specific vehicle impacts that a given characteristic can have on the BRT vehicle for each of the BRT service types.

Further analysis and synthesis of the data gathered from the transit agencies and the selected vendors who make transit vehicles revealed a number of direct design impacts to the BRT vehicle. The potential characteristics required for a particular BRT system will have implications for the design of the vehicle used in the BRT system. Each BRT system characteristic, such as rapid loading, on-board fare collection, or vehicle tracking capabilities, will have a direct implication on the design of the vehicle. Also, certain vehicle attributes, such as buses with low floors, enable a BRT system characteristic, specifically rapid load and unloading, to be more easily incorporated into the BRT system. However, given the various types of BRT systems planned, it is important to note that not all BRT system characteristics or their vehicle attributes are necessary, or even desirable, for a particular BRT system type. The BRT system type, and therefore the vehicles used in a particular community, will be selected based upon the unique transportation needs that the BRT system is addressing.

Each of the BRT system characteristics, defined in Section 2.2, was examined to see what, if any, impact there would be on the design of the BRT vehicle. This analysis is presented in Table 4-1. For each of the 20 BRT System Characteristics, a number of BRT Vehicle Impacts were determined. The BRT Vehicle Impact is a feature of the vehicle (as opposed to a feature of the infrastructure, method of operations or land development of the BRT system) that will enable that system characteristic to be met. (A similar analysis could be conduct for other impacts as well, such as infrastructure design or ITS technologies.) For each of the BRT Vehicle Impacts, the likelihood of it occurring for each of the BRT System Types was evaluated. A black circle is used to indicate Very Common occurrence, a circle with a black dot indicates the feature would be common, and a clear circle indicates that the feature would be uncommon for that BRT system type. Finally, based upon current knowledge and the vendor interviews a relative cost was associated with each vehicle impact. These cost, however, are only estimates and should be compared relative to each vehicle attribute within each BRT System Characteristic.

The table provides an overview convenient manner for transit agencies to determine which system characteristics and vehicle features they might want, based upon their individual needs, system type and funding. For example, if an agency selected the BRT System Characteristic of High Capacity Vehicles as highly desirable, the impact on the design of that BRT vehicle may be one of three features: Larger Buses, Articulated Buses, or a Re-designed Interior Layout. If the agency had an Express Service type, it would be very common for that system to incorporate all three feature at relatively moderate cost. However, if the agency was planning a Local Service type, all three features may be uncommon.

Table 4-1 Detailed Implications for BRT Vehicles

BRT System Characteristic	BRT Vehicle Impact	BRT System Types			Relative Cost
		Express Service	Urban Shuttle	Local Service	
Roadway Operations					
Dedicated Lanes	1. Lateral Control for Narrow Lanes	●	⦿	○	$$$
	2. Narrow Vehicle Design	⦿	●	○	$$$$$
	3. Lane Assist	●	⦿	○	$$$$$
Semi-Dedicated Lanes	1. Lateral Warning System	●	●	○	$$$
Mixed Traffic Expressway Operations	1. Lateral Warning System	●	○	○	$$$
	2. Lane Assist	●	○	○	$$$$$
Mixed Traffic Corridor & Street Operations	1. Signal Priority Equipment	○	●	●	$$$
	2. Signal Preemption Equipment	○	●	●	$$$
Operations Management					
Vehicle Tracking	1. AVL Technology	●	●	●	$$$
	2. Transponder-Based	○	○	○	$
	3. Passenger Counters	⦿	⦿	⦿	$
High Capacity Vehicles	1. Larger Buses	●	⦿	○	$$$
	2. Articulated Buses	●	⦿	○	$$$$$
	3. Re-designed Interior Layout	⦿	●	○	$$$
Central Security Tracking	1. Silent Alarms	●	⦿	⦿	$
	2. CCTV Cameras and Microphones	●	⦿	○	$
	3. AVL Technology	●	●	●	$
Passenger Information	1. Next Stop Annunciation	●	●	●	$$$
	2. Passenger Information Display	●	⦿	⦿	$$$
Dependable Service	1. Proven Technology Vehicles	●	●	●	$$$
	2. On-Board Vehicle Diagnostics	●	⦿	⦿	$$$$$
Flexible Service	1. Multi-Use BRT Vehicle	●	●	●	$$$
Rapid Load & Unload					
Level Boarding	1. Low Floor Buses	⦿	●	●	$$$
	2. Kneeling Buses	○	⦿	⦿	$$$
	3. Doors Compatible with Raised Platfroms	●	●	○	$$$
	4. Precision Docking Technology	●	●	○	$$$$$
Ease of Access	1. Larger/Wider Doors	●	⦿	○	$$$
	2. Increased Number of Doors	●	⦿	○	$$$
Rapid Fare Collection					
Vehicle-Based	1. Electronic Fare Payment	●	●	⦿	$$$$$
Station-Based	1. Increased Number of Doors	●	⦿	○	$$$
	2. Wider Doors	●	●	○	$$$
System Image					
Rail-Like Operation	1. Dependable Service	●	●	●	$$$
Rail-Like Image	1. Distinct and Modern Vehicle Façade	⦿	⦿	○	$$$
	2. Wrap Treatment	⦿	⦿	○	$
	3. Special Paint Scheme	●	●	●	$
	4. Low Floors Buses	⦿	●	●	$$$
	5. Articulated Buses	●	⦿	○	$$$$$
	6. Next Stop Annunciation	●	●	●	$$$
	7. Comfortable Interior	●	●	●	$
	8. Smooth & Quiet Operation	●	●	●	$$$
Smooth & Quiet Operation	1. Low-noise Propulsion Technology	⦿	⦿	○	$$$
	2. Advanced Suspension Technology	○	○	○	$$$
	3. Low rolling Resistance Tires	⦿	⦿	○	$
Low Environmental Impact					
Alternative Fuels	1. Compressed Natural Gas	⦿	⦿	○	$$$
	2. Other (LNG, Propane, Biodiesel)	○	○	○	$$$
Electric Drive Technologies	1. Externally Powered	○	⦿	○	$$$
	2. Fuel Cell	○	○	○	$$$$$
	3. Hybrid Electric Drive	○	○	○	$$$
	4. Battery Powered	○	○	⦿	$$$
Lightweight Chassis Design	1. Composite Bus Structure	⦿	⦿	○	$$$$$

● — Very Common, ⦿ — Common, ○ — Uncommon

$$$$$ — Very Expensive, $$$ — Expensive, $ — Less Expensive

5.0 Acquiring BRT Vehicles

Acquiring vehicles for a BRT system is one of the major challenges faced by a transit agency interested in BRT. This section discusses the availability of BRT vehicles, and addresses some of the design and procurement issues involved in BRT vehicle acquisition.

Meetings were held with four of the vehicle suppliers that have facilities in the United States and that have expressed interest in Bus Rapid Transit. The purpose of the meetings was to get vendor reactions to the BRT characteristics. The meetings were not intended to be a comprehensive vendor survey; rather, the meetings gave the research team a flavor of the manufacturers' points of view on BRT. The results of the meetings, detailed in Appendix C, were used in preparing this report.

5.1 Commercial Availability of BRT Vehicles

Potential BRT vehicle vendors were identified from a broad pool of transit vehicle vendors using transit publications such as *Janes Transit Systems, June 2000*, as a reference. Likely BRT vendors were then identified based on those currently manufacturing BRT vehicles, or vendors with standard offerings that include many core BRT vehicle features. Appendix D lists non-U.S. transit vehicle vendors that are likely BRT suppliers. Transit is a primary means of transportation in many other countries; thus, there are many vendors that either make BRT-like vehicles today, or have the potential to do so. The vendors listed do not necessarily represent a complete set of BRT suppliers; rather, the list gives the reader an idea of the scope of transit vehicle suppliers outside of the U.S.

Several vendors, both in the U.S. and in other parts of the world, are potential vendors for BRT vehicles. Appendix D also lists the U.S. transit vehicle vendors that are considered candidate BRT vehicle suppliers. As is true with many other industries, globalization has affected the transit vehicle industry, so many of the vendors have partnerships or ownership arrangements with non-U.S. interests.

Meetings were held with four bus vendors that have facilities in the United States and that have expressed interest in Bus Rapid Transit; two of the vendors were in the same meeting. The purpose of the meetings was to get vendor reactions to the BRT features that transit agencies had indicated were important.

The meetings were not intended to be a comprehensive vendor survey; rather, the meetings gave the research team a flavor of the manufacturers' BRT points of view. Vehicle vendors are interested in BRT, and are prepared, each in their own way, to work with the transit agencies in meeting BRT goals. Their thoughts on BRT focused on definitions of BRT systems, and insights into potential vehicle procurement issues.

Today's vehicle vendors have standard vehicle products that are tailored to meet each transit agency's specified needs. Some of the transit agency requirements for BRT vehicles are easier to meet than others. The vehicle vendors are accustomed to certain options being added to buses, such as fare collection boxes, engine and transmission options, radio systems, AVL systems, special seats, special paints, etc. In those cases, the vehicle vendor often has component supplier relationships established, and is able to respond quickly with prices and shipment times.

The vendors are not able to respond as quickly when there is additional "custom" engineering design necessary to accommodate the agency needs. Examples of those requirements could include:

- Specification of components by supplier name when the vendor does not have a working relationship established; this is particularly a problem when the vehicle vendor is expected to integrate electronic components from agency-specified component suppliers. Moreover, specification of components by supplier name are not allowed under third party contracting guidelines.
- Specification of changes that affect the design of the vendor's basic vehicle product, such as curved sides, different lengths, etc.

