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DATE: July 8th, 2009

SUBJECT: Fresno Public Transportation Infrastructure Study (PTIS) Memorandum #6 – Transit Technology and Service Alternatives Feasibility Assessment

This memorandum describes the results of Task 1.3 – Identify Transit Technology and Service Alternatives of the Fresno Public Transportation Infrastructure Study (PTIS) Phase 2, which is being conducted by Kimley-Horn and Associates (KHA) for the Council of Fresno County Governments (FCOG).

The intent of this memo is to identify the various transit technologies and service alternatives that might have future application in Fresno County. The focus is on local/regional transit opportunities and not long-distance mass transportation services like high speed rail. This is to keep the analysis in line with the scope of the Fresno Public Transportation Infrastructure Study (PTIS), Phase 2. Also, although the review presents a long list of technologies found throughout the U.S., it targets the more limited number of technologies that appear most suitable given the development patterns of metropolitan Fresno and, to a lesser extent, of smaller Fresno County communities.

Overview

Currently bus transit is the primary transit technology in use in metropolitan Fresno County. The common bus type operated on fixed-route service is an approximately 35- to 40-foot, compressed natural gas (CNG) or clean diesel powered vehicle. This vehicle is often referred to as a standard transit bus. To provide paratransit services (for seniors and the disabled) in the Fresno-Clovis metropolitan area and both paratransit and demand responsive services in smaller communities elsewhere, smaller vans and minibuses powered by gasoline, diesel or CNG are used. The only other transit technologies commonly operating within Fresno County are over-the-road transit coaches (diesel) and passenger rail trains (diesel-electric) for long-distance intercity or interstate travel.

As Fresno County and the state grow and demand for transit increases, other technologies could become attractive for the area. One exciting new opportunity is high speed rail for long-distance intercity travel. Fresno is a candidate for a station served by ultramodern steel-wheel-on-steel-rail trains running at speeds upwards of 250 miles per hour. Planning is underway for this system, with construction several years off. But voters have already approved the first major funding allocation. For local travel, new bus rapid transit (BRT) services are under study. Special high-capacity vehicle types are often deployed on these systems. Depending upon population and employment growth, transit corridor services could be considered using high-capacity rail technologies like light rail and commuter rail. Finally, to support better local access and to facilitate higher-density development, transit circulator technologies ranging from at-grade running streetcars to grade-separated automated people mover and personal rapid transit (PRT) systems could hold promise.

Transit Technologies

Table 1 summarizes the characteristics of 12 common types of transit in the U.S. and one additional technology that holds promise but has yet to find more than a couple of applications in the U.S. and abroad. From left to right in the table, the technologies are listed generally in terms of vehicle and also line capacity, although line (or route) capacity can be highly variable and depends on service frequencies. Certain technologies, which can operate at very high frequencies, will offer greater line capacities than other technologies that actually have higher per vehicle capacities. Each transit type is described below along with general thresholds for application.

Rail Systems

The highest volume systems are typically rail systems, with heavy rail, as represented by San Francisco's BART and Los Angeles' Red Line, among the fastest and having the most carrying capacity. Such lines are typically grade-separated in exclusive right-of-way and can carry 10,000 passengers or more per hour each direction.

At the other end of the rail spectrum are streetcars, which usually operate on existing city streets, sharing the right-of-way with autos and trucks, and are limited to one- or two-car trains. Individual vehicle capacities can exceed well over 100 passengers, but train frequencies tend to be limited due to the challenges of operating in mixed-flow traffic environments with multiple traffic lights. In the middle ground are light rail and commuter rail systems. Light rail vehicles can hold over 150 passengers on trains of typical two to three vehicles, for total capacities of 300 to 500 passengers. Commuter rail vehicles include passenger cars seating 100 or more (standees on commuter rail trains are assumed to be avoided or kept to a minimum), linked together in trains of five to eight or more cars for a total train capacity similar to heavy rail. Line capacity per hour is usually less due to lower train frequencies. Diesel multiple units (DMUs) are an alternative to conventional commuter rail and even light rail technologies. Each vehicle or married-pair vehicle (essentially two cars permanently hinged in the middle) is self-propelled, but DMUs can be linked into two to four cars per train. They are best deployed where large commuter rail trains are not needed due to limited demand and where electrification for propelling light rail trains is not practical and present too high a capital cost.

