Assessment of New Technologies: Personal Rapid Transit

INTRODUCTION

This section presents the results of the assessment of new technology in transportation. Specifically, the application of Personal Rapid Transit (PRT) or Group Rapid Transit (GRT) in appropriate locations within the Fresno metropolitan area. This section describes PRT, explains its relationship to the PTIS and Measure C, summarizes a case study application of PRT at California State University Fresno, and presents a procedure identifying applications for PRT in Fresno County.

The PTIS' assessment of PRT is intended as an objective evaluation of the technology's feasibility and an analysis of the types of applications it might have in Fresno County. This section does not delve deeply into the technology and operational characteristics of PRT. The study also makes no recommendations as to the fiscal or political feasibility or PRT—these decisions are left to Fresno's elected leaders and their budget priorities. The PRT test case modeling results can be found on www.fasttrackfresnocounty.com or requested from the Fresno Council of Governments.

What is Personal Rapid Transit?

PRT is a form of public transportation that operates on a network of fixed guideways using small cars intended to accommodate an individual or a single party of travelers, typically carrying no more than four to six passengers per car (see Figure B1). PRT is distinguished from other forms of transit by being completely automated and providing non-stop service to the passenger's destination. Similar to other types of fixed guideway transit, like Light Rail Transit or subways, PRT uses stations. However, PRT stations are located on sidings off of the main guideway that allow cars in service to bypass stations. See sidebar for guidelines that define true PRT.

According to the proponents of PRT, this system of direct personal travel provides the following benefits as compared to conventional forms of public transportation (Komerska, 2007).

- Customer-oriented approach which provides on-demand non-stop service anywhere in the network and which allows the individual the privacy to travel alone or in a small group.
- Automated vehicle control and station fare collection which reduces labor operating costs.
- Higher seat-utilization than other forms of mass transit which yields increased operational revenues.
- Minimal stop-and-go travel, thereby reducing travel time and increasing customer appeal.
- Reduced guideway size and right-of-way requirements due to smaller vehicles and dynamic loading effects; reducing guideway costs and visual impact.
- Reduced station size resulting from smaller vehicles, high station densities, high station vehicle throughput and real-time allocation of vehicles; reduce station costs and visual impact.
- Feasible with off-the-shelf technology, due in part to advances in vehicle propulsion, lightweight materials, solid state electronics, automated fare collection and passenger handling, and computer control.

Figure B1. The ULTra PRT System Vehicle as deployed at London Heathrow Airport.

- Ability to be implemented in an incremental manner; beginning as a single loop, networks can evolve into comprehensive systems as demand warrants.

PRT is not a long-range transit system. It is often called a "last mile solution" because it is intended to transport people from one mode of transportation to their final destination or from place to place within an area that, while compact, may be too far to walk. Common examples of PRT applications are from airport parking lots to terminals, from train stations to central business districts, or as a circulator with a central business or large office campus. **Figure B2** illustrates a conceptual application of PRT within a central business district connecting public transportation, parking, and key destinations.

To date, PRT as a form of public transportation with multiple lines and closely-spaced stations as defined above has yet to be constructed in the United States[1]. Despite this fact, PRT remains an active topic within the transportation planning and engineering profession and some municipalities and agencies are currently studying the feasibility of PRT or GRT applications.

The PTIS PRT assessment includes a similar technology called Group Rapid Transit (GRT). GRT is much like PRT but employs vehicles with greater passenger capacity and serves groups with different origin-destination pairs, similar to other forms of fixed-guideway systems. As a result GRT may have fewer non-stop trips than PRT but still experiences fewer stops than conventional fixed guideway systems which stop at every station. GRT has different applications than PRT such as venues where high numbers of passengers need to be moved in a short period of time (i.e., a stadium after a sports event). The application criteria developed in the PTIS distinguishes between applications for PRT and those for GRT.

WHAT IS PERSONAL RAPID TRANSIT?

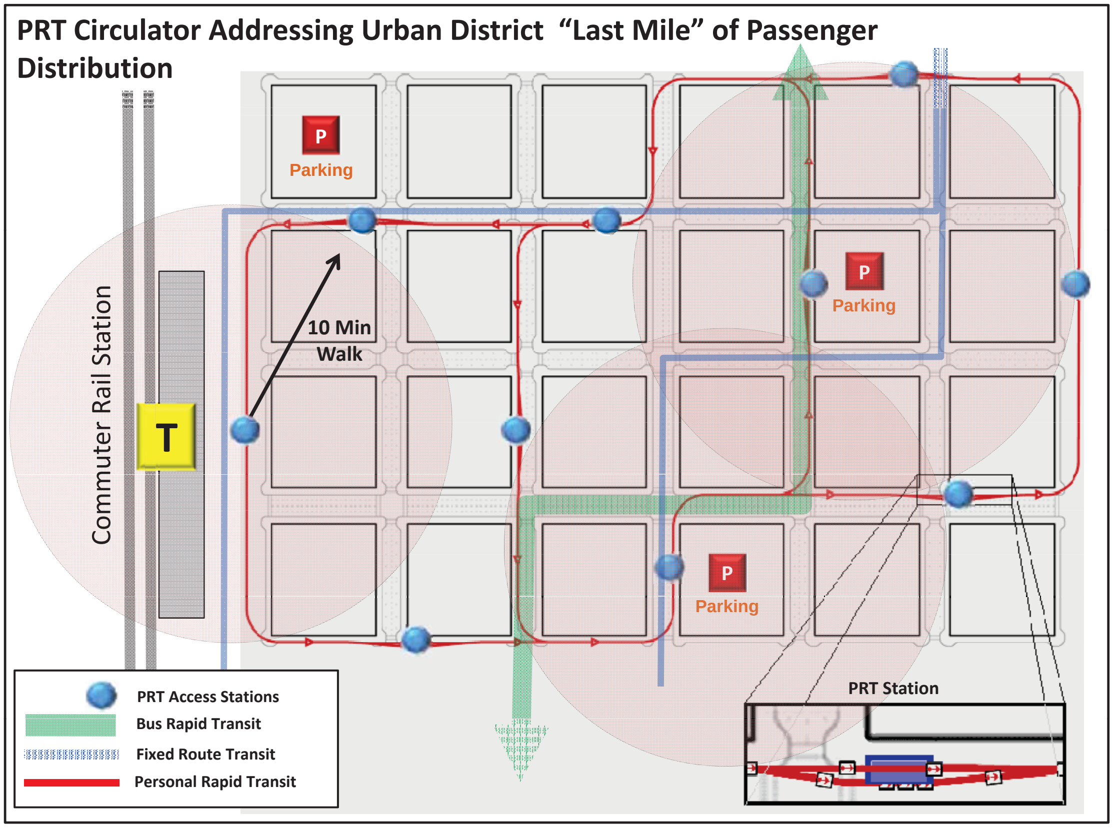
Personal Rapid Transit (PRT) is a form of public transportation known as Automated People Movers (APMs). The Advanced Transit Association, an organization that advocates the research, development, and commercial application of PRT, adopted the following guidelines that define a true PRT system.

1. Fully automated vehicles capable of operation without human drivers.
2. Vehicles operate on an exclusive fixed guideway.
3. Small vehicles available for exclusive use by an individual or a small group, typically 1 to 6 passengers, traveling together by choice and available 24 hours a day.
4. Small guideways that can be located aboveground, at ground level or underground.
5. Vehicles able to use all guideways and stations on a fully coupled PRT network.
6. Direct origin to destination service, without a necessity to transfer or stop at intervening stations.
7. Service available on demand rather than on fixed schedules.

Source: The Advanced Transit Association (ATRA).

[1] *The only "PRT type" of transit technology that has been in service for a number of years is currently operating at West Virginia University in Morgantown. However, the original manufacturer, Boeing Aircraft Company, never developed the technology further following this single project in the 1970's.*

Figure B2. Schematic illustration of a conceptual PRT application in an urban downtown



Overview of Measures C Funding for New Technology

The Regional Public Transit Program of the Measure C Expenditure Plan allocates reserve funding for New Technology Reserve. This funding allocation (about 2% identified in the Final 2006 Measure "C" Extension Expenditure Plan) is available to be programmed for efforts needed to implement transit technologies such as Personal Rapid Transit (PRT) or similar advanced public transportation. The expenditure plan identifies the need for a detailed feasibility study and identification of a timeframe or the funding reserve may revert to other programs. The PTIS is one of the mechanisms for evaluating the technical feasibility of PRT.

