Central Area Loop Study

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1.0 Introduction

1.1 Scope of Study

The Central Area Loop Study (Study) was commissioned by the Ohio-Kentucky-Indiana Regional Council of Governments (OKI) in 1999, and is being directed by the Central Area Loop Study Advisory Committee, which is made up of representatives from the cities of Cincinnati, Ohio and Covington and Newport, Kentucky, as well as state and other agencies. The scope of the Study included three distinct elements: the analysis of a loop circulator system between Cincinnati, Covington and Newport; the evaluation of traffic congestion on 4th and 5th Streets in Newport and Covington and determination of the feasibility of constructing a light rail link to Newport from the proposed I-71 Corridor Light Rail Transit (LRT) line.

The analysis of traffic on 4th and 5th Streets in Covington and Newport was completed in March of 2001. The recommendations and evaluation of this piece of the study can be found in the 4th and 5th Street Traffic Analysis Technical Memorandum located in Appendix C.

The determination of the feasibility of constructing a LRT Spur servicing Newport has also reached consensus. In April 2001, the Advisory Committee passed a resolution approving a preferred alignment. The resolution also stated that the Newport LRT Spur should be considered in Phase I of the I-71 Corridor Light Rail Line. The request was analyzed by the I-71 Oversight Committee, and it was determined that it would not be feasible to include the Newport Spur as part of the I-71 study. This objective would be better served by an individual corridor study. In May 2001, the OKI Executive Board approved a measure to begin the process of evaluating the transportation needs in the Southeast Corridor, including the Newport LRT Spur. The results of the Newport LRT Spur analysis can be found in Appendix D.

This report will detail the analysis and evaluation of a preferred technology for the loop circulator portion of the Study.

1.2 Goals

A list of transportation problems in the study area were identified and the goals of the Study were established through Advisory Committee meetings, public workshops, stakeholder interviews, and community presentations. These goals served as the basis for the evaluation criteria listed below and discussed in Section 7.1. This report and evaluation will focus on satisfying the first and fourth goals only, which are directly related to the loop circulator.
Goal #1 – Need for Loop Circulator

Problems Identified

- The entertainment facilities, visitor attractions and business centers of Cincinnati, Covington and Newport are linked by a system of bridges over the Ohio River. These connections can be difficult to identify and negotiate, especially for visitors not familiar with the area. Visitors and commuters alike need an efficient, convenient, easily accessible alternative to the roadway system that links the three communities.
- The transportation system linking the Central Riverfront areas of Cincinnati, Covington and Newport has reached maturity; therefore, when an incident or special event occurs, the system tends to break down.
- The transportation system in the Central Riverfront areas is being outstripped by new development, which is leading to decreased accessibility.
- The transit systems between Cincinnati, Covington and Newport are not linked efficiently. Transit dependant users, including populations have difficulty moving around the Central Riverfront.
- There is a shortage of parking in the Cincinnati Central Business District. If the cities were linked more efficiently, parking in Newport and Covington could be utilized.

Goal Established

To provide an efficient, convenient and easily accessible transportation system to link the cities of Cincinnati, Covington and Newport.

Goal #2 – Need for Traffic Improvements

Problems Identified

- The east/west traffic in Northern Kentucky is congested and constrained, especially on 4th and 5th streets. These conditions exist not only when an incident occurs, but also on a daily basis.

Goal Established

To improve the east/west flow of traffic in the 4th and 5th street corridor between I-75 and I-471 in Northern Kentucky.
Goal #3 – Need for Light Rail Transit to Newport

Problems Identified

- In light of the I-71 Light Rail Corridor study, it is important to consider the possibility of a link to Newport becoming part of the initial minimum operable segment.

Goal Established

To evaluate the need for and to demonstrate feasible alignments for a light rail link from the I-71 Corridor light rail line to the City of Newport.

Goal #4 - Need to optimize the region’s existing and future investment in transportation infrastructure.

Problems Identified

- In addition to developing new transportation alternatives, it is important to maximize and optimize use of existing infrastructure and transportation improvements.
- Any new transportation investment should include accommodations for multiple mass transit options.

Goal Established

To optimize the region’s existing and future investment in transportation infrastructure.

1.3 Public Involvement

Throughout the Central Area Loop Study, an extensive public involvement program was conducted. It involved stakeholder interviews, public workshops, presentations, newsletters and media alerts. A summary of these events may be found in Appendix B.

1.4 Study Area

The Central Area Loop Study Area is bounded by Interstate-75 (I-75) on the west, Central Parkway in the City of Cincinnati on the north, the eastern boundary of the City of Newport and 12th and 11th Streets in Covington and Newport, respectively, in the south (Figure 1-1). This area contains a high concentration of population that is a mix of residential, retail, institutional and commercial interests. Complicating the study area is the Ohio River, which separates Cincinnati from Northern Kentucky and the Licking River, which
separates Newport from Covington. Six (6) bridges link Cincinnati to Newport and Covington: the Brent Spence (1-71/I-75) Bridge, the Clay Wade Bailey Bridge, the Roebling Suspension Bridge, the Taylor-Southgate Bridge, the L&N Bridge and the Daniel Carter Beard (I-471) Bridge. Both the Veteran’s Memorial Bridge at 4th Street and the 12th Street Bridge link Covington and Newport within the confines of the study area.

Over the past few decades, the urban cores of Cincinnati, Covington and Newport have experienced substantial economic growth. In the last five years alone, the Central Riverfront Area has seen a major reconstruction of its transportation system: Newport on the Levee; The Banks; Fort Washington Way; Paul Brown Stadium; the Newport Aquarium; and the revitalization of both the Cincinnati and Northern Kentucky Riverfronts. While these new projects have led to many community benefits, they have also produced some of the following problems: increased congestion, a rise in single-occupant vehicle (SOV) trips and a complicated signage system.

The Central Area Loop Study focused on mitigating these problems while at the same time promoting increased activity in the area by moving people around the Central Riverfront area more efficiently through the development of a circulator system.
Figure 1-1: Central Area Loop Study Area
2.0 Technology Descriptions

Transit system technologies can be categorized into several classifications. Each has particular characteristics that serve to meet certain specific functional requirements. Because a variety of transit technologies can serve similar needs, it is important to determine the best match between the technology and requirements. The loop circulator is intended to move moderate numbers of people between three urban downtowns. Therefore, the following technologies will be evaluated: rubber-tire bus (Southbank Shuttle), Light Rail Transit (LRT)/Streetcar and Personal Rapid Transit (PRT). These technologies emerged from a larger list of possibilities through the screening process discussed in Section 7.0. Each of these technologies work well in an urban setting and are appropriate for application as a loop circulator. Table 2-1 provides a listing of the common characteristics and requirements for each alternative. This section examines these technologies, their general operating characteristics and applications.
### Table 2-1: Technology Characteristics

<table>
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<tr>
<th>Characteristic</th>
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<th>Streetcar</th>
<th>Light Rail</th>
<th>Personal Rapid Transit</th>
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<td>Existing System</td>
<td>TSM</td>
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<td>Manned by Operator</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Electric</td>
<td>Electric</td>
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<td>6-8</td>
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<td>Minimum Horizontal Curve Radius (feet)</td>
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<td>Yes</td>
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<td>Rail</td>
<td>Rail</td>
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<td>Mixed Traffic/Minimal</td>
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<td>Aesthetic Issues</td>
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<td>Minimal</td>
<td>Catenary</td>
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<td>Technical Maturity</td>
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<td>Proven</td>
<td>Proven</td>
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<tr>
<td>Availability</td>
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<td>Good</td>
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<td>Good</td>
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<td>Key West, FL</td>
<td>Portland, OR</td>
<td>Minneapolis, MN</td>
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</table>
2.1 Southbank Shuttle

Rubber-tired buses are one of the most prevalent forms of transit in urban areas. This transportation mode operates at-grade, and is easily integrated with other transportation modes and pedestrian traffic flow. In general, at-grade, in-street type systems are favorable because they are able to reach a variety of passengers and destinations with few implementation obstacles and minimal costs. They are also very flexible; routes and stations can be changed or added easily, often with minimal or no additional cost.

The Southbank Shuttle is an at-grade, in-street system, implemented by the Transit Authority of Northern Kentucky (TANK) in 1998 and connects the riverfront cities of Cincinnati, Covington and Newport. The Southbank Shuttle uses a fleet of 14 Orion II low-floor buses for the regularly scheduled service and 4 Gillig 40-foot low-floor buses for special events. The Orion II low-floor buses are approximately 27 feet long, 8 feet wide, and have a height of 9 feet with a capacity of a 22 seated passengers and up to 12 standees. Figure 2-1 shows a picture of the Southbank Shuttle compared to TANK’s full size bus. The Southbank Shuttle buses are unique and distinctive in their size and color and are easily recognizable when compared to the rest of TANK’s fleet.

![Southbank Shuttle Bus](image1) ![TANK Bus](image2)

**Figure 2-1: TANK Low-Floor Buses**

The vehicles used for the Southbank Shuttle are capable of speeds of 65 mph on highways, but the shuttle’s typical operating speed is reduced to 10 to 12 mph in the urban environment with mixed traffic and frequent stops. TANK is currently having numerous maintenance problems with the Orion II Low-Floor buses including differentials, axles, bearings and access to the engine compartment. Parts for the vehicles are also difficult to acquire.

The Southbank Shuttle currently runs on two separate routes: one serving Newport and Cincinnati and the other serving Covington and Cincinnati. The routes overlap in Cincinnati. The routes focus on the commercial districts, hotels, restaurants and entertainment attractions. This makes the Southbank Shuttle a unique service that encourages visitors to ride public transit; total ridership in 2000 was 305,522 passengers.
The current operational hours are as follows: Sunday 10 a.m. to 10 p.m., Monday – Thursday 6 a.m. to 10 p.m., Friday 6 a.m. to 1 a.m., and Saturday 10 a.m. to 1 a.m. The shuttle’s headway is twenty minutes Sunday through Thursday and fifteen minutes Friday and Saturdays. The shuttle runs extended hours and adds service for special events. Regularly scheduled service requires six buses Sunday through Thursday and seven buses on Friday and Saturday. Vehicles are added to supplement service during special events, with as many as twenty-five additional buses. The fare is 50 cents or a Southbank token for each trip and there are no transfers issued or accepted to or from other routes. A complete “loop” from Covington to Newport and back to Covington is 17.2 miles. The round trip time is 120 minutes Sunday through Thursday and 105 minutes Friday and Saturday. The complete route consists of 44 stops.

An on-board transit survey of the Southbank Shuttle route was performed in September and October of 2000, as part of the Study. The survey indicated:

- The Southbank Shuttle receives a majority of its ridership from the Cincinnati/Northern Kentucky area;
- Many residents are using the shuttle as means of daily transportation;
- Visitors to the area utilize the shuttle as a means of transportation between cities;
- 60% of visitors are beginning their trips on the Southbank Shuttle from hotels and that 55% of residents began their trips from home;
- The survey suggests that residents and visitors rely on the Southbank Shuttle as their single mode of transportation between the Cincinnati/Northern Kentucky areas.

A complete summary of the survey results is contained in Appendix E.

2.2 Light Rail Transit (LRT)

There are over 300 LRT systems in operation in the world today. Twenty-one of these are in U.S. cities. U.S. cities that have constructed LRT systems in the last ten years include: Baltimore, Dallas, Denver, Los Angeles, Portland, Salt Lake City, San Jose and St. Louis. Figure 2-2 shows operating light rail lines in Portland, Oregon and Hudson-Bergen, New Jersey.

LRT is a flexible transportation mode that can operate in a variety of physical settings. LRT uses dual rails for both support and guidance. A distinctive feature of LRT is that the vehicles draw power from an overhead wire. This is in contrast to heavy rail transit vehicles, such as the MARTA system in Atlanta and the New York subway, that usually are powered by a track-level third rail. This overhead power collection feature allows LRT systems to be integrated with other at-grade transportation modes such as automobiles and pedestrians. With overhead power collection and the availability of articulated LRT vehicles, LRT can operate on tracks embedded in the street (like streetcars or trolleys), on a segregated at-grade right-of-way with street and pedestrian crossings, or on a fully-separated right-of-way such as a tunnel or elevated structure.

Modern light rail systems in the U.S. use vehicles that are 90 to 95 feet long, up to 9.5 feet wide and comprised of two or three body sections connected by pivoting articulated joints. Operator cabs at both ends of the vehicles allow bi-directional operation.
Vehicles can operate either as a single car or in multi-car trains. The capacity of a typical LRT vehicle ranges between 120 to 170 passengers (seated and standing).

The maximum operating speed of modern light rail vehicles generally ranges from 55 to 65 mph in exclusive right-of-way. However, the operating speed is reduced when operating in an urban environment with mixed traffic and frequent stops. Where LRT occupies an exclusive lane in a roadway, the speed normally matches the posted limit for road vehicles. In a mixed traffic situation, speeds are lower due to road traffic delays.

Light rail vehicles are characterized as high-floor or low-floor, which refers to the floor height relative to the top of rail. High-floor vehicles require high platforms for level boarding, or steps from a street level platform. Low floor vehicles have approximately 70% of the seating area at a height of 14 inches above top of rail. For the Cincinnati region, the I-71 Oversight Committee has selected low-floor vehicles for the proposed regional light rail system. Depending on the vehicle type and surrounding environment, LRT station design may incorporate high or low boarding platforms. Generally transit systems with on-street operation, as is the case with the loop circulator, use simple stations with low platforms.

Entry into light rail vehicles (LRVs) has traditionally been provided in one of two ways: step entry or level boarding. With passage of the Americans with Disabilities Act of 1990 (ADA), all new rapid transit stations must provide accessibility for disabled passengers to every train. This means that all public transit systems that open after January 1993 must provide level boarding for high floor vehicles. Level boarding can be accomplished in several ways: high-level station platforms, which match the floor height of the LRV; low platforms with wayside lifts; or “mini-highblock” platforms with ramps to a partially raised platform area. The alternative is to provide level boarding from the platform to a low-floor vehicle. This typically requires a platform height of 14 inches.

Low-floor LRVs were developed by European vehicle manufacturers in response to the prevalent use of LRT in street rights-of-way in European cities and the demand for easier, faster boarding at stations. In the U.S., low-floor LRVs are currently in operation in Portland, OR and Hudson-Bergen County, NJ, see Figure 2-2. The Siemens-Duewag SD600 low-floor vehicle, used in Portland, meets ADA regulations through the use of

![Light Rail Transit – Portland](image1.png) ![Light Rail Transit – New Jersey](image2.png)

**Figure 2-2: Light Rail Transit Vehicles**
vehicle-mounted bridge plates to provide near level boarding from the 10 ½ inch high platforms. Low-floor LRVs have also been ordered for Minneapolis, MN.

Many mid-sized U.S. cities have adopted LRT systems as a trunk line or regional radial system. For such U.S. applications, the mode is cost-effective and offers reasonably high capacity and overall speed. However, the loop circulator does not require the speed or capacity offered by LRT. Although the loop circulator system can be designed to accommodate LRT vehicles, which are proposed for a regional system serving Cincinnati and Northern Kentucky, they are probably not the appropriate transit vehicle for use on a “stand alone” loop circulator type system.

2.3 Streetcar

The Streetcar has been in operation as a form of public transportation for over 100 years. In fact, Streetcars were once very common on the streets of Cincinnati and Northern Kentucky. The Streetcar alternative for the Loop Study consists of new cars designed to resemble streetcars or trolleys of the past. This alternative is able to incorporate into the built, and in many areas historic, environment while at the same time providing reliable transportation and offering a sense of nostalgia.

Streetcars, like light rail vehicles, have steelwheels, run on rail track and are powered by overhead catenary wires. The typical vehicle length is approximately 40 feet, enabling the Streetcar vehicles to negotiate the tight turns associated with urban street grids. Vehicles operate as a single car and carry approximately 40 passengers. The maximum operating speed of a Streetcar vehicle is 45 mph; however, operating speeds typically match the posted speed for the roadway. In mixed traffic, urban operations average 15 to 20 mph because of frequent stops and local traffic congestion.

Streetcar vehicles are ADA compliant. Disabled passengers can access Streetcar vehicles either by means of a raised platform, ramp and bridge plate, wayside lift, or on-board lift.

Several vendors offer a variety of Streetcar vehicles, from refurbished historic Streetcars or trolleys, some upwards of 75 to 100 years old, to newly designed Streetcars with modern equipment and an historic façade and still others are new vehicles with a modern appearance. Manufacturers such as Gomaco offer both restored cars and newly manufactured vehicles. Both types of cars are being used in the U.S.; New Orleans, LA chose refurbished vehicles for their line, while Portland, OR utilizes replica vehicles and have just opened a line with modern Streetcars. Newer, modern Streetcar vehicles are proposed for the loop circulator.

While LRT is used for short to medium length trips, Streetcars are designed to be used in dense urban settings, such as serving downtown venues where speed and system capacity are not the primary objective. The Streetcar alignment for the loop circulator can be designed to accommodate LRT vehicles, however, Streetcar is more suited to this application and it is likely that Streetcar vehicles will utilize this alignment on a daily basis.
2.4 Personal Rapid Transit (PRT)

The final technology considered for the loop circulator is Personal Rapid Transit (PRT). PRT systems utilize small, three person, fully automated vehicles, on an elevated guideway. While the other three technologies operate as traditional mass transit, carrying large numbers of people on a fixed route stopping at each station, PRT systems are fundamentally different. They provide demand-responsive, non-stop service from a passenger’s origin directly to their destination.

The PRT system runs on a series of interlocking one-way loops covering the service area. A passenger purchases a ticket that is automatically programmed with their destination. The fare card is swiped before boarding at the vehicle, and the patron is taken directly to their destination, without stopping at stations in-between. This demand responsive, non-stop service is accomplished by utilizing off-line stations and staging empty vehicles at every station platform to provide almost immediate boarding.

PRT is an unproven technology, but has gained valuable information from previous prototypical PRT systems, such as the Raytheon PRT2000 development program and from the operational Morgantown West Virginia PRT system. While PRT, as a complete urban transit system, has yet to be implemented in the U.S., the technology has been researched for over 30 years. Taxi 2000, a proprietary PRT system, which is now actively designing a full-scale prototype test track, is the technology selected for the PRT alternative.

Due to the prototypical nature of the PRT (Taxi 2000) design, it was necessary to evaluate the technology for use as a loop circulator and to complete a review of the design. This section contains not only a description of the technology, but also a design analysis. This type of detailed evaluation was not required for the other technologies since they are proven and have been successfully implemented elsewhere. The following sections contain the Taxi 2000 proposed design standards and an evaluation of those systems.
2.4.1 Taxi 2000 Vehicle

Taxi 2000 has been preparing detailed analyses of the PRT vehicle and guideway technologies, system performance requirements and operational strategies for many years. Based on actual research into the characteristics and habits of transit patrons, the Taxi 2000 concept has been focused on a system designed for no more than 3 passengers per vehicle. Larger travel groups will use more than one vehicle, but the ridership demands involving large travel-party size is expected to be limited.
The conceptual vehicle has a design-load capacity of 650 pounds and an empty weight of between 900 pounds and 1900 pounds (Refer to the weight analysis discussion below). The interior width of the passenger compartment would be about 48 inches, and the exterior width would be approximately 54-60 inches (4 ½ - 5 feet), allowing for sidewalls and sliding door panels, tracks and operators. According to the conceptual design, the body height of the vehicle is about 57 inches and the suspension/propulsion frame is about 38 inches for an overall height of about 95 inches (8 feet). Based on a total wheel-to-wheel length of about 98 inches, the overall length is assumed to be approximately 10 feet. The conceptual configuration is shown in Figure 2-5.

The vehicle is conceptually designed to carry three passengers on a bench seat about 48 inches wide. The seat is proposed to flip up to make room for a single wheelchair without other passengers onboard. According to the U.S Department of Transportation and the Federal Transit Administration’s “Accessibility Handbook for Transit Facilities,” a 60 inch minimum diameter envelope is required for wheelchair accessibility. This area provides accessible pathways for individuals in wheelchairs to have space to turn around or reverse their course. Currently, the Taxi 2000 vehicle design specifies a 48 inch interior width, which does not meet these ADA standards. However, Taxi 2000 has proposed that a few specially designed vehicles with larger space provisions for both a wheelchair patron and another passenger be available for dispatch when needed. In order for the Taxi 2000 standard vehicle to be ADA compliant, either a waiver would have to be obtained or the interior vehicle space increased. Therefore, for the purposes of this study, the standard vehicle was assumed to be slightly larger than the Taxi 2000 conceptual design principally to accommodate mobility devices (refer to Appendix F). The cost estimate for the PRT vehicle reflects this increase in space.
Vehicle Performance
The published data from Taxi 2000 states a range of cruise speeds of 30 mph or higher, the 30 mph speed was used as the top cruise speed for downtown sections in the Central Area Loop Study Taxi 2000 operations simulations. The propulsion analysis is based on an operating speed of 18 meters/second (40 mph). Peak acceleration is proposed to be 0.25 g with typical operation on the order of 0.08 g. Braking is proposed to be 0.25 g in a normal stop and 0.4 g in an emergency stop.

Vehicle Equipment
Vehicle propulsion is provided by electric Linear Induction Motors (LIM), with the variable-voltage, variable-frequency propulsion package powered from DC power rails along the guideway. The system would have two inverter drives to provide variable frequency / variable voltage power to two LIMs for redundancy purposes. The automatic train control (ATC) system would include on-board computers communicating with a wayside supervisory system to monitor and control the speed and position of the vehicle. The ATC controls would also provide guidance to the destination station and monitor vehicle systems as required. Guideway switching and diverging to station access sidings would be provided by switch mechanisms on-board the vehicle, allowing the vehicle to follow the guideway left or right at branches, as required.

Passenger accommodations and safety provisions would include:
- Passenger compartment floors level with the station boarding platform (allowing easy access by wheel chairs);
- Automatic doors with obstruction detection to recycle the door opening if anything is caught in the closing door;
- Station platform edge barriers with automated gates or barrier-opening detection of objects near the guideway;
- On-board heating, ventilation, and air conditioning (HVAC) systems;
- Two-way radio intercom to provide direct emergency communications with a central control;
- Emergency-stop controls to automatically direct the vehicle to the closest station.

In the event of vehicle stalled on the guideway away from a station, the vehicle design concept includes shock-absorbing draft gear with couplers, which are sufficient to dissipate the energy of a worst-case collision. The couplers will be principally used to allow the following vehicle to couple the failed vehicle and push it to the next station in an automated recovery mode. The cabin interior would include padded surfaces and possibly passenger airbags, if the development of the design indicates this would be beneficial.

Taxi 2000 Vehicle Analysis
The following section describes the design of the vehicle as stated by the Taxi 2000 Design Manual.

The vehicle will be designed to provide a cost effective and safe transport environment for the passengers. Its operations will be totally automated, and will include the following design features:
• Vehicles will be designed in accord with the fire safety requirements of the ASCE Automated People Mover (APM) Standards (also ref. NFPA 130), providing fire retardant materials with limited smoke and toxic gas emission characteristics.
• The vehicles will require that passengers be seated. Up to three medium sized adults can be accommodated in each vehicle (16 inch seat width per passenger).
• Seating and “dashboard” will be padded for comfort and safety.
• Each vehicle will have direct communications with Central Control through an onboard intercom system.

