Tennessee Street Corridor Transit Alternatives Criteria Study

A Vision for an Enhanced Transit Application in Tallahassee

FINAL REPORT – Fall 2011

Prepared for

StarMetro Transit
Tallahassee, Florida

Prepared by

Fall 2011 Transit Alternatives Studio Members
Department of Urban and Regional Planning
Florida State University
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<td>ADA</td>
<td>Americans with Disabilities Act</td>
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<td>BART</td>
<td>Bus Area Rapid Transit</td>
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<td>BRT</td>
<td>bus rapid transit</td>
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<td>CAT</td>
<td>Central Arkansas Transit</td>
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<td>CBD</td>
<td>central business district</td>
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<td>CDBG</td>
<td>Community Development Block Grants</td>
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<td>LOS</td>
<td>level of service</td>
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<td>light rail transit</td>
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<td>Metropolitan Atlanta Rapid Transit Authority</td>
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<td>MATA</td>
<td>Memphis Area Transit Authority</td>
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<td>MCE</td>
<td>Medical Center Extension</td>
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<td>MMLOS</td>
<td>multi-modal level of service</td>
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<td>multi-modal transportation district</td>
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<td>miles per hour</td>
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<td>metropolitan statistical area</td>
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<td>Société d’économie mixte des transport en commun de l’Agglomération Mancelle</td>
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EXECUTIVE SUMMARY

INTRODUCTION

The Department of Urban and Regional Planning at Florida State University (FSU) entered into an agreement with StarMetro, the city-owned and operated bus service for Tallahassee, Florida, for the preparation of this transit report. This report is intended to be a guidance document that presents criteria to aid StarMetro in defining the Tennessee Street Corridor (TSC) enhanced transit alternatives, including a modern streetcar, a light rail transit (LRT), or a bus rapid transit (BRT) system. An enhanced transit mode has the potential to greatly improve public transportation in Tallahassee if it is planned and designed correctly. An enhanced transit mode provides an opportunity to build upon the recently implemented Nova2010 decentralization plan through enhancing the existing transit system and to support land use changes along the TSC. Due to the substantial capital investment required to implement an enhanced transit mode, the mode must offer substantial benefits over and above the existing transit service along the TSC.

TSC is the eight-mile segment of U.S.90/Tennessee Street/Mahan Drive that traverses east-west through central Tallahassee. The corridor is one of the major arterials to and through downtown connecting the eastern and western portions of Capital Circle, as well as linking FSU and Tallahassee Community College (TCC) with downtown. Primarily a commuter route with heavy automobile traffic volumes, demand modeling of the Nova2010 network showed that the TSC will have the heaviest transit ridership of any route in the area, making it ideal for enhanced transit.

The purpose of this studio is to provide guidance to StarMetro on what characteristics make an enhanced transit mode successful or unsuccessful. These performance characteristics were developed into a set of criteria that an enhanced transit mode along the TSC should meet during the development of an alternatives analysis. The scope of the analysis for this studio is limited to developing criteria in order to guide StarMetro towards an enhanced transit mode alternative that is first and foremost designed to enhance and build upon the existing transit system in Tallahassee. These criteria are based on research of modern light rail practice in the United States, modern streetcar practices in the United States and modern tramway practices in France. Several in-depth case studies were developed to describe what aspects of each modern
rail transit practice Tallahassee and StarMetro could adapt to the TSC and what aspects should be avoided.

The study consisted of five distinct components, including a literature review, case studies, system criteria analysis, key findings, and recommendations to StarMetro.

**Methodology**

In evaluating the issue of what criteria contribute to the success or failure of an enhanced transit mode, the SPT (Studio Project Team) examined three types of enhanced transit, including modern U.S. streetcar systems, modern U.S. light rail systems, and modern French tramway systems. The SPT first conducted a literature review on certain aspects relating to enhanced transit modes. Case studies were then selected, and pertinent data was obtained. The streetcar systems in Little Rock, Arkansas, Seattle, Washington, Tampa, Florida, and Memphis, Tennessee were analyzed. The light rail systems in Houston, Texas, Phoenix, Arizona, and Salt Lake City, Utah were also analyzed as were the tramway systems in Reims, Le Mans, and Orléans, France. The streetcar case studies were selected primarily due to their use of either in-street or exclusive ROW in order to gauge the effect of ROW conditions on streetcar performance. The modern light rail case studies were selected because their alignments were constructed by taking formerly road right of way and incorporating that right of way into the light rail line. The French case studies were selected due to population size that is relatively comparable to Tallahassee, the presence of a university whose campus is served by a tramway line, and the potential availability of data on the public transportation system. In conducting the studies, inquiries were made to a variety of individuals and organizations. After collecting the pertinent data for each city, each city’s system was examined to ascertain those facts leading to the systems’ successes and failures with respect to increasing ridership. The SPT’s key findings were based on this examination. The SPT used these findings to develop system criteria and recommendations for an enhanced transit vision for Tallahassee. These recommendations have largely incorporated those factors which have led to success in the other systems’ transit performance and enhanced economic development.

**Literature Review**

The first component of this study consists of a literature review. The purpose of a literature review was to help the Studio Project Team (SPT) become familiar with enhanced transit options and provide the reader with background information on contemporary streetcar
objectives, applications, and performance in the United States and France as well as BRT features and other pertinent information identified in the statement of work. The literature review focuses on five areas: 1) Streetcar Vehicle Design and Performance Characteristics; 2) Bus Rapid Transit Characteristics; 3) Justifying Taking Street Space for Transit; 4) Common Route Stops and Safety Features; and 5) Theory and Fact of Economic Development Related to Transit. This section of the report allows the reader to familiarize him or herself to any contrasting perspectives and viewpoints on these areas.

The main points that emerge from the literature are that the type and design of the transit vehicle directly impacts the level of performance and efficiency the system will operate at, as well as the overall accessibility of the system. Secondly, BRT systems usually display a low capital cost per mile of investment then other enhanced transit options. Thirdly, the development of justification for using street space for transit should not be limited to assessing travel time impacts only. This narrow approach is insufficient and ignores the other positive impacts an enhanced transit system can have, such as urban beautification. Fourth, there are specific route and stop design characteristics that can be incorporated into an enhanced transit system that will improve the overall safety level of the system as well as increase passengers’ perceived level of safety. This can impact ridership. Lastly, there is a major disconnect with the theoretical and empirical analyses of how transit investments affect land use changes and economic development. Some researchers have indicated that transit investment directly stimulates and fuels economic impact around the line and its stops, but others do not. The empirical evidence or the lack of evidence supports those who do not and shows that there is no direct correlation that can be found. The examples of increased economic benefit surrounding a transit investment are always in conjunction with other stimulating factors (i.e., land use density changes, other major development projects, pre-existing growth, etc.) that were most likely the driving force.

**CASE STUDIES**

A major component of this study and the basis for developing the evaluation criteria and performance indicators for StarMetro’s proposed enhanced transit system are the case studies. The SPT conducted a case study evaluation of the transit systems in ten cities in the United States and France, including Little Rock, Arkansas, Memphis, Tennessee, Tampa, Florida, Seattle, Washington, Salt Lake City, Utah, Houston, Texas, Phoenix, Arizona, Le Mans, France,
Orléans, France, and Reims, France. The case studies presented in this report assess the impact and performance of the modern streetcar and light rail and their impact on the larger transit systems in the areas that they serve. Performance measures for both the streetcar/light rail and the local bus systems were analyzed for comparison purposes. These evaluations look at the role of streetcar/light rail development in each city compared to the overall development of the city transit system. The case studies also document how the streetcars impact land use and development within each city. Information on cost and performance of the systems is presented as well.

**U.S. Streetcar**

The four cities selected as case studies for U.S. streetcar practice are Memphis, Little Rock, Tampa, and Seattle. The Memphis Area Transit Authority (MATA) operates the Memphis Trolley System, comprised of three lines that together act as a central city circulator: Main Street, Riverfront, and Madison Avenue. Daily ridership for the streetcar system in 2009 was 3,052. The streetcar lines make up only 2% of total transit system ridership, as measured by passenger miles, with 2.5 passenger miles per vehicle mile. The streetcar operating expense per passenger mile is $4.35, compared to $0.75 for bus. The streetcars operate a variety of vintage streetcar rolling stock. There are transfer points along all three streetcar lines where patrons may transfer to buses, and fares are transferable between modes. The streetcar operates primarily in mixed traffic.

The Central Arkansas Transit Authority operates the River Rail Streetcar system in Little Rock, Arkansas. The line is 3.37 miles long and operates in mixed traffic at an average speed of 4.6 mph. In 2009, the streetcar averaged 500-600 passengers per day with approximately 2,000 passengers on the weekend. The streetcar represents approximately 1.47 percent of total system patronage based on passenger miles and had 3.4 passenger miles per revenue mile. The streetcar operating expense per passenger mile is $4.89 compared to $0.90 for bus. The River Rail Streetcar operates vintage streetcar vehicles. Bus passes, tickets, and ride cards are valid on the streetcar system, however, streetcar passes and tickets are not valid for the buses. Both modes operate along the same routes and therefore allow the traveler to choose the faster option which is usually the bus.
The TECO Streetcar Line operates in Tampa, traveling from the Convention Center area in downtown Tampa, out to Channelside and Ybor City, and opened in the early 2000s. The streetcar line is 4.76 miles long, serving eleven stations at an average speed of six miles per hour. The streetcar line (as measured by passenger miles) represents 1.2 percent of total transit system patronage, and it should be noted that passengers can get from downtown Tampa to the destinations served by the streetcar (such as Ybor City) faster than the streetcar by taking the bus. The streetcar had an average of 1,200 boardings per day, with an average of 10.4 passenger miles per revenue mile. The streetcar operating expense per passenger mile is $3.07 compared to $0.93 for bus.

Opening in 2007, Seattle Streetcar Union Line operates from Downtown Seattle to the South Lake Union neighborhood of the city. The Line is 2.6 miles long, and has eleven stops. The Union Line runs within mostly mixed-traffic with limited segregated ROWs near the maintenance facility, Lake Union Park, and transfer hubs. The system uses three modern low-floor Inekon Trio-12 streetcars designed and manufactured by Inekon Group of the Czech Republic. The Union Line has an average of 6.9 passenger miles per revenue mile, and has around 1,200 boardings daily. The bus averaged 14.3 passenger miles per revenue mile. The streetcar operating expense per passenger mile is $5.71 compared to $0.95 per passenger mile for bus. The Union Line also represents less than one percent of total transit system ridership.

**U.S. Light Rail**

The three cities selected as case studies for modern U.S. light rail practice are Houston, Phoenix, and Salt Lake City. Houston’s METRORail Red Line opened in 2004 along a 7.5 mile alignment that runs north/south through Houston’s downtown. As of 2009, the Red Line had an average daily ridership of 38,769 on weekdays. The line carried roughly 30.4 passenger miles per revenue mile (compared to 11.6 for bus) and captures 20% of total system ridership. The line connects with approximately eighty-six east/west bus routes. When the line opened, six hundred bus trips were removed from the downtown area, feeding passengers into the light rail line. The Red Line’s operating expense per passenger mile is $0.57 compared to $1.24 for bus.

The Valley Metro Light Rail line in Phoenix is a twenty mile light rail line, which opened in January 2009. The line runs east/west from Phoenix to Mesa, connecting to Arizona State University in Tempe along the way. The line has an average daily ridership of 38,030 on weekdays. As of 2009, ridership performance was reported as approximately 33.04 passenger
miles per revenue mile compared to 5.83 for the bus system. Light rail operating expense per passenger mile is $0.38 compared to $1.25 per passenger mile for bus. Overall, ridership on the rail line represents roughly 18% of all ridership on the transit system. The line connects with the Valley Metro bus system at twenty-six of the twenty-eight stations.

The UTA’s TRAX light rail system runs throughout the Salt Lake City area over a thirty-five mile long alignment. The focus of this report is on the University Line, which (A subsequent 2011 expansion incorporated the University Line into the TRAX Red Line) runs from the city center of Salt Lake City to the University of Utah campus, terminating at the University Medical Center. Annual ridership on TRAX in 2009 was 13,385,148, with a reported 18.3 passenger miles per revenue mile, compared to 6.3 for bus. The operating expense per passenger mile for TRAX is $0.48 compared to $1.04 per passenger mile for bus.

Modern French Tramway

The three cities selected as case studies for modern French tramway practice are Orléans, Le Mans, and Reims. The Orléans tramway system opened in 2000 and consists of a single line running along an 11.2 mile alignment (Line A). The line runs north-south connecting the city center of Orléans to its suburbs, as well as connecting to the Université d’Orléans. The line serves roughly 40,000 passengers per day, and transit ridership across the entire system has steadily increased since the opening of the tramway. This single line now accounts for 47% of the total system’s ridership. The ROW of the Orléans tramway is representative of many types of ROW typically used in French tramway design (such as grassed medians and protected ROW). Line A also runs directly through the heart of the Université d’Orléans.

The Le Mans tramway is one line with two branches, running along an approximately 9.6 mile long alignment, serving twenty-nine stations. The tramway began operation in 2007, and since the tramway’s implementation the tramway has seen a large shift from bus patronage to tramway ridership, and the tramway now accounts for 51% of total transit system ridership. The line carries roughly 51,000 boardings per day out of a total system ridership of 100,000. The Le Mans tramway, like many tramways in France, has been used as an opportunity to completely enhance the urban design of the city of Le Mans, with particular focus on the streetscape along the rail corridor and the city center of Le Mans.

The Reims tramway opened in April 2011, and consists of two lines, with a total alignment length of 6.9 miles. Lines A and B begin in the northern end of the city, travelling
through the city center of Reims before Line A turns east to the Debré Hospital, while Line B
continues to the Gare Champagne TGV station. As of June 2011, the tramways reported
boardings of 35,000 per day. Like the other French tramway systems, the Reims tramway is an
opportunity to enhance the urban design of the city along the tramway alignment through the
complete reconstruction of the streetscape.

The French case studies and light rail case studies examined in this report show a
contrasting transit philosophy compared to that of the American application of modern streetcar
systems. American systems typically have the bus as the centerpiece, with very little integration
with other transit modes (i.e., streetcar and light rail) as they are introduced. The French
approach transforms the entire transit network to make the modes (tramway and bus) fully
integrated, and the higher capacity tramway becomes the backbone of the system. The
differences between the American and French contrasting systems are further illustrated in
Figure ES-1, which shows the modal contribution each of the case study systems have on their
area transit system as a whole.

![Figure ES-1: Case Study Systems’ Contribution to Total Transit System](image)

Source: NTD, 2009
KEY FINDINGS

Below are key findings that have been identified based on the operations and performance of the four streetcar case studies. In general, these case studies demonstrate the modern streetcars have:

- **Limited Coverage** - In terms of the service area, all of the case studies appear to service a very small area of the cities and, as a result, a small portion of the total population.

- **Low Ridership** – Streetcars have seen low ridership on both a per-day basis and in terms of passenger miles per revenue mile when compared to modern light rail and French tramways.

- **Low Efficiency** - The average cost of carrying one passenger one mile on a streetcar in all four case studies was $5.21. In comparison, the average operating cost of carrying one passenger one mile on the bus systems in all four case studies was $0.89.

- **Low Operating Speeds** – All four case study systems have low operating speeds. The average operating speed for the streetcars is 5.6 mph while for buses it was 13.52 mph.

- **Vehicle Design and Capacity** – It has been noted that the modern streetcar vehicle design have seen improved productivity. The larger capacity modern streetcar vehicles are capable of carrying more passengers per mile, and in general are seen in a more favorable light than the heritage design vehicles.

- **Low Contribution to Transit Ridership** – In terms of contributing to overall transit ridership, streetcars show a very low contribution to the system as a whole. Total streetcar ridership makes up for its area averages to be less than 2.5 percent of total public transit ridership.