Objective

The objective of the PRT assessment is to describe to Fresno County's decision-makers the requirements to implement such this new technology from a technical and cost perspective and to identify and evaluate potential applications. The technical and cost description is based on a detailed prototypical application of PRT at the California State University Fresno campus. Potential applications are based on criteria developed by the PTIS consultants using their experience, professional judgment, and available international research on PRT applications.

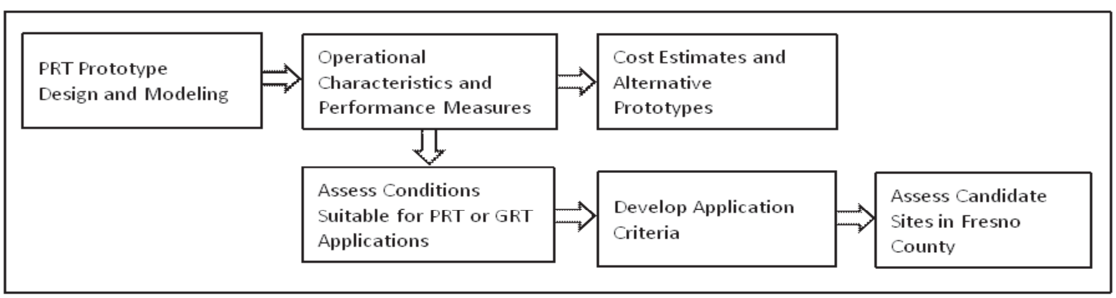
The outcome of the PRT assessment is intended to provide the County with a tool to assist in determining the use of the Measure C New Technology Reserve. The assessment is not intended to determine if PRT is feasible or infeasible; nor is it intended to recommend a definitive application of PRT in Fresno County.

Scope of PRT Evaluation

Assessment Process

The consultant team established the process shown in Figure B3 to assess PRT applications in Fresno County.

Figure B3. Steps in the PRT assessment process.



The process is comprised of two parallel tracks, one track to develop a technical model and a second track to develop the application criteria. The technical track feeds operational and performance characteristics into the development of application criteria.

The process began with the development of a prototypical PRT system at an actual Fresno location (California State University Fresno was selected) to develop operational characteristics and cost estimates. The operational and performance characteristics of the prototype determined the conditions suitable for PRT or GRT which were the basis of the application criteria. The application criteria were applied at candidate sites to test the operational feasibility of PRT in Fresno. The steps in the process are described in more detail in the following sections.

Develop Prototypical PRT System

Simulating a PRT application at the CSU Fresno campus analyzes the operational characteristics, cost implications, and transit user benefits of this emerging, advanced transit technology. However, no PRT system has ever been designed, constructed, and operated on the scale or complexity of the CSU Fresno prototype or some of the other potential applications being considered for Fresno. Therefore, the PTIS' approach used a simulation model of a specific location under hypothetical demand and operational conditions, to develop metrics for assessing PRT in other locations within the Fresno region. The simulation-based performance and operational information also assisted in preparing estimates of capital, operating and maintenance costs, as well as ridership and level-of-service which can be compared against conventional forms of public transportation.

The PTIS consultant team worked with CSU Fresno planners to define a PRT system that would provide a campus access and circulation function. The goals of the conceptual campus PRT system are to:

- Connect the planned new campus intermodal transit station on Shaw Avenue with all parts of the main campus.
- Connect the parking facilities around the perimeter of the campus with all parts of the main campus.
- Connect all parts of the main campus with university property on the fringe; the CSU sports complex on the west side and the Save Mart Center/Student Recreation Center on the east side.
- Provide an internal circulation function within the main campus to serve students moving between classes.
- Provide a more convenient access to the main campus from nearby student housing areas to the west and northwest of the main campus.
- Connect the main campus with the new Campus Pointe mixed use development adjacent to Save Mart Center.

The length of the PRT track system (guideway) and the number of stations (the physical attributes) of the CSU Fresno prototype listed below are benchmarks for reference as other potential dense urban settings are evaluated for PRT applications.

- Number of Stations: 20
- System Route Miles: 5.3
- Stations per Route-Mile: 3.8

The physical attributes of the campus model reflect the way that the PRT system would fit into a typical urban district which has a moderately dense cluster of destinations. The prototype then serves as a template for approximating PRT systems in other urban locations which have a mix of moderate and low demand stations, combined with a few high demand generators that must be served by multiple stations, within a mixed-use environment such as a central business district, a large office campus, or a sprawling mixed-use area.

Application Criteria for Implementing PRT in Fresno County

Not all contexts and conditions are suitable for PRT or GRT. Certain conditions should exist (or will exist) to 1) incent people to use the system, and 2) justify the cost of constructing and maintaining the system. A small town central business district consisting of several blocks within a few minutes walk is an obvious example of a context not suitable for PRT. Other contexts may not be suitable for PRT but may be suitable for GRT.

Development of the application criteria first explored the conditions (operational, physical, environmental) that are suitable for PRT or GRT then examined the types of "places" or contexts in these conditions exist. The conditions and their associated contexts are described below.

Conditions Suitable for Personal Rapid Transit

The following lists operational or contextual conditions where PRT might be a viable transportation option:

- Uniform and continuous demand for travel between origins and destinations.
- Random arrival of demand at stations (no surges at regular intervals).
- Walk distance between origins and destinations typically exceeds 10-15 minutes.
- Existence of physical barriers that either significantly increases walking distance, create an undesirable or insecure environment for pedestrians, or require the use of motorized transportation to overcome (e.g., freeway, river, steep topography).
- Locations where there is a need to minimize land used for parking or automobile circulation due to cost of land, need for higher densities, or other factors.
- Connectivity between one transit system and another, particularly where the transfer of luggage is required.
- Locations where public transportation requires grade-separation (e.g., need land for denser development, or to avoid conflicts with pedestrians and bicyclists).
- Locations where access to the interior of buildings is desirable (e.g., hospitals, or places with inclement weather).
- Property with a single owner or developer interest where it is less challenging to build consensus on the configuration, or share the costs of, a significant and permanent fixed guideway system.

Conditions Suitable for Group Rapid Transit

While GRT shares some of the conditions that make PRT viable, GRT has its own distinct list of conditions. The following lists operational or contextual conditions where GRT might be a viable transportation option:

- Locations where there are peaked surges of demand such as sporting events.
- Employment sites with remote parking and/or regular shift changes where many people travel between worksite and parking at the same time.
- Locations or corridors where there is very high demand between a single origin and destination similar to the line haul function of a bus system.
- The need to connect adjacent activity centers that are outside a reasonable walking distance or are separated by barriers.

Place Types Suitable for PRT / GRT

The operational and contextual conditions listed above were distilled into place types (individual facilities, institutions, or districts) in which PRT or GRT might be considered.

- **Major activity center(s) –** multi-use districts or multiple adjacent activity centers where users link trips, but distance are too far to walk. Examples include regional shopping centers.
- **Sprawling mixed–use districts –** large areas of separated, but diverse, land uses where there is demand to travel between the uses. Typically such districts have areas of high density residential, shopping, entertainment, and employment.
- **Very large institutional or corporate campus –** locations comprised of a single entity or type of land use where there is travel demand between the uses, but because of design, size, topography or environment the destinations are too widespread for convenient walking. Examples include regional medical centers and surrounding offices, college campuses, and business parks.

- **Downtown with widespread venues –** central business districts of large cities where diverse uses are widespread or where there is demand to connect to relatively distant outer districts or facilities such as stadiums, convention centers, shopping or entertainment districts.
- **Remote parking for major employers, and events –** locations or individual facilities with remote parking typically outside reasonable or convenient walking distance such as sporting venues, convention facilities, corporate campuses, or regular large special events.
- **Connecting major travel modes to other destinations –** especially connecting rail stations (which are fixed by the location of the railroad line) with other nearby destinations or other modes of travel such as major bus transfer centers or other rail stations.
- **Large Communities on Urban Fringe (Edge Cities) –** new high growth communities outside of the established metropolitan edge or un-served by public transportation may be planned with PRT or GRT to connect its internal activity centers, particularly growth areas planned under new urban principles.

Case Study Selections

The PRT assessment includes the evaluation of potential applications in the Fresno metropolitan area where the place types described above are likely to exist. This section identifies the case study place types that were selected. A subsequent section provides a brief evaluation of each case study site and expands on a case study which was found to be the most viable location for the application of PRT.

In addition to the CSU Fresno prototype case study, the place types identified for Fresno-specific case studies include the five listed below. Some of these candidate case study types contain multiple place types and thus the five types below address nearly all of the place types identified in the previous section.