As with the entire Taxi 2000 system, the vehicle underwent an independent evaluation by the consultant team. The following lists concerns and modifications suggested to proposed Taxi 2000 vehicle design features:

• Provision for vehicle collision using air bags could lead to other hazards for children and wheelchair users; therefore, the system headways should be constrained such that it does not require the use of airbags for safety during collision.
• The onboard switch, which controls vehicle direction at turnouts, will require the switch position to be “locked” far enough in advance of the diverge point to allow the vehicle to stop safely, should the switch’s “safe” condition not be properly indicated to the onboard control system.
• The vehicle door design is not defined, and the concepts of either a door that opens both the side and top of the passenger compartment (as indicated by information provided by Taxi 2000) or one that opens as a side-only sliding door both have inherent problems. If the side and top door opening is used, the weather-tight sealing of the vehicle will be very difficult to maintain, and if only the side panel opens, there will be a propensity for people to strike their head as they stoop and enter the low vehicle.

  Note: Design studies of similar passenger compartment designs for gondola systems (low roof vehicles for seated passengers) have shown that when the vehicle floor is level, passengers are more inclined to strike their head than during the more familiar entry into an automobile, where the passengers are simultaneously stepping up as they bend over to enter.
• The vehicle and chassis configuration, with a tall and narrow chassis and a wide body on top that weighs approximately 1.5 times the chassis (when carrying a maximum design load of 650 pounds), create conditions where the center of gravity is above the guideway “channel”.
• The vehicle may need modification to allow another adult to ride in the vehicle with a passenger using a mobility device (wheelchair). An alternative concept that Taxi 2000 has proposed is to maintain a small fleet of vehicles that have a different passenger cabin design to accommodate both a mobility device and a separate seat for an attendant. Upon notice to central control by the passenger at the station, these vehicles would be dispatched from a special storage area.
• The design of the vehicle, with primary suspension of only high pressure tires and with no secondary suspension between the chassis and the passenger compartment will create a potential for a rough ride. This is especially true since the running surfaces are adjustable and aligned in the field during installation (surface variations may be felt when traversed by the vehicle). The ride-quality will also depend on a continuous maintenance of the running surface alignments.
Vehicle Weight Analysis
A detailed listing of component parts and unit weights has been prepared. This includes the original Taxi 2000 preliminary weight estimation and a revised weight assessment by the consultant team. A breakdown of each of the vehicle subsystems is given below and discussed in Appendix F.

The estimated vehicle weight that the consultant has determined for purposes of this study is as follows:

Table 2-2: Estimated Vehicle Weight

<table>
<thead>
<tr>
<th></th>
<th>Original Taxi 2000 Estimate</th>
<th>Consultant Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Chassis Weight with Equipment</td>
<td>535 lbs.</td>
<td>1,093 lbs.</td>
</tr>
<tr>
<td>Vehicle Body with Equipment</td>
<td>464 lbs.</td>
<td>647 lbs.</td>
</tr>
<tr>
<td>Design Allowance Contingency</td>
<td>None</td>
<td>174 lbs.</td>
</tr>
<tr>
<td>Total Vehicle Weight</td>
<td>999 lbs.</td>
<td>1914 lbs.</td>
</tr>
</tbody>
</table>

Based on this analysis, an approximate vehicle weight of 1900 pounds has been used for purposes of evaluating the cost per vehicle, as well as the aerial guideway design and related cost. For a more complete discussion, refer to Appendix F.

2.4.2 Operating Characteristics

This section outlines the vehicle operating characteristics of the Taxi 2000 system. It also includes an evaluation of these characteristics performed by the consultant.

Failed Vehicle Recovery and Emergency Evacuation
The proposed Taxi 2000 system has provisions for the automated recovery of failed vehicles, as well as assumptions about the emergency evacuation of passengers should a vehicle stall away from a station. These provisions include the following features:

- The control system and vehicle coupler (shock absorber type and “draft gear”) will be designed to allow an automated coupling maneuver such that the following vehicle can be used to push a failed vehicle to the next station siding.
- The vehicle parking brake system will be disengaged during coupling and pushing maneuvers by the following vehicle.
- The pushing of the emergency stop button inside the vehicle passenger compartment will automatically redirect the vehicle to the next station stop without stopping.
- Emergency walkways will be provided along the guideway in locations where it is very high and on the bridges over the river, when the height is such that the guideway is not accessible by emergency personnel using fire trucks with appropriately designed rescue platforms.
• The presence of a stalled vehicle on the mainline of the system will cause disruption to all following vehicles until the vehicle can be recovered and moved to the maintenance facility.

As with the entire Taxi 2000 system, the Failed Vehicle Recovery and Emergency Evacuation processes underwent an independent evaluation by the consultant team. The following lists concerns and modifications suggested:

• The release of the vehicle doors by the emergency door opening handle will only be possible in sections of the guideway where an emergency walk is available or in a station.
• Emergency walks will be provided on the entire station sidings, from the diverge point to the station and from the station to the merge point to provide for emergency evacuation of passengers and stalled vehicles accessibility by maintenance personnel.

Power Distribution System
The power distribution system will have a number of substations spaced throughout the network in appropriate locations (e.g., within building’s adjacent to the guideway). Each substation will typically have the following features:

• Fully redundant transformer/rectifier units and associated power conditioning equipment to provide 400 VDC power.
• Uninterruptible power supply (UPS) system (batteries, voltage monitoring equipment and automated high-voltage switching)
• Emergency power supply generator units to provide sufficient electricity to continue system operations during power outages.
• Resistor-bank and line-voltage regulation controls to provide a continuous receptivity for the regenerative braking of every vehicle (key vehicle design feature). An option would be to design the vehicles for dynamic braking rather than regenerative braking, which would require the addition of an “on-board” resister bank for dissipation of electrical energy generated during braking. This additional weight to the vehicle should be accommodated within the contingency weight allowance (refer to Table 2-2).

Concerns and modifications to the Power Distribution System were also identified during the consultant team’s the independent evaluation. They were as follows:

• The system must include provisions to the electrically isolated sections of the guideway so that repairs can be made to the non-energized guideway.
Operating System Evaluation
The Taxi 2000 System, as applied for the loop circulator application, would be consistent with the fundamental PRT concepts endorsed by the developer, including the following characteristics:

- Each vehicle would be dispatched by the automated train control (ATC) system from its origin station to the passenger’s specific destination station. This would be initiated by the passenger using the ticketing/pass-card reading process at the station platform boarding position. The ATC system will meet the functional requirements of the automated train protection (ATP), automated train operations (ATO) and automated train supervision (ATS) subsystems, as defined in Chapter 5 of the ASCE APM Standard – Part 1 (ASCE 21-96). This control system will be one of the most advanced designs in the world.
- Empty vehicles would be staged in each station, with passengers alighting the vehicles at the forward most position available when the vehicle enters the station; if another vehicle is in the station at the time the vehicle enters, the empty vehicle would jog forward to the forward most position, when it clears, and wait there for passengers to board.
- If two vehicles were boarding at the same time, the second vehicle would wait for the lead vehicle to finish its boarding process and close its doors, and then both vehicles would platoon out of the station pre-staged for merging onto the main line.
- If a station is “full” of vehicles waiting for passengers to board, and a vehicle is destined for the station to deliver alighting passengers, the ATC system will dispatch the front empty vehicle from the station and move all other vehicles up to provide a space for the arriving vehicle to berth.
- High capacity stations would platoon inbound and outbound vehicles to and from boarding positions during heavy passenger flows.

The System Operations underwent an analysis by the consultant team. The following lists modifications and concerns regarding the proposed Taxi 2000 system:

- The actual capacity of such “heavy demand station” operations (e.g., at the stadiums) will have to be demonstrated during the Taxi 2000 design development program, but the capacity should be assumed for this study to be a value of about 1500 vehicles per hour (vph) for a 15-berth station operating with heavy demand in one direction only (inbound or outbound).
- The minimum operating headways of vehicles on the mainline, including vehicles merging onto the mainline stream of vehicles, should be limited to 5 seconds until the Taxi 2000 system has demonstrated safe operations below this level and the hazards analysis process has determined that operating conditions would remain safe under all potential failure conditions. In order to evaluate the effects of an increase in PRT headways from 0.5 seconds (as conceptually designed by Taxi 2000) to 5 seconds (as recommended by the consultant team) a sensitivity analysis was performed using the projected ridership numbers from the travel demand model and the Taxi 2000 operating model. See Appendix G for the results of the analysis.
  Note: The proposed operating system does not provide allowances in the design for collision impact absorption between vehicles, instead providing train control requirements consistent with “brick-wall stop” design criteria (reference ASCE
21-96, Section 5.1.2 Separation Assurance). These criteria must be validated even when power is lost to the vehicle. Furthermore, vehicle impact absorption design features will still be required for the worst-case failure condition of full propulsion power during a station braking or “jog” maneuver on low speed sections not on the main line.

- The sophistication of the control system requires it to be very complex, since it will be controlling hundreds of vehicles simultaneously with each on a unique route. This will require the automated train protection and train operations functions to be spread over many station and wayside control “zones”, and merge/diverge junctions, as well as in on-board ATC equipment in each vehicle.

  Note: This sophistication will require extensive safety analyses during design, an extended startup and “debugging” process on site, and potentially control logic changes in many places within the overall control system when modifications to the system configuration occur.
3.0 Travel Demand Modeling

This section describes the methods and assumptions used to develop travel demand models for the Central Area Loop Study. The modeling effort uses, as its base, the Ohio-Kentucky-Indiana (OKI) Regional Model and is buttressed by four sub-models, namely: Parking Location / Mode Choice model, Midday Intra-CBD model, Visitor Intra-CBD model, and a Special Event model. Following a brief discussion of the modeling approach, each of these models, as well as their interactions with one another, are described below. After the model descriptions, short discussions of each of the alternatives, along with a discussion of modeling assumptions for each alternative, are provided. The section concludes with a summary of the model forecasting results.

3.1 Modeling Approach

The first step in modeling travel behavior within the Study area was to determine the travel markets, which would use a downtown circulator system. This was done in two ways. First, experience from other downtown people mover studies in the U.S. were examined. Second, the trips captured by the Southbank Shuttle Survey (see Appendix E for the results of the survey), performed over four days in 2000, were analyzed. These two sources indicated the travel markets likely to use a Central Area Loop system include the following:

- Home-based Trips
- Transfers to/from system (distributor trips)
- Midday Workplace-based Trips
- Midday Non-Workplace Based Trips
- Parking Location to Work Location Trips
- Out-of-town Visitor Travel
- Special Event Trips

After determining the key market segments, a modeling strategy was determined for each segment. It was decided that the OKI Regional Model will be used to capture the Home-based trips as well as transfers to and from the system. The Midday trips, both Workplace-based and Non-Workplace-based, are currently captured by the OKI Regional Model’s Non-Home-based trip purpose. However, a more sophisticated modeling technique was used to replace these trips using separate models for Workplace-based and Non-Workplace-based trips. The final three markets, Parking Location to Work Location, Hotel-based Visitor, and Special Event, were not captured by the existing OKI Regional Model and special sub-models were used to capture these markets.

3.2 Model Description

Four separate sub-models were developed for the project in an effort to improve the OKI Regional Model’s ability to capture the unique behavior of intra-CBD travel in the
Cincinnati-Newport-Covington downtown areas. Each sub-model relied on the networks as well as output from the OKI Regional Model. This section briefly describes the role each of the sub-models, as well as the OKI Regional model, play in the modeling process.

3.2.1 OKI Regional Model

The existing OKI Regional Model is the basis for all the model development and plays a key role in describing intra-CBD travel in the downtown area. The Southbank Shuttle Survey indicated approximately 38 percent of all Southbank Shuttle trips originated at home. The OKI Model, which contains Home-based Work, Home-based University, and Home-based Other trip purposes, adequately captures the behavior of such trips. Also, longer trips which use regional transit to travel to and from the downtown areas and use the Southbank Shuttle as a distributor are captured by the OKI Model.

3.2.2 Parking Location / Mode Choice Model

The Parking Location / Mode Choice sub-model enhances the OKI Regional Model's ability to describe the behavior of home to work trips in the AM peak period. Currently, the OKI Model assigns trips directly from their home zone to their work zone, which assumes all workers park at the same location as their jobs. Such a model formulation ignores the impact of parking on the home to work trip and eliminates the possibility of commuters who choose to park in a distant, inexpensive lot and rely on some form of public transit to arrive at their place of work. The Southbank Shuttle survey indicated such behavior was currently occurring in the Cincinnati-Northern Kentucky CBD (approximately 100 trips per weekday).

The Parking Location / Mode Choice model combines a parking location choice model with a parking location to final destination mode choice model. Commuters traveling from home to work during the AM peak period are forced to choose a parking location, and after doing so, must then choose a mode to travel from that parking location to their work location. The sub-model uses as input, a Home-based Work trip table, for the AM peak period, produced by the OKI Regional Model.

The parking location choice portion of the sub-model chooses a parking location based on cost, distance from the work location, parking capacity, travel time from home to the parking location, and the accessibility from the parking location to the work location.

After the parking location is determined, the parking location to work location mode choice model is applied. This model considers both walk and transit modes for commuters to complete their journey to work. The mode choice is based on time and cost of each mode.
3.2.3 Midday Intra-CBD Model

In such areas as Washington DC, the addition of convenient transit opportunities greatly increased the amount of non-home-based travel during the midday period. Such travel includes workers journeying to more distant locations to eat lunch, or to do some midday shopping. Non-workers, once in the CBD may also be more likely to stop at other downtown locations if a convenient transit option is available. The Midday Intra-CBD sub-models attempt to capture this market.

The Midday Intra-CBD sub-model is broken down into two components, namely: Workplace-based trips and Non-Workplace-based trips. The Workplace-based model combines trip generation, destination choice, and mode choice into a single model. Each downtown worker chooses whether or not to make a trip, if the decision to make a trip is made, he/she must then choose a destination in the downtown area. After choosing the destination, the worker must then select a travel mode (walk, transit, or auto). An interesting aspect of the Workplace-based model is that the accessibility of downtown locations drives the decision to make a trip. Meaning, if a transit line is added connecting point A to point B, not only will more travelers going from A to B use transit, but more workers at point A will choose B as a destination, and more workers at point A will choose to make a trip during the midday period.

The Non-Workplace-based model is similar to the Workplace-based model in that it combines destination choice and mode choice into a single model. It differs in the way it generates trips. In the Workplace-based model, each downtown worker makes the choice whether or not to make a trip. In the Non-Workplace based model, the unit of production is travelers making Home-based Other trips (obtained from the OKI Regional Model) to the downtown area. It assumes that some fraction of these trip makers will make another trip in the downtown area, and the Non-Workplace based models (destination choice and mode choice) are applied to these travelers.

3.2.4 Visitor Intra-CBD Model

Perhaps the most interesting result of the Southbank Shuttle Survey was the substantial number of out-of-town visitors who were using the transit service. The survey found that twenty percent of all riders are out-of-town visitors making a trip from a CBD area hotel to a downtown attraction.

The Visitor Intra-CBD model attempts to capture the travel of visitors from downtown area hotels to downtown area attractions. It should be noted that the model form chosen for this application does not attempt to capture the entire universe of visitor travel. Rather, the Visitor model attempts to only capture out-of-town visitors making isolated trips from their downtown area hotels to a specific downtown area attraction. The attractions considered in the base year are as follows:

- Newport Aquarium
- Mainstrasse Village
• Cincinnati Convention Center
• Northern Kentucky Convention Center
• Cincinnati Fire Museum
• Contemporary Arts Center
• Taft Museum of Art
• Aronoff Center – Cincinnati Ballet
• Aronoff Center – Broadway Series
• Main Street District
• Shakespeare Festival

The future, or forecast, year uses the above attractions, as well as the following attractions (not yet completed in 2000):

• Underground Railroad Freedom Center
• Newport on the Levee
• IMAX at the Aquarium

The model allows each downtown hotel occupant to consider each attraction separately. Each hotel occupant first decides whether or not to make a trip to the attraction, then decides by what mode (auto, transit, walk, taxi) they will use to get there. Such a decision is made for each attraction independently. Similar to the Midday Intra-CBD model, the accessibility between each hotel and each attraction helps determine whether or not a trip is made to that location. Thus, if a transit line is added connecting a downtown Cincinnati hotel to, for example, the Newport Aquarium, more visitors staying in that hotel will make trips to the Newport Aquarium.

3.2.5 Special Event Model

Key features of the Study Area are the sports complexes located on the Ohio Riverfront. Paul Brown Stadium, Great American Ballpark, and the Firstar Center are located within a short distance from each other as well as within a few miles of the Cincinnati, Covington, and Newport CBDs. Any improvement to intra-CBD travel in the area should also address the needs of moving people to and from the stadiums and arena. The special events model estimates these trips.

The Special Event sub-model has two components, namely: trip production and parking location / mode choice. The trip production component simply distributes the Special Event attractions to production areas around the Cincinnati area based on travel time and cost, population, employment, and auto ownership levels. The output from the trip production component is a trip table of auto trips from home and work zones to the Special Event zone.

The trip production component feeds into the parking location / mode choice component, which holds the exact same form as the Parking Location / Mode Choice sub-model described previously. Instead of choosing a parking location and then a mode from a parking location to a work location (as in the Parking Location / Mode Choice sub-
model), travelers here are forced to choose a parking location and then choose a mode to travel from their parking location to the Special Event location.

Separate Special Event models are applied for Cincinnati Bengals games, Cincinnati Reds games, and events at the Firstar Center.

3.3 Alternative Assumptions

This section describes the assumptions that are made to produce ridership estimates for each of the four transportation alternatives (Existing Southbank Shuttle – No Build, Transportation System Management (TSM) – Improvements to the Southbank Shuttle, Personal Rapid Transit, and Streetcar. The discussion for the Existing Southbank Shuttle (No Build) alternative is longer than the other discussions because it gives a general outline of all the base assumptions made for each sub-model.

3.3.1 Existing Southbank Shuttle (No Build)

The Existing Southbank Shuttle, or No Build alternative share many of the same base assumptions with the remaining alternatives. These assumptions for each sub-model are described below.

OKI Regional Model
The Southbank Shuttle was coded in the OKI Regional Model as part of the “L5U” input set. It is coded as two separate transit lines with a headway of 20 minutes during the Peak and Off-peak periods. The fare is 50 cents per trip, with no discount given to transfer trips. The future year forecasts also used the OKI Regional Model “L5U” input set, with a forecast year of 2020.

Parking Location / Mode Choice Model
A key input into the Parking Location / Mode Choice sub-model is the parking costs and occupancy of each Central Area Traffic Analysis Zone (TAZ). The costs and occupancies were taken from a variety of sources, but many assumptions had to be made to account for differing levels of detail between the source information and the OKI Network. Further, no cost information was available for parking lots in Covington and Newport, and, as a result, that information had to be derived from parking cost data for Cincinnati.

In calibrating the Parking Location / Mode Choice models, very little data was available to adjust the models, originally developed elsewhere, to local conditions. As a result, many behavioral characteristics, such as willingness to use transit, had to be assumed.

Midday Intra-CBD Model
The cost of downtown parking during the midday period had to be assumed for each CBD TAZ as little data was available. For the Workplace-based component, the total employment, taken from the OKI Socio-Economic data, was used as the base production unit. For the Non-Workplace-based component, the OKI Home-based Other trip ends were used as the production unit.
Fortunately, the OKI Home Interview survey provided a sufficient amount of calibration information to fine-tune the model for the Study Area. Adjustments, such as adding a Cincinnati CBD walk dummy, which concentrates the majority of the midday walk trips in the Cincinnati CBD, were made possible as a result of the information contained in the Home Interview survey.

**Visitor Intra-CBD Model**

The Visitor Model is heavily dependent upon assumptions, which are very difficult to estimate, much less verify. The Visitor Model requires an estimate of downtown hotel-based visitor attractions for each attraction location. For example, if 2,000 people visit the Newport Aquarium on an average day, the percentage of these trips made by visitors to the Cincinnati-Northern Kentucky region must first be assumed. Then, the percentage of those visitors making such a trip from a downtown area hotel must be assumed. These two assumptions can vary greatly from attraction to attraction and each attraction has varying amounts of data available. Further, an average hotel occupancy rate and an average party size must be assumed in order to convert hotel rooms into number of visitors.

No adjustments to modal choice were made to the model because no data on visitor travel was available. The number of Southbank Shuttle trips the model produced was comparable to the number of hotel-based visitor trips recorded in the Southbank Shuttle survey.

The Visitor model generates ridership for a day in which each attraction is either open or an attraction event is occurring. While such a day may or may not exist, using this output allows for comparing the alternatives. A factor could easily be developed to convert this figure into a number representing an average weekday, an average weekend day, an average month, or an average year.

**Special Event Model**

The Special Event model requires input describing the size and location of each event, as well as the parking environment which serves the event. As the Special Event portion of the model produces only auto trips, the first assumption made is the percent of attendees who travel to the special event via auto, as well as the average number of persons arriving in each auto.

A very thorough description of the parking environments for the Bengals and Reds events was provided and the Firstar Center events used parking lot information which pivoted off this data. Additionally, no-cost lots were added to distant locations in the Northern Cincinnati CBD as well as portions of Covington and Newport to give travelers the option of parking a good distance away from the game for free and then using public transit to arrive at the game.

For Cincinnati Reds games, the existing Southbank Shuttle offers improved service by sending buses directly from distant parking locations to Cinergy Field. As a means of estimating such special service without having any detailed information regarding the service, the Southbank Shuttle headway was reduced to 10 minutes for all special events (Bengals, Reds, and Firstar Center Events).
3.3.2 Transportation System Management (TSM)

The Transportation Systems Management or Southbank Shuttle Improvement option is very similar to the existing Southbank Shuttle. The route was coded in the OKI model as four separate transit routes – the existing two Southbank Shuttle routes plus two new lines connecting Newport and Covington. The two new routes include both Option 1, which runs south down Monmouth Street and Option 2, which runs along the Newport Riverfront. Each line has a headway of 10 minutes during the peak and off-peak periods, and 10 minutes during special events. A fare of 50 cents is assumed for each line with no discount given for transfers from other lines.

3.3.3 Personal Rapid Transit

Modeling the personal rapid transit (PRT) option offers a variety of challenges. First, describing the PRT system in the OKI modeling environment presented problems due to the systems station to station travel patterns (as opposed to a fixed route pattern of a bus line). This issue was overcome in two ways. First, a small highway network, developed in the TRANPLAN modeling software, was used to simulate travel in the PRT environment. Using a highway network allowed persons to travel from any station on the network to any other station on the network, as long as they traveled along the PRT infrastructure. To approximate the operating conditions of the system, the following was assumed:

- Line operating speed of 23 miles per hour
- 10 percent of loop travel time added at the destination station to account for the possibility of the station being full and the PRT vehicle forced to travel around the loop

Modeling the PRT in such a way is extremely useful because it gives a more detailed representation of zone to zone travel times. The travel time matrices produced by this methodology are used in all the sub-models, which consider personal rapid transit as an independent mode. Unfortunately, this type of representation is not compatible with the OKI Regional Model structure, which considers the PRT system as simply another transit mode. For this reason, the PRT system was represented in a slightly different manner in the OKI Regional Model. The system was modeled as a series of transit lines (14 total), in an effort to replicate the station to station movements available in the network. The two methods of producing transit travel time matrices were then compared to ensure consistency between the two approaches. The system is considered a rail mode in the OKI context.

