SOUTH FLORIDA
EAST COAST CORRIDOR
ALTERNATIVE ANALYSIS

Modal Technologies

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TABLE OF CONTENTS

INTRODUCTION

The South Florida East Coast Corridor (SFECC) extends almost 100 miles from Tequesta in Palm Beach County through Broward County to two potential termini: (Downtown Miami and the Miami Intermodal Center) in Dade County. The SFECC study area is roughly centered upon the alignment of the Florida East Coast Railroad (FEC) and paralleled in large part by the South Florida Rail Corridor (SFRC), Interstate 95, Dixie Highway and US Route 1.

Existing transit services in the SFECC study area are outlined in the *Existing Conditions Report.* A range of new passenger transport services are also being considered in the Corridor to address growing regional transportation needs. These new services would be additive and/or supplemental to the services already operating in the study area.

The purpose of this memorandum is to describe the range of passenger transportation modes that should be considered for the SFECC study area as part of the alternatives analysis.

URBAN TRANSIT MODES

MODAL DISTINCTIONS[1]

An urban transit mode is defined by three basic characteristics:

- *Right of Way (ROW)* category, distinguished by their degree of separation from other vehicular and pedestrian traffic. There are three basic categories of ROW:
  - *Category A*, which is a fully controlled ROW without grade crossings or legal access by other vehicles or pedestrians (in most cases, a ROW with widely spaced, signalized and gated at-grade crossings may be considered Category A if such crossings have little effect on line performance).
  - *Category B,* which is longitudinally separated by physical barriers (curb, barriers, grade separations) from other traffic but with at-grade crossings for vehicles and pedestrians, including frequent street intersections without gate protection.
  - *Category C,* which represents surface streets with mixed traffic

ROW Category A has the following advantages (+) and disadvantages (-) over ROW Category B:

+ Highest performance in terms of speed, reliability, capacity, riding comfort and safety.
+ Separation from other traffic and control systems result in the safest transit services.
+ Permits operation of longer trains, reducing costs per passenger.
+ Level floor boarding through multiple doors minimizes dwell times.
- Higher initial capital investment (except for some regional rail on railroad ROW).
- Less flexible in response to changes in passenger travel patterns.
- Higher cost, more complicated stations.

ROW Category B has the following advantages (+) and disadvantages (-) over ROW Category C:

+ Considerably higher performance in terms of speed, reliability, capacity, riding comfort and safety.
+ Ability to operate trains of two or more vehicles with a single operator (rail modes).
+ Stronger system identify and image.
+ Lower operating costs per passenger.
- Urban space required for ROW.
- Higher initial capital investment.
- May require special transit/traffic control and priority treatments.

[1] The following discussion of modality is based, for the most part, on the hierarchy of transit modes described by Dr. Vukan R. Vuchic in *Urban Public Transportation Systems and Technology* (Prentice-Hall, 1981) and elsewhere.

(transit vehicles may have preferential treatment such as reserved lanes separated by lines or special signals, or travel mixed with other vehicles and pedestrians.

The modal characteristics typically associated with different ROW categories are summarized in Table 1.

Table 1. Characteristics of Modes with Different ROW Categories

	Right of Way (ROW) Category		
	A	B	C
System Performance	High	High	Moderate
Initial Investment Costs	High	Moderate	Low
Level of Service	High	High	Moderate
Image/Identification	Strong	Strong	Weak
Passenger Attraction	High	High	Weak
Potential Influence on Urban Form	Strong	Moderate	Weak
Possible Degree of Automation	Full	Limited	None

- *Technology,* distinguished by the mechanical features of the transit vehicles and way. The four most important technology features are:
  - *Support*, the vertical means by which the vehicle's weight is transferred to the riding surface. The most common types are r*ubber tires* on a concrete, asphalt or other surface, and steel wheels on steel rail. Other types of support can include a hull or foil in water, air cushions, and magnetic levitation.
  - *Guidance,* the means by which the vehicle is steered. Most rubber-tired vehicles are guided by an operator (driver) while steel wheeled vehicles are guided by their rails. A distinct feature of rail technologies are that the rail/wheel assembly combines support and guidance (externally guided rubber-tired vehicles require additional wheels and surfaces for guidance). Guided systems also provide the opportunities to enhance system performance and safety through control systems of various complexities up to and including complete automation.
  - *Propulsion,* distinguished by its means of locomotion and the method of transferring the tractive forces of acceleration and deceleration. The most common means of locomotion are internal

Using steel-wheels vs. rubber-tires for support has the following advantages (+) and disadvantages (-):
+ Fewer wheels are required (up to 2/3 less), lowing rolling resistance, energy consumption, and operating costs.
+ Less complicated, more compact switches, junctions and yard configurations.
+ Higher speed capabilities.
+ Elimination of rubber-dust hazards and maintenance requirements in enclosed spaces.
+ Elimination of independent guidance systems.
- Rubber-tired systems can negotiate sharper turning radii and steeper grades.
- Rail vehicles produce more noise and vibration in sharp curves.

Using guided vs. steered transit vehicles have the following advantages (+) and disadvantages (-):
+ Ability to use larger vehicles operating in trains, increasing capacity and reducing operating costs per passenger.
+ Higher overall performance in terms of speed, reliability, and safety.
+ Control systems enhance safety thorough possible fail-safes and automation.
+ Require narrower ROW.
+ Exact ROW delineation when operating in areas of pedestrian traffic.
- Higher initial capital investment.
- Less flexible in response to changing passenger travel patterns.

combustion engines (ICE) or electric motors, although hybrid combinations of both are becoming increasingly popular. The predominant means of transferring tractive forces is through friction/adhesion, although there are limited examples where the transfer is made through electromagnetic force (linear induction), cables, cogs and propellers (for waterborne modes).

> Using electric vs. diesel propulsion has the following advantages (+) and disadvantages (-):
> + Produces higher acceleration and higher overall commercial/operating speeds.
> + Regenerative braking recovers energy, reducing consumption.
> + Produces less noise and vibration.
> + Produces no air pollution in areas of passenger concentration, compatible with tunnels and enclosed spaces.
> + Eliminates transport of flammable materials. thorough possible fail-safes and automation.
> - Higher initial capital investment.
> - Power failure halts all affected vehicles.
> - Overhead wires vulnerable to storm damage.
> - Third-rail hazardous near pedestrians.

- *Service*, distinguished by the differing levels of service provided. The three characteristics that define service type are:
  - o *Service Extent*, reflecting the intended markets for the service, subdivided into:
    - – *Community Service,* typified by circulator services directed towards providing access to or within a specific market area such as a central business district, neighborhood, campus, or airport.
    - – *Metropolitan Service,* the most common service type, reflecting a line-haul function serving an entire city along a generally defined corridor.
    - – *Regional Service,* serving the entire region along a defined corridor.
  - o *Stop Density*, reflecting the frequency of stop spacing along a route. The most common service types have frequent stops spaced within blocks of each other. Other services have stops spaced on average a quarter-mile or more apart, while some regional services average four miles or more between stops. Note that expedited service patterns (e.g.: express or skip-stop service) do not by themselves constitute a fundamental change of stop density with respect to the definition of mode.
  - o *Time of Operation,* reflecting the duration of service. Most basic transit services operate daily from early morning to evening. Other services operate only during peak periods of travel or periodically in conjunction with special events, and should be considered as a supplement to rather than a substitute for all-day transit service.

There are no meaningful definitions of what differences in right-of-way, technology or service constitute a unique mode. Technology alone is an unreliable determinate of mode. For example, the functional characteristics of the Illinois extension of the St. Louis Metrolink system are comparable to those of a regional (commuter) rail service in terms of station spacing and extent despite its use of light rail transit (LRT) technologies. Conversely, much of Philadelphia's commuter rail network is evocative of LRT despite being operated with rolling stock fully compliant with Federal Railroad Administration (FRA) regulations. The clearest differentiator between urban transit modes is typically right-of-way, which serves as a proxy for operating speed and reliability.

No clear correlation between urban transit modes can be drawn solely on a basis of one or two characteristics. This is demonstrated in the matrix of modes classified by ROW category and major technology characteristics (primarily support and guidance) provided in Table 1. ROW categories closely correspond to but do not precisely define modal distinctions. ROW Category C can be used by low-end street modes (regular buses and streetcars) as well as higher-capacity modes such as bus rapid transit (BRT), guided bus and LRT. But higher-capacity modes require at least a significant proportion of ROW Category B in order to achieve the higher commercial (average operating) speeds. Rail or rubber-tired rapid transit modes and regional (commuter) rail all require ROW Category A by definition, but that ROW category can also include lighter-capacity modes that would not otherwise provide the productive capacity rapid transit, such as BRT, LRT, automated guided transit (AGT), personal rapid transit (PRT) and monorails. Other specialty modes do not clearly correlate to any of the three groupings, such as waterborne transit and cable-propelled funiculars, aerial tramways or cable cars.

