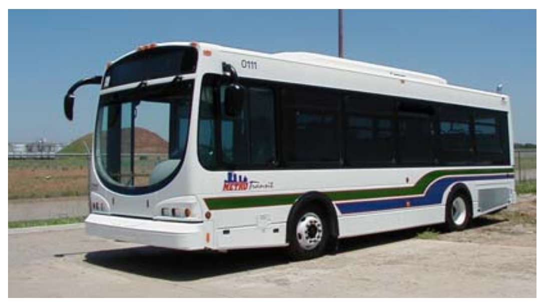
# Chapter Four: Transit Technology Alternatives

This chapter defines and evaluates transit technology alternatives to assess their suitability for the potential fixed guideway corridors of the Oklahoma City Metropolitan area. Potential technology alternatives identified in this chapter will be further evaluated in subsequent chapters. Characteristics of the alternative technologies as they relate to the specific corridors are presented below.

## *Identification of Transit Technology Alternatives*

Alternative transit technologies considered for potential application include Conventional Bus service, High Occupancy Vehicle (HOV) lanes, Bus Rapid Transit (BRT), Light Rail Transit (LRT), Historic Streetcar, Modern Streetcar, Commuter Rail, Heavy Rail, and Monorail. Characteristics of each alternative technology are described in the following paragraphs.

### Conventional Bus Service

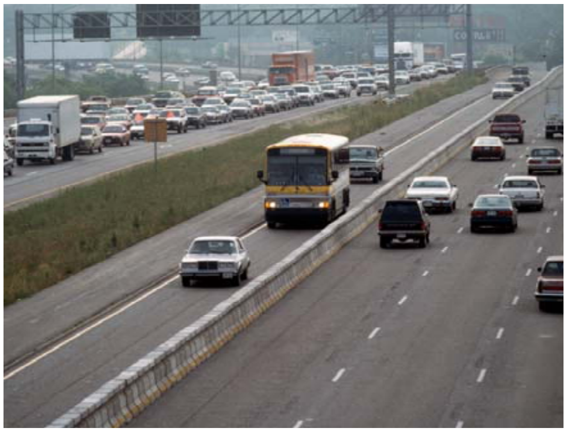


The primary advantages of bus operations are low cost and high flexibility. Buses do not require a significant initial investment in infrastructure. Capital costs are primarily limited to vehicles and maintenance facilities. Operating costs per passenger are also on the lower side when compared with those for most other alternatives. Routes can be flexible. Routing changes can be implemented, for all practical purposes, immediately. Buses can serve a wide range of passenger demand and bus size can be adapted to passenger loads. Small or mid-sized buses can be assigned to routes with lower peak demand. For high ridership routes with frequent service, economies of scale can be realized with articulated buses which can accommodate 50 percent more passengers with one bus operator.

Buses are compatible with the existing transit system. However, the efficiency and effectiveness of additional routes in attracting ridership and providing a significant improvement in travel time would be less than that of a fixed guideway option. Operating costs would also rise substantially to provide significantly increased capacity. Bus stops are typically low cost and easily accessible since stop spacing is close. Buses on streets and roadways are subject to traffic delays. Diesel emissions create a localized environmental impact, but use of alternative fuel buses may reduce bus emissions.

### High Occupancy Vehicle (HOV) Lanes and Managed Lanes

As compared to a fixed guideway alternative, HOVs, or high occupancy toll (HOT) lanes are relatively low-cost, easy to implement, and allow joint utilization by transit and other authorized vehicles. HOVs or HOTs may be implemented along selected freeways by adding a new lane, re-striping the freeway, or re-designating a central shoulder lane in operation with managed lane (tolls). HOV can add more options for commuters. Bus service routed along HOVs would be compatible with the regional transit system but may not provide a corridor alternative meeting community desires. HOVs typically serve longer trips with few or very limited access to neighborhoods.



Managed lanes are toll facilities featuring congestion pricing, such that tolls increase during peak hours. Such lanes are not common around the country, but maybe more feasible in cities where motorists already pay tolls in some corridors.

Because passenger capacity of buses on HOVs is lower than that of rail or busway, there is typically less of an effect on roadway network performance in terms of levels of service and travel time savings. Buses must also operate in mixed traffic to get to and from the HOV lanes. Therefore, traffic congestion will affect operations and schedule reliability.

HOVs and managed lanes can face directionality and access issues. For one-way reversible HOVs, traffic in the opposite directions must operate in mixed traffic along congested roadways. Therefore, reversible HOVs are not appropriate for corridors with roughly equal bi-directional travel demand during peak periods. Since HOVs are typically located along freeways, passenger access and transfers must occur at transit centers or off-line bus stops adjacent to the freeway, but this is comparable to commuter rail access. Access between these stops and the freeway HOV lane may be circuitous and subject to congestion delay. Direct ramps can be provided from the HOV to adjacent transit or parking facilities. However, these may significantly increase HOV cost.