Two separate fares were tested for the PRT alternative – $0.50 and $2.00. The two separate fares are tested in an effort to model a “subsidized” system (50 cents) as well as a system, which pays for itself through its fare ($2.00). The fares are per trip and are divided by the occupants of the PRT vehicle. No discounts are given for transfers from other transit providers. Three separate wait times were also modeled, 2 minutes (off-
peak travel), 4 minutes and 6 minutes (peak travel), to test the sensitivity of increased total travel time. All wait times were modeled with the $2.00 fare. Tables 3-2 and 3-3 present modeled ridership for the 2 minute and 6 minute wait time only to give an example of wait-time variation.

The Special Events model for PRT was modeled with separate wait times for before and after a Reds and Bengals game. It is assumed that an average wait time to the event is 4 minutes and after the event is 20 minutes. These times were assumed because it is common for patrons to arrive at an event at various times before the game, but generally leave an event at approximately the same time. The special events model with separate arriving and departing wait times was modeled with a $2.00 fare.

3.3.4 Streetcar

The Streetcar alignment is coded as part of the OKI Regional model as two separate transit lines. The lines have headways of 10 minutes during the peak and off-peak periods and have a fare of 50 cents. No discounts are given for transfers from other transit providers. The Streetcar mode is considered to be a separate, independent mode in each of the sub-models and is considered as a rail mode in the OKI Regional model.

3.4 Projected Demand

Each of the above alternatives was tested using each of the models – OKI Regional Model, Parking Location / Mode Choice Model, Midday Intra-CBD Model, Visitor Intra-CBD Model, and Special Event Model. Ridership estimates are developed for the base year of 2000 and the forecast year of 2020.

The output from the Parking Location / Mode Choice model is combined with the OKI Regional Model to produce an estimate of the peak period transit ridership during a typical weekday. The output from the Midday Intra-CBD model replaces the midday Non-Home-based intra-CBD trips from the OKI Regional Model, and, when combined with non-intra-CBD trips from the OKI Regional Model, produces an estimate of off-peak period transit ridership during a typical weekday.

The Visitor Model produces an estimate of ridership on a typical day in which each attraction is either open, or holding an event. Such a day may or may not exist, but factors could easily be developed to produce visitor trips during a typical weekday or weekend, a yearly, or monthly estimate of visitor trips. Here, they are presented in their raw form.

The Special Event Model produces an estimate of ridership during each special event – Bengals game, Reds game, Firstar Center event. Again, a factor could be applied to produce total transit ridership per year, but the results are presented here as they are output by the model.
3.4.1 Base Year Ridership Estimates

Tables 3-1 illustrates the no-build ridership estimates utilized to validate the travel demand model. The following definitions apply to Tables 3-1 to 3-3

- **Peak Hour (CBD Trips)** – Trips that pass through the study area. These persons both live and work in the CBD or transferred from TANK or Metro buses within the CBD. Peak Hour trips are divided evenly between the AM Peak (6:00am to 8:30am) and the PM Peak (3:00pm to 6:30pm). It is assumed that trips from home or transfer to the workplace in the AM Peak are repeated from the workplace to home in the PM Peak.

- **Peak Hour (Commuter Trips)** – Trips by individuals who drive into the CBD, park their vehicle and take transit (Southbank Shuttle, Streetcar or PRT) to their destination or workplace.

- **Off-Peak** – All other trips made within the CBD during the Midday (8:30am to 3:00pm) and night (6:30pm to 6:00am). It is assumed that all trips begin and end within the Off-Peak hours. For example, if someone goes to lunch during the Midday they will make a return trip within the Midday hours.

- **Average Weekday** – Average Weekday equals the Peak (CBD Trips and Commuter) plus the Off-Peak trips.

- **Visitor Trips** – These trips are categorized as hotel to attraction trips only on an average day when attractions are open.

- **New Transit Trips** – These trips are made by persons who did not previously use transit. For example, someone who normally drove to work is now utilizing a Park and Ride location and transit. While it is normally assumed that these persons utilizing transit are making round-trips, this table is presented as one-way trips only by persons not previously using transit.

<table>
<thead>
<tr>
<th>Model Group</th>
<th>Alternative</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No-Build</td>
<td></td>
</tr>
<tr>
<td>Peak Hour (CBD Trips)</td>
<td>409</td>
<td></td>
</tr>
<tr>
<td>Peak Hour (Commuter Trips)</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>Off-Peak</td>
<td>699</td>
<td></td>
</tr>
<tr>
<td>Average Weekday (Peak + Off-Peak)</td>
<td>1,214</td>
<td></td>
</tr>
<tr>
<td>Visitor Trips (Average All Day Event)</td>
<td>317</td>
<td></td>
</tr>
</tbody>
</table>
3.4.2 Future Year Ridership Estimates

Tables 3-2 and 3-3 provide an estimate of the ridership for the future year of 2020, for each of the alternatives and for new transit ridership, respectively.

Table 3-2: Estimated Ridership for Each Technology -2020

<table>
<thead>
<tr>
<th>Model Group</th>
<th>Alternative</th>
<th>No-Build</th>
<th>TSM (Enhanced Southbank Shuttle)</th>
<th>Streetcar</th>
<th>PRT $0.50/2 min</th>
<th>PRT $2.00/2 min</th>
<th>PRT $2.00/6 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak Hour (CBD Trips)</td>
<td>856</td>
<td>2,502</td>
<td>2,342</td>
<td>12,630</td>
<td>10,855</td>
<td>5,852</td>
</tr>
<tr>
<td></td>
<td>Peak Hour (Commuter Trips)</td>
<td>79</td>
<td>2,232</td>
<td>2,698</td>
<td>12,234</td>
<td>9,856</td>
<td>8,094</td>
</tr>
<tr>
<td></td>
<td>Off-Peak</td>
<td>626</td>
<td>1,267</td>
<td>1,914</td>
<td>6,805</td>
<td>5,193</td>
<td>2,396</td>
</tr>
<tr>
<td></td>
<td>Average Weekday (Peak + Off-Peak)</td>
<td>1,560</td>
<td>6,042</td>
<td>6,994</td>
<td>32,152</td>
<td>26,506</td>
<td>17,011</td>
</tr>
<tr>
<td></td>
<td>Visitor Trips (Average All Day Event)</td>
<td>424</td>
<td>779</td>
<td>1,258</td>
<td>1,722</td>
<td>1,697</td>
<td>1,388</td>
</tr>
</tbody>
</table>

Table 3-3: New Transit Trips for Each Technology – 2020

<table>
<thead>
<tr>
<th>Model Group</th>
<th>Alternative</th>
<th>No-Build</th>
<th>TSM (Enhanced Southbank Shuttle)</th>
<th>Streetcar</th>
<th>PRT $0.50/2 min</th>
<th>PRT $2.00/2 min</th>
<th>PRT $2.00/6 min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Weekday (Peak + Off-Peak), one-way trips</td>
<td>0</td>
<td>2,389</td>
<td>1,889</td>
<td>28,000</td>
<td>22,240</td>
<td>13,994</td>
</tr>
</tbody>
</table>
3.4.3 Conclusions

Existing Southbank Shuttle and TSM
The existing Southbank Shuttle is providing effective transit service linking the three communities. Geographic coverage of the CBDs is generally good, although frequency of service is somewhat less than desired. As expected the TSM option does increase ridership estimates. This increase is attributed to the shorter headways (10 minutes compared to 20 minutes) and the larger geographic coverage of the Enhanced Southbank Shuttle.

Streetcar
The streetcar option produced ridership comparable to the Enhanced Southbank Shuttle. Both systems run in mixed traffic and have comparable coverage areas. The streetcar line is modeled as a traditional streetcar operating in an isolated, independent system. If the streetcar were to work in conjunction with the proposed I-71 LRT line or other elements of a Regional Rail System, the streetcar would then serve as a distributor and the ridership would likely increase. As illustrated in Table 3-3, many of the streetcar passengers are already utilizing transit.

Personal Rapid Transit (PRT)
The PRT alternatives attract the greatest number of passengers, as shown by the ridership estimates. This can be attributed to the somewhat broader coverage area and short wait and travel times experienced with PRT.

During the course of the Study it was determined that it would be appropriate to model the PRT alternative using two fare structures; a $0.50 fare, comparable to the current Southbank Shuttle and a $2.00 non-subsidized fare. As expected, ridership is sensitive to cost, with the $0.50 fare attracting greater ridership than that of the $2.00 fare.

The PRT alternative was also modeled with three wait times. A 2-minute wait time, which is considered the time for vertical circulation, fare purchase and vehicle wait time in free-flow conditions (where there is no wait for the elevator or fare purchase and vehicles are generally available), a 4-minute wait time which is comparable to a slightly congested system and a 6-minute wait time which simulates a peak hour condition where there may be a wait for the elevator or to purchase a ticket and that there is heavier vehicle traffic. As expected, the PRT ridership numbers are lower with a higher wait time.

As illustrated in Table 3-3, many of the PRT passengers are new transit riders, those not previously utilizing bus as their means of travel. These numbers reflect the short wait time and rapid travel times associated with the direct point to point service of the PRT system. Over half of the new transit passengers projected are parking at locations such as Paul Brown Stadium and utilizing PRT to get to their workplace. The PRT alignment provides excellent service to and from the ample, reasonably priced parking available on the riverfront.
While the ridership projections for both the Southbank Shuttle and the Streetcar options seem reasonable given conditions in the study area and operational characteristics, the PRT estimates seem remarkably high by comparison. However, these projections are not unreasonable since PRT, has by far the lowest in-vehicle travel times and offers non-stop service to many destinations within the study area. Two uncertainties remain with respect to ridership. First, will the system handle the projected ridership and second, will the predicted ridership be attained. Capacity will be determined by the Taxi 2000 operational model and eventually demonstrated by a full-scale test track. The second will be determined by the persons living and working in the Greater Cincinnati Area and the transportation choices they will make. According to demographic data from OKI for the year 2030, approximately 30,000 persons will live in the study area and approximately 70,000 employees will work in the study area. Therefore, the model predicts that approximately 10% to 20% (8000 to 16000 round trips per day) of residents and workers will use PRT on a daily basis.

Special Events Model Results
The Special Events model predicts ridership for sporting events along the Cincinnati Riverfront, namely Bengals and Reds Games and events at the Firstar Center.

The Enhanced Southbank Shuttle shows an increase in ridership over the current Southbank Shuttle for a Reds Game but fails to carry any passengers at a Bengals Game. This is due to the fact that the stops near Paul Brown Stadium have been eliminated in the TSM option. Because of the flexibility of rubber-tire buses, the Southbank Shuttle and larger TANK and Metro buses could supplement normal service on game days.

The streetcar option serves the Bengals games quite well, but not the Reds games. This result is the product of two things: the alignment of the streetcar, which passes in front of Paul Brown Stadium, as well as the relatively coarse nature of the network and zone structure along the Riverfront.

The PRT alternative was modeled a bit differently than the Southbank Shuttle and the streetcar. The PRT model assumes a wait time of 2 minutes for passengers traveling to the event and a wait time of 20 minutes after an event. This is consistent with generally observed pre and post event behavior. The Firstar Center alternative did not consider separate wait times before and after the event because it is anticipated that the system would not experience significant post-event delays due to the relatively low number of passengers predicted. A constant wait time of 2 minutes was used for Firstar Center Events for the estimation of PRT ridership. Because there is more than one PRT station at both Paul Brown Stadium and the Great American Ballpark, the ridership shown in Table 3-4 is the total ridership for all stations around each stadium.
### Table 3-4: Estimated Ridership by Alternative – Special Event Model – 2020

<table>
<thead>
<tr>
<th>Model Group</th>
<th>No-Build</th>
<th>TSM (Enhanced Southbank Shuttle)</th>
<th>Streetcar</th>
<th>PRT $2.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bengal's Game</td>
<td>274</td>
<td>0</td>
<td>3,288</td>
<td>5,338</td>
</tr>
<tr>
<td>(per game)</td>
<td></td>
<td></td>
<td></td>
<td>1,186</td>
</tr>
<tr>
<td>Red's Game</td>
<td>248</td>
<td>773</td>
<td>120</td>
<td>1,989</td>
</tr>
<tr>
<td>(per game)</td>
<td></td>
<td></td>
<td></td>
<td>302</td>
</tr>
<tr>
<td>Firstar Center</td>
<td>2</td>
<td>5</td>
<td>44</td>
<td>412</td>
</tr>
<tr>
<td>Event (per event)</td>
<td></td>
<td></td>
<td></td>
<td>(to and from event)</td>
</tr>
</tbody>
</table>
4.0 Typical Structures and Stations

4.1 Southbank Shuttle Typical Stations and Shelters

Southbank Shuttle shelters are typically located every fourth block along the route. At all other stops, there is a sign with the Southbank Shuttle logo on it. Shelters have also been provided at those stops that handle a larger percentage of the ridership. Shelters are recognizable and unique to the area. Current shelters are 9 feet long, 5 feet wide, 7.5 feet high and are enclosed, provide a bench and have an advertisement logo on them. Figures 4-1 and 4-2 depict a typical Southbank Shuttle shelter and station. Eventually these shelters will provide route maps and schedules.

![Proposed Shelter](image1)
![Existing Shelter](image2)

**Figure 4-1: Southbank Shuttle Shelters**

![Southbank Shuttle Sign](image3)
![Southbank Shuttle Stop](image4)

**Figure 4-2: Southbank Shuttle Stations**
4.2 Streetcar Typical Structures and Stations

**Structures**

The Streetcar alternative will operate on standard gauge railroad track. Two tracks will be provided to allow passengers to travel either clockwise or counter-clockwise. The majority of the track will be embedded in the roadway where Streetcars will share a lane with road traffic. The majority of the Streetcar alignment will be at-grade with the existing roadways, except when it crosses the Licking River and the Ohio River. Where a bridge supports the track, it is anticipated that the rails will be flush with the top of the adjacent road surface. The rails will be fastened directly to the bridge structure. It is proposed that the Streetcar alternative would share lanes on the existing Clay Wade Bailey Bridge, and one-lane on the Taylor-Southgate Bridge. The northbound track would cross the Ohio River from Newport on the existing L&N railroad bridge. There is a proposal for a new bridge over the Licking River, which would provide exclusive rail rights-of-way. If a new Ohio River rail transit bridge is built as part of a Regional Rail System, the Streetcar alternative could use that bridge rather than sharing lanes on the Clay Wade Bailey Bridge.

**Typical Station**

The Streetcar station is relatively simple and includes a raised platform, ramps for ADA compliance and is basically a sidewalk bump-out. Exiting and alighting takes place on only one side of the car. Figures 4-3 shows typical Streetcar on-street stops in Portland, OR.

![Figure 4-3: Typical Streetcar Stop/Station-Portland, OR](image-url)
Fare Collection
Fare collection for the Streetcar alternatives will use a self-service, proof-of-payment system. This system is barrier free and is used successfully on most modern systems in the U.S. Patrons purchase a ticket at the station from an automatic ticket vending machine. The ticket is either pre-validated or validated using a validator on the station platform. The patron retains the validated ticket as proof of payment throughout their trip. Validated tickets may also serve as transfers to the other transit services operated by SORTA/TANK. Pass-holders with annual or monthly passes use the system without purchasing additional tickets.
4.3 Personal Rapid Transit (PRT) Typical Structures and Stations

**Structures**
The guideway structure, as designed by Taxi 2000, is composed of a lightweight, U-shape steel member supported on steel posts and concrete foundations with removable aluminum covers. The guideway has an open bottom, which allows for passage of moisture and minimizes accumulation of debris. The guideway section is 3-ft-wide by 3-ft-deep and is fabricated in 60 to 90 foot sections. The guideway carries power rails, communications equipment and switching mechanics. The typical center-to-center span for support posts is 60 feet and can be increased to 90 feet. The height is generally 16 feet above ground level to provide clearance for vehicles and pedestrians. Post foundations are 4-ft in diameter reinforced concrete. Once the foundations are installed, the guideway is erected by bolting the support post to the foundation and bolting the guideway to the support post. See Figure 4-6 for an illustration of the Taxi 2000 typical guideway and vehicle.

**Figure 4-6: Taxi 2000 Guideway and Vehicle**

**PRT Guideway Review**
A drawing of the prototypical PRT guideway was provided by Taxi 2000. This guideway design underwent an independent structural review to verify the design. The Taxi 2000 guideway consists of a structural steel truss and a three-inch steel moment channel. The truss is braced by diagonal members at the two sides and bottom, but lacks top bracing because the guideway must be open for vehicle passage. The three-inch channels must then act as a moment frame to transfer the lateral load. This channel would appear not to provide enough stiffness for the possible 60-90 foot spans. Also, due to the nature of the PRT alignment, the guideway structure will have to negotiate curves. Truss structures are typically not used on curved alignments. The consultant team recommends a plate girder design with lateral bracing to account for vibration and curves. The current Taxi 2000 steel truss and channel would work in conjunction with the plate girders to give the structural support required for this application. The
The guideway would be approximately six feet in width and would have the same outward appearance as the original design by incorporating the aluminum covers. This guideway would still allow access to the trackwork and mechanics, as required by the maintenance guidelines. The column design of a 2.5-foot diameter drilled shaft foundation with a 2.0-foot outside diameter column would be recommended to adequately support the new recommended design.

**Maintenance of the Guideway Trackwork**

The guideway, or “trackwork” is comprised of the running surfaces, the side guiding surfaces and the power rails along the guideway. All of these elements are located inside the enclosed Taxi 2000 guideway structure, and all are critical to maintain ride quality and guideway/vehicle subsystem reliability. The most common failures of an automated transit system are not the electronics but rather the mechanical elements of the vehicle, the station doors, the guideway and the trackwork. Of all of these elements, the most crippling system outages tend to be caused by trackwork problems, which result in major mechanical failures along extended lengths of guideway as a moving vehicle catches and damages pieces of the trackwork.

The consultant team recommends the following modifications to the Taxi 2000 guideway maintenance plan:

- **Bi-directional maintenance-of-way (MOW) vehicles should be provided and located at strategic locations around the system.** These MOW vehicles would provide fast response, as needed, to carry maintenance personnel along the guideway to make rapid response repairs to guideway elements and trackwork, when required.
- **The MOW vehicles should be capable of recovering stalled vehicles from along the guideway by coupling and towing them to a station or maintenance area.**
- **The MOW vehicles should also be equipped to allow monitoring and inspection of the trackwork elements inside the guideway by maintenance personnel without requiring the removal of the side panel covers, and potentially even making adjustments to the alignment of the running, guiding and power rail equipment inside the guideway.**

**Typical Station**

Stations are elevated and will utilize an off-line siding to decelerate, load/unload passengers and accelerate vehicles. Passengers will purchase tickets via ATM style machines at the station. The proposed “average” PRT stations, for the purposes of cost estimating the loop circulator, will contain 5 berths for vehicle loading/unloading. The ridership estimates and predicted demand will determine the total number of berths at each unique station during subsequent stages of development. Stations will utilize platforms level with the primary track and can be stand-alone facilities or integrated into existing urban structures. One or more stations in the network will be specially designed as storage-only stations to absorb excess vehicles during low demand periods. See Figure 4-7 for typical Taxi 2000 station designs. Figure 4-9 is a photo-simulation of a PRT station in downtown Cincinnati.

At each station, a map of the system and stations would be posted near a ticket machine similar to an ATM machine. A patron selects a destination on the network, takes the
ticket to the loading platform and inserts it into a slot in a stanchion in front of the first empty vehicle. The ticket is read and the destination is transferred to a microprocessor board the vehicle. After the passenger boards the vehicle, the door is closed and they proceed non-stop to their pre-coded destination.

![Typical Freestanding Station](image1)

![Typical Station Floorplan](image2)

**Figure 4-7: Taxi 2000 Typical Aerial Stations**

**Boarding Platform Configuration**
The boarding platform in the station will typically accommodate at least three or more vehicles in order to provide berths for arriving vehicles with passengers destined for the station, and additional berths for a combination of empty vehicle storage/standby and active boarding of passengers, see Figure 4-8. Because of the aerial configuration of the station platform and the automated dispatching of vehicles (often by the supervisory system apart from passenger actions), important features of the station platform are:

- Platform edge partitions and full-height doors (or possibly partial height gates), which operate in coordination with the vehicle’s automated doors, will protect the passenger from falling from the platform. An option that could be considered during system design will be the placement of a railing on the platform edge, with gaps in the railing where the vehicle doors align for boarding and alighting. This design requires that the encroachment of a passenger into the space near the opening be detected, the movement of any vehicles in the area stopped and an alarm sounded. Whatever platform edge protection is implemented will be designed in accord with the requirements of the ASCE APM Standard – Part 3, Section 10.2 and subsections thereof.

- Destination/dispatch request action by the boarding passenger(s) at the boarding berth location will be accomplished by inserting an encoded ticket or pass card and pushing (or touching) a destination station “button”. This will initiate the door opening for boarding, or the dispatching of an empty vehicle from somewhere else to the station if one is not present.

- The floor of the vehicle and the station platform will be at the same level to accommodate entry by the elderly or handicapped (ADA compliant).

- The vehicle will not be permitted to move unless both the platform edge door and the vehicle doors indicates that they are fully closed and “locked”.

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4-6
The following are modifications and concerns regarding the Taxi 2000 boarding platform configuration made by the consultant team:

- The vehicle should detect the passenger’s entry and proper seating and then automatically close the doors without requiring the passenger to interact with the system’s automated controls. The passenger will be able to initiate an early door closure by pushing a door close button.
- The platform edge doors and the vehicle doors must detect obstacles retarding the door closing and reopen the doors to allow the passenger to clear the doorway.

Figure 4-8: Conceptual Taxi 2000 Boarding Platform

Figures 4-9: Taxi 2000 Photo Simulation –Hyatt Hotel Station (Cincinnati)
5.0 Description of Alternatives

5.1 Existing System

The Southbank Shuttle currently operates two routes: from Covington to Cincinnati to Newport and from Newport to Cincinnati to Covington. Both routes travel along the same alignment and share stops when possible. The existing routes are each approximately 17 miles long and have total travel times of 120 minutes.

The existing Southbank Shuttle connects many of the destinations and attractions within the study area and does provide direct access to fixed bus routes via the TANK transit center in Covington and the Southwest Ohio Regional Transit Authority (SORTA) transit center at Government Square. The Southbank Shuttle will also provide direct access to the proposed I-71 Corridor Light Rail line. Shared Southbank Shuttle/LRT stops include Main & Fifth Street and Walnut and Second Street in Cincinnati. At these stops, passengers can easily transfer between modes. In Covington, shuttle and proposed LRT stops are within walking distance of each other.

While the Southbank Shuttle provides a wide coverage area, it does operate in mixed traffic and, therefore, has increased travel times as compared to the other loop circulator alternatives. The goal of the current shuttle route is to connect hotels in Covington, Cincinnati and Newport, where most visitor transit ridership originates, to the entertainment and shopping destinations in the area. Figure 5-1 illustrates the existing route.