Table 2. Matrix of Urban Transit Modes by ROW Category and Technology

Technology:	Rubber-Tired Steered Vehicles	Rubber-Tired Guided Vehicles	Steel-Wheeled Guided Vehicles	Other
ROW Category C:	Regular Bus Express Bus Trolley Bus		Streetcar	Cable Car
ROW Category B:	Bus Rapid Transit	Guided Bus	Light Rail Transit	
ROW Category A:		Rubber-Tired Rapid Transit Monorails Automated Guided Transit Personal Rapid Transit	Rail Rapid Transit Regional (Commuter) Rail	Ferryboat Aerial Tramway Funiculars

Most modes can be grouped into one of three generic classes based predominately on right-of-way category, however:

1. *Street Transit*, consisting of modes operating in a mixed traffic environment (ROW Category C). Modes of this class operate at commercial speeds lower than that of surrounding traffic due to time lost at passenger stops. Reliability is often compromised as the result of various interferences. Many forms of regular bus transit (RBT) fall within this class using rubber-tired, steered vehicles and various propulsion technologies (ICE, electric, hybrid). Streetcars (SCR) are a form of street transit using guided, electrically propelled vehicles.

2. *Semi-Rapid Transit,* consisting of modes operating mostly in ROW Category B but using ROW Categories A and C when available. Modes of this class operate at commercial speeds higher than adjacent corridor traffic, although that advantage is diminished by time lost at passenger stops (but to a lesser degree than for street transit modes, as stops are more widely spaced). Higher forms of semi-rapid transit can match or exceed the speed and reliability of auto travel. There are, however, a broad range of performances represented in this class of mode depending on the degree and location of ROW separation, from bus rapid transit (BRT)[2] and light rail transit (LRT) operating predominately in ROW Categories B and C to largely grade-separated LRT systems in

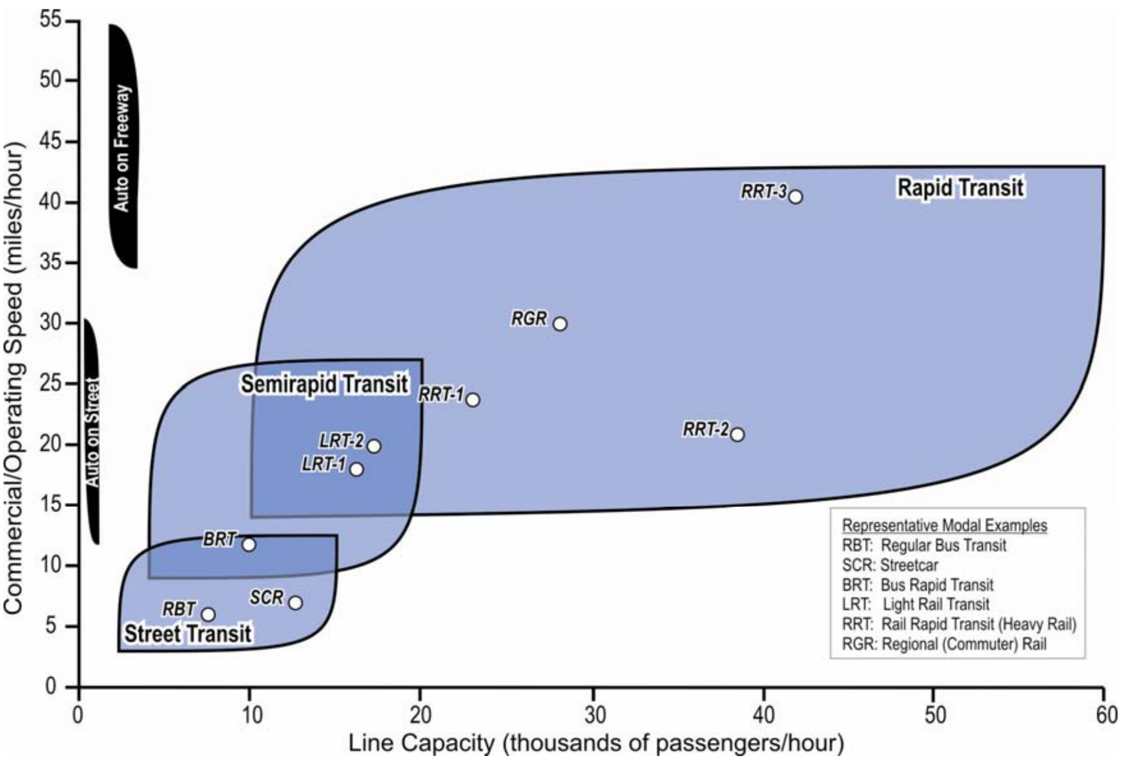
[2] Vuchic more appropriately titles this as "semi-rapid bus," noting that BRT does not possess all the characteristics of a true rapid transit mode.

ROW Categories A and B. Technology is more a factor with semi-rapid transit as rail modes can operate in short trains and safely move at higher speeds through automatic signalization (driver-steered modes do not share this advantage).

3. *Rapid Transit*, consisting of modes operating almost exclusively on ROW Category A and exhibit high speeds, capacity, reliability and safety. All existing rapid transit systems use guided technologies (rubber-tired or rail), which permit operating trains (higher capacity and lower operating costs) and automatic signaling or train control (higher safety). Rapid transit modes running on tracks that are part of the general network of railroads under the jurisdiction of the FRA operate in a different regulatory environment from other rail transit modes and fall in the general modal category of regional rail transit (RGR), also referred to as "commuter rail."

The relationship between these three groupings of mode is illustrated in Figure 1, which plots transit productive capacity in terms of commercial (operating) speeds versus functional line capacity. Note that the three groupings overlap, such that BRT can represent a "high-end" form of Street Transit as well as a lower-end Semi-Rapid Transit mode, and LRT can represent a "low-end" form of Rapid Transit as well as a higher-end form of Semi-Rapid Transit. There can be a wide variation in the productive capacity associated with individual modes, as illustrated by the placement of the three examples of Rail Rapid Transit (RRT). As such, transit modes represent a continuum of right-of-way, technology and service type combination rather than a succession of discrete technological quanta.

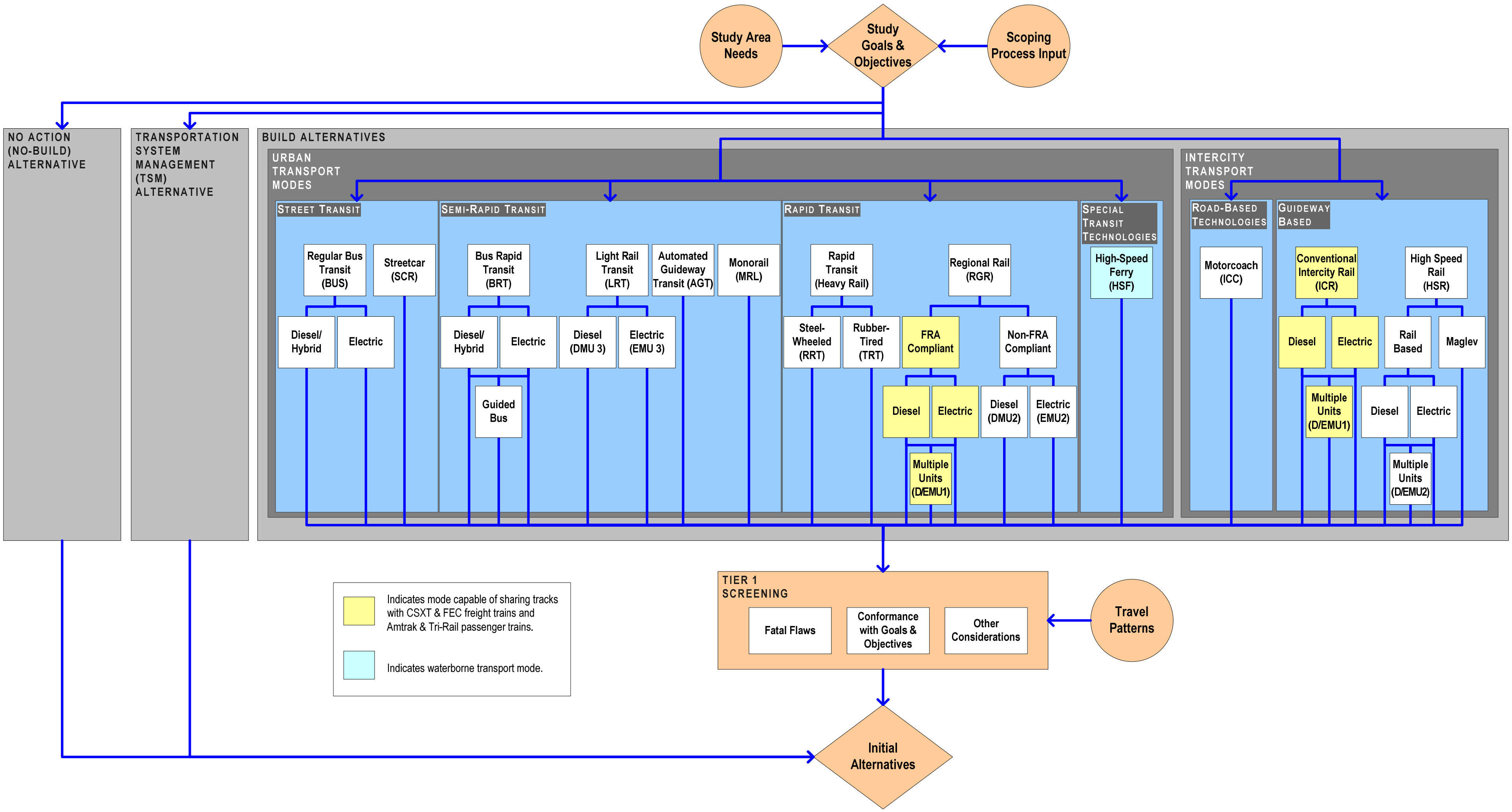
Figure 1. Comparative Transit Productive Capacity by Modal Groupings



