

KDOT Exploratory Concepts in Advanced Transport

Mobility and Land Use Enhancements Enabled by Automated Small-Vehicle Transport Technologies at the Village West Development

A PERSONAL RAPID TRANSIT CASE STUDY

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Executive Summary

In June of 2008 an Automated Small-Vehicle Transit (ASVT) application study commenced at a popular development on the western edge of the Kansas City metropolitan area. The purpose of the project was to investigate the potential of PRT to solve transportation and mobility issues in a popular commercial development that encompasses retail and entertainment, commonly known as the Village West development. This development has extensive retail, restaurants, and entertainment, and borders on a major NASCAR race track and a former greyhound racing facility available for redevelopment. Village West also contains a minor league ball park, and a regional medical facility is located immediately to the east. Planned additional development includes a casino, a water resort, a soccer stadium and business park.

As with most modern development, the dominant uses of land are parking lots and access roads to serve the attractions. The objective of this study was to investigate the viability of a Personal Rapid Transit (PRT) system to improve the inter-accessibility of existing and planned facilities, to serve as a feeder to any existing and planned transit systems, and to reduce the quantity of land dedicated to roads and parking lots, freeing up land for additional development. PRT is an ASVT system comprised of a fleet of completely autonomous small vehicles to deliver personalized, on-demand transport service.

In short the study concluded the following:

- A PRT network that interconnected the retail and entertainment facilities was both technically and fiscally feasible, and would assist in transforming the area from a loose collection of day attractions into a cohesive, easily accessible, multi-day family destination.
- Candidate PRT layouts linking existing facilities and planned facilities (such as the casino and water park) can also make remote parking facilities efficient and thus open existing surface parking to redevelopment.
- PRT could assist with race-day operations (such as disability access and linking complimentary attractions), but volumes of NASCAR events generally exceed throughput capacities of affordable PRT systems.
- A 26- station PRT system can effectively serve the development, and be available for expansion for either future development or extended as a public transit service. Such a system includes approximately 9.7 miles of guideway and a fleet of 150 transportation pods (T-Pods). The capital cost was estimated at \$137M.
- The estimated capital and operating costs are offset approximately 2-1/2 times by the benefits to users, society, increased land values, and increased economic activity.
- Environmental impacts are positive, though a complete Environment Impact Statement would be required if public funds were used.
- If the development had incorporated PRT from the outset, PRT could be more efficiently integrated into the development both in terms of cost and land use.

Overall, the study indicated both financial and technical feasibility and considerable benefits to mobility, sustainability, and the environment. The research team presents these findings both as a case study for the Village West development as well as representative of benefits (and issues) of implementations of such technology elsewhere in the region.

Introduction

Utilizing funds provided by a research grant from the Kansas Department of Transportation, Kansas State University, working with a consulting team lead by PRT Consulting and supported by research undertaken and funded by the University of Kansas, investigated the potential of personal rapid transit (PRT) to solve transportation and mobility issues in a popular retail and entertainment district, commonly known as the Village West Development. This development is on the western edge of the Kansas City, Kansas metropolitan area, located north of the intersection of Interstates 70 and 435. Existing development in the northwest quadrant includes the Kansas Speedway, the Legends at Village West (an upscale shopping district), mega retail stores of Nebraska Furniture Mart and Cabela's Outfitters, and many other smaller retail shops and restaurants. Also in the vicinity are the Woodlands Race Track and the Providence Medical Center. Planned development includes a casino and major water resort. See Figure 1 for a contextual map of the study area.

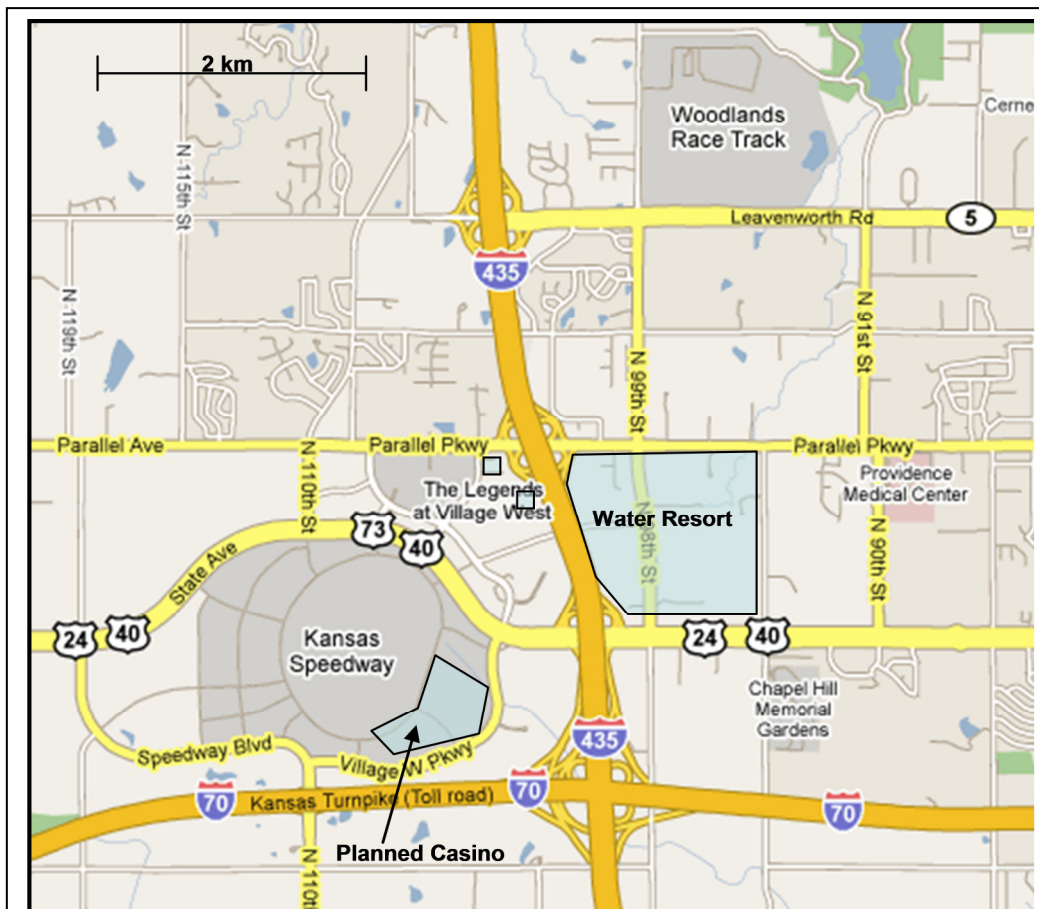


Figure 1. Map of western Wyandotte County showing development areas.

Despite the number of attractions, the dominant use of developed land, however, is parking lots and roads to serve these attractions.

Although this development has been successful in terms of revenue and patronage, issues related to ease of access and mobility within the development are detractors, and are representative of the transportation and mobility needs that are common to large scale developments, campus settings, or any other development characterized by closely spaced activity centers accessed primarily by private vehicles. Parking of vehicles dictates that an inordinate amount of real-estate be dedicated to vehicle storage, which in turn requires attractions to be spaced further apart, and impedes pedestrian access between attractions, which induces re-circulating of vehicles for patrons visiting more than one attraction. This vicious cycle tends to limit the density and inter-accessibility of large developments – and, in general, detracts from the overall experience.

Conversations with stake-holders in the development indicated mobility issues within the development inhibit the development from growing from a one-to-two day attraction to a multi-day family destination. After parking near and visiting their primary attraction, patrons need to return to their vehicle and find new parking for secondary attractions, minimizing the probability of multi-destination trips. Stakeholders would prefer patrons to be able park anywhere in the development and easily access all attractions, thus encouraging longer stays and maximizing revenue potential.