- Major activity center (office/retail/entertainment/high-density housing)
- Downtown / Central Business District
- Regional medical center and surrounding medical-related districts
- Individual compact residential / commercial development
- Large-scale new town on fringe of metro area

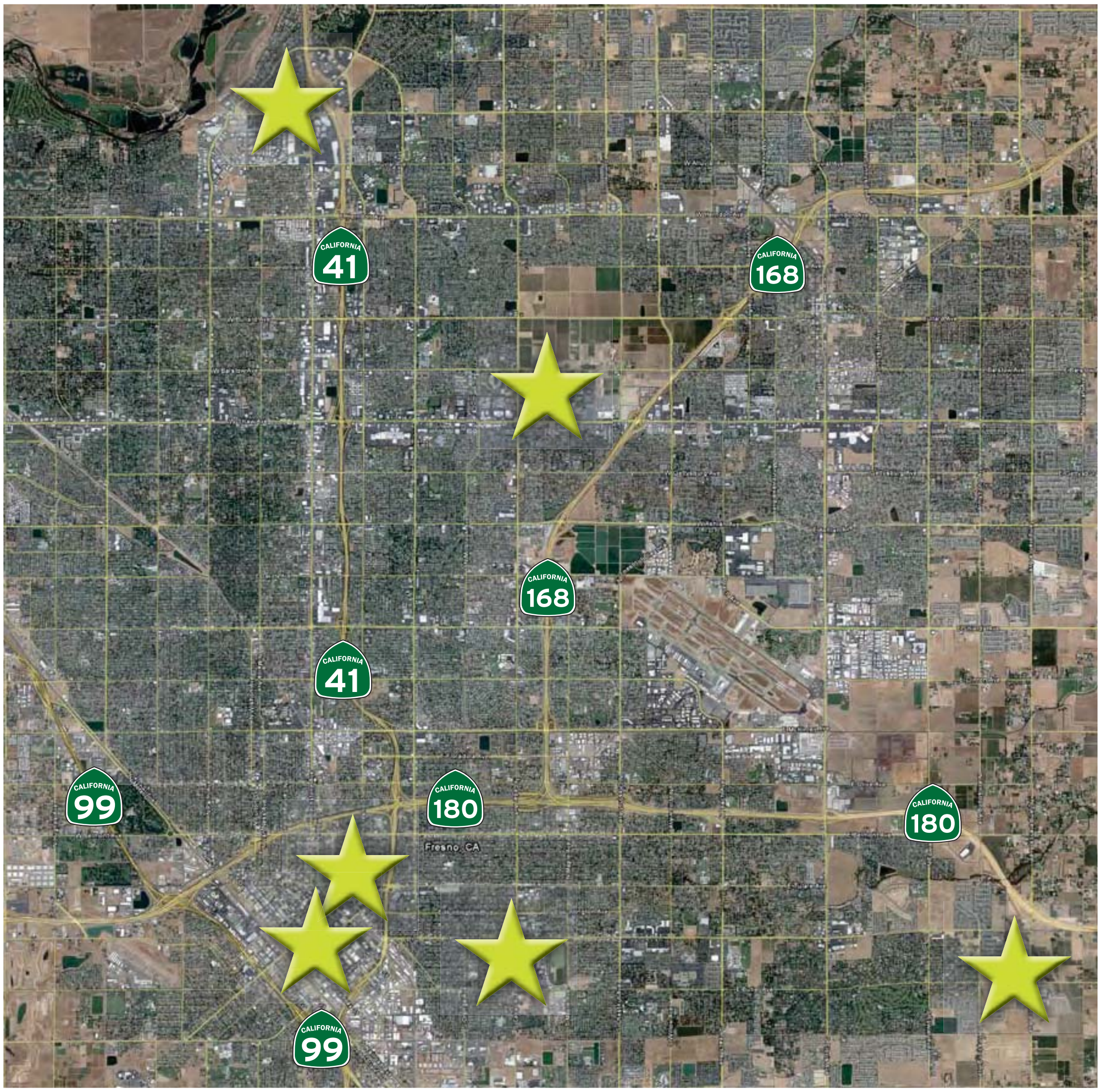
Figure B4 identifies the general location of the five case studies and CSU Fresno within the metropolitan area.The section on Selecting and Evaluating Case Studies identifies the specific locations that were explored under each of the place types identified above.

AN OVERVIEW OF PERSONAL RAPID TRANSIT AND APPLICATIONS

Findings of the CSU Fresno PRT Prototype

The study of a hypothetical PRT system on the campus of CSU Fresno has proven useful for the analysis of PRT for larger urban settings, since it provides a pedestrian intensive environment with a well defined pattern of trips throughout the day. As a prototype, CSU Fresno represents two conditions that need to be assessed in order to evaluate a range of place types. The campus' trip patterns have origin/destination pairs that exhibit both 1) high surge flow conditions, and 2) more distributed and random flow conditions. The study of both conditions is useful for assessing PRT in a diversity of urban applications.

Figure B4. General Location of Case Study Sites Within the Fresno Metropolitan Area



Summary of Key Findings

This section provides a high level summary of the key findings of the evaluation of the prototype CSU Fresno PRT system.

- PRT on the CSU Fresno campus is technically feasible to construct and operate. There is space for the guideway system, stations, storage and maintenance facility and other ancillary fixtures. It can be operated efficiently and would capture about 17% of the daily pedestrian travel that occurs on campus.
- The PRT system, as designed and rested in concept, provides high level of service. It can accommodate a moderate proportion of the campus' daily pedestrian travel between classes, and between parking and the main campus. It can also be configured to accommodate high demand sporting events or special events at the Save Mart Center. Finally, it can connect all of the campus' points to the Campus Pointe development and a transit intermodal center on Shaw Avenue.
- The size of the system (number of vehicles and stations) was challenged in attempting to accommodate peak surges of riders at class change and, as a result, passengers experienced delay during the peaks, and the system incurred extra cost for more vehicles and track.
- The analysis determined that walking competes with PRT. In addition to the general youthfulness of the majority of riders, campus parking is relatively close to most campus destinations, and because the interval between classes is short, delays caused peak surges resulted in competitive travel times with walking. This issue could, in part, be resolved with using GRT rather than PRT on high demand segments of the system.
- Because many of the campus' trips travel similar origin-destination pairs, some segments of the system could more effective by using GRT based on a line-haul function with connecting loops of PRT for less traveled routes.
- The cost of the system ($265 million or about $25 million per mile, see next section for details) may appear cost-prohibitive. However, the prototype was designed to meet peak demands at class change to the extent possible and therefore required a substantial number of stations and vehicles which added dramatically to the cost. An alternative case study—the "Condensed Parking" scenario—looked at a smaller system (reduced by 1.8 miles of guideway), fewer stations, and a focus on moving people between the main campus and parking[1]. This alternative case study resulted in about the same ridership and other similar metrics as the full system but at a lower cost ($215 million).
- It is important to note that because a PRT system has never been constructed in the United States and the technology is advancing quickly but still evolving, estimates of cost, by the nature of an evolving technology, are high. However, as with any technology, once PRT as several commercial applications and multiple manufacturers are competing for the design and implementation of systems, the costs are expected to reduce dramatically to a point similar to ULTra's $7 to $15 million range, competitive with Light Rail Transit, streetcar, and high-end Bus Rapid Transit. The timing of such advancements may be a decade or more or only a few years depending on successful trials in Europe and the United States and customers willing to invest in such a system.

1 The Condensed Parking case study reflects a 2025 future demand scenario and models a modified configuration of the basic PRT system in which the scale of the alignment and the area served by the system is reduced. In the reduced scale system the eastern loop that had served the Campus Pointe development has been removed. Similarly, the western loop that served the stadium and athletic complex has also been removed, leaving only the core campus and the Save Mart Center with direct PRT system access/circulation.

Kimley-Horn and Associates, Inc.

PRT Model Development

University planners and their master planning consultant team collaborated with the PTIS consulting team to prepare sketch-planning level alignment studies. These studies, combined with site visits to investigate the campus layout, led to the development of a baseline configuration reflecting the ultimate buildout of a PRT network serving the campus. To represent a represent a lower cost first phase of PRT implementation the ultimate network was scaled down. This variation of the full prototype is presented in the technical documentation of the PTIS report, available on www.fasttrackfresnocounty.com or on request from the Fresno COG.