Costs per vehicle will increase with these types of changes, both because engineering design work is necessary, and because market risks involved. Other potential issues the vendors raised in the meetings include:

- Finding suppliers for reliable specialized equipment, such as lateral control and precision docking technologies, may be difficult.
- Specifying "rail-like image" for competitive bidding will be very difficult.
- There does not seem to be any consistency of vehicles, with specifications varying from one agency to another. There are also too many variations. More standardization would mean less expensive vehicles.
- Building special designs for small quantities of buses raises the price per bus substantially.
- A "BRT White Book", in the mode of APTA's Standard Bus Specifications Manual might be useful.

5.2 VEHICLE DESIGN

Most, if not all, bus vendors provide "tailored" vehicles for each customer. These tailored designs build upon the manufacturer's standard product line; the vendor offers a range of more-or-less standard options that allow tailoring to meet the customer's needs. As long as the customer's specified features can be met by the manufacturer's standard offerings, the price per bus will most likely be competitive. However, if a transit agency must have a non-standard feature, then the vendor must custom design and develop the feature, and the cost of this design and development will be reflected in the cost of the vehicles delivered to that transit agency. For orders with only a few vehicles, the cost per bus will be high.

5.2.1 Standard Product Line

Most, if not all, transit vehicle vendors have a standard product line, which may include different vehicle lengths (possibly including articulated), widths, door sizes and configurations, and power trains (possibly including alternative fuels and hybrids). What is considered standard varies from one vendor to another. Costs for components on standard vehicles such as engines, transmissions, and door mechanisms are well known by the supplier as are the manufacturing costs, so the supplier's costs for these vehicles is relatively fixed. Prices may not vary greatly from a small transit agency to a large one.

5.2.2 Standard Options

Most, if not all, vendors offer sets of "standard" options; that is, the vendor has established suppliers for the optional items. These optional components are added to tailor the standard product line bus to meet the customer's specifications. These options may include items such as air conditioning, seat choices, fare boxes, radios and paint colors, to name a few. The transit agency may choose to install some of these items themselves; for example, the agency may want to reuse its fare boxes or radios. The transit agency may also choose to give the items for reuse to the vendor for integration into the bus. As with the standard product lines, the vendor's costs for these options as well as the procedures and costs for their installation should be fairly well known.

5.2.3 Non-Standard Options

Specifications from many transit agencies are not performance-based; that is, they do not specify the desired end performance. Instead, many agencies specify by component description with an "or equal" statement. If the vendor has not used the component and/or the component supplier before, or if a new model is specified, then the vendor must:

- Establish ties with the vendor;

- Perform engineering analysis to define how the component will be mechanically and electrically integrated with the bus;
- Define new procedures to be followed on the factory floor for assembly; and
- Define the testing necessary to ensure that the component is properly integrated into the bus.

In some cases, these non-standard options may impact the standard vehicle design. For example, the electric power needs of the new components may require the vendor to upgrade the electrical system capacity; or new cabling may be needed to handle the unique needs.

These non-standard options will cost the vendor money and time that will be passed on to the transit agency as an increased cost per bus and possibly longer delivery time. If the transit agency is acquiring 500 buses, the per-bus cost will probably be small; if the agency is acquiring five buses, then the cost per bus may be substantial.

5.2.4 Custom Designs

If the transit agency customer requests changes that impact a vendor's standard transit vehicle product line design, then the transit agency customer should expect one of two replies:

- No bid
- Substantially higher price per vehicle

These are changes that will impact the vendor's basic assembly operation, and may require a different assembly and manufacturing procedure, fabrication of new parts, acquisition of different parts from new suppliers, new engineering drawings for the basic vehicle, and new testing procedures. It may also involve a new engineering discipline for the design team (for example, expecting a bus manufacturer to produce an electric trolley bus). Depending on the changes, the new design may also trigger re-testing of the vehicle at the Altoona facility.

Depending on the vendor, custom designs could include the following:

- Unique length or width
- Curved sides and/or windows to give a less box-like appearance
- New power source (e.g., electric trolleys or fuel cells)

Customized designs can be very expensive, both in terms of money and time. In some cases, a U.S. vendor may be able to reach an agreement with a non-U.S. supplier that has a design that meets the requirements; but even then, approaches for manufacturing, assembly, testing and shipping must be developed. Most likely these are costs that the vendor will want to write off across a large bus order unless the vendor feels that there is sufficient market for the design so that they are willing to cover some of the costs as new product design.

5.3 Electronics Integration

The number of electronic components that transit vehicle vendors are expected to install and integrate has grown substantially in the past few years. This is not a BRT-unique occurrence and BRT vehicles will probably increase the need for more electronics integration as more ITS features are specified by transit agencies.

As the number of electronic components has increased, integration of these components has become a major problem for transit vehicle vendors. Integration problems faced by the vendors include equipment furnished by the transit agency customer that is obsolete and no longer is compatible with new versions, and AVL systems that cannot interact with radio systems and/or messaging systems.

Some of the component suppliers solve these problems by offering complete electronics systems. However, transit agencies that specify by-vendor and by-component may undermine this potential integration strategy. Consequently, the transit vehicle vendors are left with the problem of electronic component integration. This can be a costly and difficult role for some transit vehicle vendors. Examples of components that may need to be integrated, today and in the future, include:

- AVL systems
- Mobile data computers
- Radio systems
- Fare collection systems
- Messaging systems
- Voice annunciation systems
- Precision docking systems—sensors and actuators for vehicle steering, brakes and engine control
- Automated lateral control—sensors and actuators for vehicle steering, brakes and engine control
- Collision avoidance sensing and control

Some of the bus vendors are using multiplexing or local area networks (LANs) for their own bus wiring. For example, the multiplexed signals may be available for engine speed, transmission, brake system, etc. Unfortunately, there is no standard multiplex or LAN protocol being used by both the bus vendors and/or the component suppliers. Consequently, integration is difficult. An industry standard could greatly simplify the problem.

5.4 ALTOONA BUS TESTING

The FTA Bus Testing program was established in 1989 in response to legislation included in the Surface Transportation and Uniform Relocation Assistance Act (STURAA). This legislation requires all new and modified bus models to be tested before being purchased with Federal funds. The program promotes the production of better transit vehicles and components, and to ensure that FTA customers purchase safe vehicles able to withstand the rigors of transit service. FTA pays for 80-percent of the cost of testing, with the manufacturer or transit agency paying for the remaining 20-percent. The Pennsylvania Transportation Institute (PTI) operates and maintains the Altoona Bus Research and Testing Facility on behalf of FTA.

BRT vehicle and technologies may present new challenges with respect to bus testing requirements. Some of the concerns and issues BRT vehicles raise regarding testing are similar to those raised for all buses.

One concern expressed by manufacturers is the expense related to bus testing, particularly for highly specialized vehicles where the number of vehicles deployed is relatively low. However, considering the potentially high costs of some specialized BRT vehicles, testing can minimize the risk to the transit agency of utilizing a bus model that has not yet been proven in the rigors of transit service.

Adjustments to current procedures may also need to be developed to accommodate BRT vehicles with designs that are significantly different than traditional transit buses. Vehicles with extremely low ground clearance, or a long wheel base with low breakover angles may not be able to clear certain features on the current durability track.

PTI is currently examining new procedures that would replicate the BRT environment more accurately than the current durability test track. For example, BRT vehicles, particularly in express BRT service, may operate on smoother roadways, and at higher speed than traditional transit buses. Use of simulation tools in testing may offer some potential advantages.

Currently, most buses are tested at Altoona before any ITS technologies are incorporated on the vehicle. Some of these technologies, while enhancements to more traditional buses, are critical to the effective operation of BRT systems, such as precision docking and lane assist technologies.

It is not well known how operation in the harsh environment of a transit vehicle would effect the operability of some of these key vehicle features. Incorporating these critical technologies on the vehicle prior to Altoona testing would enable testing of the components in operation on the vehicle, and provide an indication of their reliability and durability in transit service.

5.5 BUY AMERICA PROVISIONS

FTA's general requirements concerning domestic preference for the procurement of manufactured products are set forth in 49 U.S.C. Section 5323(j). This section provides that all rolling stock (including buses and BRT vehicles) procured with FTA funds must have more than 60 percent of the cost of all components produced in the United States and final assembly in the United States.

Often BRT system image and operability are closely linked to the BRT vehicle. Since the U.S. market for these vehicles is just now emerging, some of these highly specialized vehicles may not be available from U.S. manufacturers. In some instances, transit agencies planning to implement BRT systems are finding, through their competitive procurement process, that no U.S. manufacturer was able to supply the BRT vehicles they had specified. In those cases where there was no U.S. manufacturer that could meet the vehicle requirement specified, Buy America issues needed to be addressed before contract award could be made.

5.6 POTENTIAL PROCUREMENT STRATEGIES

Considering the issues involved in acquiring BRT vehicles, strategies can be pursued by transit agencies that can potentially simplify, or reduce the costs of procuring BRT vehicles. Not all strategies are applicable to all agencies; and for some agencies there are other factors such as compatibility with their existing procurement procedures that may limit the transit agency's ability to utilize new procurement strategies. Some potential procurement strategies include:

1. Define vehicle specifications that are performance-based, versus specifications that require specific components and suppliers with "or equal" clauses. (If the buses in the agency's fleet already use particular components, then the strategy may need to be examined). For example, specifying the conditions under which the bus must operate to avoid overheating as opposed to the specific type and manufacturer of the radiator. This approach allows the vehicle manufacturer to determine how to best meet the required performance attributes of the vehicle, at the most reasonable cost.
2. Consider relevant vehicle priorities in terms of the overall phased BRT implementation plan. For example, if platforms requiring precision docking are not going to be installed for six more years, perhaps less expensive buses could be acquired now, and could be upgraded if and when the platforms are installed.

