CONNECTOR

Ann Arbor Connector Study

Conceptual Engineering Basis of Design

FINAL DRAFT

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Prepared by URS Corporation

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1.0 INTRODUCTION

This report documents the proposed Basis of Design for conceptual engineering of the Ann Arbor Connector. Presented herein are basic design parameters and assumptions that will, as appropriate, form the basis of the civil, track, systems, structural, and utility engineering design effort. The transit modes documented include light rail/streetcar, bus rapid transit, and elevated guideway transit.

The objective is to deliver conceptual engineering consistent with nationally accepted practices and existing local standards within the established project goals. The criteria herein are presented in an abbreviated form for higher level decision making. It is important that the assumptions stated in this document be reviewed and concurrence obtained to avoid miscommunication; an early consensus is also important to avoid impacts to the project design cost and schedule. This Basis of Design has been developed using information received from URS's experience with transit projects in urban environments similar to those found in the project area and various design guidelines that are referenced, where applicable. This is intended to be a "living document" and upon entering advanced engineering efforts, the Basis of Design should be developed further and reevaluated to ensure that it remains consistent with the project goals and the desires of the project team.

2.0 OTHER PROPOSED PROJECTS

There are two commuter rail studies underway in the Ann Arbor area that would provide regional rail connections between Ann Arbor and other parts of Southeast Michigan while using existing rails and tracks. These projects are the Ann Arbor – Detroit Regional Rail Project and the Washtenaw and Livingston Line (WALLY). The Ann Arbor – Detroit Regional Rail Project will provide regional rail service in the Ann Arbor – Detroit corridor and the WALLY is a proposed north-south commuter rail service between Ann Arbor and Howell. The end points for the service (Ann Arbor and Howell) are located in Washtenaw and Livingston Counties.

In order to meet demand, the Ann Arbor Transportation Authority is reconstructing the existing Blake Transit Center. This project involves demolishing the existing one-story building and constructing a new two-story transit center that will serve as the main downtown hub. This new center is estimated for completion in Fall 2013.

Additionally, the City of Ann Arbor is currently studying options for a new Amtrak station to be located in the city.

3.0 LIGHT RAIL/STREETCAR

Although both are fixed guideway transit mode options, light rail and streetcar will be discussed separately, where applicable, to distinguish the similarities and differences between these modes.

Light Rail Transit (LRT) is a moderate to high capacity transit system operating in two to three car trains with power provided by overhead wires. LRT can provide adequate passenger capacity for Ann Arbor and is appropriate for an urban environment with stops located at one-quarter to one mile distances.

Streetcars generally operate as single cars with power provided by overhead wires and are intended for shorter trips with frequent stops. Streetcars can provide adequate passenger capacity for Ann Arbor with frequent service and are appropriate for an urban environment with stops located at one-quarter to one mile distances.

3.1 Vehicle Assumptions

Light Rail Transit

A typical LRT vehicle is shown in the figure below:

Figure 3.1
Typical LRT Vehicle

Source: Siemens S70 Light Rail Vehicle Specifications

As noted above, LRT generally operates in two or three car trains. Assumed values for various LRT vehicle specifications are shown in the table below:

Table 3.1
LRT Vehicle Specifications

Specification	Details
Turning Radius	82 feet
Vehicle Width	8.7 feet
Vehicle Length	93.6 feet per car
Speed	20-35 mph (average) 66 mph (maximum)
Passenger Capacity	68 seats 230 passengers per car
Boarding Height	14 inches
Grade	7%

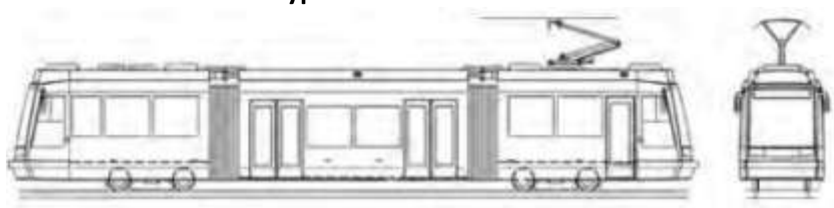
Source: Siemens S70 Light Rail Vehicle Specifications

LRT vehicles will require a larger turning radius than buses or large trucks. Buses or trucks generally require a turning radius between 40-45 feet, while LRT requires 82 feet. A larger turning radius is less likely to be compatible with the existing Ann Arbor street system, especially in the downtown area.

Streetcar

A typical streetcar vehicle is shown in the figure below:

Figure 3.2
Typical Streetcar Vehicle



Source: URS/City of Portland – "Why Streetcars?"