The Village West development is a representative case study in that many developments face similar intra-facility movement inefficiencies. Personal Rapid Transit promises much greater efficiency. The objective of this study was to analyze the impact (both positive and negative) of form of automated transit on access to, and mobility within, such developments.

This study investigated the ability of a PRT system to:

- Improve the inter-accessibility of the existing and planned facilities
- Serve as a feeder to any existing and planned transit systems
- Reduce the quantity of land dedicated to roads and parking lots, freeing up land for additional development or open areas
- Reduce green-house gas emissions, run-off, and mitigate other environmental consequences related to development

It also estimated the cost of implementing and operating a PRT system. In addition, it investigated not only the impact of a PRT system to serve the existing development, but also how development may have been designed differently, had it incorporated PRT from the beginning. The work commenced with a literature review which is reported in Appendix A.

Much of the work of this report was undertaken as individual tasks, each documented in its own report and included as an appendix to this report. The body of this report describes the entire project. However, tasks documented in the appendix are only briefly summarized in the body.

Stakeholders and Facility Description

The initial task was to identify stakeholders and invite their participation. Representatives from various organizations attended the project kickoff meeting and subsequent one-on-one briefings. These organizations include:

- The Kansas Speedway
- Wyandotte County Unified Government
- Federal Transit Administration
- Federal Highway Administration
- Kansas Department of Administration
- Kansas Department of Transportation
- Mid-America Regional Council
- Department of Aging
- RED Development Corporation

On June 16, 2008 a stakeholders meeting was held to initiate the project and solicit input. Additional one-on-one meetings were held with several participants in order to document in greater detail the issues of concern. Highlights of the input provided by the stakeholders are summarized below in a topical fashion to provide insight of the stakeholders perspective.

“... the Casino proposals for the area ... included a stipulation that the casino provide transit service.”

Circulation within the development was recognized as a concern even before this study commenced. Plans for a casino near Village West are moving forward and proposals were being solicited from prospective developers at the time of this study. A requirement of any casino proposal was to provide some type of shuttle system to serve the entire Village West area (not just the casino). Although the requirements for the shuttle system are modest, it is an acknowledgement by development owners and city officials alike that inter-development circulation is inadequate.

(a representative from the department of Aging) noted that “the aging population would like and benefit from the convenience and practical nature of such a system.”

With the aging of baby boomers and subsequent demographic shift, completely automated circulation systems will serve a growing population sector with significant political and economic clout.

“ADA parking at the track is filled by about 8:30 am on race days and others are turned away. Track operators would like to see a remedy so that folks needing special transportation accommodations can be more readily served.”

Race track officials openly shared concerns of high-quality handicapped accessible service. Current close-in parking lots are over-subscribed (and likely abused) by race fans, leaving many disabled patrons unable to efficiently access the attractions. A convenient transit link between

the track and parking reserves in other areas of the development could provide this - avoiding the need to compete with race fans for highly desirable close-in parking.

“... a remote parking lot might not be needed if existing parking could be used more efficiently.”

Pooled, or shared parking becomes feasible if efficiently linked. The increased parking requirements for the new soccer stadium could be met if existing parking reserves could be linked.

“... the Racetrack wants to move people around the racetrack and the nearby businesses as a benefit to all on race days and other days.”

“Wyandotte County is implementing a Bus Rapid Transit system that will link Kansas City, Kansas with the Legends development. A circulator system at the development would greatly improve the efficiency of the transit link.”

A detailed map of the development area is shown in Figure 2.

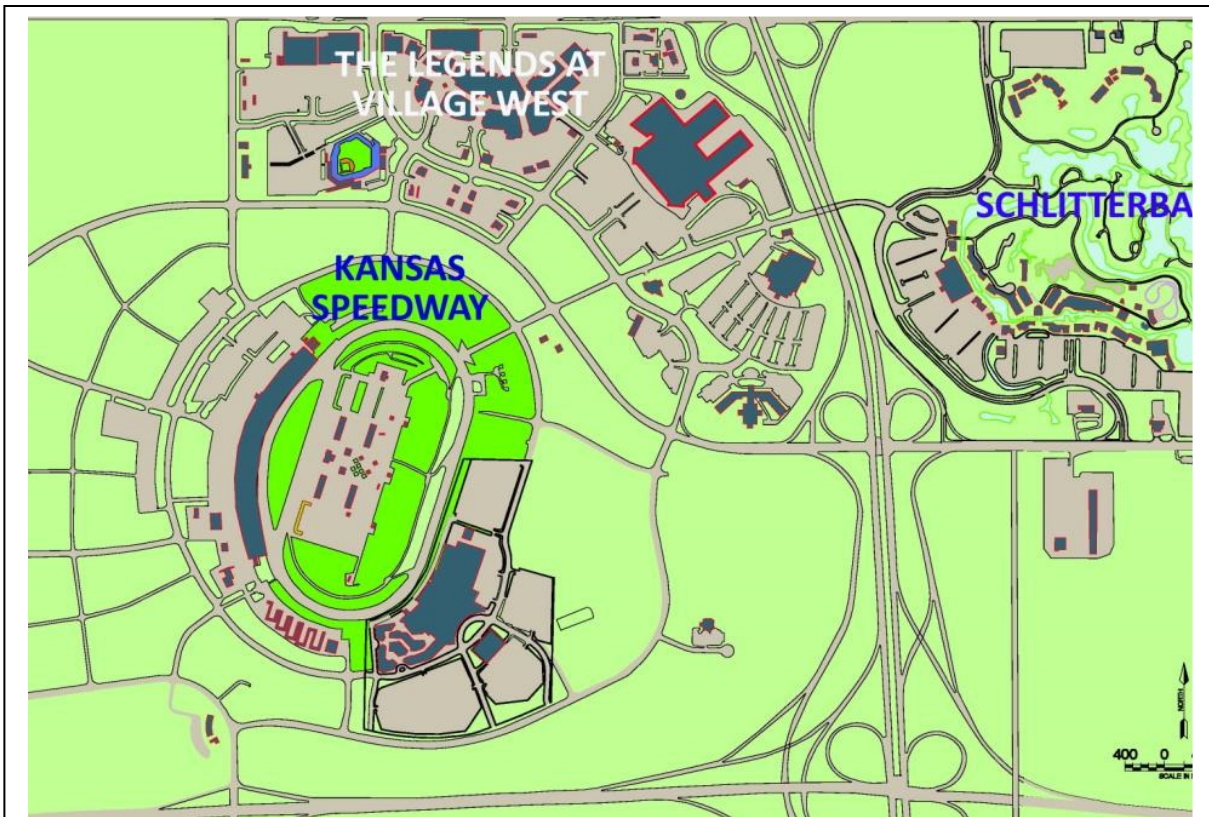


Figure 2. Detailed site map of the development area, both existing and planned.

The initial stakeholders meeting led to many follow-up meetings with suggested contacts. As a result of the contacts, the project team met with the developers of the Schlitterbahn water resort at their headquarters in Texas. Schlitterbahn had previously proposed a monorail system for the development

area, including detailed cost estimates and proposed methods of financing (see section on finance). The latter contained analysis that was still relevant to the PRT study. As an additional benefit, the prior proposal to investigate monorail concepts had initiated county government discussions of methods other than traditional vehicles and buses to better circulate patrons in the area.

The project team also held separate meetings with representatives of the Kansas Department of Transportation, Wyandotte County Unified Government, Wyandotte County Transit Department, Kansas Speedway, Olsson Associates and Berger Devine Yaeger, Inc.