- **Operating Costs** – All expenditures, such as capital cost and operations and maintenance (O&M) cost, are directly related to the size of the system in terms of length of the line and number of vehicles. The longer the line and the more vehicles there are the higher the expenditures for the system. It should be noted that as the size of the system increases, corresponding increases in ridership could lead to a reduced overall operating cost per passenger.
Below are key findings that have been identified based on the operations and performance of the three U.S. light rail case studies:

- **Exclusive Right-of-Way** – A large part of light rail systems’ success is the exclusive ROW the systems use throughout the route. This maximizes operating speed and efficiency by reducing interference from automobiles.

- **Designed to board and alight large passenger volumes quickly through vehicle design with multiple doors, platform design, and proof of payment fare collection system**

- **Access to Universities** – A major factor of two light rail systems is that the systems travel directly to major universities. With direct access to universities, light rail systems have been successful in attracting college students onto the transit system who may have not used a bus-only system.

- **Integration with Transit System** – An additional factor in light rail success is the light rail’s interconnectivity with the overall transit system. All the light rail systems have routes that provide access to many connecting bus routes.

- **Student Fares** – Both METRO light rail and UTA TRAX have made conscious efforts to promote free or heavily discounted transit passes for university students. The use of dedicated university passes can entice the university community to use the enhanced public transit mode since it can greatly lower transportation costs.

- **Park and Rides** – To further help feed the enhanced transit mode, all three light rail case study systems used park and rides located along the routes. Dedicated light rail park and rides allow passengers to drive to various stations along the light rail line route and park their car for free before using the system.

- **Connections to Large Populations** – All three light rail systems involved in the study are part of large metropolitan areas. The large population sizes and densities of these regions have all contributed to high ridership levels since there are enough people to support an enhanced travel mode.
Below are key findings that have been identified based on the operations and performance of the three modern French tramway case studies:

- **High Ridership** – Some of the French tram systems have an overall system ridership in excess of fifty percent of total transit ridership. Characteristics that contribute to the systems’ high ridership include high operational speeds, high frequencies, extended service hours, and high connectivity with the city center and surrounding areas, directly serving many destinations with a small number of lines.

- **Integration with Transit Network** – French tramway systems are generally well integrated with the overall transit network and function as the core of the transit network. Various systems, such as Reims, restructure their bus networks into frequent, core routes that connect various parts of the city to the tramway and secondary feeder routes that connect to tramway stations in order to create a complete network centered around the tramway line(s).

- **Urban Design** – Care is taken to ensure that the tramways fit into the existing urban fabric and character of the city and that they enhance the urban design of the corridors along which they run.

- **ROW Separation and Priority at Intersections** – French tramways, when possible, are placed in a ROW that is protected from vehicle traffic, rather than being mixed in with vehicle traffic. Tramway ROW is often taken from existing vehicle lanes with no replacement. French tramways have priority at all times at all intersections in most cases. These characteristics allow for faster travel times, high operating speeds, and prevent the tramways from being delayed by vehicles.

**SYSTEM CRITERIA ANALYSIS**

Criteria necessary for alternative evaluation requires the establishment of clear goals and objectives for transit and the specification of indicators appropriate to those goals and objectives. Two broad goals were identified during the process; one primary and one secondary.

- **Primary Goal**: Transit System Improvement and Efficiency
- **Secondary Goal**: Economic Development
The following objectives for any enhance transit mode were determined to be paramount to achieving the **primary goal** of StarMetro:

- Ensure system operates efficiently and cost effectively;
- Improve system reliability and frequency;
- Increase transit accessibility;
- Maximize system integration and connectivity with existing bus system;
- Reduce safety risks by incorporate appropriate safety and design features; and
- Ensure adequate service area and ridership.

The following objectives for any enhance transit mode were determined to be paramount to achieving the **secondary goal** of StarMetro:

- Promote economic development in Tallahassee;
- Increase residential and commercial development along TSC; and
- Increase employment and population densities along TSC.

The evaluation criteria identified below are based on various performance and operation characteristics identified in the case studies and are generally accepted throughout the transit profession. These proposed enhanced transit alternatives along the TSC should be analyzed against these criteria in order for StarMetro’s transit objectives to be achieved.

**KEY RECOMMENDATIONS**

Below is a list of key criteria for an enhanced transit mode based on the findings from the case studies. Where applicable, specific performance measures have been tied to each specific recommendation.

- **Route Length:** The end to end route length of the alignment should be at least **five miles** long.
- The enhanced mode should serve both the **city center and outside the city center**. It should not solely be focused on downtown Tallahassee.
- The enhanced mode should **maximize connections to key destinations**.
- The enhanced mode should **serve the FSU campus**.
- **Operating Speed:** End to end scheduled operating speed should be **greater than an average of 10 MPH** or than existing fixed route bus service (whichever is faster).

- **Stop spacing:** The average stop spacing from end to end along the alignment should be **1/3 to 1/2 mile apart.**

- **Headways:** AM peak, mid-day, PM peak and evening headways should be **every 15 minutes of better.**

- **Span of Service:** early morning to late evening/night, **14-16 hours a day during weekdays.**

- **ROW:** The enhanced mode should have a **dedicated ROW** wherever possible.

- **Priority:** The enhanced mode should have **priority over all other traffic at intersections.**

- **Proof of payment:** The enhanced mode should use a **proof of payment fare system** in conjunction with vehicles with multiple large doors.

- **Transferability:** **Fares should be transferable** between the enhanced mode and regular fixed route buses.

- **System interconnectivity:** The overall transit network should be designed to create **ample connections between fixed route buses (particularly north-south crosstown routes) and the enhanced mode.**

- **Transfers between the bus network and an enhanced mode:** **Bus stops and enhanced mode stations should be located in close proximity to each other** to facilitate seamless transfers between modes.
INTRODUCTION

PURPOSE OF STUDY

The Department of Urban and Regional Planning at Florida State University (FSU) entered into an agreement with StarMetro, the city-owned and operated bus service for Tallahassee, Florida, for the preparation of this transit report. This report is intended to be a guidance document that will present criteria to aid StarMetro in defining the Tennessee Street Corridor (TSC) enhanced transit alternatives – a modern streetcar, light rail transit, or a bus rapid transit (BRT) system. The purpose of the proposed enhanced transit alternatives is to accommodate an increasing transit ridership demand along the TSC while improving and increasing public transit service for Tallahassee residents. In addition, the alternatives are intended to expand upon transit improvements that were achieved by StarMetro’s Nova2010 route restructuring, while also supporting land use change.

This study was based upon the knowledge that any enhanced transit mode selected for the TSC must yield substantial benefits over and above what local buses bring to the corridor but be well integrated into StarMetro’s bus network to reduce redundancy and inefficiency. The enhanced transit alternative must reduce transit travel times and increase capacity as well as maximize Tallahassee’s land use and development objectives. Thus, the goal of this study is to prepare evaluation criteria based on various performance indicators that enhanced transit should possess in order for StarMetro’s and Tallahassee’s transit objectives to be achieved.

SCOPE OF ANALYSIS

An enhanced transit mode has the potential to greatly improve public transportation in Tallahassee if it is planned and designed correctly. The scope of the analysis for this studio is limited to developing criteria in order to guide StarMetro and other interested parties in defining enhanced transit mode alternatives that are first and foremost designed to enhance and build upon the existing transit system in Tallahassee. These criteria are based on research of modern light rail practice in the United States, modern streetcar practice in the United States and modern tramway practice in France. Several in-depth case studies are developed to describe what aspects of each modern rail transit practice Tallahassee and StarMetro could adapt to the TSC, and what aspects should be avoided.
METHODOLOGY

This project focused on addressing to what extent various criteria contribute to the success or failure of an enhanced transit mode. This question is particularly focused on to what extent those criteria lead to an enhanced transit mode that improves the overall transit system. In order to answer these questions, the practice of three types of enhanced transit was examined in this study: modern streetcars in the United States, modern light rail systems in the United States, and modern tramway systems in France.

An initial review of existing literature on various aspects relating to enhanced transit modes was performed. After a review of the literature and initial examination of each of the enhanced transit modes, case studies were then selected for each enhanced transit mode based on a variety of selection criteria. Each case study was carefully analyzed to examine the implementation and performance of the enhanced transit mode based on a variety of factors, both quantitative and qualitative. System criteria and recommendations were developed based on the results of the case studies and available literature.

In the case of streetcars in the United States, streetcar systems in the cities of Little Rock, Arkansas, Seattle, Washington, Tampa, Florida, and Memphis, Tennessee were selected. All the case studies were selected primarily due to their use of either in-street or exclusive ROW in order to gauge the effect of ROW conditions on streetcar performance. Little Rock was selected in part due to its comparable size to Tallahassee. Tampa was selected in part due to its location in Florida.

The case studies selected for modern light rail practice in the United States are Houston, Texas, Phoenix, Arizona, and Salt Lake City, Utah. These three case studies were selected because their alignments were constructed by taking formerly road right of way and incorporating that right of way into the light rail line. For Salt Lake City, analysis was focused on the University Line portion of the light rail system due to its direct service to the University of Utah and the right of way treatment used along the portion of the alignment that serves the university campus.

After an initial examination of roughly twenty French tramways, three cities were selected for analysis as case studies in this report: Reims, Le Mans, and Orléans. These three cities were selected due to several factors: a population size that is relatively comparable to Tallahassee, the presence of a university whose campus is served by a tramway line, and the
potential availability of data on the public transportation system. The final factor was based on contacts that the Studio Director had with individuals who potentially had access to performance data for these three systems.

The collection of data was a major component of the study. Inquiries were made to a wide variety of individuals and organizations, with varying degrees of success. In the case of the French case studies, data was provided by third parties who had contacts at various French public transportation agencies or who had previously worked at public transportation agencies in France. After data was collected, each case study was carefully examined to determine what factors led to its success or failure in increasing ridership on the overall transit system. Key findings for modern streetcar, light rail, and tramways were drawn from this analysis. These key findings represent the primary factors that have led to the success or lack thereof for these three enhanced transit modes.

Once this analysis and development of key findings was completed, these findings were used to develop system criteria and recommendations for an enhanced transit vision for Tallahassee. The system criteria were developed based on the case studies and literature. The recommendations, based on factors developed in the system criteria, were developed grounded in evidence from the examination of the three enhanced transit modes, and were designed to incorporate the factors that have led to success in improving the performance of the overall transit system, and to a lesser extent, factors that have led to enhanced economic development.

**BACKGROUND ON EXISTING TALLAHASSEE TRANSIT SYSTEM**

StarMetro is the local transit agency for Tallahassee, Florida, operating both fixed route and paratransit service. StarMetro is not an independent authority, but a department of the City of Tallahassee. According to National Transit Database (NTD) data, in 2010, StarMetro had a fleet of seventy-three maximum available fixed route vehicles (fifty-six operated in maximum service) and seventeen maximum paratransit vehicles. Its annual operating budget in 2010 was $12,856,536.¹

Tallahassee is the state capital of Florida, with a population of 162,310. One significant factor contributing to transit ridership is the presence of three higher educational institutions: Florida State University (FSU) with 40,000 students (2011), Florida Agricultural and Mechanical University (FAMU) with approximately 13,000 students (2010) and Tallahassee Community
College (TCC) with approximately 20,000 students in 2010-11. FSU, FAMU and TCC have a universal bus pass agreement with StarMetro, allowing students unlimited access to the city bus system.

As of Fall 2011, StarMetro operates twelve bus routes that make up the new decentralized transit system. Importantly, StarMetro also operates multiple routes geared towards FSU and FAMU students, who travel from student housing areas to campus. In the case of FSU, the students circulate through the campus before going back to off-campus housing destinations. These routes are funded through contractual agreements between StarMetro and FSU or FAMU. Total annual unlinked boardings in 2010 totaled 4.8 million, with 13.9 million annual passenger miles.²

**System before July 2011**

For many decades, StarMetro, which was known as TalTran until the mid-2000s, operated a fixed route system centered around C.K. Steele Plaza, a single transfer center in Downtown Tallahassee. All buses arrived at and departed from the Plaza at the same time on a pulse system with several minutes in between the arrival and departures to facilitate passenger transfers. While this downtown centric system was very good for passengers to go to Downtown from all corners of Tallahassee, it meant that passengers going to a destination outside of Downtown likely had to transfer at the Plaza. Additionally, many of StarMetro’s routes were centered around making loops through neighborhoods on residential streets in order to minimize walking time for residents accessing transit, but at the cost of greater and slower bus travel times. This system remained intact without significant changes for several decades.

**July 2011 System Decentralization**

In July 2011, the StarMetro system switched over to a new multi-destinational decentralized system, where rather than going to a central Downtown transfer hub, routes were laid out in a rough grid pattern around the city. The goal of this route restructuring was to increase ridership, increase the frequency of transit, improve travel time, reduce out-of-direction travel for riders, and reduce the need for patrons to transfer Downtown. Instead, transfers occur at intersections across Tallahassee. The impetus for route decentralization came from an examination of public transit needs based on consultations with a variety of stakeholders performed in a 2004 Department of Urban and Regional Planning Studio at Florida State University. Additional analysis by StarMetro also led to the conclusion that less than ten percent
of its riders were actually traveling to a destination Downtown\textsuperscript{3}. Unfortunately, with the Downtown-centric transit system, this meant that one hundred percent of riders had to go Downtown to transfer, meaning that many patrons had to travel out-of-direction from their destination. A key component of the route decentralization plan is that it was designed to use existing resources and be cost-neutral. The 2011 route decentralization (called the Nova plan for “Innovation in Transit”) was designed to address these issues and ultimately create a more productive, higher ridership transit system that would attract more choice riders (i.e. transit patrons who have access to a vehicle but choose to use transit instead).

**Ridership & System Performance**

Fixed route ridership in 2010 was 4.8 million (annual unlinked trips), with 185,982 annual revenue hours, 25.51 unlinked passenger trips per revenue hour, and 6.8 annual passenger miles per annual revenue vehicle mile. Further ridership and system performance details are shown in the Table 1. StarMetro’s passenger trips have gradually increased over time from 3.6 million in 1995 to 4.4 million in 2009. Over this same time period, the number of passenger miles per revenue mile has decreased slightly from 7.15 to 6.56. Like most transit agencies, StarMetro’s operating expense per passenger trip has also increased. It is important to note that these figures are before the implementation of the Nova decentralization plan, and the effects of system decentralization could have a significant impact on both the productivity of the system and on future ridership in the years ahead.
A Vision for an Enhanced Transit Application in Tallahassee

Table 1: StarMetro Historical System Performance

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<th>Year</th>
<th>Operating Expense Per Passenger Mile</th>
<th>Operating Expense Per Passenger Trip</th>
<th>Passenger Miles</th>
<th>Passenger Trips</th>
<th>Passenger Miles Per Revenue Mile</th>
<th>Revenue Hours</th>
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Source: FTIS, 2009

CORRIDOR DESCRIPTION

The TSC is the eight-mile segment of U.S.90/Tennessee Street/Mahan Drive that traverses east-west through central Tallahassee (Figure 1). The corridor is one of the major arterials to and through downtown and extends from Capital Circle Northwest to Capital Circle Northeast. The TSC is mostly a four-lane road with a median but it widens to six lanes between Monroe Street and Ocala Road. The TSC connects the eastern and western portions of Capital Circle, as well as linking FSU and TCC with downtown. The corridor also bisects a Multi-modal Transportation District (MMTD) that was recently adopted by the City, as seen in Figure 1.
As a corridor with heavy automobile traffic volumes, demand modeling of the Nova2010 network showed that the TSC will have the heaviest transit ridership of any route in the area. The corridor serves a significant population area and has many roadway intersections that offer an opportunity for strategic stops to support enhanced transit, as well as pedestrian-oriented amenities.