The CSU Fresno campus was selected as the location for a prototype design because it has the attributes listed below which produce conditions suitable for PRT:

- Large campus environment
- Very high on-site walk demand between campus locations
- Walk demand spread over the entire campus (wide geographic distribution of trips)
- Parking is relatively distant from campus core and spread over entire campus
- Distance between some campus facilities exceeds the maximum walk distance
- Regular special events with peaked demand are held on campus (e.g., Save Mart Center, sports events)
- The campus is served by external transit with a common transfer point
- The campus has land for expansion and is developing a nearby mixed-use districts

Figure B5 shows the alignment analyzed for operational performance and passenger service levels. The baseline system comprised a double guideway loop that ringed the center of the campus where the majority of the classroom buildings are located, with several station sidings located along its length. Extending across this campus loop were three single-guideway connectors to serve stations internal to the main loop – one on the east end, one central to the campus, and one on the west end. Also extending outside the double-guideway loop were additional single-guideway loops that served Save Mart Center and Campus Pointe on the east, the parking facilities on the northwest edge of the campus, and the west stadium area. Although a number of additional possible configurations could have been developed the conceptual system shown in Figure B5 was sufficient for analyzing PRT in general.

Figure B5. Conceptual PRT system developed for California State University Fresno campus.

Kimley-Horn and Associates, Inc.

Future PRT Modeling Results

This section summarizes a variety of operational metrics and performance measures for the Year 2025 future conditions scenario. Trip demand that drives this scenario represent a hypothetical class schedule for student and faculty person-trips in 2025, approximated by factoring the 2009 class schedules using a 34.5% growth rate. The PRT ridership person-trip activity not only represent an escalation of student person-trip activity for the future year, it also represents an assumption that 20% of the regional access trips come by way of FAX transit to the proposed new intermodal center on Shaw Avenue. Table B1 presents the operational metrics drawn from the computer models for the future conditions scenario.

Table B1. Summary of Operational Metrics for CSU Fresno Campus PRT System

Operational Metric	Year 2030 Campus Conditions
Operating Mode	Shared ride service
Daily Ridership	14,249 people
Total Daily Pedestrian Trips on CSU Fresno Campus	86,086 person-trips
Share of Total Daily Pedestrian Trips Using PRT	17 percent
Fleet Size Requirement	140 vehicles
Average Wait Time to Board PRT Vehicle	2.3 minutes
Average Trip Time [1]	5.95 minutes
Average Travel Time from Departure to Arrival	3.58 minutes
Vehicle Miles Traveled [2]	10,028 miles
Passenger Miles Traveled	11,253 miles
Average Trip Length	0.79 miles
Average Vehicle Occupancy [3]	2.33 passengers
System Capital Cost (see cost section below) [4]	$265,000,000
System Operations & Maintenance Cost [4]	$3,100,000

Notes:
[1] Including wait in the station to board.
[2] Including both empty vehicles and vehicles carrying passengers.
[3] Empty vehicles not included in the averaging.
[4] In 2010 dollars. See section on Estimated Operations and Maintenance Costs below.
Source: Kimley–Horn and Associates, Inc.

Comparison of PRT and Alternative Modes of Transportation

In this case study, implementing PRT has the highest cost when compared to alternative forms of campus circulators or with the current form of on-campus transportation – walking. Table B2 compares the capital construction and operating costs of three types of transit system that might be considered for large area circulators: trolley bus, streetcar, and PRT. Clearly, trolley bus systems are the most cost-effective when compared to the fixed guideway systems used by streetcars and PRT. The comparison, however, is wholly academic because campus planners are unlikely to implement trolley bus or streetcar systems at-grade in the interior of the campus where conflicts with pedestrians would be significant. Trolley and streetcar systems would likely only be implemented on vehicular streets circumscribing the campus and penetrating into the campus infrequently. Therefore, unless grade-separated like PRT an alternative system would not provide the same connectivity or level of service as PRT.

Table B2. Comparison of Capital and Operating Costs of Alternative Campus Circulators

Circulator System [1]	Capital Construction Cost	Daily Operating Costs
Trolley bus [2]	$1.1 million	$1.60 - $2.00 per route-mile
Streetcar [3]	$53-$79.5 million	$12 - $15 per route-mile
Personal Rapid Transit [4]	$79.5 – $265 million	$1,800 - $2,000 per route-mile

Notes:

[1] Each system cost based on a similar 5.3–mile route connecting the same origins and destinations as the CSU Fresno prototype PRT System described in detail in the following sections.

[2] Capital cost for three rubber–tired trolley vehicles.

[3] Streetcar cost estimates based on general per–mile costs published by the Federal Transit Administration in recent requests for grant.

[4] The lower end of the range to construct PRT is based on $15 million per mile from ULTra, the company that design and manufactured the Heathrow Airport PRT system. The upper end of the range was estimated by Kimley–Horn and Associates based on the prototype design. See cost estimating section below for details.

Source: Kimley–Horn and Associates, Inc.

ESTIMATING THE COST OF PRT

Introduction

The estimated costs for the conceptual PRT system on the CSU Fresno campus are order-of-magnitude approximations, since the design is conceptual and the ridership estimates are hypothetical. The capital cost estimates are, however, suitable cost-per-mile approximations as a basis for estimating PRT applications at alternative sites. The estimates presented here are based on sources from multiple automated transit system projects, including “automated people movers” (APM’s) as well as preliminary cost data drawn from other PRT projects.

At the present time, no PRT system on the scale and complexity of the CSU Fresno campus prototype has ever been built, and as a result there is no historical cost data for reference. Therefore, the approach to cost estimation presented here is defendable in light of the past 25 years of actual APM costs. Furthermore, various elements common to APM systems are also required for implementation of a PRT system on the scale defined for the CSU Fresno campus, so their use in the CSU Fresno estimates is justified.

Estimated Capital Costs of CSU Fresno Prototype

A detailed explanation of the basis of the capital cost estimates as well as the operations and maintenance (O&M) costs are presented in the modeling data tables associated with this report. In this section, Table B3 summarizes the capital costs for the system equipment (vehicles) and the fixed facilities.

Table B3. Summary of Capital Cost for the CSU Fresno Campus Prototype PRT System

System Equipment [1]	**$80,000,000**
Fixed Facilities [2]	$124,540,000
Engineering Design	$36,000,000
Contingency (10%)	$24,000,000
Total System Capital Cost	**$264,540,000**
System Lane Miles (both uni-directional and bi-directional):	10.3
Cost Per Mile:	**$25,800,000**

Notes:

[1] Includes vehicles, power and control, spare parts and provisions for maintenance facility, operations control center equipment, office/ employee facilities, and includes costs for developing, installing, testing and commissioning the computer control system.
[2] Includes guideway structures, stations, operations control center and maintenance and storage facility.

Source: Kimley–Horn and Associates, Inc.

Estimated Operations and Maintenance Costs of CSU Fresno Prototype

The operations and maintenance (O&M) costs of the CSU Fresno PRT prototype were estimated considering other similar scaled automated transit projects adjusted to reflect the prototype's specific operating characteristics. Of significance in developing the O&M estimates is that most of the operating fleet required to service the peak demand conditions upon class change remains fairly idle throughout the rest of the day. In fact, the average total mileage for the entire fleet totaled a relatively low 9,000 to 10,000 vehicle miles per day, less than 70 vehicle-miles per day per vehicle. This allows the fleet to be operated and maintained by a fairly small work force. This fact, combined with the availability of technically capable students who would be willing to work part time allows the O&M costs to be kept fairly low. Table B4 summarizes the system's annual operating and maintenance costs.

Table B4. Estimated Annual Operating and Maintenance Costs for the PRT System

Expense	Annual Cost
Payroll (Manager, Admin, Supervisors and Mechanics)	$1,956,738
Maintenance Expenses	$652,246
Energy Expenses	$211,980
Contingency (10%)	$282,096
Total Annual Operations and Maintenance Cost	**$3,103,061**

Source: Kimley–Horn and Associates, Inc.

Although the O&M costs do not include the costs for depreciation costs for replacement of vehicles, stations and guideways, the operating life of these elements should be quite long. The most common item for transit systems that typically needs replacement within 10 years are the vehicles. However, the very low accumulation of mileage per vehicle will allow vehicle replacement cost to be pushed well into the future. Under moderate to high usage the vehicles would wear out faster and the depreciation / replacement cost of the fleet would be about $3,000,000 annually over the 20-year lifespan of the vehicles.