HOV lanes on highly congested arterials and freeways could improve travel times for carpools, vanpools, and transit during congested periods (especially true with managed lanes). This capital investment could be implemented in phases. However, the capital cost of this option would require analysis as an independent transit alternative.

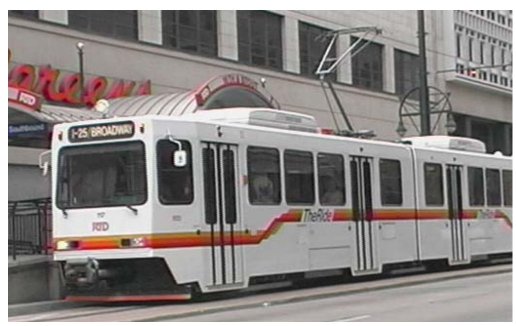
## Bus Rapid Transit (BRT)


Bus Rapid Transit (BRT) on busways provides the speed and guideway advantages typically attributed to a rail line with the added advantage of circulation within local areas. Busways allow high-speed operation, express/non-stop service and one-seat rides. BRT vehicles are designed to look more like rail vehicles with wide doors, large windows, and low floor access. BRT stations are also designed to resemble rail stations with off-vehicle fair collection, and intelligent transportation systems (ITS) that show the arrival time for the next bus. This technology has been implemented at various levels of exclusive right-of-way and operates effectively in several cities. Required right-of-way is wider than that for a rail line and may result in significant impacts. For an at-grade busway to be effective and provide faster operating speeds the numbers of grade crossings should be limited, transit priority signal systems should be installed, or queue jump lanes should be added. Bus Rapid Transit vehicles may operate in mixed traffic, but often have their own dedicated lane for a substantial part of the route.

Guided bus technology is appropriate for corridors where right-of-way is severely restricted or joint operation over a narrow streetcar/LRT trackway is required. Buses can be operated at very close intervals along the guideway without interference from other traffic. Buses can be operated along narrow rights-of-way similar to a streetcar or a light rail route, or along roadways, thereby allowing one-seat rides and fewer required transfers for a larger percentage of passengers.

Whereas BRT uses a guideway or street right-of-way and standard buses, guided bus technology requires specially adapted buses. Guided bus technology is less flexible since buses cannot bypass each other. Operation along a guideway within a downtown activity center is possible. However, the guideway may prove to be a hazard and visually intrusive. Therefore, buses would operate in mixed traffic in activity centers and would be subject to congestion delay.

## Light Rail Transit (LRT)



The primary advantage of modern light rail transit is its adaptability to a variety of operating environments and passenger capacities. Furthermore, the lower labor requirements and higher passenger capacity generally allow light rail to be operated at a lower cost per passenger than bus alternatives. LRT design can range from a high-speed, high-capacity system comparable to heavy rail or other completely grade separated technologies, to a low-speed, medium-capacity streetcar or shuttle service. LRT trains can consist of up to four vehicles, thereby accommodating ten times the number of passengers of a standard 40 foot bus with one operator, resulting in lower operating cost per passenger. Capital costs for LRT can range from $40 – $70 million per mile, making this technology unaffordable for most communities.

Light rail can operate at-grade and cross roadways at-grade. These operations can be cost-effective, particularly in areas where grade separation is unnecessary. Station spacing can be close enough to provide convenient walk access. Stations can be simple, sidewalk stops with a shelter or as elaborate as desired. Light rail is a higher capital cost alternative as compared to buses, requiring more costly investment in tracks, electrification, and modifications to streets and traffic control. In some cases, delaying some features such as selected stations, structures, or trackage can defer construction costs over several years. This would allow the corridor to have service sooner with upgrades provided as ridership grows and funds become available.

Light rail at-grade operation can be affected by traffic in areas of shared right-of-way. This can be mitigated by provision of exclusive right-of-way and traffic control that favors light rail. LRT can operate in multi-car trains at speeds up to 70 mph. The number of grade crossings and on-street sections will slow operating speeds significantly. Improvements to benefit transit may impact traffic flow and pedestrian movements.

The flexibility and relatively low cost, compared to other rail alternatives, could allow a LRT system to emerge as a viable alternative in any high-capacity transit corridor. While much more expensive, and far less flexible than a busway, potentially lower operating costs may prove LRT a viable transit option. Moreover, LRT may play a significant role in transit oriented development and redevelopment near LRT stations.