<u>**Application Thresholds:**</u> With the possible exception of streetcars and single vehicle DMUs, rail is best applied where transit demand is very high. This typically means service connects to highly concentrated employment centers with high residential

densities also required to generate ridership and improve rail's effectiveness (ridership capture) and efficiency (cost per vehicle mile or hour of service). Heavy rail is very capital intensive and its cost only justified in certain U.S. cities. Commuter rail can be successful where residential densities are low if convenient large-lot park and ride access to train stations is provided. But on the attraction end of the transit service, meaning the employment destination, large central business districts are required to generate large number of users.

Small DMU trains have found applications in lower density commute corridors. If able to use existing freight or similar lines, capital costs are low. The critical issue is usually operating rights and priority over freight rail traffic, which if frequent, can disadvantage passenger train movements. Streetcars are finding new applications in urban activity centers where construction is not overly disruptive to existing uses or very costly. Costs cans be reduced by running track in existing streets, following the street contour, and building stations as sidewalk or sidewalk-extension stops with limited amenities. Streetcars are best justified where residential and commercial activity is mixed and intense. Some systems have been applied in lower density areas (Little Rock, Galveston, and Tacoma) although they would not be considered major transit lines.

Bus Systems

Three types of bus services are profiled in **Table 1**. The newest application is bus rapid transit (BRT), which attempts to replicate many of the aspects of light rail service at a fraction of the capital costs. BRT has a broad definition. At the high end, it includes dedicated bus lanes (usually in existing public right-of-way); passenger stations with amenities such as real time information, canopies, seating, and safety and security measures, among other features; and high capacity, high frequency service. Vehicles and the service in general are branded to distinguish them from regular buses and conventional fixed-route service. Many BRT lines have articulated buses with a seated capacity of 50 to 60 and total capacity of 90 passengers. Vehicles receive transit signal priority, or use "queue-jump lanes" to move more quickly through intersections.

Express bus service can appear similar to BRT services but are now considered an intermediate service between BRT and local service. Limited stops and peak hour service to and from work places are the defining characteristics. Express buses may share traffic lanes or operate in the high occupancy vehicle lane on freeways and expressways.

Local buses operate in a multitude of environments. They are usually defined by frequent stops and slow average speeds from stopping often and running along arterials in mixed-flow traffic.

<u>Application Thresholds:</u> BRT and express services are similar to light rail in requiring higher densities or, for freeway express operations, at least the attraction end of transit trips located in a large central business district. Because of their much lower capital costs, they are better justified in lower demand corridors than light rail. Because buses can operate as very high frequencies, especially if not restricted to mixed-flow lanes, line capacities typically exceed those for streetcars and often approach those for light rail systems. Bus frequencies can be readily tailored to match demand, and range considerably, from five minutes or less on local and BRT lines in central cities to hourly service in low density, low demand suburban and small community applications. Finally, bus systems are entirely flexible, unlike rail systems, and can be substantially modified to meet changing needs.

Automated Guideway Transit: People Movers (Monorail) and Personal Rapid Transit (PRT)

Although proposed for conventional transit applications, including moderately high demand corridors, these types of automated systems have failed to gain a foothold. People movers are becoming more common in airports throughout the U.S. and abroad and as local circulator/excursion services (e.g., Las Vegas, Disneyland/Disneyworld) but not as line haul services to substitute for express bus, BRT or light rail services. PRT systems are still extremely limited, with almost no recent track record of construction and operation, but they are proposed at airports, office/university campuses, and in unique situations (several locations in the Middle East, such as Masdar City in Abu Dhabi, and a system to be opened at Heathrow Airport this year).

Application Thresholds: People movers can carry moderate line volumes while PRT is designed more for convenience and local access. PRT vehicle capacities are two to possibly five individuals for small vehicles and 12 to 15 individuals for large vehicles. PRT may be most effective in relatively compact areas with multiple origins and destinations not well served by line haul services. While there are no reliable track records of either technology that would suggest their performance is superior to other more conventional transit modes, there may be unique environments in Fresno County where these technologies may be cost-effective, or where they may be considered for serving special transit needs.