An analysis of the land uses in the portion of the development depicted in Figure 3, showed that road and parking comprised 51% while buildings only comprised 13% of the land area. Note that one building in the picture is a parking garage.



Figure 3. Aerial photo showing buildings and pavements.

Personal Rapid Transit (PRT) Overview

The Advanced Transit Association (1) describes modern PRT as meeting the following criteria:

1. Fully automated vehicles (no human drivers).
2. Vehicles captive to the guideway, which is reserved for their exclusive use.
3. Small vehicles, available for exclusive use, by an individual or small group traveling together by choice. Available for service 24 hours a day.
4. Small guideways can be elevated, or near ground level, or underground.
5. Vehicles able to use all guideways and stations on a fully connected network.
6. Direct origin-to-destination service, with no necessity to transfer or stop at intervening stations.
7. Service available on demand, rather than on fixed schedules

Unlike a conventional automated people mover (APM), PRT vehicles (transportation pods or T-Pods) are typically already waiting when passengers arrive at a station. If a T-Pod is not already available, one usually comes within a minute. All of the PRT systems discussed here are fully compliant with the American with Disabilities Act (ADA) and accommodate three or more adults with luggage. T-Pod floors are at platform level, allowing wheeled objects to roll on and off.

Since T-Pods are used only by individuals, or small groups traveling together to the same destination by choice, each T-Pod can be individually routed to its destination. Guideways are typically laid out in interconnected loops, and it is possible for multiple routes to exist between any origin and destination pair. In this event, T-Pods can be routed along the most appropriate route. Stations are typically off-line (on bypasses), thus enabling non-stop origin-to-destination travel.

T-Pods not currently in service, or being repositioned to provide service, wait in stations, maintenance or storage depots. This results in reduced empty vehicle movement, saving energy over conventional systems, which often have large vehicles running around, mostly empty in off-peak periods.

Rather than using a small fleet of large vehicles to obtain transport capacity (as is typical of most modern transit systems) PRT mimics the automotive system in order to efficiently serve the traveling public. The current road system links diverse origins to diverse destinations by transporting each party privately and non-stop. Busses, trains, and light-rail work efficiently only when geography naturally groups large numbers of travelers to common destinations – which is rare in today's cities. Automobiles have served the diverse trip making nature of our society well in most areas, but the mass success of the automobile has in turn created parking, vehicle and pedestrian congestion in areas (such as the Village West development) in which the storage of parked vehicles requires long walks to access and prevents multiple attractions from being efficiently linked. Automated Small Vehicle Transit (ASVT), or PRT as it is commonly known uses a fleet of completely automated vehicles to provide enhanced mobility services in such areas.

Automated service allows vehicles to be operated safely without fear of human error, and also allows dispersion of empty vehicles either for reuse by other patrons, or efficient storage away from attractions.

Small vehicles have a two-fold impact. Transit stations have to be as long as the longest vehicle or train servicing the station. By shrinking the transit vehicle to the size of a small car, transit stations need not be any larger than a taxi stand for effective service. Individual stations can be sized according to their specific demand. More stations can be placed and (through the use of automation) service a more diverse set of attractions.

Lastly, small vehicles conform to existing trip making practice in which it is rare that two or more parties share common origins and destinations within the small window of time that would allow for shared use of vehicles.

Ultimately the efficiency and use of a transport system is governed by its efficiency of moving people in a timely fashion. Repeated studies have shown that forcing the public to wait three minutes or more drastically impacts the attractiveness of the system, sending them back to their automobiles to vie for parking in a congested vehicle environment rather than to be grouped in large numbers (and the accompanying delay associated with large grouping) in order to make the use of outdated modes of busses and trains feasible.

There are many more technical aspects of Personal Rapid Transit, but this short introduction is intended to provide a broad overview of its capabilities and concept for understanding the application study at Village West development. A review of PRT-related literature was undertaken by The University of Kansas and is included under Appendix A.

On a final note before proceeding with the results of the study, PRT concepts have been studied at the research and development level for four to five decades. With the exception of the experimental system installed on the campus of West Virginia University in the 1970s, no commercial development has flourished in the present. Currently four companies have PRT offerings that have either been installed or been fully prototyped, though none in North America. For this reason the study did not address viability of the technology, as industry has already proven this, but rather its appropriate implementation in campus and development settings for areas such as the Village West development.

There are currently five PRT systems that are commercially available, or close to being so. In approximate order of availability, these are:

The ULTra PRT System

Offered by ULTra PRT, of Bristol, United Kingdom, the ULTra system (2) is rubber-tired, battery-powered, and runs on an open guideway. The front wheels are steerable, and the T-Pod keeps itself on the guideway without any physical lateral guidance, simplifying switching, which is accomplished by steering. This system



Figure 4. ULTra T-Pods operating at Heathrow.

is currently in final passenger trials at London's Heathrow International Airport, where it is scheduled to go into passenger service in June, 2010. The commitment to using off-the-shelf technology, wherever possible, coupled with a rigorous testing and development program, has allowed the ULTra system to be the first modern PRT system to win a commercial contract. Once the initial two-mile phase, employing 18 T-Pods, has proven successful, Heathrow plans to expand the system to 30 miles of guideway, with some 400 T-Pods, carrying approximately 30 million annual passengers.

The ULTra system has obtained safety approval from the British rail authorities to carry members of the public at 6 second headways (time between vehicles) and 25 mph.

The ULTra T-Pod was designed for four adults, plus luggage. However, Heathrow has opted to replace the bucket seats with bench seats set further apart, allowing the vehicle to carry a family of six plus luggage.

Open guideway PRT, such as that used by ULTra and 2getthere, tends to be more economical, but the rubber/guideway interface can be problematic during inclement weather conditions. ULTra has plans to address this issue, by using a glass fiber reinforced, plastic grating as the riding surface. Preliminary testing by PRT Consulting, in the winters of 2006 and 2007, has shown this solution to be very successful in mitigating the effects of Colorado snowfall.

The 2getthere PRT System

2getthere, a Dutch company (3), has been operating an automated PRT-like shuttle bus system, in cooperation with Frog Navigation Systems in Rotterdam, Holland, for a number of years. All told, 2getthere has about ten years of experience in operating automated people movers in the public domain. However, none of these systems comply with the definition of PRT provided above. 2getthere's newly-developed PRT system has been chosen, as the primary form of internal transportation, for the new city of Masdar in the UAE. This system is planned for approximately one hundred stations and two thousand vehicles. The initial system is planned to go into public service in 2010.

2getthere's PRT system is of the open guideway type, with somewhat similar attributes to those of the ULTra system. However, there is little information publicly available about this system.

The Vectus PRT System

Vectus (4) is a subsidiary of POSCO, one of the world's largest steel manufacturers. Despite being a British company owned and operated by Koreans, Vectus chose to



Figure 5. 2getthere T-Pod



Figure 6. The Vectus T-Pod and station.

establish a full-size test track, with an off-line station, in Sweden, in order to prove operability in winter weather conditions and to meet the rigorous Swedish safety requirements. They now appear to have accomplished both of these goals. They have received Swedish rail authority approval for operation at 3 second headways at 25 mph.

The Vectus (and Skyweb Express) system is of the captive-bogey type, where the undercarriage, or bogey, is not steerable, but has wheels which run along vertical side elements, thus, keeping the T-Pod on the guideway. Switching is accomplished by movable wheels mounted on the T-Pod. The T-Pod is propelled (and braked) by linear induction motors, which are mounted in the guideway. Mounting the motors in the guideway reduces the weight of the vehicles, but increases the cost of the guideway. This is advantageous for high-capacity systems, but expensive for low-capacity systems. Propulsion batteries are not required, allowing the T-pods to be lighter-weight.