## Historic Streetcar

Historic trolleys are a specialized type of service or tourist attraction that is appropriate for a shuttle or circulator function. However, it would have limited capacity to meet overall community mobility needs. Vehicle capacity is limited and performance characteristics, such as acceleration and maximum speed, restrict its utility for line-haul service, but it could provide connection between other modes and/or circulator service within or between growth centers. A historic streetcar route could also operate on a portion of modern light rail tracks, such as Portland's downtown historic streetcar. However, LRT as a line-haul transit service may not operate on tracks, at stations, or with a power system designed specifically for a historic streetcar. This does not, however, preclude operation of a historic trolley service as a feeder or shuttle service that could complement a line-haul transit service.

## Modern Streetcar

Modern streetcar technology has passenger capacity and operating characteristics approaching those of LRT with predominately on-street, at-grade operations. Vehicles and power systems are generally lower in cost than higher speed, higher capacity light rail systems. In areas where maximum speeds are restricted by street-running operations, modern streetcars may represent a lower cost alternative to light rail.

A modern streetcar could serve a variety of functions in Oklahoma City. A downtown area circulator could connect commercial and residential areas to major employment centers and link key districts (Bricktown, Medical Center, Midtown, Downtown) to each other. As a frequent service on relatively short routes, modern streetcars could operate in line-haul transit service between Oklahoma City's major activity centers. Like the light rail systems in Boston and San Francisco, a streetcar system in Oklahoma City could eventually be upgraded to higher capacity light rail services as demand warrants.

The flexibility and relative low cost compared to other rail alternatives could allow a modern streetcar system to emerge as a viable alternative in any high-capacity transit corridor. While this option is similar to light rail, a streetcar alternative may be further differentiated from LRT as a low-cost option by minimizing station features and design, maximizing single-tracked and on-street operations, and procuring off-the-shelf technologies (e.g. minimizing custom design features).

Modern streetcar can also serve to improve the image of public transportation in the region and is an investment in the future that tends to attract community support. As such, it strengthens the appeal of other transit technologies.

## Commuter Rail

Passenger capacity, speed and access to central cities are the primary advantages of commuter rail. Trains can comfortably accommodate a large number of seated passengers over a long distance. Provided that track and signal system conditions are good, service can be implemented at a relatively low cost and within a short time frame. Commuter rail is often ill suited to serve areas where closer station spacing is required. The slower acceleration rate of commuter rail as compared to heavy or light rail is mitigated by wider station spacing, which allows faster travel times, but diminishes its accessibility for walk-on passengers. Some vehicles like diesel multiple units (DMU's) have improved acceleration when compared to traditional locomotives.

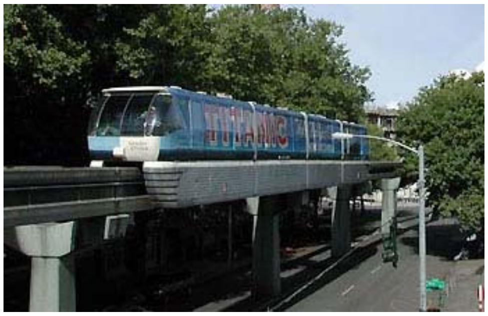

Commuter rail can penetrate the core of a central business district (CBD) or activity center if the track bisects the CBD or if the core is small. In Oklahoma City, Union Station is on the periphery of the CBD and will not provide passengers with "front door" service. However, the Santa Fe Station, located within the CBD, would provide passengers a short walk to Bricktown, the baseball stadium, and employment centers.

Extending commuter rail to better serve urban activity centers can benefit from existing grade separated right-of-way that currently exists in Oklahoma City. Introduction of commuter rail may not be feasible where limited by geometric constraints, conflicts with freight traffic, inconvenient access for vehicles and pedestrians, or where extensive rehabilitation of track and structures is needed to meet acceptable operating criteria. Grade separation of commuter rail to serve a downtown or activity center would be expensive and probably less cost-effective than an at-grade light rail extension, but in Oklahoma City the grade separation is already present.

## Heavy Rail

Heavy rail can reliably transport high numbers of passengers per hour at a high average speed. However, the capital cost per mile can be significantly higher than LRT or commuter rail. Because total guideway separation is required, heavy rail routes are basically inflexible. Alignment changes can be costly unless implemented in an already separated right-of-way. Like the guideway, stations must be separated from traffic. These requirements lead to higher cost stations that typically have high platforms and elevators. Downtown alignments would be elevated or in subways. Construction and operation of heavy rail would offer few benefits over that of a comparable light rail system that is completely grade-separated. Moreover, it is unlikely that the current development patterns in Oklahoma City could generate ridership to warrant such a high-capacity transit investment, and high construction costs would likely exceed METRO Transit's ability to fund such a system.

## Monorail



Monorail can provide fast operation along an elevated guideway that is often perceived as less intrusive than those for other rail modes. The rubber-tired vehicles operate quietly. No overhead wires are required, and the single beam structure may be perceived as less visually intrusive than other elevated transportation modes.