Assumed values for various streetcar vehicle specifications are shown in the table below:

Table 3.2
Streetcar Vehicle Specifications

Specification	Details
Turning Radius	82 feet mainline 66 feet yard/storage track
Vehicle Width	8.0 feet (typical)
Vehicle Length	66-82 feet
Speed	20-35 mph (average)
Passenger Capacity	30-60 seats 115-150 passengers
Boarding Height	14 inches
Grade	6% (sustained) 7% (< 1/4 mile)

Source: Crystal City Streetcar Project Conceptual Engineering Basis of Design

As with LRT, streetcar vehicles will require a larger turning radius than buses or large trucks (82 feet for streetcars and 40-45 feet for buses or large trucks). A larger turning radius is less likely to be compatible with the existing Ann Arbor street system, especially in the downtown area.

It should be noted that there is overlap in vehicle types that might be considered streetcar or LRT. For the purposes of this study, it is assumed that LRT refers to a two or three car train while streetcar refers to a single car. While the dimensions noted above would indicate that streetcars are generally narrower and shorter than LRT vehicles, this is not the case for all vehicle manufacturers. There are wider and longer streetcars and narrower and shorter LRT vehicles. In the Ann Arbor Connector Feasibility Study (2011), LRT was assumed to operate as 2- or 3-car trains and streetcar was assumed to operate as a single vehicle. Based on preliminary potential peak hour capacity analysis, streetcar could meet the design capacity operating on headways of 2 minutes. A 2-car LRT would provide the necessary capacity with 5-minute headways and a 3-car LRT would provide the necessary capacity with 10-minute headways.

3.2 Roadway and Civil Design Approach

For shared auto/transit lanes, a width of 12 feet is desirable with a recommended minimum of 10 feet. In transit-exclusive alignments where LRT or streetcar is operating by itself, the minimum lane width will be based on the operating characteristics of the design vehicle, which has an assumed width of 8.7 feet for LRT and 8.0 feet for streetcar.

As surface-based transit systems, LRT and streetcar could add impervious surface area which would require mitigation for the additional surface runoff. The extent of mitigation required will be calculated as design progresses.

Americans with Disabilities Act (ADA) accessibility must be maintained or introduced regardless of the selected transit option. Pedestrian and bicycle facilities along the project corridor will be evaluated during the design process to determine if upgrades are required to meet ADA guidelines. Necessary upgrades to sidewalks, ramps, and crosswalks at intersections and other affected locations throughout the project corridor will be included as part of this project.

3.3 Track Elements

All LRT and streetcar track for this project is assumed to consist of rail embedded in concrete that will allow buses or other autos to operate in shared lanes, if necessary. There are numerous designs for light rail and streetcar embedded track structures in use through the country. The design of the track slab will ultimately depend upon factors such as the choice of rail section, local soil conditions, pavement design life expectations, and the potential for spanning utilities. The standard rail gauge of 4 feet, 8.5 inches will be assumed for this project.

3.4 Station Design Approach

Typical LRT stops may be anywhere from 90-270 feet in length, depending on the number of cars needed to accommodate passenger demand. Streetcar stops will be approximately 75-90 feet long, depending on the vehicle selected. With both LRT and streetcar, platforms will need to be long enough to permit boarding from all doors on the vehicle. LRT and streetcar stops are generally spaced 1/4 mile to 1/2 mile apart. ADA compliance is required for all stations and canopies or shelters are anticipated over the platform area, in addition to other potential passenger amenities.

Compared to elevated guideway transit, LRT and streetcar stations are less complex and have lower construction costs due to the fact that the stations are generally constructed at ground level and would not require elevators or other structure.

3.5 Typical Systems Elements and Design Approach

LRT and streetcar operate on DC electric current supplied from Traction Power Supply System (TPSS) substations by an Overhead Contact System (OCS). The final size and spacing of the substations will require a detailed analysis based on the selected vehicle, frequency of service and headways, track alignment profile, passenger stations, and the speed and load cycle over specific time intervals. This information will determine the actual utility power demands. Typical loading requirements require substations spaced at approximately half-mile intervals on wired sections of the alignment. The substations can be located in several locations along the alignment, including parking structures, at-grade in adjacent parcels, in the maintenance yard/shop area, or in underground vaults.

Several types and sizes of substations are available for use. The most cost effective substations are prefabricated traction power units. If required, these units can be enhanced with architecturally designed external finishes. In addition to space and location, other factors to be considered include security and accessibility, ease of replacement/installation of equipment, and proximity to utility feeders and street feeder pole locations.