3. Specify vehicles that meet the system requirements, and possibly surpass them. This may involve prioritizing which vehicle attributes are critical and which are desirable, but not essential to meet the BRT system goals. Successful procurements may involve compromising on less critical attributes.
4. For smaller agencies in particular, consider teaming with other transit agencies so that the per bus cost of unique requirements may be distributed across more vehicles.
5. Consider the need for standardization of BRT characteristics or vehicles. If the vehicle vendors know that transit agencies consider certain vehicle feature to be “standard” or “core”, then the cost of those features will most likely come down.

6.0 Summary

The outlook for BRT systems is promising. Already there are seventeen communities in the U.S. that have an interest in implementing a BRT system right now. The innovations developed and demonstrated in BRT systems will not stay within the umbrella of BRT, but instead improve all types of bus service. Therefore, BRT could lead to raising the quality of all types of transit services.

Before innovations in BRT systems can be applied, there are some issues that must be addressed. First, the definition of both a BRT system and BRT vehicle need to be agreed upon. This report has attempted to address both of these definitions. BRT systems will not be the same from agency to agency. In fact, each system will be unique because of the community in which it is built and the roadway where it is operated. Also, a single BRT vehicle cannot be designed to meet the needs of each agency. In other words, one size does not fit all. Table 4-1, Detailed Implications for BRT Vehicles, provides a concise summary of BRT vehicle impacts as a result of the BRT system characteristics.

Second, the commercial availability of BRT vehicles will need to be enlarged. Already there is support and interest from U.S. bus manufacturers in designing and marketing BRT vehicles. However, there may still be concern among transit agencies regarding Buy America provisions restircting their choice in vehicle design and attributes. Third, ITS technologies will be an integral part of any BRT system and the need for integrating these technologies onto a BRT vehicle will only increase. Finally, bus testing issues related to BRT vehicles will need to be addressed to effectively deploy new BRT vehicles.

The U.S. can be a leader in wide-scale implementation of quality BRT systems that push the boundaries of vehicle design, environmental impact and technological development. The BRT vehicle can be a platform for innovative bus technologies—vehicles based upon a common platform but able to accommodate the individual needs of communities.

Appendix A: Results of Transit Agency Visits

1. **Alameda Contra Costa Transit**
2. **Port Authority of Allegheny County**
3. **Charlotte Area transit System**
4. **Greater Cleveland Regional Transit Authority**
5. **Connecticut Department of Transportation**
6. **Lane Transit District**
7. **Los Angeles Metropolitan Transit Authority**
8. **Massachusetts Bay Transportation Authority**
9. **Valley Transportation Authority**

ALAMEDA CONTRA COSTA TRANSIT (AC TRANSIT)

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BRT Project Information

The agency serves Alameda and Contra Costa Counties, which includes the cities of Oakland and Berkeley. The BRT project is on the number 72, and 72 Limited lines, which operate along San Pablo Ave extending from Oakland through Berkeley and four other cities to Richmond. The corridor is being improved as part of an overall Congestion Management Agency plan to make the corridor more livable; ACT has responsibility for the transit portion of the plan. There are a total of 15 agencies and 7 cities involved in the upgrade.

New buses have been ordered and are being delivered, but only limited funds ($3 million) are currently available for BRT features on top of the new buses; therefore, BRT features will need to be added incrementally. A large portion of San Pablo Avenue is a state highway, so cooperation with CALTRANS on issues such as signal prioritization is required.

Overall Service Characteristics

The BRT service will start with the 72 Limited service. This existing service has 23 stops along 9 mile limited stop section on a 17-mile four-lane arterial, with 20-minute headways. AC Transit anticipates that the BRT limited service will have fewer stops and operate on more frequent headways.

The new buses are low floor clean diesel-powered, painted a distinguishing green. The service will include easily identified bus stops and AVL for “Next Bus” signs at the stops.

Currently the line has 15,000 rides per day; it is hoped that BRT will increase that by 25 percent.

Specifics of Roadway Operation Characteristics

The route of operation is an existing four-lane arterial that is to be repaved as part of its renovation.

AC Transit hopes to work with CALTRANS and city governments to make queue-jumping lanes part of the street renovation; however, this may be difficult at some of the more congested intersections such as the one with University Avenue in Berkeley.

The signals along the route are being coordinated by CALTRANS. Initially, there will be no bus signal prioritization; however, plans are for there to be signal priority in the future where it is feasible. Far side stops are being examined as well.

Specifics of Managed Operations Characteristics

Buses will have GPS-based AVL, with bus locations transmitted via radio to a control center. The AVL may or may not provide on-board annunciation of “Next Stop”, but will provide input to the “Next Bus” style information display at the special 72 Limited stops.

Buses will have passenger counters.

Specifics of Rapid Loading/Unloading Characteristics

Low floor buses with entry and exit from existing curb heights is planned. Wheel chairs will have access via deployable wheel chair ramps. Rear door entry, made possible by proof of payment fare collection, is anticipated.

Specifics of Rapid Fare Collection Characteristics

Fare collection will be exact change with passes and pre-purchased tickets. Fare verification will be through proof-of-payment and pre-purchased fare media will be encouraged.

Specifics of System Image Characteristics

The BRT service is distinguished from normal bus operations by:

- Reduced travel times
- Articulated low floor buses
- Unique colors for buses
- Unique bus stops that include shelters, kiosks, phones, trees and lighting
- “Next Bus” information displays
- Transit priority (assuming other relevant agencies agree)
- Proof-of-payment fare collection

Specifics of Low Emissions Characteristics

Their vehicles are clean diesel powered.

Specifics Desired Characteristics

Many of the specified BRT characteristics for the project are in the “desired” category rather than firm design decisions. These include the following:

- Bus-only lanes in key locations including queue jumper lanes
- Signal priority, possibly with far-side stops

PORT AUTHORITY OF ALLEGHENY COUNTY

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BRT Project Information

The Port Authority's BRT system basically consists of three dedicated transit lanes/corridors, or "busways". Two of the three busways have been in existence for several years. They are the East Line to Wilkinsburg (28,000 passengers per day) and the South Line to Glenbury (13,000 passengers per day). The West Line to Carnegie is still under development, but is to go in service in September 2000. The cost for the five mile long West Line is $276 million, about $50 million less than originally projected. It is built on existing railroad right-of-way, but substantial upgrading was required including expansion of a single lane train tunnel into a two-lane busway.

In all cases, they have built their busways on existing right-of-ways

Overall Service Characteristics

The Port Authority primarily serves Allegheny County, which has a population of about 1.3 million, although some services extend beyond the county border by agreements with surrounding counties. Its buses and trolleys handle 260,000 trips a day; it is expected that over 50,000 of those trips will be on busways once the West Line opens.

There are three busways in the system. Each terminates at a station where local buses allow riders to continue their trip into the neighborhoods. There are also stops and ramps along the busways that allow flexibility in accessing the busways. This flexibility allows the busways to provide connectivity to local buses and other transportation modes (pedestrians, bike riders, trolleys, rail station, and the intercity bus station). Plans are for parking lots at busway stops along the new West Line. The busways terminate downtown where they follow a small loop to drop off arriving passengers and pick up new passengers.

There are two types of bus service on the busways:

1. Busway buses that travel only on the busways and stop only at the infrequent busway stops—there were five stops on the East Line. There were both "local" busway buses—they stop at each busway stop—and "express" buses—they stop only at the terminus stop and the downtown stops.
2. Local buses that collect and distribute passengers in neighborhoods, but then use the busways for direct access to downtown stops. Generally, these local neighborhood buses do not stop at the busway stops—only at the downtown loop stops.

Since the busways do not require any special equipment or operating characteristics, then regular buses can be used for the BRT service. This flexibility allows the Port Authority to configure the bus routes to best provide service to its customers.

Even though the maximum speed is only 50 mph, at rush hour buses from the Wilkensburg terminus can be in the center of downtown in 14 minutes, even on the local busway bus. Drivers on the parallel I-376 are facing a 45-minute trip.

Roadway Operation Characteristics

Three dedicated busways, each with occasional passenger stops and ramps. Most local neighborhood buses operate in the neighborhoods and drop off passengers destined for center city at the busway terminus or at one of the busway stops. Some local neighborhood buses—those with center-city passengers only--enter the busway and travel downtown to let their passengers off at the downtown loop stops.

The West Line busway does not extend into the downtown area, so the buses must operate for a mile or so on a relatively lightly used corridor. There is no signal preemption, although there will be signal priority since the cross-streets are mostly for shoppers entering and leaving a shopping area.

One local neighborhood bus goes downtown from the north side on an HOV lane along with other HOV traffic. Again, there are no priorities or preemptions for the bus traffic.

There are a few contra-flow lanes in Pittsburgh, but they are not part of the BRT system. The one in Oakland is contra to three lanes of one way traffic; apparently there are occasional incidents on this contra-lane since it is not obvious to first-time pedestrians or drivers that the lane is contra.