Adapted from Urban Public Transportation Systems and Technology (Vuchic)

Figure 2 outlines the SFECC alternatives development and evaluation process. The following sections provide generic information concerning specific urban transit modes, organized in these three groupings.

Figure 2. SFECC Alternative Development & Evaluation Process



STREET TRANSIT MODES

Street transit modes consist of modes operating in a mixed traffic environment (ROW Category C). Modes of this class operate at commercial speeds lower than that of surrounding traffic due to time lost at passenger stops. Reliability is often compromised as the result of various interferences.

Regular Bus Transit

Overview

Regular bus transit (RBT) is a relatively low capacity urban transit mode using conventional transit buses typically on public streets in mixed traffic. RBT services typically operate on a fixed-schedule over a fixed-routing, although schedules and routes can be varied in "real time" in response to passenger demand.[3] RBT service levels can be easily tailored to match changes in passenger demand by adjustments in service frequency and/or vehicle size.

RBT represents the most common form of urban public transit, operating on standard roadways in mixed traffic using driver-guided motorbuses. It is typically the "backbone" of an urban transit network, providing service within and between urban centers and facilitating circulation within the community. This reflects a key attribute of RBT, which is its ability to combine feeder, line-haul and distributor functions, offering passengers a one-seat ride from origin to destination. Buses can be easily rerouted to serve new or transient traffic generators or detour around.

Use of public roadways virtually eliminates any special infrastructure requirements for RBT. Passenger stops can be as simple as a defined curbside location, with signage and sometimes passenger shelters as the only amenities.

Typical Characteristics

Minimum Right-of-Way Requirements	Traffic Lanes
Operating Speeds	6 to 12 mph (average/commercial speed) 65 mph (maximum)
Station Spacing	⅒ to ¼ mile
Station Type	Defined locations along public sidewalks
Vehicle Size	40 feet long by 9 feet wide (nominal) Non-articulated options range from 25 to 45 feet in length Articulated options can be up to 65 feet in length
Vehicle Capacity (seated and standing)	12 to 125 passengers (60 nominal)
Vehicle Propulsion	Internal Combustion Engine[4] with mechanical or electro-mechanical transmission.

[3] Paratransit and "dial-a-ride" services are the most flexible variation of RBT and completely demand-responsive.

[4] Typically diesel but alternative fuel options abound.

Consist (Train Length) ....Single units
Nominal Extent (Route Length).........................3 to 10 miles
Maximum Frequency (peak direction) ....60 moves per hour per lane
Nominal Line Capacity (peak direction)............2,400 to 7,500 passengers per hour

Technological Variations

Electric Trolley Bus (ETB) is a variation of RBT using conventional transit buses using only electric motors for propulsion. Power is drawn through a pair of poles from an overhead contact-wire system.

Electric Trolley Bus

ETB vehicles can be articulated or non-articulated and share most of the other characteristics associated with RBT. ETB possesses superior acceleration characteristics due to the use of electric traction and an off-vehicle power source. Power distribution system infrastructure and maintenance requirements are significantly greater than RBT. Overhead wires, however, are vulnerable to damage from storms and wind-blown debris.

Regional Bus (RGB) is a long-distance variation of RBT using conventional over-the-road motorcoaches or conventional urban transit buses fitted with "suburban-style" seating for longer-distance, limited stop service. Line-haul RGB services are of a regional extent (15 to 50 miles) exhibit high commercial speeds (averaging 35 mph) and broad stop spacing (5 to 10 miles), differentiating them from other street transit modes.


Regional Bus

The infrastructure associated with RGBs is relatively minor as they typically use existing roadways and limited access highways, occupying high-occupancy vehicle (HOV) lanes where available. On-highway passenger stations can increase capital costs but provide opportunities to access intermediate markets without losing time exiting and re-entering the highway.

RGB service is often operated as a supplement to a regional line-haul rapid transit service in a corridor. GO Transit, centered on Toronto, uses integrated RGB services as peak-period feeders to and off-peak substitute for its commuter railroad trains, based on the principle that more costly train service should operate only when there is sufficient ridership to justify their expense. RGB services are a more cost-effective means of sustaining levels of service to outlying train stations at all other times. RGB services are sometimes operated as a precursor to a more capitally intensive regional line-haul rapid transit service in a corridor.

Examples

RBT services are operated throughout the SFECC study area by Miami-Dade Transit, Broward County Transit, and Palm Beach County Transit (Palm Tran) as well as a number of specialty and human services carriers. There are thousands of RBT operations throughout North America. EBTs can be found in Boston, Dayton, Edmonton, Mexico City, Philadelphia, San Francisco, Seattle, Toronto, and Vancouver. There are scores of RGB services operating through North America as regional supplements to urban transit networks, the most notable examples serving Toronto, New York City, Seattle, Denver, St. Louis, and Boston.

Applicability to the South Florida East Coast Corridor Study

RBT services already operate throughout the SFECC study area. The mode's low capacity, relatively slow commercial speed and short nominal extent limit its applicability as a new primary line-haul service for the SFECC. RBT services have the potential to be a significant secondary service throughout the service area, providing necessary collector and distributor functions in support of primary corridor line-haul service. RGB services could also function as an off-peak substitute for primary line-haul service in the corridor.

Streetcar

Overview

Streetcar (SCR) is a low capacity urban transit mode using electrically self-propelled vehicles on rails typically embedded in public streets, operating in mixed traffic. SCR service levels can be tailored to match changes in passenger demand by adjustments in service frequency and/or consist (train length), although the practicality of the latter strategy is often limited by traffic and stop considerations.

SCR is essentially a shorter distance, lower speed variant of LRT, designed to function exclusively as a circulator within urban centers. As such, the relationship between LRT and SCR can be compared to that of former interurban railways and city streetcar systems in the early 20th Century in the US, or that of the *stadtbahn* and *straßenbahn* systems presently operating in Germany and elsewhere in Europe.

The technologies utilized by LRT and SCR systems are fundamentally the same. The boarding, fare collection, and the interior of SCR vehicles, however, are typically configured to accommodate a greater proportion of larger volumes of standee passengers reflective of a propensity for relatively short passenger trip lengths as well as the need to handle surges in traffic following the bulk discharge from major activity centers and/or special events.

The circulator function of a SCR system results in a specialized set of design criteria for its infrastructure and vehicles:

- SCR vehicles operate mostly in mixed traffic and therefore have performance optimized for slower speed ranges and maximum speeds not exceeding 50 miles per hour, more nearly reflecting the characteristics of vehicular traffic within a CBD.
- SCR vehicles operate over alignments designed to negotiate urban center street patterns with smaller turn radii

(50 feet/15 m or less) and more complicated curves than most LRT track standards recommend.