The LRT and streetcar OCS will be an unobtrusive design consisting of a trolley wire supported by poles and cantilever brackets designed to be architecturally compatible with the streetscape. The trolley wire will provide power to the vehicle pantograph (arm). Supporting poles will be spaced approximately 80-120 feet along tangent sections, with reduced spacing at connections and curves.

In order to meet the National Electric Safety Code (NESC), the overhead wire must be at least 18 feet above the pavement with shared lanes. If there are any cases where the 18-foot clearance cannot be obtained, the LRT or streetcar should be in an exclusive lane or special approval will be necessary.

3.6 Right-of-Way

While it is recommended that LRT and streetcar have an exclusive guideway, the vehicles are capable of operating in semi-exclusive alignments or in shared lanes with automobiles. In shared lanes, LTR and streetcars should flow with traffic. Crossings are possible since LRT and streetcar are not grade-separated. By industry standards and the Manual on Uniform Traffic Control Devices (MUTCD), the design speed shall not exceed 35 mph on all routes where transit operates within the existing roadway and is only controlled by traffic signals.

3.7 Utility Conflicts and Relocation

Utility conflicts and relocation associated with LRT or streetcar right-of-way can be a major cost and there is specific concern with pressurized utilities such as water or gas mains and inherent clearance issues associated with the LRT and streetcar overhead wires. It is recommended that all utilities crossing under the proposed LRT or streetcar be encased. Encasing utilities will allow utility companies to access their facilities without disrupting transit operations.

The methodology for identifying potential utility conflicts with the transit system and addressing relocations, rehabilitations, other utility adjustments, or the procedures for maintaining utilities in place will need to be developed as design progresses.

3.8 Traffic

The implementation of LRT or streetcar service within existing streets in Ann Arbor will require evaluation and, likely, adjustments to traffic operations and traffic signals. In most cases, typical LRT and streetcar operation is similar to that of other vehicles in shared lanes, with no additional traffic signal heads required unless a transit-only phase is used and incorporated into the signal operation. This would typically occur if operating in a transit-exclusive lane or if a separate phase is needed to transition from an exclusive lane into a shared lane. As there are many intersections in the downtown area, traffic signals will be impacted. Typically, any signal equipment located over the LRT or streetcar guideway will need to be removed in order to provide adequate clearance for the overhead wire. It is assumed that Transit Signal Priority (TSP) will be used for the Ann Arbor Connector. TSP helps ensure transit travel time reliability by adjusting traffic signal phasing to give a green signal for transit vehicles that are approaching, minimizing the amount of time that they are stopped at intersections. Traffic operational details will be developed in future phases of the design.

3.9 Structural Evaluation Approach

Structures such as bridges may be required for surface transit modes, but compared to elevated guideway modes, LRT and streetcar will require significantly fewer structures. Additional structural analysis will be required in future phases of the design.

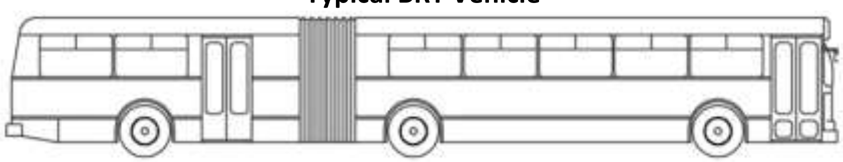
4.0 BUS RAPID TRANSIT

Although standard bus service is meeting the current transit demand in Ann Arbor and is appropriate, the current system is operating near- or at-capacity and cannot accommodate future needs. Bus Rapid Transit (BRT) is an integrated system of facilities, services, and amenities that collectively improves the speed, reliability, and identity of bus transit. BRT generally operates with frequent service, can provide adequate passenger capacity for Ann Arbor, and is appropriate for an urban environment.

4.1 Vehicle Assumptions

A typical BRT vehicle (articulated bus) is shown in the figure below:

Figure 4.1
Typical BRT Vehicle



Source: AASHTO – A Policy on Geometric Design of Highways and Streets

Assumed values for various BRT vehicle specifications are shown in the table below:

Table 4.1
BRT Vehicle Specifications

Specification	Details
Turning Radius	40 feet
Vehicle Width	8.5 feet
Vehicle Length	60 feet
Speed	25-40 mph (average)
Passenger Capacity	100-120 passengers
Boarding Height	14 inches
Grade	6-8%

Source: AASHTO – A Policy on Geometric Design of Highways and Streets and TRB – Bus Rapid Transit Practitioner's Guide

BRT vehicles will require a much smaller turning radius than LRT and streetcar vehicles. These vehicles require a turning radius of 82 feet, while standard articulated buses require only 40 feet. This smaller turning radius is much more likely to be compatible with the existing Ann

Arbor street system, especially in the downtown area. In the Ann Arbor Connector Feasibility Study (2011), BRT was assumed to operate operate as a single vehicle. Based on preliminary potential peak hour capacity analysis, articulated buses could meet the design capacity operating on headways of 2 minutes.