The Southbank Shuttle proceeds along the following alignment starting in Newport:

- The route begins at a turn-around at the Bellvue Medical Arts Building and proceeds west on Riverboat Row. There are four stops along this segment to serve the restaurants and hotels in this area.
- The route turns south onto Columbia, then east on Court Street to south onto York and loops back to York via Monmouth. This portion of the route features five stops serving not only the new TANK Newport Transit Center and the Newport CBD, but also attractions such as the World Peace Bell, Newport on the Levee and the Newport Aquarium.
- The alignment then crosses the Ohio River via the Taylor Southgate Bridge into Cincinnati. To serve downtown Cincinnati, the Shuttle proceeds north on Main, then west on Sixth to Central Avenue to east on Fifth Street and finally south on Walnut and across the Roebling Suspension Bridge. By making the large Fifth and Sixth Street loop in Cincinnati, many of the downtown hotels have “front door service” and attractions such as the Contemporary Arts Center, the Aronoff Arts Center and Fountain Square are also served.
- After crossing the river into Covington, the route proceeds south on Madison, east through the TANK transit center, then south on Scott to east on Park Place, then north on Greenup to Rivercenter Boulevard. This segment of the alignment serves the Covington CBD.
- The alignment continues west on Rivercenter Boulevard serving hotels and Covington Landing then turns south onto Bakewell to east on Third Street to the Hampton Inn. The shuttle continues south on Crescent to west on Fifth Street,
stopping at Mainstrasse Village. The route turns south on Philadelphia to west on Sixth and finally south on Main to a turn around at Jillian’s Entertainment Complex.

- The Shuttle then follows the same alignment back from Covington to Cincinnati to Newport turning around at the Bellvue Medical Arts Building.

The following is a list of current Southbank Shuttle stops.

**Newport Stops**

- Bellvue Medical Arts Buildings
- Comfort Suites
- Riverboat Row and Park
- Riverboat Row near KY 8
- Riverboat Row near the Aquarium
- Riverboat Row and York Street
- Travel Lodge
- York Street and Court Street
- York Street and Fifth Street
- Monmouth and Fifth Street
- Fourth Street between York Street and Monmouth Street

**Cincinnati Stops**

- Firstar Center
- Fourth and Main Street – Contemporary Arts Center
- Sixth and Main Street – Aronoff Center
- Sixth Street between Main and Walnut Streets
- Sixth and Race Street – Cincinnatian Hotel
- Cincinnati Convention Center
- Fifth and Elm Street – Hyatt Regency
- Fifth and Race Street – Netherland Plaza
- Fifth and Vine Street – Fountain Square, Government Square and the Westin
- Walnut Street between Third and Fourth Streets
- Ted Berry Way – Cinergy Field

**Covington Stops**

- TANK Transit Center
- Court and Park Place
- Greenup and Park Place
- Second and Greenup Street
- Madison and Rivercenter Blvd.
- Covington Landing
- Bakewell and Main Street
- Philadelphia and Third Street
- Hampton Inn
- 5th and Crescent
- Mainstrasse Village
- Philadelphia and Sixth Street
- Bakewell and Sixth Street
- Sixth and Main Street
- Seventh and Main Street
- Ninth and Main Street
- Main and Pike
- Eleventh and Pike
- Jillian’s Entertainment Complex
Figure 5-1: Southbank Shuttle Existing Route
5.2 Transportation System Management (TSM)

The TSM alternative is defined as improvements to the existing Southbank Shuttle. While each of the other transportation alternatives for the loop circulator are single technology systems, the TSM alternative is a package of improvements that includes traditional TSM improvements and the addition of a new Newport-Covington Southbank Shuttle route. TSM improvements may be implemented individually or in combinations.

Traditional TSM Improvements
Each of the proposed TSM alignments, the existing route and the Newport-Covington routes, include the following TSM improvements:

- Transit Signal Priority
- Traffic Signal Optimization
- “Real Time” Information Maps at Transit centers
- Dedicated Bus Lanes in Cincinnati Along Fifth and Sixth Streets Between Main Street and Central Avenue

Revisions to Existing Route and Service
The existing route, as shown in Figure 5-1, has been modified in Covington to begin at Sixth Street & Main instead of at Jillian’s. This change was made due to the lack of demand for the system south of Sixth & Main. The headways along this route will be reduced to ten minutes compared to the existing headways of fifteen minutes on Fridays and Saturdays and twenty minutes throughout the rest of the week. With the reduction of headways, additional buses will be necessary along this route. This revised route, see Figure 5-2, will improve round trip times and headways along the existing system.

Recommendation:
Currently, TANK operates the Southbank Shuttle with 7 Orion II buses. However, TANK owns 14 buses. To reduce the headways to 10 minutes, the 8 unused buses will be put into service.

Transit Signal Priority
Signal priority is a system that extends a traffic light’s green time for public transit such as buses. The traffic signal is designed to receive information from a transit vehicle or central control system indicating that the transit vehicle or bus is approaching the intersection. The traffic signal will maintain a green time to allow a transit vehicle to clear the intersection. If the signal is red when the when the bus approaches, the system may turn green a few seconds earlier than it would have without priority. Signal priority can also be tied with Advanced Traveler Management Systems (ATMS) and Automatic Vehicle Location (AVL) so that buses running behind schedule will receive more green time.

The advantage of signal priority for buses is that it helps keep buses on schedule. It can reduce the round trip time of a bus, which in turn reduces the number of buses necessary and related capitol and operating costs. Improved system reliability helps increase ridership.
Recommendation:

Install priority signaling along Fifth and Sixth Streets in Cincinnati and Fourth and Fifth Streets in Newport. These roadways were selected because they constitute a large portion of the Southbank Shuttle’s route.

Traffic Signal Optimization
As part of the Central Area Loop Study, the traffic on Fourth and Fifth Streets in Northern Kentucky where examined. The analysis determined that signal timing changes could greatly benefit traffic flows on Fourth and Fifth Streets. The traffic signal system throughout Covington, Cincinnati and Newport should be re-examined to determine if signal timing is optimal. Signals can be timed so that the main thoroughfare has more green time. This type of timing can improve traffic flow and reduce congestion.

Recommendation:

Optimize the traffic signals in Covington, Cincinnati and Newport.

Real Time Information Maps at Transit Centers
With the introduction of AVL, real time maps can be provided to inform passengers when their particular bus will be arriving at that stop. They can also use this information to determine how long their trip will take. The advantage for passengers is that they receive timely and accurate information.

Recommendation:

Provide Real Time information at Covington Transit Center, Newport Transit Center and Government Square Transit Center in Cincinnati.

Dedicated Bus Lanes
Dedicated bus lanes are proposed on Fifth and Sixth Streets between Main and Central Avenue in Cincinnati. Dedicated bus lanes are used exclusively for buses except when automobiles are making turns. Currently, there are three lanes along this thoroughfare and one of these lanes would be dedicated to a bus lane. In addition, parking in off peak times, which currently exists, will be eliminated to accommodate this additional lane.

Recommendation:

Dedicated bus lanes should be implemented on Fifth and Sixth Streets in Cincinnati.

Additional Buses
Additional buses will be necessary for the two new Covington to Newport routes. TANK is interested in acquiring new buses that are 30-feet in length and are between 96 to 102 inches wide.
Recommendation:

Purchase two to three new buses (depending on route selection) to accommodate additional service.

Additional Cincinnati Service
SORTA is interested in providing an east to west connection service along Fifth and Sixth Streets in Cincinnati. The route would provide service to the following attractions in Cincinnati: Main Street Entertainment District, Mount Adams, Museum Center, Music Hall and the Fire Museum. This route would be provided in conjunction with the TANK’s Southbank Shuttle route and the buses would be designed the same as TANK’s Southbank Shuttle buses. This service would provide the same headways, and transfers would take place at the Government Square Transit Center. The fare would be 50 cents with no free transfers, but a day pass would also be offered for two dollars where free transfers would be allowed.

Recommendation:

A coordinating east-west shuttle service in downtown Cincinnati should be studied further by SORTA.
Figure 5-2: Southbank Shuttle Revision to Existing Route
5.2.1 TSM Alignments and Station Locations

The Southbank Shuttle does not currently provide a direct connection between Newport and Covington. Feedback from the general public, as well as from the Advisory Committee, suggested that a direct connection between these cities was both needed and desired. As part of the TSM alternative, a new Covington-Newport alignment is proposed in addition to the existing route. The new Covington-Newport alignment will operate as two routes: an east-west route and a west-east route and will run at 10 minute headways. There are two options for the new alignment. Both alignments are identical in Covington and differ only slightly in Newport. Option 1 serves new business development in south Newport, while Option 2 serves the entertainment destinations on the Newport Riverfront. When implementing the TSM alternative, it is assumed that both Options would have a trial period where actual ridership numbers would determine the final route. The following describes the two options.

Option 1, beginning in Covington, proceeds along the following route. Note that much of the new alignment in Covington follows the existing Southbank Shuttle route. A map of alignment Option 1 can be seen in Figure 5-3.

- The alignment begins at Sixth and Main near the Mainstrasse Village and then proceeds north on Philadelphia, then east on Third Street to the Hampton Inn.
- From the Hampton Inn it continues south on Crescent to Fifth Street to again north on Philadelphia to east on Rivercenter. This portion of the route serves the hotels along the West Covington Riverfront.
- The alignment then proceeds south on Madison to the TANK transit center, then continues south on Scott then east on Park Place to east on Third then south on Garrard and across the Licking River Bridge. This section of the alignment serves the Covington CBD.
- The alignment follows Fifth Street then proceeds south on Monmouth to a turn-around on Eleventh Street in order to travel north on Monmouth to Fourth Street and back to Covington. The Monmouth Street turn-around serves business development in Newport.

Option 2 follows an identical alignment as Option 1 but instead of utilizing the Monmouth Street turn-around, the alignment proceeds north from Fifth Street to Riverboat Row and turns around just past the Comfort Suites Hotel. The alignment then returns to Covington. Alignment Option 2 is shown in Figure 5-4.

Stations

Many of stations for the proposed TSM alignments are existing Southbank Shuttle stops and will be shared by both routes. However, there are additional stops proposed along Options 1 and 2.
Alignment Option 1 Stops:

- Sixth Street and Main Street
- Sixth Street at Bakewell (Mainstrasse)
- Philadelphia Street at Sixth Street (Goebel Park)
- Fifth Street at Clarion Hotel
- Crescent Ave. at Willie’s Sports Bar and Grill
- Crescent Ave. at Hampton Inn
- Third Street at #650 West (Extended Stay America)
- Third Street at Philadelphia (Holiday Inn)
- Philadelphia at Fourth Street
- Bakewell at Second Street (Waterfront Restaurant)
- IRS Gate
- Rivercenter at Madison
- TANK Transit Center
- Greenup Street at Second Street (Mike Fink Restaurant)
- Greenup Street at Third Street
- Park Place at Court Street
- Garrard Street and Fourth Street *
- Fifth Street and Central Avenue *
- York at Fifth Street
- Monmouth and Seventh Street *
- Monmouth and Ninth Street *
- Monmouth and Eleventh Street *
- Monmouth at Fifth Street
- Fourth Street near Monmouth Street
- Fourth and York Street *
- Fourth Street & Central Avenue* 

* notes a new stop along the route.

Alignment Option 2 Stops:

- Sixth and Main Street
- Sixth Street at Bakewell (Mainstrasse)
- Philadelphia Street at Sixth (Goebel Park)
- Fifth Street at Clarion Hotel
- Crescent Avenue at Willie’s Sports Bar and Grill
- Crescent Avenue at Hampton Inn
- Third Street at #650 West (Extended Stay America)
- Third Street at Philadelphia (Holiday Inn)
- Philadelphia at Fourth Street
- Bakewell at Second Street (Waterfront Restaurant)
- IRS Gate
- Rivercenter at Madison
- TANK Transit Center
- Greenup at Second Street (Mike Fink Restaurant)
• Greenup at Third Street
• Park Place at Court St.
• **Garrard and Fourth Street** *
• **Fifth Street and Central Avenue** *
• York at Fifth Street
• Monmouth at Fifth Street
• Fourth near Monmouth Street
• **Fourth and York Street** *
• Columbia Street at Travelodge
• Riverboat Row at Columbia
• Riverboat Row at Aquarium
• Riverboat Row at Barleycorns
• Riverboat Row at various restaurants
• Riverboat Row at Chart House & Comfort Suites

* notes a new stop along the route.

The new route and associated stops were developed to provide new service to new areas, which have the potential to increase ridership for the Southbank Shuttle. The Covington-Newport Route provides a direct link between the two communities without having to go through Cincinnati. This is not an express service; it is a circulator service with frequent stops located to provide maximum ridership and connection with the existing shuttle and fixed route transit.
Figure 5-3: Proposed Newport/Covington Route Option 1
Figure 5-4: Proposed Newport/Covington Route Option 2
5.3 Streetcar

The Streetcar alternative utilizes a circular route approximately 8 miles (clockwise and counter-clockwise loops) in length and has a total travel time of roughly 30 minutes double-tracked. The alignment connects the three CBD’s, their attractions and business centers. The Streetcar will run in mixed traffic on existing streets in Cincinnati, Newport and Covington. While the gage of the trackway will be identical to LRT, it is assumed that Streetcars will be the primary vehicles running on this alignment.

The Streetcar alignment is double-tracked with both a clockwise and counter-clockwise loop. Both loops will operate simultaneously and will share stations when appropriate. This alignment will run on 10 minute headways and serve 30 stations. A total of 7 vehicles will be needed to operate the system, including one spare. Figure 5-5 illustrates that commonly, only a single track occupies a given street with the exception of double-tracking on the bridges and in limited segments where the loops are combined. The Streetcar alignment not only connects the businesses and attractions of the three cities effectively, but also integrates well with the historical and urban nature of setting.

The clockwise loop will proceed along the following alignment, which begins at the proposed station located on Third Street and Clay Wade Bailey Bridge in Covington:

- The Streetcar vehicle will travel across the Ohio River at the approximate location of the Clay Wade Bailey Bridge,
- then proceed east on Second Street with a stop serving the western riverfront of Cincinnati and Paul Brown Stadium,
- turn north on Elm Street to Fifth Street, then proceed east on Fifth Street and turn south onto Broadway. Three proposed stops would serve the downtown Cincinnati Business District, the Cincinnati Convention Center and the SORTA/METRO Transit Center at Government Square on Fifth Street between Main and Walnut Streets.
- The route then continues south on Broadway to the Taylor Southgate Bridge. This portion of the loop contains two stations serving the eastern downtown businesses and attractions as well as the Firstar Center and the Reds Ballpark.
- After crossing the Ohio River on the Taylor-Southgate Bridge into Newport the route turns west onto Fourth Street and continues to progress west on Fourth Street, with four stations serving downtown Newport businesses and the Newport TANK Transit Center.
- Upon leaving Newport via the Veteran’s Memorial Bridge, the route will continue west on Fourth Street in Covington then turn north onto Greenup Street, with a station located on Fourth and Garrard Street and Third and Greenup Street. This section of the loop will serve the rapidly growing CBD of Covington.
- The route will then proceed west on Rivercenter Boulevard, with four stations serving the TANK transit center and the growing Covington riverfront area.
- The route will then loop around MainStrasse, stopping at Philadelphia and Fourth Street and Fifth and Main Street, before crossing the Ohio River. This loop segment will serve the Covington riverfront and popular attractions such as MainStrasse.
The counter-clockwise loop will follow a similar route with some minor exceptions, including some additional stations:

- Again beginning at the Ohio River Crossing, at the proposed station on Third Street and the Clay Wade Bailey Bridge in Covington, the loop will proceed around MainStrasse to east on Rivercenter Boulevard in Covington.
- The alignment then continues south on Madison to east on Fifth Street and across the Veteran’s Memorial Bridge in Newport. This portion of the alignment serves the Covington Transit Station at the Northern Kentucky Convention Center.
- Once in Newport, the Streetcar route proceeds east on Fifth Street to Saratoga and across the L&N Bridge. The Newport Riverfront, the Newport Aquarium and other attractions will be served by this segment of the loop.
- From the L&N Bridge, the alignment continues in Cincinnati west on Pete Rose Way to north on Broadway, then west on Sixth Street to south on Elm and finally west on Third Street to the Clay Wade Bailey Bridge.

There are 18 clockwise loop stations and 22 counter-clockwise stations along the proposed Streetcar alignment. As stated before the entire trip using either the clockwise or counter-clockwise loop should take approximately one-half hour with a streetcar arriving at the station every 10 minutes.
Figure 5-5: Streetcar / Light Rail Alignment
5.4 Personal Rapid Transit (PRT)

The PRT circulator network provides non-stop service from passenger origin directly to their destination. The system is comprised of a series of one-way interlocking loops covering the service area. Non-stop service is accomplished by using off-line stations. The PRT will operate on an elevated guideway structure. The system will serve major activity centers in the Riverfront area, the Central Business Districts, and provide links between the cities of Cincinnati, Covington, and Newport. The PRT alignment will have a total of 30 stations; 28 passenger-boarding stations and 2 vehicle storage-only stations. The average station size is assumed to be 5-berths. Approximately 700 vehicles will be needed to operate the system including spares.

The PRT system will utilize existing infrastructure when crossing the Ohio and Licking River bridges. Bridge crossings may require additional structural support. For all other locations, a new guideway structure will be required.

The PRT service area includes the following, which may be seen in Figure 5-6:

Cincinnati
- Loop circling Paul Brown Stadium
- Loop circling Cinergy Field, Central Avenue through Pete Rose Way
- Central Avenue between Second Street and Sixth Street
- Fifth Street from Central Avenue to Plum Street traversing to Fourth Street between Plum Street and Elm Street
- Fourth Street between Plum Street and Elm Street
- Sixth Street from Central Avenue to Walnut south to Fifth between Walnut Street and I-471

Newport
- Ohio River, and the Licking River from the Ohio River to the Licking River Bridge
- Fifth Street from the Licking River to Saratoga
- Saratoga from Fifth Street to Third Street
- Washington from Third Street to Cowens Drive
- Columbia Street from Fifth to the Ohio River

Covington
- Fourth Street from Philadelphia to the Licking River
- Scott Boulevard from Fourth to River Center Boulevard
- River Center Boulevard from Scott Boulevard to I-75
- Parallels I-75 from Ohio River front to 5th Street
- Philadelphia from Fifth Street to Fourth Street

Links Between Cities
- The system connects the cities of Cincinnati and Newport via the L&N Bridge
- The system connects the cities of Newport and Covington via the Licking River Bridge
- The system connects the cities of Covington and Cincinnati via the Clay Wade Bailey Bridge
Note: The Licking River Bridge and the Clay Wade Bailey Bridge are currently owned by the KYTC. The use of this bridge will require their permission.

The current PRT alignment is conceptual and is subject to change. In the current configuration there are 28 boarding station stops and 2 storage-only stations in Covington, 8 boarding stations in Newport and 16 boarding stations in Cincinnati.

Covington
- Goebles Park
- IRS and Fourth Street
- Northern Kentucky/Covington Convention Center
- Riverfront/West
- West Storage 1 and Maintenance and Control Facility Near I-71/I-75
- West Storage 2 and Maintenance and Control Facility Near I-71/I-75

Newport
- Isabella and Fifth Street
- Millennium Monument
- Fairfield and Washington
- York and River Boat Row
- Storage along River Boat Row
- Columbia and Fourth Street
- River Boat Row
- River Boat Row

Cincinnati
- Paul Brown Stadium West
- Paul Brown Stadium South
- Paul Brown Stadium East
- Paul Brown Stadium North
- Underground Railroad Freedom Center & Intermodal Transit Center (Second Street)
- Cinergy Field North and Firstar Center
- Cinergy Field South and Firstar Center
- Cinergy Field West
- Sawyer Point Park
- Fourth East of Main – Atrium I & II, Firstar Tower
- Fourth East of Race (Former McAlpin’s Bldg.) - Tower Place, Omni-Netherland Hotel
- Cincinnati Convention Center – South
- Cincinnati Convention Center – North
- Sixth between Vine and Walnut - Fountain Square, Aronoff Center, Proposed Contemporary Arts Center
- Government Square – Fountain Square, Westin Hotel, Cincinnati
- Chiquita Center, Taft Theater, Proctor & Gamble
Figure 5-6: Personal Rapid Transit Alignment/Taxi 2000
6.0 Capital and Operating Cost Estimates

A detailed explanation of the capital cost estimating process is contained within the technical memorandum entitled “Capital Cost Estimating Methodology,” (Appendix H). This section outlines key assumptions, in addition to those listed in the memorandum, for each of the cost estimates and summarizes capital and operating costs for each technology.

6.1 Existing System and TSM

Costs for the existing system were provided by TANK. These costs were used to develop the capital and operating costs for the TSM improvements. There is no need to expand the TANK maintenance facility. The existing TANK facility has a capacity of 150 vehicles and currently services only 142. The enhancements to the Southbank Shuttle require a maximum of 6 new vehicles. It was assumed that no additional right-of-way is required for the TSM Alternative. The capital costs are summarized in Tables 6-1 thru 6-3. The operating costs for all of the technology options are summarized in Table 6-6.

6.2 Streetcar

Although it will be technically and physically possible to operate both LRT and Streetcar vehicles on this route, it is unlikely that a Light Rail Vehicle would be used for this application. Therefore, the cost estimates are based on seven Streetcar vehicles running on the proposed pair of circulator routes. The cost estimates for the Streetcar were based on the proposed alignment and historical unit costs from similar installations as well as recent local construction costs. The capital costs for the Streetcar can be found in Table 6-4.

Right-of-Way

It was assumed that some additional right-of-way would need to be acquired for this project. Recent studies conducted in the area show the cost of urban right-of-way to be $15 per square foot. A right-of-way multiplier of two is applied to account for legal fees, appraisals and similar related costs. This unit cost is used for both the Streetcar and PRT alignments. Streetcars will run in existing streets; therefore, no right-of-way will be required for the majority of the alignment. However, it is likely that some incidental right-of-way will be required. It was assumed that 2% of the area of the proposed Streetcar alignment will be on new right-of-way, and that each of the stations will also require right-of-way. The footprint of a station is approximately 50 feet by 10 feet; therefore, an area of 500 square feet will need to be acquired for each station. An additional 60,000 square feet of right-of-way will be required for the Streetcar maintenance facility. These costs are included in the estimate.

Operations and Maintenance

SORTA and all other public transit systems report their operating costs to the Federal Transit Administration (FTA) each year. These costs include wages, benefits and other operating costs and are compiled in FTA’s National Transit Database. The operations and maintenance costs for the Streetcar were estimated using costs reported by SORTA
for 1998, and for similar properties with electrified light rail systems. The numbers were adjusted to reflect 2001 dollars. These numbers were used to determine an average hourly wage for SORTA and the ratio of labor costs to other operational costs. Based on the proposed Streetcar alignment and information from similar systems, approximately 35 employees will be needed to operate the system on a daily basis. This includes managers and supervisors, clerical staff, streetcar operators, vehicle maintenance and maintenance-of-way personnel and unskilled laborers. Based on information from the FTA regarding similar Streetcar systems, other operating costs are approximately 38% of the labor costs. This percentage was used to calculate the other operating costs.

6.3 Personal Rapid Transit

Cost estimates for Personal Rapid Transit were developed using unit costs and weights provided by TAXI 2000 and historic costs where applicable. The vehicle weights and guideway designs provided by TAXI 2000 were verified independently by the consultant team. This resulted in some revisions to the cost estimates. The estimates are based on a 12.84-mile, 700-vehicle system with 28 boarding stations, 2 storage-only stations and one maintenance facility. While the cost estimates were based on the proposed 700 vehicle system, a sensitivity analysis was conducted by Taxi 2000 with regard to the number of vehicles required to support the ridership estimates. This analysis can be found in Appendix G.