- SCR system scheduling practice relies more on service frequency than on train length to provide sufficient capacity for passenger demand, so multiple-unit (MU) operational capability (i.e., operating several cars coupled together in a train) is seldom required. Shorter trains provide a better "fit" into pedestrian-oriented urban streetscapes.
- Most SCR systems have simpler, single-car stops integrated with public sidewalks. They also have more frequent stops in comparison to most LRT systems.

Infrastructure requirements for SCR include tracks, power and special passenger stops. Passenger stops are typically curbside locations integrated into public sidewalks, improved with special signage, passenger shelters and raised edges to facilitate car-floor level boarding.

Typical Characteristics

Minimum Right-of-Way Requirements	Traffic Lanes
Operating Speeds	6 to 12 mph (average/commercial speed) 45 mph (maximum)
Station Spacing	⅒ to ¼ mile
Station Type	Passenger stops along public sidewalks
Vehicle Size	Typically 50 feet long by 8½ feet wide for rigid car body options Articulated options range from 76 feet to over 120 feet in length
Vehicle Capacity (seated and standing)	100 to 240 passengers
Vehicle Propulsion	Electric, typically drawn from OCS through poles or pantographs
Consist (Train Length)	Single units
Nominal Extent (Route Length)	3 to 5 miles
Maximum Frequency (peak direction)	60 moves per hour per lane
Nominal Line Capacity (peak direction)	6,000 to 14,400 passengers per hour

Technological Variations

SCR systems operate with modern-styled vehicles, historically-styled replica vehicles, authentic restored historic vehicles, or various combinations thereof. Vehicle styling typically reflects local preferences and do not have a substantial effect on productive capacity in comparison to other vehicle characteristics.

Examples

No SCR services presently operate in the SFECC study area, although SCR systems are under consideration in Downtown Miami and Fort Lauderdale. SCR systems are operating or under construction in 19 North American cities.

NORTH AMERICAN SCR CITIES

Boston
Charlotte
Dallas
Fort Smith
Galveston
Kenosha
Little Rock
Memphis
New Orleans
Philadelphia
Portland
San Francisco
San Jose
San Pedro
Seattle
Tacoma
Tampa
Toronto
Washington DC *
** under construction*

Applicability to the South Florida East Coast Corridor Study

The mode's low capacity, relatively slow commercial speed and short nominal extent limit its applicability as a new primary line-haul service for the SFECC. SCR services have the potential to be a significant secondary service in Downtown Miami and/or Fort Lauderdale, providing necessary collector and distributor functions in support of primary corridor line-haul services.

SEMI-RAPID TRANSIT

Semi-Rapid Transit consists of modes operating mostly in ROW Category B but using ROW Categories A and C when necessary or available. Semi-rapid transit can match or exceed the speed and reliability of auto travel. Modes of this class operate at commercial speeds higher than adjacent corridor traffic, although that advantage is diminished by time lost at passenger stops (but to a lesser degree than for street transit modes, as stops are more widely spaced). Technology is more a factor with semi-rapid transit, especially with rail versions of this mode that can operate in short trains.

Bus Rapid Transit

Overview

Bus Rapid Transit (BRT) is a medium-capacity mode using conventional transit buses operating on predominately reserved, but not necessarily grade separated rights-of-way. A key characteristic of BRT is its capability to offer higher operating speeds and ride quality compared to RBT, but also combine feeder, line-haul and distributor functions in a one-seat ride from origin to destination. Buses can be easily rerouted to serve new or transient traffic generators or detour around. BRT service levels can be tailored to match changes in passenger demand by adjustments in service frequency and/or vehicle size.

Bus Rapid Transit

Infrastructure requirements for BRT include exclusive busways and passenger stops. Fully controlled rights-of-way are desirable but also the most capital-intensive type of facility. Passenger stops on busways are typically improved with passenger shelters and other amenities. In ROW Category C, passenger stops can be curbside locations shared with RBT services.

With the strong promotion of this mode, there is a tendency to apply the term "BRT" to any form of expedited or express RBT service with partial lane separation or distinctive designation in terms of passenger facilities or vehicle styling. True BRT systems should at a minimum meet the following technical specifications:

- Operate predominately in ROW Category B that is not shared with other modes with limited applications of ROW Category C.
- Distinct stops or stations with passenger shelters, information spaced at least a quarter-mile apart outside of central business districts.
- Stations and stops that allow simultaneous berthing of two or more vehicles and bypassing.
- Distinctive routes operating with frequent, reliable service throughout the day.
- Distinct vehicles designed for rapid passenger exchange.
- Preferential treatment at roadway intersections and other intelligent transportation system (ITS) elements for vehicle monitoring, central dispatch and passenger information.

Typical Characteristics

Right-of-Way Requirements	25 foot minimum for two travel lanes with additional width at stations
Operating Speeds	12 to 25 mph (average speed) 65 mph (maximum speed)
Station Spacing	⅒ to ¼ mile (downtown distribution) ¼ to ¾ mile (busway operations)
Station Type	Low level platforms with bus pull-off and shelter
Vehicle Size	30-40 feet by 8½ feet (standard bus) 60 feet by 8½ feet (articulated bus)
Vehicle Capacity (seated and standing)	25 to 125 passengers (60 nominal)
Vehicle Propulsion	Internal Combustion Engine (typically diesel but alternative fuel options abound) with mechanical or electro-mechanical transmission.
Consist (Train Length)	Single units
Nominal Extent (Route Length)	5 to 12 miles
Maximum Frequency (peak direction)	120 moves per hour per lane
Nominal Line Capacity (peak direction)	7,200 to 15,000 passengers per hour

Technological Variations

Electric Rapid Bus (ERB) is a variation of BRT using electric motors for propulsion. Power is drawn through a pair of poles from an overhead contact-wire system. ERB vehicles can be articulated or non-articulated and share most of the other characteristics associated with BRT. ERB possesses superior acceleration characteristics due to the use of electric traction and an off-vehicle power source. Power distribution system infrastructure and maintenance requirements are greater than BRT using diesel/hybrid propelled vehicles.

Guided Rapid Bus (GRB) is a variation of BRT in which vehicles are steered by infrastructural elements when operating in ROW Category A or B. Of the limited experiments with the mode in the 1980s, only the O-Bahn system in Adelaide remains the only major facility intact. Other experiments are currently being conducted using optical and magnetic guided buses, but have not yet been accepted for wide spread use by North American transit systems.

Examples

Miami-Dade Transit's South Miami-Dade Busway is an example of BRT operating in the SFECC study area. Other operating North American examples of line-haul or feeder BRT services can be found in Boston, Ottawa, Pittsburgh, Los Angeles and Vancouver. BRT is used as a downtown circulator in Denver and Orlando.

Applicability to the South Florida East Coast Corridor Study

The mode's medium capacity, moderate commercial speed and nominal extent make it potentially applicable as a new primary line-haul service for segments of the SFECC centered on Downtown Miami, Fort Lauderdale, and West Palm Beach. BRT could also provide a secondary collector or distributor function in conjunction with longer-distance primary line-haul service in the corridor.

NORTH AMERICAN BRT CITIES

Boston
Denver
Los Angeles
Orlando
Ottawa
Pittsburgh
Vancouver

Light Rail Transit

Overview

Light rail transit (LRT) is a medium-capacity urban transit mode utilizing electrically self-propelled rail vehicles operating singularly or in trains on predominately reserved, but not necessarily grade separated rights-of-way. LRT service levels can be tailored to match changes in passenger demand by adjustments in service frequency and/or consist (train length), although the practicality of the latter strategy is often limited by traffic considerations when operating in ROW Category C.

LRT is unique among rail modes in its capability to operate effectively in a full range of rights-of-way while sustaining the advantages generally associated with rail technologies: superior capacity, labor productivity, operating speeds and ride quality. Street running in mixed traffic is the least desirable right-of-way condition; fully controlled rights-of-way are more desirable, but also the most capital-intensive type of facility.

LRT has become the predominate medium-capacity line-haul transit service in the world, connecting central business districts with outlying residential areas as well as providing circulation within the CBD. A significant number of passengers access LRT service through park-ride lots or connecting bus services at outlying stations. LRT can operate in urban corridors without substantial modifications and the initial capital costs are often dramatically less than that of a comparable conventional heavy rail system. Single track sections are possible where physical space is constrained and the corresponding capacity limitations are acceptable.

Infrastructure requirements for LRT include tracks, power, passenger stops and stations, and optional structural elements such as subway or elevated track segments. Note that overhead power transmission systems are vulnerable to damage from storms and wind-blown debris.

Fully controlled rights-of-way are desirable but also the most capital-intensive type of facility. Capital costs can be reduced through the use of existing railroad rights-of-way, when available, and LRT trains can share existing tracks under certain circumstances defined and regulated by the FRA. Passenger stops are typically improved with canopies, shelters and other passenger amenities. When operating in ROW Category C, passenger stops can be curbside locations shared with SCR services.