The State-of-the-Industry in PRT Cost Estimates

Based on available literature of the costs of constructing PRT systems, costs to construct and operate a PRT system will vary significantly depending on the complexity of the system, and by the ridership demand placed on the system. While the guideway and computer control systems will generally remain constant, station capacity and the number of vehicles will vary widely based on the amount of passengers for which the system is designed. The following information is paraphrased from material published by ULTra, the company that designed and built the Heathrow International Airport PRT system currently operational and undergoing testing.

ULTra identifies a generic range of $7,000,000 to $15,000,000 per mile based on a composite cost derived from a typical anticipated PRT application including vehicles, guideway structure, stations, and control system. ULTra's generic cost does not appear to include all of the costs included in the CSU Fresno prototype estimate such as storage and maintenance facilities, control center, and employee facilities.

This range is similar to the range published by The Association of Advanced Transit (ATRA) which states:

"……one can reliably predict that fully costed PRT will run about $12.5 million (M) per mile. Utilizing a "fudge factor" of plus or minus 20% gives us a cost range of $10M/mile to $15M/mile. Although somewhat higher than most PRT estimates, this range provides an added degree of confidence until an actual system is deployed. For purposes of estimating the costs of PRT in transit projections, most transit professionals accept a range of $10M/mile to $15M/mile for all economic costs of putting into operation a PRT system."

To be objective, it is prudent to disclose that there are challenges to ULTra's general per mile cost estimates. Below is a quote from www.publictransit.us where author Michael D. Setty writes:

"The website for the personal rapid transit (PRT) system claimed by proponents as closest to revenue operation, the 2.5 mile "ULTra" PRT parking lot shuttle currently undergoing testing at Heathrow International Airport outside London, recently released more information regarding construction costs. In most applications, ULTra estimates costs of $7 to $15 million per one–way guideway mile. After reviewing this cost, it is highly probable that ULTra proponents have underestimated likely PRT capital costs per mile by at least a factor of two to three."

The author goes on to describe a technical analysis related to the lifespan and replacement needs of the PRT vehicles and concludes that the cost of the ULTra system under circumstances similar to the Heathrow International Airport system is more likely to cost in the range of $20-$40 million per one-way guideway mile if reinforcement of the vehicles for longevity and associated reinforcement of the guideway was to be implemented[2]. To be fair, the author appears to be skeptical of PRT as a cost-effective for of public transportation.

Table B5 presents a comparison of other cost information collected by the US DOT and the cost estimates developed for the European EDICT program. Table B5 was published in a report titled "Viability of Personal Rapid Transit in New Jersey"[3]. The report identified a range of "conservative" capital cost estimates for PRT and other transit systems. The low end of the theoretical costs for PRT presented in Table B5 are similar to the per mile costs developed by Kimley-Horn and Associates, Inc. for the CSU Fresno Prototype.

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2 The reader is referenced to www.publictransit.us/index.php?option=com_content&task=view&id=201for details of the technical discussion.
3 Carnegie, Jon A., Hoffman, Paul S., Alan M. Voorhees Transportation Center Rutgers at The State University of New Jersey and Booz Allen Hamilton, Inc. The Viability of Personal Rapid Transit In New Jersey Final Report. Governor Jon S. Corzine and The New Jersey State Legislature, New Jersey Department of Transportation Bureau of Research and NJ Transit. February 2007.

Table B5. Capital Costs – Conventional Transit Versus PRT

Mode	Capital Cost/Mile ($M)		
	Low	Average	High
Observed Construction Costs			
Heavy Rail	$110	$175- $250	$2,000
Light Rail	$25	$50-$70	$195
APM – Urban	$30	$100-$120	$145
APM – Airport	$50	$100-$150	$237
BRT Busway	$7	$14-$25	$50
BRT Tunnel	$150	$200 - $250	$300
Theoretical Engineering Cost Estimates			
PRT One Way	$15	$20-$35	$50
PRT Two Way	$25	$30- $50	$75
CSU Fresno Prototype	$25	$43	$61
Notes: Sources: See Footnote. Authors cite sources of costs as Kerr 2005, TCRP R90, GAO 2000, Vendor estimates & case studies.			

Additional Sources and Examples of PRT Cost Estimates

Morgantown / West Virginia University GRT System

The Morgantown / West Virginia University system is the only operating near-PRT system in the United States. Built in the 1970's by Boeing Aircraft, the system remains in operation today. Being the only near PRT system in long term use it's useful to compare the cost of Morgantown with estimated costs of the CSU Fresno prototype. While there are many differences between the systems and their configurations (e.g., PRT versus GRT) there some noteworthy similarities as shown in Table B6.

The following section is a qualitative analysis of the Morgantown / CSU Fresno comparison by Mr. Dennis Manning, a member of the Advanced Transit Association and member of the PTIS Technical Advisory Committee.

Table B6. Comparison of Operating and Cost Characteristics (Morgantown GRT versus CSU Fresno Prototype)

Characteristics	Morgantown (GRT)	CSU Fresno Prototype (PRT)
Students and Faculty	28,000	22,000
Miles of guideway	8.7	10.2
Stations	5	21
Ridership (approx.)	15,000	15,000
Number of vehicles	70	135
Vehicle size (passengers)	20	4
End to end distance (miles)	3.6	2
Total capital cost (2010 dollars)	$484m	$265m
Cost/mile (2010 dollars)	$55m	$26m
Annual O&M (2010 dollars)	$2.0m	$4.3m
Fare box return	50%	N/A
Source: Dennis Manning, Member of the PTIS Technical Advisory Committee.		

At first glance it would appear that the Morgantown capital costs are double the CSU Fresno prototype estimate. On closer inspection and in light of 35 years of technical and planning advances the modern equivalent could be built for a cost of under $20 million per mile [in Mr. Manning's estimation].

According to Mr. Manning there were a number of extenuating circumstances that resulted in the high construction cost of Morgantown, circumstances that would be easy to overcome with today's advances in the technology. Mr. Manning summarizes these circumstances below[4].

- As a result of an extremely rushed schedule there was a series of planning and design errors. All design was from scratch and there were no test facilities built prior to the project. Note that these "experimental" costs are not included in the CSU Fresno prototype estimate based the assumption that any CSU Fresno prototype will have completed testing of vehicles and will have control system technology already completed.
- The guideway was over built because the vehicle weight was unknown at the time of the design. So it was designed to carry far more than was necessary.
- The vehicle's heating system was an afterthought and the design resulted in an overly costly heating system. The operational cost runs are four times higher than the power requirement for the entire system. No heating system is included in the CSU Fresno prototype design.
- Midway through the project, Boeing redesigned the vehicles for four-wheel steering in order match the width of the predesigned guideway.
- The Morgantown system was built over challenging terrain with grades as high as 10%.

4 *Source of Mr. Manning's information: www.tinyurl.com/25dxhhv www.tinyurl.com/2ekb9n6*

- There is no information on right of way costs except that much of the alignment required acquisition of right of way outside the campus in contrast to the CSU Fresno prototype which assumed all right of way was owned by the university.
- During construction of Morgantown there was a change in the principal contractor adding another cost burden to the project.

Mr. Manning concludes that the Morgantown system's cost, under scrutiny, provides evidence that a modern well designed and planned PRT system should cost no more than $20 million per mile for capital costs.

Vendor Stated Costs and Feasibility Study Cost Estimates of PRT Systems

Table B7 summarizes PRT system costs (on a per mile basis, operations and maintenance or per trip basis if available) from data compiled by Mr. Manning. The source of this information is identified in the notes section of the table. The following summary is Mr. Manning's analysis of this and other data presented above.

As stated previously PRT has a wide range of possible costs. The range appears to be about $15 to $30 million per mile for a full system layout. Using a cost per mile is an old standard for cost comparisons. Mr. Manning concludes that overall capital cost divided by the number of stations (cost per system station) is an important metric that defines the cost of the walking area provided. For example the Morgantown system has five stations at a cost of $484 million or a cost per station of $96.8 million. For this example, assume walking distance is the same at each station and covers an area of 1.0 square mile. Therefore, the cost of providing 1.0 square mile of walking area (1 station) is $96.8m. Assuming the same coverage area, the CSU Fresno prototype cost is $265 million divided by 21 stations or $12.6 million for each one square mile of walking area.

Factors That Influence the Cost of PRT

Many factors will influence the cost of constructing a complex PRT station and cause the costs to increase significant above the basic rule of thumb of $7 to $15 million per mile. Such is the case for the CSU Fresno prototype where many stations were designed into the system to reduce wait time and make PRT competitive with walking.