Station costs are higher than for at-grade rail and similar to grade-separated heavy rail. Guidebeam switching is more complicated than conventional track switches. The switch issue has tended to relegate monorail to shuttle or loop service within an activity center and limited its use for line-haul transit. An elevated monorail guideway could be extended along roadways or other rights-of-way, but this may be considered visually intrusive in some areas.

## *Alternatives Evaluation Criteria*

In determining which fixed guideway technology would be potentially applicable for corridors in the Oklahoma City Metropolitan area, a set of evaluation criteria was established for testing general applicability. The following are the corridor technology evaluation criteria:

1. **Ability to Satisfy Operations and Service Levels**
   This criterion will determine how well a technology accommodates the initial and future ridership projections and how well it satisfies the required levels of service. Such factors as service frequency, trip time, vehicle capacity, fleet size, and operational efficiency and flexibility will be considered.

2. **Compatibility with Existing Transit System**
   The technology should be compatible with the existing and planned METRO Transit systems as well as community desires and travel needs of the Oklahoma City Metropolitan area. The chosen technology should coordinate with planned and existing bus routes. The chosen technology should facilitate more direct and convenient travel and a decrease in travel time.

3. **Cost Effectiveness**
   This criterion will evaluate the capital, operations and maintenance costs associated with a technology and its system elements will be evaluated at least on a low, medium, high basis.

4. **System Accessibility**
   Stations should be easily accessible for passengers and allow for easy coordination with the transit network. This relates to the number or stations; station type, at-grade or grade separated; and the type of platform (high, low, center, or side). Station spacing should allow for convenient walk access. If bus access is required to reach a station, the total number of transfers for most trips should be low.

5. **System Flexibility**
   The technology should be adaptable to a variety of operating environments. This refers to grade separation requirements, ease or feasibility of system extension, transfer convenience, and feasibility of implementation in various rights-of-way.

6. **Service Frequency**
   Service frequency should increase ridership and should be coordinated with existing METRO Transit bus service. The technology should provide sufficient operating capacity for expected ridership.

7. **Environmental Impacts**
   This criterion will have a qualitative assessment of potential traffic, visual, historic, and other environmental impacts. The technology should not result in extensive environmental impacts.

8. **Land Use Compatibility**
   The technology should be compatible with existing and planned land uses. The chosen technology shall be appropriate based on a qualitative assessment of existing and planned development densities, mixed uses, socio-economic factors, neighborhood compatibility, and other factors which could affect level of transit demand.

9. **Availability of Technology**
   The availability and production requirements of a technology will be evaluated under these criteria.

## *Evaluation and Conclusion*

The results of the evaluation of each alternative transit technology are described in the following paragraphs.

### Conventional Bus Service

1. *Ability to Satisfy Operations and Service Levels* – Bus routes in high ridership corridors often face severe street congestion, and lower bus speeds require additional vehicles to provide a comparable level of service as compared to a rail alternative. Even where large (articulated) buses are used, bus services can be limited by traffic congestion and other factors that impact operating speed and adherence to published schedules. High volume bus routes are seldom as efficient, in terms of operating cost per passenger as comparable rail services.

   Rating – 2

2. *Compatibility with Existing Transit System* – Expanded bus service would be compatible with METRO Transit's existing fleet, operating and maintenance facilities.

   Rating – 5

3. *Cost Effectiveness* – Although rail technologies are often more cost-effective in terms of operating costs, bus services have a low capital cost requirement and are therefore considered cost-effective for this evaluation.

   Rating – 4

4. *System Accessibility* – Local bus services offer frequent stops, providing a high degree of accessibility to most potential passengers. While some areas of the city lack sidewalks or accessibility to persons with mobility limitations, these infrastructure problems can be corrected around affected bus stops with minimal expense.

   Rating – 3

5. *System Flexibility* – Local bus services are highly flexible, and routes can be changed virtually on demand. Only customer service, policy, funding and administrative reasons limit the ability to make rapid changes to the bus network; other transit options generally require construction.

   Rating – 5

6. *Service Frequency* - Bus services are able to adapt to increasing passenger demands by increasing bus frequency. Buses operating every few minutes on a single route in a congested corridor are generally far less cost-effective than a comparable rail transit service. While limited capital improvements can often improve operating performance on high-demand routes, frequent bus services in a congested corridor are less reliable than grade separated options.

   Rating – 4

7. *Environmental Impacts* – In terms of environmental impacts. Emissions can be mitigated through the use of alternative fuels, but noise from internal combustion buses can impact residential areas. In most other respects, bus services do not significantly impact their operating environments any more significantly than other traffic.

   Rating – 3

8. *Land Use Compatibility* – Bus services have not been shown to have any significant positive or negative impact on surrounding land use. Bus services do not require any infrastructure that may negatively impact surrounding land uses.