Managed Operations Characteristics

The local neighborhood buses can be timed to arrive at the busway so that passengers need to wait only a few minutes before the next busway bus departs. The service has maximum flexibility because any bus type can be used on the busways. No special equipment is required; however, the drivers must be trained on how to drive the busway.

There is no real time operations management system, no AVL and no Next Bus signage.

Rapid Loading/Unloading Characteristics

The busway buses are low-floor articulated buses. The low floor encourages faster loading and unloading. The articulation allows buses with larger capacity to maneuver while operating in the downtown loop area. There are no platforms since not all buses are the same height, and there has not been an apparent need for platforms. Wheel chairs are loaded using extendable ramps. The bus doors are normal.

Rapid Fare Collection Characteristics

The buses require exact change cash. However, the large majority of rush hour riders are familiar with the requirement. They have these options:

- Passes
- Pre-purchased roll of tickets
- Exact change

The bus system has zones. For the most part, the patrons are honest and the driver keeps track of those that may cheat. For example, at rush hour, most passengers are going downtown. The passenger that says they are only traveling within the first zone will stand out.

Because the busway express buses and local neighborhood buses do not need to stop at the local busway stops, these buses can by-pass these stops and the local busway buses that collect fares from the passengers there.

System Image Characteristics

The BRT system is distinguished from other Pittsburgh bus systems by the busways, even though some "regular" buses can use the busways, and by the use of articulated buses for express busway service.

The Pittsburgh busways, particularly the East and West Lines, are attractive and have the appearance of rail or light rail. The busway buses are low floor and articulated; the other buses are unabashedly buses. Because of the good service, the BRT has high usage by the Allegheny county residents; the acceptance of the system is reflected by the fact that the county has been able to fund the BRT expansion.

Emissions Characteristics

All of the buses are diesel.

Additional Desired Characteristics

When asked what features the Port Authority would like to add to their BRT system if they had the funding, the following was the priority:

1. AVL for fleet management and wait-time notification
2. Low emissions—the cost of new alternative fuel buses is significantly higher
3. Customer amenities—features to make using the buses easier and more pleasant; specifics mentioned included more park and ride lots and better inter-modal connections
4. We discussed the value of stored value cards, particularly in a zone fare system. Their feeling was that this is not a big need; it is not obvious how an investment in a more sophisticated fare collection system would pay for itself since bus loading time does not seem to be a big issue for the Port Authority.

Charlotte Area Transit System

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BRT Project Information

Charlotte has existing bus service and has been upgrading the service with enhancements such as AVL, automatic voice annunciators and passenger counters.

The current BRT service explicitly applies to express buses operating on a 2.6 mile an HOV lane on Independence Blvd. that is temporarily dedicated to the BRT service. The HOV service will not be offered to the public until 2005. At the bus express lane's eastern terminus, a queue-jumper signal allows the bus to avoid a recurring traffic backup upon leaving the HOV lane and entering mixed-traffic operation.

A Major Investment Study is currently underway in the Independence (Southeast) Corridor. A decision on technology and alignment should be adopted in early 2002 along with an implementation schedule.

Overall Service Characteristics

The Metropolitan Transit Commission serves a county-wide population of 650,000. A 0.5 percent sales tax was initiated in 1999; this tax will contribute about $55 million annually to the operating and capital budget. The existing service includes local, express, and regional commuter bus service and para-transit. In addition to the initial BRT service, an 11.5-mile light rail project in the South Corridor is currently in Preliminary Engineering. Also, Major Investment Studies are underway in four major transit corridors including the Independence Corridor. BRT is a technology being considered for all four corridors.

Specifics of Roadway Operation Characteristics

One 2.5 mile long HOV lane that is temporarily dedicated to express bus service; that is, there are no stops along the 2.5 miles. The HOV lanes are in the center of Independence Boulevard. The service also includes a queue-jumper lane on the HOV lane's eastern terminus, which allows the express buses to avoid a significant evening traffic jam. The express bus lanes will be maintained during construction and extended during the upcoming phase of the Independence Freeway project. The project will extend the HOV/bus express lanes an additional 1.1 miles.

Specifics of Managed Operations Characteristics

Route-scheduling software has been purchased, and AVL will be put on some of the buses. This will allow real-time tracking of buses along the routes in 18 months. Buses are equipped with silent alarms and digital video. Fixed time departure and arrival scheduling is used for bus schedules.

Specifics of Rapid Loading/Unloading Characteristics

Charlotte operates low-floor buses in the city center to enable easier and faster loading and unloading. Buses have two doors of normal size. BRT busways will likely have a mixture of low floor, regular floor, and inter-city style buses operating on them. Wheel chairs are accommodated with flip-out ramps on the low floor model buses.

Specifics of Rapid Fare Collection Characteristics

Charlotte has a stored value card they are using in their system. About 40 percent of the peak period riders are using the stored value cards. Passes are also accepted as is exact change.

Specifics of System Image Characteristics

The BRT service is distinguished from normal bus operations by the dedicated busways with associated travel time savings and on-line stations which offer a more rail-like image. Time of next arrival will also be available at these stations, and on-board annunciations will announce the next stop for riders.

There is no special bus image. Long distance express bus service is using inter-city types of buses for rider comfort. Express service on today's Independence Boulevard corridor is both low floor and regular floor buses.

Specifics of Low Emissions Characteristics

North Carolina has mandated that 50 percent of all new bus purchases must be for light chassis designs. The new clean diesel engines meet North Carolina emissions requirements; however, they have borrowed a hybrid vehicle from New York City to test.

Specifics of Desired Characteristics

Their desired characteristics are expressed in their interim and long range plans.

GREATER CLEVELAND REGIONAL TRANSIT AUTHORITY

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BRT Project Information

The Euclid Corridor Transportation Project will provide more efficient transit service between downtown Cleveland and the University Circle area, Greater Cleveland's two largest employment centers. The 7-mile corridor includes Euclid Avenue between Public Square and the Stokes Rapid Transit Station in the City of East Cleveland. Building face to building face reconstruction is planned. Sidewalks along Euclid Avenue in the City of Cleveland will be rebuilt, and a utility chase will be installed next to the curb for all overhead power and traffic signal lines. Euclid Avenue will be reconstructed with an exclusive busway on either side of a center landscaped median. The project also includes a downtown transit zone to better distribute bus and auto traffic throughout the downtown area. The construction along the 7-mile corridor and transit zone is expected to take four years and cost approximately $220 million, including $1.2 million for each of 30 vehicles. There continues to be a tremendous amount of public involvement in the planning and design of the Euclid Corridor Transportation Project. From the very start, community groups and elected officials made suggestions as to how they wanted the transportation improvement to operate and to complement ongoing land redevelopment.

Overall Service Characteristics

The plan is to run 60 foot, articulated diesel-electric buses along a dedicated busway on Euclid Avenue. There are three segments to the Euclid Corridor Transportation Project (heading east along Euclid Avenue):

- Public Square to East 17th Street: Center Platform stations in the median of Euclid Avenue using only left-side boarding diesel-electric vehicles.
- East 17th Street to East 107th Street: Center Platform stations in the median of Euclid Avenue using both diesel-electric and other GCRTA right side boarding vehicles that have routes on this section of Euclid Avenue. All vehicles travel along the center median. At intersections where stations are located, the median shifts slightly and the buses cross the intersection at a slight diagonal so that the buses can load and unload on the right side.
- East 107 th Street to Stokes Rapid Transit Station: Curbside Stations in mixed traffic on the right side of either direction using both diesel-electric and other GCRTA vehicles.

Specifics of Roadway Operation Characteristics

The BRT vehicles will operate in dedicated lanes along the center of the street for two-thirds of the route and in mixed traffic in the right-side curb lanes for one-third of the route. In the transit zone, regular motor coaches will operate in dedicated curbside and/or peak hour reserved lanes.

The GCRTA is in the process of procuring transit vehicles for the Euclid Corridor Transportation Improvement Project. This project has been selected as part of FTA's Bus Rapid Transit (BRT) Demonstration Program. GCRTA identified four requirements for their proposed BRT vehicle. These requirements include:

- Left- and Right-Side Doors—Left- and right-side operational doors are needed to accommodate both curbside (right-side doors) and center platform stations (left-side doors).
- Low-Floor—The vehicles will permit easy passenger loading and unloading.
- 60 Foot Articulated—The vehicle must be able to accommodate the expected demand. This will be accomplished through an articulated vehicle that includes a full bus in the front and a half-bus in the rear connected through an accordion-like enclosure.

Specifics of Managed Operations Characteristics

The vehicles will utilize a GPS/AVL system to help manage their operations. The details of how this will work are being explored under a separate effort outside of the BRT project that will include other agency vehicles as well. A new bus communications system is currently being installed on GCRTA buses and will be available for use on the Euclid Corridor BRT vehicles.

Specifics of Rapid Loading/Unloading Characteristics

The buses will utilize both left and right-side doors to accommodate unloading and loading of passengers at both center and curbside platform stations. The right side of the vehicle will have three wide doors and the left side will have two.

Specifics of Rapid Fare Collection Characteristics

The payment system will not be vehicle-based, but will include off-bus fare collection. A proof-of-payment system is being considered.

Specifics of System Image Characteristics

The system is part of a larger urban revitalization project for Euclid Avenue being undertaken by several local development groups.

Specifics of Low Emissions Characteristics

The vehicle will have clean diesel/electric propulsion.

Specifics Desired Characteristics

No additional characteristics were discussed. However, the current system design incorporates many characteristics of BRT.