ULTra has identified primary and secondary factors that will influence the variation of cost for any individual PRT system, as well as identified elements of a PRT system that would result in a cost-effective optimal system. These factors are listed below.

Table B7. Summary of Vendor Stated Costs and Costs Cited in Feasibility Studies

Vendor / Supplier	Cost Per Mile	Other Cost Data (If Available)
PRT System Vendor Stated Costs		
2getthere [1]	$5.5 to $11.0 million (system cost only)	O&M cost: 8% - 10% of overall investment
Vectus [2]	$21 million +/- 15%	Cost per trip: $0.50
ULTra [3]	$13 million (system cost only)	
Cabintaxi [4]	$28 million (or under)	
Skyweb Express [5]	22m/mi. - $33m (may include supplier profit margin)	
PRT International [6]	$10 to $15 million (system only)	
PRT Minnesota [7]	$10 million (system only)	
Cybertran (GRT) [8]	$25 to $30 million Bi-directional system	
PRT Feasibility or Planning Studies		
Agency / Client /Sponsor	**Cost Per Mile**	**Other Cost Data (If Available)**
State of New Jersey [9]	$30 to $50 million Bi-directional system	
City of Ithaca [10]	$30 to $50 million Bi-directional system (from NJ study)	Cost per passenger mile: $0.40
Daventry, UK [11]	$22 million Bi-directional system	
Swedish Studies (multiple cities) [12]	$18 million	
Fort Carson [13]	$14 million	

Notes:

[1] Source: Email from 2getthere Marketing Manager Robbert Lohmann to Dennis Manning.

[2] Source: Minnesota Dept. of Transportation (MnDOT) Request For Information (RFI) responses www.tinyurl.com/28dxyja (very large file of 116mb).

[3] Source: MnDOT RFI responses www.tinyurl.com/28dxyja

[4] Source: Email from Marsden Berger. He indicated that Cabintaxi does not divulge costs because business plan calls for private financing with Cabintaxi as system owner.

[5] Source: www.tinyurl.com/2bybjer

[6] Source: MnDOT RFI responses www.tinyurl.com/28dxyja

[7] Source: MnDOT RFI responses www.tinyurl.com/28dxyja

[8] Source: Email from CEO Neil Sinclair to Dennis Manning.

[9] Source: www.tinyurl.com/cljgld

[10] Source: ftp://ftp.cscos/com User name: ithacaprt Password: cscompanies

[11] Source: www.tinyurl.com/2ct6j89

[12] Source: www.tinyurl.com/287bufc

[13] Source: www.tinyurl.com/2ee5ph8

Table compiled by Kimley-Horn and Associates, Inc.

Primary Capital Cost Factors

- System size (particularly if custom elements are required)
- Station density - stations required per guideway mile
- Desired average passenger wait time
- Peak system loading
- Amount of uni-directional versus bi-directional guideway
- Amount of elevated/at-grade/tunnel/culvert/cantilever guideway
- Open environment deployment (urban and public areas or semi open/closed, controlled access such as airports and private campus areas
- Integration with other site facilities/roads/pedestrian areas etc.
- Security requirements
- Level of architecture and amenity of station design.
- Custom vehicle appearances and characteristics

Secondary Capital Cost Factors

- Raw material commodity costs (concrete and steel)
- Soil conditions
- Seismic conditions and associated engineering requirements
- Presence of utilities
- Geographic location of system installation
- Inflation and cost construction labor
- Site access and integration with other site activities (most systems are prefabricated off site)
- Time available for deployment
- Local safety legislation

Optimum Cost Systems

An optimum capital cost system would typically have:

- Ten or more miles of guideway
- A high percentage of at-grade guideway
- Fewer [2 - 2.5] stations per mile of guideway
- Lower passenger demand
- Simple stations
- Favorable soil conditions
- Lower regional construction costs
- High use of standardized components
- Higher Cost systems
- A relatively higher capital cost system would typically have
- 3 or fewer miles of one-way guideway
- A high percentage of elevated, tunnel, or culvert guideway
- More stations per mile of guideway
- Higher passenger demand
- Stations with high level of architectural interest or amenities
- Poor soil conditions
- High regional construction costs
- High customer requirement for system customizations

Leveraging the Measure C New Technology Reserve Funds

The New Technology Funding Reserve (NTFR) set aside was approximately $35 to $40 million when the 2006 Expenditure Plan was prepared. This reserve has likely reduced under current projections of sales tax revenues (or extended well beyond original estimates). Based on the significant amount of cost data presented above it is clear the reserve, even under its full allocation, is insufficient to construct a working PRT system of any practical or functional value. However, the funds may be used to leverage other sources of funds to develop some form of research and development or testing facility. There are benefits to applying the NTFR in this manner.

Fresno is the only jurisdiction in the United States with funds set aside to develop PRT. If not utilized within a specific timeframe there is a possibility that the Measure C NTFR will be diverted to other high priority transportation needs. Once used for other needs, it is unlikely that the NTFR would ever again be available for PRT.

This section of the report presents a strategy for using the reserve to leverage additional funds from federal, state, regional, institutional, capital venture, international or private sources to advance PRT towards commercial viability in the United States. This strategy is also consistent with the PTIS' strategy to identify and promote/recruit new industry to the Fresno Metropolitan area—industries that would attract young professionals who desire a transit-supportive lifestyle in a redeveloped Downtown Fresno or within high capacity transit corridors.

A possible first step of the strategy is to construct a PRT test facility. This step is consistent with the NTFR priority to "identify best potential projects for new technology funds" and is proposed for the following reasons:

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1. Enable the leverage of matching funds available from federal or state sources in the future, or from other public or private sources.
2. Use reserve as a job creation and industry attracting program by leveraging public funds and attracting critical private investment for high tech firms that manufacture and deploy PRT in Fresno or throughout the Country.
3. Create an operational platform to develop and evaluate performance capability and costs of PRT for government, industry, consultants, academia, etc.
4. Establish a PRT regulatory and safety evaluation platform for government, industry, consultants, academia, and a platform for the development and testing of industry manufacturing and safety standards.
5. Assert Fresno CleanTech leadership in developing 21st century economic development by creating an industry nucleus that attracts ancillary and supporting businesses.
6. Develop ongoing PRT Research and Development Center that can be a nexus of innovation for development of AB 32 and SB 375 compliance strategies for Fresno and the San Joaquin Valley.
7. Help the United States become competitive with the more highly developed PRT industry in Europe and Asia.

For more information on the individual strategies identified above, please refer to "The Case For Building a PRT Test Facility in Fresno" (Dennis Manning in 2010) located on the project website on www.fasttrackfresnocounty.com or on request from the Fresno COG.

APPLICATION CRITERIA FOR PRT

This section summarizes the development of criteria to determine the applicability of PRT within the Fresno metropolitan area. The criteria build upon the conditions that the PTIS consulting team found suitable for the application of PRT or GRT presented earlier in this chapter. This section provides an overview of the criteria and discusses the case studies used to test the criteria. Finally, this section presents a hypothetical application of PRT to the most promising case study site.

Overview of Application Criteria

Because of its cost, complexity and permanence Personal Rapid Transit is not always an appropriate solution even when high frequency and high quality public transportation is justified. An appropriate site for PRT or GRT must possess certain travel demand characteristics and must have the correct physical attributes that create an environment where PRT is a cost-effective alternative. The criteria are divided into categories that represent travel demand characteristics, physical attributes, site operational characteristics, land use / land value characteristics, and special attributes suitable for Group Rapid Transit. The criteria are:

Travel Demand Related Criteria

- **Uniform and continuous rider demand—**passengers arrive at stations in a uniform flow but frequently. Arrivals are split between individual passengers and groups. Some groups may be larger than vehicle capacity (4 to 6) but infrequently.
- **No peak surges—**passengers arrive randomly and not in highly peaked surges. Peak surges such as shift changes, release of special events, of class changes at schools puts substantial demand on the system which either needs to be designed to handle peak loads or viewed as an inadequate system during peaks.
- **Need to connect adjacent activity centers—**where there is a demonstrated high level of travel interchange between adjacent activity centers such as between two large shopping centers or an employment center and a retail center.

