NORTHEAST CORRIDOR MOBILITY STUDY

DRAFT
UNIVERSE OF ALTERNATIVES
DEFINITION AND EVALUATION

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1.0 Introduction

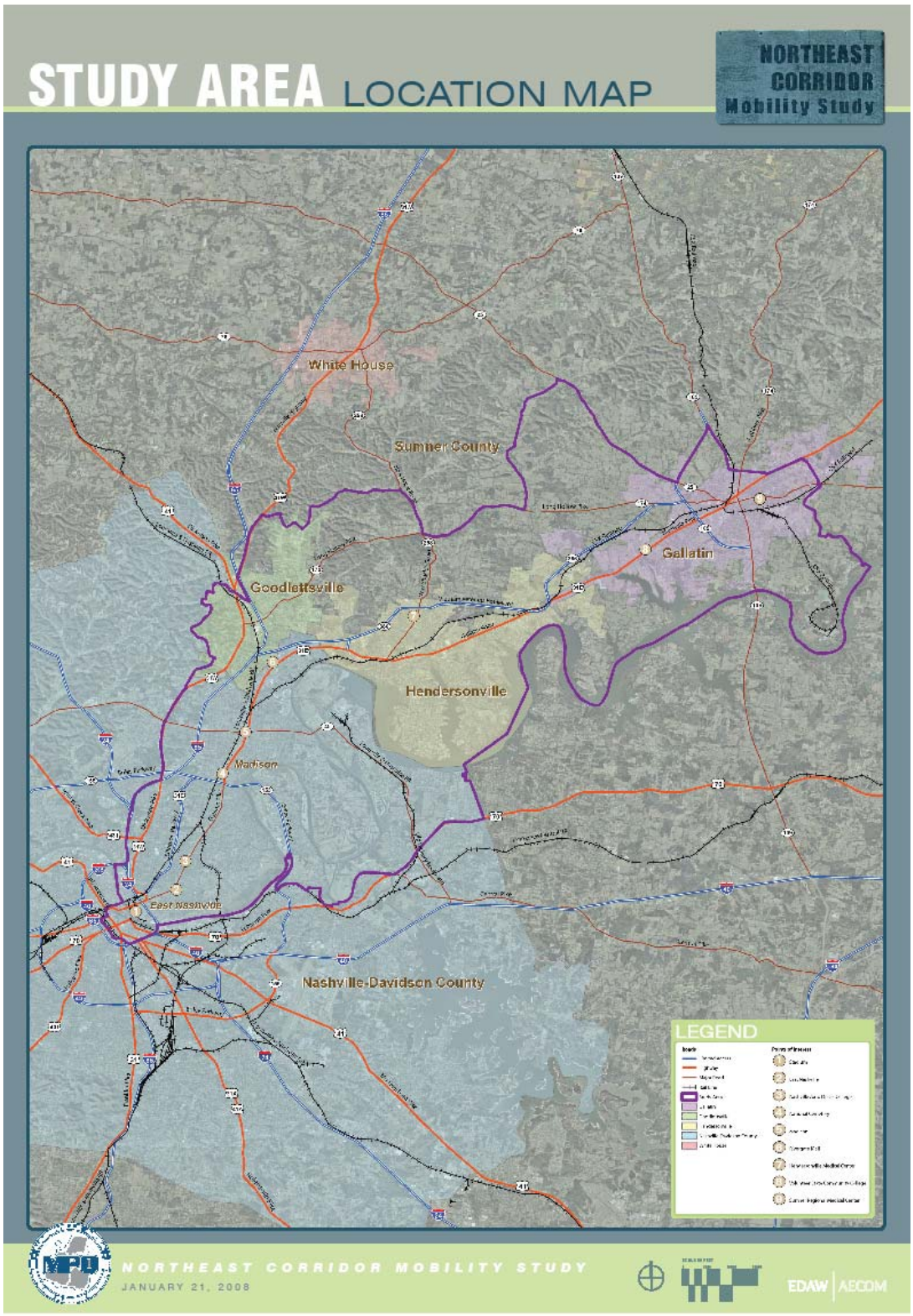
The Northeast Corridor Major Investment Study was initiated at the request of the Nashville Area Metropolitan Planning Organization (MPO). The intent of the study is to identify the current mobility challenges within the Corridor and to investigate multimodal solutions to the increasing transportation demand created by the currently projected and envisioned (preferred) future land use patterns. The Northeast Corridor begins just west of the Cumberland River in downtown Nashville and continues through the cities of Goodlettsville, Hendersonville and Gallatin in Sumner County. The study area is illustrated in Figure 1-1.

This study is predicated by the MPO's 2030 Long Range Transportation Plan, intended to help alleviate traffic congestion, provide more transportation choices, improve transportation system operations, and meet the region's air quality goals.

1.1 Alternatives Development and Evaluation Methodology

Describe process and part this report plays in it

Figure 1-1: Study Area



2.0 Definition of Candidate Technologies

The purpose of this chapter is to describe the alternative modal technologies under consideration for the Northeast Corridor Mobility Study. This chapter provides an overview of technologies and its guideway, and examples of where the technology currently operates, as well as typical performance characteristics of the transit technology. This is followed by photographs of the technology and/or its guideway, and a table of information related to system performance characteristics, including advantages and disadvantages.

In Chapter 3, the alternative technologies are evaluated qualitatively using criteria such as system characteristics (e.g., station spacing and speed), infrastructure compatibility, study purpose and goals, as well as costs. Appendix A shows example projects with capital costs adjusted to year 2007 dollars. Capital costs for each technology are based on FTA New Starts documents, planning studies and existing costs for example projects. The intent of the evaluation is to define a narrowed set of technology options. These are used in defining the initial range of alternatives (combinations of specific modes and alignments) in Chapter 4.

Eleven categories representing the range of technologies that operate in urban settings were identified as potential options in the study corridor. The public transportation technologies analyzed include:

- Bus
- Bus Rapid Transit (BRT)
- Light Rail Transit (LRT)
- Heavy Rail Transit (HRT)
- Commuter Rail
- Monorail
- Automated Guideway Transit (AGT)
- Personal Rapid Transit (PRT)
- Magnetic Levitation (Maglev)
- High Speed Rail
- Water Taxi/Bus

2.1 Bus

Buses are rubber-tired vehicles that operate on roadways in mixed traffic or in specially designated bus lanes or high-occupancy vehicle (HOV) lanes. Buses represent the most common and most flexible type of public transportation. Bus systems of some form exist in virtually every urban and suburban area of the country. Buses can operate on fixed routes according to published schedules, or may be dispatched individually to pick up passengers on a demand-responsive basis. Local bus route stops are typically as frequent as every one to two blocks, or every one-eighth mile. Express or limited service is characterized by fewer stops and higher average speeds.

In the past, the majority of buses in operation were diesel powered. However, vehicles powered by alternative fuels, such as clean diesel, biodiesel, and natural gas, are becoming more widespread as a means of reducing emissions. After participating in a successful pilot project to test a biodiesel blend in 18 of its buses, the Nashville MTA is

seeking funding to convert all its buses to the biodiesel blend. Battery-powered electric buses have been implemented in several cities, primarily as short-haul, special use vehicles in activity centers because of their short operating range. New hybrid-electric buses have been tested and are being put into service. Fuel cell buses are in the evaluation and testing stage by manufacturers and transit agencies.

Although buses typically operate in mixed traffic, in several cities they operate in HOV lanes or in exclusive busways, providing faster service by by-passing roadway congestion. Other means to give priority treatment to buses include Intelligent Transportation System (ITS) components, such as bus signal priority or pre-emption (refer also to Section 2.2, Bus Rapid Transit).

Bus transit encompasses a wide variety of vehicle types, ranging from converted vans to double-deck and articulated transit buses. Other technological innovations include low-floor buses, automatic vehicle location systems, automated demand responsive dispatching, transit operations software, electronic ticketing and automated fare payment.

Examples of bus service are present in most cities in the United States. In the corridor study area, the Nashville MTA provides bus service in Nashville-Davidson County, and operates regional bus service through contract with the RTA.

Bus Characteristics	**Descriptions**
Person/Vehicle Capacity	40 to 60 seats; 50 to 80 passengers per vehicle
Vehicles per set	One
Guideway	Mixed traffic (or separate right-of-way - see BRT)
Speed (Maximum)	65 mph
Speed (Average)	Local: 10-20 mph; Express: 20-40 mph
Power Supply	Diesel or alternative fuels (CNG, biodiesel, hybrid)
Suspension	Rubber tire on pavement
Station/Stop Spacing	Local: One to two blocks; Express: 1+ mile
Capital Cost	$300,000 – $600,000 per vehicle + supporting facilities
Current revenue operations	Widespread
Advantages	• Can operate in mixed traffic or on its own guideway • Adaptable to a variety of fuels • Lower capital cost • Unequaled routing flexibility
Disadvantages	• Higher operating cost per passenger in very high-volume corridors • Travel times and reliability compromised in mixed traffic • Higher emissions with diesel engines

40’ Bus - Nashville

40’ Buses on downtown bus mall – Minneapolis, Minnesota

Articulated Bus – Minneapolis, Minnesota

2.2 Bus Rapid Transit (BRT)

There is a broad range of perspectives as to what constitutes Bus Rapid Transit (BRT). BRT is difficult to define because it encompasses a wide variety of elements and applications. BRT emulates rail systems in many ways, but offers the flexibility of bus service. BRT encompasses a number of key elements, each with a range of options from which planners can select the most appropriate combination in designing a specific system for an area. The recent FTA publication, Characteristics of Bus Rapid Transit for Decision-Making (August 2004) explains six major element options and typical applications. The major elements and some of their typical options include:

- **Running Ways:** Options range from general traffic lanes to fully grade-separated BRT transitways. Bus priority running ways include queue-jump lanes, bus lanes, bus streets, and busways. Queue-jump lanes are installed at major intersections to allow buses to bypass traffic. A bus lane reserves a lane on an arterial or city street for the exclusive or near-exclusive use of buses. Bus streets or transit malls can be created in an urban center by dedicating all lanes of a city street to the exclusive use of buses. Busways physically separate buses from other vehicles.
- **Stations:** Options range from simple stops with basic shelters to complex intermodal terminals with many amenities. Station amenities provide for passenger safety, comfort, and convenience, including pedestrian-oriented improvements such as streetscaping.
- **Vehicles:** BRT systems can use a wide range of vehicles, from standard buses to specialized vehicles. Specialized vehicles can enhance the system's

attractiveness by having a unique image and/or improving passenger comfort on the buses.

- **Fare Collection:** Options range from traditional pay-on-board methods to pre-payment with electronic fare media (e.g., smart cards).
- **Intelligent Transportation Systems (ITS):** ITS options include vehicle priority, operations and maintenance management, operator communications, real-time passenger information, and safety and security systems. Bus signal priority or pre-emption at intersections can involve the extension of green time or actuation of the green light at signalized intersections upon the detection of an approaching bus.
- **Service and Operations Plan:** Because BRT vehicles can travel anywhere there is pavement, BRT can be tailored to the unique origin and destination patterns of a corridor's travel market. For example, buses may exit exclusive busways and operate along streets to provide local area circulation and distribution.

Examples of BRT and the wide variation in BRT characteristics are illustrated in the following examples:

- **Orlando LYMMO** – operates in a downtown environment in exclusive bus-lanes with standard buses, free fares, enhanced station amenities and includes ITS features.
- **Los Angeles Wilshire** – operates on arterial streets in mixed traffic, with conventional buses, on-board fare collection, enhanced station amenities and includes ITS features.
- **Las Vegas MAX** – operates on arterial streets, primarily in exclusive bus lanes, with specialized vehicle, off-vehicle fare collection (TVM's), enhanced station amenities and includes extensive ITS features.
- **Cleveland Euclid Corridor** – will operate in exclusive busways transitioning curb lanes with signal priority, with unique, 62-foot aerodynamic vehicles, off-board fare collection, enhanced station amenities and ITS features.