TAXI 2000 Components

A vehicle weight analysis was performed as described in Appendix F. This analysis determined that the vehicle weight would be nearly double that previously estimated by TAXI 2000. The per-vehicle unit cost reflects this disparity. The station costs were estimated using the size of the station provided by Taxi 2000 and station components. The per-station estimates reflect the cost for a 16-foot by 50-foot platform with five berths. A five-berth station was used for all stations, although some stations such as Paul Brown Stadium may have up to 15 berths and others only three. The Taxi 2000 guideway design was subjected to an independent structural review as part of this Study. The results of this analysis are contained within Section 2.4.2, and the cost estimates reflect the required adjustment to the design.

Right-of-Way

Similar to the Streetcar alternative, some right-of-way will need to be acquired for the PRT system. Right-of-way for the alignment is estimated in the same way as the Streetcar, i.e., 2% of the alignment area. This area is multiplied by the $15 per square foot cost described earlier with a multiplier of two applied to account for legal fees, appraisals and other related costs.

Station Right-of-Way

Each of the stations will require right-of-way. Based on the proposed alignment, seven stations will be attached to buildings and 21 will be freestanding. Right-of-way for the storage-only stations is calculated with the maintenance facility. Right-of-way for the freestanding stations was calculated using the area of the station footprint (50 feet by 16 feet = 800 square feet) multiplied by the cost of urban right-of-way plus the right-of-way...
multiplier. Fifty feet is the length of the station platform for a five-berth station and 16 feet is the width to accommodate the elevator, stairs, ticket vending machines and related amenities. The consultant team agrees that 50 feet is adequate length for a 5-berth station, however, the 16-foot width is the absolute minimum needed to accommodate the facilities required in a station. It is more likely that the width of an elevated station would be approximately 25 feet. For the purposes of this estimate, the station costs were calculated using the width of 16 feet described by Taxi 2000.

![Figure 6-1: Attached Station Schematic](image)

The right-of-way calculation for an attached station is more complicated. The width of the sidewalk from the curb to the building face was measured at the location of each attached station. Each attached station requires at least 10 feet of space inside the building to accommodate the elevator and stairs. The 16-foot platform may cantilever off the building face. Figure 6-1 provides a schematic of this situation. The area of space needed inside the building was then calculated and multiplied by the current cost of office space in Cincinnati ($25 per square foot per year). A 30-year, three-floor lease

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value was then determined. The lease value includes the cost of the office space per year (adjusted for inflation) and a multiplier to account for lease buyout, legal fees, relocation and appraisal.

**Maintenance Facility Right-of-Way**

Right-of-way for the PRT maintenance facility was calculated using the number of vehicles plus other required facility elements such as offices, warehousing, and parking. 700 vehicles are required according to the TAXI 2000 business plan. A total of one hundred vehicles will be stored in two storage-only stations. Taxi 2000 proposes that another 150 vehicles be stored in boarding stations overnight. The consultant feels that an operating entity would not allow vehicles to be stored at public stations overnight. Therefore, the remaining 600 vehicles will require space within the maintenance facility. The right-of-way required for the storage-only stations and the maintenance facility are calculated together, since the space required is the same whether they are in the facility or a storage station. In both locations, the vehicles are assumed to be stored in a chain, bumper to bumper. The maintenance facility requires approximately 68,000 square-feet, which includes control facilities, employee areas, vehicle-storage, maintenance and parking. The total capital costs for PRT are listed in Table 6-5.

**Operations and Maintenance**

The annual costs for operations and maintenance were estimated using wage data for SORTA’s system, plus other operating costs for automated guideway systems from FTA’s National Transit Database and the operating plan for TAXI 2000 provided by the Skyloop Committee. The TAXI 2000 plan states that only 20 full-time employees are needed to operate the system with cleaning of the vehicles being sub-contracted and not included in the 20 person total. Considering the large number of vehicles in the system, guideway and station maintenance, and other requirements, the consultant team determined that a minimum of 120 employees, including 16 full-time vehicle cleaners, would be needed to operate the PRT system. This number includes supervision and management, clerical staff, mechanics, guideway operations staff, unskilled labor and cleaning personnel.

Other operating costs were calculated using the FTA data for automated guideway systems. Based on FTA data, other operating costs should be approximately 58% of the total labor costs. Costs developed using this methodology were similar to the operating costs listed in the TAXI 2000 plan developed by Dr. Anderson. The operations and maintenance costs are shown in Table 6-6.
Table 6-1: TSM Cost Estimate Summary – Existing System Revised
Table 6-2: TSM Cost Estimate Summary – Covington/Newport Route Option 1

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<tr>
<th>Description</th>
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<td>Item 1</td>
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<tr>
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<tr>
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<td>$300,000</td>
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</tbody>
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Total: $1,000,000
Table 6-3: TSM Cost Estimate Summary – Covington/Newport Route Option 2
Table 6-4: Streetcar Cost Estimate Summary
Table 6-5: Personal Rapid Transit Cost Estimate Summary
Table 6-6: Operations and Maintenance Cost Estimate Summary
7.0 Evaluation Methodology

This section describes the screening process and evaluation criteria applied to the transportation system alternatives developed for the Central Area Loop Study (Study). The alternatives include the following technologies: the existing Southbank Shuttle Service, Transportation System Management (improvements to the Southbank Shuttle), Streetcar and Personal Rapid Transit (PRT)/Taxi 2000. The evaluation criteria build on earlier efforts by examining the transportation problem defined in the Purpose and Need Statement and the Goals established by the Central Area Loop Study Advisory Committee. The section ends with a general description of the methodology to be followed in assessing the technical feasibility of each transportation system for the Loop Circulator.

7.1 Evaluation Criteria

A list of technology assessment categories and evaluation criteria were developed and approved by the Advisory Committee. The categories include cost effectiveness, equity, safety/access, effectiveness, environmental impacts, system flexibility, utilization of infrastructure and implementation obstacles. The evaluation criteria are reflected in Table 7-1 and discussed below.

Cost Effectiveness
Evaluation of cost-effectiveness is based on the Federal Transit Administration’s (FTA) established criteria, which considers the incremental cost per passenger in the forecast year. This measure, expressed in current year dollars, is based on annualized total capital investment and annual operating costs divided by the forecasted change in annual transit ridership compared to the baseline system. The capital cost for each transportation system will include vehicle, station, guideway/track structure, control systems, operational systems, right-of-way and construction costs. These costs will be determined using the selected alignments and information from similar type applications. The capital cost will be presented as the total cost of completing the transportation system.

The operations and maintenance costs will be based on the fleet size, the operating systems required, reliability of the system and the maintenance facility size. These costs will be determined using information from similar type systems. Operating and maintenance costs will be presented in dollars per year.

Equity
The ability to provide an equal distribution of benefits, costs and impacts.

This category refers to environmental justice as defined by Executive Order 12898 that requires, to the greatest extent practicable and permitted by law, achieving environmental justice by identifying and addressing, as appropriate, disproportionately high and adverse human health and environmental effects on minority and low-income populations. Information gathered from census data identifies minority and low-income communities. Impacts from each transportation system will then be assessed to
determine if there are any disproportionately high and adverse effects. These criteria will be evaluated using a rating system.

**Safety/Access**
*The ease of compliance with safety and access requirements.*

These criteria involve the transportation system’s ability not only to comply with federal, local, and state regulations, but also to provide passengers with a sense of personal safety at the station and in the vehicles. In addition, it considers the transportation system’s safety implications for pedestrian and motorists. Compliance with the American’s with Disabilities Act, Fire/Life Safety Requirements, and Building Code Requirements is a necessity; therefore, technologies will be compared to each other with respect to how complicated or difficult achieving compliance will be and how easily accessibility for all passengers is accomplished. For example, an at-grade technology may require a wheel-chair lift, while an elevated technology would require compliant vertical circulation. These criteria also involve the personal safety of passengers in the vehicles and at the stations. For example, the following questions may be asked: are the stations protected from the elements; are video surveillance cameras present, or are the stations manned by employees 24 hours a day?

**Effectiveness**
*Improves the speed and mobility within the study area.*

While each transportation system alignment was chosen to adequately connect the three Central Business Districts with key destinations, each transportation system operates differently resulting in a varied degree of effectiveness. Typically, for a transit system to be effective service levels must be high to attract riders; therefore, total trip time (the combined access, wait and travel times) becomes a key indicator of service levels. Other important factors to be considered when determining effectiveness are frequency and reliability. Many times, passengers will be more likely to utilize transit if the system runs on time and is frequent. The loop circulator will work in conjunction with other modes such as bus transit, potentially light rail or possibly commuter rail to create the region’s transportation system. Therefore, it is vitally important that the transportation system chosen provides efficient intermodal transfers and accents park and ride lots.

**Environmental**
*Compatibility with the natural and built environment.*

The environmental impacts of each transportation system to the natural and built environment will be evaluated using four categories: general environmental impacts, right-of-way impacts, visual impacts and urban integration impacts. Each is discussed below.

General environmental impacts include effects to historic structures and districts. The effects of noise and vibration will be quantified in terms of the technology’s inherent characteristics and on similar type projects. Finally, the impacts associated with ecology, hazardous materials and/or wetlands will be estimated based on information researched from federal, state and local agencies.
Right-of-way impacts include displacements and relocations associated with either the construction or operation of the transportation system, the ability of the technology to meet geometric constraints of the study area with minimal right-of-way acquisition and the need for an exclusive operating envelope. Given the scope of this study, right-of-way impacts will be determined using the technologies inherent characteristics and the characteristics of the alignment chosen.

The visual impacts will include effects to the view shed of the study area, effects to the character of neighborhoods along the alignment, and the degree to which the elements of the system (vehicles, stations and track/guideway structures) are aesthetically pleasing.

Urban integration includes the measure of the less tangible, but equally important, factors of the transportation system. Examples may include being supportive of the urban design concept for the system, being supportive of land use/joint development expectations for the area, the visual acceptance of the system and its facilities, the enhancement of pedestrian movement, street level activation and station access and the ability to pull together and connect the communities in the corridor rather than building barriers between them.

**System Flexibility**

*Ability to locate and expand the guideway, stations and operations and maintenance facilities within the built environment.*

This factor evaluates the ability of the system to be expanded and adapted to the current and future transportation needs/constraints of the study area. This criteria not only includes information regarding the location of the stations and track/guideway, but also the siting/size requirements of the staging and maintenance facilities and the ability to accommodate changes in ridership and peak demand associated with large events. The transportation system is being developed to facilitate transportation between three built urban environments. Therefore, it is necessary to assess the technology’s ability to adapt and change in these areas.

**Utilization of Existing Infrastructure**

To reduce the costs of the loop circulator system, it would be advantageous for the preferred transportation system to use existing and planned infrastructure in the study area. The loop circulator requires at least two river crossings: the Licking River between Newport and Covington and the Ohio River. It is important to determine if the existing bridges can support the structural load imposed by fixed transit and if they can also handle a capacity reduction if an exclusive operations envelope is required. While the Kentucky Transportation Cabinet is opposed to the use of an exclusive lane on any of the Ohio River bridges, they are open, if the capacity analysis is favorable, to traffic and transit sharing a lane on an Ohio River bridge.

Traffic impacts also affect existing infrastructure and include effects to traffic flow during both construction and operation of the loop circulator. These impacts will be determined using the technologies inherent characteristics and based on similar type projects.
Connections and integration with existing transit centers are also important to the success of the transportation system. Currently, there is one transit center located in downtown Cincinnati, one in Covington and a planned facility in Newport. The preferred transportation system must link to these facilities and provide for efficient passenger transfers.

**Implementation Obstacles**

In selecting a technology for a new system, it is important to assess the associated developmental and implementation risk. Risk can be determined by examining such factors as the years of proven service in similar urban transit applications, the number of systems currently in operation (and future projects), the reliability of cost estimates and the safety records of the operational systems. Due to the appropriately risk-adverse nature of public projects, failure to meet these criteria is usually considered detrimental to the project.

As in all public funded projects, procurement for a new system is an important consideration. There should be an adequate number of suppliers to ensure that a solicitation of proposals or bids will receive a competitive response. It is also important to ensure that a good solid technical product will be available at reasonable prices when future acquisitions warrant. All vehicles of any technology have some proprietary components. The concern here is for concepts or major assemblies that are unique to only one supplier.

### 7.2 Methodology

The purpose of the screening process is to continue refining the list of possible alternatives until the locally preferred alternative is selected. This screening process is necessary to identify and screen alternatives that address issues identified in the Problem Statement and meet the Study's Goals.

Initially, a few pertinent and important details will be identified about a broad array of initial alternatives. As the analyses progress, the range and depth of information will widen as the number of alternatives decrease. Table 7-1 below depicts the levels of screening and the depth of information that will be developed as the number of alternatives narrows.
The “fatal flaw” analysis or Level I screening process applied limited measures of evaluation to all alternatives eliminating those that did not meet the Goals, were not acceptable for the application, or did not address the problems identified by the Problem Statement. This first level analysis relied on qualitative criteria and judgments of the Study’s decision makers as applied to a limited number of criteria. Consequently, several alternatives were eliminated. The technologies that remained were as follows: the existing Southbank Shuttle, Improvements to the Southbank Shuttle, Streetcar, Light Rail Transit, People Mover or Monorail (AGT), and Personal Rapid Transit (PRT).

During the Level II screening process more information was known about each of the transportation alternatives and decisions were made based on qualitative data in each of the eight criteria categories described in Section 7.1. At the completion of the Level II screening, four system alternatives were carried forward:

- The existing Southbank Shuttle
- Transportation Systems Management (Improvements to the Southbank Shuttle)
- A combination of Light Rail and Streetcar
- Personal Rapid Transit (Taxi 2000)

Section 8.0 details the results of the Level III screening analysis and includes descriptive characteristics of each of the remaining transportation systems as well as an analysis based on the evaluation criteria.
Table 7-1: Evaluation Criteria

<table>
<thead>
<tr>
<th>Cost Effectiveness</th>
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<tbody>
<tr>
<td>• To what extent does this transportation system represent a cost-effective investment?</td>
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<tr>
<td>• Are there front-end costs and time associated with this transportation system to ready it for implementation?</td>
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<td>• How severe are the secondary costs (utilities, street changes) due to placing this transportation system and its structures in likely locations?</td>
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<td>• What is the technical life expectancy of this technology?</td>
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<td>• To what extent does this transportation system imply a reasonable level of annual costs?</td>
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<td>• Is this transportation system labor intensive to operate and maintain?</td>
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<tr>
<td>• Are there any extraordinary power requirements associated with this technology?</td>
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<tr>
<td>• Is this transportation system susceptible to failures of its rolling stock, systems, or fixed facilities?</td>
</tr>
<tr>
<td>• What relative degree of vehicle failure or downtime is likely with this technology?</td>
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<tr>
<td>• What level of vehicle spares seems indicated as prudent?</td>
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<tr>
<th>Equity</th>
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<tbody>
<tr>
<td>• Will the transportation system distribute costs and benefits equally to all segments of the population within the affected area?</td>
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<tr>
<td>• Will the transportation system serve a variety of populations?</td>
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<tr>
<td>• Will the transportation system provide affordable transportation to low-income individuals?</td>
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<tr>
<th>Safety/Access</th>
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<tbody>
<tr>
<td>• Is the transportation system ADA compliant?</td>
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<tr>
<td>• Does the transportation system meet fire/life safety requirements?</td>
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<tr>
<td>• Will there be difficulties in meeting building code requirements?</td>
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<tr>
<td>• Is there a perception of personal safety within the vehicle and at the station?</td>
</tr>
<tr>
<td>• Does the transportation system provide convenient access to all users?</td>
</tr>
<tr>
<td>• Does the transportation system present a safety hazard to non-users?</td>
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<table>
<thead>
<tr>
<th>Effectiveness</th>
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<tbody>
<tr>
<td>• Does the transportation system have acceptable point-to-point travel times including station dwell time?</td>
</tr>
<tr>
<td>• Does the system provide reliable service levels?</td>
</tr>
<tr>
<td>• Does the transportation system provide adequate service to the study area destinations in terms of frequency of service and geography coverage?</td>
</tr>
<tr>
<td>• How reliable is the transportation system in maintaining schedule?</td>
</tr>
<tr>
<td>• Will the transportation system adequately serve projected ridership and/or attract sufficient ridership to justify the investment?</td>
</tr>
<tr>
<td>• Does this transportation system facilitate intermodal transfer movements among public transit service providers?</td>
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<table>
<thead>
<tr>
<th>Environmental General Impacts</th>
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</thead>
<tbody>
<tr>
<td>• Will there be adverse effects to historic structures and districts?</td>
</tr>
<tr>
<td>• Are noise and vibration generated or caused by the operation of this transportation system acceptable or manageable?</td>
</tr>
<tr>
<td>• Are impacts associated with ecology, hazardous materials, or wetlands anticipated?</td>
</tr>
<tr>
<td>• Can the transportation system be installed within existing public rights of way?</td>
</tr>
<tr>
<td>• Will there be displacements or relocations associated with the construction and operation of this technology?</td>
</tr>
<tr>
<td>• Will the transportation system, including its associated structures, create visual impacts within the study area?</td>
</tr>
<tr>
<td>• Will the vehicles, line structures, stations, and system wide elements integrate well into the urban form and character of the area served?</td>
</tr>
<tr>
<td>• Can the geometric requirements of the transportation system (turning radius, gradeability, vehicle envelope, etc.) be accommodated within the study area?</td>
</tr>
<tr>
<td>• Will the fixed facilities or operations of this transportation system create real or perceived barriers dividing neighborhoods?</td>
</tr>
<tr>
<td>• Does the transportation system and its guideway structures and stations cause diminished capacity for motor vehicle traffic flow in general?</td>
</tr>
<tr>
<td>• Will there be any specific traffic impacts associated with the technology?</td>
</tr>
<tr>
<td>• Will there be any specific construction impacts associated with the technology?</td>
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<table>
<thead>
<tr>
<th>Right-of-Way Visual Impacts</th>
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</thead>
<tbody>
<tr>
<td>• Can this transportation system respond to changes in ridership levels?</td>
</tr>
<tr>
<td>• Is the alignment easily expandable?</td>
</tr>
<tr>
<td>• Are there extraordinary requirements of the transportation system in its storage and maintenance facility location or design?</td>
</tr>
<tr>
<td>• Are new stations or boarding area accommodated easily?</td>
</tr>
<tr>
<td>• Can the barrier-free, proof-of-purchase fare collection method be used with this technology?</td>
</tr>
<tr>
<td>• Are there excessive or unusual clearance requirements associated with this technology?</td>
</tr>
<tr>
<td>• Does this transportation system require a fully-separated operating envelope?</td>
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<thead>
<tr>
<th>Urban Integration</th>
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<tbody>
<tr>
<td>• Can this transportation system utilize existing bridges within the study area?</td>
</tr>
<tr>
<td>• Will the transportation system require the construction of a guideway or track structure?</td>
</tr>
<tr>
<td>• Will the transportation system enhance the existing regional transportation investment?</td>
</tr>
<tr>
<td>• Does this transportation system have enough vertical alignment flexibility to minimize guideway costs?</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>System Flexibility</th>
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</thead>
<tbody>
<tr>
<td>• Are there several operational systems using this transportation system in the U.S. or internationally?</td>
</tr>
<tr>
<td>• Is there significant technical risk associated with the implementation of the transportation system?</td>
</tr>
<tr>
<td>• Are vehicles of this transportation system generally reliable and safe in operation?</td>
</tr>
<tr>
<td>• Are there at least two suppliers worldwide who produce this technology?</td>
</tr>
<tr>
<td>• If this transportation system becomes selected for an initial order, is it likely additional compatible sets of equipment can be procured in five years under competitive circumstances?</td>
</tr>
<tr>
<td>• Does this transportation system drive the scoping of a procurement such that the vehicles, guideway, and systems must be combined?</td>
</tr>
<tr>
<td>• Is there confidence that cost estimates can be projected accurately?</td>
</tr>
<tr>
<td>• Are there any factors that would preclude cost estimates from being projected accurately?</td>
</tr>
<tr>
<td>• Does the transportation system utilize proven available technology?</td>
</tr>
<tr>
<td>• Does the transportation system utilize proprietary transportation system, or is the transportation system generally available?</td>
</tr>
<tr>
<td>• Are multiple suppliers available to allow competition for the initial system?</td>
</tr>
<tr>
<td>• How long a period will be required to demonstrate and prove the safety and operational reliability of the system?</td>
</tr>
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<table>
<thead>
<tr>
<th>Implementation Obstacles</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Are there front-end costs and time associated with this transportation system to ready it for implementation?</td>
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<tr>
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</table>
8.0 Technology Evaluation

8.1 Cost Effectiveness

To what extent does this transportation system represent a cost-effective investment?

Table 8-1 below illustrates the average cost per passenger for each technology. The costs were calculated using the Annualization Cost Factors found in Appendix H, Section 4.1.5. The capital and operating costs are located in Section 6.0 of this report. The yearly ridership was calculated using the average weekday ridership in the future year 2020 multiplied by 300 average days per year. The future year ridership estimates can be found in Section 3.0 of this report. This calculation is presented as a basis of comparison only.

- **Existing**: As illustrated in Table 8-1 the cost per passenger for the Existing Southbank Shuttle is $3.78, which is in the mid-range as compared to the other alternatives.

- **TSM**: The improvements to the Southbank Shuttle are the most cost effective of the alternatives at $3.34 per passenger.

- **Streetcar**: The cost per passenger for the streetcar alternative is $10.10 per passenger which is the highest of the alternatives. As compared to the other technologies, the streetcar alternative is the least cost effective.

- **PRT**: The cost per passenger for the PRT alternative is $6.15 which is less than costs for streetcar but higher than the Existing Service and TSM alternatives. Therefore, as compared to the other technologies, PRT is less cost effective than the Southbank Shuttle but more than the streetcar.
### Table 8-1: Alternative Transit Costs per Passenger

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Existing</th>
<th>TSM (Option 1 &amp; Option 2)</th>
<th>Streetcar</th>
<th>PRT ($2.00 / 2 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Costs (with contingency)</td>
<td>$0</td>
<td>$2,900,000</td>
<td>$215,000,000</td>
<td>$450,000,000</td>
</tr>
<tr>
<td>Design Life (Weighted Average for components)</td>
<td>10</td>
<td>12.50</td>
<td>31.62</td>
<td>34.27</td>
</tr>
<tr>
<td>Annualization Factor</td>
<td>0.142</td>
<td>0.123</td>
<td>0.079</td>
<td>0.078</td>
</tr>
<tr>
<td>Annualized Capital Costs per Year</td>
<td>$0</td>
<td>$350,000</td>
<td>$17,000,000</td>
<td>$35,000,000</td>
</tr>
<tr>
<td>Operating &amp; Maintenance Costs</td>
<td>$1,770,000</td>
<td>$5,710,000</td>
<td>$4,200,000</td>
<td>$13,900,000</td>
</tr>
<tr>
<td>Passengers per Year (Year 2000 Estimates)</td>
<td>468,000</td>
<td>1,812,600</td>
<td>2,098,200</td>
<td>7,951,200</td>
</tr>
<tr>
<td>Cost per Passenger</td>
<td>$3.78</td>
<td>$3.34</td>
<td>$10.10</td>
<td>$6.15</td>
</tr>
</tbody>
</table>

Are there front-end costs and time associated with this transportation system to ready it for implementation?

