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

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

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 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 ($2.00) is significantly higher than the current fare ($.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 ($.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

Technology Alternative	Wait Time (minutes)	Average Walk Time (minutes)
Southbank Shuttle	10	10
TSM	5	5
LRT/Streetcar	5	5
PRT	4	5

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

		Station to Station Travel Time			
Origin	Destination	Existing Southbank Shuttle (minutes)	TSM (minutes)	Vintage Trolley (minutes)	PRT (minutes)
Government Square	TANK Transit Center	8	7	12.4	7.5
Cincinnati Convention Center	Newport Aquarium	14	12	6.1	4.85
Fountain Square	Downtown Newport	6	5	6.8	6.9
Downtown Covington	Downtown Newport	23	5	4.2	3.1
Paul Brown Stadium	Covington Riverfront	16	14	9.8	7.2
Newport Aquarium	MainStrasse	39	19*	9	5.8
	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:** T he 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 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, is 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 Soutbank 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 carriers 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.