Capital costs for BRT vary depending on the application. For the purpose of this study, three categories of BRT have been defined. Enhanced arterial BRT operates in shared roadways, and uses technology to help speed up service, including signal priority, queue jumpers, skip stop/express service and improved bus stations. Capital costs can range from $3 to $4.2 million per mile for enhanced arterial BRT. Premium arterial BRT and freeway/major BRT are similar in that they operate on exclusive guideways such as bus only lanes or busways that are separate from traffic with dedicated stations. Premium arterial BRT capital costs range from $11.7 to $13 million per mile and freeway/major BRT capital costs range from $24 to $45 million per mile.

BRT Characteristics	Descriptions
Person/Vehicle Capacity	40 to 60 seats; 50 to 80 passengers per vehicle
Vehicles per set	One
Guideway	Mixed traffic but separate right-of-way recommended
Speed (Maximum)	70 mph
Speed (Average)	15-45 mph (depends on application)
Power Supply	Diesel, CNG, hybrid; electric in some applications
Suspension	Rubber tire on pavement
Station/Stop Spacing	Half mile to several miles
Capital Cost	$3 to $45 million per mile
Current revenue operations	Yes
Advantages	• Can operate in mixed traffic or on its own guideway; this can reduce the number of transfers for many passengers • Moderate to high capacity system for less cost than LRT and other fixed guideway systems • Bus operating speed and reliability is improved by eliminating various types of delay • Can access both low- and high-density land uses
Disadvantages	• Higher operating cost in very high-volume corridors • Travel times compromised in mixed traffic • Wider guideway in station areas

Las Vegas MAX

Exclusive Bus Transitway – Ottawa, Canada

2.3 Light Rail Transit (LRT)

Light rail transit is primarily an at-grade rail mode with electrically powered vehicles receiving current from an overhead wire (catenary). This is in contrast to heavy rail vehicles that usually are powered from a track-level third contact rail. The overhead power collection feature allows LRT systems to be integrated with other at-grade transportation modes and pedestrians. The most recent LRT systems in the U.S. use articulated vehicles that are 90 feet long.

LRT operates primarily in an exclusive right-of-way, but it can also operate with other traffic along existing roadways. A light rail alignment may also be grade separated, either in tunnel or elevated. Station spacing can be as close as one-quarter mile in activity centers, but typically ranges between one-half to one mile in other areas, with total corridor lengths generally not exceeding 15 to 20 miles.

The maximum operating speed of modern LRT systems is 55 to 65 miles per hour making it suitable for medium distance trips in suburbs or between central business districts and other major activity centers. System operating speeds are a function of the exclusivity of the right-of-way and the number of stops. Streetcars are a subset of LRT; they have a smaller capacity and operate at slower speeds of 10-20 miles per hour. Streetcars are more suitable for high density urban applications with frequent stops.

Light rail operates as a single vehicle or in trains of up to four cars. The LRT train length is a function of the minimum length of a city block so that stopped vehicles do not block cross streets. LRT is currently operating in many North American cities including:

Denver, Portland, Baltimore, St. Louis, Buffalo, Dallas, San Diego, Los Angeles and Minneapolis.

LRT Characteristics	Descriptions
Person/Vehicle Capacity	70 seats; 120 persons per vehicle
Vehicles per set	Typically, 2-3; can be single or up to four car trains
Guideway	Exclusive right-of-way or mixed traffic
Speed (Maximum)	65 mph
Speed (Average)	20-30 mph including stops
Power Supply	Electrically powered via overhead catenary wires
Suspension	Steel wheel on steel rail
Station/Stop Spacing	Half to one mile
Capital Cost	$34 to $77 million per mile
Current revenue operations	Widespread
Advantages	• May operate in mixed traffic, with cross traffic, or on exclusive right-of-way • Moderate to high capacity system • Can negotiate steeper grades and small radius curves than heavy rail • Less noise and emissions than buses
Disadvantages	• Cannot operate jointly with freight trains • Overhead catenary system may be visually intrusive • Moderately high capital cost • Routing not as flexible as buses or BRT

Sacramento, California

Denver, Colorado

Dallas, Texas

2.4 Heavy Rail

Heavy rail systems are at the upper end of the transit spectrum in terms of speed, capacity and reliability. Heavy rail is a fully grade separated rail mode with electrically powered vehicles receiving power from an electrified third rail. The alignment is required to be in an exclusive right-of-way and may be elevated, in a tunnel or at-grade. No crossings of the right-of-way are permitted in the same plane with heavy rail operations.

Station spacing can be as close as one-half mile in activity centers, but typically ranges between one to three miles in most areas. Train length can vary from two to ten cars.
Due to infrastructure costs, heavy rail is implemented where very high passenger capacity is required. Cities where heavy rail is currently operating include New York, Philadelphia, Atlanta, Washington D.C., Baltimore and San Francisco.

Heavy Rail Characteristics	Descriptions
Person/Vehicle Capacity	64 seats; 120-300 passengers
Vehicles per set	Two to ten
Guideway	Exclusive Fixed Guideway
Speed (Maximum)	70 mph
Speed (Average)	30-40 mph average including station stops
Power Supply	Electrified third rail
Suspension	Steel wheel on steel rail
Station/Stop Spacing	One-half mile to 3 miles
Capital Cost	$128 to $293 million per mile
Current revenue operations	In major cities
Advantages	• Very high capacity system • Lower O&M costs per passenger basis in very high-volume corridors • High capacity system good for both short and long distance travel • Higher speeds
Disadvantages	• Very high capital costs • No crossing of right-of-way permitted • Large grade-separated structures can have major impacts

MARTA - Atlanta

2.5 Commuter Rail

Commuter rail is generally most applicable for longer-distance regional rail trips. Most commuter rail systems provide suburban to urban service with little CBD coverage. Station spacing typically ranges from 2 to 5 miles. Commuter rail systems usually provide more frequent service in the peak period/peak direction and may also offer limited midday, evening and weekend service.

A major advantage of commuter rail is its ability to share track with freight trains and other intercity passenger service (Amtrak). Commuter rail operations must meet Federal Railroad Administration (FRA) crash worthiness regulations when operating on freight trackage. Collision requirements are usually based on a crush load design of 2G or double the vehicle weight (e.g., about 200,000 lbs. buff strength).

Commuter rail operations in the United States typically consist of one to ten single or bi-level passenger cars that are pushed or pulled by a diesel or electrically-powered locomotive. In an electric system, power is supplied by a third rail or overhead catenary system.

Federal regulations require an automatic train control system for speeds in excess of 79 mph. Most commuter rail systems, however, operate below this maximum speed. Service headways usually range from 20 to 90 minutes at average operating speeds between 40 and 50 mph. Commuter rail systems tend to be grade-separated in dense urbanized areas and at grade in suburban areas. Due to its slower acceleration and longer braking distances compared with other rail technologies, commuter rail is best suited to longer distance trips with widely-spaced stations.

Commuter rail passenger cars can accommodate high or low platform boarding and up to 160 seated passengers, with a normal capacity of 300 passengers. Although individual trains have a high capacity (e.g., 10 to 12 cars), the total line capacity of commuter rail is typically less than heavy rail because headways are longer.

Commuter rail capital costs range between $1.3 million and $14 million per mile. Operating costs, largely dependent upon the rail system operating plan, vary considerably from system to system.

2.5.1 Locomotive-Hauled Commuter Rail

Locomotive-hauled trains can be diesel or electric-powered. Examples of conventional, diesel locomotive-hauled commuter rail systems include Metrolink in Los Angeles, Tri-Rail in South Florida, MARC in Baltimore, and commuter operations in New York and Chicago. Nashville's Music City Star, a 32-mile commuter rail line with 6 stations, opened in the east corridor in September 2006. Electric-powered locomotives haul commuter trains to and from New York, Chicago, and Philadelphia.

2.5.2 Self-Propelled Commuter Rail

Self-propelled rolling stock is an alternative to locomotive-powered trains for commuter rail service. Whether run as single cars or in trains, they are generally designed for one-person operation. Self-propelled railcars have been around almost as long as the internal combustion engine. Although they have seen only limited service in the U.S.,

new designs in Europe and Australia are performing reliably and economically in a wide range of regional passenger services.

Diesel multiple unit cars (DMUs) are self-propelled commuter rail cars that do not require a locomotive to push or pull them. Multiple unit cars can operate singly or as trains of up to 10 cars. These vehicles are typically 85 feet long and seat 60 to 100 passengers. They are capable of speeds from 80 to 120 miles per hour. DMUs are used widely in Europe for commuter service, rural branch lines, and cross-country express trains. In the U.S., the South Florida Regional Transportation Authority (Tri-Rail) is operating the latest DMU prototype with FRA's approval as part of a demonstration project. In a number of European and U.S. cities, including New York, Chicago, and Philadelphia, self-propelled electric multiple units (EMUs) operate as commuter trains.

Commuter Rail Characteristics	**Descriptions**
Person/Vehicle Capacity	Varies, up to 300 passengers
Vehicles per set	Varies, up to 12 vehicles
Guideway	Dedicated right-of-way
Speed (Maximum)	79 mph
Speed (Average)	40-50 mph
Power Supply	Varies: Diesel locomotive, electrically-powered third rail or overhead catenary system.
Suspension	Steel wheel on steel rail
Station/Stop Spacing	2-5 miles apart
Capital Cost	$1.3 to $14 million per mile
Current revenue operations	In major U.S. cities
Advantages	• Can share existing track with freight • Competitive peak hour travel times
Disadvantages	• Not suitable for short distances • Stations are further apart than other rail modes

Music City Star, Nashville

DMU Demonstration Project - Tri-Rail, South Florida

EMU - Metra, Chicago

2.6 Monorail

Monorail is a fixed guideway transit mode in which a series of electrically propelled vehicles straddle or suspend from a single guideway beam, rail, or tube. If fully automated, they are similar in operation to automated guideway transit systems but are classified separately due to their unique guideway configuration. The trains generally consist of permanently coupled cars where electric power is picked up by collectors on the vehicle in contact with a bar mounted on the side of the guideway beam.

Vehicles may travel in single units or may be linked together in train sets of one to six vehicles. A monorail must be grade separated from other traffic. The majority of monorail installations have been elevated; however, it could operate in tunnel or at-grade within in

its own right-of-way. Station spacing is comparable to light rail, one-third to one-half mile in activity centers and one-half to one-mile or more in other areas. In the United States, monorail has been implemented in limited applications, such as recreational areas or amusement parks (Disneyland/Walt Disney World) and short (approximately 1 mile) systems in downtown Seattle and Newark International Airport. Outside of the United States, straddle beam, large vehicle monorail systems are in operation in Sydney, Australia and Osaka, Kitakyushu, and Tokyo, Japan.

Monorail Characteristics	**Descriptions**
Person/Vehicle Capacity	Varies
Vehicles per set	Varies
Guideway	Exclusive fixed guideway
Speed (Maximum)	55 mph
Speed (Average)	20-30 mph with station stops
Power Supply	Electric powered from separate rail
Suspension	Rubber tire on mono-beam, or suspended from elevated beam
Station/Stop Spacing	One-third to one mile
Capital Cost	$76-$152 million per mile
Current revenue operations	Yes (in Europe and Japan; limited operation in the U.S.)
Advantages	• Narrow width of beam is less visually intrusive than other elevated systems • Automated system can provide frequent service and lower labor costs • Serves low to medium passenger volumes
Disadvantages	• Complex guidance/switching systems leads to reduced operating flexibility • Right-of-Way must be grade separated. Emergency egress from vehicles on this elevated guideway has historically been a problem • Limited vehicle suppliers • High capital cost per mile • Limited experience in urban applications. Mostly amusement parks and airports in U.S.