Typical Characteristics

Right-of-Way Requirements	16-foot minimum for single track 25-foot minimum for double track with additional width at stations
Operating Speeds	12 to 25 mph (average speed) 65 mph (maximum speed)
Station Spacing	¼ to ½ mile (downtown distribution) ½ to ¾ mile (normal operations)
Station Type	High or low level platforms with shelter
Vehicle Size	50 feet long by 8½ feet wide (rigid car body) 92 feet long by 9 feet wide (articulated car)
Vehicle Capacity (seated and standing)	100 to 180 passengers

Vehicle Propulsion	Electric, typically drawn from OCS through pantographs
Consist (Train Length)	Single units to four or more car trains
Nominal Extent (Route Length)	10 to 12 miles
Maximum Frequency (peak direction)	40 moves per hour per lane
Nominal Line Capacity (peak direction)	4,000 to 28,800 passengers per hour

NORTH AMERICAN LRT CITIES

Baltimore
Boston
Buffalo
Calgary
Cleveland
Dallas
Denver
Edmonton
Guadalajara
Houston
Jersey City
Los Angeles
Mexico City
Minneapolis
Newark
Philadelphia
Pittsburgh
Portland
Sacramento
Salt Lake City
San Diego
San Francisco
San Jose
St. Louis
Toronto

Technological Variations

A variation of LRT uses self-propelled diesel multiple-unit (DMU) vehicles capable of operating on public streets in a mixed traffic environment (ROW Category C). This eliminates the infrastructure and maintenance requirements associated with LRT overhead power distribution system. Dual-powered variants of these vehicles that can switch between external and internal power sources are in the early deployment stage of development in Europe.

Examples

No LRT services presently operate in the SFECC study area, although an east-west corridor in Broward County centered on Downtown Fort Lauderdale is considering an LRT option. LRT systems are presently operating in 25 North American cities (see box).

Applicability to the South Florida East Coast Corridor Study

The mode's medium capacity, moderate commercial speed and nominal extent make it potentially applicable as a new primary line-haul service for segments of the SFECC centered on Downtown Miami, Fort Lauderdale, and West Palm Beach. LRT could also provide a secondary collector or distributor function in conjunction with a longer-distance primary line-haul service in the corridor. Electrification is a concern due to its vulnerability to storm damage.

Automated Guideway Transit

Overview

Automated guideway transit (AGT) is a medium-capacity mode operating electrically self-propelled, driverless vehicles on exclusive rights-of-way (sometimes referred to "Advanced Light Rail Transit" or "ALRT"). AGT vehicles may be supported on and guided by rubber-tires or steel wheels. Relatively small cars can be operated singularly or coupled into multiple unit trains. AGT systems rely on computer-based control systems which communicate directly with vehicles from a central location. The characteristics of individual systems and the service they provide vary greatly, ranging from urban center circulators to airport people movers to line-haul metro systems. AGT systems commonly operate relatively smaller vehicles on short


Automated Guideway Transit

headways and can adjust service rapidly in response to changes in passenger demand.

AGT is the most capital intensive and costly semi-rapid transit mode, but that investment yields a highly frequent, reliable and attractive service for passengers. AGT systems can operate very frequent service at little additional operating cost. Infrastructure requirements for AGT include tracks, power, passenger stops and stations, and structural elements such as subway or elevated segments. Fully controlled rights-of-way are a mandatory safety requirement due to automated operations. Grade separated alignments complicate the design of stations, which are often equipped with platform doors to control access to the guideway and permit an air-conditioned passenger environment.

AGT systems are proprietary in nature and procured through a turnkey or design-build contract with the vehicle manufacturer. This tends to lock an agency into a long-term relationship with a specific vendor for servicing, repairs and subsequent extensions.

Typical Characteristics

Right-of-Way Requirements	16-foot minimum for single track 30-foot minimum for double track with additional width at stations (no grade crossings permitted)
Operating Speeds	20 mph (average speed) 50 mph (maximum speed)
Station Spacing	¼ to ¾ mile
Station Type	High-level platform and shelter (often enclosed with platform doors
Vehicle Size	42 feet by 8 feet
Vehicle Capacity (seated and standing)	50 to 75 passengers
Vehicle Propulsion	Electric, typically drawn from wayside rail
Consist (Train Length)	Up to six cars per train (typically two)
Nominal Extent (Route Length)	3 to 5 miles
Maximum Frequency (peak direction)	40 moves per hour
Nominal Line Capacity (peak direction)	2,000 to 12,000 passengers per hour

Technological Variations

New AGT concepts regularly emerge every few years, introducing different guideway design, propulsion, and control elements. AGT systems variations can include linear induction propulsion systems and magnetic levitation systems.

Examples

Miami-Dade Transit Metromover AGT system presently operates in the SFECC study area and is the best North American example of an urban AGT circulator system integrated with other line-haul transit services. An urban AGT circulator system also currently operate in Detroit. North American line-haul AGT systems include Skytrain in Vancouver and the Scarborough Line in Toronto.

NORTH AMERICAN AGT CITIES
Detroit
Miami
Toronto
Vancouver

Applicability to the South Florida East Coast Corridor Study

The mode's relatively high capital costs limit its applicability as a new primary line-haul service for the SFECC or as a cost-effective secondary collector/distributor service anywhere other that in Downtown Miami, where it already exists.

Monorail

Overview

Monorail (MRL) is a medium-capacity mode operating electrically self-propelled vehicles supported on and guided by a single concrete "monobeam." Physically, it is a variation of AGT in which relatively small rubber-tired cars are semi-permanently coupled into multiple unit trains. MRL systems are typically elevated and at-grade and subway installations, while feasible, are not cost-effective for a number of technical reasons. MRL systems can adjust service frequency in response to changes in passenger demand.

There is a popular romance associated with monorails, drawn from science fiction notions that suggest they are "the mode of the future," and it can be expected they will continue to do so.

However, MRL systems are in fact capitally intensive but exhibit the lowest line capacity of any semi-rapid transit mode. They require specialized elevated guideway, power systems, and passenger stations, in addition to highly complicated switching systems at terminals, yards and branch-line junctions. Aerial alignments complicate emergency passenger egress and the design of stations, which are often equipped with platform doors to control access to the guideway and permit an air-conditioned environment for waiting passengers.

MRL systems are proprietary in nature and procured through a turnkey or design-build contract with the vehicle manufacturer. This tends to lock an agency into a long-term relationship with a specific vendor for servicing, repairs and subsequent extensions.

Typical Characteristics

Right-of-Way Requirements (aerial envelope)	12-foot minimum for single beam 30-foot minimum for double beam with additional width at stations (no grade crossings permitted)
Operating Speeds	20 mph (average speed) 50 mph (maximum speed)
Station Spacing	¼ to ¾ mile
Station Type	High-level platform and shelter (often enclosed with platform doors
Vehicle Size	28 feet (40 feet for cab cars) long by 8 feet wide
Vehicle Capacity (seated and standing)	60 passengers
Vehicle Propulsion	Electric, typically drawn from wayside rail
Consist (Train Length)	Up to six cars per trains
Nominal Extent (Route Length)	3 to 5 miles
Maximum Frequency (peak direction)	40 moves per hour
Nominal Line Capacity (peak direction)	1,800 to 10,000 passengers per hour

Technological Variations

Some overseas applications of MRL use suspended vehicles versus the beam-supported approach used in North American applications.

Examples

No MRL services presently operate in the SFECC study area. Urban MNR systems operate in Seattle WA, Las Vegas NV and Jacksonville FL.

NORTH AMERICAN MONORAIL CITIES

Jacksonville
Las Vegas
Seattle

Applicability to the South Florida East Coast Corridor Study

The mode's relatively high capital costs and low productive capacity limit its applicability as a new primary line-haul service for the SFECC or as a cost-effective secondary collector/distributor service.

RAPID TRANSIT

Rapid transit consists of modes operating almost exclusively on ROW Category A and exhibit high speeds, capacity, reliability and safety. All existing rapid transit systems use guided technologies (rubber-tired or rail) which permit operating of trains (higher capacity and lower operating costs), and automatic signaling or train control (higher safety). Rapid transit modes running on tracks that are part of the general network of railroads under the jurisdiction of the FRA operate in a different regulatory environment from other rail transit modes and fall in the general modal category of regional rail transit (RGR), also referred to as "commuter rail."