CONNECTICUT DEPARTMENT OF TRANSPORTATION

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BRT Project Information

The Hartford, Connecticut BRT project was selected to be the best alternative among a host of alternatives that was studied as part of the I-84 Corridor Study. The BRT alternative predicted to be a better trip generator with more ridership at half the cost of light-rail. Other alternatives studied included addition of an HOV lane, highway widening, heavy-rail and light rail. It was the Connecticut Department of Transportation that chose the BRT alternative, not a transit agency.

The BRT project will utilize a busway to be built parallel to an already existing freight rail right-of-way and abandoned right-of-way. Preliminary station locations have been identified; however, the final location will be determined closer to construction.

Overall Service Characteristics

The busway will provide a convenient avenue for a number of transit vehicles to bypass congestion. The BRT service along the busway will provide end-to-end service between Downtown New Britain and Union Station in the CBD of Hartford. Headway and running times have not been identified. Other transit services that will use the busway include community routes, long distance express service, and feeder buses. The BRT buses will not require unique design; rather, they will use options that are currently available from bus vendors.

Specifics of Roadway Operation Characteristics

The BRT busway will be constructed adjacent to existing AMTRAK right-of-way. There are currently some safety technical issues with barrier protection but these details will be worked out in the future. All of the land needed to construct the busway has been identified and is available for construction for the lower five miles of the corridor. However, details of whether the land will be leased or purchased for the upper five miles need to be ironed out. Stations will be off-set from one another and away from the busway so that non-BRT buses will not have to wait for buses at each station. There are currently three intersections that may need to have a grade separated interchange. These details will be worked out.

Specifics of Managed Operations Characteristics

There is currently an AVL study being conducted for improved management and communication among all agency vehicles. Whatever the results of the AVL study are, they will be applied to the BRT service. First and foremost, there needs to be a state-standard. The BRT service will not define the state-standard. As part of the AVL study, communication issues will also be addressed which will play a large role in managed operations and ITS technologies.

ITS technologies will include voice/visual information at stops and on the bus. Signal priority will be used at key intersections along the busway.

Specifics of Rapid Loading/Unloading Characteristics

The rapid loading and unloading of the BRT vehicles has not been fully addressed. Buses will be ordered with standard door, both the number and their width.

Specifics of Rapid Fare Collection Characteristics

The specifics of the fare collection system have not been finalized. Initial thoughts include reduced fare collection time using off-bus fare collection and proof-of-payment or the honor system. The system will not use controlled fare pay areas at the stations. Currently, 62 percent of the riders use some type of non-cash payment.

Specifics of System Image Characteristics

The BRT service is distinguished from normal bus operations by some element of "sexiness". They want the BRT service to be identified as rail-like. A new name for the service will be developed (i.e. CT Rapid, Blue Line). A logo will also be created. The stations will be outfitted with rider amenities.

Specifics of Low Emissions Characteristics

Buses will use conventional fuels, not alternative fuels. This leaves open the possibility of CNG or LPG powered buses if the respective fuels become more main-stream and seen less as an alternative. Electric vehicles or hybrids may be a possibility. However, electric/hybrid will not be a requirement.

Specifics Desired Characteristics

The utilization of IVI technologies was seen as a definite possibility. Since they will be marketing the service as rail-like, precision docking may useful as well as some type of guided bus technology. They would like to use articulated buses. However, the agency currently does not own or operate articulated buses.

LANE TRANSIT DISTRICT

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BRT Project Information

The LTD's BRT project will provide semi-express service between downtown Eugene and downtown Springfield, Oregon. The project is currently in the design and construction phase. The length of the demonstration is about 14 miles, to be constructed in three phases:

- Phase I: This is a four mile stretch on West 11th Street that will cost about $11 million; funding is in place; completion is estimated for late 2002
- Phases II and III: These phases total 10 miles; funding is not yet in place, and Phase III is still in the definition phase
- Long term (to 2020), up to 60 miles of BRT are envisioned for the area.

The transit agency has spent considerable effort working with the public to get their input on the BRT system; the system is viewed as a corridor improvement. As a result, much of the emphasis of the LTD system is on image, green space and low impact on residents and businesses. The system serves a population of about 200,000.

Ridership is projected at 8,000 trips daily for Phase I—a 40 percent rise from today; many of the riders will be college and high school students.

Overall Service Characteristics

The system will mostly consist of dedicated busway between the two downtown areas. The busways will have green media between the wheel tracks and there will be amenities such as parallel bike paths and lighting to give a pleasant parkway appearance to the infrastructure.

The plan is to have vehicles that are unique and look more rail-like. Buses will be low floor, and platforms will allow easier, rapid loading. Articulated buses are not a firm requirement. Noise level is a concern, so buses will not be diesel or CNG—maybe hybrid.

The buses and the stations will be readily identifiable, although each station will be unique to the neighborhood. Automated lateral control is a must since the busways are narrow and precision docking is required at platforms.

Specifics of Roadway Operation Characteristics

In most areas, there will be dedicated busways, one in each direction. The buses will operate on city streets in downtown; and in one location, the busway is one way, requiring "block control" similar to that used in train systems to avoid collision. In another section, the busway is on a public street, but the busway is raised an inch or two to distinguish it from the rest of the street. Other vehicles can cross over the busway to turn or to access businesses.

There will be bus-height platforms at each station. Left-side doors (as well as right-side doors) would be desirable (but not required) so that the platforms can be in the center between the two busways.

Signal priority is a must in those areas where the buses are operating on downtown streets or where the busway has crossing streets.

There will be parking lots at a few locations. The system will have stops near the inter-city bus terminal and Amtrak station; there will not be a stop at the airport. Neighborhood bus lines (collector/distributor) will intersect with the BRT system at many locations, allowing riders to easily reach the major BRT destinations from their local community.

Specifics of Managed Operations Characteristics

Buses will operate on fixed time schedules with scheduled arrival times at each stop. AVL is not a high priority for the LTD project. Central control center and “Next Bus” signage will come later. The silent alarm is part of the buses’ radio system.

Specifics of Rapid Loading/Unloading Characteristics

A major feature of the LTD system is platform loading. The stations will have platforms at bus floor height, and buses will have precision docking capability to allow them to pull within the required ADA distance (two or three inches?) so that wheelchairs can load directly onto and off of the buses.

The buses will have wider doors so that people can easily flow into the bus without climbing steps. The bus floor may be flat throughout the bus if the vehicle is electric powered.

All buses will be equipped with bike racks on the front. Ironically, with the station’s loading platforms, placing a bike in the bike rack will take longer.

Specifics of Rapid Fare Collection Characteristics

The system will be prepaid, fixed price throughout the system; cash will not be collected, and tickets will not be collected on the bus. It will be an honor system with proof of payment. The LTD planners do not believe this will be a problem; today, only 30 percent of their customers use exact change.

Specifics of System Image Characteristics

The BRT service is distinguished from normal bus operations by dedicated busways, unique system identification (signs, color) on buses and stations, loading platforms and bus design. The LTD people want a bus that looks rail-like, or at least not like the typical bus “shoebox” design. The BRT system is the centerpiece of the revitalization effort along the system’s corridor, so the vehicles must be attractive. How that is specified for bus vendors will need to be addressed.

Specifics of Low Emissions Characteristics

Buses will be either electric or hybrid, both for low emissions and for low noise.

Specifics Desired Characteristics

In the future, the system may implement AVL, and install “Next Bus” signage. A control Center may then be considered.

Los Angeles Metropolitan Transit Authority

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BRT Project Information

The current BRT effort demonstration (called "*Metro Rapid*") encompasses Ventura Boulevard corridor and the Whittier-Wilshire Boulevards corridor. The service is distinguished from the normal MTA bus service (as well as other bus company services) in these ways:

- Simple route layout
- Frequent service
- Headway-based schedules with free running time
- Less frequent stops
- Level boarding and exiting
- Color-coded buses and stops
- Bus signal priority at key intersections

The combination of these characteristics is expected to speed up bus service by 25 percent. Approximately $8-10 million will be spent by the MTA along with the LA Department of Transportation for the demonstration, excluding 100 new buses. The money is largely for a loop detection capability along the corridors that is tied into the local traffic signal controllers. This information is then transmitted to a control center that is able to provide some level of control and observation over the BRT fleet.

Overall Service Characteristics

Bus service in Los Angeles is confusing and disconnected. There are 18 separate bus companies in the Los Angeles area. Integration among the services is a problem. These are also new light rail and heavy rail lines. The MTA is working toward a plan to integrate the BRT, light rail and heavy rail services.

Specifics of Roadway Operation Characteristics

Service is along normal corridor roadways. Signal priority combined with reduced numbers of stops for the *Metro Rapid* buses provides faster service. The *Metro Rapid* service is all express bus service. That is, the buses only stop at selected stops every .7 or .8 miles. Local buses without the *Metro Rapid* markings also operate along the corridors and stop at all of the bus stops (approximately every .2 miles).

Specifics of Managed Operations Characteristics

The LA DOT developed the software that allows the BRT buses to be closely monitored. Transponders on the buses identify each bus as they pass over the newly installed loop detectors. This information is transmitted to the central control via the local signal controller. The information is displayed on large screens where the entire corridors are represented and the bus locations are shown.

Buses operate on a “free running time basis. Buses have a standard time for departing from each terminus; however, once on the corridor, they are not constrained by schedule; in fact, they are encouraged to move as quickly as possible along the route. If a bus in front of them is delayed, perhaps through a large group loading or because of a wheel chair loading, then the slower bus is passed. If a rider does not indicate that they want to exit at a station, and if no one is waiting at the station, it is passed.