   Rating – 3

9. *Availability of Technology* – Buses are manufactured by numerous vendors in North America and are operated in a wide variety of services, environments, and conditions.

   Rating – 5

## High Occupancy Vehicle (HOV) Lanes

1. *Ability to Satisfy Operations and Service Levels* – HOVs have been shown to carry up to three times the number of people as a regular lane of traffic. HOVs often operate in existing freeway rights-of-way, but where additional right-of-way is required; HOVs approach busway or light rail costs. Since busways and light rail can carry many more passengers than HOVs, HOVs are rated low for carrying capacity, particularly in relation to the cost of the infrastructure.

   Rating – 3

2. *Compatibility with Existing Transit System* – HOVs can support METRO Transit's express bus system, help encourage a vanpool system, and enhance carpooling. However, ODOT has not included HOV facilities in its final highway improvement plans, but concurs that certain highways were designed to retain the option in the future. HOV often has such a negative perception that it is not used sufficiently to justify dedicating lanes for HOV use. This perception is less likely if the HOV lane is a new lane or is used in a city where highway users are more accustomed to toll roads.

   Rating – 3

3. *Cost Effectiveness* – HOVs can save bus operating costs and increase transit ridership.

   Rating – 4

4. *System Accessibility* – HOV access is rated poorly, compared to other transit options, since HOV and transit access is predominately by auto. HOVs with a high level of transit access are generally dependent on park-and-ride passengers.

   Rating – 2

5. *System Flexibility* – HOVs offer a relatively high level of system flexibility for bus routes. Prior to entering the HOV lane, buses can circulate through neighborhoods collecting passengers or local routes can provide connections to express service. Many HOVs operate with a moderate level of transit service focused on park-and-ride lots as suburban neighborhoods are often too dispersed to warrant a high level of connecting transit services. This ability to connect neighborhoods to transit allows this category to be rated highly.

   Rating – 4

6. *Service Frequency* – HOVs offer the potential to increase transit demand and warrant frequent services. Bus services on existing HOVs are generally limited to peak periods with little service during other periods. Service frequency is rated high, since bus services on HOVs can be adjusted to meet demand as warranted.

   Rating – 4

7. *Environmental Impacts* – HOVs generally have a marginal impact on the environment. If HOVs increase carpooling and transit ridership or reduce congestion, environmental benefits are possible. The high rate of auto access to park-and-ride facilities, however, generally allows few, if any, environmental benefits to be realized. Some studies have suggested that many HOV users would carpool without the HOV and a study in Houston showed that transit users often form informal carpools at park-and-ride lots, reducing transit use.

   Rating – 2

8. *Land Use Compatibility* – Park-and-ride lots associated with HOV facilities can, in some cases, affect the potential for development. Generally, HOVs have not been shown to have any impact on land use, but can help make central business districts and other large nodes more accessible.

   Rating – 2

9. *Availability of Technology* – HOVs are a proven technology in terms of construction and operation. In certain cases, HOVs have been shown to improve transit ridership, notably in Houston.

   Rating – 3

## Bus Rapid Transit (BRT)

1. *Ability to Satisfy Operations and Service Levels* – Buses of all sizes can operate frequent service that allows busways to approach the carrying capacity of rail lines.

   Rating – 5

2. *Compatibility with Existing Transit System* – A BRT improvement combined with expanded bus services would be compatible with METRO Transit's existing fleet and operating and maintenance facilities and allows a high ranking of BRT technology. This ranking excludes

consideration of guided bus technology, which may not be compatible with the existing bus fleet.

Rating – 5

3. *Cost Effectiveness* – Although rail technologies are often more cost-effective in terms of operating costs, a BRT alternative would not necessarily require procurement of a new bus fleet or maintenance facilities. BRT is also eligible under the Federal Transit Administration's BRT pilot program and may allow Oklahoma City to leverage a higher share of federal funds.

   Rating – 4

4. *System Accessibility* – Local bus services offer frequent stops, providing a high degree of accessibility. Local bus services can operate on a busway for a degree of flexibility. Increased services and improved operating speeds could improve access for many passengers.

   Rating – 4

5. *System Flexibility* – Local bus services can operate on a busway for a portion of their route, or new routes can be designed to operate exclusively on the busway. Moreover, certain busway alignments might be constructed incrementally, reducing up-front capital costs. The high degree of flexibility in service design allows this category to be ranked highly.

   Rating – 4

6. *Service Frequency* – Bus services are able to adapt to increasing passenger demands by increasing bus frequency. Buses operating every few minutes on a single route in a congested corridor are generally far less cost-effective than a comparable rail transit service. However, many different bus routes can branch from the busway, allowing localized services in neighborhoods while maintaining a high cumulative frequency on the busway.