Las Vegas

Japan

2.7 Automated Guideway Transit (AGT)

AGT refers to a broad range of fixed guideway technology in which the most prominent feature is the automatic train operation. AGT can include steel-wheel/steel-rail or rubber tired vehicles which operate under automated control on an exclusive guideway, grade-separated from vehicular traffic. AGT may utilize conventional or alternative propulsion types such as magnetic levitation or linear induction.

AGT characteristics can vary considerably. Vehicles typically are smaller than other rail modes. However, the most significant operating standard for this technology is service at very short intervals. This frequent service mitigates the smaller vehicle size so that AGT hourly passenger capacity can be comparable to that of light rail. Station spacing is comparable to light or heavy rail, one-quarter to one-third mile in activity centers and one-half to one-mile or more in other areas. Train lengths vary between one and six vehicles. Depending on the AGT setting, the speed of the AGT vehicle ranges from 20 to 55 miles per hour.

AGT technology is in widespread use in airports such as Atlanta, which has a rubber-tired system, and amusement parks in the U.S. and other countries. There are also downtown circulator systems, such as the Miami MetroMover. Urban scale systems are found in Vancouver and several European cities.

AGT Characteristics	**Descriptions**
Person/Vehicle Capacity	Varies; typical 40' car has 40 seats, 70-passengers
Vehicles per set	Varies
Guideway	Exclusive fixed guideway
Speed (Maximum)	55-62 mph
Speed (Average)	20-35 mph with station stops
Power Supply	Electrified third rail or linear induction
Suspension	Steel wheel on steel rail or rubber tired
Station/Stop Spacing	Between one quarter to one third miles in activity centers and one half to one mile in other areas
Capital Cost	$89-$157 million per mile
Current revenue operations	Many airport applications but few urban applications
Advantages	• Automated operations may reduce labor costs • More frequent service • Smaller stations • Hourly passenger capacities are comparable to light rail • Higher capacity system good for short distance travel in urban applications
Disadvantages	• Highest capital cost per mile except heavy rail • Grade separation required due to electrified third rail • Limited pool of vehicle suppliers

Miami MetroMover

2.8 Personal Rapid Transit

Personal Rapid Transit (PRT) systems are small typically low speed systems (25 mph or less) designed to provide personalized service, traveling to the desired stop without intermediate stops at other stations, and requiring an exclusive right-of-way. PRT is distinguished from other forms of AGT systems by two characteristics: vehicles sized like taxicabs and a non-stop ride from origin to destination by having passable or off-line stations. The capacity of PRT systems is approximately 5,000 pphpd or less.

PRTs are defined as having:

- Fully-automated vehicles capable of operation without humans
- Vehicles operating on small, grade-separated guideway
- Small vehicles with a capacity of one to six people
- Direct, origin-to-destination service, without the necessity of transfers or stops at intervening stations
- Service available on demand, rather than on fixed schedules

A pilot PRT system is under constructions at London Heathrow Airport to test the systems for future expansion to other British Airports.

PRT Characteristics	Descriptions
Person/Vehicle Capacity	3-6 seats
Vehicles per set	One
Guideway	Exclusive fixed guideway
Speed (Maximum)	25 mph
Speed (Average)	10-20 mph
Power Supply	Electric AC motor or linear induction
Suspension	Rubber tires on a guideway
Station/Stop Spacing	Very closely spaced
Capital Cost	No reliable estimates
Current revenue operations	None in operation
Advantages	• Automated operations may reduce labor costs
Disadvantages	• No existing systems in operation • Capacity is approximately 5,000 pphpd or less

PRT on Test Track

2.9 Magnetic Levitation (Maglev)

Magnetic levitation (Maglev) is an advanced technology in which magnetic forces lift, propel, and guide a vehicle over a guideway. Utilizing state-of-the-art electric power and control systems, this configuration eliminates contact between vehicle and guideway and permits cruising speeds of up to 300 mph, or almost two times the speed of conventional high speed rail service. Because of its high speed, Maglev offers competitive trip-time savings to auto and aviation modes in the 40 to 600-mile travel markets. This technology can also be automated.

In these systems, the technology is analogous to that of an electric motor. By taking the development of the stator winding as the fixed guideway, and making it the total length of the transit system, the vehicle takes the form of the rotor development, and “rides” on the magnetic flux between stator and rotor. During movement there is no contact between the vehicle and guideway. Automatic electronic controls maintain a constant air gap of 5 to 15 mm (.2 to .6 inches) and compensate for variations in vertical loads. Levitating the train above the guideway eliminates most of the frictional drag inherent

with other technologies, thus reducing the power required at high speeds and creating the opportunity for operating speeds at the high end of operations of up to 300 mph. Two basic types of Maglev technology exist: the electrodynamic suspension (repulsive forces) or EDS and electromagnetic suspension (attractive forces) or EMS.

Maglev technology is generally applied to high speed (100+ mph) travel needs (inter-city, longer distances), however; new permutations of maglev are being developed for use in slow speed (30-60 mph) applications. Shanghai, China has the only high speed maglev in revenue operation, which travels from downtown Shanghai to the Pudong International Airport. Low-speed maglev system line capacity ranges from 2,000 to 10,000 pphpd. Linimo is the first low-speed maglev, which opened in Japan in 2005 and serves the local community of Aichi and the Expo 2005 fair site. Maglev is in final planning stages in Munich, Germany.

Maglev has been proposed for several corridors in the U.S., such as Denver to Vail, Colorado; Baltimore to Washington, DC, and greater Los Angeles. Closer to home, the Tennessee Maglev Feasibility Study is researching possible routes and station locations for the maglev train between Chattanooga and Nashville. Currently, plans are to connect the major airports, downtown areas, and points in between.

Maglev Characteristics	**Descriptions**
Person/Vehicle Capacity	Varies
Vehicles per set	Varies
Guideway	Exclusive fixed guideway
Speed (Maximum)	300 mph
Speed (Average)	60-100 mph in urban applications; 250-300 mph for intercity routes
Power Supply	Magnetic forces lift, propel, and guide vehicle
Suspension	Concrete or steel guideway
Station/Stop Spacing	n/a
Capital Cost	No reliable estimates
Current revenue operations	None in U.S.
Advantages	• Competitive trip time • Can be automated
Disadvantages	• None operating in U.S.

Linimo, Japan

2.10 High Speed Rail

High speed rail technology provides service between cities that are 100-500 miles apart. With speeds from 150-200 miles per hour, high speed rail is competitive to air travel. High speed rail uses a steel wheel on steel rail technology that is either turbine propelled or electric. High speed rail operates on new, dedicated right-of-way or upgraded existing tracks at slower speeds. Speeds are also limited by vertical and horizontal curves. Like commuter rail, high speed rail is subject to FRA regulation.

High speed trains are found throughout the world. The three most prominent high speed trains are the Japanese Shinkansen (Bullet Train), ICE (Germany) and TGV (France). Capacity for these three trains ranges between 850 passengers in 8 sections on the ICE; 1,090 passengers in 12 sections on the TGV; and 1,634 passengers in 15 sections on the Bullet Train. Three minute headways were demonstrated by TGV. Capital costs for high speed rail in the U.S. would vary, depending on the speed of the train and the track improvements.

While not truly high speed, the Amtrak Acela Express is the only comparable high speed rail service in the U.S. Operating between Washington DC, New York and Boston, the average speed is 72 miles per hour, with a maximum speed of 150 miles per hour. Other potential high speed rail corridors have been identified in the U.S., including the Florida High Speed Rail Project, the California High Speed Rail Authority and the Southeast High Speed Rail Corridor.

Acela Express

High Speed Rail Characteristics	**Descriptions**
Person/Vehicle Capacity	Varies 850-634 passengers
Vehicles per set	Varies based on demand: 8-15 sections
Guideway	Dedicated right-of-way
Speed (Maximum)	200 mph (150 mph Acela Express)
Speed (Average)	150 mph (72 mph Acela Express)
Power Supply	Turbine or electric propelled
Suspension	Steel wheel on steel rail
Station/Stop Spacing	Intercity
Capital Cost	Unknown
Current revenue operations	Acela Express in U.S., several throughout the world
Advantages	• Competitive travel times for heavily traveled intercity corridors
Disadvantages	• High capital costs

2.11 Water Taxi/Bus

Water taxi/bus technology is a water based service that follows a fixed route between points or terminals on a waterfront. Vessels are 50 feet long or less and speeds can vary between 5 to 25 knots (5.8-28.8 mph). Water taxis/buses typically provide service for short to medium length trips with low passenger volumes at low to medium speeds. Terminal spacing is usually .5 to 1 mile apart. Water taxis typically provide service on demand; whereas, water buses operate on a fixed schedule. Service headways for water taxis/buses can be 5 minutes because of their small size.

Water taxis vary by technology, size and speed. Battery-powered electric monohull vessels are designed for short trips at slow speeds (5 knots), and hold around 25 passengers. Diesel-electric hybrid monohull vessels can make longer trips, operate at slow speeds (8 knots) and hold up to 72 passengers. Diesel monohulls operate at low to medium speeds (14-25 knots) and carry up to 80 passengers. Diesel catamarans operate at medium to high speeds (up to 28 knots), carry 150 passengers, and can accommodate long trips. Because diesel catamarans have two hulls, they are more costly to build and maintain. Hovercraft electric monohulls can operate at speeds of 37 knots with 50 passengers; however, they have limited maneuverability and are best for shorter trips.

Capital costs are determined by the type of vessel and amount of dock construction needed. These costs can range from $150,000 to $2.5 million. Operating and maintenance costs are high, due to staffing requirements, low fuel efficiency and other costs associated with water operations.

Examples of water taxi/bus service found in the U.S. that operate on fixed schedules include Long Beach Transit Aquabus, Fort Lauderdale Water Taxi, and Chicago Water Taxi (weather permitting).

Ferry/Water Taxi Characteristics	Descriptions
Person/Vehicle Capacity	Varies by vessel: 25-150 passengers
Vehicles per set	One
Guideway	Exclusive right of way on navigable waterways
Speed (Maximum)	5-25 knots (5.8-28.8 mph)
Speed (Average)	Slow-varies by vessel size
Power Supply	Battery powered electric, diesel-electric or diesel engine
Suspension	Water vessel: Monohull or Catamaran
Station/Stop Spacing	.5-1 Mile apart
Capital Cost	Varies by type of vessel, $150,000 to 2.5 million
Current revenue operations	Yes. Public and private operations in U.S.
Advantages	• Can have low capital costs • Smaller vessels can have higher frequencies
Disadvantages	• High operating and maintenance costs • Slow speeds over a longer distance compared to other modes

Fort Lauderdale Water Taxi

3.0 Technology Screening

The initial screening of alternatives for the Northeast Corridor Mobility Study includes a total of 11 technologies that are rated based on criteria that determines the suitability and applicability of each technology in the corridor. This section summarizes the screening criteria and results of the initial screening for each technology.

3.1 Screening Criteria

Seven criteria determine the suitability and applicability of each technology in the corridor. Each technology is rated based on these criteria with a positive (+) rating by comparison, a neutral (=) rating by comparison, or a negative (-) rating by comparison. Criteria used to rate the technology are listed below.

Suitability

Average Operating Speed: This evaluates the attractiveness of the technology from a passenger viewpoint. Average speeds (including station stops) may be affected by the inherent characteristics of the vehicle, the degree of separation from roadway traffic, and the station spacing. Technologies with average speeds of 30 miles per hour or greater have a positive rating, 20 to 35 miles per hour have a neutral rating, and technologies with less than 20 miles per hour average speed have a negative rating.

Average Station Spacing: Average station spacing is rated based on suitability for the Northeast Corridor. Technologies that require closely spaced stations in dense areas or intercity stations across states have a negative rating. Technologies with station spacing at ¼ to 1 mile have a positive rating. The remaining technologies that require regional stations greater than one mile have a neutral rating.