Because the buses operate every five minutes or so, riders only need to wait a few minutes for service.

Specifics of Rapid Loading/Unloading Characteristics

The buses have two sets of doors that are the wider options offered by the bus vendors. The low floors allow a direct step from the curb into the bus and vice versa for both the front and back doors.

Specifics of Rapid Fare Collection Characteristics

Fare collection uses exact change (about 40 percent), passes and tokens. Since the service was instituted, the ridership has risen and changed; the peak period is now mid-day. Over the next few months, they will find out why this shift has occurred.

Specifics of System Image Characteristics

The *Metro Rapid* service is readily identified with a unique color and emblem on both the buses and the stations. A special station was designed that does not take away much sidewalk space but still gives the feel of a safe, secure station.

The buses look somewhat unique because of the low floor and the CNG tank on top of it. They are not rail like.

Specifics of Low Emissions Characteristics

The buses use compressed natural gas (CNG) for their fuel.

Specifics Desired Characteristics

Next Bus Coming signing at the stations is at the top of their desired characteristics. A stored value or deducted value fare card good for all of their transit services is also desired. Dedicated lanes, while desirable, is not feasible along the corridors chosen, but may be an option for other corridors.

MASSACHUSETTS BAY TRANSPORTATION AUTHORITY

Contact Information

Richard J. Daley, Jr.
Director of Bus Operations
Massachusetts Bay Transportation Authority (MBTA)
45 High Street
Boston, Massachusetts
617-222-5491

BRT Project Information

The BRT system is termed the Silver Line to distinguish it from the other Boston rail transit lines. It consists of three sections:

- Section B: This 2.5 mile long section is to be the first Silver Line segment to be opened in late 2002. It will be a surface line along Washington Street between Dudley Station and New England Medical Center, with bus-specific lanes. CNG vehicles will be used. Construction is to begin "next week.
- Section A: This segment is the second portion of the Silver Line to be opened in late 2003; it includes a 1.1 mile long tunnel. It is to connect the Logan Field (Boston's airport) with South Station in downtown using "trackless trolley" buses with hybrid diesel power. CNG vehicles cannot be used in the tunnel. Construction of this segment is underway as part of the "big dig" in Boston.
- Section C: This last section to be constructed will connect the New England Medical Center to South Station via tunnel; it will use trackless trolleys. This short segment is not funded as yet, but completion is currently planned for 2008 –2010.
- Eventually the Silver Line may offer a one-seat ride from Dudley Station to Logan Field. For that to happen, the CNG vehicles on Washington Street would need to be replaced with trackless trolleys.

The MBTA is currently pursuing a joint acquisition for trackless trolleys with Cleveland, Ohio. Those 30 vehicles will be used to replace 27 existing bus trolleys on a non-BRT line in Cambridge.

Overall Service Characteristics

Section B will use 44 low floor articulated CNG buses to operate along Washington Street where an elevated train, whose tracks have been torn down, had operated. At the time of bus procurement, only one vendor offered articulated CNG buses—Neo Plan. Volvo now claims to also have an articulated CNG bus. The Massachusetts Bay Transportation Authority plans on completely redesigning the Washington Street corridor as part of the corridor's revitalization. A semi-dedicated bus lane along most of the corridor is part of the redesign; it will be on the right side of the street. Only buses are to use the lane except for vehicles turning right or accessing a parking spot. Special Silver Line stations will be located on curb "bump-outs".

Section A will have an underground terminus at South Station and will primarily operate in the Ted Williams tunnel to access Logan Airfield. Thirty two dual mode electric trolley buses with diesel engines will operate on this Silver Line segment.

Specifics of Roadway Operation Characteristics

Section B BRT roadway will primarily consist of a semi-dedicated bus lane on the right-hand side of Washington Street. In some narrow sections the buses will need to share the roadway with other vehicles, and vehicles turning right and/or accessing parking spots will be allowed to use the bus lane. Entry to and exit from the buses will be from normal curbs, not platforms. The stops have been reduced to every half mile to help speed up service.

Section A BRT will consist mostly of an underground dedicated BRT roadway between South Station and Logan Airfield. Entry to and exit from the buses will be from normal curbs, not platforms.

Links to Amtrak and to the Boston subway are provided at South Station, to the airport at Logan Airfield, and to various bus connector routes along Washington Street.

Total ridership for all three segments of the Silver Line is projected at 60,000 rides per day—16,000 on Washington Street corridor, 30,000 on the Logan Airfield segment, and an additional 14,000 when Segment C is open to connect the other two segments.

Specifics of Managed Operations Characteristics

The existing central control center for other MBTA systems will be augmented to provide real time central tracking of the BRT Silver Line and its vehicles. A GPS-based AVL system with information will be used to locate each bus, and the CDPD radio system will transmit the information to the central control facility. The bus location information will also be used to provide "Next Stop" information for bus riders, and "Next Bus" information to kiosks located in some of the Silver Line stations.

Specifics of Rapid Loading/Unloading Characteristics

Buses are low floor design with loading from normal height curbs. Wheel chairs are accommodated using wheel chair ramps which can generally be deployed in 20 seconds or so.

Specifics of Rapid Fare Collection Characteristics

Fare collection today is on-bus exact change, monthly passes and flash passes for visitors. Their plan is to go to magnetic stripe ticketing with card readers on the buses. Underground, fare collection will be on the mezzanines with proof of payment for on-board verification.

Specifics of System Image Characteristics

The BRT service is distinguished from normal bus operations by color (silver), the bus style (low floor, articulated) and by the design of the unique curbside stations, even though other non-BRT buses will be allowed to use these stations on the Washington corridor.

Specifics of Low Emissions Characteristics

Section B, the Washington Street corridor, will use CNG vehicles. Sections A and C will use hybrid electric-catenary and diesel vehicles.

Specifics Desired Characteristics

Completion of Section C, automated fare collection and one-seat ride from the terminus of the Silver Line to Logan Airfield seem to be the MBTA's three most desired future features for BRT.

VALLEY TRANSPORTATION AUTHORITY

Contact Information

Jim Lighbody, Planning and Development Division
Sandy Nichols, Consultant
Valley Transportation Authority (VTA)
3331 North First Street
San Jose, California
408-321-5744

BRT Project Information

The VTA is upgrading its service along El Camino Real highway by adding some new features to the route. Today, travel from one end to the other on the 27 mile long route takes about 2.5 hours. The route has 24 hour local bus service with 117 stops (about every .2 mile). There is also an express bus service on the route with stops at only key locations; it runs every 15 minutes during peak periods. There are 25,000 rides per day on the route. Up to 95 percent of the people that live in Santa Clara County also work in the county; however, there are a lot of people from other counties that commute into Santa Clara.

The VTA plan is to upgrade the local service with new buses; they will continue to operate the express bus service with existing buses. They estimate about $8 million for the initial infrastructure upgrade; most of the funding is lined up. Upgrades will be completed by late 2002.

El Camino Real is a state highway that goes through several small cities, so the VTA must cooperate with CALTRANS for traffic signals and loops in the pavement. The addition of queue-jumper lanes requires full cooperation of each individual city. Businesses along El Camino Real are concerned about loosing parking spaces in front of their stores. In total, there are 27 different bus operator companies in the area as well as light and heavy rail systems.

Overall Service Characteristics

The new VTA system will consist of 40 new low floor, articulated diesel buses operating along El Camino Real Boulevard between San Jose and Palo Alto, California. The new buses will be added to the local bus service, not the express service, and queue-jumper lanes will be added at key intersections where possible. This bus route is seen as supplementing the existing light and heavy rail services in the county.

Specifics of Roadway Operation Characteristics

Existing roadway will be used. In a few key locations, queue-jumper lanes will be added. For the most part, this will not require acquisition of new land since El Camino Real is six to eight lanes and the queue-jumper lane can be squeezed out the existing roadway. Loop detectors will be installed in the queue-jumper lane, and the traffic light will be modified to give the initial signal to the bus lane only.

Specifics of Managed Operations Characteristics

A new radio system is being procured that includes AVL, passenger counters, "Next Stop" signage on the buses, messaging to the driver, and fixed messages from the driver. The AVL will tie to the central control center. They are looking at having buses represented on a map like in Los Angeles. The system has its own radio channel.

The buses currently have silent alarm capability with their radios. They are starting to install cameras, but pictures will not be transmitted to central control.

Buses use fixed time headway control. The new system will not include new stations or stops.

Specifics of Rapid Loading/Unloading Characteristics

The new buses will be low floor to help speed up loading and unloading. Wheelchairs will be accommodated using wheelchair ramps on the new vehicles.

Specifics of Rapid Fare Collection Characteristics

Fare collection will not change. Buses will require exact change or passes, although the fare boxes are being replaced. The VTA is part of a regional *Smart Card* demonstration program next year.

Specifics of System Image Characteristics

The BRT service is distinguished from normal bus operations by the new buses and the queue-jumping lanes. There will be no special symbols or colors to distinguish the service, and bus stops will not change. The existing express bus service will not be part of the new service; just the local service.

Specifics of Low Emissions Characteristics

Clean diesel engines will be used in the new buses. Someday VTA will consider fuel cells when they are practical.

Specifics Desired Characteristics

No advanced plans have been prepared for a BRT system. Further upgrades to the current system may include the following:

- Signal priority is the most important
- "Next Stop" signage
- New stops

Appendix B: FTA BRT Questionnaire

This Questionnaire was used in the interviews with the transit agencies in Appendix A.