Figure 1: TSC Corridor
Source: StarMetro Request for Proposal, 2011
LITERATURE REVIEW

The section presents the key aspects of the literature reviewed for the case studies and criteria analysis. The purpose of the literature review is to help the Studio Project Team (SPT) become familiar with enhanced transit options and provide the reader with background information on contemporary streetcar objectives, applications, and performance in the United States and France as well as other pertinent information identified in the statement of work. Sources consulted for the literature review include articles retrieved from the Transportation Research Record, and the TCRP 86 Synthesis report. The literature review focuses on five areas: 1) Streetcar Vehicle Design and Performance Characteristics; 2) Justifying Taking Street Space for Transit; 3) Common Route Stops and Safety Features; and 4) Theory and Fact of Economic Development Related to Transit.

STREETCAR VEHICLE DESIGN AND PERFORMANCE CHARACTERISTICS

United States Streetcars

The rolling stock used by streetcar systems in the United States can be broken out into two categories. The first category is historic or heritage streetcars, which are often based on the design of streetcars used in the early twentieth century. The second category is modern streetcars, which exhibit a contemporary design originally based on European models.

Heritage streetcars are based on the design of historic streetcars that were used in many cities in the United States in the first half of the twentieth century. These streetcars may be modern replicas based on historic models, or in some cases, refurbished and restored historic streetcars. Little Rock, Arkansas, Tampa, Florida, and New Orleans, Louisiana are examples of cities with streetcar systems using this type of rolling stock. According to a report examining the feasibility of a streetcar in Davis, California, heritage streetcars are less expensive than their modern counterparts, but this comes at a price of limited capacity and limited performance (particularly in terms of acceleration). For example, the streetcars used in Little Rock carry approximately eighty-eight passengers (compared to up to 140 for a modern streetcar). The report also found that historic streetcars tend to be “lacking in both capacity and speed compared to modern streetcars”. Heritage streetcars typically have four doors, located on each side of the
front and rear ends of the cars, and in the case of Little Rock, Arkansas, are approximately fifty feet (15.2 meters) in length.\textsuperscript{8}

Modern streetcars in the United States are provided by a variety of manufacturers, based both in North America and Europe. Seattle, Washington and Portland, Oregon are two cities whose streetcar systems use modern rolling stock. According to a draft report by the American Public Transportation Association’s (APTA) Streetcar Subcommittee, in examining modern streetcar vehicles in North America and world operating environments, modern streetcars in the United States are typically low-floor, with an average floor height of fourteen inches.\textsuperscript{9} This configuration allows for fully level or nearly level boarding at streetcar platforms, which expedites boarding, and provides more convenient service for wheelchair users or other handicapped passengers.\textsuperscript{10} The length of modern streetcars in the United States ranges from sixty-five feet (twenty meters) to seventy-five feet (22.9 meters), longer than their heritage counterparts but shorter than many European models.\textsuperscript{11} Modern streetcars in the United States also have multiple doorways (three on each side in the case of Portland), and are designed to allow patrons to enter and exit from any door using a proof-of-payment fare system. This allows for the maximum usage of all doors during boarding and alighting, which results in less dwell time at stops and a faster overall travel time.\textsuperscript{12} Another advantage that modern streetcars offer over their heritage counterparts is increased capacity and potentially higher performance. Modern U.S. streetcars can typically accommodate well over one hundred persons, and open floor configurations allow for increased standing room capacity.\textsuperscript{13}

\textit{French Tramway/Streetcars}

According to the \textit{Comparative Performance Data from French Tramways Systems Final Report}, tramway construction is generally very similar throughout France. The tramways possess their own ROW, which runs parallel with the streets for motorized vehicle traffic and tram vehicles are given high priority at signalized junctions. The two tram systems within France that differ from this description are Nantes and a suburban Paris line. Neither of these systems had enough roadway space to create dedicated ROWs for the tram system, and the system authorities had to create alternatives. In Nantes, the road is shared by both cars and trams and the suburban Paris Line T2 operates on a segregated alignment that was a former railroad. Another characteristic common to the majority of French tram systems is high capital costs of construction. These high capital costs are because the majority of these tram systems require in-
According to the report released in 2003, the capital costs of reconstructing and beautifying streets for French tram systems was between eighteen and twenty million Euros per kilometer ($23.94 - $26.60 million per 0.62 miles). It is unknown if this includes the cost of vehicles.

According to the Parkinson, European Union law states that all tram vehicle producers are eligible to place bids for contracts to supply rolling stock to different cities investing in tram systems. However, the French tram vehicle market is dominated by a French company named Alstom. Alstom tram vehicles allow the buyer to customize the exterior and interior designs of the trams, especially the front car, giving the buyer the ability to almost completely design the tram’s visible characteristics. Alstom produces two types of trams: a high floor model and a low floor low profile model. The high floor model is only used in three systems and those trams eventually had centre low profile sections added. The low profile model, Citadis, is much more prevalent with over 1,500 models having been delivered to seventeen French cities and to eighteen overseas cities.

The appeal of the Citadis trams produced by Alstom is that they allow for the cities to integrate their tram systems with the urban design of the city. The Citadis trams are produced so that the buyer has the ability to design various features of the modular unit, which results in the tram designs reflecting the atmosphere and character of the city. According to Alstom, the Citadis tram systems consist of low platforms and are only eighty percent standardized, which allows the communities purchasing the trams to design the exterior style of the tram. The customizable features include the design of the lead vehicle (Figure 2), the interior arrangement, and whether or not overhead cables are a part of the tram system.

Alstom noted several key figures of the Citadis trams, which included that the trams have a width of 2.65 meters and a length of thirty to forty meters depending on how many vehicles are included and that the trams can have capacities ranging from 145 to 302 passengers. The trams that are thirty meters long have a capacity to carry up to two hundred passengers.

Figure 2: Various Citadis Exterior Styles
Source: Alstom.com
passengers and consist of five modules while the trams that are forty meters long have a capacity of three hundred passengers and are extended to include two extra modules.

**JUSTIFYING TAKING STREET SPACE**

A review of the pertinent literature addressing the use of street space for public transit use such as streetcars and light rail systems confirms that street-space management involves the need to balance conflicting pressures. In cities where public transportation use is high, it is much easier to justify giving such transportation priority as compared to those areas where public transportation use is low and road traffic levels are high.\(^{14}\) Much of the research that has been done in this area has focused on travel time impacts for road and public transportation users, sometimes to the exclusion of other types of impacts. In one study, however, several other criteria were evaluated, including travel time, reliability of the public transportation, and road congestion relief impacts, such as reduced vehicle operating costs, reduced accident costs, and reduced vehicle emissions.\(^{15}\) What this study showed was that viable public transportation projects occurred where public transportation service frequencies and patronage were high and where traffic volumes were low. This study also supports the view that provision of a bus or tram lane is more viable where public transportation is carrying the equivalent of a lane’s worth of the person travel on the road. For instance, if public transportation carries a third of the travel on a three-lane road, a public transportation lane is likely to be viable. Importantly, it has been found that traffic disruption was more likely to occur where only parts of the street space were allocated to bus or tram use.\(^{16}\) Another important consideration is the “1KL Threshold” rule, which recommends that planners and governmental entities avoid introducing exclusive lane priority where traffic in the remaining lanes operates at more than 1,000 vehicles per hour per lane.\(^{17}\) Thus, in situations where street space is entirely allocated to bus or tram use, negative traffic impacts have been found to dominate the evaluation where traffic volumes per remaining lane operate at volumes above 1,000 vehicles per hour per lane.\(^{18}\) At these flows, delays are considerable.

As the literature also shows, restricting access to congested areas can improve mobility for everyone by having fewer vehicles on the road.\(^{19}\) Dedicating street space to sustainable modes of travel, such as buses and trams, can improve the accessibility for all modes, including automobiles. The key, as stated, is that the greater the vehicle occupancy, the greater the benefit
of public transportation. As such, the dedicated public transportation lane must be well-utilized in order to justify exclusive lane priority. An important point to keep in mind is exclusive lane priority is most effective if the public transportation lines can be designed to fully utilize the dedicated space. In order to avoid congestion, which can lead to the public’s disfavor of dedicating street space to transportation such as trams and light rail systems, exclusive lane priority is best handled on roads that are wide enough to accommodate both the public transportation and automobiles.

Another feature that has been shown to promote and facilitate transit activity includes adequate pedestrian/bicycle connections with transit stations and stops. Transit stations or stops should be a visible point of identity for the community. Access to the stops should be along direct and convenient routes. Access to the stations and stops includes good accommodations for bicycles. Safe pedestrian access should also be a priority. The stops and stations should be both safe and comfortable. They should provide direct or reasonable access to major points of interest in a community. The stations and stops should also be accessible to those people with disabilities. Adequate parking having direct access to stations and stops should be provided as well.

When performing an evaluation of a transportation project, the level of service (“LOS”) refers to the speed, convenience, comfort, and security of transportation facilities and services as experienced by those who use them. LOS ratings are widely used in transportation planning when evaluating problems and their possible solutions. In many situations, current planning analyzes transportation system performance based on motor vehicle traffic speed and delay. As such, there are usually no LOS ratings for other transportation modes, which often leads to road expansion being favored over other types of transportation improvements. This narrow approach has led to the development and use of the Multi-Modal Level of Service (“MMLOS”) indicators.

The MMLOS indicators lead to a more comprehensive and balanced transport method of planning that considers different modes and impacts. Stated differently, the MMLOS leads one to consider how the right-of-way (ROW) design and operation impacts the driver of a vehicle, the bus/transit passenger, the bicyclist, and the pedestrian. The MMLOS indicators can assist in identifying if a particular planning idea has indirect effects that are undesirable in the community. They can also be used to identify and evaluate consumer demands when the planning process is underway. The rating factors can be quantified to measure changes in
service quality and the indicators can be used to establish performance standards and targets. The MMLOS method estimates the LOS for the various mode users within the ROW. Each mode’s LOS is based on different factors, but the different LOSs are interrelated to one another as well. As the quality of one mode improves, that may have a positive, neutral, or negative effect on the other modes. For instance, as the running speed of automobiles increases, the LOS may improve for automobiles but the LOS for bicyclists may decrease. In another example, certain travelers might choose to shift from driving an automobile to taking public transit if the public transit had better service quality. Figure 3 provides a look at how the modes and their LOSs are connected.

![Figure 3: Multimodal Connection](image)

Source: FDOT, 2010

It is important to note that the Florida Department of Transportation ("FDOT") has adopted the MMLOS approach in evaluating transportation projects and has developed its own Multimodal Transportation Districts and Areawide Quality of Service Handbook. Although there is certainly a link between the modes of travel, each mode has a distinct LOS output. It is for this reason that FDOT chose not to create an index that would produce a single LOS grade for all modes combined on a single roadway. The FDOT has reasoned that a single grade would
mask the effects of the lesser-used modes, which would negate the effort involved in conducting a multimodal analysis.

A sound example of an MMLOS plan being used in Florida is the City of Largo’s Downtown Largo Multimodal Plan (“Plan”). The Plan has been described as the “framework for the improving quality of life in Downtown Largo through a paradigm shift that takes people out of their personal automobiles and allows them to safely travel by foot, bicycle, or transit throughout the area”.

The Plan is consistent with the City of Largo’s Comprehensive Plan and Strategic Plan in that it encourages development and redevelopment of downtown along commercial corridors, activity centers, and mixed use centers.

The Plan is intended to serve as a pilot project to develop mobility strategies that can be applied throughout the City of Largo, the third largest city in Pinellas County. With a study underway for potential regional rail service in Pinellas County, the Plan will assist the City of Largo in being transit-ready should the rail service travel through its city limits. The Plan is important in that it provides an indication of what aspects were important to the community during the Plan’s formulation. With respect to transit service, the local community has expressed strong support for regional rail service in Downtown Largo. The community also asked that the city increase frequency and operating hours of public transit and that it reduce travel time, that it centralize transfer points, and that it connect to other parts of the region. In its attempt to engage the public as much as possible, the city promoted greater awareness and understanding of its multimodal transportation needs, it used focus groups to identify multimodal needs for further review and comment at the public workshop, it engaged partner agencies to ensure the multimodal needs and policies included in the Plan were consistent with other plans throughout the region, and it used the results of the public process as a basis for development of an efficient multimodal transportation system. MMLOS can be a helpful tool in the project development process with the following:

- Design and Operational Analysis- What LOS does the project team want the system to run at?
- Evaluation of Project Alternatives- Which alternative has the best LOS?
- Establish Base Conditions for Alternative Analysis- What is the current LOS of the ROW?
- Development of Impact Evaluations- How does this alternative impact the different modes’ LOSs?
- Determining Route Choices- Which route provides the best LOS?
- Evaluation of Intermodal Connectivity - *Which alternative maximizes connectivity to other transit systems?*

Overall, justification for taking of street space for viable public transportation projects such as streetcar/light rail occurs when public transportation ridership is high and traffic volumes are low as well as when public transportation is carrying the equivalent of a lane’s worth of road travel. In addition, the literature shows that using a narrow approach of assessing only the impacts on travel time is insufficient and ignores the other impacts (positive and/or negative) a streetcar/light rail system can have. Thus, several other criteria should be evaluated, including travel time of various modes, reliability of the public transportation, road congestion relief impacts, reduced vehicle emissions, and the impact on LOS of the other modes of travel (i.e., an MMLOS analysis). Applying the MMLOS analysis to a project evaluation process allows for a more comprehensive and balanced method of planning that considers how the ROW design and operation impacts the various mode users. This can help justify the proposed streetcar/light rail project. The French have an further justification, in that the tramway takes street space from the auto and returns it to the residents of the city for the betterment of the entire city.

**COMMON ROUTE STOPS AND SAFETY FEATURES**

Stops and safety are important elements in designing a transit system. These elements protect pedestrians, transit riders, and the driving public from harm. A better streetcar system that benefits all members of the community can be designed by studying which elements of the existing streetcar systems are the most productive. The most accepted conclusion is that “on-street running in mixed traffic…[is]…the least desirable ROW for light rail and tram systems”.

The most significant issues as determined by Currie and Shalaby include safety, accessibility, and transport efficiency. These elements influence the perceived safety of the system and may influence ridership numbers. The most up to date information on streetcar stops and safety design is from the Currie and Shalaby study, which is focused on the cities of Melbourne, Australia and Toronto, Canada, the results of which could be applicable to an enhanced transit application in the U.S.

**Traffic Interference**

Melbourne, Australia faces the two major challenges of traffic interference and universal access with the operation of its streetcar line. It is proven that mixed traffic reduces operating
performance and causes lower than average speeds because of traffic impacts, number of tram stops, and type of stops.\textsuperscript{29} A complicated issue is the efficient use of road space, which Melbourne is attempting to solve by experimenting with different types of streetcar stops because the common curbside stop is not an efficient use of space at this time. Currie and Shalaby’s 2007 study of Melbourne determined that mixed operation is not a good environment for fast and reliable services, and that future performance will continue to deteriorate.\textsuperscript{30}

Toronto faces similar operating issues experienced by other streetcar systems. Toronto experiences low running speeds and a large variability in headway, and these issues are amplified by the small proportion of dedicated ROW operation. Curbside stops also exacerbate the issue of headway reliability. Until Toronto can figure out a solution for the narrow ROW and traffic interference, the system will continue to experience major issues.\textsuperscript{31}

\textit{Universal Access}

The issue of universal access came to the forefront in the 1990s and continues to cause problems for both the Melbourne and Toronto streetcar systems. Systems are now required to comply with Disability Acts, which means existing streetcar stops need retrofitting and future stops needs to be built properly. This proves to be difficult because the solutions are either expensive or not feasible for certain areas. For example, ramps are the lowest-cost solution, but are not practical because the grade of the ramp from the road to the streetcar is steeper than acceptable standards. The next solution is a platform, but this is only possible for stops that are next to the curb. Many stops in both Melbourne and Toronto are center lane operations making platforms not feasible.