   Rating – 4

7. *Environmental Impacts* – Emissions can be mitigated through the use of alternative fuels, but noise from internal combustion buses can impact residential areas. Electric trolleybuses are quiet and clean, but overhead wires represent a visual intrusion. In most other respects, bus services do not significantly impact their operating environments any more significantly than other traffic.

   Rating – 3

8. *Land Use Compatibility* – The limited number of busways in North America has not shown notable impact on transit-oriented development or transit-related land uses in either a positive or negative sense.

   Rating – 3

9. *Availability of Technology* – Buses are manufactured by numerous vendors in North America and are operated in a wide variety of services, environments, and conditions. Busways, as conventional streets, are also a proven technology.

   Rating – 4

## Light Rail Transit (LRT)

1. *Ability to Satisfy Operations and Service Levels* – Light rail vehicles can operate in trains that allow a high carrying capacity.

   Rating – 5

2. *Compatibility with Existing Transit System* – LRT would be a new technology in Oklahoma City, requiring new guideway and operating and maintenance facilities.

   Rating – 3

3. *Cost Effectiveness* – Although rail technologies are often more cost-effective in terms of operating costs than comparable bus services, LRT alternatives require a high level of capital investment, much of the cost could be funded by federal grant programs, but the local cost remains quite high.

   Rating – 3

4. *System Accessibility* – While feeder bus services can provide system access, many residents will not have direct access to the LRT system.

   Rating – 3

5. *System Flexibility* – LRT can operate in a separate guideway, in mixed traffic, at-grade, elevated or subway. It has the maximum speed to provide a travel time savings in an exclusive guideway with wide station spacing and can fulfill a distribution/circulation function with station spacing of a few blocks in a central business district environment.

   Rating – 4

6. *Service Frequency* – LRT has the ability to operate services every few minutes on a double-tracked alignment. This frequency of service allows this category to be ranked highly.

   Rating – 5

7. *Environmental Impacts* – Electrically-powered LRT can reduce emissions where ridership is substantial. LRT is generally quiet and typically has few negative impacts on surrounding land uses.

   Rating – 5

8. *Land Use Compatibility* – LRT has often encouraged transit-oriented development, allowing new land developments around stations to support additional ridership while reducing automobile usage.

   Rating – 5

9. *Availability of Technology* – LRT is widely used around the world. Light rail vehicles are manufactured in both mass production and custom configurations by a number of manufactures.

   Rating – 5

## Historic Streetcar

1. *Ability to Satisfy Operations and Service Levels* – Historic trolley services could operate as frequently as other light rail and bus transit options.

   Rating – 4

2. *Compatibility with Existing Transit System* – Historic streetcars would be a new transit technology in Oklahoma City, requiring new guideway and operating and maintenance facilities.

   Rating – 3

3. *Cost Effectiveness* – Although rail technologies are often more cost-effective in terms of operating costs than comparable bus services, historic trolley alternatives can require a high level of capital investment. Likewise, the costs to procure, restore, and maintain an authentic historic vehicle is typically high.

   Rating – 3

4. *System Accessibility* – While feeder bus services can provide system access, many residents will not have direct access to the streetcar system, and it is unlikely that a historic streetcar system could be expanded as a regional service. Additionally, older vehicles are often not ADA-accessible, and ensuring that the system maintains full access may be a formidable issue.

   Rating – 2

5. *System Flexibility* – Although historic streetcar systems operate slowly, which limits future expansion, the smaller size and shorter turning radius of the vehicles allows them to operate in dense urban areas where other vehicles cannot operate. The low passenger capacity and low maximum speed of the vehicles do not limit this mode's potential to serve a large metropolitan area.

   Rating – 4

6. *Service Frequency* – Like LRT, historic streetcar services have the ability to operate services every few minutes on a double-tracked alignment in a moderate speed operation.

   Rating – 4

7. *Environmental Impacts* – Electric powered vehicles would be environmentally friendly, and the historic character of streetcars would be compatible with historic areas. Noise and vibration impacts can be more significant than conventional light rail, and lower ridership generally results in fewer mobility benefits.

   Rating – 3

8. *Land Use Compatibility* – Like LRT, historic streetcar systems have often encouraged transit oriented development, encouraging new land development along transit lines. Moreover, historic streetcars are often compatible in historic districts where visual impacts might be more severe for modern transit options.

   Rating – 5

9. *Availability of Technology* – There is manufacturers of replica equipment using new vehicle chassis and components. In addition, several suppliers remanufacture older equipment into working condition.

   Rating – 4

## Modern Streetcar

1. *Ability to Satisfy Operations and Service Levels* – Modern streetcars can operate in single or double car configurations with capacities similar to small LRT trains or single LRT vehicles.

   Rating – 5

2. *Compatibility with Existing Transit System* – Modern streetcars would be a new transit technology in Oklahoma City, requiring new guideway and operating and maintenance facilities.