Demand Responsive Transit

Paratransit and demand responsive services are widespread and rely on vans and minibuses. These vehicles operate along existing public roadways and typically follow no fixed route. Paratransit is mainly a subsidized service for seniors and the disabled who cannot use fixed-route transit. Demand responsive services work when fixed-route service cannot attract sufficient uses to be cost-effective.

Application Thresholds: As noted, paratransit vans and minibuses operate in most urban areas as a complementary service to standard transit buses on fixed-route service. Demand responsive vans and minibuses provide service in small urbanized and even rural areas and may be no longer justified when residential densities average four or more units per acre in larger communities where paratransit service can be replaced with fixed-route service.

Carpool/Vanpool Service

Although included **Table 1**, some may view such service as a personalized mode of transit more akin to the auto than to public transit. However, carpools and especially vanpools serve an important function, and fill an important niche, in many large urban transit environments. Carpools and vanpools may operate in HOV lanes or in mixed traffic lanes. Generally, a significant portion of the trip is made in HOV facilities resulting in a travel time advantage compared to regular auto trips. Carpools and vanpools avoid the congestion of mixed-flow lanes and may be afforded relief from tolls and other transportation system user charges.

Application Thresholds: Carpools and vanpools usually only become attractive where freeway congestion is high and travel is concentrated in certain corridors proceeding to and from major employment areas. In fact, like commuter rail, large central business districts where parking is limited and/or costly are a precondition to making carpools and vanpools viable. Car and vanpooling are attractive components of Transportation Demand Management programs implemented by individual employers or Transportation Management Associations, as they can be most effective when serving a single employer, campus, or complex.

Where's Fresno?

Which of these transit technologies and service types would be suitable for Fresno in the near- and long-term futures? That question will be answered later in the PTIS as FCOG and the study team evaluates different growth areas for Fresno County for 2030 and 2050. However, it is clear that, to be viable, certain transit technologies in **Table 1** will require major changes in development patterns.

Standard buses and demand responsive vans and minibuses are currently the dominant transit technologies in Fresno because they are most effective in meeting both the type and level of demand. Fresno does not yet exhibit development patterns that will support high volume transit modes. Also it lacks the concentration of activity centers that could support lower volume, advanced technology Automated Guideway Transit and PRT circulator systems.

The City of Fresno population density in 2007 was approximately 4,098 persons per square mile, comparable to that for Sacramento (4,187 persons per square mile).[1] In developments built between 1990 and 2004, the average residential density was 6,016 persons per square mile (9.4 residents per acre). These densities correspond to dwelling units averaging between three to four units per acre, sufficient to support local bus but low for BRT, light rail and higher volume transit. However, Sacramento and other cities with comparable residential densities support light rail services. But they have employment concentrations and corridor densities that Fresno lacks. Employment densities are probably more important than residential densities when considering high volume BRT and rail modes. It appears that, at minimum, central business districts with 15,000 to 20,000 jobs per square mile (San Jose and Phoenix, respectively) are necessary for light rail to be considered.[2] Fresno currently falls short of these thresholds.

This may be changing, however, or at least changes can be brought about to provide for development patterns that will support certain higher capacity transit modes in metropolitan Fresno. In fact, in some corridors within the City of Fresno, demand

[1] Other California city densities in terms of persons per square mile are: San Diego-3,772; San Jose-5,117; Stockton-4,456.
[2] Other central business district job densities are: San Diego-33,179 and Sacramento-30,364.

appears high enough to support BRT service at 10-minute peak hour frequencies. FAX is pursuing federal support to implement the first major service and capital improvements to introduce BRT technology in the next two to three years. The most promising BRT corridors generate transit demand from a combination of high transit dependency (due largely to low auto ownership and low income), concentrations of commercial and retail uses along the proposed BRT arterial, and also concentrations of employment in downtown Fresno, which would be served by proposed BRT routes.