Rail Rapid Transit (Heavy Rail)

Overview

Rail rapid transit (RRT)—also referred to as "heavy rail transit" or "Metro"—is a high-capacity mode using electrically self-propelled rail vehicles operating singularly or in trains up to ten cars on a fully controlled right-of-way (ROW Category A). RRT rights-of-way may be below grade (subway), above grade (elevated) or on the surface, but cannot be shared or crossed at-grade by other vehicular traffic or pedestrians. A significant number of passengers access RRT service through park-ride lots or connecting bus services at outlying stations.

RRT represents the ultimate mode for line-haul transit service, designed to carry high volumes of passengers at high speed with a high degree of efficiency. The mode exhibits the advantages generally associated with rail technologies: superior capacity, labor productivity, operating speeds and ride quality. Modern RRT systems are further characterized by a high degree of automated operation. RRT's high level of performance is achieved, however, at an investment cost higher than for any other mode. RRT systems provide a range of passenger comfort levels, ranging from New York City's hard, car-length benches designed to maximize standee capacity to the Lindenwold Speed Line in South Jersey with plush commuter-style seating and minimal standee space.

Typical Characteristics

Right-of-Way Requirements.............................30-foot minimum
with additional width at stations
Operating Speeds...35 mph (average/commercial speed)
Up to 75 mph (maximum speed)

Station Spacing	¼ to ½ mile (downtown distribution) ½ to 1 mile (normal operations)
Station Type	High level platform with fare control
Vehicle Size	66 feet long by 10 feet wide
Vehicle Capacity (seated and standing)	140 to 225 passengers
Vehicle Propulsion	Electric, typically drawn from wayside third-rail or overhead catenary wire
Consist (Train Length)	One to ten cars per train
Nominal Extent (Route Length)	10 to 15 miles
Maximum Frequency (peak direction)	30 moves per hour per lane
Nominal Line Capacity (peak direction)	4,200 to 67,500 passengers per hour

Technological Variations

Rubber-tired rapid transit (TRT) systems exist as an alternative to steel-wheeled, rail-based RRT systems. The relative complexity and higher operating costs associated with TRT technologies (see box in the guidance section, above) has limited applications to very few systems worldwide.

NORTH AMERICAN RRT & TRT CITIES

Atlanta
Baltimore
Boston
Chicago
Cleveland
Los Angeles
Mexico City *
Miami
Montréal *
New York City
Philadelphia
San Francisco
San Juan
Toronto
Washington DC
* *TRT systems*

Examples

Miami-Dade Transit's Metrorail RRT system presently operates in the SFECC study area. RRT operates in 11 other North American cities. Montréal QC is the sole regional example of TRT.

Applicability to the South Florida East Coast Corridor Study

The mode's relatively high capital costs limit its applicability as a new primary line-haul service to the lower end of the SFECC (where it can possibly achieve economies of scale in conjunction with the existing Metrorail system) and to areas of high residential densities.

Regional Rail (Commuter Rail)

Overview

Regional rail (RGR)—also referred to as "commuter rail"—is a high-capacity mode operating on existing railroad rights-of-way, either intermixed with other freight and passenger train traffic or in parallel exclusive rights-of-way. A primary distinction between RGR and the other modes discussed earlier is that all operations are regulated by the FRA to varying degrees.

RGR service is characterized by longer trip lengths and more distant station spacing in comparison to other urban transit modes. RGR tracks are not necessarily grade separated at vehicular and pedestrian crossings, but at-grade highway crossings need some form of active protection.

The overwhelming majority of RGR trains are made up of strings of unpowered railcars propelled by an independent locomotive unit as prime mover. A cab placed in the coach at the opposite end of the train from the locomotive permits the train to be operated in either direction ("push-pull") without a configuration change at terminals, expediting direction reversals and improving equipment utilization.

Locomotive & Push-Pull Coaches

Most push-pull coaches in RGR service today carry passengers on multiple levels—either the ubiquitous "tri-level" car now manufactured by Bombardier or one of a number of gallery cars found in Chicago, Nashville and San Francisco. Northeast RGR operators prefer single level or low-profile bi-level cars due to limited tunnel and overhead wire clearances.

RGR is the predominant rapid transit mode, primarily due to its flexibility to share rights-of-way and oftentimes tracks with other types of trains. This flexibility results in a heterogeneous mode, however, without clearly defined limits (see the discussion of technological variations below).

Typical Characteristics

Right-of-Way Requirements	35-foot minimum for single track 50-foot minimum for double track with additional width at stations
Operating Speeds	25 to 45 mph (average speed) 80 mph (maximum speed/Class 4 track)
Station Spacing	Few CBD stations (typically one) 1 to 4 miles (outlying areas)
Station Type	High or low level platform with shelter
Vehicle Size	85 feet long by 10 feet wide
Vehicle Capacity (seated and standing)	125 to 155 passengers (no standees)
Vehicle Propulsion	Diesel-electric locomotives with push-pull coaches
Consist (Train Length)	Two to ten cars per train
Maximum Frequency (peak direction)	10 to 30 trains per hour
Line Capacity (peak direction)	2,250 to 11,160 passengers per hour

Technological Variations

There are many technological variations in the RGR mode that can influence the outcome of an alternatives analysis. These variations revolved around three basic issues:

- FRA Regulatory Environment;
- Choice of Rolling Stock; and
- Source of Motive Power.

These three issues are often inter-related, as elaborated upon in the following discussion.

FRA Regulatory Environment. All of the forms of bus and rail passenger transport discussed up until this point are governed by Federal Transit Administration (FTA) and applicable state safety regulations. All RGR operations in the United States, however, are governed by FRA safety regulations.

The question of whether or not a new-start passenger rail transit service is under FRA jurisdiction revolves around its anticipated interfaces with *the general railroad system of transportation*. Title 49 of the United States Code of Federal Regulations mandates that a passenger rail transit system must comply with FRA requirements if it is part of the general railroad system of transportation except where:

- Located inside an installation which is not part of the general railroad system of transportation; or
- Used exclusively for rapid transit service in a metropolitan or suburban area.

The excepted “stand-alone” installations and rapid transit services are primarily regulated on the state, rather than federal, level of government. Not being FRA compliant does not suggest that state-regulated systems are inferior or less safe than a comparable federally regulated systems, merely that their standards and practices are a matter of local determination as to what is appropriate and prudent.

FRA requirements regulate a broad range of operating practices that influence the design and maintenance of rail track, signals, and rolling stock. A fully-compliant RGR system is capable of sharing track, signals and other appliances with freight railroad carriers such as CSXT and FEC, as well as Amtrak and Tri-Rail. Use of non-compliant rolling stock, however, virtually curtails shared used of infrastructure that is part of the general system except under severely restrictive conditions, such as "temporal separation" that typically relegates freight train traffic to narrowly defined windows in the middle of the night.[5]

The choice of whether to employ FRA-compliant rolling stock (which could be locomotive-hauled trains or MUs) or to pursue a non-compliant approach (which is practically limited to MUs) needs to consider a number of factors unique to each RGR rail system.

Rolling Stock. The use of self-propelled rail vehicles (generically referred to as "Multiple Units" or "MUs") is an alternative to the aforemented use of locomotive-hauled, push-pull equipment for RGR operations.

MUs enhance operating flexibility and economy for an RGR service. MUs are capable of operating safely and cost-effectively as single-car units or coupled together to make longer trains, so consists (train lengths) can be adjusted to more closely meet changing levels of passenger demand. Locomotive-hauled trainsets, in contrast, are less cost-effective in smaller consists due to the diseconomies of scale associated using locomotives as a sole large prime mover. Studies have demonstrated that operating and maintenance costs can be lower with MUs when trains are three cars long or less. This becomes particularly relevant with RGR services desiring to supplement traditional commuter-oriented service with off-peak and reverse peak trips.

MUs out-perform locomotive-hauled trainsets since their tractive effort is distributed among more sets of axles, the number of which is proportional to train length, instead of isolated to the few axles of a large prime mover. As a result, MUs exhibit greater acceleration and sometimes braking characteristics than comparable locomotive-hauled trainsets. MUs can also handle steeper grades and perform better around curves.

The choice of MUs can result in a capital cost savings for new-start passenger systems. Since opening day ridership is likely to be less than in subsequent years of operation and MUs can operate effectively in smaller consists or even as singular units, rolling stock acquisition can be phased to reflect growths in passenger traffic. The initial capital outlay for a three car MU trainset, for example, is less than the comparative cost of a locomotive and three push-pull coaches.