   Rating – 3

3. *Cost Effectiveness* – Modern rail technologies are often more cost-effective in terms of operating costs than comparable bus services. However, modern streetcar alternatives can require a high level of capital investment.

   Rating – 3

4. *System Accessibility* – While feeder bus services can provide system access, many residents will not have direct access to the streetcar system. Future expansion of streetcar service could allow the service to branch to several neighborhoods or growth centers.

   Rating – 3

5. *System Flexibility* – Modern streetcar options are ranked low since systems operate slowly, limiting future expansions, and operate on dedicated guideway, requiring construction of new guideway for any expansion of service.

   Rating – 2

6. *Service Frequency* – Like LRT, modern streetcar services have the ability to operate frequently on a double-tracked alignment.

   Rating – 5

7. *Environmental Impacts* – Modern streetcar technology is rated highly in terms of environmental impact.  Electrically-powered vehicles, along with high transit ridership, could help improve air quality.

   Rating – 4

8. *Land Use Compatibility* – Like LRT, modern streetcar systems are likely to encourage transit-oriented development along transit lines.  Moreover, modern streetcars are often compatible in neighborhood districts where smaller vehicles would be more widely accepted.

   Rating – 5

9. *Availability of Technology* – Although modern streetcars are not widely used in the United States, they are widely used throughout the world.  Modern streetcar technology is very similar to LRT technology and, therefore, represents a technology that is compatible with light rail.  Streetcars are also mass-produced by several manufacturers for use on existing transit systems.

   Rating – 5

## Commuter Rail

1. *Ability to Satisfy Operations and Service Levels* – Commuter rail services have very high passenger capacities due to the large potential train length.

   Rating – 5

2. *Compatibility with Existing Transit System* – Commuter rail would be a new transit technology in Oklahoma City, requiring new guideway and operating and maintenance facilities.  However, with the vast amount of existing freight lines traversing the city, existing lines might be utilized.

   Rating – 4

3. *Cost Effectiveness* – Extremely high operating costs sometimes prove other rail technologies more cost-effective.  Commuter rail offers a lower capital cost than other technologies; however, commuter rail systems that reach their maximum operating speeds and carrying capacity often require a high level of capital investment and dedicated

operations that severely limit freight railroad traffic. These requirements could limit the cost-effectiveness of commuter rail alternatives.

Rating – 3

4. *System Accessibility* – Commuter rail stations are generally located several miles apart, and many existing freight corridors would place stations in industrial areas, flood plains, and other areas where access to the system is limited. A preliminary review of existing and potential commuter rail corridors indicates that the primary mode of access to the system would be by auto. While feeder bus services can provide system access, many residents will not have direct access to the rail system without driving or taking a bus.

   Rating – 2

5. *System Flexibility* – Commuter rail systems operate on a dedicated guideway. Several low-capacity rail corridors could prove ideal for commuter rail operations. High freight volumes may limit applicability of commuter rail in some corridors. Creation of new corridors within the existing urban environment would present numerous challenges.

   Rating – 3

6. *Service Frequency* – Commuter rail services do not operate as frequently as other rail modes.

   Rating – 3

7. *Environmental Impacts* – Commuter rail operations would occur within existing railroad rights-of-way where there would be limited impacts from construction or operations on adjacent land uses. Most freight railroad operations are in industrial or transportation corridors (adjacent to existing roadways or highways), and impacts to residential and commercial areas from increased frequency of operations would be limited. It is likely that the dominant access mode would be by automobile, and air quality benefits would only be realized on longer transit trips or where commuter rail significantly reduced congestion.

   Rating – 5

8. *Land Use Compatibility* – Existing freight railroad tracts often lie in industrial or flood-prone areas, limiting opportunities for new transit-oriented development.

   Rating – 3

9. *Availability of Technology* – Commuter rail is widely used around the United States and the world. Commuter rail vehicles are manufactured in both mass production and custom configurations by a number of manufactures. Aside from locomotives that pull several passenger cars, some vehicles are essentially passenger cars powered by a hidden motor.

   Rating – 5

## Heavy Rail

1. *Ability to Satisfy Operations and Service Levels* – Heavy rail services have very high passenger capacities.

   Rating – 4

2. *Compatibility with Existing Transit Systems* – Heavy rail would be a new transit technology in Oklahoma City requiring new guideway, operating and maintenance facilities.

   Rating – 2

3. *Cost Effectiveness* – Although rail technologies are often more cost-effective in terms of operating costs than comparable bus services, heavy rail alternatives can require an extremely high level of capital investment. Requirements that guideway and stations be grade separated add to the capital costs. The extremely high capital costs rate this option negatively, since they are not likely commensurate with the expected ridership levels.