There are numerous different types of stops that are possible in a given streetcar system. Currie and Smith detail four stops that both Melbourne and Toronto are considering in order to satisfy the universal access requirement. They are:

- **Safety Zone Stops**: a boarding area located in the center lane with railings to protect waiting passengers from the traffic flow. Traffic is not permitted on tracks at these stops.
- **Super Stops**: high-quality station style designs located in center lanes and including platforms and shelters. The road is narrowed to a single lane in each direction. Traffic is not permitted in the track area.
- **Curb Access Stops**: sidewalk flare outs, or curb extensions, where the road is thinned to a single lane in each direction. Traffic can drive on the tracks but must wait behind the
Tram as passengers board. This significantly affects road space and road capacity (Figure 4).

The type of stop that Currie and Smith promotes most heavily is the **Easy Access Stop** (Figure 5). This stop increases safety by reducing approaching vehicle speed, improving motorists’ perceptions of pedestrians, and raising the profile of public transportation. However, this type of stop is not as effective at reducing passenger access safety concerns as curb access stops are. This stop is the most cost effective and has a good performance record in terms of accessibility and traffic delays. The Easy Access stop is described as a stop that is staggered by direction with one at either side of an unsignalized intersection. Other elements include a curbside shelter and stop where passengers wait, a speed hump that lies in the road traffic lanes, full-time tram fairway system where road traffic is not permitted into tram tracks, speed humps that act as the walk platform for passenger access for near-level boarding, flexible bollards placed at intervals along the platform to guide traffic and delineate traffic lane edge, merge signage, and no curbside parking for the length of the platform and ramp. Effects of
these improvements include improved perception of safety for riders.35

**THEORY AND FACT OF ECONOMIC DEVELOPMENT RELATED TO TRANSIT**

A common theme in the transportation field is whether there is a link between transportation and land use. Whether based on new highway investment, new transit investment, or even new streetcar investment, there are intrinsic theoretical beliefs which lead experts from both the transportation and the economic development fields to argue for transportation investment as a way to spur new land use developments. In Giuliano’s *Land Use Impacts of Transportation Investments: Highway and Transit*, as well as the *TCRP Synthesis 86, Relationships Between Streetcars and the Built Environment*, the relationship between different types of transit investment and the subsequent effects on land use are explored. While results are mixed and vary on a city-by-city basis, generally speaking, current data has found that transit investment may not spur the type of land use and economic development that had initially been hoped for.

Giuliano’s *Land Use Impacts of Transportation Investments: Highway and Transit* delves into two specific forms of transportation investment: highway and transit. Based on many classical theories of land use-transportation interaction, it is believed that transportation costs are a major factor in determining land use decisions and housing settlement patterns. By looking at historical trends such as the decentralization of cities that has occurred as transportation costs decline, or the increasingly higher land values associated with more accessible areas, one could easily believe that transportation, and by association transportation investment, is the catalyst for land use changes. Instead, Giuliano finds that this relationship is not clearly defined, and instead there are many factors which actually influence the impacts of transportation investment on land use, and these factors can often be quite complex. The following paragraphs outline the relationship between highway investment and transit investment on land use impacts respectively.

Overall, there are six key items to understand when trying to analyze the relationship between highway investment and land use impacts. These six items are as follows: any single transportation investment provides marginal accessibility improvement in relation to the overall system; developable land must be available in the area; even if land is available, local policies, i.e. zoning, must favor development; the regional economy can dictate local results; the scale of
analysis needs to be factored in; and land use changes must be viewed as separate from regular economic growth. Based on these six items, the impacts of highway or transit investment on land use can instead be measured by travel outcomes, changes in property values, and changes in land use (including changes in employment or population density). After looking at both historical and more recent studies comparing highway investment to land use impacts, Giuliano found that overall results were mixed. For instance, the Beltway Study, which looked at fifty-four U.S. cities during 1960-1977, found that “the existence of a beltway, that beltway’s relative location, and its length had no consistent effect on growth”. Instead, it was the existence of local conditions which greatly shaped the land use impacts in these cities.

More recently, study results have also proven inconclusive, with Boarnet, Chalermpong, and Voith finding a connection between highways and economic growth, while Henry, Barkley, and Bao did not find highways to have a significant impact on growth. Possibly more indicative of the overall uncertainty in this field of study are the results of both Boarnet and Chalermpong’s study of Orange County, California and Singletary, Henry, Brooks, and London’s study of South Carolina. While both studies found evidence of a connection between highway access and economic growth, albeit the Orange County study was for intraregional impacts and the South Carolina study was for regional impacts, they both highlight the intricacies of linking transit-investment to land use. For example, the Orange County study discovered that both the new development and the highways were planned together, meaning that local policies may have conspired to help foster success. Similarly, though the South Carolina study found highway access was significant in boosting employment growth for durable manufacturing (highway access was not significant for nondurable manufacturing), this growth may have been influenced by agglomeration economies, access to I-85, and the overall specifics of the highway investment that occurred. Thus, both regionally and intra-regionally, while highway investment may spur economic growth, outside factors might play a large role.

Much like the research on the link between highway investments and land use, the effect of rail investment on land use also appears to be mixed. In recent years, both for the perceived environmental and societal impacts of rail transit, there has been a large push for increased development of rail transit. It is assumed that rail transit will boost accessibility along the rail corridor thereby increasing development and land values along that corridor. In the early stages of rail development, much of the literature found the assumptions to be false. For instance,
earlier studies of systems such as San Francisco’s BART, Atlanta’s MARTA, and the Philadelphia-Lindenwald commuter line found few significant impacts on either development or land values.

With the older modern rail systems now having been operated for over twenty years, new research has been conducted to again measure the impacts of rail transit on land use. Much like the highway investment studies, results have been mixed. Cervero and Landis looked at the impacts of BART twenty years after it opened and discovered that results actually differed throughout the system; while downtown San Francisco has experienced large growth and increases in its employment density, Berkeley and Richmond station-area growth has been largely non-existent due to either public opposition or economic issues. To further show the disparity in results, while Bohlinger and Ihlandfelt and Banister and Berechman found that Atlanta’s MARTA and Buffalo, New York’s light rail line had no significant impact on land use or employment growth, Harder and Miller noticed that in Toronto, residential land values were positively impacted by proximity to a subway station. Based on the disparity between different transit systems, it is clear that the results of rail investment can vary, and that many factors can influence the success or failure of a system. According to Giuliano, three observations can be drawn regarding the impacts that rail transit can have on land use. First, in order to land use impacts to occur, the investment must have “a significant impact on accessibility” (which most rail systems, built where auto accessibility is near universal, do not). Impacts often occur in fast-growing areas, and the investment of rail transit on its own is not enough to encourage development in declining areas. Other initiatives, such as zoning, parking, and other policies, are often necessary for impacts to occur. Based on these observations, it can be concluded that rail transit investments generally do not on their own have a direct impact on land use; rather, other factors (such as a strong real estate market) must be concurrent with these investments in order to have an impact on land use.

Finally, similar to the research on highway and transit investment, the studies of the relationship between streetcars and land use have also proven largely inconclusive. As stated by Ohland and Poticha, “streetcars don’t cause development to happen, but they do create the right decision making environment for policy and investments, which leads to development”. This means that under ideal circumstances, new streetcars can lead to positive land use changes in combination with other factors. For instance, Portland and Seattle have both successfully altered
their land use due to streetcar implementation leading to average daily ridership of 13,214 in Portland and 1,607 in Seattle.\(^4\) Portland partially constructed the first part of its streetcar system to encourage higher density development in an already revitalizing district near downtown, while Seattle has utilized the streetcar as a way to achieve certain planned densities and new pedestrian oriented development in an area that was already fast growing. This suggests that streetcars can have some impact on urban design and land use through supporting higher-density, transit oriented development in areas that have other factors (such as a strong real estate market) at play.

Unfortunately, while Portland and Seattle are examples of cities where streetcars have led to positive land use effects, the *TCRP Synthesis 86* found that this is not the norm. Most streetcar representatives and the public officials who approved these projects believe that the streetcar had a positive effect on land use and would thereby attract new development or enhance revitalization and redevelopment efforts. But these claims seem unfounded due to a critical lack of data and analysis that actually demonstrates a positive correlation between the two. For example, “few systems reported ancillary changes to the built environment, such as reduced parking garage construction, increased pedestrian or bike lane investments, or explicit reductions in parking requirements if located near streetcar”.\(^4\) To make matters worse, the average streetcar capital costs are typically in the $12-25 million per mile range, and without concrete proof of success, it may be hard to justify this type of expenditure.\(^4\)

While general results have pointed to inconclusive evidence regarding the link between transportation investment, including highway, transit, and streetcar, and land use impacts, positive results have occurred where local factors have been conducive to growth. Whether in the form of favorable land use policies, high area population growth, or generally positive development trends in an area, there are factors which can help ensure that transit investment leads to positive land use impacts. For example, while a city such as Buffalo did not experience overwhelming positive impacts on land use after building a light rail line, long-term land use impacts were in fact noticeable in downtown San Francisco following rail implementation. Overall, while the link between all three forms of transportation investment and land use impacts has varied by location, when the right factors combine, transit investment can be justified as a way of impacting land use.
BUS RAPID TRANSIT CHARACTERISTICS

The 2009 “Characteristics of Bus Rapid Transit for Decision-Making” (CBRT) report analyzes the implementation of Bus Rapid Transit through three key aspects of BRT: major elements of BRT, system performance, and system benefits. Running ways are possibly the most important element of BRT, since the running ways determine how fast and how effective BRT service may be. Running ways can be either on-street or off-street, but variations do occur within each type. For example, on-street running ways may include mixed-flow lanes, mixed-flow lanes with queue jumpers, on-street bus lanes, and bus-only streets; off-street running ways include expressway bus lanes, at-grade transit ways and grade-separated transit ways. Systems in the U.S. have utilized various types of running ways, with cities such as Cleveland and Los Angeles using at-grade transit ways and Phoenix using mixed-flow freeway operations. For the most part, however, on-street running ways are the more common type of running way in the United States. A second aspect of running ways is whether the systems use specialized markings to separate BRT running ways from the rest of the road. Special signage and signals, as well as colored pavement, not only highlight the unique nature of BRT, but also lend the service a brand identity. Finally, BRT systems can implement mechanical guidance systems as is occasionally used in in Europe. In the United States only Cleveland has chosen to use a mechanical guidance system.

The second major element of BRT- stations, takes into consideration all factors which go into a station’s design: station type, platform height, platform layout, passing capability and station access. Most often, a station’s design is linked to the system’s type of running way, meaning that if the system uses either off-street or segregated running lanes, the system’s stations are usually higher quality. The higher quality stations serve to heighten brand identity for the BRT, and may provide better amenities, including seating, public telephones and real-time system information. Generally, stations are spaced between one-half to one mile apart, although some systems have stations as little as one-quarter mile apart.

BRT vehicles are generally differentiated from traditional buses, and will often contain superior seating, better quality materials, and special styling to show that it is a distinct service. These distinctions are used to market the BRT systems as decidedly different from local bus service, and create a level of brand distinction for BRT. Additionally, the BRT buses, at least in the United States, will often use alternative propulsion systems, such as CNG. Articulated
buses are also commonly used in U.S. BRT systems, although only select systems exclusively use articulated buses.

The majority of U.S. BRT systems use traditional on-board fare payment, although alternate methods such as proof-of-payment and electronic fare collection are being increasingly used on systems such as the Las Vegas MAX and Los Angeles Orange Line.50

In-lieu of using dedicated guide ways for BRT, many cities use Transit Signal Priority to ensure efficient service without extra infrastructure expenditures. Similarly, Intelligent Transportation System applications such as Automatic Vehicle Location Systems and Automated Scheduling and Dispatch Systems are also used.51

Service and operating plans can also differ among systems depending on the type of running way used. Systems with exclusive transit ways, such as Miami-Dade’s South Busway and Pittsburgh’s grade-separated transit ways, use integrated networks with routes that not only can serve all stops, but also serve feeders and express routes; conversely, typical on-street BRT systems use single, all-stop routes.52 Running ways also dictate the frequency of service, with BRT systems on arterial roads operating with headways of five to fifteen minutes compared to 4 to ten minutes for systems with at-grade running ways.53

**BRT System Performance**

System performance for BRT was measured based on the data from at least forty systems throughout the United States and internationally, and analyzed for five factors: travel time, reliability, image and identity, capacity, and safety and security. Generally, systems fared better overall when buses operated on more exclusive running ways. For example, buses operating in exclusive transit ways averaged twenty to thirty miles per hour compared to twelve to eighteen miles per hour for buses operating in mixed-flow traffic or designated lanes.54 With such a difference in travel time, it is not surprising that reliability rankings were also much higher for systems with exclusive transit ways, as those systems were better able to perform as scheduled. Due in part to the increased reliability and better travel times associated with BRT, as well as due to the use of distinct branding and higher quality service, BRT systems generally receive higher customer satisfaction ratings than the traditional local bus service. Even with all of these positive characteristics of BRT, at this time, it appears most American BRT systems have been operating under their maximum capacity. Capacities, much like reliability and travel time, differ based on the types of running ways utilized within the system. On-street running ways typically have
lower capacities than exclusive bus lane and off-street systems—f

Finally, in terms of safety and security, due to a very low amount of data reported by systems, it is too early to reach any definitive conclusions. Earlier data showed increased accident rates for systems with at-grade intersection crossings, but more recent data has shown far fewer incidents.56

**BRT System Benefits**

Recently, systems have started to experience benefits from the implementation of Bus Rapid Transit. In almost all corridors where BRT was implemented, transit ridership has increased. Unfortunately, it is difficult to compare transit increases between systems, since some have experienced increases after months of operations, while others have been only after years.57 It is clear however, based on aggregate results of ridership surveys, the ridership increases from BRT are greater than what would be expected from basic levels of service improvements, and can range from five to twenty-five percent.58

Aside from gains in ridership, an added benefit to BRT is that these systems usually display low capital costs per mile of investment. While some systems have required more capital-intensive investment, the majority have shown relatively low capital costs per mile when considering the ridership and service improvements, as well as the short timeframe needed to implement BRT.59 Additionally, BRT systems have been shown to increase operating efficiency and service productivity for transit systems, as well as increasing corridor performance measures in those areas where passengers can choose between BRT service and other options.60

Finally, a major benefit for implementing BRT service is the possible increase in transit-supportive land development. In cities such as Pittsburgh and Ottawa, there have been positive development effects following investment in transit infrastructure and streetscape improvements. New developments have arisen both adjacent to the transit facility as well as in an integrated fashion with the transit station. Although these developments are in the early stages, and it is still difficult to ascertain whether BRT systems can effectively attract TOD, factors that lead to development along rail lines are expected to help create development alongside BRT.61
A major element of this report and the foundation for the analysis and criteria for the TSC alternatives are the case studies conducted on the transit systems in ten cities in the United States and France, including Little Rock, Arkansas, Memphis, Tennessee, Tampa, Florida, Seattle, Washington, Salt Lake City, Utah, Houston, Texas, Phoenix, Arizona, Le Mans, France, Orléans, France, and Reims, France. The transit systems are grouped into three main system types which include U.S. Streetcar, U.S. Light Rail, and the French Tramway. The four U.S. Streetcar case studies are presented first, followed by the three U.S. Light Rail systems, and then finally the three French Tramway cases. The case studies assess the impact and performances of the modern streetcar/light rail/tramway and their impact on the larger transit systems in the areas that they serve. Performance measures for both the streetcar/light rail/tram and the local bus systems are presented for comparison purposes. These evaluations look at the role of streetcar/light rail/tramway development in each city compared to the overall development and contribution to the whole transit system. The case studies also document how the transit mode impacts land use and development within each city.
STREETCAR CASE STUDIES

This section of the report presents the U.S. Streetcar Case Studies of Memphis, Little Rock, Tampa, and Seattle. A brief discussion on modern streetcar systems currently in U.S. is included as well as key operational and performance data on eight systems.