Future No Build and Transportation System Management Transit Scenarios

As stated previously, the PTIS will identify opportunities for new transit technologies and service options and the attendant land uses required to support their use. Part of the evaluation will be comparing the potential benefits of the technology against a future (1) No Build Alternative, which represents doing no more than planned and programmed incremental improvements to transit systems in Fresno County, and (2) a Transportation Systems Management (TSM) Alternative, which assumes a level of improvements beyond the No Build condition, including enhancements to transit services but at limited capital cost. The purpose of the TSM Alternative is to provide more than a straw man basis of comparison when considering the benefits of more extensive transit capital investments. The Federal Transit Administration (FTA) guidelines call for development of a TSM Alternative, referred to as the Baseline, when evaluating the merits of a large capital project for award of federal funds.

In the final section of this memorandum, a menu of technology options and service assumptions is formulated to represent future No Build and TSM/Baseline alternatives. These options and assumptions are to be reviewed with FAX, Fresno County Rural Transit Agency (FCRTA), and the PTIS Technical Advisory Committee (TAC) for reasonableness. They will then be incorporated into 2030 and 2050 travel demand forecast scenarios as part of the base transit network. At this point the service assumptions remain generalized, but they will ultimately become represented by the individual transit routes and service characteristics that are coded into the 2030 and 2050 base networks of the FCOG travel demand forecasting model.

No Build Transit Services

Metropolitan Fresno/Clovis: Future transit service in Fresno/Clovis is assumed to reflect service enhancements rather than the implementation of major capital improvements. Transit technologies will continue to be those found today plus planned BRT services.

> **Local FAX bus service:** This will continue to be the backbone of fixed-route transit in the future. Service enhancements will include improved service frequencies on major routes, with more lines operating on 15-minute peak and 30-minute off-peak headways. Routes will be reorganized somewhat to concentrate service enhancements over the best performing segments. Some long routes will be divided into two services. Existing routes will be extended, and where they appear most logical, new routes proposed to serve metropolitan growth areas, including the Southeast Growth Area (SEGA), north Fresno, northeast Clovis, and also northwest Fresno (west of SR 99). Better

continuity of existing service between Fresno and Clovis will be considered. Service levels in 2050 will be higher than those assumed for 2030.

BRT service: The planned improvements along Ventura Avenue/Kings Canyon Road and Blackstone Avenue to the Manchester Center will be assumed to be in place. This is the only BRT service to be provided under the No Build condition by 2030. By 2050, service would be extended along the proposed BRT corridors to growth areas in SEGA and north Fresno.

Express bus service: No new or expanded express bus services are assumed to operate in the 2030 network. By 2050 express service along SR 99 and SR 41 during peak periods would appear warranted, particularly serving demands between Madera and Tulare Counties and downtown Fresno.

Paratransit service: Senior and disabled services will continue to operate like today and be expanded as necessary to serve expanding populations in the area.

Urban and Rural Communities Outside Fresno/Clovis: No major change in future services would be assumed. Service would be primarily paratransit and demand responsive in urbanized areas outside of Fresno/Clovis. Intercity express bus service would be retained with a limited increase in the number of daily or weekly trips between Fresno/Clovis and the various communities now having some level of scheduled service.

Future TSM/Baseline Transit Services

Metropolitan Fresno/Clovis: The TSM/Baseline would expand local, BRT, and express bus services in Fresno/Clovis.

Local bus service: Further enhancements to local bus service are assumed under the TSM/Baseline. The number of routes with service frequencies of 15 minutes peak and 30 minutes off-peak would be expanded. Otherwise, no major reorganization or expansion of local bus services would be proposed. The TSM improvements would focus on expansion of express and BRT services in the most promising transit corridors.

BRT service: In addition to the BRT routes assumed under the No-Build Alternative, BRT would be provided under the TSM Alternative along Shaw Avenue. BRT connector services along cross town north-south arterials such as Clovis, Chestnut and Cedar avenues and east-west arterials such as Herndon, Shields, and McKinley avenues would have improved frequencies.

Express bus service: Express bus enhancements in the SR 99 and SR 41 corridors would be proposed in 2030 as well as 2050, and new express bus services in the SR 168 and SR 180 corridors would be possible by 2050.