The Vectus T-Pod is designed to carry four adults, plus their luggage. It is large enough to accommodate a six-seat option. They were recently selected to install a PRT system in Korea which is scheduled to go into service in 2013.

Critical Move

The Critical Move system is offered by the Critical Group, based in Coimbra, Portugal. It is rubber-tired and battery-operated like the ULTra and 2getteher systems. Its initial deployment is in a hospital environment and its folding seats facilitate accommodation of wheelchairs and gurneys. The initial deployment (scheduled for public service in Portugal in 2010) is a simple shuttle arrangement, but Critical claims the system can be upgraded to full PRT capabilities.



Figure 7. The Critical Move T-Pod.

The Skyweb Express PRT System

The Skyweb Express system is offered by Taxi 2000 (5), a Minnesota company. It is of the captive-bogey type but, unlike the Vectus system, has the linear induction motors mounted in the T-Pods. The motors obtain power from the guideway, so propulsion batteries are not required. Switching is by movable vehicle-mounted guide wheels. The T-Pod is designed to mimic the back seat of a taxi and, as such, has a three-cushion tilt-up bench seat designed for three adults.

Taxi 2000 has a sixty-foot guideway, with a full-size T-pod, constructed and operating in Fridley, MN. However, the test track does not demonstrate switching capabilities. It is not known if they have any commercial customers; they are



Figure 8. The Skyweb Express T-Pod.

working on a PRT system in Dubai.

Guideway Layout and Station Locations

Since the ULTra, 2getthere and Move systems' entry into public service is imminent, it was decided to base the station and guideway layout on the geometric requirements of these systems which is somewhat more flexible than those of Vectus and Skyweb Express. One of the first and primary exercises was to investigate guideway layout and station locations to serve both the existing and planned development at the Legends.

Layout of a PRT route to serve the complex, both existing and planned development, was developed through collaboration of professions from multiple disciplines, including planners, architects, engineers and advanced transit consultants. The issues considered include:

- Locate stations adjacent to key trip generators
- Circulate patrons easily between all existing attractions and planned development
- Make efficient use of land area, minimize the need for additional parking
- Open up land currently dedicated to parking for denser development
- Link remote parking facilities
- Plan for future expansion to regional transit, and expansion of system to different land uses (for example residential and office space)
- Allow the development to grow to a 5-7 day resort destination (up from the present one to two day visits), by seamlessly linking attractions.

Several concepts were rendered, a target layout (see Figure 9) was adopted that took into account the issues listed above, plus feedback from stakeholders to be used for simulation, cost estimate and ridership studies. The analysis results from this targeted layout should be representative of any guideway layout that meets the design objective. The selected target layout is shown in Figure 5. Notable aspects of the layout include:

- Links all existing development
- Provides for future development (areas in dark green)
- Constructed in a series of loops, conforming to PRT design concepts
- Layout encompasses 10 miles of guideway and 26 stations
- Links to planned regional transit (BRT station shown in yellow)
- The Kansas Speedway is not served directly (as per feedback from developers on nature of race day traffic.)

The proposed layout links all existing attractions except the speedway. Stations are designated either directly at the entrance of existing facilities, or with the assumption that the station would be integrated into the current structure. The routes were chosen to not only link attractions with parking, but also to efficiently open up additional areas for development. The layout provides for efficient access of the

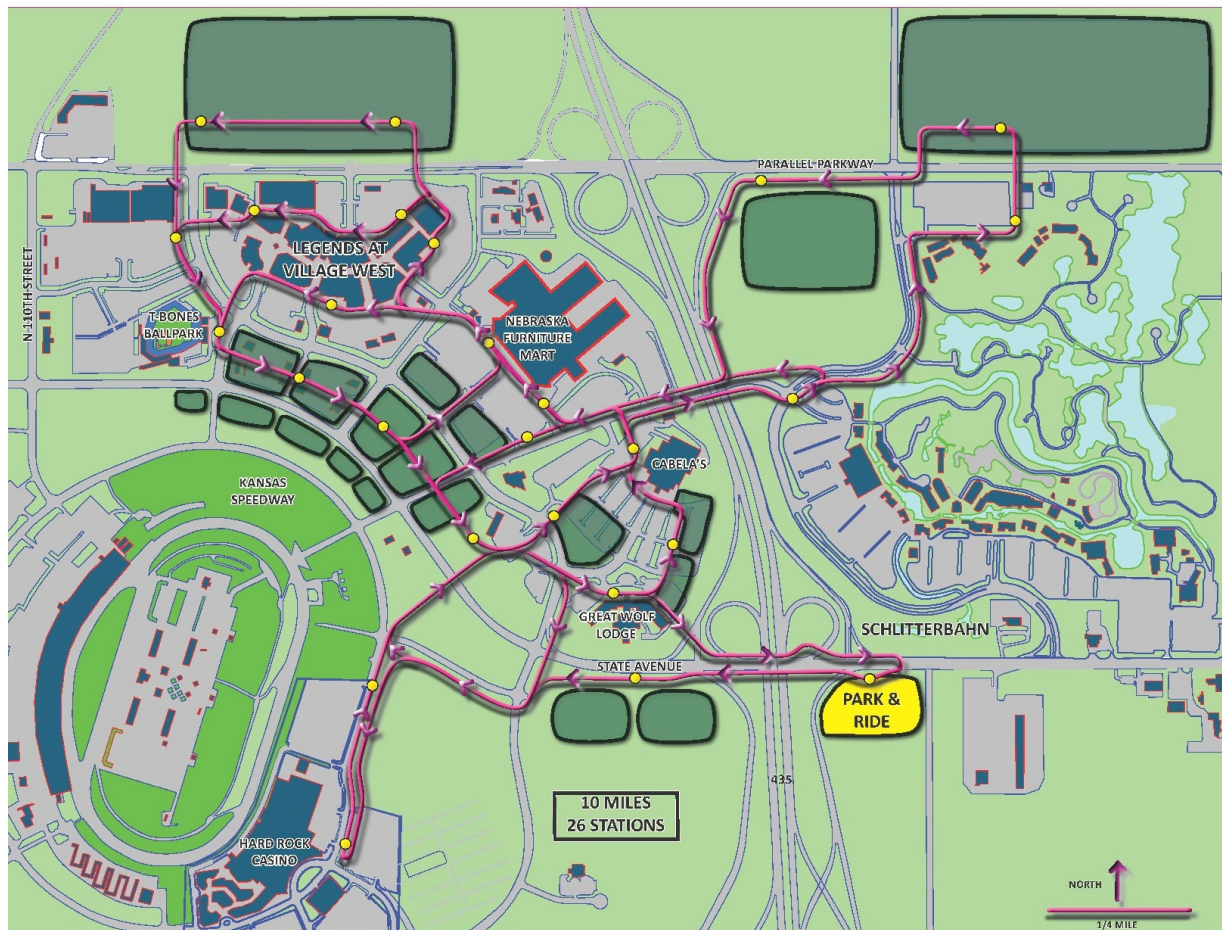


Figure 9. Target PRT Layout Plan.

entire complex with stations at all major attractions, allowing patrons to park once and enjoy multiple attractions with relative ease.

Note that, as is typical for PRT, the guideways are mostly laid out in one-way loops rather than two-way corridors. This allows the system to serve a wider area. Connecting loops are provided where necessary to avoid excessive out-of-the-way travel.