Compatibility with Transportation System*:* The introduction of other modes in the corridor will have capital and operating cost impacts, since new supporting facilities and staff will be required. Technologies that are consistent with current transportation systems in place in the Northeast Corridor have a positive rating. Technologies that require minor improvements to existing infrastructure have a neutral rating, and systems that required new exclusive guideways have a negative rating.

Satisfies Study Purpose and Goals: Each technology that satisfies one or more of the purpose and goals of the study has a positive rating. If a technology has the potential to meet one or more goals, it is neutral. A negative rating means a technology does not meet the purpose and goals of the study.

Order of Magnitude Capital Costs per Mile (Millions*):* This assesses the overall capital costs of constructing and implementing a technology. Specific cost estimates are not being made during the prescreening step; this guideline will be evaluated based on average costs per mile in other urban applications. Total capital costs, adjusted to 2007 dollars, for each technology are based on FTA New Starts documents, planning studies, and existing costs for example projects, and are shown in Appendix A. Each technology has a positive rating if capital costs are low (up to

$30 million per mile), a neutral rating if costs range between $30 and $75 million per mile, and a negative rating for costs greater than $75 million per mile.

Applicability

Proven Revenue Service in U.S.: Finally, each technology is rated to determine if it can be applied to the Nashville Northeast Corridor. The system should be reliable and based on proven technology. The technology should be considered appropriate based on the number of active applications, especially those in urban settings, and the corresponding records for maintenance and reliability. Technologies in widespread use have positive ratings, and technologies with few to no applications in revenue service in the U.S. have negative ratings.

3.2 Summary of Findings

Eleven technologies are evaluated using the screening criteria listed above, and either chosen to carry forward for further analysis in the Northeast Corridor Mobility Study, or eliminated based on one or more factors. Table 1 displays the evaluation matrix with all technologies, criteria and ratings, as well as a brief summary of each characteristic. Technologies that are eliminated include heavy rail transit (HRT), monorail, automated guideway transit (AGT), personal rapid transit (PRT), magnetic levitation (Maglev), high speed rail, and water taxi/bus. Technologies selected to be carried forward are conventional bus, bus rapid transit (BRT), light rail transit (LRT), and commuter rail.

There are seven technologies eliminated from consideration based on characteristics that make them unsuitable or not applicable in the Northeast Corridor. These factors are highlighted in Table 3.1, as the overriding factor that eliminates the technology. Eliminated technologies are listed below.

- **HRT** is likely not financially feasible for the Northeast Corridor, with high capital costs of $128-$293 million per mile. Heavy rail requires an exclusive guideway, which can be costly and visually intrusive. Additionally, the Northeast Corridor is not conducive to heavy rail, as heavy rail is a high capacity system designed for dense and highly congested areas.

- **Monorail** has high capital costs of $76-$153 million per mile, limiting the financial feasibility of this technology in the Northeast Corridor. Like HRT, monorails require new exclusive guideways, which can be visually intrusive and costly. Monorails are typically designed to serve local circulation needs, and there are few urban applications of monorails in the U.S. For these reasons, monorail is not suitable for the Northeast Corridor.

- **AGT** is eliminated for many of the same reasons as monorail. High capital costs of $89-$157 million per mile limit financial feasibility. AGT typically provides frequent service over a short distance, and requires a visually intrusive, exclusive guideway. A limited number of urban AGT systems exist in the U.S., making AGT not applicable in the Northeast Corridor.

- **PRT** is eliminated because it is not a feasible alternative for the Northeast Corridor. PRT is a low capacity system that does not reduce traffic congestion.

The typical application of a PRT would be as a local circulator. Because there are no PRTs in existence, the feasibility and cost of the system is untested and, therefore, PRT is not suitable in the Northeast Corridor.

- **Maglev** is an untested system with no operational systems in U.S. and no reliable cost estimates. Additionally, Maglev is suitable for high speed intercity travel and does not support access and mobility needs in the Northeast Corridor.

- **High Speed Rail** operates through a chain of stops in cities across states and does not support access and mobility needs in the Northeast Corridor. High speed rail requires a new exclusive guideway or existing track upgrades to accommodate higher speeds, which increases capital costs. Therefore, high speed rail is eliminated from the alternatives in the Northeast Corridor.

- **Water Taxi/Bus** is eliminated because it fails to serve major activity centers and areas of high population density along the Northeast Corridor. Additionally, water taxi/bus technology in the Northeast Corridor would be less competitive than other modes because it travels at slow speeds along the river. Thus, water taxi/bus fails to meet the study goals to reduce travel time in the corridor.

Four technologies were chosen for the pre-screening of alternatives based on the benefits they provide to the Northeast Corridor as they compare to the screening criteria. Technologies carried forward are listed below.

- **Conventional Bus** is carried forward as a fundamental element of all alternatives. For the Baseline and Build alternatives, conventional bus service will support the high-capacity investments, (e.g. feeding into stations).

- **BRT** offers the flexibility of bus and the travel time benefits of rail. BRT can operate in exclusive bus lanes or mixed traffic, which provides access to low and high density land uses. BRT has lower capital costs compared to rail technologies, at $3-$45 million per mile. Although BRT is a relatively new concept, it is successful in many U.S. cities. Therefore, BRT will be carried forward to the next screening.

- **LRT** is the most flexible of the rail modes. LRT can operate on exclusive guideways or on-street with station spacing of ½ to 1 mile. This provides better access to land uses along the alignment than other rail modes. LRT also supports short to medium distance trips between suburbs, central business districts and major activity centers, which makes LRT suitable for the Northeast Corridor.

- **Commuter Rail** typically provides service between suburban park-and-ride lots and urban centers generally focused on peak period travel. Commuter rail is consistent with the Music City Star commuter rail. Capital costs can be low from $1-$14 million because commuter rail can operate on existing tracks. Commuter rail meets the study goals to reduce travel time along the corridor with faster speeds of 40 to 50 miles per hour. For these reasons, commuter rail will be carried forward.

Table 3-1: Technology Evaluation Matrix

Technology	Suitability					Applicability	Carry Forward?
	Average Operating Speed	Average Station Spacing	Compatibility with Transportation System	Satisfies Study Purpose & Goals	Order of Magnitude Capital Cost per Mile (Millions)	Proven Revenue Service in U.S.	
Conventional Bus	10-40 mph; depends on application	Local: 1-2 blocks Express: 1+ Miles	Consistent with Current Bus Operations	Meets Essential Mobility & Access Needs	Comparatively Low; Primarily Vehicle Related	Widespread Use	Yes
rating	=	=	+	+	+	+	
Bus Rapid Transit	10-50 mph; depends on application	1/2 to Several Miles	Requires Roadway Improvements	Provides Access to Low and High Density Land Uses	$3-45	Many Systems; Use is Expanding	Yes
rating	=	+	=	+	+	+	
Light Rail Transit	10-30 mph; depends on application	1/2 to 1 Mile	Substantial Infrastructure; Can Operate in-Street	Flexibility Allows Better Access to Land Uses	$34-77	Operates in Numerous Cities	Yes
rating	=	+	=	+	=	+	
Heavy Rail Transit	30-40 mph	CBD: >1 Mile Periphery: 1 to 3 Miles	Requires New Exclusive Guideway	High Capital Cost Limits Financial Feasibility	$128-293	Oeprates in High Density Cities	No
rating	+	=	-	-	-	+	
Commuter Rail	40-50 mph	2 to 5 Miles Serves Regional Travel	Can Operate on Existing Tracks; Consistent with Music City Star	Moderate Potential to Stimulate Economic Development	$1-14	Operates in Major Cities	Yes
rating	+	=	+	=	+	+	
Monorail	20-30 mph	1/3 to 1 Mile	Requires New Exclusive Guideway	High Capital Cost Limits Financial Feasibility	$76-152	Few Urban Applications; Some Theme Parks	No
rating	=	+	-	-	-	-	
Automated Guideway Transit	20-35 mph	1/4 to 1 Mile	Requires New Exclusive Guideway	High Capital Cost Limits Financial Feasibility	$89-157	Few Urban Applications; Many Airport	No
rating	=	+	-	-	-	-	
Personal Rapid Transit	10-20 mph	Closely Spaced Stations in Dense Area	Requires New Exclusive Guideway	Low Capacity Does Not Address Congestion Reduction	No Reliable Estimates	No Operational Systems - In Testing	No
rating	-	-	-	-	-	-	
Magnetic Levitation (Maglev)	100+ mph	Primarily Intercity	Requires New Exclusive Guideway	Does Not Support Access & Mobility Within Corridor	No Reliable Estimates	No Operational Systems - In Testing	No
rating	+	-	-	-	-	-	
High Speed Rail	70 mph	Chain of Stops in Cities Across States	Requires New Exclusive Guideway or Existing Track Improvements	Does Not Support Access & Mobility Within Corridor	Not Available	Washington to Boston (Amtrak)	No
rating	+	-	-	-	-	-	
Water Taxi/Bus	Slow - Varies by Vessel Size	1/2 to 1 Mile	Operates on Navigable Waterways	Does Not Meet Travel Market Needs of Corridor	Vessel and Terminal Costs	Many Large Cities	No
rating	-	=	=	-	+	+	

Rating scale:

+	**Positive Rating by Comparison**
=	**Neutral Rating by Comparison**
-	**Negative Rating by Comparison**

4.0 Initial Range of Alternatives and Evaluation

The previous chapter set aside certain transit technologies from consideration for the Northeast Corridor Mobility Study. However, there are still a number of potential combinations of technology and alignment that could be considered as part of the initial range of alternatives:

- There are three primary technologies to be considered for the high capacity transit corridor: BRT, LRT, and Commuter Rail.
- There are three parallel north-south alignments extending the full length of the corridor (Downtown Nashville to Gallatin) that should be considered: a freeway corridor along I-24, I-65, and SR 386, an arterial corridor along Gallatin Pike and US 31E/SR 6, and the railroad corridor along the CSX Railway.
- South of Briley Parkway, there are two additional roadways to be considered as alternates connecting to the freeway and arterial corridors: Ellington Parkway and Dickerson Pike.

4.1 Potential Alignments

This section describes the freeway, arterial, and railroad corridor alignments. Included is a discussion of the options south of Briley Parkway. The potential alignments are shown in Figure 4-1.