MODERN CIRCULATOR STREETCAR SYSTEMS IN THE UNITED STATES

Based on a review of transit systems which include modern circulator streetcars as part of their service (as seen in Table 2), streetcars handle a very low percentage of their overall transit system’s ridership based on passenger miles. Table 2 presents other key performance variables for both streetcar and bus in the selected cities. It is important to note that there are several systems missing from Table 2 due to data discrepancies in Florida Transit Information System (FTIS) in terms of reporting the numbers. Some systems (e.g. the Portland Streetcar) combined both their light rail and streetcar numbers when reporting them, and therefore those systems were omitted. Systems that only run on the weekends were also omitted as those would not be fairly comparable to the other systems. Overall, this shows that streetcar ridership is not utilized as a mass transit option in most cases and only represents a small portion of the total transit system in terms of both service offered (revenue miles) and ridership (passenger miles and passenger trips).

Table 2: Snap-shot of All Available Streetcar Systems and Bus System in U.S.

<table>
<thead>
<tr>
<th>Location</th>
<th>Mode</th>
<th>Passenger Miles</th>
<th>Passenger Trips</th>
<th>Percent Total Passenger Miles</th>
<th>Passenger Miles Per Revenue Mile</th>
<th>Revenue Miles</th>
<th>Operating Expense Per Passenger Mile</th>
<th>Operating Expense Per Passenger Trip</th>
<th>Operating Expense Per Revenue Mile</th>
<th>Total Operating Expense</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seattle, WA</td>
<td>Streetcar</td>
<td>414,617</td>
<td>451,203</td>
<td>0.1</td>
<td>6.9</td>
<td>60,150</td>
<td>$5.71</td>
<td>$5.25</td>
<td>$39.35</td>
<td>$2,366,620</td>
</tr>
<tr>
<td>Memphis, TN</td>
<td>Streetcar</td>
<td>940,028</td>
<td>1,113,809</td>
<td>1.7</td>
<td>2.5</td>
<td>374,280</td>
<td>$4.35</td>
<td>$3.67</td>
<td>$10.92</td>
<td>$4,088,540</td>
</tr>
<tr>
<td>Tampa, FL</td>
<td>Streetcar</td>
<td>776,734</td>
<td>505,703</td>
<td>1.2</td>
<td>10.4</td>
<td>74,603</td>
<td>$3.07</td>
<td>$4.71</td>
<td>$31.95</td>
<td>$2,383,666</td>
</tr>
<tr>
<td>Kenosha, WI</td>
<td>Bus</td>
<td>63,651,970</td>
<td>13,125,468</td>
<td>98.8</td>
<td>8.6</td>
<td>7,421,599</td>
<td>$0.93</td>
<td>$4.49</td>
<td>$7.93</td>
<td>$58,879,358</td>
</tr>
<tr>
<td>Little Rock, AR</td>
<td>Streetcar</td>
<td>183,751</td>
<td>119,758</td>
<td>1.4</td>
<td>3.4</td>
<td>53,903</td>
<td>$4.89</td>
<td>$7.51</td>
<td>$16.67</td>
<td>$898,802</td>
</tr>
<tr>
<td></td>
<td>Bus</td>
<td>12,752,928</td>
<td>2,343,232</td>
<td>98.6</td>
<td>5.5</td>
<td>2,317,089</td>
<td>$0.90</td>
<td>$4.88</td>
<td>$4.93</td>
<td>$11,427,069</td>
</tr>
</tbody>
</table>

Source: FTIS, 2009

In the case of modern circulator streetcars in the United States, streetcar systems in the cities of Little Rock, Arkansas, Seattle, Washington, Tampa, Florida, and Memphis, Tennessee were selected. All the case studies were selected primarily due to their use of either in-street or exclusive ROW in order to gauge the effect of ROW conditions on streetcar performance. Little
Rock was selected in part due to its comparable size to Tallahassee. Tampa was selected in part due to its location in Florida. The application and performance of the streetcar in the U.S. is further analyzed and discussed in the four case studies presented below.

**Memphis, Tennessee**

**Introduction**

Memphis is located in the western corner of Tennessee along the Mississippi River. It is the largest city in Tennessee with a population of 646,889 as of the 2010 census. Memphis is the third largest city in the southeastern United States and the twentieth largest in the entire United States. The greater Memphis metropolitan area, which includes counties in Mississippi and Arkansas, had a 2010 population of 1,316,100, making Memphis the second largest metropolitan area in Tennessee. Memphis’ location makes it ideal for transportation and shipping industries. It has the world’s busiest cargo airport and is the home of three Fortune 500 companies – FedEx Corporation, AutoZone Incorporated, and International Paper. Memphis Medical Center and St. Jude Children’s Hospital, also located there, are leaders in research and medical care. The metropolitan statistical area (MSA) employment force is 1,009,471 jobs. The City of Memphis currently has 562,800 people employed, with an unemployment rate of 10.3 percent. The median household income is $45,377. Memphis is home to several colleges and universities, including the University of Memphis, Rhodes College, Memphis College of Art, LeMoyne-Owen College, Christian Brothers University, Baptist College of Health Sciences, and Memphis Theological Seminary.

The Memphis area is served by the Memphis Area Transit Authority (MATA), the largest transit operator in Tennessee. According to the agency, MATA transports nearly 40,000 riders each weekday throughout Memphis and its surrounding communities on 244 transit vehicles. These vehicles include paratransit vans, vintage rail streetcar trolleys, and conventional buses. A majority of the routes serve MATA’s two downtown intermodal terminals. The North End Terminal, which is located just north of downtown, is the largest transfer point in the MATA system, allowing patrons to transfer from route to route or to the trolley system. Central Station serves as a hub for buses, trolleys and Amtrak on the south side of downtown.
MATA’s streetcar trolley system, the “Main Street Trolley,” serves as a circulator within the downtown area. This system is comprised of three lines - Main Street, Riverfront, and Madison Avenue. Annual ridership for the streetcar system in 2009 was 1,113,809, compared to the rest of the bus system, which had 10,358,212 riders for the same year. Based on the 2009 data, MATA’s Streetcar line accounts for less than two percent of the total transit system passenger miles (Figure 6), which is typical performance percentage compared to other modern streetcar systems in the U.S. The streetcar’s contribution to the total transit system is further illustrated by comparing passenger miles and trips of the bus and streetcar systems over thirteen years (Figure 7). The exact passenger miles and trips for each systems used to develop the graphs are presented in Appendix B.
Based on the Trend Graph, some direct effects from the two streetcar lines (Riverfront and Madison Avenue) coming into operation after 1996 can be seen in the bus and streetcar data presented. The passenger miles and trips for the streetcar rose between 1997 and 1998 after the Riverfront line began operating; while bus passenger miles and trips dropped during that same period. This same trend, although small, is seen again between the years 2004 and 2005 after the Madison Avenue line began operating. There was a spike in bus operations and a decrease in streetcar operations in the year prior (2003-2004). This is attributed to the disruptions in streetcar service during construction connecting the Madison line with the downtown Main Street line; the construction led those passengers to utilize the bus service more. Use of the streetcar since 2004 is lower than in the late 1990s, despite the fact that the system after 2004 was almost twice as large as the system in 1998-1999.

**Streetcar System**

Memphis has a long history of using streetcars for public transit. By the early 1880s, Memphis had 160 streetcars pulled by as many as six hundred mules and over forty miles of track.74 Electrically powered rail streetcar service soon replaced the mule powered version, and the streetcar system was the lifeblood of the Memphis transit system by the 1920s. The Memphis Street Railway Company, along with other competitors, operated streetcar service in the city until the 1950s, when the automobile and bus surpassed the rail as the leading transportation option in Memphis.75 It was not until the late 1980s, when it was recommended to utilize electric-powered vintage streetcars along the pedestrian-oriented downtown area that the streetcar reemerged in Memphis. The City transformed portions of the downtown area (Main Street) into a pedestrian mall in the mid-1970s in hopes of revitalizing the declining central business district (CBD) due to suburbanization. However, the transformation did not work and only created additional public parking and transportation issues in the downtown area. The streetcar was seen as the best public transit option that would preserve the downtown character and pedestrian-oriented design, while also fulfilling the public transportation needs of the area. MATA began planning and engineering for the reintroduction of the streetcar in Memphis in 1990.
The construction of the three lines (Figure 8) was done in a phased approach over an eleven-year period, starting in 1993 and ending in 2004. The 2.5 mile Main Street line was first opened in May 1993. The Main Street line operates between Auction and Calhoun streets along the Main Street Mall and serves the downtown CBD along with downtown landmarks and attractions. The principal reason for developing the Main Street line was to provide public transit along the corridor and to stimulate economic growth in the CBD. The 2.5 mile Riverfront line was opened four years later in 1997 and runs parallel to the Main Street line along the Mississippi River (Figure 9). The Riverfront and Main Street lines connect at the North End Terminal and at the Central Station on the south. The driving force for the Riverfront line is tourism. The line services multiple tourist destinations, such as the Pyramid Arena, Visitor Center, riverboat landing, and various restaurants and parks along the riverside.76
The Madison Avenue line was the last addition in 2004 with two miles of track extending eastward from Main Street along Madison Avenue to the Medical District. This extension connected the two largest employment centers of the city – the CBD and Medical District - as well as residential areas along the route.\textsuperscript{77} The total track length of the system is 10.02 miles with thirty-five stops along the three lines.

The most recent population and employment data captured within a ¼ mile buffer along the three lines was based on 2000 data. Based on the 2000 data, the total population within that buffer was 18,446 people and the total number employed was 101,345.\textsuperscript{78} Compared to the total population and employment of the MSA, the system captures approximately 1.62 percent of the total population and 19.2 percent of the MSA employment. This indicates that this area has a high level of business commuters; however, the system is not capturing that ridership given an average daily ridership of only 3,052.

The three lines of the MATA Streetcar run at street grade level and within mostly mixed-traffic ROWs. However, there are areas where the line runs on exclusive ROW segments (Figure 9). The Main Street line includes approximately 0.75 miles of exclusive ROW along the downtown pedestrian mall with the remaining in shared lanes with mixed traffic. Two miles of the Riverfront line operate in exclusive rail ROW previously utilized by freight rail along the Mississippi River. The remaining half mile operates in shared lanes with mixed traffic along Tennessee Street and G.E. Patterson Avenue.\textsuperscript{79} The Madison Avenue segment operates entirely in mixed traffic located in the two center travel lanes (Figure 10). The Madison Avenue line was the first line to integrate the capability for signal priority at all signalized intersections along the alignment.\textsuperscript{80}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{Madison_Avenue_Mixed ROW.jpg}
\caption{Madison Avenue Mixed ROW}
\end{figure}

Source: MATA Website
The system utilizes an array of various vintage streetcars types, including two Birney Replica, six Portugal Types (Porto), and eight Melbourne Types (sixteen total). The Porto are single-truck (two axles assembled into a truck that does not swivel with respect to the car body) vehicles with a fifty-person capacity. The Melbourne type is a larger double-truck design (four axles, two each assembled into a pair of trucks that swivel beneath the body) with one hundred-person capacity. The Birney Replica is similar in size and capacity to the Melbourne type. It is a double-truck design with a ninety-person capacity. Some of the key design limitations of the vintage system vehicle include non-level boarding, which requires additional infrastructure at stops to have ADA-compliant mini high platforms to board wheelchair passengers. In addition, passenger boarding is only possible through one set of doors, which reduces boarding times and overall system operating speed. However, vintage vehicles offer a historic look and feel that fits well into a historic downtown setting. Vintage vehicles also provide significant capital cost savings compared to modern vehicle designs.

The thirty-five stops along the three lines of the Main Street Trolley are spaced approximately ¼ mile apart. Stops along the route include side-platform corner-curb bulbs located within the parking lane at the far side of an intersection, center platform configurations, and conventional side-platforms (Figure 11). All station platforms are wheelchair accessible, including curb cuts, sidewalk cross-slopes, ramp slopes, and/or are equipped with an elevator-type lift. Fares for the Main Street Trolley streetcar are $1.00 for a single trip and can be purchased using fare vending machines at certain platforms, all transit transfer centers, and/or directly from the driver inside the cars. In addition to the one-ride fare, patrons can purchase all-day ($3.25), 31-day ($25.00), or 6-month ($75.00) passes. Passengers must board the vehicle and present the driver with the pass or pay for a single trip as they enter. This is in contrast to modern streetcar systems, which use a proof-of-payment system and have multiple boarding
doors on the vehicles. Using a payment system that requires each passenger to pass by the driver before boarding can cause significant delay times at stops, decrease overall system headway times, and reduce on/off boarding capacity times.

System Performance and Operation

The Main Street Trolley streetcar system operates seven days a week at mostly ten-minute scheduled intervals. The system had a total of 1,113,809 passenger boardings, with average daily ridership of 3,052 in 2009. During this same period, the system completed 940,028 Passenger Miles and 376,915 Vehicle Miles. Based on the performance data for the system, some additional measures of service effectiveness, productivity, and efficiency can be calculated; these are presented below in Table 3. Based on the total population of the Memphis MSA in 2009, passenger trips per capita for the streetcar and bus were 0.85 and 7.87, respectively. Passenger miles per vehicle mile was 2.5 for the three lines and 7.88 for the bus system.

Table 3: Operational Performance Measurements for MATA Streetcar and Bus Systems (FY2009)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Streetcar</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headway Time (minutes)</td>
<td>10</td>
<td>58</td>
</tr>
<tr>
<td>Operating Speed (mph)</td>
<td>6.48</td>
<td>14.72</td>
</tr>
<tr>
<td>Annual Vehicle Mile</td>
<td>376,915</td>
<td>7,106,750</td>
</tr>
<tr>
<td>Ridership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily (average)</td>
<td>3,052</td>
<td>28,379</td>
</tr>
<tr>
<td>Annual – Passenger Trips</td>
<td>1,113,809</td>
<td>10,358,212</td>
</tr>
<tr>
<td>Annual – Passenger Mile</td>
<td>940,028</td>
<td>56,019,024</td>
</tr>
<tr>
<td>Effectiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger mile per capita</td>
<td>0.71</td>
<td>42.55</td>
</tr>
<tr>
<td>Passenger trip per capita</td>
<td>0.85</td>
<td>7.87</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger mile per vehicle mile</td>
<td>2.49</td>
<td>7.88</td>
</tr>
<tr>
<td>Passenger trip per vehicle mile</td>
<td>2.96</td>
<td>1.46</td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of carrying passenger 1 mile</td>
<td>$5.69</td>
<td>$0.90</td>
</tr>
</tbody>
</table>

Source: NTD, 2009
Based on the performance data measurements of both systems, the MATA bus system outperforms the Main Street Trolley. The MATA bus system has a passenger mile per capita value of 42.55, which equates to 42.55 miles of service consumed per person in the MSA. The streetcar, on the other hand, has less than one passenger mile per capita. This further demonstrates the streetcar’s small contribution to the overall transit system. The “efficiency” measurement looks at the cost of carrying one passenger one mile for each system. As presented, the streetcar system is over six times less cost effective than the MATA bus line. However, the streetcar does have a better passenger trip per vehicle mile ratio of 2.96. This is only because the majority of the passengers ride on the streetcar less than a mile which skews this ratio.

**System Cost**

The total capital cost of the three lines was $102 million, which did not include the purchase of the sixteen streetcar vehicles.\(^{83}\) The first Main Street segment cost $35 million in 1993, equating to $14 million per mile.\(^{84}\) The Riverfront segment cost $9 million at approximately $3.6 million per mile.\(^{85}\) However, there were considerable cost savings with the utilization of existing railroad lines that reduced the cost per mile ratio drastically. Close to $45 million of the Main Street and Riverfront lines were funded by FTA funds from a prior interstate highway project.\(^ {86}\) Lastly, the Madison Avenue line cost $58 million in 2004, which comes to $29 million per mile.\(^ {87}\) The majority ($46.7 million) of the Madison line was funded by an FTA New Starts program.\(^ {88}\) The high cost for the Madison Avenue mile is attributed to the additional design and infrastructure components necessary to make it compatible for modern light rail transit. For example, the stations are equipped with ninety-foot long platforms to accommodate articulated ninety-foot long modern light rail vehicles. Thus, a regional light rail system can utilize the Madison Avenue line in the future to transport commuters into the CBD without having to change over to the streetcar. Total construction for all three lines included thirty-two stations and a vehicle maintenance facility. In addition, the sixteen vintage streetcars purchased from 1993 through 2004 cost an estimated $600,000 to $850,000 each, for an estimated total vehicle investment between $9.6 and $13.6 million.