- **Existing**: None
- **TSM**: Some time may be required to obtain additional buses, and a study to determine the best ITS alternative.
- **Streetcar**: Approximately 3 to 4 years will be required for the design and construction of the system.
- **PRT**: Taxi 2000 is a conceptual design. This alternative will require a prototype design development on a test track before the final design for the Central Area Loop Study project can proceed. The design must undergo a variety of independent tests to meet federal and state requirements. This design prototyping process is expected to take an additional 2 to 3 years and cost $25 million, according to Taxi 2000.
How severe are the secondary costs (utilities, street changes) due to placing this transportation system and its structures in likely locations?

- **Existing:** None

- **TSM:** Some in-street utility work maybe required to install ITS wiring and associated equipment.

- **Streetcar:** The secondary costs for Streetcar may include the relocation of underground parallel utilities from beneath the trackbed, relocation of overhead utility lines in conflict with the catenary, and the installation and revision of traffic signal detection loops. These costs are accounted for in the cost estimate in the utility and roadway modification category (approximately $6 million) and carry a contingency of 50% and 40%, respectively.

- **PRT:** The secondary costs for PRT will include the reconstruction of sidewalks, the relocation of underground utilities from the foundation construction and the possible relocation of office personal in buildings with attached stations. These secondary costs are accounted for in the cost estimate in the utility and roadway modification category (approximately $14 million) and carry a contingency of 50% and 45%, respectively.

What is the technical life expectancy of this technology?

- **Existing:** The Orion II has a useful life of 7-years and the Gillig 40-ft has a useful life of 12-years. The current fleet of Orion II has been in operation for approximately 3 years, but is plagued with maintenance problems and TANK is investing in replacement vehicles.

- **TSM:** The Gillig 30-foot bus has a useful life of 10 years, and the bus shelters have a life expectancy of approximately 20 years. The ITS equipment has a life expectancy of approximately 10 to 20 years, provided it is upgraded and maintained.

- **Streetcar:** A typical design life for a Streetcar system is approximately 30 years.

- **PRT:** The fixed facilities should be designed for 30 years. The guideway is modular and should be structurally designed for 30 years but its replacement in sections should be possible whenever required. The vehicles are anticipated to have a design life of about 10 years, or 500,000 miles.
To what extent does this transportation system imply a reasonable level of annual costs?

Table 8-1 presents annual costs in two components: operating and maintenance costs; and annualized capital costs. The combined costs are the basis for the following comparison.

- **Existing:** The Southbank Shuttle is a successful existing service, therefore its operation can be considered to have a reasonable level of annual costs. Annual Operating and Maintenance are estimated at $1.8 million per year.

- **TSM:** The improved Southbank Shuttle is projected to have combined annual costs of $5.7 million which is in the mid-range of the alternatives considered.

- **Streetcar:** The combined annual costs for the streetcar system are approximately $20 to $25 million dollars per year based on costs from similar type systems. These costs are higher than that of the Southbank Shuttle and can be considered moderately high.

- **PRT:** The combined annual costs for the PRT alternative are approximately $50 million dollars based on the estimated workforce and costs from similar automated systems. These costs are considered high with respect to the other technologies considered.

Is this transportation system labor intensive to operate and maintain?

- **Existing:** The existing Orion II is relatively labor intensive to operate due to its limited passenger capacity. A modest amount of labor is required to service and repair the fleet. TANK’s regular transit supervisors provide supervision. While the O&M costs can be considered labor intensive, relative to existing companion bus service, there is no change in labor intensity.

- **TSM:** Additional labor will be required to operate and maintain the added vehicles and ITS system. The operating costs component may decrease if larger vehicles are purchased to replace the Orion II.

- **Streetcar:** The Streetcar system is a manned system with one driver per vehicle. Maintenance can be classified as routine and uncomplicated. This alternative is considered moderately labor intensive as there is only 7 vehicles. This fleet size is similar to the Southbank Shuttle and thus the operating labor requirements will be similar. Some additional personnel will be required to maintain and service the track, electrification and signal equipment.

- **PRT:** No labor is required to operate the individual PRT vehicles. One or more operators in a central control room will be required to supervise and monitor the automated control system on each shift. Additional personnel will be required to monitor the numerous Closed Circuit Television cameras installed on the system and respond to passenger-initiated communications via the intercom. Because of the
large fleet size and need to regularly clean and maintain the vehicles, a relatively
large staff of maintenance personnel is anticipated. Additional personnel will be
required to service and repair the guideway, control systems, elevators and ticket
vending equipment.

Are there any extraordinary power requirements associated with this technology?

- **Existing**: No significant electrical power requirements are associated with the
  existing Southbank Shuttle.

- **TSM**: No significant electrical power requirements are associated with the proposed
  increase in Southbank Shuttle service. An increase in diesel fuel usage will
  accompany the expansion of service.

- **Streetcar**: Electrical power consumption will increase due to the operation of the
  Streetcar system. The peak demand and energy requirements should not pose any
  significant problem for the local utility company.

- **PRT**: Electrical power consumption will increase due to the operation of the PRT
  system. The peak demand and energy requirements should not pose any significant
  problem for the local utility company. The actual power requirements of this
  technology are not yet own. The prototype will verify these costs.

Is this transportation system susceptible to failures of its rolling stock, systems, or fixed
facilities?

- **Existing/TSM**: The existing fleet of Orion II buses has experienced a variety of
  maintenance problems. Vehicle breakdowns, which result in the stranding of
  passengers, are rare. In the event of a breakdown a substitute bus can be used or
  the passengers can board the next scheduled shuttle or walk to their destination if
  necessary.

- **Streetcar**: Failure of a Streetcar vehicle is relatively uncommon. In the event of a
  failure, passengers can wait for the next scheduled Streetcar or alternatively a bus
  can be dispatched to pick-up the passengers and complete the trip. Failure of the
  guideway is rare and redundancy in the traction power system virtually eliminates
  electrical failures, which would shut down the system.

- **PRT**: Due to the proprietary design of the Taxi 2000 system, it is impossible at the
  present to predict its susceptibility to failure, although the stated design intent is to
  provide ample redundancy for a highly reliable system. Because precise alignment
  of the guideway elements is required, constant attention to this portion of the system
  will likely be necessary. In the event of a vehicle failure, the following vehicle must
  push the disabled PRT vehicle to the next station. In the unlikely event of an overall
  system failure, emergency vehicles equipped with man-lift capability would be
  required to assist stranded passengers in safely leaving their vehicle if stopped on a
  section of guideway without emergency walks.
What relative degree of vehicle failure or downtime is likely with this technology?

- **Existing/TSM**: A relatively low degree of vehicle failure or downtime is associated with the existing fleet of Orion II buses; however, there have been problems with the A/C, differential, axle and bearings. Service and repairs normally occur outside of normal operating hours.

- **Streetcar**: Modern electric powered rail transit vehicles are considered highly reliable. Service and repairs are normally performed outside normal operating hours.

- **PRT**: The quantity of vehicles will result in system failure rates that will create delays to a few passengers. However, the network configuration and the large number of vehicles proposed, will mean that no single failure will result in delays to all passengers. A higher than normal failure rate should be anticipated during the initial period of operation. As the Taxi 2000 design progress, more will be known regarding the failure rate and downtime associated with the technology.

What level of vehicle spares seems indicated as prudent?

- **Existing**: A 15-20 percent spare ratio consistent with current operating experience.

- **TSM**: A 15-20 percent ratio consistent with current operating experience.

- **Streetcar**: A 15-20 percent spare ratio (one additional vehicle) is considered normal industry practice for rail transit vehicles.

- **PRT**: Due to the unproven nature of the vehicle, a somewhat higher than normal spare ratio of 20 percent (140 vehicles) is indicated to maintain an operating fleet of 700 vehicles.

8.2 Equity

*Will the transportation system distribute costs and benefits equally to all segments of the population within the affected area?*

- **Existing**: The Southbank Shuttle operates as a special service, which complements the fixed route transit and paratransit services offered by TANK in Northern Kentucky and SORTA in Ohio. The present system is designed to serve residents, employees, and visitors in the vicinity of the riverfront areas in Covington and Newport and in the Cincinnati CBD. The system’s costs are borne by the residents of Kenton, Boone and Campbell Counties in Northern Kentucky.

- **TSM**: The enhanced system will better serve residents, employees, and visitors in the vicinity of the riverfront areas in Covington and Newport and in the Cincinnati CBD.
CBD through more frequent service. The revised routing will enhance travel between Covington and Newport, and one option would increase service to areas in the south of Newport’s CBD. The system’s costs will continue to be borne by the residents of Kenton, Boone and Campbell Counties in Northern Kentucky.

- **Streetcar:** The Streetcar alternative will generally serve the same populations as the enhanced Southbank Shuttle (TSM), with connections to the regional transit system. Funding for construction and operation of this alternative would likely be shared between TANK and SORTA under an Inter-local Agreement, which would result in a more equitable distribution of costs within the community.

- **PRT:** The PRT alternative is designed to serve generally the same populations as the existing Southbank Shuttle, and the route structure is somewhat more extensive than the Streetcar alternative. Because the projected fare for the PRT system ($2.00) is significantly higher than the current fare ($0.50), lower-income populations may be deterred from using the system. Some members of the disabled community and some other users may find access to the elevated stations more difficult than a street-level system. Funding for construction and operation of the system has not been determined, however, both public and private funding options have been discussed. The distribution of costs will depend on the funding option selected. At the present time, neither TANK nor SORTA have expressed any interest in owning or operating the proposed PRT system.

**Will the transportation system serve a variety of populations?**

- **Existing:** The Southbank Shuttle operates as a special service, which complements the fixed route transit and paratransit services offered by TANK in Northern Kentucky and SORTA in Ohio. The present system is designed to serve residents, employees, and visitors in the vicinity of the riverfront areas in Covington and Newport and in the Cincinnati CBD.

- **TSM:** The enhanced system will better serve residents, employees, and visitors in the vicinity of the riverfront areas in Covington and Newport and in the Cincinnati CBD through more frequent service. The revised routing will enhance travel between Covington and Newport, and one option would increase service to areas in the south of Newport’s CBD. During the course of the study, the Advisory Committee confirmed that the Loop Circulator was not designed to serve the general residential populations in the northern and southern portions of the Study Area. These populations are presently served by the fixed-route and paratransit services provided by TANK and SORTA.

- **Streetcar:** The Streetcar system will generally serve the same populations as the enhanced Southbank Shuttle (TSM), with connections to the regional transit system.

- **PRT:** The PRT alternative is designed to serve generally the same populations as the existing Southbank Shuttle, and the route structure is somewhat more extensive than the Streetcar alternative. Because the projected fare for the PRT system ($2.00) is significantly higher than the current fare ($0.50), lower-income populations...
may be deterred from using the system. Some members of the disabled community and some other users may find access to the elevated stations more difficult than a street-level system.

Will the transportation system provide affordable transportation to low-income individuals?

- **Existing:** The Southbank Shuttle fare of $0.50 per ride is the lowest transit fare in the region. There is currently no transfer privilege between the Southbank Shuttle and the regular SORTA and TANK systems.

- **TSM:** The enhanced Southbank Shuttle is expected to have the same fare structure as the present service.

- **Streetcar:** The fare for the Streetcar is expected to match the existing fare structure ($0.50) for the Southbank Shuttle.

- **PRT:** A fare of $2.00 per trip has been proposed with the alternative of a $60 per month fare card. These fares are higher than the other alternatives and may be prohibitive for some low-income riders. If the PRT system is privately operated, the possibility of future interchange of fare instruments with TANK and SORTA would be more complicated than for the other alternatives.

### 8.3 Safety and Access

Is the transportation system ADA compliant?

- **Existing:** The Southbank Shuttle is ADA compliant. The buses are low-floor and are fully accessible.

- **TSM:** The Southbank Shuttle is ADA compliant. The present buses and future additions will be low-floor and fully accessible.

- **Streetcar:** The system is ADA compliant with ramps to platforms and bridge-plates for mobility device access to the vehicles.

- **PRT:** The present design of the Taxi 2000 vehicle does not appear to meet ADA standards as stated in the U.S. Department of Transportation’s and Federal Transit Administration’s “Accessibility Handbook for Transit Facilities.” Compliance requires a 60-inch diameter envelope for wheelchair mobility. However, Taxi 2000 has proposed a fleet of specially designed vehicles for disabled patrons. For the vehicle weight analysis (Appendix F) of this Study, it was assumed that the vehicle interior would be slightly larger to accommodate a wheelchair patron and at most one other seated passenger. The requirement for special vehicles to accommodate disabled passengers is judged to be undesirable and presents a barrier to use by the disabled community.
Does the transportation system meet fire/life safety requirements?

- **Existing and TSM:** The current vehicles in use by the Southbank Shuttle meet all applicable federal standards for transit vehicle construction. Emergency egress from the vehicle is provided by doors and pop-out windows to the road surface in the event of an emergency.

- **Streetcar:** The Streetcar vehicle will meet all federal standards applicable to transit vehicles construction. Emergency egress is provided through the vehicle doors to the surface of the roadway or track way. The system will also have emergency power shut-offs located at regular intervals to isolate portions of the overhead power system.

- **PRT:** The PRT system can be designed to meet fire and life safety requirements. The conceptual design is intended to meet the National Fire Protection Association (NFPA) 130 and the American Society of Civil Engineers (ASCE) Automated People Mover (APM) Standards. Meetings with local fire officials have been favorable, however, emergency evacuation from a stranded vehicle on the elevated guideway will be more difficult than the other alternatives.

Does the transportation system meet building code requirements?

- **Existing:** Not Applicable

- **TSM:** Not Applicable.

- **Streetcar:** Shelters comply with applicable codes.

- **PRT:** The PRT system intends to place some stations inside existing buildings. Design and construction of these building modifications will be more difficult in light of the NFPA 130 requirement for a three (3) hour firewall between transit and non-transit occupancies. In other circumstances, the ASCE APM Standard is based on the principle that an APM station inside a building will meet the same type of building code requirements as an elevator lobby.

Is there a perception of personal safety within the vehicle and at the station?

- **Existing:** Riders board from marked stops along existing streets. Security is provided by existing police patrols in the areas served. Research indicates that transit customer security concerns increase with an increase in nuisance behavior of other riders. No unusual security concerns are associated with the Southbank Shuttle.
**TSM:** Same as the existing system. Additional on-board security could be provided by the installation of CCTV cameras in the buses.

**Streetcar:** Boarding areas will be similar to bus stops, however, passenger safety will be improved over the existing bus system by extending the platform to the vehicle boarding location. Stations are generally located in well-lighted areas, and lighting can be supplemented if required. Passenger safety and security is generally good in a transit vehicle. Additional on-board security could be provided by the installation of CCTV cameras in the vehicles. No unusual safety or security concerns are anticipated.

**PRT:** PRT stations will not be manned but will be monitored by CCTV and communication with the Central Control is possible. The elevated stations may feel isolated from normal street activity due to their location, which may make some passengers feel unsafe. Elevated stations are generally more difficult for police patrols to observe than normal street level transit stops. While the opportunity to travel alone or in a small group is perceived as safe to some passengers, the possibility of an unwanted passenger entering a PRT vehicle can be problematic. Also, after programming the destination station, the passenger must contact the Central Control operation to change it during the ride. If a programmed station is perceived as unsafe upon arrival, there is no way to continue on to the next station. PRT is a completely automated system, which requires the passenger to totally release control; this concept may make some users feel uneasy. The crashworthiness of the proposed PRT vehicle has yet not been proven, however, it would be expected to meet established standards for fully automated transit vehicles. The PRT system is judged to provide a lower degree of perceived safety and security than the other alternatives.

**Does the transportation system provide convenient access to all users?**

- **Existing:** The majority of Southbank Shuttle patrons access the service by walking. The Shuttle has 44 stops along the two routes. All stops are located at-grade.

- **TSM:** The enhanced Shuttle has 47 to 51 stops along the route depending on which option is selected. This mode has the highest number of stops compared to other alternatives. All stops are at-grade and are convenient to access. The addition of direct service between Covington and Newport should increase convenience.

- **Streetcar:** The Streetcar system generally provides access to the same areas served by the enhanced Southbank Shuttle. There are 30 total stations along the proposed Streetcar route. The Streetcar alignment provides convenient access to many of the destinations and attractions within the study area.

- **PRT:** The PRT system provides non-stop origin to destination access to many of the destinations and attractions identified within the study area. There are 28 boarding stations along the alignment.

**Does the transportation system present a safety hazard to non-users?**
• **Existing/TSM:** The Southbank Shuttle presents no unusual hazards to drivers or pedestrians.

• **Streetcar:** The Streetcar system will share lanes with existing road vehicles. This increases the possibility of conflicts between Streetcar vehicles and vehicular traffic and pedestrian movements. The strategic placement of crosswalks, control of some vehicular traffic movements, and effective traffic control devices and signage should minimize conflicts.

• **PRT:** The system is elevated throughout the entire alignment, except on the bridge crossings where it would have a dedicated right-of-way. The moving vehicles are, therefore, completely removed from other road vehicle traffic and pedestrian ways. However, the guideway will have large diameter columns on a 60 foot spacing (typical) located adjacent to the roadway. These columns may present hazards for roadway vehicles if a driver loses control and his vehicle leaves the roadway. The columns may also restrict visibility for drivers and pedestrians in certain locations.

### 8.4 Effectiveness

*Does the transportation system have acceptable point-to-point travel times including station dwell time?*

Tables 8-1 and 8-2 give travel times for each of the technologies for some of the more popular destinations within the study area.

• **Existing:** For a number of the origin/destination combinations defined in Table 8-2, the Southbank Shuttle provides point-to-point times comparable to the other alternatives. However, because it is affected by traffic congestion, the Southbank Shuttle does not perform as well on average as the other alternatives, but this mode can be considered acceptable.

• **TSM:** The increase in service frequency will improve point-to-point travel times by reducing the waiting period. ITS equipment may further decrease travel times by providing selective transit vehicle priority. In-vehicle times should generally be similar to the existing system.

• **Streetcar:** Travel times for this alternative are expected to similar to the enhanced Southbank Shuttle. In some cases, the streetcars may experience traffic conflicts, which could be avoided by the buses. Providing limited signal priority could improve operations and reduce travel times.

• **PRT:** The PRT system provides the best possible transit service in terms of point-to-point travel time, since the vehicle does not stop between the origin station and the destination station. It has a comparable number of stations to the Streetcar alignment. In vehicle delays may occur if the destination station is full and a “waive-off” occurs. Station access times are increased over the other alternatives due to the need for elevators or stairways.
### Table 8-2: Wait Times and Average Walk Times

<table>
<thead>
<tr>
<th>Technology Alternative</th>
<th>Wait Time (minutes)</th>
<th>Average Walk Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southbank Shuttle</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>TSM</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>LRT/Streetcar</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>PRT</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### Table 8-3: Station-to-Station Travel Times

<table>
<thead>
<tr>
<th>Origin</th>
<th>Destination</th>
<th>Existing Southbank Shuttle (minutes)</th>
<th>TSM (minutes)</th>
<th>Vintage Trolley (minutes)</th>
<th>PRT (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government Square</td>
<td>TANK Transit Center</td>
<td>8</td>
<td>7</td>
<td>12.4</td>
<td>7.5</td>
</tr>
<tr>
<td>Cincinnati Convention Center</td>
<td>Newport Aquarium</td>
<td>14</td>
<td>12</td>
<td>6.1</td>
<td>4.85</td>
</tr>
<tr>
<td>Fountain Square</td>
<td>Downtown Newport</td>
<td>6</td>
<td>5</td>
<td>6.8</td>
<td>6.9</td>
</tr>
<tr>
<td>Downtown Covington</td>
<td>Downtown Newport</td>
<td>23</td>
<td>5</td>
<td>4.2</td>
<td>3.1</td>
</tr>
<tr>
<td>Paul Brown Stadium</td>
<td>Covington Riverfront</td>
<td>16</td>
<td>14</td>
<td>9.8</td>
<td>7.2</td>
</tr>
<tr>
<td>Newport Aquarium</td>
<td>MainStrasse</td>
<td>39</td>
<td>19*</td>
<td>9</td>
<td>5.8</td>
</tr>
</tbody>
</table>

**Average:** 17.7, 10.3, 8.2, 5.9

Note: The existing Southbank times are from the TANK timetable.
*For Option 2 only. All other times in the TSM alternative are for Options 1 & 2.
The PRT times are from the operational model.
The Vintage Trolley times are calculated using a 12mph average speed and 20 second/station dwell time.
Does the system provide reliable service levels?

- **Existing:** The present service is considered reliable but somewhat unpredictable. Traffic congestion affects service during certain periods.

- **TSM:** The proposed modifications will improve service frequency with 10 minute headways and should improve reliability.

- **Streetcar:** The Streetcar system will run at 10-minute headways and is expected to provide reliable service. Reliability can be affected by unforeseen traffic problems such as an incident.

- **PRT:** The PRT control system is very complex. An automated demand dispatch control concept for passenger service on this scale has not been demonstrated anywhere in the world at this time. The Taxi 2000 design concept emphasizes high system service reliability, but it has yet to be proven. However, a control system that has the complexity and the reliability intended is believed to be possible to implement. Vehicle reliability is also unproven. Overall system reliability may also be adversely affected by guideway alignment, which must maintain very close tolerances.

Does the transportation system provide adequate service to the study area destinations in terms of frequency of service and geography coverage?

At the start of the Study, the Advisory Committee identified over 100 destinations and attractions within the study area for which service was desirable.

- **Existing:** The Southbank Shuttle connects numerous destinations within the Study Area. The Shuttle has 44 stops and adequately serves the CBD’s of the three cities. The Shuttle’s headway is 20 minutes.

- **TSM:** The enhanced Southbank Shuttle provides a new direct connection between Covington and Newport in addition to maintaining the existing service. The enhanced Shuttle has 3 to 7 additional stops depending on the option selected and headways are reduced to 10 minutes.

- **Streetcar:** The Streetcar alignment is designed to serve as many of the identified destinations as possible. The Streetcar routes have 30 stops providing service the CBD’s of the three cities. The Streetcar will operate with 10-minute headways with 3 cars running in each direction at any given time.

- **PRT:** The PRT system is designed to provide immediate service for most patrons (vehicle waiting in the station) and a very short wait (less than three minutes) for all patrons under normal circumstances. Twenty-eight stations provide direct or convenient service to many of the identified destinations.
How reliable is the transportation system in maintaining schedule?

- **Existing:** Schedule adherence is relatively good, however, buses sometimes run late. Schedule adherence should improve with the implementation of the Automatic Vehicle Locator (AVL) system.

- **TSM:** Schedule reliability should improve with the implementation of ITS measures.

- **Streetcar:** The Streetcar vehicles are very reliable. Schedule delays may occur because of traffic conflicts or an incident.

- **PRT:** The system should function reliably under normal circumstances. Delays will occur if the destination station is full and a “waive-off” results. Delays may also result from a system failure or incident blocking the guideway or destination station. If a station was blocked for any reason, the Central Control operator would be able to advise passengers bound for that station of the problem and the vehicle would be rerouted to a nearby station. Incidents that occur on the guideway may affect only a limited number of stations or many, depending on the location.

Will the transportation system adequately serve projected ridership and/or attract sufficient ridership to justify the investment?

- **Existing:** The present Southbank Shuttle is among TANK’s most used service and justifies the continued investment to maintain the service.