Paratransit service: Senior and disabled services would operate similar to the No Build.

Other Transit Improvements: These would include expanded and new transit centers in growth areas. The areas could include Riverdale in north Fresno, the SaveMart Center at Fresno State University, and new centers in the Fancher Creek and eastern portions of SEGA by 2050.

Urban and Rural Communities Outside Fresno/Clovis: Service would continue to be primarily paratransit and demand responsive in urbanized areas outside of Fresno/Clovis. An expansion of intercity express bus service, in terms of the number of daily or weekly trips and locations served in Fresno/Clovis, would be assumed between these communities and the Fresno/Clovis metropolitan area. This would also include limited intercity service along SR 99 between the City of Madera (Madera County) and Fresno/Clovis and Visalia (Tulare County) and Fresno/Clovis.

It is important to stress that the transit technology and service assumptions of the TSM/Baseline Alternative do not in any way limit those for consideration in future build scenarios that evaluate alternative land uses and transit options for Fresno County. These scenarios, along with more detail for the No Build and TSM/Baseline conditions, will be established during Stage 2 of the PTIS. It is anticipated that build scenarios will consider additional BRT and express bus services beyond the TSM/Baseline and possibly new fixed guideway improvements, such as commuter or light rail.

Table 1: Transit Technologies and Service Alternatives

Basic Characteristics \ Transit Types	Heavy Rail	Commuter Rail	Light Rail	Diesel Multiple Unit (DMU)	Modern Streetcar	Heritage Streetcar	Bus Rapid Transit
							