The system’s total operating and maintenance (O&M) costs were $5,344,990 in 2009.\(^ {89}\) In terms of service efficiency, operating expenses per vehicle mile were $14.18. For cost
effectiveness, the Cost-to-Ridership Ratio (operating expense per passenger trip) was $4.80; thus, it costs $4.80 for each passenger who boards the streetcar. The system reportedly brought in $769,193 in fare revenues in 2009.\textsuperscript{90} The MATA bus system has similar cost effectiveness performance. The bus system’s total O&M costs for 2009 were $50.2 million with a Cost-to-Ridership Ratio of $4.85.\textsuperscript{91} The fare revenues for the bus system were a little over $8.3 million in 2009.\textsuperscript{92} Overall, both the streetcar and bus systems in Memphis are heavily subsidized with local, state, and federal funding. Figure 12 presents the sources of operating funds for the MATA bus and streetcar systems.

![Figure 12: Source of Operating Funds (2009)](source: NTD, 2009)

**Bus Transit Integration**

Overall, the bus and streetcar seems to be well integrated with minimum redundancy in routes due to being owned and operated by the same entity. They serve the same general area, but not on the same roadways. All three lines connect to transit stations for streetcar/bus transfers (Figure 13). The Riverfront and Main Street lines connect to two transfer points at the North End Terminal, which are located just north of downtown and at the Central Station on the south side of downtown. Madison Avenue connects to the Cleveland Station for streetcar/bus transfers on the east end of the line. Bus routes service parallel roadways downtown (2\textsuperscript{nd} and 3\textsuperscript{rd} Street) on their way to the transfer

![Figure 13: Bus and Streetcar Transfer Stations](source: MATA Website)
stations (Figure 14). Fares for both systems are transferable between the two systems with proof-of-payment/pass card. With that said, even with this system integration and coordination, the streetcars’ overall contribution to the transit system is low and did not supplant any major bus routes when it began operation.

![Figure 14: MATA Bus Routes](Source: MATA Website)

**Impact on Economic Development**

As is the case with most transit projects, the true economic impact of the Memphis Streetcar system is difficult to quantify. However, it does appear at least for the Main Street and Riverfront lines, additional economic development has occurred after the opening of the streetcar. The downtown area was experiencing a decline and businesses were closing due to a lack of patronage. Many point to the addition of the streetcar for bringing more tourists to the downtown area. The number of tourists utilizing the system is shown by looking at an on-board survey conducted by MATA in 2001. The survey showed that during the week (Monday through Friday), the ridership on the Main Street line was split between fifty-two percent local residents and forty-eight percent non-residents. The weekend ridership (Saturday and Sunday) showed the split as thirty-eight percent local residents and sixty-two percent non-residents. The percentage of weekend non-resident riders for the Riverfront line was even greater with seventy-five percent. This seems to confirm the public perception that the streetcar is primarily for tourists.

However, some city leaders seem to disagree with that perception and think the streetcar has played a role in getting businesses to relocate to Memphis. Direct correlation with the streetcar and economic development could not be determined, since other redevelopment
projects occurred at the same time. For instance, the Central Station (south end of the line) mix-use redevelopment, which was completed in 1999, included sixty-three one- to two-bedroom apartments, commercial conference space, 12,000 square feet of additional commercial space, an Amtrak ticket office and a police station.\textsuperscript{96} At the north end, a similar multi-modal transit center also offers a day care center, a welfare-to-work career center and another police station.\textsuperscript{96}

It is also uncertain or too early to tell if the Madison Avenue line has helped development in that area. The Madison Avenue corridor had several unpleasant and abandoned properties. Many thought the line would benefit the property values and help accelerate the revitalization of the corridor. Based on a study conducted for the City of Charlotte by Bay Area Economics in 2008-2009, it does appear that the corridor did experience increased property values after the line was opened. The study determined that residential properties near the Madison Street line (¼ mile buffer from stops) increased in total value more than 780 percent between 2002 and 2008.\textsuperscript{97} The study also states that existing commercial property within that same area decreased in value over that same period as similar commercial properties in the city increased in value.\textsuperscript{98} However, the increase in residential value along the corridor coincided with an urban condominium and residential building explosion that was taking place in many U.S. cities. Thus, direct correlation between the streetcar and economic development/property values cannot be determined with certainty.

**Expansion Plans**

The original streetcar transit plan included five phases/lines to be constructed. Only three of the five have been developed to date. The remaining phases include a Mud Island line and a St. Jude/St. Joseph Hospital line. There are no plans in progress to construct the final two lines; however, the latest addition to the existing downtown trolley system (Madison Avenue) was designed and built to accommodate modern light rail as previously stated. The Long Range Transportation Plan includes fixed guide way transit investment for a regional light rail system. MATA is currently conducting an alternatives analysis study for the top priority regional corridor, the Downtown-Airport Corridor, which would connect to the downtown trolley system.

**LITTLE ROCK, ARKANSAS**

**Introduction**
Little Rock is the largest city in Arkansas and serves as the state capital. It is located along the south bank of the Arkansas River in the geographic center of the State. Little Rock served as the marked transition from the flat Mississippi Delta region to the Ouachita Mountain foothills for travelers using the Arkansas River. The river separates the cities of Little Rock and North Little Rock. The city's economic boom began after the construction of a series of locks and dams on the Arkansas River, turning Little Rock into a port in the late 1960s. The Little Rock port is now an intermodal river port with a large industrial business complex. Major corporations headquartered in Little Rock are Dillard’s Department Stores, Windstream Communications, and Acxiom. Major employers in the area include Baptist Health Medical Center, AT&T, and Siemens.

Little Rock’s MSA population totals 583,845, with less than one percent of the population residing within a quarter mile of the streetcar station stop. The employment population within a quarter mile of the line is 41,088.

The Central Arkansas Transit Authority (CAT) provides transit services in Little Rock and serves the needs of workers, students, persons with disabilities, and senior citizens. CAT operates the local bus, paratransit, and River Rail Streetcar routes. The entire transit system is comprised of twenty-one regular fixed bus routes, four express bus routes, and a 3.7 mile streetcar route. Figure 15 shows the comparison of streetcar ridership to bus ridership for the CAT system; streetcar passenger miles account for less than two percent of the total transit system. Figure 16 compares the bus system to the streetcar line using both passenger miles and passenger trips. Prior to the introduction of the River Rail, the bus system’s passenger trips decreased, indicating a downward trend in ridership. Bus ridership began to increase in 2004, while streetcar passenger miles decreased despite the extension of services into North Little Rock.
Streetcar System

River Rail was formed by the ideas of local leaders and the executive director of CAT. It was created to promote tourism and new area development with ridership being a secondary goal of the system. River Rail was a part of redevelopment efforts in both downtown areas of Little Rock and North Little Rock and serves mainly to link popular destinations in both cities. The first phase of River Rail opened in 2004 and the second followed in 2007. Figure 17 shows the connectivity between Little Rock and North Little Rock.
River Rail is a 3.7 mile line that operates in mixed traffic on city streets as shown in Figure 18. The only time River Rail has a dedicated ROW is when it crosses the bridge over the Arkansas River. Here there are barriers separating automobiles from the streetcar ROW (due to the streetcar’s slow speed crossing the river). River Rail maintains a speed of 4.6 mph and stops at fifteen curbside platforms. It operates seven days a week averaging twelve to fourteen hours a day. Service runs every fifteen minutes on all days.

CAT currently has five vehicles for the streetcar line, but only three are in daily operation with the remaining two used as spares. The five vehicles are replica vintage Birney Streetcars purchased from the Gomaco Trolley Company. Each vehicle cost $883,000 for a total of $4.4 million. The average length of the streetcar is 49.75 feet with a capacity of eighty people. The streetcars have no low floor design, but are equipped with wheelchair lifts making the streetcars handicap accessible. Figure 19 shows a River Rail streetcar.

Fares for the River Rail line start at $0.50 for ages five through eleven and sixty-five plus while adults, twelve through sixty-four, must pay $1.00 for a single ride. Day passes provide unlimited boardings for $2.00, three day passes cost $5.00 and offer unlimited trips for a three consecutive calendar day period, and a twenty-ride pass is $15.00. These fares are usually purchased from the driver on board the streetcar and can also be purchased from CAT operators at transportation plazas.

CAT relies on three major sources for funding: passenger revenue, local governments, and the federal government. Passenger revenue ranges from twelve to seventeen percent of CAT’s operating funds with federal contributions representing a
smaller percentage of funds. Appropriations from local governments represent CAT’s largest single source of revenue. There is currently no area tax dedicated to transit.\textsuperscript{102}

As a way to promote local business and support the streetcar system, CAT offers opportunities to purchase the naming rights of individual streetcars, station stops, and/or the entire system. The streetcars, stations, and route maps will have the sponsor’s name for a period of time determined by level of sponsorship. All levels of sponsorship allow the sponsoring business to host special events on the streetcar.

**System Performance and Operations**

For fiscal year 2009, River Rail has a daily ridership of up to five to six hundred people during the weekdays and up to two thousand on the weekends. The annual ridership according to FTIS is 119,758 people, an average of 358 per day. The system completed 183,751 passenger miles, 54,256 vehicle miles, and 53,903 revenue miles. The bus system had 12,752,928 passenger miles and 2,343,232 passenger trips in fiscal year 2009. Table 4 reflects the performance measurements taken from both the streetcar system and the bus system for data comparison.

**Table 4: Operational Performance Measurements for CAT Streetcar and Bus Systems (FY2009)**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Streetcar</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headway Time (minutes)</td>
<td>15</td>
<td>27</td>
</tr>
<tr>
<td>Operating Speed (mph)</td>
<td>4.6</td>
<td>14.34</td>
</tr>
<tr>
<td>Annual Vehicle Mile</td>
<td>54,256</td>
<td>2,446,783</td>
</tr>
<tr>
<td>Ridership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily (average)</td>
<td>328</td>
<td>6,419</td>
</tr>
<tr>
<td>Annual –Passenger Trips</td>
<td>119,758</td>
<td>2,343,232</td>
</tr>
<tr>
<td>Annual –Passenger Mile</td>
<td>183,751</td>
<td>12,752,928</td>
</tr>
<tr>
<td>Effectiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger mile per capita</td>
<td>0.31</td>
<td>21.84</td>
</tr>
<tr>
<td>Passenger trip per capita</td>
<td>0.21</td>
<td>4.01</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger mile per vehicle mile</td>
<td>3.39</td>
<td>5.21</td>
</tr>
<tr>
<td>Passenger trip per vehicle mile</td>
<td>2.21</td>
<td>0.96</td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of carrying passenger 1 mile</td>
<td>$4.89</td>
<td>$0.90</td>
</tr>
</tbody>
</table>

Source: FTIS, 2009
Based on the performance data for the system, some additional measures of service effectiveness can be calculated. Passenger trips per capita were 0.21. Passenger trips per vehicle revenue mile were 2.22 and passenger trips per vehicle revenue hour were 9.91 for the 200 fiscal year. The passenger mile per capita was 0.3, while passenger miles per vehicle revenue mile was 3.4. The bus system outperforms the streetcar in terms of passenger miles per revenue mile.

**System Costs**

The total capital cost to build the streetcar system was $30 million with phase one costing $21 million and phase two costing $9 million. Eighty percent of the funding came from Federal sources ranging from New Starts Rail Funds, flex STP funds, and High Priority funds from TEA 21. Local funds were provided by Pulaski County, Little Rock, and North Little Rock. The Federal Transit Administration awarded a grant of $5.9 million for the second phase of streetcar system. The grant covered more than half of the costs of the extension.

For fiscal year 2009, FTIS reported total operating costs of $898,802. In terms of service efficiency, operating expenses per vehicle revenue mile were $16.67 while operating expenses per vehicles revenue hour were $74.36. Additionally, the estimated streetcar operating expense per passenger mile was $4.89 compared to $0.90 per passenger mile for the bus system.

**Transit Integration**

CAT has limited transit integration between the bus system and the streetcar system. Both systems operate along the same routes (Figure 20) and therefore allow the traveler to choose the faster option which is usually the bus. Local traffic frequents the bus system while tourist traffic utilizes the streetcar. Bus passes, tickets, and ride cards are valid on the streetcar system, however, streetcar passes and tickets are not valid for the

![Figure 20: River Rail and CAT bus Routes](Source: CAT, 2011)
buses. There is no information as to why this is the case and CAT does not track transfers from the streetcar system to the bus system. It should be noted that streetcar operators have reported an increase in streetcar ridership after the River Rail system began accepting bus transfers. However, there is no firm data to confirm this report.

**Economic Development**

In the seven years following the opening of Phase 1, more than $750 million in new development has occurred on the route or in close proximity. Many locals view the streetcar system as an economic engine for development and enhancement that attracts conference and convention planners and tourists. However, there is no direct evidence showing that the River Rail has increased economic growth along the transit corridor.

**Expansion Plans**

No plans to expand the River Rail system exist at the time of this report.

**TAMPA, FLORIDA**

**Introduction**

The City of Tampa, located on the west coast of Florida, is the third largest city in the State of Florida and the county seat of Hillsborough County. According to the 2010 U.S. Census, Hillsborough County has a total population of 1,229,226 people, while Tampa has a population of 335,709 people. With a total landmass of over 113 square miles, Tampa has an average density of 2,960 persons per square mile. Of the 335,709 people residing in Tampa, 175,023 people (66.5 percent of the population) are age sixteen or over. This working age population can seek employment in any of the area’s diverse economic sectors, including tourism, government and construction. Based on this wide ranging economy, the larger Hillsborough County area’s top employers include Macdill Air Force Base, Hillsborough County government, Tampa International Airport, and the University of South Florida. As of 2000, there were 20,137 people employed within a quarter-mile of the TECO streetcar line, and 1,642 people residing within a quarter-mile of the streetcar line.

The Hillsborough Regional Transit Authority, HART, has served the Tampa area since HART’s inception in 1980. While HART had operated almost exclusively as a bus transit agency, beginning in 2002 streetcars were added to the system. Even with the addition of
streetcars, based on total systemwide data, streetcar ridership appears to make up only a fractional percentage of the overall system ridership. Based on a comparison of the streetcar to the total system, in 2009 the streetcar completed only about one percent of the total system passenger miles. Similarly, the streetcar completed less than four percent of the total system passenger trips for that same time period. Overall the TECO streetcar line plays a very minor role in the total transit system for the Tampa Area.

Tampa added streetcars to its transit system in 2002. When looking at the system as a whole, the streetcar ridership based on passenger miles is insignificant when compared to bus transit. Figure 21 looks at the passenger miles for the overall transit system and compares streetcar to bus performance in the area. The total streetcar ridership is less than two percent of the total transit. Further illustration of the low contribution of the streetcar is seen in Figure 22 which shows the HART trend data and the effect that different modes of transit have on each other.