4.2 Roadway and Civil Design Approach

Dedicated BRT lanes, like standard auto/transit lanes, have a desired width of 12 feet, with a recommended minimum of 11 feet. This is based on the assumed BRT vehicle and may need to be modified after the vehicle is selected. It is recommended that vertical clearances should be at least 13-14.5 feet for urban transit buses.

As a surface-based transit system, BRT could add impervious surface area which would require mitigation for the additional surface runoff. The extent of mitigation required will be calculated as design progresses.

Americans with Disabilities Act (ADA) accessibility must be maintained or introduced regardless of the selected transit option. Pedestrian and bicycle facilities along the project corridor will be evaluated during the design process to determine if upgrades are required to meet ADA guidelines. Necessary upgrades to sidewalks, ramps, and crosswalks at intersections and other affected locations throughout the project corridor will be included as part of this project.

4.3 Track Elements

No track elements are necessary for BRT.

4.4 Station Design Approach

BRT stations can range from smaller passenger waiting areas with simple shelters to large-scale terminals with many passenger amenities. Stations should be accessible by foot, automobile, bicycle, and/or bus. They should be placed at major traffic generators and at intersecting bus lines. Park-and-ride facilities should be provided in outlying areas where most access is by car. BRT stations should be widely spaced (except in central areas and other densely developed areas) to allow higher operating speeds. BRT stations are generally spaced 1/2 mile to 1 mile apart.

Berths at a typical BRT station should be 65-70 feet long for a 60-foot articulated bus. The number of berths required at each station will be determined based on anticipated peak-hour bus flows. Right-hand side platform configurations should be used unless custom buses with doors on the left-hand side will be utilized. An appropriate curb height for efficient passenger-service operation is approximately between six and nine inches. If curbs are too high, the bus will be prevented from moving close to it and the operations of a wheelchair lift could be negatively affected. If curbs are too low, passengers with mobility impairments may have difficulty boarding and alighting. ADA compliance is required for all stations.

Compared to elevated guideway transit, BRT stations are less complex and have lower construction costs due to the fact that the stations are constructed at ground level and would not require elevators or other structure.

4.5 Typical Systems Elements and Design Approach

Unlike the other transit modes discussed in this report, no power systems/substations are required for BRT operation.

4.6 Right-of-Way

Busways on a separate right-of-way provide the highest type of BRT service in terms of travel speeds, service reliability, BRT identity, and passenger attraction. However, due to cost or construction difficulty, on-street BRT operations in median busways, bus lanes, or mixed traffic lanes are also possible.

Busways could be designed to allow for possible future conversion to rail or other fixed guideway transit. Additionally, busways with rails embedded in the pavement can allow both buses and LRT/streetcar to operate in the same right-of-way.

4.7 Utility Conflicts and Relocation

Utility conflicts and relocation associated with BRT right-of-way (especially widening for BRT in a separate right-of-way) can be a major cost and there is specific concern with pressurized utilities such as water or gas mains. Unlike other the other fixed systems discussed in this report that require tracks, BRT has the ability to temporarily move the route to accommodate utility service in the event that utility companies need to access their facilities. As such, BRT has greater operating flexibility than other possible modes.

The methodology for identifying potential utility conflicts with the transit system and addressing relocations, rehabilitations, other utility adjustments, or the procedures for maintaining utilities in place will need to be developed as design progresses.

4.8 Traffic

The implementation of BRT service within existing streets in Ann Arbor will require evaluation and, likely, adjustments to traffic operations and traffic signals. As there are many intersections in the downtown area, traffic signals will be impacted. It is assumed that Transit Signal Priority (TSP) will be used for the Ann Arbor Connector. TSP helps ensure transit travel time reliability by adjusting traffic signal phasing to give a green signal for transit vehicles that are approaching, minimizing the amount of time that they are stopped at intersections. Additionally, queue jumps/bypass lanes are recommended for BRT vehicles operating in mixed traffic lanes at congested intersections to reduce vehicle travel times. Traffic operational details will be developed in future phases of the design.

4.9 Structural Evaluation Approach

Structures such as bridges may be required for surface transit modes, but compared to elevated guideway modes, BRT will require significantly fewer structures. Additional structural analysis will be required in future phases of the design if necessary for an exclusive guideway.

5.0 ELEVATED GUIDEWAY TRANSIT

Although included together in this study as the elevated guideway transit option, Automated People Movers (APMs) and monorail will be discussed separately in order to distinguish the similarities and differences of these modes.