Definition:	"Heavy Rail is high-speed, passenger rail cars operating singly or in trains of two or more cars on fixed rails in separate rights-of-way from which all other vehicular and foot traffic are excluded" (APTA)	"Commuter Rail is long-haul rail passenger service operating between metropolitan and suburban areas, whether within or across the geographical boundaries of a state, usually characterized by reduced fares for multiple rides, and commutation tickets for regular, recurring riders." (APTA) Commuter Rail can operate along existing freight tracks with freight trains if cars meet FTA safety standards (i.e., are FRA compliant).	"An electric railway with a 'light volume' traffic capacity compared to heavy rail. Light rail may use shared or exclusive rights-of-way, high or low platform loading and multi-car trains or single cars" (APTA). Light rail is an intermediate rail transit between high speed rail and streetcars.	A passenger vehicle similar to a commuter rail but with lower capacity used for providing passenger service on short or medium distances. DMUs are self propelled vehicles typically powered by diesel. DMUs can operate as a single unit or multiple units based on the demand. Limited options exist in U.S. for FRA-compliant vehicles, limited DMU applications in active freight corridors.	Streetcars are rail transit vehicles designed for local traffic movement and are powered by electricity from overhead catenary wire.	Same definition for Modern Streetcar applies, except replicas of 20th century trolley are used and typically are non-articulated.	Bus Rapid Transit is an integrated system of facilities, equipment, services, and amenities that improve the speed, reliability, and identity of bus transit.
Service Type:	Urban/Regional	Interurban/Regional	Urban/Regional	Urban/Regional	Urban Circulator	Urban Circulator	Urban and Regional
Station Type:	Raised high-floor level platform. Location: Center or Side	Raised high/low floor level or low-level step up platform. Location: Center or Side.	Sidewalk sign, raised high/low floor level or low-level step up platform. Location: Center or Side.	Raised high/low floor level or low-level step up platform. Location: Center or Side.	Sidewalk sign, raised low-floor level platform or low level step-up platform	Sidewalk sign, low level step-up platform	Sidewalk sign, raised low-floor level platform or curb level step-up platform
Distance between Stations:	1 to 3 miles apart (except in CBD)	2 to 5 miles apart	1/2 mile to 1 mile	2 to 5 miles apart	approximately every 1/4 mile	approximately every 1/4 mile	approximately every 1/2 to 1 mile
Service Frequency:	5 to 10 minutes during peak	20 to 30 minutes	5 to 30 minutes during peak	Varies. Typically 15 to 30 minutes	8 to 15 minutes during peak	8 to 15 minutes	10 minute (peak) and 15 minutes (off peak)
Alignment:	Separate right of way	Uses existing tracks (at grade or grade separated crossings)	Either center or side of street in separate or shared right of way with other traffic; exclusive right of way also sometimes provided	Can use existing freight tracks (at grade or grade separated crossings) if meeting FRA requirements; separate guideway is a more expensive alternative.	On street with traffic	On street with traffic	On street with traffic, dedicated lanes
Right-Of-Way Width:	25 to 33 feet (Double Track)	> 37 feet (Double Track)	25 to 33 feet (Double Track), 11 to 13 feet (Single Track)	25 to 37 feet (Double Track)	19 to 24 feet (Double Track), 11 - 13 feet (Single Track)	19 to 24 feet (Double Track), 11 - 13 feet (Single Track)	12 feet (single lane), 25 feet (double lane)