Figure 22 compares the HART bus system to the TECO line using both passenger miles and passenger trips. The data goes back to 1995 to provide an overview of the overall transit system. It is clear that with the introduction of streetcars, there has been no effect on bus ridership. The bus system actually continues its upward trend of increased miles and trips. The data used to develop the graph can be found in Appendix B.
Streetcar System

The first electric streetcar line in Tampa started in 1892 and was a necessary part of everyday life for both recreational and work travel. The streetcar transported passengers to destinations such as Ybor City, Ballast Point, Hyde Park, and Sulphur Springs. The successful system had almost twenty-four million passengers in 1926, but the system was shut down after World War II. Streetcars returned to Tampa in 2002 with the opening of the first phase of the TECO line connecting downtown Tampa, Channelside, and Ybor City. The second phase extended the system northward to connect Whiting Street and the Fort Brooke parking garage. According to TECO, this extension connects more than 35,000 people who work in the downtown area to almost every major downtown parking structure. The TECO streetcar connects various areas of Tampa. Stations 1 through 4 are in Ybor City, a major entertainment and nightlife district in the city. Stations 5 through 9 are in the district of Channelside along Tampa Bay, and stations 10 and 11 provide access to downtown Tampa. Station 10 also provides access
to the Tampa Convention Center. Station 9 provides access to the St. Pete Times Forum, a major sports arena and the home of the Tampa Bay Lightning NHL team. The TECO streetcar system map, as shown in Figure 23, provides further details on the route and stations of the TECO streetcar.

Figure 23: TECO Trolley System Map
Source: TECO Website, 2011
The line is a 4.76 mile line on single tracks on a segregated ROW. An example of the segregated ROW is shown in Figure 24. The streetcars maintain an average speed of six mph and stop at eleven stations spaced about 1/3 of a mile apart. There are passing sidings installed to permit operations of up to eight cars at one time. The TECO line operates seven days a week with different frequencies and hours of service. The streetcar does not operate during morning commute times, preventing the working population from using its service.

There are currently ten vehicles used in the TECO streetcar system. Nine of the vehicles are double truck Birney Streetcars manufactured by the Gomaco Trolley Company. The vehicles are 49.75 feet long with no low floor design and a capacity of ninety-eight people. Passengers board through the front door and can exit through either the front or rear door. The cost of each Birney Trolley at the time of purchase was $600,000. The tenth streetcar is the Breezer car. The vehicle is 43.5 feet in length with a capacity of eighty-eight people. The Breezer car only operates in good weather due to its open air design. Figures 25 and 26 show the Birney Trolley and the Breezer car.
Fares for the TECO Line start at $2.50 for a one way fare. The one-day unlimited ride fare card is $5.00 and can be used on all the transit systems. A twenty-ride pass is also available for $20.00. Fares can be purchased at TVMs at stops, streetcar sales outlets, directly from the streetcar operator, or at the Dick Greco Plaza Transportation Center. Proof-of-payment is shown to the driver when boarding the streetcar. The TECO line is managed by Tampa Historic Streetcar Incorporated (THS). This not-for-profit corporation was created by an inter-local agreement between the City of Tampa and Hillsborough Area Regional Transit Authority (HART), to manage day-to-day operations and maintenance of the system. HART was then retained under contract with THS to perform these functions.\(^{109}\)

The major sources of funding for the TECO streetcar system are endowments, fare box recovery revenues, and special assessments.\(^{110}\) The endowment consists of revenues from the naming rights of the streetcars, stations, and the system. The endowment fund at the beginning of operations had $5 million earning a return. There was an additional $1.5 million in commitments.

**System Performance and Operations**

In 2009, the system carried 776,734 passenger miles and 505,730 passenger trips. It operated 74,913 revenue miles, and 76,403 vehicle miles as well as 14,564 revenue hours and 14,650 vehicle hours. The streetcars operate at an average headway time of fourteen minutes carrying an average of 1,200 passengers daily. The bus system carried 63,651,970 passenger miles and 13,125,468 passenger trips. Table 5 reflects the performance measurements taken from both the streetcar system and the bus system for data comparison. The streetcar system actually outperforms the HART bus system in terms of passenger miles per revenue mile and passenger miles per vehicle mile. But in terms of overall efficiency (as measured by the operating cost per passenger mile) the streetcar is a much more expensive mode, costing $3.07 per passenger mile compared to only $0.93 per passenger mile for bus. Furthermore, the streetcar makes an extremely small contribution to the overall transit system in terms of both passenger trips and passenger miles.
Additional measures of service effectiveness can be calculated based on the performance data for the system. Passenger trips per capita based on the total population of Tampa was 0.21. Passenger trips per vehicle revenue mile were 6.78 and passenger trips per vehicle revenue hour were 34.72 for fiscal year 2009. Passenger miles per capita were 0.94 (passenger miles/service area population) while passenger miles per vehicle revenue mile were 10.37 and passenger miles per vehicle revenue hour was 53.3.\textsuperscript{111}

### System Costs

The initial capital cost of the TECO line was $32 million with half of the funding coming from a federal TEA-21 grant as well as contributions from the Florida DOT.\textsuperscript{112} The extension project on Whiting Street was $5.3 million and was paid mostly with federal funds, including $1 million from the American Recovery and Reinvestment Act of 2009.\textsuperscript{113} This brings the total capital cost of the system to over $38 million.

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**Table 5: Operational Performance Measurements for HART Streetcar and Bus Systems (FY2009)**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Streetcar</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headway Time (minutes)</td>
<td>14</td>
<td>29</td>
</tr>
<tr>
<td>Operating Speed (mph)</td>
<td>6.0</td>
<td>12.76</td>
</tr>
<tr>
<td>Annual Vehicle Mile</td>
<td>74,913</td>
<td>8,449,218</td>
</tr>
</tbody>
</table>

**Ridership**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Streetcar</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily (average)</td>
<td>1,200</td>
<td>40,000</td>
</tr>
<tr>
<td>Annual –Passenger Trips</td>
<td>505,730</td>
<td>13,125,468</td>
</tr>
<tr>
<td>Annual – Passenger Mile</td>
<td>776,734</td>
<td>63,651,970</td>
</tr>
</tbody>
</table>

**Effectiveness**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Streetcar</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger mile per capita</td>
<td>0.94</td>
<td>26.57</td>
</tr>
<tr>
<td>Passenger trip per capita</td>
<td>0.21</td>
<td>5.48</td>
</tr>
</tbody>
</table>

**Productivity**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Streetcar</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger mile per vehicle mile</td>
<td>10.37</td>
<td>7.53</td>
</tr>
<tr>
<td>Passenger trip per vehicle mile</td>
<td>6.75</td>
<td>1.55</td>
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</table>

**Efficiency**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Streetcar</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of carrying passenger 1 mile</td>
<td>$3.07</td>
<td>$0.93</td>
</tr>
</tbody>
</table>

Source: FTIS, 2009
For fiscal year 2009, FTIS reported that the streetcar operating costs totaled $2.3 million. In terms of service efficiency, operating expenses per vehicle revenue mile were $31.95 while operating expenses per vehicle revenue hour were $163.67. For cost effectiveness, the operating expense per unlinked passenger trip was $4.71, meaning that it costs HART $4.71 for each passenger who boards a streetcar. Additionally, the estimated operating expense per passenger mile was $3.07.

**Transit Integration**

HART has successfully managed transit integration between the streetcar and buses in Tampa. The one day unlimited fare cards can be used on each system, facilitating transfers. It is unknown whether transfers actually do occur, and in what number. The Dick Greco Transportation Plaza provides connections between multiple transit modes. This facility provides access for and connections between pedestrians, streetcars, buses, and taxis. HART also has several transit centers as well as park and ride facilities which provide access to multiple bus routes. Figures 27 and 28 show the streetcar and bus routes in Downtown Tampa and Ybor City. HART still faces the issue of the buses being much faster than the streetcar when traveling to the same place.

**Economic Development**

There is no explicit evidence showing that the TECO streetcar line has directly influenced economic growth along the transit corridor.

**Expansion Plans**

No plans to expand the TECO streetcar line exist at the time of this report.
SEATTLE, WASHINGTON

Introduction

Seattle is the largest city in the state of Washington and is located between Puget Sound and Lake Washington. Originally known for lumber, shipping, and fishing, Seattle has become a commercial and cultural center of the Pacific Northwest and has attracted such companies as Microsoft, Amazon, Boeing, Costco, and Starbucks. Other key industries in the Seattle area include electronics, environmental engineering, and biotechnology. These industries help maintain a metropolitan statistical area (MSA) employment force of 2,753,332 people. Seattle’s business environment and cultural attractions have contributed to it being one of the fastest-growing MSA in the United States with a total population of 3,449,059. The median household income for metropolitan Seattle in 2010 was $63,088. Seattle has three major universities - the University of Washington, Seattle University, and Seattle Pacific University - as well as multiple community colleges. The three major universities had a total enrollment of 54,262 students in 2009-2010.

The Seattle area is served by multiple transit systems and authorities at the regional, county, and city level. Sound Transit provides regional train, light rail and express bus service and serves sixty transit facilities (i.e. stops and/or transfer stations) throughout the region. At the county level, King County Department of Transportation (DOT) operates a public transit division known as Metro Transit. Metro Transit controls a fleet of about 1,300 vehicles, including standard and articulated buses, electric trolleys, dual-powered buses, hybrid diesel-electric buses and historic streetcars. These vehicles have an annual ridership of one hundred million within a 2,134 square mile area. Other area transit service providers include Community Transit (bus service), Seattle Monorail, Pierce Transit (bus service), Washington State Ferries, and Seattle Water Taxi.

Even with this abundance of public transportation serving the Seattle area, significant new transit systems have been implemented in the past few years to further integrate public transportation in the metropolitan area. These include the Sound Transit’s Central Link light rail system and Sounder commuter rail, King County Metro’s RapidRide bus network, the City of Seattle’s new modern streetcar system, which is the subject of this case study. Seattle opened the
modern streetcar line (Union Line) in December 2007. The annual ridership in 2009 was 451,203 passengers, an average of 1,236 per day.\textsuperscript{120} When compared to the total bus system of the area, which had an annual ridership of over ninety million in 2009,\textsuperscript{121} the Seattle Streetcar accounts for less than one percent of the total transit system ridership based on passenger miles (Figure 29). The streetcar’s impact is further illustrated when looking at passenger miles and trips of the bus and streetcar system over time as depicted in Figure 30. The exact passenger miles and trips for each systems used to develop the graphs are presented in Appendix B.

There was a drop in bus ridership in the first full year of streetcar operation. However, this drop does not directly correlate with the number of additional streetcar riders. Even though the introduction of the Union Line may have attracted some bus users, its overall impact to
transit system remains very low. With that said, it should be noted that the bus system services the entire King County area, while the streetcar only services a small but high density area (South Lake Union). Thus, Union Line’s low contribution to the total transit system ridership is not surprising.

Streetcar System

The construction of the Union Line was a cooperative effort by the City of Seattle Department of Transportation (SDOT) and the Federal Transit Administration. The City of Seattle owns the streetcar system but King County DOT runs the day-to-day operations through an intergovernmental agreement. The Union Line operates on a round-trip route from the corner of Fairview Avenue and Ward Street in the fast-growing South Lake Union neighborhood to the corner of Westlake Avenue and Olive Way near Westlake Transit Hub in the downtown core (Figure 31). Eleven stops along the 2.6 mile line provide access to the business and entertainment districts along the corridor as well as Lake Union’s new twelve acre water front park on the north side of the route. The Union Line was first proposed to the city by Microsoft co-founder Paul Allen to help improve the South Lake Union neighborhood and encourage more development along the Westlake Avenue corridor. It should be noted that Mr. Allen’s venture capital company, Vulcan Inc., is one of the largest property owners along the corridor. Land uses along the line include commercial retail, commerce/trade and medical office spaces, recreation/cultural, schools, and residential. The streetcar line connects the South Lake Union area with the regional transit hub at Westlake Center, which is a major connection point for light rail, buses, and the monorail.

The most recent population and employment data along the Westlake Avenue corridor within a ¼ mile buffer of the Union Line and its stops was from 2000. Based on the 2000 data,
the total population within that buffer was 8,158 people which equates to less than one percent (0.23) of the total MSA population.\textsuperscript{122} Approximately ten percent (9.9) of the MSA employment falls within that same service area which totaled 159,040.\textsuperscript{123} This seems to indicate that this area has a high level of business commuters who could be utilizing the streetcar via connections from other transit providers.

The Union Line runs at the street grade level and within mostly mixed-traffic ROWs (Figure 32) with limited segregated ROWs near the maintenance facility, Lake Union Park, and transfer hubs. The system uses three Inekon Trio-12 streetcars designed and manufactured by Inekon Group of the Czech Republic. The streetcars are a modern European double-articulated vehicle design, are bi-directional, and have multiple doors and a lowered floor in the middle section for easy boarding (Figure 33). Each vehicle is sixty-six feet long, eleven feet high and eight feet wide with 140-person-capacity and a top speed capability of thirty mph.\textsuperscript{124} The low floor design and multiple door arrangement enable passengers to get on and off easier and faster than older heritage-type streetcar vehicles. This reduces potential delays both for the streetcar and surrounding automobile traffic. In addition, the bi-directional design of the streetcars allows the cars to be operated in both directions thereby eliminating the need for turn-around space and improving operating efficiency.

The Union Line’s eleven stops are spaced approximately \( \frac{1}{4} \) mile apart. Stops along the route include four side-platform corner-curb bulbs located within the parking lane at the far side of an intersection and seven center-platform configurations. In an effort to reduce overall transit
redundancy and facilitate bus/streetcar integration, seven out of the eleven stops are shared with Metro bus service.

Fares for the Union Line streetcar start at $2.50 and can be purchased using fare vending machines at the various platforms, transit centers, and inside the cars. In addition to the one-ride fare, patrons can also purchase all-day and monthly passes. Seattle Streetcar uses a proof-of-payment system that keeps the system moving efficiently since passengers can board through multiple doors instead of having to enter the door nearest the driver to pay as they enter. This is in contrast to other non-modern streetcar systems in the U.S., which may not have multiple boarding doors on the vehicles. Under the proof-of-payment method, passengers are expected to keep their receipt after purchasing as they may be subject to random inspections from fare inspectors. Using proof-of-payment decreases delay times at stops and increases on/off boarding capacity times.

**System Performance and Operation**

The Union Streetcar operates seven days a week at mostly fifteen-minute intervals. However, within the past year (2011), a third streetcar was added to operate during peak commuting hours (3-6 pm) thereby reducing headways from fifteen minutes to ten minutes during that time period. Union Line had a total of 451,203 passenger boardings, with average daily ridership of 1,236 in 2009. During this same period, the system completed 414,617 passenger miles and 60,433 vehicle miles. Based on the performance data for the system, some additional measures of service effectiveness, productivity, and efficiency can be calculated; these are presented below in Table 6. In addition, similar performance data is presented for the Metro bus system for overall comparison purposes. Based on the total population of Seattle MSA in 2009, passenger trips per capita for the Union Line and Metro bus were 0.13 and 26.49, respectively. Passenger mile per vehicle mile was 6.86 for the Union Line and 14.33 for the Metro bus system.
Overall, the Metro bus system seems to outperform the Union Line based on the measurements presented, especially when looking at the “Efficiency” measurement which looks at the cost of carrying one passenger one mile. The Union Line is almost nine times less cost effective. In addition, based on the “Passenger mile per vehicle mile” between the two modes, the bus is twice as productive as the streetcar. The Union Line is carrying on average approximately 7 passengers at any given moment, while the bus is carrying approximately 14 passengers.