An APM system is a moderate to low capacity transit system that generally operates over a limited distance. Vehicles are automated (i.e. driverless) and generally operate on a fixed headway throughout the day. APM systems have proven operational systems, can provide adequate passenger capacity for Ann Arbor, and may be compatible with Ann Arbor's urban environment.

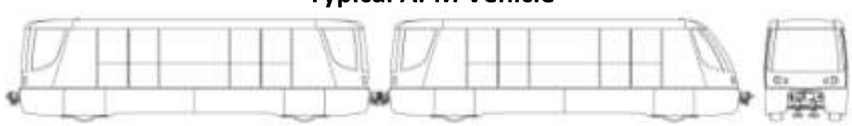
Monorails are a system of automated (i.e. driverless) guided transit vehicles operating on a single elevated rail or beam. Monorails have proven operational systems, can provide the necessary passenger capacity for Ann Arbor, and may be compatible with Ann Arbor's urban environment.

5.1 Vehicle Assumptions

Automated People Mover

A typical APM vehicle is shown in the figure below:

Figure 5.1
Typical APM Vehicle



Source: Bombardier INNOVIA APM 300 Vehicle Specifications

Assumed values for various APM vehicle specifications are shown in the table below:

Table 5.1
APM Vehicle Specifications

Specification	Details
Turning Radius	72 feet
Vehicle Width	9.5 feet
Vehicle Length	42 feet per car
Speed	30 mph (average) 50 mph (maximum)
Passenger Capacity	8 seats per car 103 passengers per car
Boarding Height	3.6 feet
Grade	10% (sustained) Maximum 6% recommended based on ride quality

Source: Bombardier INNOVIA APM 300 Vehicle Specifications

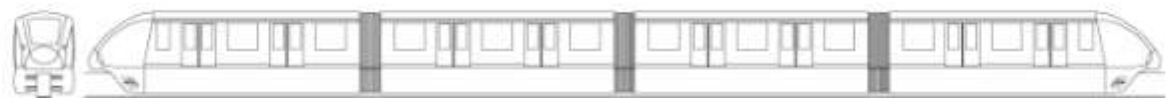
It should be noted that with this APM vehicle, a maximum train consists of between one and six cars.

APM vehicles require a slightly smaller turning radius than LRT and streetcar vehicles. These vehicles require a turning radius of 82 feet, while the assumed APM vehicle requires 72 feet. This turning radius is less likely to be compatible with the existing Ann Arbor street system, especially in the downtown area, and may require such a system to be elevated over buildings. In comparison, buses or large trucks generally require a turning radius between 40-45 feet.

Monorail

A typical monorail vehicle is shown in the figure below:

Figure 5.2
Typical Monorail Vehicle



Source: Bombardier INNOVIA Monorail 300 Vehicle Specifications

Assumed values for various monorail vehicle specifications are shown in the table below:

Table 5.2
Monorail Vehicle Specifications

Specification	Details
Turning Radius	150 feet
Vehicle Width	10.3 feet
Vehicle Length	43.5 feet (end car) 39 feet (mid car) 165 feet (4-car train)
Speed	30-40 mph (average) 50 mph (maximum)
Passenger Capacity	16 seats per car 89 passengers per car
Boarding Height	1.5 feet
Grade	10% (sustained) Maximum 6% recommended based on ride quality

Source: Bombardier INNOVIA Monorail 300 Vehicle Specifications

It should be noted that with this monorail vehicle, a maximum train consists of between two and eight cars.

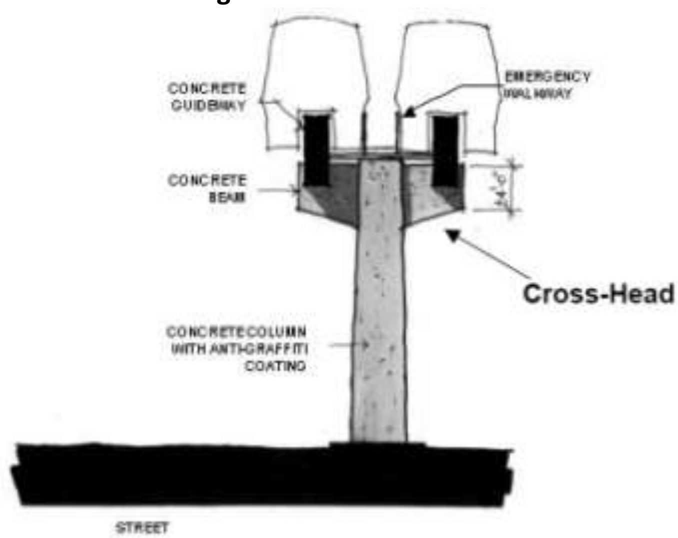
Monorail vehicles require a significantly larger turning radius than LRT and streetcar vehicles. These vehicles require a turning radius of 82 feet, while the assumed monorail vehicle requires 150 feet. This turning radius is not compatible with the existing Ann Arbor street system, especially in the downtown area, and would require such a system to be elevated over buildings. In comparison, buses or large trucks generally require a turning radius between 40-45 feet. In the Ann Arbor Connector Feasibility Study (2011), APM and monorail were assumed to operate as 4-car trains. Based on preliminary potential peak hour capacity analysis, 4-car APM or 4-car monorail would provide the necessary capacity with 5-minute headways.