It may be desirable to develop a PRT system in phases. Most PRT systems can also be easily expanded to meet growing demands. Figures 10 and 11 depict alternative layouts that were considered and that illustrate this concept.

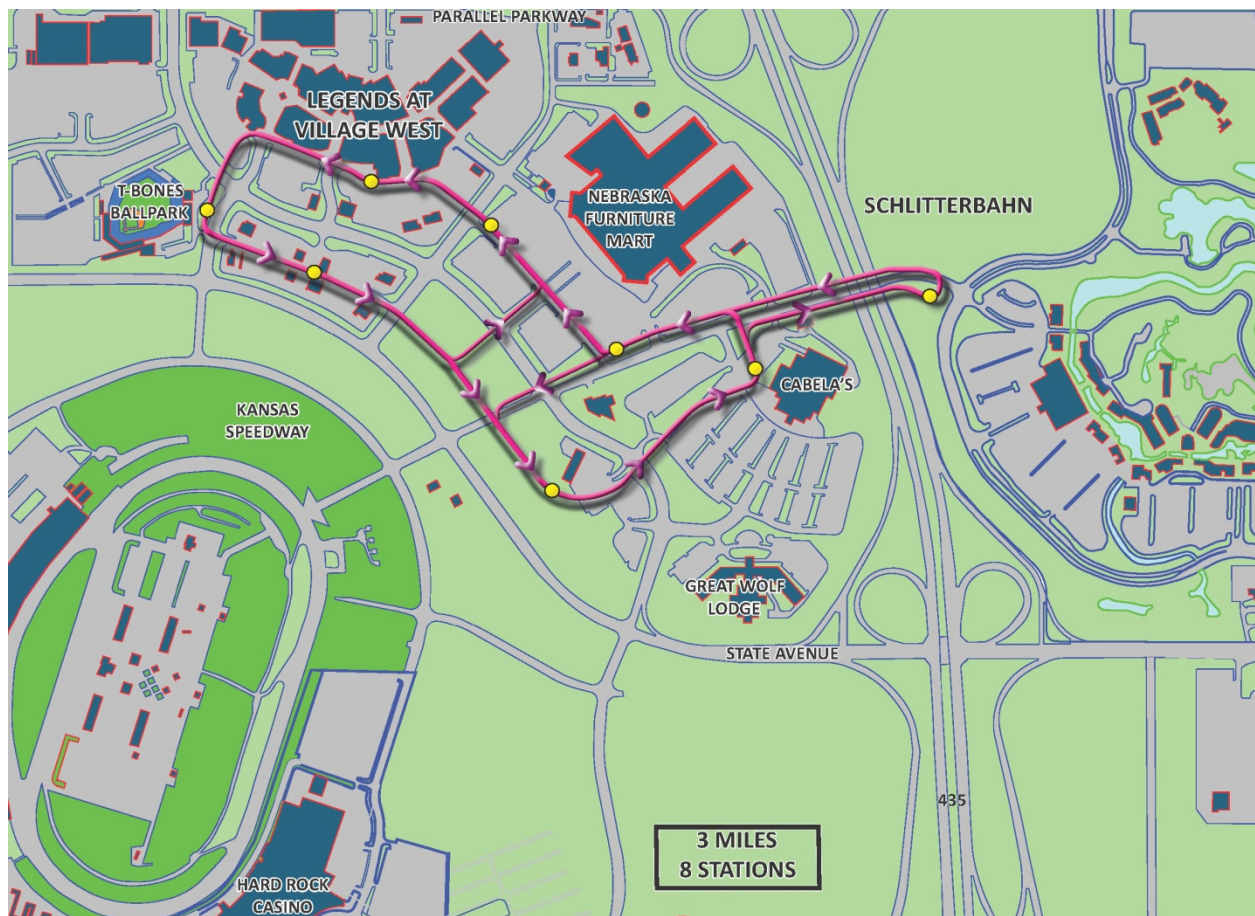


Figure 10. Possible Initial Layout Plan.

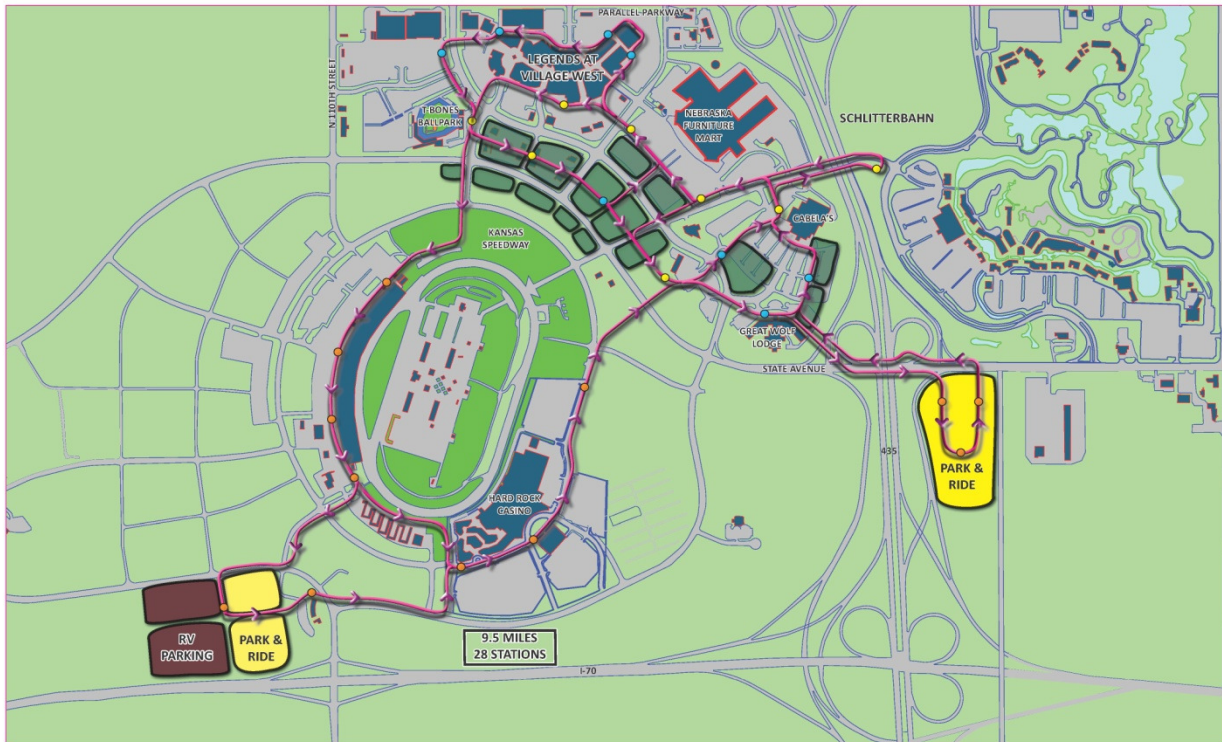


Figure 11. Alternative layout Plan.

Ridership Estimates

Ridership estimates were determined by Dean Landman, P.E., President of LTR, P.A. whose report is attached as Appendix B. The results are summarized here.

A previous report by Schlitterbahn had estimated ridership for a monorail system at 25% of visitors. This figure was used for stations serving the Schlitterbahn complex but was thought to be too high for the remaining stations where 20% was used. The State Avenue Park and Ride facility was an exception where it was assumed all 2,000 daily riders would use the PRT system.

Distance and travel times on the system are all relatively short and, instead of using a conventional urban area gravity model, it was decided to distribute the trips among the stations based on their proportion of total riders to all stations. In other words, the ridership was highest between station pairs that each had high trip generation.