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Physical Attribute-Related Criteria

- **Large district / campus (exceeds reasonable walk)—**where there is a demonstrated demand for travel interchange within an individual large site or district and driving between buildings or parking lots is undesirable but origin and destination pairs are outside of a reasonable walking distance (greater than 15 minutes), or there is demand to circulate within a district but the area is so large as to make it impractical to traverse the district by walking.
- **Barriers to traversing site by walking—**where there is a demonstrated demand for travel interchange within an individual large site or district but pedestrian and bicycle travel is impeded by a significant physical or perceptional barrier such as topography, body of water, freeway, vacant land, etc.
- Site Operational-Related Criteria
- **Remote parking—**where, because of price, availability or simply because of distance, a site's parking area is outside of a reasonable walking distance. The site must generate enough parking demand to meet the other requirements for travel demand listed above, such as a large employment site or center, a large retail site, or an institutional use such as a hospital, college or university.
- **Connectivity to other transit modes—**where a major public transit mode is separated from another transit mode either by distance or inconvenience and there is a demonstrated demand for transfer between modes. An example might be the High Speed Rail station and the Blackstone Bus Rapid Transit line.
- **Access to interior of buildings—**where access to the interior of a building is desirable due to inclement weather, or for the buildings operational needs such as a hospital where patients are transported from other buildings or parking and should remain within the hospital environment.

Land Use and Land Value-Related Criteria

- **Require grade–separation—**where land value is significant enough that circulation infrastructure should be grade-separated to allow use of the land below for more valuable purposes, or where the combination of travel modes creates numerous conflicts which only grade-separation can resolve.
- **Minimize parking footprint and car circulation—**sites with significant land value where parking and automobile infrastructure (i.e., streets) is located remotely in order to maximize the amount of developable land.
- **Single owner or developer interest—**a large site which meets other criteria listed above and is owned or controlled by a single owner, entity or interest creates an easier environment to plan, fund, and implement PRT.
- **Master planned development—**a wholly new development or major redevelopment site in which PRT infrastructure can be planned and designed into the development's fundamental armature in order to establish a permanent public transportation system in advance of development, occupancy, and even travel demand. Examples would include large Greenfield developments, or new communities on the fringe of urban areas.

Group Rapid Transit Special Criteria

- **Peaked surge demand—**any site where large numbers of passengers desire transportation at the same time. Examples include class change at colleges, release of sporting event, concerts, or major entertainment venues. It also includes shift change or end of work day employee releases at very large employment centers.
- **Regular special events—**similar to above, any site which holds regular highly attended evenets but parking or other public transportation is distant.
- **Remote parking with shift changes—**employment sites where because of price, availability, or Transportation Demand Management, parking is located remotely from the site and large numbers of employees surge to parking at the end and the beginning of shifts.

Selection and Evaluation of Case Studies

The PTIS scope of work for assessing PRT includes testing the application criteria at up to five actual sites within the Fresno metropolitan area. The five sites were chosen to match the place types discussed earlier—place types are sites and uses that have appropriate operational and contextual conditions in which PRT or GRT might be considered.

Table B8 presents the results of the case study evaluation of the five candidate sites. Each case study is discussed on the next page.

Site A: River Park Activity Center

A large area (approximately 500 acres) comprised of a segregated mix of office park, large retail centers, entertainment uses, medical facilities, and moderate to high density housing. See Figure B6.

The River Park Activity Center also meets the criteria for application of PRT. Within its more than 500 acres the activity center contains a mix of uses that generate internal travel demand. As shown in Figure B7. These uses include moderate and high-density residential, a large business park, institutional uses including two medical centers, a corridor lined with strip commercial, big box retail, and community shopping centers, schools, a regional park and other recreational facilities, a regional retail and entertainment center, and some isolated industrial uses. The site straddles the Woodward Park and Bullard Community Plan areas, and the planned Blackstone Avenue Bus Rapid Transit route passes through the activity center and terminates in the business park in the northernmost end of the site.

The land uses comprising the activity center draw travel from the entire region but also create a substantial amount of internal travel demand for shopping, dining, medical visits, office visitors, deliveries, and social and recreational trips. These trips are uniformly spread throughout the day with moderate peaks in the morning, midday and evening. Thus the activity center meets the travel demand criteria. The area is very large and while individual developments are walkable, it is not practical to walk from one segregated activity center or land use to another. Furthermore, barriers to pedestrian travel are created by Highway 41 bisecting the site and numerous large parking lots surrounding most uses creating an auto-dominated environment.

Table B8. Evaluation of Case Study Sites for PRT or GRT Applicability

Application Criteria	Downtown Fresno	Activity Center	Medical Center	Mixed Use Development	Fringe New Town
Travel Demand Related Criteria					
Uniform and continuous demand	✓	✓	✓	NO	✓
Random arrival of demand (no peak surges)	✓	✓	✓	NO	✓
Connect adjacent activity centers	✓	✓	✓	NO	✓
Physical Attribute Related Criteria					
Large district / campus (exceeds 15 min walk)	✓	✓	NO	NO	✓
Barriers to traversing site by walking	NO	✓	NO	NO	✓
Site Operational Related Criteria					
Remote parking	✓	✓	NO	NO	✓
Connectivity to other transit modes	✓	✓	NO	NO	✓
Access to interior of building	NO	NO	✓	NO	NO
Land Use and Land Value Related Criteria					
Require grade-separation	P	NO	✓	NO	NO
Minimize parking footprint and car circulation	✓	✓	✓	NO	✓
Single owner or developer interest	NO	NO	✓	NO	NO
Master planned development	NO	NO	NO	✓	✓
Group Rapid Transit Special Criteria					
Peaked surged demands	✓	NO	Shift Change	NO	NO
Regular special events	✓	NO	NO	NO	NO
Remote parking with shift changes	NO	NO	Potentially (future)	NO	NO
Suitable for: Personal Rapid Transit	YES Circulator	YES	If Expanded with Remote Parking	NO	Connect Town Centers and Employment
Suitable for: Group Rapid Transit	Some Sites – Stadium, High Speed Rail, Remote Parking	YES	NO	NO	YES

Source: Kimley–Horn and Associates, Inc.

Figure B6. River Park is a major multi-use activity center in north Fresno.

Figure B7: River Park Mixed-Use District

The activity center offers an opportunity for remote parking in the future but presently there is ample free parking for all of the land uses in the activity center. The need to connect multiple activity centers and land uses with demonstrated trip interchange and the long distances between the uses, combined with the random arrival patterns of users spread throughout the day and evening justifies the application of PRT or GRT. Based on the evaluation criteria the River Park Activity Center is a potential application for PRT or GRT.

Site B: Downtown Fresno

Site B is comprised of the Central Business District bounded by Highway 99, Divisadero Street, and Highway 41. This area would include the future High Speed Rail Station, the Chukchansi Park stadium, the Fresno Convention Center, the City and County government centers, the Amtrak Train Station, and the FAX downtown transit center. See Figure B8.

Downtown Fresno meets most of the criteria for application of PRT. Downtowns, in general, benefit from the circulating function of PRT. Under travel demand related criteria, Downtown Fresno's diverse range of land uses ensures uniform and continuous demand with random arrivals. The size of the downtown reflects a series of major activity centers (e.g., government center, Fulton Mall, convention center, stadium area, Chinatown, etc.) that are too distant to walk. While there are few physical barriers to walking downtown the distance between certain districts in itself becomes a barrier.

With the opening of the proposed High Speed Rail (HSR) Station there will be a need to connect HSR with Amtrak, the FAX transit center and Bus Rapid Transit. Parking is distributed throughout downtown and is low cost at the present. This situation might change as the downtown revitalizes and intensifies and parking becomes a commodity. Lower cost remote parking at the downtown fringe might then attract employees and the need for circulator connectivity to employment centers. Land in the downtown is valuable and street capacity may require preservation if streets are narrowed in the future to accommodate wider sidewalks and parking. Land and street value then justifies a grade-separated transit system.

Some uses in the downtown meet the special criteria for Group Rapid Transit such as Chukchansi Park stadium and the Fresno Convention Center, and potentially the HSR station. Based on the evaluation criteria Downtown Fresno is a potential application for PRT or a combination of PRT and GRT.

Site C: Regional Medical Center District

A district located northeast of Downtown Fresno containing the Community Regional Medical Center, medical related educational facilities, and surrounding medical office buildings. See Figure B9.

Generally, institutional facilities in a campus environment such as major medical centers or universities are good candidates for PRT because of their sprawling nature and high level of travel demand between the individual uses within the campus.

Figure B8. Downtown Fresno case study site.

Figure B9. The Community Regional Medical Center lies within the heart of the regional medical center district case study area.