5.2 Roadway and Civil Design Approach

Depending on the selected vehicle, the elevated guideway width is assumed to be approximately 14 feet on center to accommodate two guide beams (which both support and guide the vehicles) and vehicles traveling in either direction, in addition to an emergency evacuation walkway located between the two guide beams. As these are automated vehicles travelling with no other traffic, horizontal clearance on the guideway is not as critical as with surface-based transit modes. However, minimum vertical clearance is recommended at 18 feet if following the existing street system. If the elevated guideway travels “as the crow flies” and does not follow the street system, additional column height will be required to travel over existing buildings. Additional airspace requirements would also need to be analyzed as design progresses.

For elevated guideways, the size of the structure columns varies with span length, train loads, and other requirements. Spans typically range from 50 feet to 120 feet in length. Using the Las Vegas Monorail system as an example, spans for the guide beams average approximately 100 feet. The typical column has a rectangular section, 56 inches by 32 inches. Guideway foundations typically consist of concrete cast-in-drilled-hole piles in the range of four to six feet in diameter. A typical section of the Las Vegas Monorail is shown below:

Figure 5.3
Las Vegas Monorail Cross Section



Source: Las Vegas Monorail Team

Due to the elevated guideway design, APM and monorail do not add impervious surface area and will not require mitigation for additional surface runoff. Elevated guideway transit is the only mode that does not increase impervious surface area.

Americans with Disabilities Act (ADA) accessibility must be maintained or introduced regardless of the selected transit option. Pedestrian and bicycle facilities along the project corridor will be evaluated during the design process to determine if upgrades are required to meet ADA guidelines. Necessary upgrades to sidewalks, ramps, and crosswalks at intersections and other affected locations throughout the project corridor will be included as part of this project.

5.3 Track Elements

Depending on the selected supplier, the elevated guideway can be constructed of steel or reinforced concrete. The design of the guideway will ultimately depend upon factors such as local soil conditions, desired span requirements, and aesthetics.

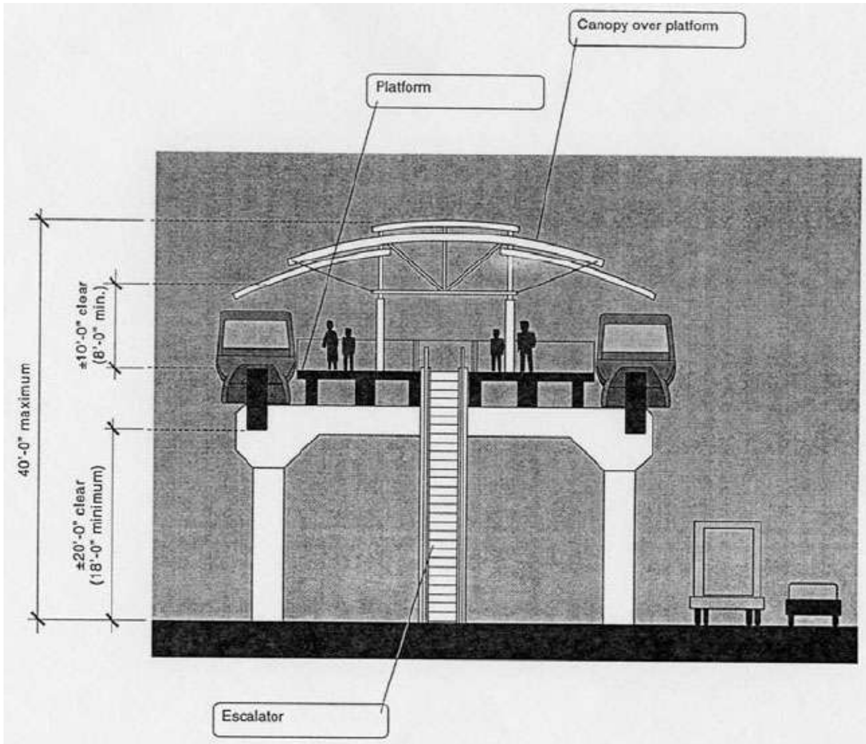
5.4 Station Design Approach

Inherent to elevated guideway systems, stations are also elevated. As such, stair and elevator access is necessary. When compared to LRT/streetcar or BRT stations, elevated guideway stations are much more complex. It is assumed that all platforms will be constructed to ensure a level boarding surface into the vehicle. Elevated guideway stations are generally spaced 1/2 mile to 1 mile apart.