Other assumptions:

- Boarding time was assumed to be one minute
- Off-loading time was assumed to be 30 seconds
- The running speed on the system was assumed to be 23 mph as a weighted average between a design speed of 25 mph for most of the system and 20 mph for some of the sharper curves.
- Peak demand would be 150% of the average hourly demand

Using these parameters, the model estimated daily ridership of the system to be 5.7 million annual trips and 15,519 trips per day. Peak hour ridership was assumed to be 10.5% of the daily ridership or 1,641 trips. Factoring by the average vehicle occupancy rate of 1.37, results in 1,200 peak hour T-Pod trips and 4.1 million annual revenue T-Pod trips.

A full four-step modeling process was beyond the scope of this analysis. Previous ASVT research (6) conducted at Kansas State University (KSU) and using the KSU campus as the study location included a full modeling process. In that process, complex student and faculty origin and destinations trip matrixes obtained from registrar records were distributed across a network containing road, pedestrian and advanced transit networks. A primary finding was the sensitivity of wait time to ridership. Transit system wait times of 3 minutes or shorter were required to begin to compete with automotive travel and draw significant ridership. The relationship between wait times and resulting ridership from the KSU effort were observed and applied when estimating the ridership in the Legends study.

PRT System Requirements

Based on the previous two sections, the requirements for a PRT system serving The Legends at Village West have been determined. The CityMobil PRT simulation program was used in order to verify system operation and determine the number of T-Pods necessary to transport peak hour passengers with waiting times of less than one minute and to estimate the number of station bays necessary at each station. In order to reduce construction costs, a rough estimate was made of those areas where it was thought the PRT guideway could be built at grade.

Guideway. 7.1 miles one-way elevated, 2.6 miles one-way at grade.

Stations. A total of 26 stations are required with the following breakdown:

- Three 2-bay at-grade
- Seventeen 2-bay elevated
- Two 3-bay elevated
- One 4-bay elevated
- Three 5-bay elevated

T-Pods. 150 T-Pods are needed. This includes those serving peak hour needs and a ten percent allowance for those under repair and maintenance. While the T-Pod average occupancy is only 1.37, the facility is family oriented, and T-pods should be capable of accommodating two adults and three to four children. In addition, they should be ADA compliant and capable of accommodating one wheelchair and an attendant.

Operating Speed. An operating speed of 25 mph has been assumed. This results in an average travel time of under 4 minutes and a maximum travel time of about 6 minutes. It seems likely that an adequate level of service could be provided at a lower speed. However, a lower speed would require more T-Pods and might not prove adequate should the system be expanded in the future. An operating speed of not less than 20 mph is recommended.

All-Weather Operation. While this system is not critical to the functioning of The Legends at Village West, it should be reasonably resistant to adverse weather conditions. The system should be able to operate in moderate wind, rain and snowfall conditions. A reasonable requirement for availability might be 99.7% (this is much higher than transit level of service A) during good weather and not less than the availability of the State Avenue BRT system during adverse weather.

Land Use Impacts

The landscape architecture company of Patti Banks Associates facilitated a project team workshop where land use impacts were explored. The team explored how the site could be redeveloped if a PRT system was added to the existing development. They also explored how the site could have been developed differently had it incorporated PRT from the beginning. This section outlines the workshop results and provides rough estimates (due to limited resources) of their financial impacts.

Assuming the demand exists, Figure 6 shows how the site could be redeveloped after the PRT system is constructed. Approximately 12 acres of existing parking could be moved offsite and redeveloped as additional commercial development. Another 6 acres of existing commercial development could be redeveloped to a higher density.

Table 1 shows that land sale prices in the area have averaged \$338,628 per acre since 2002. Assuming that redeveloping the 18 acres, as described above, generates an increase in value of half this amount, results in a one-time benefit of approximately \$3M.

Table 1. Land Sales Data

Property Location	Name of Project	Year Sold	Site Area (AC)	Total Sale Price of Land	Price per Acre
1400 Village West PKWY	Hampton Inn Site	12/31/2002	3.71	\$725,000	\$195,418
1702 Village West PKWY	Arthur Bryant BBQ Restaurant	9/30/2003	1.38	\$250,415	\$181,460
1931 Prairie Crossing	Holiday Inn Express Site	11/30/2004	2.59	\$1,129,110	\$435,950
SEC of Parallel PKWY & I-435	Assemblage for Schlitterbahn Waterpark	9/30/2006	209.67	\$53,839,326	\$256,781
1805 North 110 th Street	Country Inn & Suites Site	12/31/2006	2.22	\$1,500,000	\$675,676
10920 Parallel PKWY	Candlewood Suites Site	1/31/2007	2.53	\$900,000	\$355,731
East Side of Hutton Rd., N. of Parallel PKWY	Hotel Site	8/30/2007	2.71	\$810,000	\$298,893
NWQ Parallel PKWY & I-435	Assemblage for Plaza at the Speedway	9/11/2007	92.23	\$28,509,686	\$309,115
Total					\$2,709,024
Average					\$338,628

According to Schlitterbahn, the currently developed Legends area (300 acres) generates \$659M in annual sales (i.e. a rate of \$2.2M per acre). The annual sales tax of this additional 18 acres of development is, thus, estimated to be \$39M (18 acres x \$2.2M). Since additional development could occur in adjacent areas without a PRT system, only 10% (\$3.9M) of this additional sales tax has been

attributed to the PRT system. In addition, Schlitterbahn estimated a monorail would increase annual sales taxes for all of the facilities in the area (including the speedway and Schlitterbahn itself) by \$8.8M. Since the PRT system will provide a higher level of service, this assumption should hold true for it also. Thus, the total annual increase in sales tax in the Legends area, due to the PRT system, is estimated at \$12.7M.

The PRT system will also serve approximately 390 acres of development north of Parallel parkway and in the southeast quadrant of the Parallel Parkway/I-435 interchange. Assuming these developments will generate sales tax at similar rates to those in the Legends area, and that the PRT system will also boost these sales taxes by ten percent, the additional sales taxes due to the PRT system are \$6.4M. Thus, the total annual sales taxes, due to the PRT system, are estimated to be \$19.1M.

Figure 7 depicts how the site could have been developed had PRT been incorporated into the design from the start (Figure 8 shows an alternative configuration). It shows that the site could have been developed to present levels on a total of 233 acres (including park and rides on State Avenue and Parallel Parkway) in place of the 300 acres actually needed. At \$338,628 per acre, this would have saved \$22.7M in land costs alone. Additional savings of \$5.7M (estimated at 25% of land costs) would also have accrued from the reduced need for roads and utilities.