DATE OF INTERVIEW:

1. TRANSIT AGENCY INTERVIEWED:
   Agency Name:

   Address:

   Phone Numbers:

   Individuals Interviewed:

   FTA/Mitretek Interviewers:

2. BRT PROJECT INFORMATION:

Project Name:

Chief Engineer:

Projected Schedule:	2000	2001	2002	2003
Engineering				
Contract Issuance				
First Delivery				
Other Key Dates				
Projected Costs:				
Current Funding Status:				

Number of Contracts Issued to Date:

3. OVERALL SERVICE CHARACTERISTICS:

Population of Serviced Area?

Overall description of current transit system.

Current transit rider-ship (bus, light rail, heavy rail)

MODE	ANNUAL RIDERSHIP	PERCENT CHANGE (+/-)
Transit Bus		
Light rail		
Heavy rail		
Trolleys		
Other		

How will the BRT system affect you current system?

Overall concept of operations for new system.

Are there dedicated lanes/roadways?
Is there more than one type of vehicle;
- Express vehicle
- Downtown shuttle
- Other?

Are there terminations with;
- Parking
- Connections to local buses
- Connections to rail or trolley?
- Pedestrian/bike traffic only?

How are the vehicles powered?
What are the fare collection procedures?
How are wheelchairs accommodated:
- Raised platforms
- Low floor vehicles with extendable ramps to the curb

Other?

4. SPECIFICS - ROADWAY OPERATIONS:

NO.	ROADWAY TYPE	EXPRESS VEH.	SHUTTLE VEH.	LOCAL VEH.
4.1	Dedicated Lanes? Auto. lateral control for narrow lanes? Platforms for loading? Increased power/accel.? Top speed? Frontal collision avoid? Hi spd. crash worthy? Auto. lateral control? Lane use by other vehic?			
4.2	Semi-Dedicated Lanes in Center City (e.g., share with tram?) Lane location? Platforms for loading? - Center? Side? Articulated? Auto. lateral control?			
4.3	Expressway Operations: HOV lane operation? Toll plaza by-pass? Metered ramp by-pass? Increased power/accel.? Vehicle; - Top speed? - Front collision avoid? - Hi spd. crash worthy?			
4.4	Corridors: - Signal preemption? Pull-out right-of-way?			
4.5	Center City Streets: Contra flow lanes? Signal preemption? Pull-out right-of-way?			
4.6	Neighborhood Streets: Signal preemption? Pull-out right-of-way?			
4.7	Other			

5. SPECIFICS - MANAGED OPERATIONS:

NO.	MANAGED OPERATION TYPE	DESCRIPTION
5.1	Coordinated Express and local service?	
5.2	Central AVL Tracking of Buses with Central Schedule/Dispatch?	
5.3	Rider Count for Service Planning?	
5.4	Central Security Tracking Silent Alarm on Vehicles?	
5.5	Dependable Service: On-board diagnostics? Less frequent maint.? Std. LAN? Std. Drive-by-wire?	
5.6	Flexible Service: Multiple-use vehicles? Improved maneuverabilty?	

6. SPECIFICS - RAPID LOADING/UNLOADING:

NO.	LOAD/UNLOAD CHARACTERISTICS	EXPRESS VEH.	SHUTTLE VEH.	LOCAL VEH.
6.1	Low Floor, no Interior Stairs?			
6.2	Wider Doors?			
6.3	More Doors?			
6.4	Any Doors on Left?			
6.5	Precision Docking for Platform Loading?			
6.6	Extendable Wheelchair Ramp for Curb Loading?			

7. SPECIFICS - RAPID FARE COLLECTION:

NO.	MANAGED OPERATION TYPE	DESCRIPTION
7.1	Accept Passes, Stored Value Cards, Smart Cards?	
7.2	Card Reader on Vehicle: Pay on entering? Pay on exiting? Pay in transit? Free Service? Card Reader on Platform? Proof of Payment?	
7.3	Will fare collection be integrated with: Existing system? Other modes?	
7.4	Is this an impetus for EFC system in your agency?	

8. SPECIFICS - SYSTEM IMAGE:

NO.	SYSTEM IMAGE CHARACTERISTICS	BUSWAY AND EXPRESS VEH.	SHUTTLE VEH.	LOCAL VEH.
8.1	Present Rail-Like Visual Image?			
8.2	Rail-Like Operation? Dependable Schedule? Less Freq. Stops? On-Board Comfort?			
8.3	Time of Next Arrival for Waiting Passengers?			
8.4	On-Board Travel Info.: Visual on a screen? Audio Annunciation?			

9. SPECIFICS – LOW EMISSIONS:

NO.	LOW EMISSIONS CHARACTERISTICS	EXPRESS VEH.	SHUTTLE VEH.	LOCAL VEH.
9.1	Light Chassis Design?			
9.2	Fossil Fueled: Fuel Efficient? Hybrid Battery/Fossil?			
9.2	Alternative Fuels? Propane? Natural gas? Fuel cells?			
9.3	Battery Powered? Recharge stations? Rail recharge			
9.4	Infrastructure Powered: Catenary? Other? Vehicle operable beyond power source?			

10. SPECIFICS – VEHICLE-RELATED ITS:

What ITS technologies may become part of your BRT system:
Initially?
Planned?
Maybe in future?
What is your priority for installing ITS technologies?
Will ITS be integrated with other systems:
TOC?
TMS?
TIS?

11. SPECIFICS – DESIRED CAPABILITIES:

What capabilities—in order of priority—would you like to see added to your BRT service if you had the funding to do it?

Appendix C: Vendor Meeting Results

VENDOR A

Market

Their primary market is for 40-foot buses, either 96 inches or 102 inches wide. Currently, trolley buses and articulated buses are not part of their product offering.

Facilities

Their manufacturing facility is located in the west. They assemble the bodies at the plant, and use subcontractors for engines, transmissions, and many other bus components. They integrate the components (both mechanical and electrical) and guarantee the product to the client.

BRT-Related Vehicle Characteristics

Roadway Operations:	
▪ Top Speed	▪ Top speed of their buses is around 65 mph
▪ Auto. Lateral Control Available?	▪ At least two systems available that could be used
▪ Precision Docking?	▪ At least one system available that could be used
▪ Frontal Collision Avoidance?	▪ Could be option, both forward and side
▪ Rear Collision Avoidance?	▪ No
▪ Articulated –single?	▪ No
▪ --double?	▪ No
▪ Multiplexed or LAN On-board?	▪ Yes
▪ Drive-by-Wire?	▪ No
▪ On-board Diagnostics?	▪ Yes, to some extent
Rapid Loading/Unloading:	
▪ Low Floor - Interior Stairs?	▪ Yes – standard
- No Interior Stairs?	▪ No – only if the vehicle is electric powered.
▪ Wide Door Options?	▪ Yes – a standard option
▪ More Door Options?	▪ Yes, if low floor throughout—possible if electric
▪ Left Door Option?	▪ Yes, if frame reinforced, but takes up seat space; but may need to retest at Altoona
▪ Wheelchair Ramp - Flip out?	▪ Yes
- Extend?	▪ Yes
▪ Other?	▪ No

Low Emissions ▪ Lighter Chassis Design? ▪ Clean Diesel? ▪ Alternate Fuels - CNG - LNG ▪ Battery-Powered? ▪ Hybrid? ▪ Electric Trolley?	 ▪ No composite—use aluminum ▪ Yes ▪ No; can be dangerous—believes that the ultra-low diesel in a few years will be cleaner ▪ No straight battery-powered vehicles ▪ Could be offered ▪ No
System Integration ▪ Fare Collection Systems? ▪ AVL? ▪ Cameras? ▪ Radios? ▪ Displays? ▪ Signage? ▪ Other?	 ▪ Yes ▪ Yes ▪ Yes ▪ Yes ▪ Yes ▪ Yes ▪ Whatever is required for the customer
Alternative Appearance Options?	Could offer a different nose on the buses; the rest of t bus would be the same. Paint can be used.

Thoughts on BRT

The vendor thinks that the primary BRT characteristics are:

- Different vehicle appearance
- Dedicated guideway

Buses have a negative image today (slow, no prestige, not comfortable). The name should not include “bus”; it should be “Rapid Transit System”. BRT should be appealing, convenient, comfortable and faster. They believe that most BRT systems will be built incrementally; perhaps a few dedicated lanes followed by more modern looking vehicles. Depending on the busway, lateral control and precision docking may be required.

The vehicle will have lots of commonality with buses, but the outside appearance will be more rail-like; and inside will be more comfortable and spacious. Low emissions will be required (e.g., hybrid). A dedicated busway BRT should have about three times the capacity of today’s bus systems, and about a third of a rail system. It should provide a good interim step for corridors where rail cannot yet be justified.

VENDOR B

Market

Their primary market is for 35/40-foot buses and 60 foot articulated buses. They also make a 65 foot bus for park-and-ride applications. Currently, trolley buses are not part of their product offering.

Facilities

Bodies are manufactured in overseas; all other components are from the U.S. Assembly facility is in the U.S. In addition, they have three parts warehouses in the U.S.