Minimum Turning Radius:	330+ feet	140 to 460 feet	50 to 150 feet	> 250 feet for single car and > 300 feet for multi cars	40 to 80 feet	40 to 50 feet	40 to 70 feet
Vehicle Length:	40 to 70 feet per car	90 to 105 feet per passenger car	50 to 95 feet per car	85 feet to 135 feet	35 to 60 feet	35 to 50 feet	40 to 60 feet
Typical Operating Speed:	30 to 80 mph	30 to 79 mph	20 to 60 mph	25 to 40 mph	6 to 12 mph	6 to 12 mph	Varies, 15 to 20 mph on mixed flow lanes and up to roadway speed limit on dedicated lanes
Maximum Grade:	4 to 6 percent	3 to 4 percent	5-7 percent	< 3 percent	9 percent	9 percent	10 to 13 percent
Seating Capacity Per Car:	60 to 80 seated, 120 to 150 with standees	80 to 170 seated	32 to 100 seated, 150 to 200 with standees	Typically 80 seated	Typically 30 seated, 115 with standees	Varies, 30 to 45 seated, 70 to 100 with standees	Varies. Typically 45 seated for regular 40 foot bus, 60 for articulated buses
Route Length:	10 to 30 miles	20 to 100 miles	8 to 25 miles	10 to 35 miles	1 to 8 miles	1 to 7 miles	2 to 40 miles
Capital Cost per Vehicle:	$2 to $5 million	$1 to $3 million	$2 to $5 million	$5 (single unit)to $9 million (articulated or A-B units)	$2 to $3.5 million	Varies ($100,000 to $1 million)	$500,000 to $800,000 (articulated vehicle)
Capital Cost per Mile: (Excluding Vehicles)	$50 to $250 million (excluding right of way)	$5 to $25 million (excluding right of way)	$30 to $70 million (excluding right of way)	$5 to $45 million (excluding right of way)	$20 to $40 million (excluding right of way)	$5 to $20 million (excluding right of way)	$4 to $25 million (excluding right of way)
Power Source:	Electric	Diesel, Diesel-Electric, or electric with overhead catenary	Electric with overhead catenary wire	Diesel, Diesel-electric	Electric with overhead catenary wire	Electric with overhead catenary wire	Diesel, Alternative Fuel (CNG), Electric Trolley, Diesel-Electric Hybrid
Vehicle Life Expectancy:	25 to 30 years	25 to 30 years	25 to 30 years	NA	25 to 30 years	Varies but typically 25 years or more	12 years
Example Cities:	New York (MTA), Chicago (CTA), Washington (Metro), Atlanta (MARTA), San Francisco (BART), Boston (MBTA)	Dallas-Fort Worth (TRE), New Jersey (NJT), New York (Long Island RR), San Jose - San Francisco (Caltrain), Chicago (MetraRail), Los Angeles (Metrolink), Nashville (RTA), Albuquerque (NMRR), Northern Virginia (VRE)	Denver, Dallas, Minneapolis, Houston, Salt Lake City. Charlotte, Phoenix, Los Angeles, San Diego	New Jersey (River Line), Portland (Westside Express Service), San Diego (NCTD Sprinter Line); Austin Leander Line (2009 revenue opening)	Portland, Seattle, Tacoma	San Francisco, New Orleans, Memphis, Little Rock, Kenosha, Galveston	Boston, Pittsburgh, Los Angeles, New York, Cleveland, Eugene, Houston
Residential Density Thresholds (Pushkarev and Zupan, 1982)*	12 dwelling units/acre (100 - 150 sq. mile corridor); Service Level = 5 minute peak headways	1 - 2 dwelling units/acre (along existing tracks) and requires high density employment centers, such as large central business district, to be viable; Service Level = 6 - 80 trains/day	9 dwelling units/acre (25 - 100 sq. mile corridor); Service Level = 5 to 15 minute peak headways	1 - 2 dwelling units/acre (along existing tracks), Service Level = 6 - 80 trains/day	20+ dwelling units/acre and high density office/commercial uses such as in central city; Service Level = 10-12 minute peak and off-peak headways	Same as for Modern Streetcar but often built for excursion/tourist service	15 dwelling units/acre; Service Level = 10 minute headways