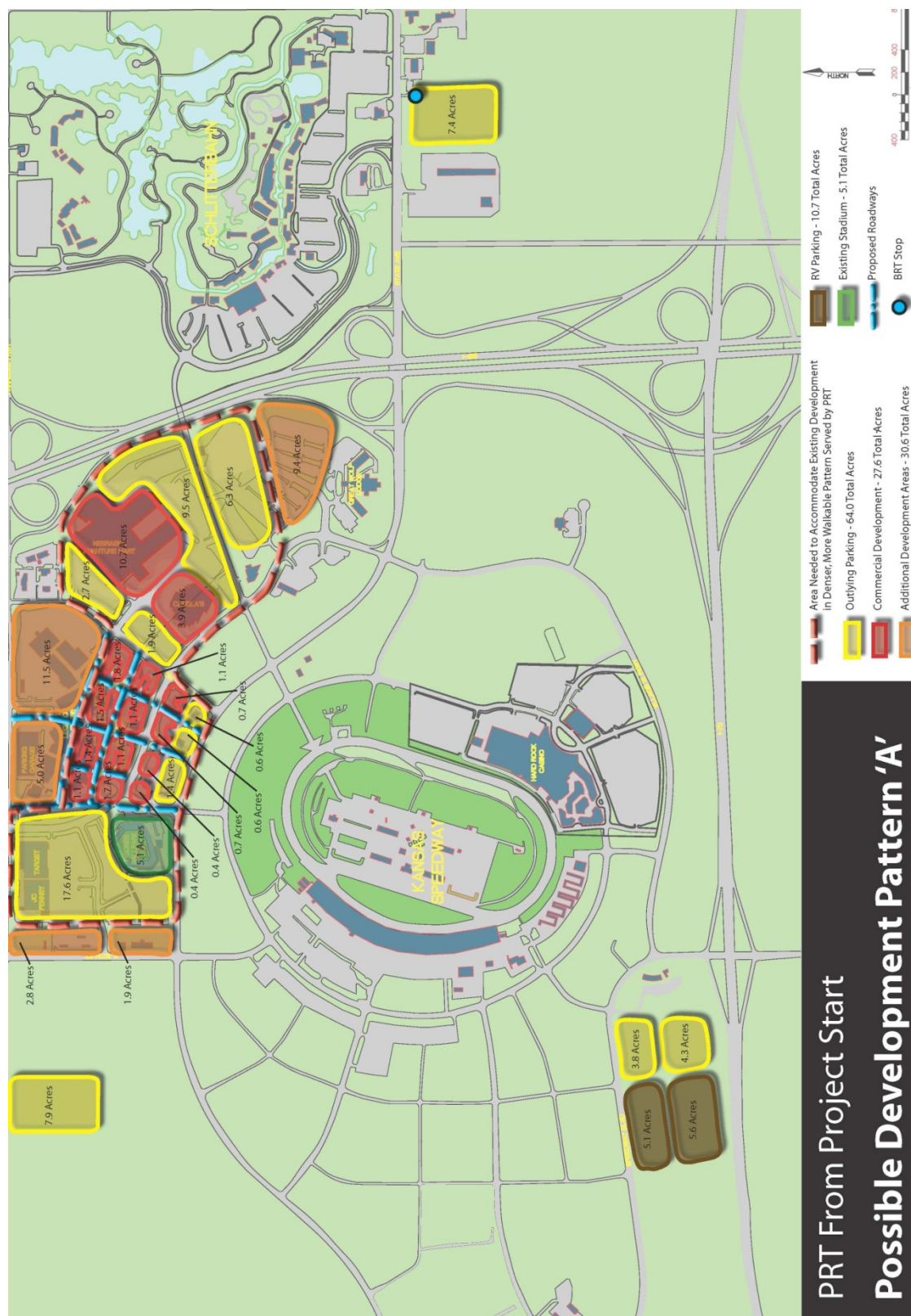
If the additional area, within the existing footprint now available for development (30.6 acres), were developed, it would generate an additional \$67.2M in annual sales tax. Most of this development would have been directly enabled by the PRT system (assuming the demand for it exists). We have assumed the PRT system to be responsible for 50% (\$33.6M) of this sales tax increase. This is in addition to the \$8.8M increase discussed above.

In summary, if a PRT system were retrofitted to the site it could provide a benefit of \$3M in land values. It could also boost sales tax revenues by \$12.7M annually.

If PRT had been incorporated into the site design from the beginning, the site could have been developed for approximately \$28.4M less cost for land, roads and utilities (ignoring the cost of the PRT system). If the site were fully developed, it would generate \$42.4M more annual sales tax, attributable to the PRT system, than it does now. See Table 2 for a summary of these results.

Table 2. Summary of Approximate Land and Tax Benefits.

	PRT Retrofitted to Site	PRT Incorporated from Start
Redevelopments of Land	\$3.0M	
Sales Tax Increase	\$19.1M	\$42.4M
Savings in Land Cost		\$28.4M
Approximate Land & Tax Benefit	\$22.1M	\$70.8M



Code Compliance

Code compliance was investigated by the University of Kansas (KU) (see Appendix C) and BG Consultants, Inc. (BG Consultants) (see Appendix D).

A review of applicable environmental and related code compliance issues was conducted by KU to explain the process that would need to be addressed, in order to complete any needed Environmental Assessment, Environmental Impact Statement, as well as any local permits that might be needed in order to get approval to construct an automated small vehicle transit system at the Kansas Speedway area. A synopsis of the report follows.

The primary law governing the environmental protection process is the National Environmental Policy Act of 1969, or NEPA (1). The NEPA meets compliance with each federal law and regulation by requiring preparation of an Environmental Impact Statement (EIS) for all major federal projects that may significantly affect the environment. Core provisions of the NEPA include three primary mandates:

- “To the extent possible, policies, regulations, and laws of the federal government must be interpreted and administered in accordance with NEPA;
- Federal agencies must use an interdisciplinary approach in planning and decision making that impacts the human and natural environment; and
- The preparation of an EIS is required on all major federal actions that may significantly affect the human or natural environment.”

Any federal assistance will likely result in the need to develop an Environmental Impact Statement (EIS). The EIS covers three primary areas: Air Quality, Noise and Vibration, Social and Economic Impacts. Note that when a proposed project does not include significant displacement of housing, is located on a single site, doesn’t disrupt major business activity, and is compatible with area land use, economic impact will be minor and will not require extensive economic analysis. No environmental impacts were identified as potentially contentious for an EIS; in fact, the environmental benefits in most areas are obvious. However, the EIS process itself is a time consuming and costly process, which could add significantly to the time line and budget of any proposed PRT system.

BG Consultants investigated the governing agencies and codes compliance for building the PRT system. They determined that the main governing agencies applicable are the Unified Government of Wyandotte County and Kansas City, KS, the Regional Transit Authority and, since some of the guideways cross state highways, the Kansas Department of Transportation (KDOT).

Mr. Fred Backus, Wyandotte County Engineer, stated the county uses KDOT and AASHTO standards for bridges built in Wyandotte County. In addition to this, any bridge structure that exceeds \$200,000 in construction costs must be reviewed and approved by KDOT.

Structural Considerations and Cost Estimates

As outlined in more detail in Appendix D, BG Consultants performed a structural study to determine the governing codes for building the guideway for a proposed Personal Rapid Transit System (PRT) in the area. The study focused on the compliance of the Cardiff Network guideway for the ULTra PRT system, as designed by Advanced Transportation Systems Ltd. (ATS Ltd.). Code governance is determined by jurisdictional authority. The project being located in Kansas City, Wyandotte County, Kansas falls under the Wyandotte County public works. Wyandotte County uses KDOT and AASHTO standards for bridges. Additionally, regulations require any bridge structure that exceeds \$200,000 be reviewed and approved by KDOT.

Cardiff Network Guideway Design Review

The Cardiff Network guideway structure consists of longitudinal spanning side beams and cross members, all in standard rolled sections. The surface for the rubber tired vehicles is constructed of pre-cast concrete planks, approximately 4 in. (95mm) thick with nominal reinforcement (1). The spans for this track are 18m (approx. 59') long. This results in a very elegant and trim design.

The KDOT bridge unit performed a review of the Ultra design for conformance to KDOT and AASHTO standards. The review cited two main concerns with this design, related to non-redundancy and the presence of fracture critical members.