On the other hand, MUs are treated as locomotives in the context of FRA inspection requirements, which can increase certain maintenance activities in comparison to a conventional push-pull coach. Greater economies of scale can also be realized by locomotive-hauled trainsets if passenger motive power is part of a large pool of motive power used and maintained for other purposes. Finally, there can be a greater “comfort level” within a railroad operating organization with traditional locomotive-hauled train sets.

MUs can be considered to fall into one of three general equipment types for the purposes of analysis:

- *Type 1 MUs:* These are self-propelled rail vehicles that are fully compliant with FRA requirements and are designed primarily for a railroad operating environment.
- *Type 2 MUs:* These are self-propelled rail vehicles that are not fully compliant with FRA requirements but are designed primarily for a railroad operating environment.

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[5] Alternative means of providing positive train separation, such as "scripted separation," is being actively explored by the FRA in conjunction with rail transit carriers. While still under development, this may define further opportunities to safely operate compliant and non-compliant rolling stock in common corridor.

- *Type 3 MUs:* Self-propelled rail vehicles that are not fully compliant with FRA requirements and capable of operating in urban street environments with mixed traffic.

As these descriptions suggest, compliance with FRA regulations is a key determinant as to the choice of a MU vehicle. This is because FRA regulations prohibit joint use of railroad facilities by non-compliant vehicles and conventional railroad trains (such as Amtrak, Tri-Rail or freight trains) without extraordinary means to maintain positive train separation. For this reason, the decision of whether or not rolling stock should be FRA compliant represents an overarching consideration in the determining the design criteria for a proposed rail system.

<u>Source of Motive Power</u>. The source of motive power for RGR trains can be:

- On-board internal combustion engines with power transmitted to driving wheels though mechanical transmission.
- On-board internal combustion engines driving an on-board electric generator with power transmitted electrically to drive motors.
- Electricity drawn from an overhead contact-wire system transmitted directly to drive motors.
- Electricity drawn from a wayside third-rail transmitted directly to drive motors.

In general, trains with electric drive motors tend to out-perform trains with mechanical transmission systems, and trains drawing electric power from external sources tend to out-perform trains with on-board power supplies (see box in propulsion technologies discussion above). Overhead power systems are vulnerable to damage from storms and wind-blown debris. Third-rail systems, while less vulnerable to storm damage, can be hazardous to pedestrians in an uncontrolled track environment.

<u>Examples</u>

South Florida Regional Transit Authority's

Tri-Rail RGR service presently operates the full extent of the SFECC study area from Miami to northern reaches of Palm Beach County using FRA-compliant locomotives and push-pull coaches. RGR systems also operate in 21 other North America cities.

- Most RGR systems operate locomotive-hauled trains with push-pull coaches, but MUs operate in nine cities as well.
- All but two are FRA-compliant (or the Canadian equivalent). The NJ Transit's RiverLine and the O-Train operation in Ottawa are both examples of non-compliant RGR systems, and two more are currently under construction in Austin and Northern San Diego County.
- Most RGR systems operate diesel-powered rolling stock, but many RGR lines in the Northeast US, Chicago, and Montréal are electrified.

NORTH AMERICAN RGR (Commuter Rail) CITIES

Albuquerque *
Baltimore ‡
Boston
Camden-Trenton †
Chicago †‡
Dallas-Ft Worth †
Los Angeles
Miami
Montréal †‡
Nashville *
New York City †‡
Newark †‡
Ottawa †
Philadelphia †‡
San Diego
San Francisco
San Jose
Seattle
Syracuse †
Toronto
Vancouver
Washington DC ‡

* *Opening in 2006*
† *Operates MUs*
‡ *Electrified*

<u>*Applicability to the South Florida East Coast Corridor Study*</u>

The mode's relatively lower capital costs and functional characteristics make RGR applicable to one or more possible new primary line-haul service in the SFECC. Given the available width of the FEC and other possible rights-of-way in the corridor, either FRA-compliant or non-compliant alternatives could be applicable to the SFECC. Either locomotive-hauled or MU rolling stock options would be applicable to the corridor, but electrification is not recommended as a primary motive power source due to its vulnerability to storms.

SPECIAL TRANSIT TECHNOLOGIES

High Speed Ferry

<u>*Overview*</u>

High Speed Ferries (HSF) are a high-capacity mode transporting passengers over waterways. HSF can be a cost-effective means of moving a large number of passengers where there is the right configuration of waterways and land-side facilities. In contrast to other US urban transport modes governed by FTA or FRA regulations, HSF services are governed by the US Coast Guard.

For decades, the Washington State Ferry system plying the waters of Puget Sound and the Staten Island Ferry in New York City Harbor were the sole remaining urban ferry systems in the US. These services operated large, relatively slow boats capable of carrying up to 600 passenger and automobiles. Renewed interest in ferries as an urban transit mode was sparked in the early 1980s by new operations by the Massachusetts Bay Transportation Authority in Boston and the Golden Gate Bridge and Transportation District in San Francisco Bay. These new systems experimented with high speed, passenger only ferries and were considered an immediate success. They were followed by a score of privately-owned and

operated high speed commuter ferries in New York Bay as well as others in San Francisco and Boston. BC Transit SeaBus service (now TransLink) in Vancouver uses a specially configured fleet of ferry boats as a fast, frequent link between North Vancouver and Downtown.

Typical Characteristics

Right-of-Way Requirements............................Public waterways (depth dependent on vessel)
Operating Speeds..21 mph (average speed)
45 mph (maximum speed)
Station Spacing...Point-to-Point
Station Type..Terminal with moveable bridges
Vehicle Size..
Vehicle Capacity (seated and standing)...........200 to 350 passengers
Vehicle Propulsion..Marine Diesel
Consist (Train Length).....................................Single Unit
Nominal Extent (Route Length).........................3 to 12 miles
Maximum Frequency (peak direction)..............Up to 6 moves per hour
Nominal Line Capacity (peak direction)............1,200 to 2,100 passengers per hour

Technological Variations

There is a wide variety of choices in hull design and marine propulsion systems. Hovercraft (in which the boat is suspended on an air cushion) and hydrofoil (in which the boat hull is supported out of the water on a planing foil) are also alternatives for HSF.

Examples

No HSF services presently operate in the SFECC study area. A lower speed, short distance "water-taxi" service operated recently in Broward County. Urban HSF systems operate in five North American cities.

NORTH AMERICAN HIGH SPEED FERRY CITIES

Boston
New York City
San Francisco
Seattle
Vancouver

Applicability to the South Florida East Coast Corridor Study

The success of HSFs is heavily dependent upon the availability of an appropriate, unencumbered waterway between two activity centers and complementary land-side transportation connections. The challenges associated with applying HSF as a modal technology in the SFECC are:

- Wake restrictions and protected manatee habitats in Biscayne Bay and along the Intracoastal Waterway would significant limit HSF operating speeds.
- Much of the waterfront in Miami, Fort Lauderdale and West Palm Beach, as well as other SFECC communities are increasingly devoted to residential uses, as opposed to commercial activities that would attract commuter trips.
- A significant proportion of the central business and commercial districts of Miami, Fort Lauderdale and West Palm Beach are not within reasonable walking distance of their waterfronts, requiring new circulator/distributor systems to transport HSF passengers to and from activity centers.

These concerns limit its applicability as a new primary line-haul service for the SFECC.

INTERCITY TRANSPORT MODES

In contrast to urban transit modes, intercity transport modes are designed to handle much longer-distance travel between regions. Intercity transport modes use technologies virtually identical to certain urban transit modes, but tend to address passenger trips in the 100+ mile range with relatively less frequent services (often daily headways or less).

Greyhound Bus operates intercity motorcoach (ICC) operations in the SFECC with origins and destinations outside the study area throughout Florida and the US. ICC services are too infrequent and focused on longer-distance travelers to be a relevant line-haul service mode in the corridor. They do represent an important source for extra-regional trips, however, and interfaces with ICC services such as Greyhound should be considered in the siting of stations and terminals.

The National Railroad Passenger Corporation (Amtrak) operates conventional intercity railroad (ICR) in the SFECC, using the tracks of the South Florida Railroad Corridor (SFRC) between Miami and West Palm Beach, then beyond to Jacksonville and New York City. As with ICC service, Amtrak operates too infrequently and has stations too broadly spaced (based on the needs of longer-distance travelers) to be a relevant line-haul service mode in the corridor. It does represent an important source for extra-regional trips, however, and Amtrak interfaces should be considered in the siting of stations and terminals. Amtrak has also expressed interest in routing a daily round trip over the FEC between Jacksonville and West Palm Beach, then connecting to the SFRC between West Palm Beach and Miami.