BRT-Related Vehicle Characteristics

Roadway Operations:	
▪ Top Speed	▪ Top speed of 65 to 70 mph
▪ Auto. Lateral Control Available?	▪ Not until available from dependable supplier
▪ Precision Docking?	▪ Not until available from dependable supplier
▪ Frontal Collision Avoidance?	▪ No
▪ Rear Collision Avoidance?	▪ No
▪ Articulated—single?	▪ Yes
—double?	▪ Would consider
▪ Multiplexed or LAN On-board?	▪ Yes
▪ Drive-by-Wire?	▪ No
▪ On-board Diagnostics?	▪ Yes, to some extent
Rapid Loading/Unloading:	
▪ Low Floor - Interior Stairs?	▪ Yes, interior stairs for non-electric
No Interior Stairs?	▪ Possible only with electric vehicle
▪ Wide Door Options?	▪ Yes; customers can choose from variety
▪ More Door Options?	▪ Up to three 42” doors on articulated
▪ Left Door Option?	▪ Yes; addition of left door can be done if enou quantity; would take up seat space
▪ Wheelchair Ramp – Flip out?	▪ Yes
▪ Extend?	▪ No
▪ Other?	

Low Emissions ▪ Light Chassis Design? ▪ Clean Diesel? ▪ Alternate Fuels - CNG ▪ LNG ▪ Battery-Powered? ▪ Hybrid? ▪ Electric Trolley?	 ▪ Yes; composite buses being developed & offered ▪ Yes ▪ Yes; meet new safety legislation; CNG for art presents problems--biggest is low power ▪ Yes ▪ As part of hybrid ▪ Built a demonstration CNG and electric vehic they now have a dependable hybrid supplier ▪ No
System Integration ▪ Fare Collection Systems? ▪ AVL? ▪ Cameras? ▪ Radios? ▪ Displays? ▪ Signage? ▪ Other?	Vendor assembles and integrates all componen including old equipment from the agency ▪ Yes ▪ Yes ▪ Yes ▪ Yes ▪ Yes ▪ Yes ▪ As specified by customer
Alternative Appearance Options?	Have made test bus with curved sides and advanc front.

Thoughts on BRT

It is not clear what the BRT really is. Some proposed BRT features will be hard to build and sell as dependable products:

- Rail-like Image: How does a transit agency buy "rail-like image" if there is competitive bidding where lowest price wins? How are competing designs judged?
- Automated Lateral Control and Precision Docking: A production supplier for a reliable product is needed.
- Hybrid Power Systems: A supplier is available, but the initial cost is high and batteries must be replaced frequently.

Building special designs for small quantities of buses raises the price per bus substantially.

VENDORS C AND D

Facilities

For normal buses, bodies and full assembly is done in the U.S. using pre-manufactured five-foot sections. For the low floor buses, the bodies are constructed outside of the U.S., with final assembly in the U.S.

BRT-Related Vehicle Characteristics

Roadway Operations:	
▪ Top Speed	▪ 65 mph for the 40 foot; may be somewhat less for the articulated models.
▪ Auto. Lateral Control Available?	▪ No
▪ Precision Docking?	▪ No
▪ Frontal Collision Avoidance?	▪ No
▪ Rear Collision Avoidance?	▪ No
▪ Articulated –single?	▪ Yes for vendor C, No for vendor D
▪ --double?	▪ Yes for vendor C
▪ Multiplexed or LAN On-board?	▪ Yes
▪ Drive-by-Wire?	▪ Maybe overseas
▪ On-board Diagnostics?	▪ Yes
Rapid Loading/Unloading:	
▪ Low Floor - Interior Stairs?	▪ The low floor buses have no interior stairs
- No Interior Stairs?	▪ Yes, up to 44 inches
▪ Wide Door Options?	▪ Yes on articulated
▪ More Door Options?	▪ Buses can have both left and right doors
▪ Left Door Option?	▪ Yes
▪ Wheelchair Ramp – Flip out?	▪ No
- Extend?	
▪ Other?	
Low Emissions	
▪ Light Chassis Design?	▪ No composite
▪ Clean Diesel?	▪ Yes
▪ Alternate Fuels - CNG	▪ Yes
- LNG	▪ Yes
▪ Battery-Powered?	▪ No
▪ Hybrid?	▪ Five prototypes delivered
▪ Electric Trolley?	▪ No

System Integration	In some cases, these are customer-supplied:
▪ Fare Collection Systems?	▪ Yes
▪ AVL?	▪ Yes
▪ Cameras?	▪ Yes
▪ Radios?	▪ Yes
▪ Displays?	▪ Yes
▪ Signage?	▪ Yes
▪ Other?	▪ Meet customer requests
Alternative Appearance Options?	Not currently

Thoughts on BRT – Vendor C:

BRT is the Curitiba, Brazil system—it is not just the vehicle. The system must have:

- Rapid entry/exit into the buses, including:
  - Boarding platforms at bus floor height
  - Pre-payment with proof-of-payment
  - Door configurations—More? Wider? Left side?
- Different bus sizes depending on demand—not just articulated
- Congestion reduction through use of:
  - Dedicated busway
  - Signal priority or preemption
  - Queue-jump lanes
- Bus image:
  - Rail-like appearance
  - Lower emissions
  - Clean

Some of the ITS systems may be of value when they are available, including:

- Lateral control
- Precision Docking

Thoughts on BRT – Vendor D:

In the U.S., there does not seem to be any consistency; specifications vary form one site to another. There are too many variations in areas such as:

- Door configurations
- Floor heights
- Propulsion system
- "Buy America"
- Need for Altoona testing

More standardization would mean less expensive vehicles. Curitiba vehicles are actually standard and simple; for example, there is no air conditioning. In the U.S., the vehicles get "too loaded up" with extras—they should be kept simple. One option would be for the FTA to work with APTA and help fund development of standard specifications for BRT. A BRT "White Book", in the mode of the other FTA White Book, might be useful. A dialog among vendors and agencies would be useful.

Appendix D: BRT Vehicle Vendor Information

Potential US BRT Vehicle Vendors

Vendor Name	Location	Contact	Likely BRT Features
Adtranz (Daimler-Benz)	Pittsburgh, PA	(412) 655-5335 Presisent: Ray Betler	Trolley Buses
Bluebird	Fort Valley, GA	(912) 757-7100 President: Paul Glaske	Flat floor bus; transbus
el Dorado	Salina, KS Chino, CA	(913) 827-1033 (909) 591-9557 President: Andy Imanse	Low floor, low emissions, up to 35 ft.
Gillig	Hayward, CA	(510) 785-1500 Vice President: Brian Macleod	Low floor, up to 40 ft.
Goshen	Elkhart, IN	(219) 264-7511 Presidnet: Sam Rozzi	Mid-size buses
NABI (owned by NABI-Hungary)	Moorpark, CA Anniston, AL (mfg)	(805) 529-5080 Marketing: Bill Coryell	Low floor, articulated up to 60 ft., alternative fuels
NeoPlan USA	Lamar, CO	(719) 336-3256 Terry Brock	Low floor, alternative fuel, articulated
New Flyer—USA	Crookton, MN	(204) 224-1251 Preseident: Jan den Oudsten	Low floor, up to 40 ft., articulated
NovaBUS (Owned by Volvo)	Roswell, NM	(505) 347-2011 Vice President: Joseph Gibson	Low floor up to 40ft, alternative fuels
Volvo—USA	Greensboro, NC	(336) 393-2647 Project Manager: Conal Deedy	Low floor, articulated up to 60 ft., alternative fuels

Potential Non-US BRT Vehicle Vendors

Vendor Name	Location	Contact	Likely BRT Features
Berkhof	Heerenveen, Netherlands	31-51-361-8500 Managing Director: P. Govaert	Low floor, articulated
Breda Menarinibus	Bologna, Italy	39-051-637-2111	Low floor, articulated
Cobus			
DAF	Eindhoven, Netherlands	31-40-2500500 Managing Director: Hubert van Wees	Low floor, articulated
Den Oudsten	Woerden, Netherlands	31-3480-123-45 Managing Director: P. Petermeijer	Low floor, articulated
Hess	Bellach, Switzerland	41-32-617-3411 General Manager: Dipl Ing Max Naef	Low floor, articulated
Hispano	Zargoza, Spain	34-976-72-0500 Vice President: Mugica Jiminenez de la Cuestra	Low floor, articulated, trolley
Irisbus	Venissieux and Paris, France	201-843-6687 Chairman and CEO: John Marino	Low floor, guided BRT technology in 40 and 60 foot lengths
Iveco	Turin, Italy	39-011-687-2111 General Manager: E. Valente	Low floor, articulated
Marcopolo	Caixas do Sul R.S., Brazil	55-542-09-4000 President: Paulo Bellini	Double articulated trolley
Mercedes Benz	Mannheim, Germany	49-621-7400 Sales Director: Wolfgang Presinger	Diesel-electric, low floor, own guideway, lateral control
NeoPlan	Stuttgart, Germany	497-117-8350 Chairman: Dipl-Ing Bob Lee	Low floor, alternative fuel
New Flyer	Winnipeg, Canada	204-224-1251 President: Jan den Oudsten	low floor, up to 40 ft. articulated
Nova Bus	Quebec, Canada	450-974-0111 President Dennis Tallon	Low floor, up to 40 ft. articulated
Orion	Ontario, Canada	905-403-7832 Chief Operating Officer: TJ Peabody	Low floor, hybrid electric and diesel
Scania	Katrineholm, Switzerland	461-505-8500 Sr. Vice President: Hakan Ericsson	Low floor, articulated
Van Hool	Lier-Koningshooikt, Bel.	323-420-2020 Chair: A. Van Hool	Low floor, double articulated, diesel and trolley
Volvo	Gothenburg, Weden	463-166-8000 President: Jan Engstrom	Curitiba supplier