* Estimated average density in housing unit needed to support indicated service frequency.

Table 1: Transit Technologies and Service Alternatives

Basic Characteristics \ Transit Types	Express Bus	Local Bus	Automated Guideway Transit (AGT), Monorail, and People Mover	Demand Responsive (Para Transit, Taxi's etc.)	Carpool/Vanpool	Personal Rapid Transit
						
Definition:	A bus service which is intended to run faster than the local bus. It is an intermediate service between the local bus and the bus rapid transit.	A bus service which is intended for passenger pick up and discharge at designated stops along road corridors.	A fixed guideway transit mode where electrically propelled, rubber-tired vehicles straddle atop or suspend from a single guideway beam, rail, or tube. These vehicles ride along grade separated guideway. Typically operates automatically and without operators as a shuttle service at tourist attractions and airports.	Demand responsive transit (includes paratransit, dial-a-ride, taxi's, etc.) is comprised of passenger cars, vans or small buses operating in response to calls from passengers or their agents to the transit operator, who then dispatches a vehicle to pick up and transport passengers to their destinations. (APTA) While many agencies offer demand responsive service, most limit the service to persons with disabilities, their attendants and companions, and older Americans (with the exception of taxis).	"Carpool/Vanpool service operates primarily from rural and outer suburban areas into urban area central business districts or suburban employment centers. Most carpools/vanpools serve large urban areas, though a few states have statewide programs." (APTA)	A concept that offers on-demand, non-stop transportation using small, independent self-propelled, electric vehicles on a network of specially-built guideways. Two different vehicle sizes and operational objectives exist. Smaller vehicles are designed to carry a single travel party and larger vehicles are sized to transport larger groups, all to the same destination.
Service Type:	Urban and Regional	Urban and Regional	Urban - Theme parks, Airports	Urban, Local and Regional	Urban and Regional	Urban / Suburban
Station Type:	Sidewalk post sign or shelter, curb-level stop	Sidewalk sign post or shelter, curb-level stop	Station, high-level platform for level boarding	Flexible routes; typically curb stops and no set stations	Sidewalk sign and/or park-and-ride lots	Station, platform level with vehicle floor; station is off-line from the main guideway.
Distance between Stations:	Approximately every 1/2 mile	Varies from couple of blocks to every 1/4 mile	Approximately 1/2 mile to 1 mile	Varies	Varies, with major destination a major activity center	Approximately 1/4 to 1 mile
Service Frequency:	10 to 30 minutes	5 to 60 minutes	Typically 5 to 15 minutes	Varies	Varies (on demand)	Demand responsive and therefore no regular schedule; vehicle waits in station until passengers board and select destination
Alignment:	On street with traffic	On street with traffic	Grade separated, dedicated right-of-way	On street with traffic	On street with traffic	Separate right-of-way; typically grade separated
Right-Of-Way Width:	10 to 12 feet (preferred 12 feet)	10 to 12 feet (preferred 12 feet)	Typically 25 ft (over city streets); 6'x8' support pillars	10 to 12 feet (preferred 12 feet)	10 to 12 feet	10 to 12 feet for single guideway; 20 to 25 feet for double
Minimum Turning Radius:	40 to 70 feet	40 to 70 feet	75 to 150 feet	Varies, approximately 25 feet	Varies, passenger vehicles approximately 21 feet	Varies, as low as 30 feet
Vehicle Length:	40 to 60 feet (latter for articulated vehicle)	30 to 60 feet (latter for articulated vehicle)	Varies, could be combined to form trains	Varies, generally less than 30 feet	Approximately 15 to 30 feet	Varies, approximately 9 to 25 feet
Typical Operating Speed:	Varies, 15 to 20 mph in mixed flow lanes; up to roadway speed limit on freeways/expressways	Varies 9 to 15 mph in mixed-flow lanes but depends on the speed of the traffic	25 to 45 mph	Varies, depends on the speed of traffic.	Varies, depends on the speed of the traffic.	15 to 35 mph
Maximum Grade:	10 to 13 percent	10 to 13 percent	6 to 10 percent (rubber tired traction for upper limit)	10 to 13 percent	Varies, depends on vehicle type and manufacturer	5 to 10 percent
Seating Capacity Per Car:	Varies. Typically 45 seated for regular 40 foot bus, 60 for articulated buses	Varies. Typically 45 seated for regular 40 foot bus, 60 for articulated buses	10 to 40 per vehicle (80 with standees; 240-person maximum with 6-car Monorail	5 to 18 (paratransit van),	5 (car/small van) to 18 (extended van or minibus)	3 to 4 for small and 12-15 for large vehicles excluding standees
Route Length:	Varies, but typically 5 to 20 miles	Varies, but typically 2-10 miles	Varies (1 to 4 miles)	Varies (no fixed routes)	Varies (5 to 30 miles)	Varies (2 to 10 miles for first generation systems)
Capital Cost per Vehicle:	$350,000 to $500,000	$300,000 to $500,000	$2 to $6 million	Approximately $60,000	Carpool-none; vanpool costs are often subsidized	$50,000 to $300,000 for first generation systems (no recent examples in U.S.)
Capital Cost per Mile: (Excluding Vehicles)	Minimal cost for bus stops and passenger amenities unless in busway ($5 to $10 million per mile)	Minimal cost for bus stops and passenger amenities	$50 to $100 million	Minimal if operating on city streets	Minimal if converting existing traffic lane to high occupancy vehicle; $10 to $30 million per mile if new facility	Estimated $10 to $20 million per mile but no recent systems in U.S.
Power Source:	Diesel, Alternative Fuel (CNG), Diesel-electric Hybrid	Diesel, Alternative Fuel (CNG), Diesel-electric Hybrid	Electric	Gasoline, Diesel, CNG	Gasoline, Diesel, Electric-gasoline (Hybrids)	Electric or Cable
Vehicle Life Expectancy:	12 years	12 years	10 to 20 years	Varies, depends on vehicle type and manufacturer	Varies, depends on vehicle type and manufacturer	10 to 15 years (estimate for first generation systems)
Example Cities:	Any city with a bus system	Any city with a bus system	Lake Buena Vista Florida (Walt Disney World), Downtown Miami (MetroMover), Las Vegas Casino District, Jacksonville (JTA Skyway), and Seattle CBD. Various U.S. and international cites have airport people movers.	Any urban area	Many areas and employers offer carpool/vanpool services and incentives.	London Heathrow International Airport (in testing), Morgantown, WVA
Residential Density Thresholds (Pushkarev and Zupan, 1982)*	7 dwelling units/acre, Service Level = 40 buses/day (Note: Service Level is for Intermediate service bus; it is assumed that intermediate service bus is equivalent to a Express Bus)	4 dwelling units/acre, Service Level = 20 buses/day (Note: Service Level is for minimum service bus, it is assumed that minimum service bus is equivalent to a Local Bus)	Suitable as circulator in amusement parks and in high-density commercial areas; public transit service would be supported by light rail density thresholds.	Suitable for low residential densities or any urban and surrounding rural areas when limited to service for mobility impaired	Requires high employment densities, typically large central business districts, to be effective	Possibly suitable in moderate and high density mixed residential and employment areas

* Estimated average density