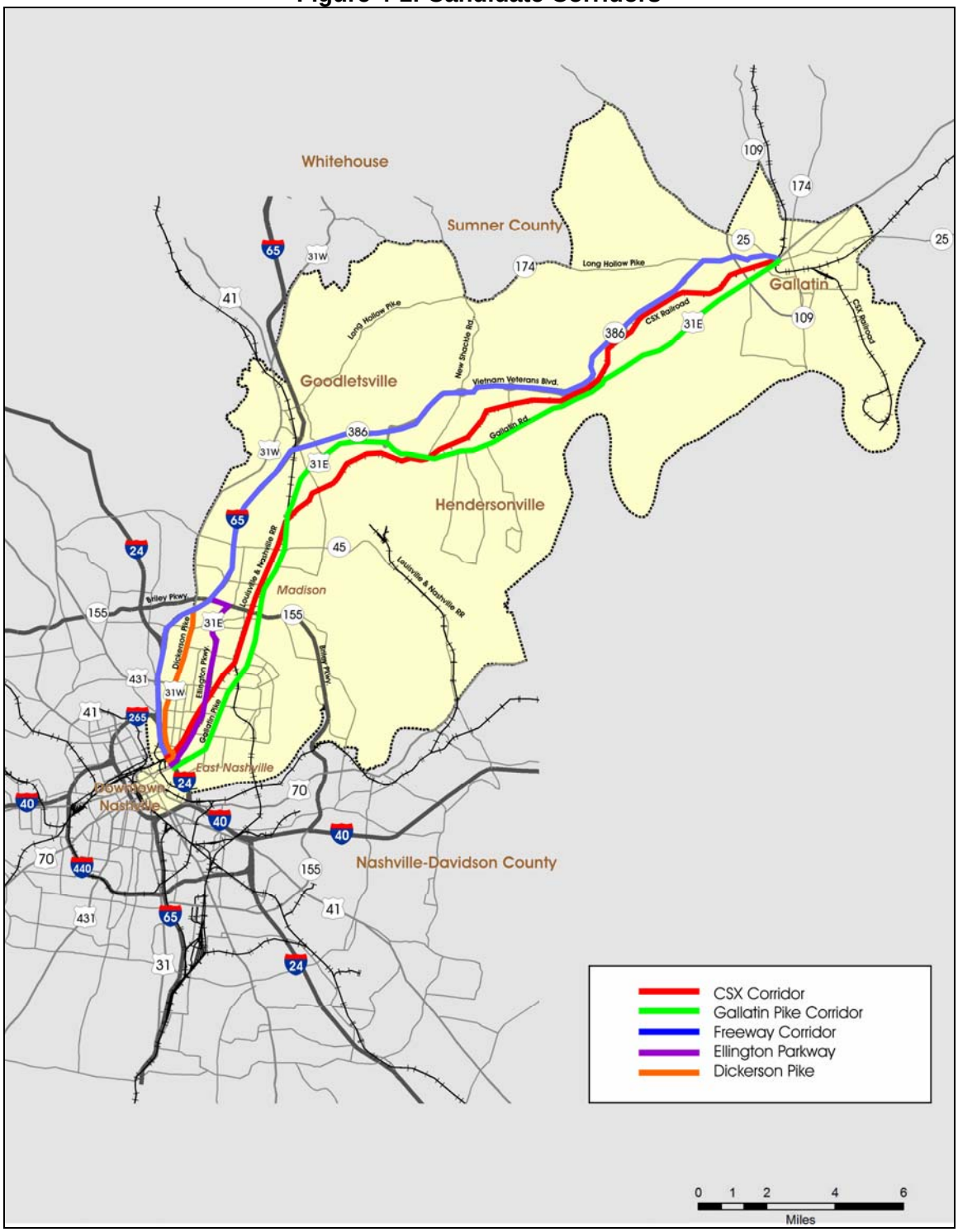
Freeway Corridor

This full length corridor connects Nashville, Goodlettsville, Henderson and Gallatin. It consists of three urban limited access freeways: I-24, I-65 and SR 386 (Vietnam Veterans Boulevard), and are briefly described here. I-24 runs from the northwest to the southwest and forms the eastern side of the interstate loop around Downtown Nashville. The downtown segment between I-65 and I-40 is currently x-lanes (Y in each direction), with no planned improvements to widen it or add HOV lanes.

Northeast of downtown, I-24 and I-65 merge and continue north, splitting again south of Ewing Drive. I-65 continues north to Goodlettsville and beyond. Reconstruction and widening of I-65 from SR 386 south to Trinity Lane has been underway since 2001. It is being widened from six to ten lanes, with two lanes being HOV. The segments from SR 386 to Dickerson Pike have been completed, including the rebuilding of the I-65/Briley Parkway/Ellington Parkway interchange. The interchange reconstruction allows a smooth transition from I-65 to Ellington Parkway without the need to enter and exit Briley Parkway. While not yet under construction, the final segment of the project from Dickerson Pike to Trinity Lane is programmed for construction in FY 2011 of the current TIP.

SR 386 (Vietnam Veterans Boulevard) splits off of I-65 in Goodlettsville in the vicinity of Rivergate Mall. Construction of this four-lane limited access freeway was recently completed. It passes through Hendersonville and ends in Gallatin where it joins with SR 174 (Long Hollow Pike). SR 174 (Long Hollow Pike and Red River Road) continues to US 31E/SR 6 (Nashville Pike) in downtown Gallatin, and is the final leg of the freeway corridor being considered for this project. This segment of SR 174 is in the LRTP to be relocated and widened from two to five lanes, but is not yet programmed in the TIP.

Figure 4-1: Candidate Corridors



Ellington Parkway Option. Ellington Parkway is a four-lane limited access freeway connecting Downtown Nashville with Briley Parkway through the center of East Nashville. The rebuilding of the I-65/Briley Parkway/Ellington Parkway interchange as part of the I-65 project now provides a smooth transition from I-65 to Ellington Parkway without the need to enter and exit Briley Parkway.

Four MTA routes currently operate non-stop along Ellington Parkway, which provides quick access to the northern part of MTA's service area. Route 35X provides limited peak period express service to Rivergate Mall and, through contractual agreement with the RTA, continues into Sumner County via SR 386 to serve Hendersonville.

Arterial Corridor

This full length corridor also connects Nashville, Goodlettsville, Henderson and Gallatin. From the Cumberland River, this four-lane arterial corridor with a center turn lane begins as Main Street and Gallatin Pike in East Nashville to Briley Parkway, where it becomes US 31E/SR 6. It continues through Madison, skirts the southern limits of Goodlettsville, and continues through Hendersonville and Gallatin with various name changes along the way. For the purposes of this study, the entire length of the corridor will generally be referred to as the Gallatin Pike Corridor. Segments of the corridor were reconstructed in 2005 and 2006. While there are no major improvements to the corridor programmed in the current TIP, the LRTP includes a project to widen it from five to seven lanes from the SR 386 Connector to Bonita Parkway in Hendersonville. Gallatin Pike is currently served by MTA's Route 26 from Downtown Nashville to the Wal-Mart and Sam's Club north of Rivergate Mall. This route has the highest ridership of all MTA routes, providing frequent weekday, as well as Saturday and Sunday, service.

Dickerson Pike Option. Dickerson Pike is a four-lane minor arterial connecting Downtown Nashville with Briley Parkway, which continues along the western edge of the Study Area into Goodlettsville. In East Nashville, Dickerson Pike runs parallel to, and in between, I-65 and Ellington Parkway. It is being considered as an alternate to Gallatin Pike south of Briley Parkway because the demographics along it are supportive of transit. It is currently served by MTA Route 23, which operates seven days a week and performs well. The transition from Gallatin Pike to Dickerson Pike (via Broadmoor Drive or Briley Parkway), however, would add distance and significant out of direction travel to the alignment.

Railroad Corridor

Within the Study Area, two CSX mainline tracks have been previously considered for commuter rail service. The Clement Landport intermodal transportation facility is located in downtown Nashville and was built in 1998 to provide boarding and transfer facilities for individuals using public transit and HOV or private vehicles. It has been identified as a potential site for a commuter rail station due to it's proximity to the existing CSX line on Demonbreun Street (just southwest of the CBD). From Clement, heading north through the Maplewood Junction to the Amqui junction (near Gallatin Pike), the CSX Nashville-Chicago mainline consists of two tracks, with the exception of a single track bridge across the Cumberland River. At Amqui, and continuing northeast to Gallatin, the Northeast Corridor (CSX's mainline between Nashville and Louisville) is single track.

Previous studies identified a number of potential commuter rail station locations in Downtown Nashville, Madison, Hendersonville, and Gallatin along the corridor, with initial segment as well as longer-term terminus options. No stations were proposed within East Nashville. The corresponding spacing between stations would be between two and three miles.

4.2 Combined Transit Technologies and Alignments

The next step in the prescreening process is to combine the technologies carried forward and the alignments described in the previous section to determine which ones are applicable and suitable for the Northeast Corridor. Commuter rail is clearly applicable only in the CSX corridor. Both BRT and LRT are applicable in the arterial corridor, as either could operate in exclusive lanes/guideways or in mixed-traffic. In the freeway corridor, both BRT and LRT are also applicable. BRT could operate either in an exclusive lane or in mixed traffic, while LRT would require an exclusive guideway in this corridor. It may be possible to operate BRT or LRT using the edge of the CSX rail right-of-way along most of its alignment. However, these mode options would be difficult to implement, given the need to maintain adequate separation from the CSX tracks for safety reasons. Additionally, there would be no real advantage to pursuing these mode options given the close proximity of the arterial corridor.

This screening of technology and alignment combinations leaves the alternatives in Table 4-1 to be considered in the next step of screening. All of these nine alternatives serve Gallatin, Hendersonville, Madison, and East Nashville. However, the Railroad Corridor Alternative does not directly serve Goodlettsville.

Table 4-1: Initial Range of Alternatives

Alternative	From Gallatin via	South of Briley Parkway Via	Mode	Distance
Freeway Corridor	SR 386/I-65	I-65/I-24	BRT or LRT	30
		Ellington Parkway	BRT or LRT	29
Arterial Corridor	US 31E/SR 6	Gallatin Pike	BRT or LRT	27
		Broadmoor / Dickerson	BRT or LRT	40
Railroad Corridor	CSX		Commuter Rail	28

The general alignments of the nine initial alternatives are shown in Figures 4-2 through 4-4. The intent of the prescreening is to reduce the number of alternatives to no more than three build alternatives with characteristics that better address the study goals, objectives, and transportation needs.

The nine potential build alternatives include one Commuter Rail alignment and four alignments that could use either BRT or LRT. In the case of BRT, a wide range of operating characteristics is possible, ranging from mixed-traffic operations with conventional buses, fairly simple stations, and Intelligent Transportation Systems (ITS) options to exclusive bus-only lanes with specialized vehicles, enhanced station amenities, and extensive ITS features.