Station design will be based on peak demand car requirements for the selected vehicle. It is not possible to predict station size, but information from the Las Vegas Monorail system can serve as a typical example. Platform lengths are approximately 250 feet. Center platforms are 35 feet wide and side platforms are 20 feet wide.

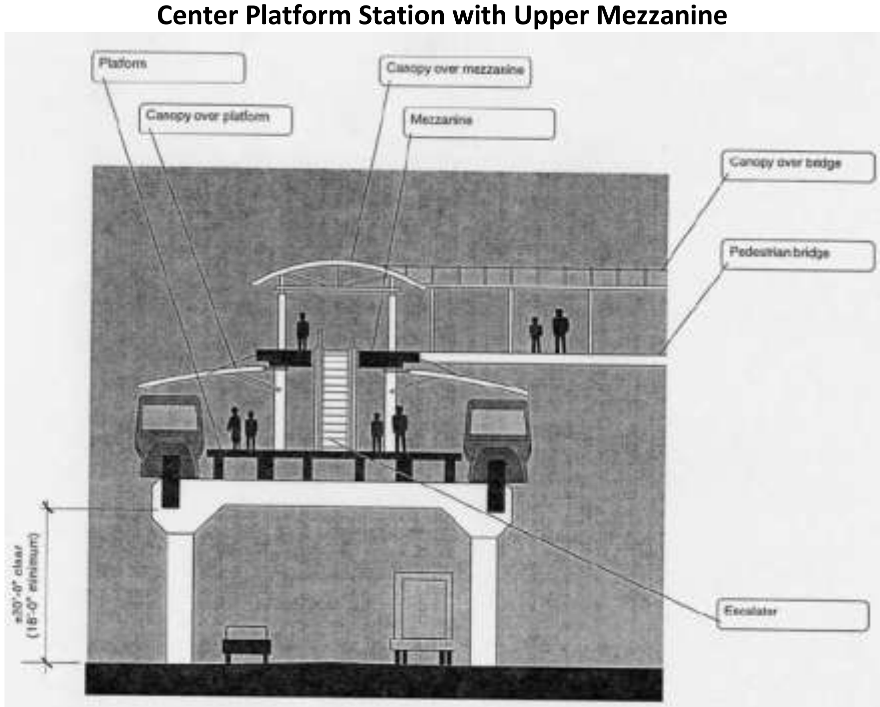
The following figures from the Las Vegas Monorail project show various station options, including center and side platforms:

Figure 5.3
Center Platform Station with No Mezzanine



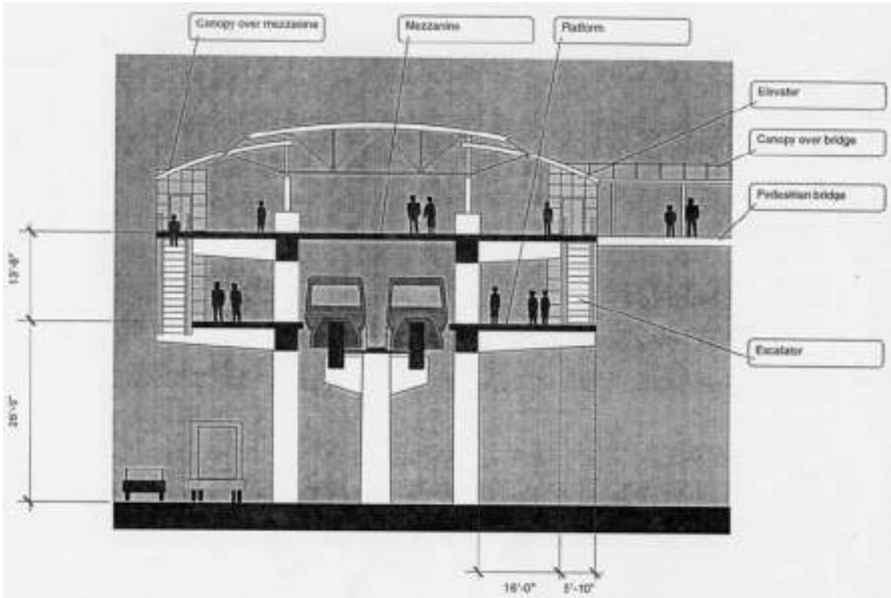
Source: Las Vegas Monorail Team

Figure 5.4
Center Platform Station with Upper Mezzanine



Source: Las Vegas Monorail Team

Figure 5.5
Side Platform Station with Upper Mezzanine



Source: Las Vegas Monorail Team

5.5 Typical Systems Elements and Design Approach

Elevated guideway systems generally operate on DC electric current supplied from Traction Power Supply System (TPSS) substations through two power rails, one positive and one negative, mounted to the guide beams. The final size and spacing of the substations will require a detailed analysis based on the selected vehicle, frequency of service and headways, track alignment profile, passenger stations, and the speed and load cycle over specific time intervals. This information will determine the actual utility power demands. In addition to space and location for substations, other factors to be considered include security and accessibility, ease of replacement/installation of equipment, and proximity to utility feeders. For the purpose of conceptual design, it will be assumed that power substations will need to be located approximately every half mile.

5.6 Right-of-Way

Elevated guideway transit operates in an exclusive, grade-separated guideway at all times. As such, right-of-way can potentially be shared, with the elevated guideway occupying air space.

5.7 Utility Conflicts and Relocation

Utility conflicts and relocation associated with elevated guideway transit right-of-way (especially support structures) can be a major cost and there is specific concern with pressurized utilities such as water or gas mains and inherent clearance issues associated with the grade-separation of the guideway. Since the guideway is elevated, utility companies will be able to access their facilities without disrupting transit operations.

The methodology for identifying potential utility conflicts with the transit system and addressing relocations, rehabilitations, other utility adjustments, or the procedures for maintaining utilities in place will need to be developed as design progresses.

5.8 Traffic

Although not operating in mixed traffic flow with other vehicles, the implementation of elevated guideway transit service within existing streets in Ann Arbor will require evaluation of traffic operations and traffic signals associated with the new service or potential station locations due to increased pedestrian traffic in certain areas. Traffic operational details will be developed in future phases of the design.

5.9 Structural Evaluation Approach

Compared to surface transit modes which may require structures such as bridges, elevated guideway transit is completely built on structures (including all stations). Additional structural analysis will be required in future phases of the design.

6.0 SUMMARY

As previously presented in the mode-specific sections of this report, the following table summarizes the vehicle specifications and other characteristics of the transit modes:

Table 6.1
Summary of Transit Vehicle Specifications

Specification	LRT	Streetcar	BRT	APM	Monorail
Turning Radius	82 feet	82 feet	40 feet	72 feet	150 feet
Vehicle Width	8.7 feet	8.0 feet	8.5 feet	9.5 feet	10.3 feet
Vehicle Length	93.6 feet/car	66-82 feet	60 feet	42 feet/car	165 feet (4-car train)
Speed	20-35 mph (average)	20-35 mph (average)	25-40 mph (average)	30 mph (average)	30-40 mph (average)
Passenger Capacity	230 passengers per car	115-150 passengers	100-120 passengers	103 passengers per car	89 passengers per car
Boarding Height	14 inches	14 inches	14 inches	3.6 feet	1.5 feet
Grade	7%	6-7%	6-8%	6%	6%
Station Spacing	1/4-1/2 mile	1/4-1/2 mile	1/2-1 mile	1/2-1 mile	1/2-1 mile

Based on the turning radii assumptions for these vehicles, LRT, Streetcar, and APM vehicles would be less likely to be compatible with the existing downtown Ann Arbor street system. Monorail would not be compatible with the existing street system and would likely require elevation over existing buildings. Buses and large trucks generally require a turning radius between 40-45 feet.

In terms of vehicle length, streetcar, BRT, and single-car APM vehicles are the shortest. The total train length of LRT, APM, or monorail will be based on peak period passenger demand and will be determined as design progresses.

Structures such as bridges may be required for surface transit modes, but compared to elevated guideway modes which are completely on structure, surface-based modes will require significantly less structures. Additionally, surface transit stations are less complex due to the fact that the stations are constructed at ground level and would not require elevators and other additional features.

In the Ann Arbor Connector Feasibility Study (2011), BRT and streetcar were assumed to operate as single vehicles, LRT was assumed to operate as 2- or 3-car trains, and APM and monorail were assumed to operate as 4-car trains. Based on preliminary potential peak hour capacity analysis, articulated buses or streetcars could meet the design capacity but would need to operate on headways of 2 minutes. A 2-car LRT, 4-car APM, or 4-car monorail would provide the necessary capacity with 5-minute headways. A 3-car LRT would provide the necessary capacity with 10-minute headways.