1. Structural redundancy allows the bridge to continue to carry loads after the damage or the failure of one of its members. *AASHTO LRFD Bridge Design Specifications, Interim 2005*, states “Multiple-load-path and continuous structures should be used unless there are compelling reasons not to use them”.
2. A fracture critical member (FCM) is defined as a tension member, or a tension component of a member, whose failure would be expected to result in collapse of the bridge. In 1978, guidelines for design went into effect, placing a more stringent set of criteria for design, manufacture and inspection of Fracture Critical Members (FCMs).

As stated in the *NCHRP Synthesis 354*, “International scanning tours for bridge management and fabrication have noted that Europe does not have special policies for FCMs. A risk based approach, coupled with more rigorous three-dimensional analysis techniques, is used to ensure that a sufficient level of structural reliability is provided. Consequently, steel bridge designs that would be considered fracture-critical in the United States are still commonly built without prejudice in Europe. At this time, the governing codes used in the United States and Kansas put stringent (and costly) requirements on FCM based designs.”

In considering the Cardiff Network guideway design as presented, both redundancy and fracture critical conditions are noted:

- The two longitudinal spanning side beams are made from standard rolled steel sections. These beams would be considered both non-redundant and fracture critical. When a two member bridge system is compromised, by loss of one load bearing member, there is no load path redundancy.
- Because the Cardiff Network system would be considered non-redundant and fracture critical, it would require fracture critical inspection. The rolled steel design would be difficult, if not impossible, to inspect for internal corrosion.

Due to the current design philosophy in the United States and in Kansas, the Cardiff Network guideway design, as presented, would not be allowed as a PRT guideway in the Village West development without significant justification and/or mitigation of the above concerns.

Alternative Inverted “T” Guideway

A viable alternative to the Cardiff Network guideway would be a pre-stressed concrete inverted T-beam structure. The inverted T-beams are placed side by side across the width of the structure. The concrete deck is formed directly on the web of the beams with falsework that is left permanently in place. Concrete curbs/parapet would provide the required guide-way safety. Once the deck is cured, the beams and deck become a composite structure with continuous beams. The underside of the inverted T-beam structure is completely enclosed, leaving a smooth, finished appearance. Between the webs of the beams is a void area which can house any mechanical or electrical elements needed to run the PRT system. Openings for manholes and junction boxes can be provided for easy access to any systems within the T-beam voids. A simple diagram of such a structure is shown in Figure 2, Appendix D.

Cost Estimates

BG Consultants estimated the construction costs for guideways and stations (see Appendix D). Their estimates are summarized in Table 3 below.

Table 3. Guideway and Station Cost Estimates

Item	At-Grade	Elevated
Guideway/mile	\$1,330,000	\$4,400,000
2-bay Station	\$48,000	\$362,000
3-bay Station	\$69,000	\$465,000

Using the above estimates, and applying them to PRT Consulting’s cost model for the PRT system requirements outlined earlier, a total capital cost of \$137M was determined for the system, including guideways, stations, T-Pods, control system, maintenance facility and a 30% contingency allowance.

The annual operating and maintenance costs are estimated at \$4.3M. The annualized capital cost, at 5% over a system life of thirty years, is \$12.6M. This results in total annual costs of \$16.9M for capital, plus operations and maintenance.

Benefit-Cost Analysis

KU estimated that the PRT system could realize annual societal benefits totaling \$5.2M, including \$3.6M savings in vehicle use costs, \$0.56M in environmental costs and \$1.05M in accident costs (see Appendix E). It was previously estimated that the system would result in an additional \$19.1M in sales tax. The societal benefits of the increased business, resulting in this increased sales tax, are thought to be significant and have been estimated to be equivalent in value to the sales tax (i.e. another \$19.1M in societal benefits). The total annual societal benefits, thus, equal \$43.4M. Since the total annual costs were estimated at \$16.9M, the benefit/cost ratio is 2.57 and the project seems, quite clearly, worth more than it costs.

Table 4. Summary of Approximate Benefits

Vehicle Use Cost Savings	\$3.60M
Environmental Cost Savings	\$0.56M
Accident Cost Savings	\$1.05M
Additional Sales Tax	\$19.10M
Societal Benefits of Additional Sales Tax	\$19.10M
Total Approximate Benefits	\$43.41M

Financing

Finance options, like the structural guidelines, are affected by state and local legislation. The State of Kansas instituted a unique system, to encourage the development of significant projects that can impact the economic vitality, on a region in Kansas or the State as a whole. The system, called STAR bonds for Sales Tax and Revenue bonds, enables eligible government units to bond infrastructure improvements that will enhance the economies in their communities, and retire the bonds through state and local sales tax revenue. STAR bonds were instrumental in the financing of the road and parking infrastructure that serves the existing Village West development.

It has been previously shown that the increase in sales tax, due to the PRT system, will be in the order of \$19.6M per year and that the annualized capital and operating cost of the PRT system will be approximately \$16.9M. If the capital costs are amortized over ten years by STAR bonds at 5%, the annual costs will be \$17.43M. Since the O&M costs are estimated at \$4.3M per year, this will result in an annual shortfall of \$2.13M. This shortfall can be covered by charging a mere \$0.52 per T-Pod trip for the estimated 4.1 million annual revenue T-Pod trips.

While the above analysis appears quite favorable, it must be appreciated that it is a simplistic analysis based on many assumptions. Much more detailed investigation is needed to determine the financial feasibility of this project.

Conclusions and Recommendations

The PRT system described in this report could provide significantly improved surface transportation services in and around the Village West development. These services would be available to the handicapped and those without access to automobiles (elderly people and children) as well as to the general public. Those using public transit to access the area will have improved access to different portions of the area with a reduced requirement for walking. These improved services are anticipated to bring numerous benefits to the community. More people are expected to access the area by transit. People will be able to park their cars once and then use the system to visit different facilities. Families will be able to split up and enjoy different forms of entertainment simultaneously. It is anticipated that people will extend their stays and spend more money.

In addition to the quality of the experience being improved, safety will also increase. At the same time, it will be possible to make better use of existing parking facilities, thus allowing more dense development which will itself promote walk-ability.

The system was found to be both technically and financially feasible and the benefits were found to significantly outweigh the costs. No environmental concerns are anticipated and a number of environmental benefits should accrue. Had the PRT system been incorporated in the design of the development from the start, it would have been even more beneficial.

It is recommended that further, more detailed, investigations into the viability of this system be undertaken. In addition, the potential for obtaining Federal funding for the capital costs should be investigated.

References

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3. <http://www.2getthere.eu/>
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5. <http://www.taxi2000.com/>
6. Young, S.E., et al Travel Demand Modeling of Automated Small Vehicle Transit on a University Campus

Appendices

- A. A Review of Literature on Automated Small-Vehicle Transport Technologies
- B. Village West Development Ridership Estimates
- C. A Review of Code Compliance Issues for a Proposed Automated Small-Vehicle Transport System at the Kansas Speedway Area
- D. Code Compliance and Structural Cost Estimates for Automated Small Vehicle Transportation near Kansas Speedway
- E. Environmental Benefit-Cost Analysis for the Proposed Personal Rapid Transport System at the Kansas Speedway Area

APPENDIX A

A Review of Literature on Automated Small-Vehicle Transport Technologies

APPENDIX B

Village West Development Ridership Estimates

APPENDIX C

A Review of Code Compliance Issues for a Proposed Automated Small-Vehicle Transport System at the Kansas Speedway Area

APPENDIX D

Code Compliance and Structural Cost Estimates for Automated Small Vehicle Transportation near Kansas Speedway

APPENDIX E

Environmental Benefit-Cost Analysis for the Proposed Personal Rapid Transport System at the Kansas Speedway Area