- **TSM:** The Enhanced Southbank Shuttle alternative sufficient capacity to accommodate the ridership projections. The ridership estimates for the TSM alternative are higher than that of the existing service due to its larger geographic coverage area and improved headways.

- **Streetcar:** The streetcar capacity with 6 vehicles running at 10 minute headways is approximately 1440 persons per hour. This capacity is more than adequate to handle the ridership projects. The ridership projections for the streetcar alternative are the lowest of the technologies evaluated.

- **PRT:** The capacity of the Taxi 2000 system largely depends on the separation required for safe operation of the vehicles. The capacity of the system will be determined by Taxi 2000’s operational model and eventually by a full-scale test tract. PRT attracts the greatest number of riders due to its non-stop service and denser geographic coverage of the study area.

Does this transportation system facilitate intermodal transfer movements among public transit service providers?

- **Existing:** The Southbank Shuttle connects directly with TANK’s fixed route service in the Covington Transit Center, and with SORTA’s fixed route service in the vicinity of Government Square. It will also serve TANK’s proposed Newport Transit Center.
and the proposed I-71 Light Rail line at points in Covington and downtown Cincinnati. Transfers to either TANK’s or SORTA’s fixed route service are at full fare.

- **TSM:** Same as the existing service, but increased frequency and new east-west route will improve intra-modal and inter-modal transfers.

- **Streetcar:** This Streetcar alternative will also provide service adjacent to TANK’s Covington and Newport Transit Centers and SORTA’s Government Square Transit Center. Stops are also planned in the vicinity of the proposed I-71 Light Rail stations in Covington and downtown Cincinnati. Transfers to other transit services will be at full-fare.

- **PRT:** This alternative also provides service adjacent to TANK’s Covington Transit Center, in the vicinity of the Newport Transit Center, and at SORTA’s Government Square Transit Center. Connections to the proposed I-71 Light Rail line could be accomplished from the Government Square station and near the station serving the Covington riverfront. Because the PRT is an elevated system, all transfers to surface transportation will involve a level change. Transfers to other transit services will be at full fare.

### 8.5 Environmental

*Will there be adverse effects to historic structures and districts?*

- **Existing:** The Southbank Shuttle serves limited historic sites in Cincinnati and provides good historic site coverage in Covington. The Shuttle is at-grade, runs on existing streets, and has minimal impact on visual sight lines within the historic district.

- **TSM:** The enhanced Southbank Shuttle provides more historic site coverage in Covington and Newport. There is no significant change in impacts to historic structures or properties as a result of the proposed service changes.

- **Streetcar:** The Streetcar alignment passes through or is adjacent to 10 historic districts within the study area. The alignment passes 6 National Register Properties including: Northern Bank of Kentucky in Covington, the Campbell County Courthouse in Newport and in Cincinnati; Police Station No. 2, the Gwynne Building, the Palace Hotel and the old Cincinnati Enquirer Building. The Streetcar will run on existing streets and is not expected to have any significant effect on any of these districts or properties. Streetcars previously served many of these Districts in the late 19th and early 20th centuries. The Streetcar vehicle is designed to complement or enhance the character of the historic areas.

- **PRT:** The PRT alignment passes through or is adjacent to 10 historic districts within the study area. The alignment passes 8 National Register Properties including: the Palace Hotel, the Tyler Davidson Fountain, Police Station No. 2, the John Church Company Building, the Ingalls Building, Northern Bank of Kentucky, the Trinity Episcopal Church of Covington and the Bellevue General James Taylor House. The
PRT vehicle is ultra-modern in appearance and may be considered out of character with the historic districts in Northern Kentucky. The elevated guideway and its support structures may result in visual impacts to the historic districts and structures in both Covington and Newport.

Are noise and vibration generated or caused by the operation of this transportation system acceptable or manageable?

- **Existing**: According to FTA publications, the noise level for a bus at a distance of 50-feet is 84dBA. The Southbank Shuttle is not known to cause complaints due to noise or vibration levels.

- **TSM**: Increased service frequencies will result in additional noise and vibration impacts. These impacts are not expected to be significant and buses will operate within the acceptable limits of FTA noise level guidelines.

- **Streetcar**: The Streetcar system runs on steel wheels on steel rails. Noise is generated at the wheel-rail interface, and by the mechanical and electrical equipment on the vehicle. Tight radius turns are a particular source of noise, known as wheel squeal, and should be avoided if possible. These turns are less of a problem with short wheel base vintage style vehicles than the longer modern LRV. The noise and vibration generated by these operations are well within the acceptable limits based on measurements taken of other similar systems, and typically lower than the noise and vibration impacts from the road vehicles. Based on FTA Noise Criteria, noises levels for a rail vehicle is measured at 74dBA at a distance of 50 feet operating at 15 miles per hour.

- **PRT**: The APM Standards – Part I, ASCE 21-96, Section 2.2.1, states that the maximum noise emission for normal operations when measured at 50 feet from the guideway is 76dBA. However, the frequency of PRT vehicle passage will be many vehicles every minute, which will create a noticeable impact. The Taxi 2000 system employs rubber-tired wheels running along a continuous steel surface as well as power collectors shoes sliding along continuous power rails. All of the above equipment is encapsulated within a shrouded guideway structure, with openings at the top and bottom. The noise emissions and structure borne vibrations are expected to be insignificant with respect to normal ambient conditions during the day, and not significant at night (less than perceptible limits inside adjacent buildings). This will be an important aspect to be evaluated when the prototype design is operating. Because the guideway is elevated, and because noise is generally radiated on the line-of-sight, any significant noise emissions may have an unacceptable impact on adjacent residential sleeping quarters located above the ground floor.
Are impacts associated with ecology, hazardous materials, or wetlands anticipated?

The ecology and wetland impacts were evaluated in a report completed by ASC Group, Inc. No wetlands were identified within the study area. The US Fish and Wildlife service anticipates no significant adverse impacts to wetlands or federally endangered or threatened species from the proposed alternatives. Phase II Environmental Site Assessments would need to be completed during the design phase for any sites that would be impacted by excavation or that would be acquired for right-of-way for any of the technologies.

- **Existing**: The Southbank Shuttle runs on existing public roadways. The hazardous materials sites identified in the report have not been affected by operation of the Southbank Shuttle.

- **TSM**: The Enhanced Southbank Shuttle will also run on existing public roadways, and is expected to have no impact to identified hazardous materials sites.

- **Streetcar**: A review of various environmental databases has identified 40 listed areas of concern adjacent to the alignment. It is anticipated that these areas would not be significantly affected by the installation of the Streetcar system, which runs in existing streets. However, excavation for the trackway may encounter hazardous materials under the existing roadway, and borings for catenary supports may also encounter hazardous materials near the identified sites.

- **PRT**: A review of various environmental databases has identified 45 listed areas of concern adjacent to the alignment. Caissons drilled to a nominal depth of 50 feet at approximately 60’ intervals will be required to support the PRT guideway. Due to the large number of borings required and the volume of material to be excavated, some contaminated material is likely to be encountered. Precautions will be needed to identify this material during the design phase and dispose of it properly during the construction phase.

Can the transportation system be installed within existing public rights-of-way?

- **Existing**: The Southbank Shuttle operates within existing public rights-of-way.

- **TSM**: The enhanced Southbank Shuttle will continue to operate within existing public rights-of-way. Bus shelters should not require additional right-of-way for installation. While additional right of way may not be needed, the elimination of parking on 5th and 6th Streets in Cincinnati would be necessary for a dedicated bus lane.

- **Streetcar**: It is anticipated that a majority of the Streetcar alignment can be installed within the existing right of way. For estimating purposes, it was assumed that approximately 2% of the total alignment area will be on newly acquired ROW. While the acquisition of ROW will be incidental, the elimination of some parking along the Streetcar alignment will be required. Right-of-way will also be required to construct the operation and maintenance facility.
• **PRT**: The majority of the elevated guideway can be constructed within existing public right-of-way. It is assumed that 2% of the guideway will be on new right-of-way. Acquisition of right-of-way (corner clips) may be needed in the areas where the guideway transitions from a street to an adjoining perpendicular street. Right-of-way for guideway ramps onto and off of the Licking River and Clay Wade Bailey bridges may need to be acquired. The PRT system incorporates two vehicle storage facilities and a maintenance facility; right-of-way acquisition for these facilities will require consideration. Right-of-way will also need to be acquired for all stations both free-standing and attached.

*Will there be displacements or relocations associated with the construction and operation of this technology?*

• **Existing**: None.

• **TSM**: None.

• **Streetcar**: No displacements or relocations are expected for the guideway; however, some displacements may be required to accommodate the operations and maintenance facility.

• **PRT**: Some business displacements and relocations will be associated with the construction of the stations attached to office buildings in downtown Cincinnati. Some displacements may also be required to accommodate the operations and maintenance facility.

*Will the transportation system, including its associated structures, create visual impacts within the study area?*

• **Existing**: The Southbank Shuttle operates on existing streets, and has minimal impact on visual sight lines within the historic district. The structures, which include the bus shelters, are small and have a minimal impact on the visual impacts of the study area.

• **TSM**: The visual impacts associated with the enhanced Southbank Shuttle will be similar in nature to the existing service, but somewhat more extensive due to the expanded route structure. The visual impacts are expected to be negligible.

• **Streetcar**: The Streetcar vehicles should integrate well with the urban environment and compliment the historic districts. The overhead catenary wires and supports may create a negative visual impact. However, Streetcars with similar catenary systems previously served many of the historic districts.

• **PRT**: The aerial guideway structure and its supports will cause a significant visual impact even when no PRT vehicles are present. These impacts affect not only the
observer on the street but also residents and building occupants whose views are obstructed by the guideway. In addition, residents particularly may find that the presence of the PRT vehicle and its passengers represents a significant loss of privacy. These impacts are expected to be more significant in Northern Kentucky.

Will the vehicles, line structures, stations, and system wide elements integrate well into the urban form and character of the area served?

- **Existing:** The existing system integrates well into the urban form and character of the areas it serves. The current system has been in operation for a number of years and has been widely accepted and embraced by the community.

- **TSM:** The enhanced Southbank Shuttle does not represent a significant departure from the existing system. Any additional signage or shelters will be simple in design and in keeping with other street furniture in the vicinity.

- **Streetcar:** The vehicles will be new vehicles with an historic façade. As stated earlier, the Streetcar alignment passes through or is adjacent to 10 historic districts. The streetcarss should add to the character of these neighborhoods. The stations will be simple, with only curb bump-outs and signage. The stations should integrate well and not cause significant disruption to pedestrian or vehicular traffic. The catenary wires may cause some visual impact.

- **PRT:** The general form of the PRT system and guideway are more in keeping with the urban form in the Cincinnati CBD and along the Northern Kentucky riverfront, than the historic neighborhoods in Northern Kentucky. The guideway structure presents several direct conflicts with the existing Skywalk system in downtown Cincinnati. The guideway supports, which are typically 2 ft. in diameter, are located in the sidewalk areas approximately every 60 ft. along the guideway. These columns will be visually intrusive regardless of location and physically intrusive in areas with narrow sidewalks. The presence of the guideway located above downtown sidewalks may cause some discomfort and inconvenience to pedestrians if rain, snow or ice accumulate and drop from the guideway. This is a detail that needs to be evaluated during the design process.

Can the geometric requirements of the transportation system (turning radius, gradeability, vehicle envelope, etc.) be accommodated within the study area?

- **Existing:** The current Southbank Shuttle buses can accommodate a turning radius of 34-feet and a grade of 15%. There are no geometric problems associated with the existing routes, corners, or hills.

- **TSM:** The proposed buses for the Southbank Shuttle can accommodate a turning radius of 30-feet and a grade of 9%. There are no geometric problems associated with the proposed routes
• **Streetcar:** The Streetcar can accommodate a 90 degree turn with a minimum radius of 82 feet. The ideal allowable grade is 6% with a maximum of 8%. The proposed alignment accommodates these requirements.

• **PRT:** The guideway is flexible and can accommodate a minimum turning radius of 50 feet, such that the alignment can be curved around street corners with 40 foot clearance between buildings on opposing sides of the street. A 15% grade can be easily negotiated.

**Will the fixed facilities or operations of this transportation system create real or perceived barriers dividing neighborhoods?**

• **Existing:** Existing transit bus operations are routine and present no barriers within the neighborhoods served. The fixed facilities consist of bus stop signs or modest bus shelters, which have a minimal impact on their environment.

• **TSM:** Same as existing. The expanded route structure is confined to existing roadways and no significant fixed facilities are proposed.

• **Streetcar:** The trackway for the Streetcar system will be installed in existing traffic lanes and presents no significant physical barrier to the neighborhoods served or pedestrian movements. The use of marked crosswalks in neighborhoods is encouraged for safety reasons. The operation of the streetcars may result in some conflicts with vehicular traffic movements. The catenary wires may be perceived as a slight visual disruption to some persons.

• **PRT:** The substantial and frequent columns required to support the PRT guideway may present both a physical and visual barrier, especially in residential neighborhoods. The guideway structure will certainly present a visual barrier to occupants of all adjacent buildings with windows, which face the guideway at the same elevation. The guideway will also present a visual barrier to viewers of historic structures, and will be inconsistent with the character of historic neighborhoods.

**Does the transportation system and its guideway structures and stations cause diminished capacity for motor vehicle traffic flow in general?**

• **Existing:** The Southbank Shuttle operates in normal traffic conditions on existing roadways. The Shuttle stops at designated transit stops to pick-up and discharge passengers. Many of the stops are located outside the normal travel lane; therefore, the bus may cause some disruption when it rejoins the flow of traffic. This reduction may slightly diminish traffic capacity on the affected streets. The operation of the shuttle reduces overall vehicle trips within the area served.

• **TSM:** The Enhanced Southbank Shuttle with increased frequency of operation will have a slightly greater impact on traffic than the present operation. The dedicated bus lanes, signal retiming and signal priority should more than offset any impacts.
resulting from the increased frequencies, and enhance the overall functioning of the transportation system.

- **Streetcar**: Operation of the Streetcar alternative will result in a slight reduction in traffic capacity on the streets carrying the alignment. The delays will generally occur at the station locations, as the streetcar stops to board and discharge passengers.

- **PRT**: The Taxi 2000 system is elevated and totally grade separated. The system should have no affect on roadway traffic capacity, except on bridges. If the guideway can be cantilevered outboard of an existing bridge structure, no traffic impact should occur.

**Will there be any specific traffic impacts associated with the technology?**

- **Existing**: No specific traffic impacts are associated with the existing Southbank Shuttle. However, traffic congestion does exist within the area served.

- **TSM**: The increased frequency of service will slightly increase the disruption of traffic flow as the Shuttle stops to pick-up and discharge passengers. Providing dedicated bus lanes, priority signaling, and retiming of the signals will reduce these impacts. However, on-street parking capacity could be reduced on those streets where dedicated lanes are provided.

- **Streetcar**: Traffic impacts from the Streetcar system will be similar to those associated with the existing Southbank Shuttle. Curb extensions at stations eliminate the need for the weaving movement that accompanies typical transit bus operations. The streetcar’s turning movements require a larger radius than a typical transit bus. Therefore, those locations where the Streetcar turns from one street to another must be considered carefully for traffic control, including placement of stop bars, parking restrictions, lane restrictions, and signalization.

- **PRT**: Placement of the guideway support columns will have to be carefully considered to avoid restricting the sight lines of drivers and pedestrians at intersections, and at the entrances and exits to parking garages and alleys. Local authorities must determine the clearance between the support column and the roadway. This placement could impact the sidewalk space available to pedestrians. Design of the guideway support system must anticipate the possibility of an impact from a vehicle that leaves the roadway.
Will there be any specific construction impacts associated with the technology?

The following description of construction impacts is general in nature and is not intended to precisely identify each and every impact associated with the various technologies. Careful design and an on going constructibility review process can often reduce the nature and extent of construction impacts.

- **Existing**: Not applicable.

- **TSM**: Minor construction impacts will be associated with the installation of new signage, bus shelters, and changes to the traffic signals. Impacts on traffic patterns may occur during installation of signal priority equipment.

- **Streetcar**: Construction impacts associated with the Streetcar alternative include excavation of roadway areas for track installation, possible relocation of selected underground utility lines in areas where conflicts occur and rearrangement of overhead wires to accommodate the catenary system, excavation for catenary pole foundations, construction of curb extensions at station areas, installation of shelters at stations, construction of an operation and maintenance facility, and temporary changes to vehicle and pedestrian traffic patterns.

- **PRT**: Construction impacts associated with the PRT alternative include excavation of sidewalk and roadway areas for installation of guideway support columns, possible relocation of both underground and overhead utility lines in areas where conflicts occur, possible impacts to basement vaults located under existing sidewalks, interior and exterior construction at existing buildings where stations are integrated, excavation and construction of free-standing stations, guideway erection and alignment, construction of an operations and maintenance facility, and temporary changes to vehicle and pedestrian traffic patterns.

### 8.6 System Flexibility

Can this transportation system respond to changes in ridership levels?

- **Existing**: Current Southbank Shuttle operations are augmented during special events with regular transit buses from TANK’s fleet. Long-term increases in ridership can be addressed by purchase of additional vehicles. Reduced ridership can be accommodated by reducing the frequency of service and hours of operation, and in the long-term, reducing the fleet size.

- **TSM**: Same as existing. Lead-time for acquisition of additional transit buses may be weeks to several months, depending on the order size.

- **Streetcar**: The ability of any fixed guideway system to respond to short-term increases in ridership is generally limited by the total number of vehicles in the fleet. The fleet size is a function of the route, planned headways, hours of operation, peak and off-peak operating plans (if any), and the mechanical/electrical availability of the
vehicles. Because the proposed Streetcar system is relatively short, the total number of spare vehicles is small. Therefore, the ability to respond to large events will be limited unless the fleet size is deliberately increased to address special event requirements. Alternatively, unbalanced headways can be used to increase service in the preferred direction for short periods. Lead times for acquisition of additional vehicles would generally exceed one-year unless it is possible to participate in an existing order or obtain a vehicle that is surplus to another system's requirements.

- PRT: The ability of the PRT system to respond to short-term ridership increases will be a function of the number of available vehicles, the number and arrangement of berthing positions available at the specific location, the cycle time for boarding and dispatching vehicles, and the guideway capacity. Because the capacity of each vehicle is small, and may be further limited by the individual rider's choice of group size, this system will not respond to large events as well as a system with larger capacity vehicles. Lead times for additional vehicles should be a matter of months, but the proprietary nature of the system, and specialized component lead times could have an adverse effect on availability.

Is the alignment easily expandable?

- **Existing:** The Southbank Shuttle routes are easily changed or expanded, but current route lengths are rather long.

- **TSM:** Same as existing. However, simplicity is one key to the popularity of the Southbank Shuttle. If the Shuttle system is expanded through the addition of new routes, or the route length is extended significantly, ridership could decline. One possibility is expanding coverage within the Study Area through a system of linked shuttles connecting to TANK and SORTA's fixed route service.

- **Streetcar:** Expansion of the Streetcar alignment requires the construction of new embedded track and extension of the catenary system with attendant construction impacts. The present design of the Streetcar alignment is a bi-directional loop, in keeping with the Loop Circulator concept. Linear extensions of the loop are possible, as is outward expansion. If extensions are contemplated, it would be appropriate to consider where they might serve to determine if a rational operating plan can be developed. Alternatively, a system of Streetcar routes can be developed to serve new areas.

- **PRT:** The PRT system is expandable by adding new loops to the network. Because the guideway is modular, it is possible to remove sections and add new merge/diverge points to facilitate the extension. Construction impacts would be generally as previously described. The complex network control system will require modification and validation whenever such a change is made.
Are there extraordinary requirements of the transportation system in its storage and maintenance facility location or design?

- **Existing:** None.

- **TSM:** The slightly enlarged fleet associated with the enhanced Southbank Shuttle can be serviced and maintained in TANK's existing facilities. This facility is located some distance from the Shuttle's service area, although freeway access is good. As TANK’s fleet increases in size, it may be practical to consider a satellite maintenance and storage facility closer to the Shuttle’s service area. There are no unusual design or construction requirements associated with such a facility, other than zoning.

- **Streetcar:** The Streetcar system will require a facility of approximately 60,000 square feet for storage and maintenance of the vehicles and control of the Streetcar operations. Ideally, the facility is located directly along the alignment so that track construction and deadheading of vehicles is minimized. An independent maintenance facility has been estimated for purposes of this study. However, if the region constructs a light rail system, there could be significant economies in using the LRT facility to store and maintain the Streetcar fleet. Design of the facility requires specialized knowledge, although construction is in keeping with general industrial facilities. Compatible zoning is also a requirement.

- **PRT:** The sheer size of the PRT fleet (700 vehicles) requires a substantial area of approximately 65,000 square feet for storage, maintenance, operational control and related functions. As with the Streetcar facility, the ideal location is adjacent to the alignment. Satellite storage facilities along the guideway have been proposed to reduce the overall size of the primary facility, and allow prepositioning of vehicles overnight or when ridership requirements are low. Design of the facility requires specialized knowledge, although construction is in keeping with general industrial facilities. Compatible zoning is also a requirement. Because of the elevated nature of the PRT system, the facility may be higher in profile than a comparable bus or streetcar facility.

Are new stations or boarding area accommodated easily?

- **Existing/TSM:** The relocation of a Southbank Shuttle stops is easily accomplished and requires only a change in signage and possible relocation of a shelter.

- **Streetcar:** The boarding area for the Streetcar is a relatively simple design that can be accommodated in many locations. Installation of a station may require the loss of several parking spaces to allow for the required curb extension, plus installation of signage and a shelter.

- **PRT:** A new station can be added to the existing network by constructing approximately 300 feet of parallel guideway, merge/diverge points and boarding areas. Because the boarding areas are elevated, more complex and costly construction is involved. New buildings could be designed with integral stations if access to the PRT system is desirable.
Can the barrier-free, proof-of-purchase fare collection method be used with this technology?

- **Existing/TSM/Streetcar:** The proof-of-payment fare system is not typically used in single vehicle/operator systems where boardings are controlled through a single door. Proof-of-payment systems rely on fare inspectors to enforce payment requirements.

- **PRT:** The PRT fare collection system relies on a fare card or similar fare instrument to operate the vehicle and control its destination. The fare instrument is purchased and inserted in a card reader prior to boarding the vehicle. Because platform edge protection will be required, insertion of the fare card could be interlocked with opening the platform barrier or gate to permit access to the vehicle.

Are there excessive or unusual clearance requirements associated with this technology?

- **Existing/TSM:** Transit vehicles meet normal clearance requirements for road vehicles.

- **Streetcar:** Clearance requirements are established based on vehicle dimensions. Typically, Streetcar vehicles are 8’6” - 9’6” wide and require a clearance of 8-9 feet from the centerline of the track to the nearest fixed obstruction (other than a platform edge). The catenary contact wire is typically from 14 - 20 feet above the top of rail although this clearance may be reduced somewhat.

- **PRT:** The PRT guideway structure must maintain a clearance of 19 feet above the street surface to allow vehicles to pass under. The total guideway depth and vehicle clearance envelope total approximately twelve feet. The vehicle envelope plus the vehicle dynamic envelope and side-to-side clearance requirements are approximately seven feet.

Does this transportation system require a fully separated operating envelope?

- **Existing/TSM:** The Southbank Shuttle runs in mixed traffic; full separation is not required.