Figure 4-2: Freeway Corridor Alternatives

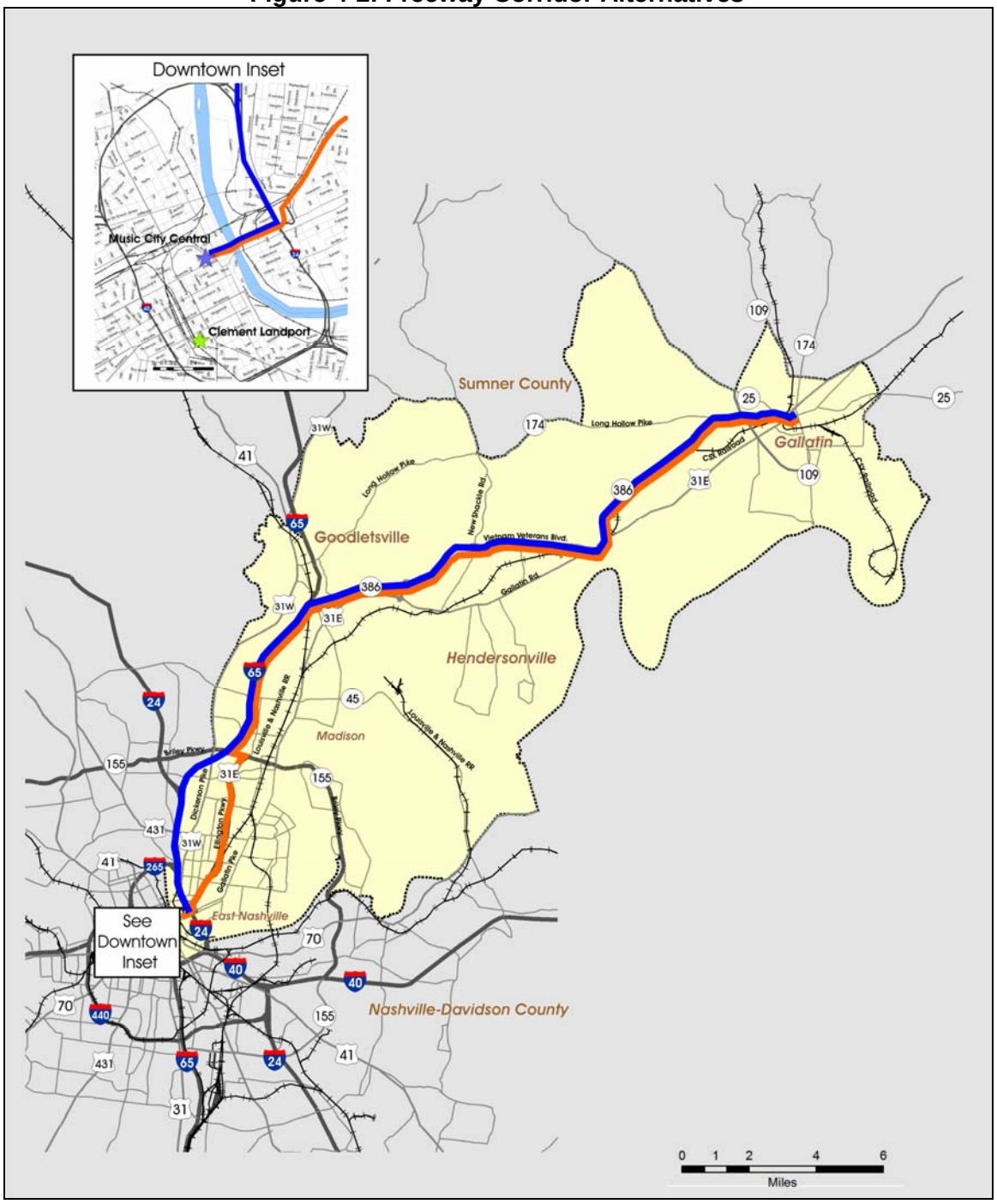


Figure 4-3: Arterial Corridor Alternatives

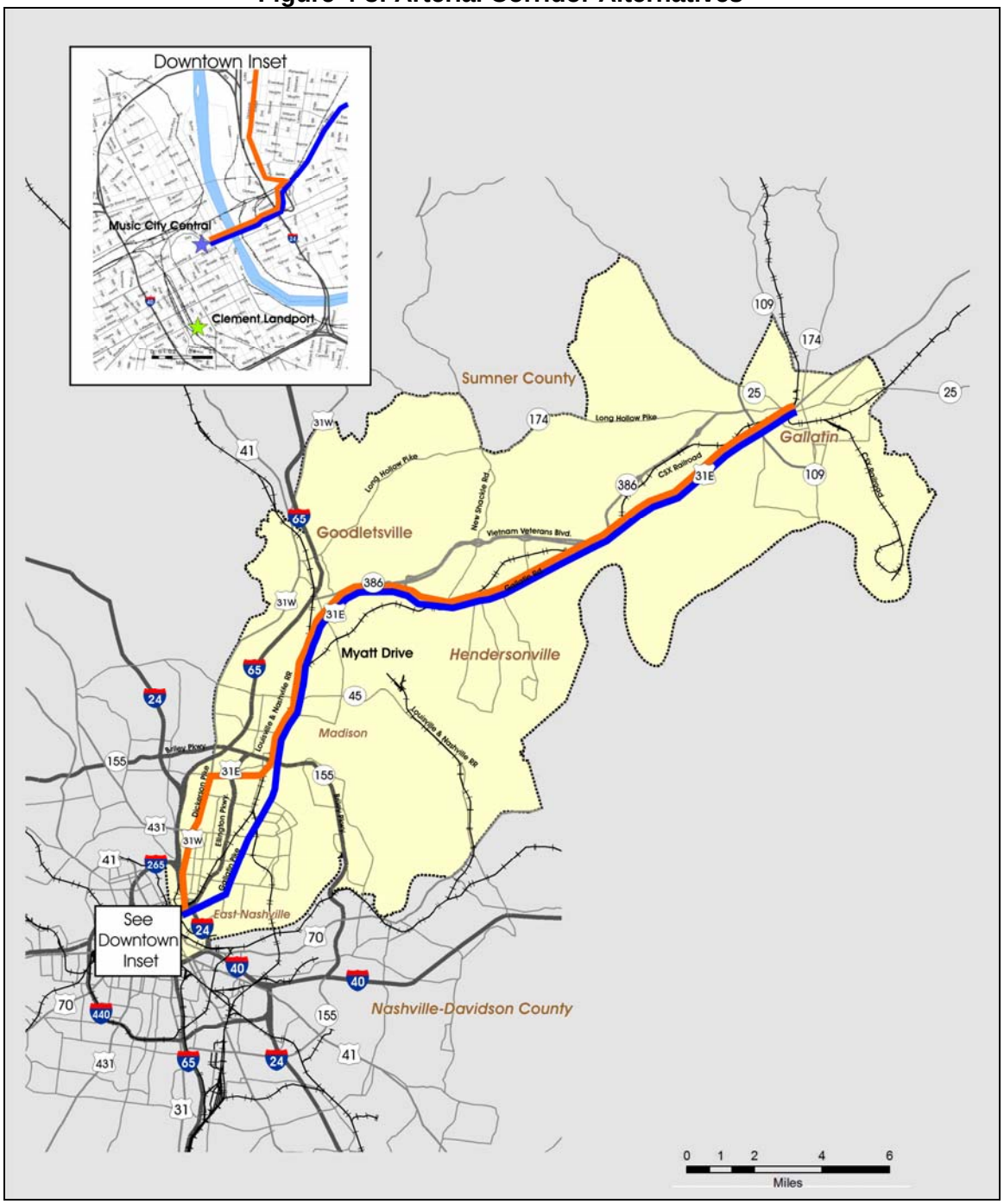
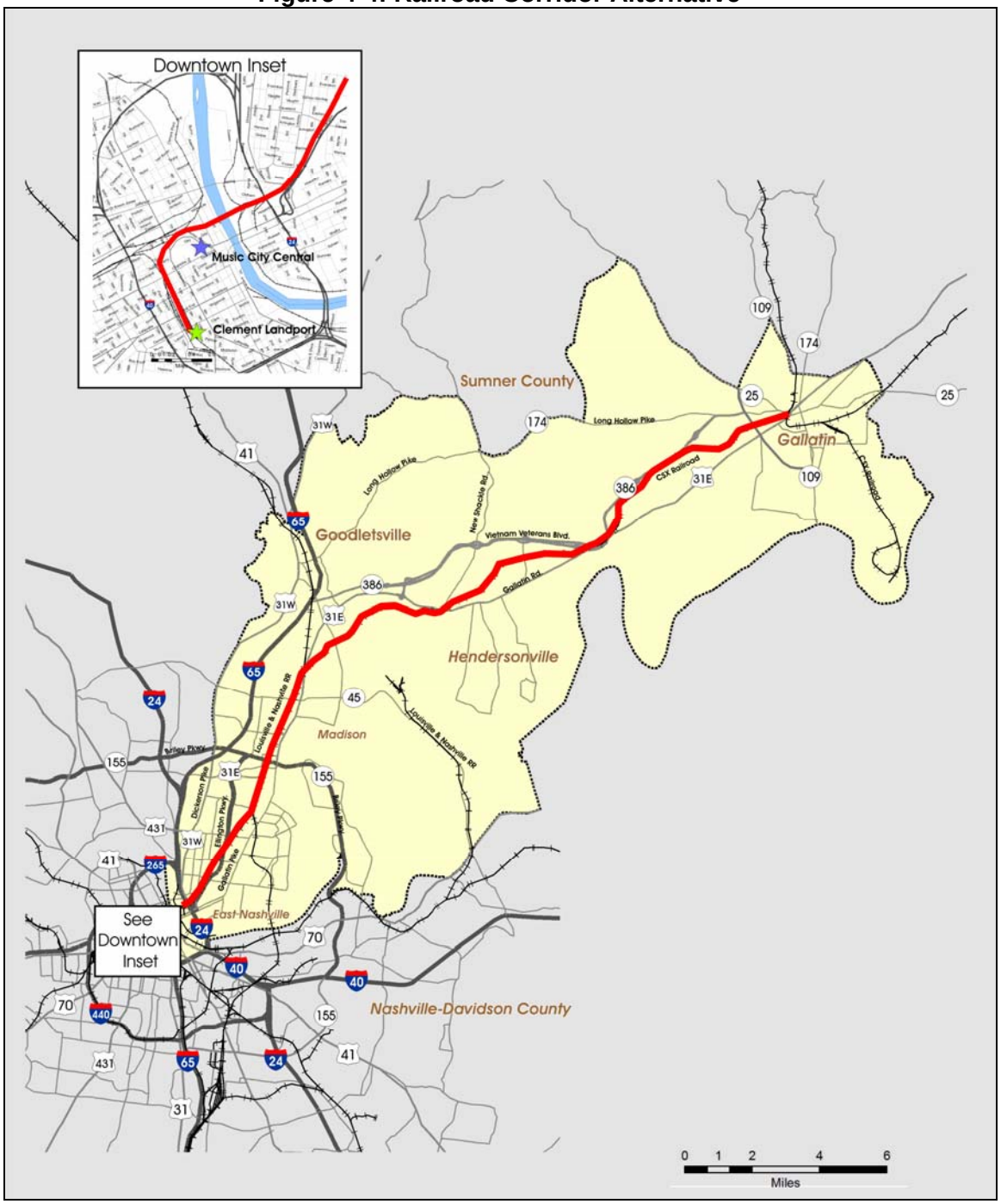


Figure 4-4: Railroad Corridor Alternative



It should also be noted that the alignments identified to date are extremely general in nature, and do not denote specific rights-of-way or other alignment engineering considerations. Station locations have not been identified for the alternatives. However, the station spacing will likely be similar to the ranges cited for each alternative technology in Chapter 2.

Two additional alternatives will be included, consistent with FTA planning guidance: a No-Build Alternative and a Baseline Alternative. These alternatives will be used as a basis for comparison in the detailed screening analysis, and are generally described as follows:

The **No-Build Alternative** will consist of the existing transportation network plus projects planned for and programmed for implementation in the short-term. These will include the projects in the MPO's current existing plus committed network (E+C) and additional projects local government are committed to implement.

A **Baseline Alternative** will be defined consistent with FTA New Starts planning guidance. FTA defines a baseline alternative as the "best that can be done" to improve transit service in the corridor without major capital investment in new infrastructure. It will emphasize transportation system upgrades, such as enhanced bus services, signal prioritization, transits hubs, real-time information systems, and off-board fare collection.

4.3 Evaluation of the Initial Alternatives

A qualitative screening method is being used to reduce the range of initial alternatives to no more than three alternatives. The three alternatives will be carried forward into the Detailed Screening Analysis. Six major evaluation criteria have been defined that tie back to the goals and objectives that were developed in the study's ***Purpose and Need Technical Memorandum.*** The criteria are as follows:

1. Proximity to Activity Centers and Community Facilities
2. Proximity to Higher Density Residential Areas
3. Proximity to Low Income and Minority Populations
4. Ability to Support Development Goals and Community Plans
5. Directness of Route Alignment
6. Relative Order of Magnitude Capital Cost

Each alternative is rated based on these criteria with a positive (+) rating by comparison, a neutral (=) rating by comparison, or a negative (-) rating by comparison. The results of this evaluation are displayed in Table 4-2.

Some general observations follow on the ratings given for each of the six criteria. This is followed by a brief discussion of the ratings that were given for each of the nine alternatives.

1. Proximity to Activity Centers and Community Facilities: These ratings reflect major destinations in the corridor in close proximity to the alignments. They also reflect the technology with respect to station spacing. Major destinations identified include existing and planned major activity centers (e.g., large shopping centers and malls, downtowns, large mixed-use developments) and community facilities (e.g., hospitals,

colleges, government centers). Major activity centers and community facilities are shown in Figure 4-5.

2. Proximity to Higher Density Residential Areas: As with the first criterion, ratings reflect a combination of alignment and technology. Higher ratings were given to alternatives with stations that would like be in close proximity to areas with transit supportive population and household densities. Study area population densities are generally highest south of Briley Parkway in East Nashville and in Madison, with pockets of higher densities to the north along the alignments, particularly in Hendersonville and Gallatin. Commuter rail score lower for these criteria because no station is anticipated within East Nashville. Projected population densities in 2030 are shown in Figure 4-6.