Interest has been expressed in high speed rail—using conventional steel-wheeled technologies or magnetic levitation (MagLev) for support and propulsion—passing through the SFECC study area. The relevance of these proposals to the SFECC study are equivalent to that of the ICC and ICR services presently operating in the corridor as important potential sources of extra-regional trips.

SUMMARY

Table 3 presents a comparison of the functional characteristics associated with the modal technologies discussed in this memorandum. Table 4 provides a summary of the applicability of modal technologies as either a primary line-haul service or as a secondary distributor mode in the corridor, as discussed in the preceding discussion.

Intercity Rai

Table 3. Comparative Functional Characteristics of Modal Technology

	Right of Way			Technology			Service				FRA	Speed		Consist		Unit Capacity		Move Capacity		Frequency	Line Capacity	
	A	B	C	Support	Guidance	Propulsion	Extent	Stop Density		Consist	Compatible	Commerical	Maximum	(Units/Move)		(Pax/Unit)		(Pax/Move)		(Moves/Hr)	(Pax/Hr)	
URBAN TRANSPORT MODES																						
Street Transit																						
Regular Bus																						
Diesel/Hybrid	■	■	■	Rubber Tires	Driver	Internal	10 mi	$^{1}/_{10}$ mi	½ mi	Single-Unit	No	12 mph	60 mph	1		40	125	40	125	60	2,400	7,500
Electric Trolley Bus	■	■	■	Rubber Tires	Driver	External	10 mi	$^{1}/_{10}$ mi	½ mi	Single-Unit	No	12 mph	60 mph	1		60	125	60	125	60	3,600	7,500
Regional Bus	■	□	□	Rubber Tires	Driver	Internal	50 mi	1 mi	4 mi	Single-Unit	No	35 mph	70 mph	1		45	60	45	60	6	270	360
Streetcar	■	■	■	Steel Wheels		External	3 - 5 mi	$^{1}/_{10}$ mi	½ mi	Single-Unit	No	12 mph	50 mph	1		100	240	100	240	60	6,000	14,400
Semi-Rapid Transit																						
Bus Rapid Transit																						
Diesel/Hybrid																						
Steerable	■	■	□	Rubber Tires	Driver	Internal	12 mi	¼ mi	¾ mi	Single-Unit	No	25 mph	60 mph	1		60	125	60	125	120	7,200	15,000
Guided	■	□	□	Rubber Tires	Guide Rail	Internal	12 mi	¼ mi	¾ mi	Single-Unit	No	25 mph	60 mph	1		60	125	60	125	120	7,200	15,000
Electric Trolley Bus																						
Steerable	■	■	□	Rubber Tires	Driver	External	12 mi	¼ mi	¾ mi	Single-Unit	No	25 mph	60 mph	1		60	125	60	125	120	7,200	15,000
Guided	■	□	□	Rubber Tires	Guide Rail	External	12 mi	¼ mi	¾ mi	Single-Unit	No	25 mph	60 mph	1		60	125	60	125	120	7,200	15,000
Light Rail Transit																						
DMU (Type 3)	■	■	□	Steel Wheels		Internal	12 mi	¼ mi	¾ mi	Variable	No	25 mph	60 mph	1	4	180		180	720	40	7,200	28,800
EMU (Type 3)	■	■	□	Steel Wheels		External	12 mi	¼ mi	¾ mi	Variable	No	25 mph	65 mph	1	4	100	180	100	720	40	4,000	28,800
Automated Guideway	■	⊠	⊠	Rubber Tires	Guide Rail	External	3 mi	¼ mi	¾ mi	Variable	No	20 mph	50 mph	1	6	50		50	300	40	2,000	12,000
Monorail	■	⊠	⊠	Rubber Tires	Monobeam	External	3 mi	¼ mi	¾ mi	Variable	No	20 mph	50 mph	1	6	60		60	360	30	1,800	10,800
Rapid Transit																						
Rapid Transit ('Heavy Rail')																						
Rail Rapid Transit	■	⊠	⊠	Steel Wheels		External	15 mi	½ mi	1 mi	Variable	No	35 mph	75 mph	1	10	140	225	140	2,250	30	4,200	67,500
Rubber-Tired Rapid Transit	■	⊠	⊠	Rubber Tires	Guide Rail	External	15 mi	½ mi	1 mi	Variable	No	35 mph	50 mph	3	10	160		480	1,600	30	14,400	48,000
Regional (Commuter) Rail																						
Diesel-Electric																						
Push-Pull Coaches	■	⊠	⊠	Steel Wheels		Internal	50 mi	1 mi	4 mi	Variable	Yes	45 mph	79 mph	3	12	125	155	375	1,860	6	2,250	11,160
DMU (Type 1)	■	⊠	⊠	Steel Wheels		Internal	50 mi	1 mi	4 mi	Variable	Yes	45 mph	79 mph	1	12	125	155	125	1,860	6	750	11,160
Non-Compliant (DMU Type 2)	■	□	⊠	Steel Wheels		Internal	50 mi	1 mi	4 mi	Variable	No	45 mph	80 mph	1	12	125	155	125	1,860	6	750	11,160
Electric																						
Push-Pull Coaches	■	⊠	⊠	Steel Wheels		Internal	50 mi	1 mi	4 mi	Variable	Yes	45 mph	79 mph	3	12	125	155	375	1,860	6	2,250	11,160
EMU (Type 1)	■	⊠	⊠	Steel Wheels		Internal	50 mi	1 mi	4 mi	Variable	Yes	45 mph	79 mph	1	12	125	155	125	1,860	6	750	11,160
Non-Compliant (EMU Type 2)	■	□	⊠	Steel Wheels		External	50 mi	1 mi	4 mi	Variable	No	45 mph	80 mph	1	12	125	155	125	1,860	6	750	11,160
Special Transit Technologies																						
High-Speed Ferry	■	⊠	⊠	Waterborne	Pilot	Internal	12 mi	Point to Point		Single-Unit	No	21 mph	45 mph	1		200	350	200	350	6	1,200	2,100
INTERCITY TRANSPORT MODE																						
Road-Based Technologies																						
Intercity Motorcoach	■	■	■	Rubber Tires	Driver	Internal	150 mi	10 mi	20 mi	Single-Unit	No	45 mph	70 mph	1		45	60	45	60	0.5	23	30
Guideway-Based Technologies																						
Conventional Intercity Rail	■	■	■	Steel Wheels		Internal	150 mi	10 mi	20 mi	Single-Unit	No	52 mph	79 mph	3	6	60	85	180	510	0.5	90	255
High Speed Ground Transport																						
High Speed Rail	■	⊠	⊠	Steel Wheels		Internal	250 mi	20 mi	30 mi	Variable	Maybe	150 mph	180 mph	5	10	50	65	250	650	4	1,000	2,600
Mag-Lev	■	⊠	⊠	Electro-Magnetic Force		External	250 mi	20 mi	30 mi	Variable	Maybe	200 mph	310 mph	5	10	50	65	250	650	4	1,000	2,600

■ Mode compatible with ROW category
□ Mode compatible with ROW category but with degraded performance
⊠ Mode incompatible with ROW category

Table 4. Applicability of Modes to SFECC

	Primary Line-Haul Service	Secondary Distributor Service
URBAN TRANSPORT MODES		
Street Transit		
Regular Bus		
Diesel/Hybrid	☒	■
Electric Trolley Bus	☒	☒
Regional Bus	□	■
Streetcar	☒	■
Semi-Rapid Transit		
Bus Rapid Transit		
Diesel/Hybrid		
Steerable	■	■
Guided	☒	☒
Electric Trolley Bus		
Steerable	☒	☒
Guided	☒	☒
Light Rail Transit		
DMU (Type 3)	■	■
EMU (Type 3)	☒	☒
Automated Guideway	☒	■
Monorail	☒	☒
Rapid Transit		
Rapid Transit ('Heavy Rail')		
Rail Rapid Transit	■	■
Rubber-Tired Rapid Transit	☒	☒
Regional (Commuter) Rail		
Diesel-Electric		
Push-Pull Coaches	■	☒
DMU (Type 1)	■	□
Non-Compliant (DMU Type 2)	■	□
Electric		
Push-Pull Coaches	☒	☒
EMU (Type 1)	☒	☒
Non-Compliant (EMU Type 2)	☒	☒
Special Transit Technologies		
High-Speed Ferry	☒	□
INTERCITY TRANSPORT MODES		
Road-Based Technologies		
Intercity Motorcoach	□	☒
Guideway-Based Technologies		
Conventional Intercity Rail	□	☒
High Speed Ground Transport		
High Speed Rail	☒	☒
Mag-Lev	☒	☒

■ Applicable
□ Limited Applicability
☒ Not Applicable