- **Streetcar:** The Streetcar will run in mixed traffic; full separation is not required.

- **PRT:** The PRT system requires a fully separated guideway and vehicle-operating envelope.

### 8.7 Utilization of Existing Infrastructure
Can this transportation system utilize existing bridges within the study area?

The Kentucky Transportation Cabinet has jurisdiction over the active Ohio and Licking River bridges. The KYTC has not agreed to permit shared-use of vehicle lanes by fixed-guideway systems, and has rejected the exclusive use of an existing vehicle lane by a fixed-guideway system. The KYTC has not approved the attachment of a fixed-guideway to an existing bridge structure.

- **Existing**: The Southbank Shuttle currently crosses the Roebling Suspension Bridge and the Taylor Southgate Bridge.

- **TSM**: The enhanced Southbank Shuttle will continue to use the Roebling and Taylor-Southgate bridges and will also use the Veterans Memorial Bridge across the Licking River.

- **Streetcar**: The Streetcar alternative proposes shared use of general-purpose lanes on the Clay Wade Bailey, Taylor-Southgate, and Veterans Memorial bridges, and exclusive use of the former rail deck on the L&N Railroad bridge. Use of the bridges would require replacement of a portion of the bridge deck to accommodate track installation and some structural reinforcement could be required. The approval of the KYTC would be required.

- **PRT**: The PRT alternative proposes use of the Clay Wade Bailey, Veterans Memorial, and L&N Railroad bridges to support the elevated guideway. This proposal may require the exclusion of general purpose traffic from a lane on the bridges if it is not possible to cantilever the guideway off the existing structure. The feasibility of structural attachment of the guideway would require additional study during a future preliminary engineering phase of the project.

Will the transportation system require the construction of a guideway or track structure?

- **Existing and TSM**: Not Applicable.

- **Streetcar**: The Streetcar alternative requires the installation of rails in existing roadways and on the bridges described above.

- **PRT**: The PRT alternative requires the construction of an aerial guideway.

Will the transportation system enhance the existing regional transportation investment?

- **Existing**: The existing Southbank Shuttle is an important element of the existing regional transportation system. The Shuttle routes connect with fixed-route transit service operated by both TANK and SORTA at the Covington and Government Square Transit Centers. The Shuttle will also connect with the proposed I-71 LRT alignment both in Covington and the Cincinnati CBD.
• **TSM:** The proposed changes to the Southbank Shuttle will extend its coverage and enhance its operational effectiveness. The Shuttle routes connect with fixed-route transit service operated by both TANK and SORTA at the Covington and Government Square Transit Centers. The Shuttle routes will also connect with TANK’s planned Newport Transit Center and the proposed I-71 LRT alignment both in Covington and the Cincinnati CBD.

• **Streetcar:** The Streetcar alternative will provide convenient transfers to the fixed route transit service provided by TANK at its Covington and Newport Transit Centers and at SORTA’s Government Square Transit Center. This alternative would also connect with the proposed I-71 LRT alignment in both Covington and the Cincinnati CBD. Because the Streetcar vehicles are similar to the proposed LRT vehicles, joint operation of the vehicles on each system's track would be possible. However, as currently planned, the Streetcar stations would not fully accommodate the longer LRT vehicles or multi-car trains. The Streetcar alternative could also make use of some of the existing bridges in the Region with the permission of the KYTC. The I-71 LRT proposal includes construction of a new Ohio River bridge east of the existing Clay Wade Bailey Bridge. This new LRT bridge could easily accommodate the Streetcar vehicles. Similarly, if the existing roadway bridges are modified for rail use by the Streetcar alternative, these tracks could be incorporated into the Regional LRT system.

• **PRT:** The PRT alternative will provide an efficient circulator/distribution system in the Study Area and adds capacity to the Region’s transportation system. This alternative will provide convenient transfers to the fixed route transit service provided by TANK at its Covington and Newport Transit Centers and at SORTA’s Government Square Transit Centers, and would also connect with the proposed I-71 LRT alignment in both Covington and the Cincinnati CBD. The PRT alternative also proposes shared use of existing bridges in the Region.

Does this transportation system have enough vertical alignment flexibility to minimize guideway costs?

• **Existing/TSM:** Not applicable.

• **Streetcar:** The Streetcar guideway design standards can accommodate the grades and vertical curvature of the roadways and existing bridges along the proposed alignment.

• **PRT:** The PRT alternative requires a fully separated and elevated guideway, which greatly increases the capital cost of the system, but is inherent to its operating concept. The PRT guideway design standards should permit its installation along the proposed alignment with good vertical flexibility. However, conflicts with existing elevated structures such as the Skywalks may require the guideway to pass over the structure, increasing the cost and size of the support structure.
8.8 Obstacles to Implementation

Are there several operational systems using this transportation system in the U.S. or internationally?

- **Existing/TSM**: Downtown bus circulators are a long-standing service concept in the U.S.

- **Streetcar**: There are over 300 LRT systems in operation internationally, 21 of those are in U.S. cities. There are 10 Streetcar systems in operation in the U.S.

- **PRT**: There are no PRT systems operating anywhere in the world with the same control concept, vehicle design and scale of the proposed PRT system. A prototype of a similar vehicle system was constructed and operated by Raytheon in a test mode in recent years, but the concept was abandoned without being placed in commercial service. A number of fully automated APM systems are in service worldwide, and the demand dispatch supervisory control concept has been implemented in several locations as part of large destination coded vehicle (DCV) baggage handling systems.

Is there significant technical risk associated with the implementation of the transportation system?

- **Existing**: None.

- **TSM**: None. The proposed signal priority system is in wide use for a variety of applications, but must be integrated into the existing traffic signal system.

- **Streetcar**: The technical risk associated with implementing a Streetcar system is low. There is good historical data and many similar systems from which to draw information.

- **PRT**: The Taxi 2000 design concept has been in existence for approximately 20 years without producing a viable operational system. Some of the design concepts will require changes to conform to current regulations and standards. The failure of the Raytheon prototype program is an indication of the technical and financial hurdles the system must overcome to enter commercial operation. Prototyping and scale-up of the system is expected to take 2 - 5 years in addition to the normal period for design and construction. This initial development period will add directly to the costs of the system. Taxi 2000 proposes investor funding of the prototype development phase, although adequate funding has not yet been secured. There are significant risks inherent in this alternative. The full risk profile will not be known until the prototype program has been completed.

Are vehicles of this transportation system generally reliable and safe in operation?
• **Existing and TSM:** Diesel powered buses are widely used and are considered reliable and safe.

• **Streetcar:** Streetcars, whether reconditioned or newly manufactured replicas, are in wide use throughout the world. The vehicle technology is proven and well understood. The vehicles are safe and reliable. Modern solid-state electronics have improved the reliability of the systems and vehicles.

• **PRT:** Fully automated transportation systems such as Automated People Movers are generally safe and reliable. The control system for Taxi 2000 has not been demonstrated in a system as complex as the current proposal or in a similar operational environment. The proposed vehicles must complete prototype development, operational, safety and environmental testing before being approved to enter commercial operation.

Are there at least two suppliers worldwide who produce this technology?

• **Existing:** There are numerous domestic suppliers of small and large transit buses. TANK currently uses both Orion and Gillig buses in their fleet.

• **TSM:** Same as existing, although TANK's experience with the Orion II buses suggests that this unit will not be repurchased.

• **Streetcar:** Historic vehicles are available from several properties around the world. Gomaco currently manufactures replica trolleys in the United States. Modern Streetcars, or street trams, are available from several international suppliers. Modern Streetcars manufactured by Skoda in the Czech Republic are now beginning commercial operation in Portland, Oregon.

• **PRT:** Several PRT concepts have been developed and are being marketed in the U.S. Only Taxi 2000 has advanced their design to the point where it is ready for prototyping. There are no comparable PRT systems in commercial operation anywhere in the world. The design of the system and vehicle are proprietary, therefore, competition for replacement vehicles is unlikely.

If this transportation system becomes selected for an initial order, is it likely additional compatible sets of equipment can be procured in five years under competitive circumstances?

• **Existing/TSM:** There are no features in the existing buses that would cause compatibility issues in the future.

• **Streetcar:** There are no features in the proposed Streetcar vehicles that would cause compatibility issues in the future, and the vehicle specifications will be developed around standards in common use by suppliers.
• **PRT**: Taxi 2000 is a proprietary technology. The purchase of a turn-key, proprietary APM system has been done successfully a number of times in a number of places. The owner's ability to purchase additional equipment in the future at competitive prices is determined by the original contractual agreements. Similarly, the owner's continuing rights to the design and manufacturing documentation should the supplier go out of business are also determined by the contract. It is unknown at this time whether Taxi 2000 will remain a propriety technology.

*Does this transportation system drive the scoping of a procurement such that the vehicles, guideway, and systems must be combined?*

• **Existing/TSM/Streetcar**: Not applicable.

• **PRT**: Taxi 2000 is a proprietary technology. Because of the risks associated with the implementation of this unproven technology, it would be wise to procure a complete operating system, with significant performance guarantees and warranties. The system supplier could adopt competitive procurement practices for commonly available system and vehicle components. Similarly, the system supplier could competitively procure construction and erection of the guideway and stations. Alternatively, the owner could procure the traction power system, the guideway, and the station facilities using a competitive bid process if the owner is willing to assume the overall risk of coordination and integration. Because of the proprietary nature of the system, and the risks involved in implementation, a challenging and lengthy contracting process should be anticipated.

*Is there confidence that cost estimates can be projected accurately?*

• **Existing**: Not applicable, although historical costs are readily available.

• **TSM**: Historical costs can be used for buses, but costs or installation of the ITS components must be estimated using traditional techniques.

• **Streetcar**: The costs for vehicles, guideway and systems controls can be estimated using historical data from other cities and local costs for common construction elements. It is more difficult to estimate right-of-way and utility relocation requirements. These costs would be refined during the preliminary engineering and final design phases.

• **PRT**: The PRT cost estimate developed for this study are based on a relatively limited amount of data provided by Taxi 2000 combined with more commonly available historic data for other automated transit systems. The PRT cost estimate carries a lower confidence level than the other alternatives.

*Are there any factors that would preclude cost estimates from being projected accurately?*
• **Existing**: Not applicable.

• **TSM**: Historical costs are readily available. Some uncertainty is attached to the timing of implementation and attendant cost inflation. However, the relatively short lead time for bus procurements and the other suggested improvements minimize this risk.

• **Streetcar**: The right-of-way and utility relocation costs are difficult to estimate. A significant uncertainty is the assumption of shared use of the existing bridges. This uncertainty would be reduced somewhat if the I-71 LRT project is implemented and the new LRT bridge is constructed. The timing of implementation and resulting cost inflation is also less certain than the TSM alternative.

• **PRT**: The right-of-way and utility relocation costs are difficult to estimate, as are the costs of modifying individual buildings to integrate a PRT station. A significant additional uncertainty is the assumption of shared use of the existing bridges. The actual system equipment costs will not be able to be projected with confidence until the prototype is successfully designed, built and tested. The timing of implementation and associated inflation risk is particularly uncertain because funding for the prototype development program has not been secured.

*Does the transportation system utilize proven available technology?*

• **Existing**: Buses are considered proven technology.

• **TSM**: Buses are considered proven technology and ITS technology is considered proven, but its evolution continues.

• **LRT/Streetcar**: The Streetcar is considered a proven technology with modern enhancements in power supply and control systems.

• **PRT**: Various elements of the PRT system are in common use in other applications. However, there are no complete PRT systems in commercial operation. Therefore, the technology is largely unproven.

*Does the transportation system utilize proprietary transportation system, or is the transportation system generally available?*

• **Existing/TSM**: Buses are not proprietary and are readily available from a number of manufacturers.

• **Streetcar**: Streetcar vehicles are available from a number of sources or manufacturers. The other components of the system are not proprietary and are generally available from a variety of suppliers or contractors.
• **PRT:** Taxi 2000 is a proprietary system. Because the design is proprietary, it has been difficult to obtain sufficient information to completely evaluate some aspects of the design. According to the system’s designer, all hardware and software elements of the Taxi 2000 design are operating in some form or fashion within the world today. The ability to combine these diverse elements and design and build a complex system with the weight, size, capacity and costs that are estimated in this study is the principal unknown. Although the Taxi 2000 design is proprietary, the opportunity apparently exists for the Central Area Loop circulator system to be implemented with equity participation Taxi 2000 which could make the proprietary aspect less onerous.

*Are multiple suppliers available to allow competition for the initial system?*

• **Existing/TSM:** Multiple suppliers are available.

• **Streetcar:** Several vehicle suppliers are available and other components are readily available.

• **PRT:** Although there are several PRT concepts being marketed, there is only one supplier of the Taxi 2000 concept. Because of the risks associated with the implementation of this unproven technology, it would be wise to procure a complete operating system, with significant performance guarantees and warranties. The system supplier could adopt competitive procurement practices for commonly available system and vehicle components. Similarly, the system supplier could competitively procure construction and erection of the guideway and stations. Because of the proprietary nature of the system, and the risks involved in implementation, a challenging and lengthy contracting process should be anticipated.

*How long a period will be required to demonstrate and prove the safety and operational reliability of the system?*

• **Existing/TSM:** None required.

• **Streetcar:** A short period of operational testing is required prior to revenue service.

• **PRT:** Funding has not been secured for the prototype development program. From the time that funding is secured, the prototype design, construction and testing program should take two to four years. Safety and vehicle environmental testing can be initiated during this period. Final design and additional design verification testing should take another one to two years. The commitment to actually implement the system would be made at that time. Construction, manufacturing, installation and operational testing and commissioning will require approximately two to three years. In total, the implementation period between the start of the prototype design and the initiation of revenue service is estimated to be five to nine years, not counting time required to fund, procure and contract for the system. This assumes that no delays will be imposed during the political approval process. However, given the controversial nature of the proposal, such delays should be anticipated.
9.0 Evaluation Summary

9.1 Criteria Summarized
<table>
<thead>
<tr>
<th>Category</th>
<th>Evaluation Question</th>
<th>Existing Southbank Shuttle</th>
<th>Improvements to Southbank Shuttle</th>
<th>Street-car PRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Effectiveness</td>
<td>• To what extent does this transportation system represent a cost-effective investment?</td>
<td>4</td>
<td>5</td>
<td>1</td>
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<tr>
<td></td>
<td>• Are there front-end costs and time associated with this transportation system to ready it for implementation?</td>
<td>5</td>
<td>4</td>
<td>3</td>
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<td></td>
<td>• How severe are the secondary costs (utilities, street changes) due to placing this transportation system and its structures in likely locations?</td>
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<td></td>
<td>• What is the technical life expectancy of this technology?</td>
<td>2</td>
<td>3</td>
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<td>• To what extent does this transportation system imply a reasonable level of annual costs?</td>
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<td>• Is this transportation system labor intensive to operate and maintain?</td>
<td>4</td>
<td>4</td>
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<td>• Are there any extraordinary power requirements associated with this technology?</td>
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<td></td>
<td>• Is this transportation system susceptible to failures of its rolling stock, systems, or fixed facilities?</td>
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<td></td>
<td>• What relative degree of vehicle failure or downtime is likely with this technology?</td>
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<td>• What level of vehicle spares seems indicated as prudent?</td>
<td>4</td>
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<tr>
<td>Equity</td>
<td>• Will the transportation system distribute costs and benefits equally to all segments of the population within the affected area?</td>
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<td></td>
<td>• Will the transportation system serve a variety of populations?</td>
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<td>• Will the transportation system provide affordable transportation to low-income individuals?</td>
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<tr>
<td>Safety/Access</td>
<td>• Is the transportation system ADA compliant?</td>
<td>4</td>
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<td></td>
<td>• Does the transportation system meet fire/life safety requirements?</td>
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<td></td>
<td>• Will there be difficulties in meeting building code requirements?</td>
<td>N/A</td>
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<td>4</td>
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<tr>
<td></td>
<td>• Is there a perception of personal safety within the vehicle and at the station?</td>
<td>4</td>
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<td></td>
<td>• Does the transportation system provide convenient access to all users?</td>
<td>4</td>
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<tr>
<td></td>
<td>• Does the transportation system present a safety hazard to non-users?</td>
<td>4</td>
<td>4</td>
<td>3</td>
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<tr>
<td>Effectiveness</td>
<td>• Does the transportation system have acceptable point-to-point travel times including station dwell time?</td>
<td>3</td>
<td>4</td>
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<td></td>
<td>• Does the system provide reliable service levels?</td>
<td>3</td>
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<td>• Does the transportation system provide adequate service to the study area destinations in terms of frequency of service and geography coverage?</td>
<td>3</td>
<td>4</td>
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<td></td>
<td>• How reliable is the transportation system in maintaining schedule?</td>
<td>3</td>
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<td></td>
<td>• Will the transportation system adequately serve projected ridership and/or attract sufficient ridership to justify the investment?</td>
<td>4</td>
<td>5</td>
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<tr>
<td></td>
<td>• Does this transportation system facilitate intermodal transfer movements among public transit service providers?</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Category</td>
<td>Question</td>
<td>Score 1</td>
<td>Score 2</td>
<td>Score 3</td>
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<tr>
<td>Environmental</td>
<td>Will there be adverse effects to historic structures and districts?</td>
<td>6</td>
<td>6</td>
<td>4</td>
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<tr>
<td>Environmental</td>
<td>Are noise and vibration generated or caused by the operation of this transportation system acceptable or manageable?</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Right-of-way</td>
<td>Are impacts associated with ecology, hazardous materials, or wetlands anticipated?</td>
<td>5</td>
<td>5</td>
<td>3</td>
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<tr>
<td>Right-of-way</td>
<td>Can the transportation system be installed within existing public rights of way?</td>
<td>4</td>
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<tr>
<td>Right-of-way</td>
<td>Will there be displacements or relocations associated with the construction and operation of this technology?</td>
<td>5</td>
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<tr>
<td>Visual Impacts</td>
<td>Will the transportation system, including its associated structures, create visual impacts within the study area?</td>
<td>4</td>
<td>4</td>
<td>3</td>
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<tr>
<td>Visual Impacts</td>
<td>Will the vehicles, line structures, stations, and system wide elements integrate well into the urban form and character of the area served?</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Urban Integration</td>
<td>Can the geometric requirements of the transportation system (turning radius, gradeability, vehicle envelope, etc.) be accommodated within the study area?</td>
<td>5</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Urban Integration</td>
<td>Will the fixed facilities or operations of this transportation system create real or perceived barriers dividing neighborhoods?</td>
<td>5</td>
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<td>4</td>
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<tr>
<td>Urban Integration</td>
<td>Does the transportation system and its guideway structures and stations cause diminished capacity for motor vehicle traffic flow in general?</td>
<td>3</td>
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<tr>
<td>Urban Integration</td>
<td>Will there be any specific traffic impacts associated with the technology?</td>
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<tr>
<td>Urban Integration</td>
<td>Will there be any specific construction impacts associated with the technology?</td>
<td>5</td>
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<tr>
<td>System Flexibility</td>
<td>Can this transportation system respond to changes in ridership levels?</td>
<td>5</td>
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<td>2</td>
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<tr>
<td>System Flexibility</td>
<td>Is the alignment easily expandable?</td>
<td>5</td>
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<tr>
<td>System Flexibility</td>
<td>Are there extraordinary requirements of the transportation system in its storage and maintenance facility location or design?</td>
<td>5</td>
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<tr>
<td>System Flexibility</td>
<td>Are new stations or boarding area accommodated easily?</td>
<td>5</td>
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<td>System Flexibility</td>
<td>Does this transportation system require a fully-separated operating envelope?</td>
<td>5</td>
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<td>Utilization of Existing Infrastructure</td>
<td>Can this transportation system utilize existing bridges within the study area?</td>
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<td>Will the transportation system require the construction of a guideway or track structure?</td>
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<td>Will the transportation system enhance the existing regional transportation investment?</td>
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<td>Implementation Obstacles</td>
<td>Are there several operational systems using this transportation system in the US or internationally?</td>
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<tr>
<td>Implementation Obstacles</td>
<td>Are there any factors that would preclude cost estimates from being projected accurately?</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Implementation Obstacles</td>
<td>Does the transportation system utilize proven available technology?</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Implementation Obstacles</td>
<td>Does the transportation system utilize proprietary transportation system, or is the transportation system generally available?</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Implementation Obstacles</td>
<td>Are multiple suppliers available to allow competition for the initial system?</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Implementation Obstacles</td>
<td>How long a period will be required to demonstrate and prove the safety and operational reliability of the system?</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>
10.0 Conclusion – Locally Preferred Alternative

On September 25, 2001 the Central Area Loop Study Advisory Committee approved the following resolutions regarding the technology for the Loop Circulator. A complete transcript of the September 25, 2001 meeting can be obtained by contacting OKI. The following recommendations and the findings of the study were approved by the OKI Executive Board on November 8, 2001.

10.1 TSM ALTERNATIVE

Background

- Traffic congestion within the urban core of the three cities of Covington, Newport and Cincinnati demands improvement to the public transportation systems serving these communities.
- The Southbank Shuttle operated by TANK has proven to be a popular and effective public transportation system.

Approved Resolution

1. Formally link the Southbank Shuttle with SORTA’s existing and proposed shuttle service, including components of the MetroMoves plan.

2. Implement additional Southbank Shuttle Rubber-Tire Service through a revised route structure to include the urban core of Cincinnati, Covington, and Newport and increased service frequency.

3. Implement additional measures to improve the operational mobility of transit service within the study area, which may include dedicated transit lanes and transit signal priorities.

4. Implementation of these recommendations by the respective transit agencies (TANK and SORTA) through amendment of their existing Inter-Local Agreement.
10.2 STREETCAR ALTERNATIVE

Background

- The OKI Region has demonstrated public interest and support for a variety of surface rail transit alternatives to improve mobility and enhance economic opportunities within the Region.

- The Central Area Loop Study reviewed and evaluated a number of surface rail alignments serving the CBDs of Covington, Newport and Cincinnati.

- During the course of the Central Area Loop Study, the community and members of the Loop Study Advisory Committee identified the need for expanded circulator type transit service both within and beyond the boundaries of the Study Area. This expanded service is not adequately provided by the proposed Streetcar alignments. The Loop Advisory Committee determined that such expanded service, while desirable, was beyond the scope of the Central Area Loop Study.

Approved Resolution

1. Additional study of surface rail alternatives serving the urban cores of Covington, Newport and Cincinnati should be conducted and incorporated as an integral part of the proposed Regional Rail Plan.
10.3 PERSONAL RAPID TRANSIT ALTERNATIVE

*Background*

- The Central Area Loop Study evaluated the Personal Rapid Transit alternative (Taxi 2000) proposed by the Sky Loop Committee.

- The proposed Taxi 2000 alternative produces potentially superior ridership due to the direct point-to-point service, which is characteristic of such a system.

- The community and the Loop Study Advisory Committee identified significant environmental, technical, and potential fire and life safety concerns accompanying the implementation of such a system. Many of these concerns stem from the elevated design of the system.

- The Taxi 2000 system is still an unproven technology with significant questions about cost and feasibility of implementation.

*Approved Resolution*

1. The Personal Rapid Transit (Taxi 2000) alternative is not-recommended for adoption as the loop circulator technology for the Central Area.

2. Taxi 2000 should pursue the construction and operation of a full-scale demonstration project to resolve questions regarding engineering design, operational feasibility and cost.