3. Proximity to Low Income and Minority Populations: These ratings also reflect a combination of alignment and technology, and relate to the provision of transportation options to transit dependent populations. Higher ratings were given to alternatives with stations that would like be in close proximity to areas with higher percentages of low income and minority populations. Data from the 2000 Census at the TAZ-level from the MPO's annual Title VI assessment was used for this criterion. Since many of the Title VI areas are within East Nashville, ratings were similar to the previous measure. Title VI areas are shown in Figure 4-7.

4. Ability to Support Development Goals and Community Plans: This criterion also reflects both the technology and the alignment. In this case LRT and BRT arterial alternatives are likely to have more potential than commuter rail or freeway LRT or BRT, given average station spacing. For the freeway corridor, Ellington Parkway receives a higher rating than I-65/I-24 given its location in the center of East Nashville and community plan transportation goals for it.

5. Directness of Route Alignment: Higher ratings were given to alternatives that provide the most direct alignment between Gallatin and Nashville. The Dickerson Pike option is the only alternative that would create significant out of direction travel.

6. Relative Order of Magnitude Capital Cost: Ratings for this criterion were based on the order of magnitude costs per mile for each technology, as the full length distance for each alternative is fairly similar.

Figure 4-5: Activity Centers and Community Facilities

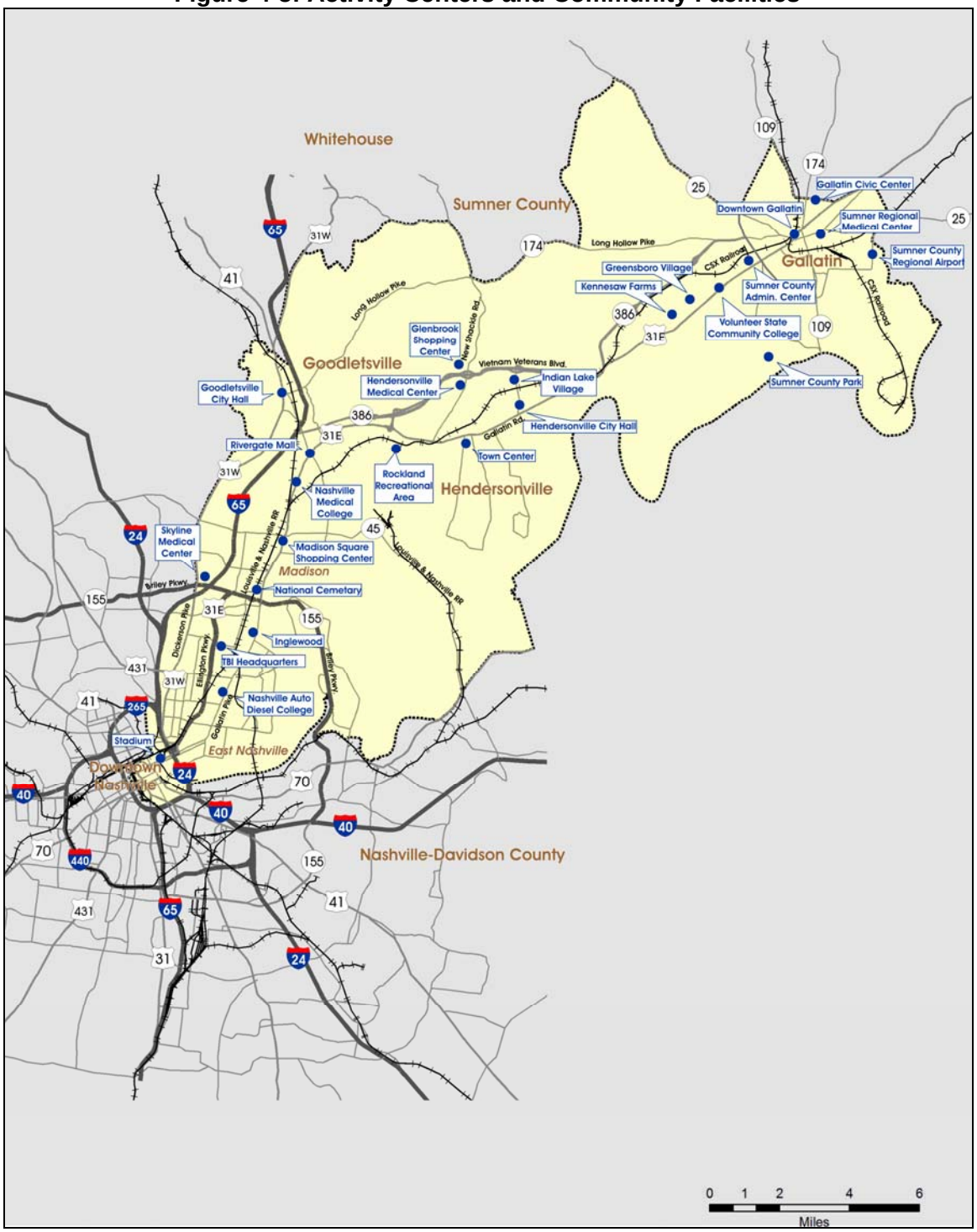


Figure 4-6: Projected Population Densities in 2030

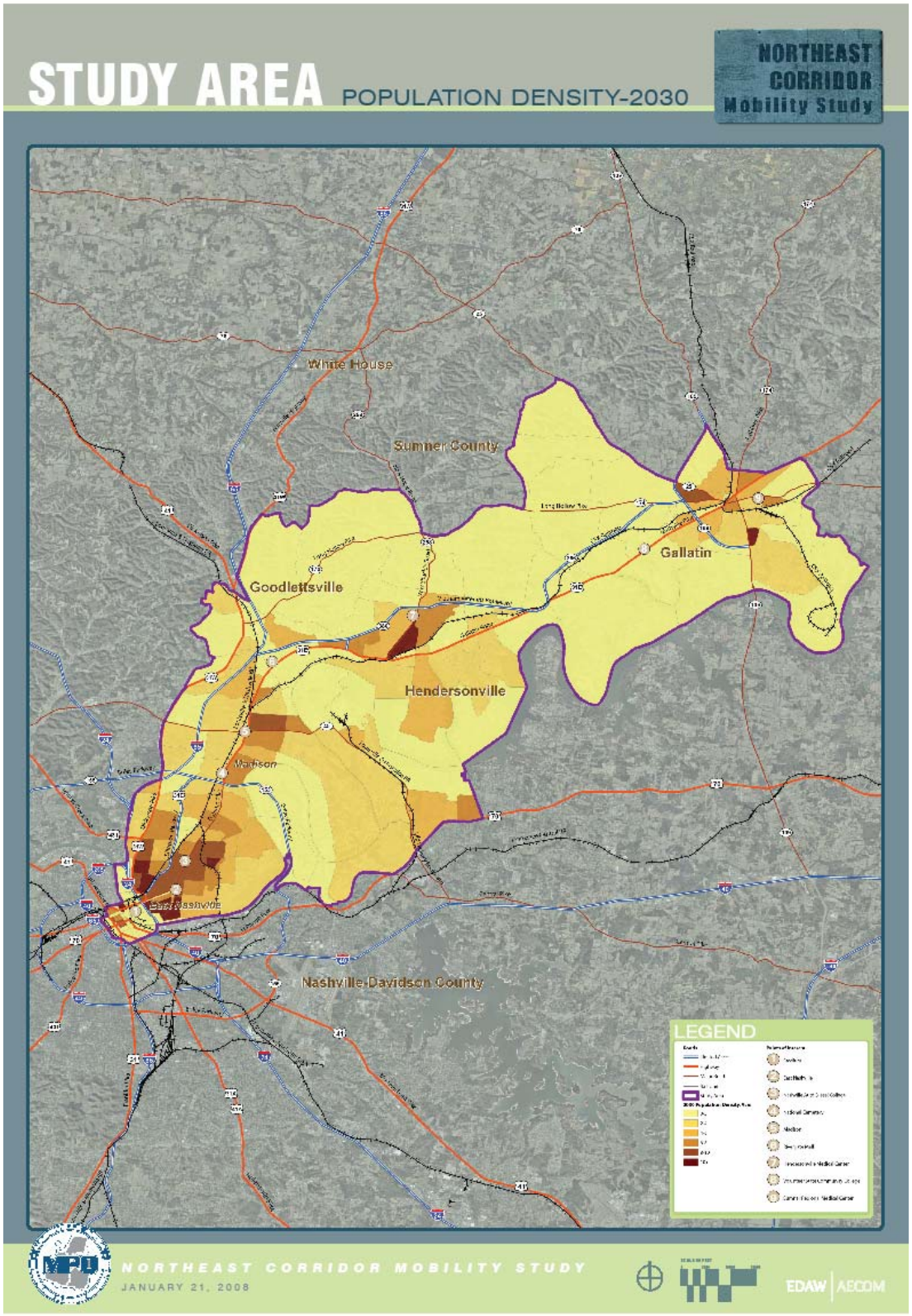
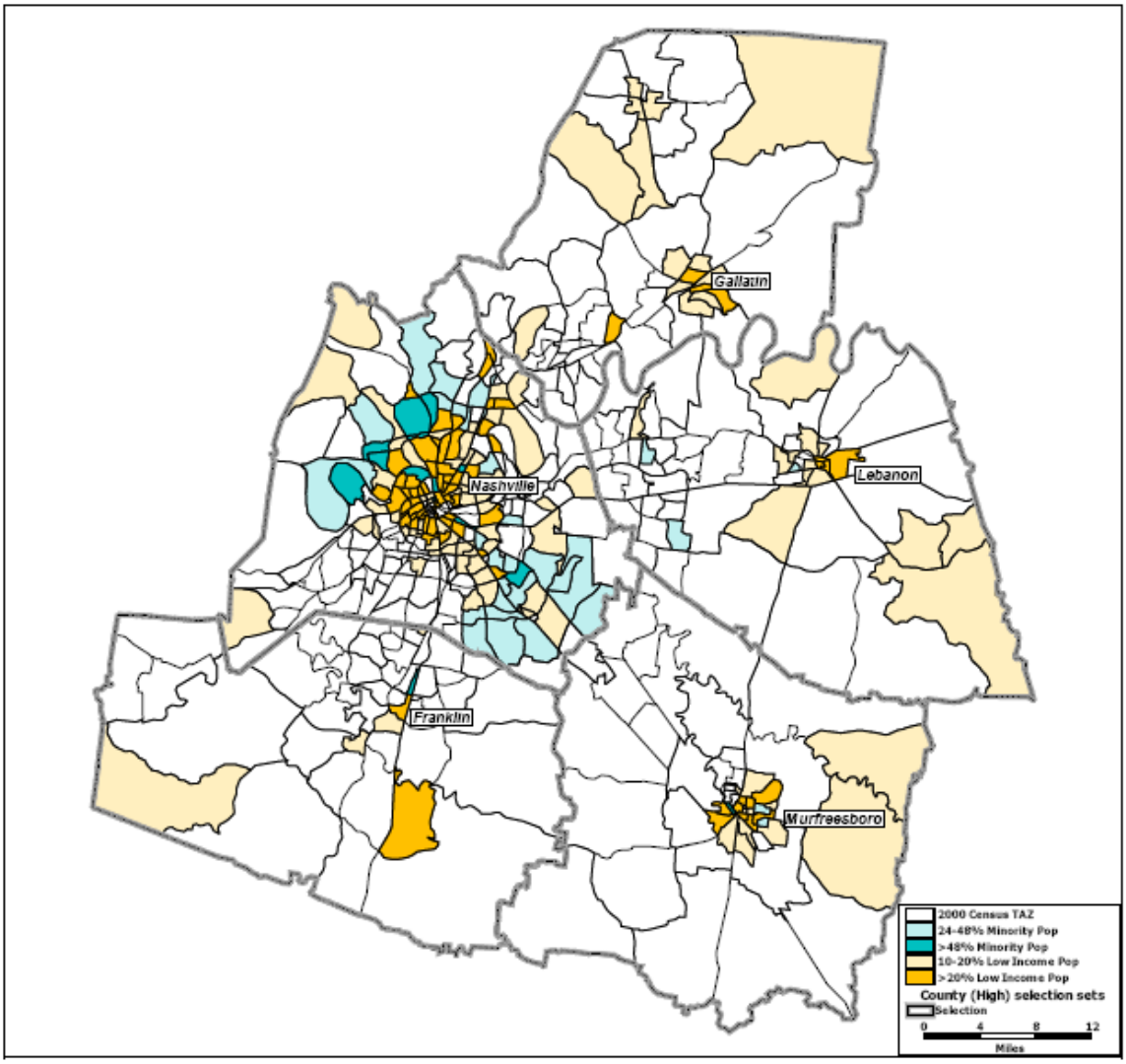


Figure 4-7: Low Income and Minority Area in 2000



Source: Nashville Area Metropolitan Planning Organization Title VI Report, May 2007

4.4 Alternatives Evaluation

The alternatives evaluated using the screening criteria listed above, and either chosen to carry forward for detailed screening, or eliminated based on one or more factors. Table 4-2 displays the evaluation matrix with all alternatives, criteria, and ratings.