   Rating – 1

4. *System Accessibility* – While feeder bus services can provide system access, many residents will not have direct access to the rail system, particularly since heavy rail stations are generally located father apart than other transit options.

   Rating – 2

5. *System Flexibility* – Heavy rail systems operate on dedicated guideway that requires full grade separation.

   Rating – 1

6. *Service Frequency* – Heavy rail services have the ability to operate frequently.

   Rating – 4

7. *Environmental Impacts* – Heavy rail vehicles are electrically powered. However, negative environmental impacts would result from construction of subways or aerial structures.

   Rating – 3

8. *Land Use Compatibility* – Like LRT, heavy rail systems have often encouraged transit-orientated development, encouraging new land development near transit stations. However, since most stations or either underground or elevated its impacts are not as great as LRT or commuter rail that have at-grade stations.

   Rating – 2

9. *Availability of Technology* – Heavy rail operates in cities worldwide and in North America, but due to the high cost of construction, no new heavy rail lines have been constructed in many years.

   Rating – 2

## Monorail

1. *Ability to Satisfy Operations and Service Levels* – Monorail services have high passenger capacities.

   Rating – 4

2. *Compatibility with Existing Transit System* – Monorail would be a new technology in Oklahoma City. A new operations and maintenance base would be required for ongoing system support.

   Rating – 3

3. *Cost Effectiveness* – Grade-separated alignments and stations result in high capital costs for monorail. Monorail in the United States is limited to shuttle operations; there are no line-haul monorail systems in operation. Low operating costs and high ridership found on Seattle's monorail shuttle, a popular tourist attraction, may not be realized in a larger monorail transit system. High capital costs and largely unknown operating costs rate this technology low.

   Rating – 1

4. *System Accessibility* – Monorail requires complete grade separation, and stations are typically several stories above street level, adding time for passengers to access stations.

   Rating – 1

5. *System Flexibility* – Monorail options are ranked low since systems operate on a dedicated guideway. Monorail often faces opposition from local neighborhoods due to the visual intrusion, further limiting where monorail alignments could be planned.

   Rating – 1

6. *Service Frequency* – Monorail operates as frequently as other rail modes.

   Rating – 4

7. *Environmental Impacts* – Monorail ranks low as aerial structures would represent a notable visual intrusion, particularly in any of Oklahoma City's historic districts.

   Rating – 1

8. *Land Use Compatibility* – Where monorail is planned as part of a development, stations can be incorporated directly inside buildings. Over time, new developments may also

incorporate stations as part of the overall development. Where monorail is constructed as part of existing development, however, aerial stations are often difficult to integrate into existing developments, particularly in areas with historic buildings.

Rating – 1

9. *Availability of Technology* – Monorail is a proven technology for short shuttle services; however, no line-haul monorail systems exist. This category is rated low since monorail manufacturers are limited, and systems consisting of several lines are limited to applications in Japan. It is likely that implementation of monorail in Oklahoma City would require a large degree of customization of vehicles and power systems.

Rating – 1

## Conclusion

Table 4.1 presents a summary evaluation for each transit technology.

**Table 4.1**
**Technology Ratings**

| Evaluation Criteria | Bus | HOV | BRT | LRT | Historic Streetcar | Modern Streetcar | Commuter Rail | Heavy Rail | Monorail |
|---|---|---|---|---|---|---|---|---|---|
| Ability to Satisfy Operations and Service Levels | 2 | 3 | 5 | 5 | 4 | 5 | 5 | 4 | 4 |
| Compatibility with Existing Transit System | 5 | 3 | 5 | 3 | 3 | 3 | 4 | 2 | 3 |
| Cost Effectiveness | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 1 | 1 |
| System Accessibility | 3 | 2 | 4 | 3 | 2 | 3 | 2 | 2 | 1 |
| System Flexibility | 5 | 4 | 4 | 4 | 4 | 2 | 3 | 1 | 1 |
| Service Frequency | 4 | 4 | 4 | 5 | 4 | 5 | 3 | 4 | 4 |
| Environmental Impacts | 3 | 2 | 3 | 5 | 3 | 4 | 5 | 3 | 1 |
| Land Use Compatibility | 3 | 2 | 3 | 5 | 5 | 5 | 3 | 2 | 1 |
| Availability of Technology | 5 | 3 | 4 | 5 | 4 | 5 | 5 | 2 | 1 |
| Total | 34 | 27 | 36 | 38 | 32 | 35 | 33 | 21 | 17 |

Technologies that received a score of 25 or higher in the nine categories are recommended for further consideration. Therefore, conventional bus service, high occupancy vehicle lanes, bus rapid transit, light rail transit, historic streetcar, modern streetcar, and commuter rail are the selected transit technology alternatives, which were carried over to the next level of analysis. During the next level of analysis, these technologies were further analyzed to determine which technology would be best for each corridor.