However, Fresno's Regional Medical Center District does not have great distances between uses nor does it have remote employee parking that would be suitable for PRT. The current campus has several parking structures in the immediate vicinity of the main buildings. The District is relatively compact and walkable at the present. However, should the medical facilities continue to expand in the future, and particularly if the educational element of the District expands and/or remote employee parking is implemented, the District might regain candidacy site for PRT or GRT. Based on the evaluation criteria the Regional Medical Center District is not currently a potential application for PRT.

Site D: Fancher Creek Development

Fancher Creek is a mixed-use master planned development that will contain residential, a town center, retail, senior housing, a business park and park space. The project is currently under construction within the Kings Canyon Road corridor as shown in Figure B10. The development will eventually cover 500 acres and provide 1,800 residential units, about 1,000,000 square feet of commercial and about 1,500,000 square feet of business park. A transit station is being planned on-site.

Although the Fancher Creek development is about the same acreage as the River Park Activity Center the density of the development is suburban. The housing is mostly single family homes and the commercial is auto-oriented with a low floor area ratio. This means that there will be less internalization of trips than if the development had much higher density residential and intensive levels of employment. Although the project is in single ownership (meeting the criteria for ease of planning and designing PRT) the lower levels of development in Fancher Creek would challenge funding a PRT system. Based on the evaluation criteria the Fancher Creek development is not a potential application for PRT.

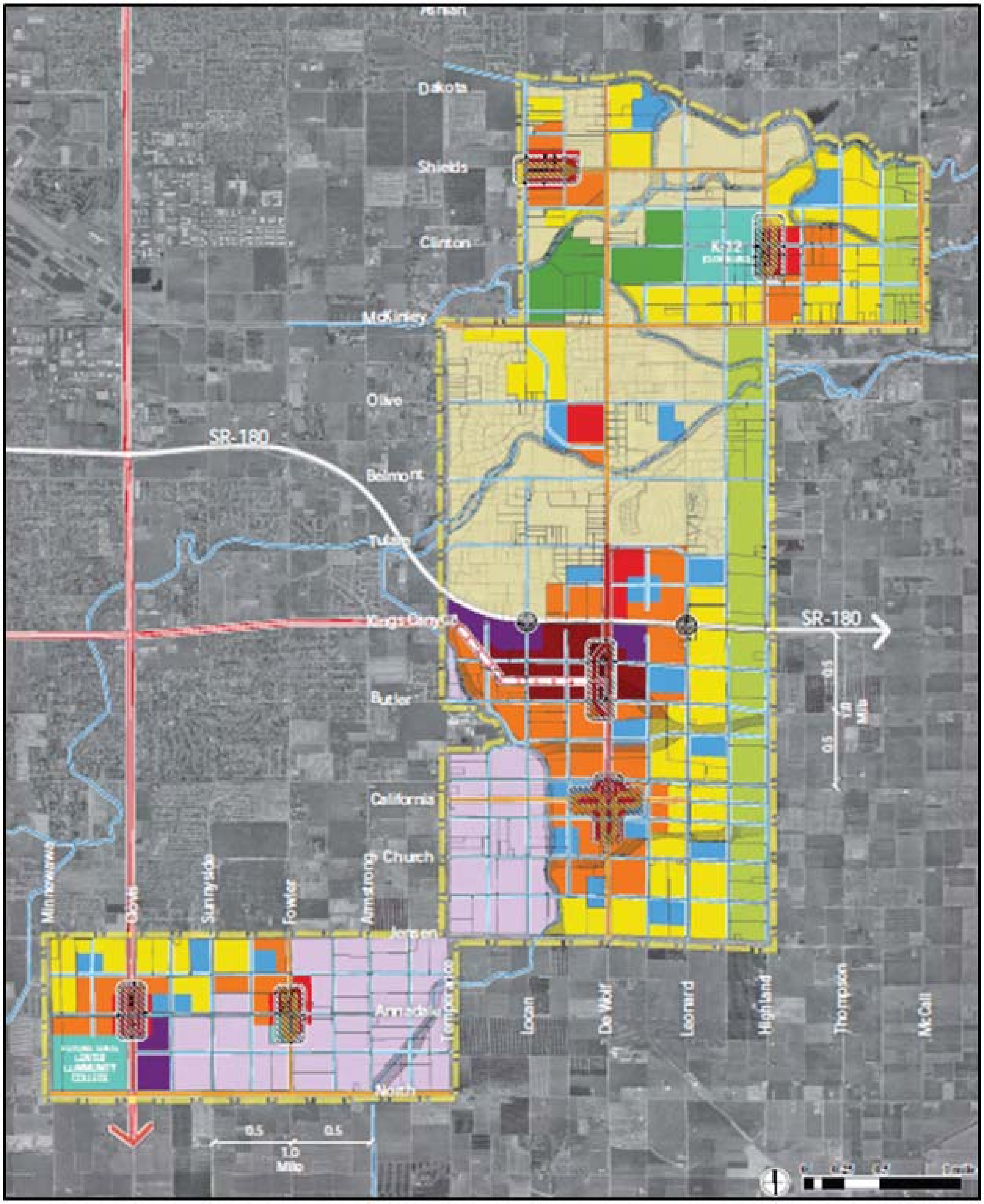
Site E: Southeast Growth Area (SEGA)

The Southeast Growth Area is a significant master planned community located in agricultural lands on the fringe of Fresno's current urban boundary. This development will contain a range of residential densities, town centers, retail, employment centers, industrial uses, schools, and other uses. The current plan calls for nearly 45,000 housing units (between 50,000 and 100,000 population) and 37,000 jobs. Figure B11 presents an illustrative plan of SEGA's general land use categories. SEGA's Specific Plan emphasizes a balance of housing and jobs, internalization of trips, and transit-orientation.

The SEGA project is still undergoing planning and final approvals. Therefore, the project plans are still at a coarse level of detail. However, based on the land use plan shown in Figure B11 this master planned community is an opportunity to plan and design PRT, GRT, or a combination of both, in the initial stages of land use planning along with SEGA's circulation armature. SEGA will take many years, perhaps decades, to build out, and during that time PRT technology will continue to evolve. If SEGA's long-range transportation system includes flexibility for future PRT, or at least doesn't preclude it, SEGA remains a strong opportunity for a PRT or GRT application. Based on the evaluation criteria the Southeast Growth Area is a potential long-range application for PRT or GRT.

Figure B10. Fancher Creek is a relatively small planned unit development on the east side of Fresno.

Figure B11. The Southeast Growth Area (SEGA) is a greenfield community located on the fringe of Fresno's metropolitan area.



Conceptual PRT System Applied to the River Park Multi-Use Area Case Study

This section illustrates a conceptual application of PRT in one of the five case study sites. In the judgment of the consultant team the most applicable case study site for planning a conceptual PRT system is the River Park Activity Center. This site mostly exists today (although there is still substantial vacant land within the bounds of the activity center) which facilitates the development of a conceptual PRT system.

The following general principles were used to develop the conceptual system:

- All areas of the site are within a maximum 10-minute walk (1/4-mile) of a PRT station.
- Align the aerial guideway along public streets to the extent feasible, but utilize private parking lots to ensure the most direct route to the next station.
- Design the system to interline with the planned Bus Rapid Transit (BRT) route and provide at least one intermodal transit center where BRT and PRT are linked.
- Design a maximum of two separate "lines" or "loops" either of which can operate PRT or GRT vehicles.
- Keep the length of the entire system approximately 5-6 miles and assume a 90 to 100 vehicle fleet.

The conceptual system is illustrated on **Figure B12**. It is comprised of approximately 5.2 miles of bi-directional aerial guideway containing 19 stations. There is some flexibility to eliminate stations because the 10-minute walk radius around stations does overlap at certain points.

Table B9 provides a rough and conservative estimate of the cost using the same PRT system unit costs as were used in the CSU Fresno prototype estimate.

Table B9. Rough Cost Estimate for River Park Conceptual PRT System

System Component	Unit Cost	Cost
System Equipment (90 vehicle fleet)	$593,000/vehicle	$53,000,000
Aerial Guideway (80% of 5.3 mile system)	$10,868,000/mile	$46,080,000
At-Grade Guideway (20% of 5.3 mile system)	$3,809,000/mile	$4,038,000
Stations (19)	$1,125,000 each	$21,375,000
Ops Center, Maintenance and Storage Facility	$5,000,000 LS	$5,000,000
Engineering Design (15%)		$19,424,000
Contingency (10%)		$14,892,000
Total System Capital Cost		$163,809,000
System Cost Per Mile		$30,907,000
Source: Kimley–Horn and Associates, Inc.		

Figure B12: Land Uses within the River Park Activity Center:

Kimley-Horn and Associates, Inc.