There are six alternatives eliminated from further consideration for the Northeast Corridor. The overriding factors that eliminate these alternatives are highlighted in Table 4-2. The primary reason each was eliminated is described below.

- The **Freeway Corridor Option via I-65/I-24** received neutral or negative ratings overall. When compared with the Ellington Parkway freeway option, it provides less proximity to activity centers, higher density residential areas, and transit dependent populations.

Table 4-2: Initial Alternatives Evaluation Matrix

	Freeway Corridor (I-65/SR 386)				Arterial Corridor (US 31E/SR 6)				Railroad Corridor
	via I-65/I-24		via Ellington Pkwy.		via Gallatin Pike		via Dickerson Pike		via CSX
Initial Screening Criteria	**BRT**	**LRT**	**BRT**	**LRT**	**BRT**	**LRT**	**BRT**	**LRT**	**Commuter Rail**
Proximity to Activity Centers & Community Facilities	-	-	=	=	+	+	=	=	=
Proximity to Higher Density Residential Areas (2030)	=	=	+	+	+	+	+	+	-
Proximity to Low Income & Minority Populations (2000)	=	=	+	+	=	=	+	+	-
Ability to Support Development Goals & Community Plans	=	=	+	+	+	+	+	+	=
Directness of Route Alignment	=	=	+	+	+	+	-	-	+
Relative Order of Magnitude Capital Cost	=	-	=	-	=	-	=	-	+
Advance to Detailed Screening?	**No**	**No**	**Yes**	**No**	**Yes**	**No**	**No**	**No**	**Yes**

Rating scale:

- **+** Positive Rating by Comparison
- **=** Neutral Rating by Comparison
- **-** Negative Rating by Comparison

- The **Arterial Corridor Option via Dickerson Pike** was eliminated because its longer and less direct alignment compared to other alternatives creates significant out of direction travel.

- The **LRT Options in the Freeway and Arterial Corridors** were eliminated because, based on order of magnitude costs per mile, BRT options could provide similar service with lower capital costs than LRT

Three build alternatives were chosen for detailed screening based on the benefits they can provide to the Northeast Corridor as they compare to the screening criteria. The result of the evaluation is that one mode in each of the three corridors will be advance to detailed screening. The alternatives and their key features are listed below:

- **Freeway Corridor Build Alternative.** BRT in this corridor would operate via Ellington Parkway, I-65, and SR 386. It would operate in mixed traffic, capitalizing on the I-65 HOV lanes, or in exclusive bus lanes. The stations locations will be driven by interchange and overpass locations. Park & ride lots would be located at stations where feasible. The Ellington Parkway segment would serve higher density residential areas and transit dependent populations in the heart of East Nashville.

- **Arterial Corridor Build Alternative.** BRT in this corridor would operate via Gallatin Pike and US 31E/SR 6. It would operate in mixed traffic with low-cost improvements to bypass congested areas or in exclusive bus lanes. Stations would be more closely than in freeway corridor. This alternative offers the best proximity to activity centers and higher density residential areas in the Study Area.

- **Railroad Corridor Build Alternative.** Commuter rail in this corridor would operate via Commuter Rail via the CSX Railroad. Subject to a negotiated agreement with CSX, it would utilize the existing freight tracks to the extent possible. Stations would be more widely-spaced that in the other corridors. The limited number of stations along this corridor will impact its benefits to higher density residential areas and transit dependent populations.

4.5 Summary of Development of Alternatives

By a combination of technology screening and qualitative analysis, three build alternatives have been selected for further analysis in the next step of the study, the detailed screening analysis. In addition to the build alternatives, a No-Build Alternative and Baseline Alternative will also be defined and evaluated. Thus, the following five alternatives will advance to detailed screening:

- No-Build;
- Baseline;
- BRT in the Freeway Corridor (SR 386/I-26/Ellington Parkway);
- BRT in the Arterial Corridor (US 31E/SR 6/Gallatin Pike); and
- Commuter Rail in the CSX Corridor.

Appendix A

Order-of-Magnitude Capital Cost Data for Modes

Order-of-Magnitude Capital Cost Data for Modes

Mode	City	Project	Mileage	Stations	Year of Exp. Cost	Year of $	2007 Cost/Mile
HRT	Atlanta	MARTA - North Line Ext.	2.3	2	$463,180,000	1998	$283,826,772
	Los Angeles	Metro - N. Hollywood Ext.	6.3	3	$1,310,000,000	1998	$293,063,777
	San Francisco	BART-SFO	8.7	4	$1,510,000,000	2000	$231,549,340
	Washington	Largo Metrorail Ext.	3.1	2	$433,900,000	2000	$186,729,876
	Miami	North Corridor Extension	9.5	7	$1,372,190,000	2010	$128,407,570
	N. Virginia	Dulles Corridor Ext.-Wiehle Ave	11.6	5	$2,065,000,000	2010	$158,256,679
HRT Order-of-Magnitude Costs:					**Min. Cost/Mile**		$128,407,570
					Avg. Cost/Mile		$213,639,003
					Max. Cost/Mile		$293,063,777
LRT	Denver	West Corridor	11	14	$624,300,000	2006	$59,592,273
	Houston	Downtown to Astrodome	7.5	16	$300,000,000	2002	$51,051,263
	Los Angeles	Mid-City Exposition	9.6	10	$343,900,000	2008	$34,117,063
	Minneapolis	Hiawatha	11.6	17	$675,400,000	2002	$74,310,394
	Portland	Interstate MAX	5.8	10	$350,000,000	2002	$77,016,991
	Sacramento	South LRT	6.3	7	$222,000,000	2001	$47,222,418
	Salt Lake City	CBD to University	2.5	4	$105,800,000	2000	$56,458,783
	Salt Lake City	Medical Center Ext.	1.5	3	$89,400,000	2002	$76,066,381
	San Diego	Mid Coast Corridor	3.4	3	$131,500,000	2006	$40,610,294
	Phoenix	East Valley Corridor	19.6	27	$1,412,120,000	2007	$72,046,939
	Denver	Southeast	19.1	13	$879,270,000	2007	$46,035,079
	Dallas	Northwest/Southeast MOS	21	16	$1,406,220,000	2009	$61,910,926
	Portland	S. Corridor I-205/Portland Mall	8.3	15	$557,400,000	2007	$67,156,627
	Sacramento	S. Corridor Extension	4.3	4	$226,250,000	2008	$50,592,576
	St. Paul-Minneap.	Central Corridor	11	16	$932,300,000	2012	$69,662,058
LRT Order-of-Magnitude Costs:					**Min. Cost/Mile**		$34,117,063
					Avg. Cost/Mile		$58,923,338
					Max. Cost/Mile		$77,016,991
Comm. Rail	Kansas City	Johnson County I-35	23	5	$30,900,000	2004	$1,555,244
	Lowell	Lowell-Nashua Ext.	12	1	$40,700,000	2004	$3,926,278
	Seattle	Everett to Seattle Line	35	6	$104,000,000	2004	$3,439,800
	Seattle	Lakewood to Tacoma Line	8	3	$86,000,000	2002	$13,720,027
	Wash. Cty, OR	Wilsonville-Beaverton Line	15.3	5	$82,800,000	2005	$5,966,471
	Salt Lake	Weber Co. to Salt Lake City	44	8	$611,680,000	2007	$13,901,818
	Minneapolis	Northstar Corridor Rail	40.5	5	$307,320,000	2007	$7,588,148
	Nashville	Music City Star	32	6	$40,000,000	2006	$1,300,000
	Albuquerque	Rail Runner Phase I	47	9	$135,000,000	2007	$2,872,340
Commuter Rail Order-of-Magnitude Costs:					**Min. Cost/Mile**		$1,300,000
					Avg. Cost/Mile		$6,030,014
					Max. Cost/Mile		$13,901,818
Frwy/ Major BRT	Cleveland, Ohio	Euclid Corridor	9.8	30	$228,600,000	2004	$27,003,375
	Honolulu	Primary Corridor	32.2	31	$683,400,000	2004	$24,568,973
	Pittsburgh	MLK East Busway Extension	2.3	?	$62,800,000	2002	$34,848,036
	Los Angeles	San Fernando Valley E-W Cor.	14.4	13	$314,000,000	2003	$26,504,789
	Hartford	New Britain-Hartford Busway	9.4	11	$458,780,000	2010	$43,388,697
	Houston	North Corridor BRT	5.4	8	$275,340,000	2010	$45,328,937
	Houston	Southeast Corridor BRT	6	11	$169,840,000	2010	$25,164,524
Freeway/Major BRT Order-of-Magnitude Costs:					**Min. Cost/Mile**		$24,568,973
					Avg. Cost/Mile		$32,401,047
					Max. Cost/Mile		$45,328,937
Enhanced Arterial BRT	Kansas City	Troost Corridor BRT	9	25	$30,730,000	2010	$3,035,429
	Springfield	Pioneer Parkway EmX BRT	7.8	14	$36,990,000	2010	$4,215,894
	Grand Rapids	The Rapid	10	n/a	$33,600,000	2007	$3,360,000
Enhanced Arterial BRT Order-of-Magnitude Costs:							$3,537,108
Premium Arterial BRT	Atlanta	SR 120	39	n/a	$311,468,000	2002	$13,008,937
	Atlanta	SR 92/SR 140	45.3	n/a	$327,538,000	2002	$11,777,591
	Atlanta	Camp Creek Pkwy	15.1	n/a	$111,452,000	2002	$12,022,753
Premium Arterial BRT Order-of-Magnitude Costs:					**Avg. Cost/Mile**		$12,269,760
Monorail	Jacksonville	Jacksonville Skyway	2.5	8	$67,000,000	1994	$76,000,000
	Las Vegas	Las Vegas Monorail	4.7	7	$127,000,000	2000	$152,000,000
Monorail Order-of-Magnitude Costs					**Min. Cost/Mile**		$76,000,000
					Avg. Cost/Mile		$114,000,000
					Max. Cost/Mile		$152,000,000
AGT	Vancouver	Vancouver Sky Train	18	33	$82,700,000	2005	$89,000,000
	Miami	Miami Metromover	7.1	22	$145,400,000	2005	$157,000,000
AGT Order-of-Magnitude Costs					**Min. Cost/Mile**		$89,000,000
					Avg. Cost/Mile		$123,000,000
					Max. Cost/Mile		$157,000,000