**System Cost**

The total capital cost of the Union Line was $45.9 million, which included $36.7 million in construction and another $6.2 million in Planning, Design, and Environmental (PD&E) review costs. Construction included a $4.3 million vehicle maintenance facility that will serve future extensions. The three Inekon Trio-12 modern streetcars each cost approximately $3.07

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**Table 6: Operational Performance Measurements for Streetcar and Metro Bus System (FY2009)**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Streetcar</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headway Time (minutes)</td>
<td>10-15</td>
<td>10</td>
</tr>
<tr>
<td>Operating Speed (mph)</td>
<td>5.37</td>
<td>12.26</td>
</tr>
<tr>
<td>Annual Vehicle Mile</td>
<td>60,433</td>
<td>32,112,437</td>
</tr>
<tr>
<td><strong>Ridership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily (average)</td>
<td>1,236</td>
<td>250,270</td>
</tr>
<tr>
<td>Annual – Passenger Trips</td>
<td>451,203</td>
<td>91,348,714</td>
</tr>
<tr>
<td>Annual – Passenger Mile</td>
<td>414,617</td>
<td>460,319,116</td>
</tr>
<tr>
<td><strong>Effectiveness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger mile per capita</td>
<td>0.12</td>
<td>133.46</td>
</tr>
<tr>
<td>Passenger trip per capita</td>
<td>0.13</td>
<td>26.49</td>
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<td><strong>Productivity</strong></td>
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<td></td>
</tr>
<tr>
<td>Passenger mile per vehicle mile</td>
<td>6.86</td>
<td>14.33</td>
</tr>
<tr>
<td>Passenger trip per vehicle mile</td>
<td>7.47</td>
<td>2.84</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of carrying passenger 1 mile</td>
<td>$7.21</td>
<td>$0.82</td>
</tr>
</tbody>
</table>

million, for a total vehicle investment of $9.2 million. Based on the 2.6-miles constructed, the cost per mile was $17.6 million, excluding vehicle cost. The total development cost was $52.1 million, which was funded using multiple sources as identified in Table 7.

Table 7: Source of Construction & Development Funds

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Grant</td>
<td>$14.9 M</td>
</tr>
<tr>
<td>State Grant</td>
<td>$3.0 M</td>
</tr>
<tr>
<td>Local Improvement District Tax</td>
<td>$25.7 M</td>
</tr>
<tr>
<td>Surplus Property Proceeds (City)</td>
<td>$8.5 M</td>
</tr>
<tr>
<td><strong>Total Funding</strong></td>
<td><strong>$52.1 M</strong></td>
</tr>
</tbody>
</table>

Source: SeattleStreetcar.org

The centerpiece of the financing was a $25.7 million Local Improvement District tax. The majority of property owners supported this tax due to the potential benefits they may receive with increased property and rental values along the line. Another example of area property owners willing to contribute to financing the project is with the purchase of the third streetcar in May 2011. Fred Hutchinson Cancer Research Center, Group Health Cooperative, UW Medicine and Amazon underwrote the third streetcar to operate during peak commuting hours in order to benefit their commuting employees.

The system’s total O&M costs were $2,990,134 million in 2009. In terms of service efficiency, operating expenses per vehicle mile were $49.48. For cost effectiveness, the Cost-to-Ridership Ratio (operating expense per passenger trip) was $6.63, meaning that it costs $6.63 for each passenger who boards the streetcar. King County Metro contributes seventy-five percent of the operating costs, net of fare revenue while Seattle DOT pays the remaining twenty-five percent from a combination of local funds and Federal assistance.

**Bus Transit Integration**

The South Lake Union line conveniently connects to Seattle's other public transit systems, including Metro buses, Sound Transit buses, trains and light rail, and the monorail. Even though these transit systems are owned and operated by separate entities, the hours of operation for the Seattle Streetcar are coordinated with the other modes of transportation as well as the regional transit hub at Westlake Center. The fact that King County DOT operates both the Metro Transit bus system and the Union Line streetcar allows for more efficient service.
coordination and system integration. As previously stated, the Union Line and Metro share seven platform stops along the route. Metro passes and Seattle Streetcar passes are transferrable via proof-of-payment.

Metro Bus routes make connections at selected streetcar stops, including Route 8 at Westlake Ave. and Denny Way, and Route 25 near the Westlake Hub (Figure 34). Nevertheless, even with this high level of system integration, there is still route redundancy between the bus and Streetcar. Bus Routes 17 and 74 parallel portions of the line and services some of the same stops. However, the plan is for these routes to be phased out as the Union Line ridership increases. This would mean passengers that currently utilize the faster bus routes along the corridor would be forced onto the slower streetcar.

**Impact on Economic Development**

As with most transit projects, the vision of the Seattle Streetcar was to shape and support economic growth by providing a new urban mobility option that would enhance the city and regional transportation system. The Union Line serves existing and emerging neighborhood business districts, major destinations for dining and shopping, and connects to various transit modes, which makes it extremely attractive for further economic development. However, due to the relatively short time frame for which the Union Line has been operating, it is difficult to quantify the true economic development benefits of the system thus far. Additionally, the South Lake Union neighborhood and the Westlake Avenue corridor were already popular areas with increasing residential and economic development within the business district prior to the streetcar. Major employers were located along the corridor prior to the Union Line as well. Given that development of the Union Line was heavily backed by Vulcan, it appears that the Union Line is a case where intense economic development led in part to the creation of the streetcar, rather than the streetcar leading to increased economic development.
Vulcan Real Estate Company has built over 7,500 housing units and more than two million square feet of commercial/biotech and mixed-use projects since 2008, with another 1.3 million square feet under construction.\textsuperscript{131} Amazon.com decided to relocate their headquarters and consolidate all employees (up to 6,000) to an eleven-building campus along the corridor, leasing up to 1.6 million square feet from Vulcan. The move began in 2010 and will continue in phases until 2013. The project is also expected to include 100,000 square feet of street-level retail. The Union Line runs right through Amazon’s campus with scheduled stops. It appears that Amazon’s decision to locate to the South Lake Union area has encouraged other key organizations and businesses to do so as well, including the Bill and Melinda Gates Foundation, the Fred Hutchinson Cancer Research Center, the Seattle Children’s Hospital Regional Medical Center (research campus), the University of Washington’s School of Medicine, and REI, a retailer of outdoor gear.\textsuperscript{132} It can be argued that the influx of additional employers to the area has also increased the demand for additional residential development thereby making South Lake Union one of the fastest growing areas in Seattle.

Residential developers are using the modern streetcar line in their marketing and advertisements. It appears that it is seen as a positive feature to the landscape and a beneficial mobility option to the residents. One example of this is with the Enso Condominium residential development (Figure 35). Enso is Vulcan’s newest luxury condominium project, consisting of an office tower, residential tower, and restaurant and retail, all of which is conveniently located on the street car line. Vulcan uses the access to the Union Line as a selling feature of the condominiums as well as for the leasing of commercial space.

\textbf{Figure 35: Enso Luxury Condominium}
Source: Street Smart
Expansion Plans

Based on future plans, the new modern Seattle Streetcar seems to have taken hold in the city and is being seen as a viable transit option for area residents. The City Council voted just three months (December 2008) after the Union Line opened to build a regional streetcar network with four more lines through downtown neighborhoods (Figure 36). In December 2008, the Seattle City Council identified the First Hill Line and Central Line as the top priorities for expansion. The 2.8-mile First Hill Line is fully funded up to $120 million, through the voter-approved sales tax measure for Sound Transit expansion. The Central Line is proposed to be four miles and will run from Seattle Center to the Central District. The other expansion lines include the 4.4 mile Fremont/Ballard line and the 3.5 mile U Line, which will run through the University of Washington campus and connect to the Westlake Transit Hub in the downtown core.

**Figure 36: Proposed Regional Streetcar Network**
Source: SeattleStreetcar.org

**KEY FINDINGS FROM THE U.S. STREETCAR CASE STUDIES**

Below are key findings that have been identified based on the operations and performance of the four streetcar case studies. In general, these case studies demonstrate the modern streetcars have:

- System Performance – the streetcars in the case study cities demonstrate generally slower speeds and lower performance (in terms of passenger miles per vehicle mile) than the bus networks of the case study cities. This can be a barrier to successful integration between the bus and streetcar networks.
• Limited Coverage - In terms of the service area, all of the case studies appear to service a very small area of the cities and, as a result, a small portion of the total population.

• Low Ridership – Streetcars have seen low ridership on both a per-day basis and in terms of passenger miles per revenue mile when compared to modern light rail and French tramways. For example, the Seattle Union Line is in a hugely populated area, yet carries relatively few passengers.

• Low Efficiency - The average cost of carrying one passenger one mile on a streetcar in all four case studies was $5.21. In comparison, the average cost of carrying one passenger one mile on the bus systems in all four case studies was $0.89.

• Low Operating Speeds – All four systems have low operating speeds. The average operating speed for the streetcars is 5.6 mph while for buses it was 13.52 mph.

• Vehicle Design and Capacity – It has been noted that the modern streetcar vehicle design have seen improved productivity. The larger capacity modern streetcar vehicles are capable of carrying more passengers per mile, and in general are seen in a more favorable light than the heritage design vehicles.

• Contribution to Transit Ridership – In terms of contributing to overall transit ridership, streetcars show a very low contribution to the system as a whole. Total streetcar ridership makes up for its area averages to be less than 2.5 percent of total public transit ridership.

• Operating Costs – All expenditures, such as capital cost and operations and maintenance (O&M) cost, are directly related to the size of the system in terms of length of the line and number of vehicles. The longer the line and the more vehicles there are the higher the expenditures for the system. However, as the size of the system increases the cost-to-ridership ratio decreases, which means it costs less per rider.
LIGHT RAIL CASE STUDIES

This section of the report presents the U.S. Light Rail Case Studies of Houston, Phoenix, and Salt Lake City University Line. These three cities were selected because ROW was taken from street space in order to construct the light rail line. Salt Lake City was further selected due to the rail line’s alignment through the University of Utah campus. A brief discussion on the application of light rail systems currently in the U.S. is included as well as key operational and performance data on seventeen systems.

LIGHT RAIL SYSTEMS IN THE UNITED STATES

Table 8 shows a snapshot of important criteria from all the transit systems in the U.S. operating a light rail line. Based on a review of the systems that include light rail as part of their services, and not including historical systems such as Boston’s Green Line, it appears that there is a wide discrepancy regarding the effect of light rail on the overall transit system. On average, twenty-four percent of each transit system’s total transit trips- based on a combination of bus and light rail- are light rail trips; however, this differed greatly among systems. For instance, the light rail system in Sacramento, California completes sixty-one percent of all public transit passenger trips for Sacramento. Conversely, light rail passenger trips in both Seattle and Houston comprise seven percent and five percent respectively. In terms of light rail passenger miles as a percentage of total transit system miles, the overall average for all systems was twenty-nine percent, with Sacramento’s light rail again the highest at forty-nine percent. Unlike passenger trips, only one light rail system’s passenger miles comprised under ten percent of total transit miles (Baltimore, nine percent), while Seattle’s and Houston’s respective percentages increased to twenty percent and fourteen percent. Some light rail systems, namely those in Sacramento, San Diego, Portland, Salt Lake City, and St. Louis, appear to be providing an even larger percentage of the overall transit system’s service. This is an impressive accomplishment, as two or three rail lines can carry ridership numbers equal to dozens of bus routes at relatively low cost per mile compared to the traditional passenger bus due to the capacity of light rail vehicles.
The application and performance of light rail in the U.S. is further analyzed and discussed in the following three case studies.

**Houston, Texas**

**Introduction**

Houston is the fourth largest city in the United States and the largest in the state of Texas. Houston’s growth was initially spurred by the port and railroad industries and the...
discovery of oil in the early 1900s, which continues to dominate Houston’s economy. Since then, Houston has become a major player in the healthcare field and is second in the United States for number of Fortune 500 headquarters; only New York City has more. The Texas Medical Center in downtown Houston exceeds one thousand acres in size and is home to forty-nine medicine-related institutions, including fourteen hospitals and two specialty institutions, two medical schools, four nursing schools, and schools of dentistry, public health, pharmacy, and other health-related practices.

These industries help maintain a metropolitan statistical area (MSA) employment force of 2,605,800 people. Houston’s business environment and cultural attractions have contributed to it being one of the fastest-growing MSAs in the United States with a total population of 5,946,800. The median household income for Greater Houston in 2010 was $63,088. Houston is home to four state universities, several private universities, and three community college districts.

The Greater Houston area is served by the Metropolitan Transit Authority of Harris County (METRO). METRO provides bus service and light rail and operates 132 bus routes and one light rail line in the region. These vehicles have an annual ridership of sixty-eight million within a 1,295 square mile area. The METRORail light rail line, the Red Line, began operating in January 2004 and is the only line in operation at the present time. The Red Line does not currently connect downtown Houston to any other areas of the city, however, the system is currently undergoing an expansion to increase light rail’s reach throughout Houston.

The annual passenger miles of the Red Line in 2009 were 27,501,371. When compared to the total bus system of the area, which had an annual ridership of 474,118,999 passenger miles in 2009, the METRORail system accounts for 5.5 percent of the total transit system (Figure 37). The light rail’s impact is further illustrated when looking at passenger miles and trips of the bus and light rail system over time as

![Figure 37: METRORail Percent of Contribution to Total Transit System](source: FTIS, Author’s calculations)
depicted in Figure 38. The bus system experienced declining ridership beginning in 2001 and saw a rise in 2006. The light rail system has experienced steady growth since it began operating in 2004. Because the bus system numbers were already declining, it is impossible to link any decline in 2004 to the presence of the light rail system. The bus system also serves a much larger area of Houston while the light rail line is confined to a single, 7.5 mile line in downtown Houston. The data used to develop the trend graphs is presented in Appendix B.

**Light Rail System**

Houston was the largest city without a rail system after the city shut down its streetcar lines in the 1940s (until Los Angeles took that distinction when it shut down its last streetcars in 1963). In the 1980s it was decided that Houston needed to focus on different forms of transit to ease traffic congestion, reduce greenhouse emissions and improve air quality in order “to keep our edge as an attractive place to live, raise a family and build a career, and to maintain our standing as a major force in the global economy”. The Red Line is a north/south line on Main Street in downtown Houston. The line begins in the north at the University of Houston-
Downtown and ends in the south at the Fannin South Park and Ride (Figure 39). Sixteen stops along the 7.5 mile line provide access to Downtown, Midtown, the Museum District, the Texas Medical Center and Reliant Center. Land uses along the line include commercial retail, commerce/trade and medical office spaces, recreation/cultural, schools, and residential. The light rail line connects Downtown Houston with the Downtown Transit Center and the Medical Center Transit Center, which are major connection points for light rail and bus.

The most recent population and employment data along the Main Street corridor within a ¼ mile buffer of the Red Line and its stops is from 2000. Based on the 2000 data, the total population within that buffer was 16,399 people. The number employed within that same service area was 132,881. Compared to the total population and employment of the MSA, the system captures approximately 0.35 percent of the total population and 2.85 percent of the MSA employment.

The Red Line runs in street with semi-exclusive ROWs with mixed traffic operations occurring in The Medical Center so vehicles can make left turns. The system uses eight Siemens S70 Low Floor Light Rail Vehicles designed and manufactured by Siemens. Each vehicle is 96.4 feet long and has a carrying capacity of 241 persons with a top speed capability of sixty-five mph. The light rail vehicles have multiple doors and lowered floors for easy boarding (Figure 40). The low floor design and multiple door arrangement enable passengers to board and alight easier and faster. This reduces potential delays both for the light rail and surrounding automobile traffic.

The Red Line’s sixteen stops along the
route are serviced by eighteen platforms and are one hundred percent compliant with the Americans with Disabilities Act (Figure 41). The stops are all for the sole use of the light rail system as bus routes from Main Street have been removed in an effort to reduce overall transit redundancy and facilitate bus/light rail integration.

Fares for the Red Line start at $1.25 and can be purchased using cash, or a credit or debit card at any METRO TVM at the various platforms and transit centers, and at METRO Ride Stores. In addition to the one-ride fare, patrons can purchase a METRO Q card that contains a fare balance and is used like a debit card. Passengers tap the Q card when they board a bus or light rail vehicle and the fare is automatically deducted from the card. The METRO Q card replaced monthly and yearly passes in 2008. Houston light rail uses a proof-of-payment system that keeps the system moving efficiently since passengers can board through multiple doors instead of having to enter the door nearest the driver to pay as they enter. Under the proof-of-payment method, passengers are expected to keep their receipt and Q card handy after purchasing as they may be subject to random inspections from fare inspectors. Using proof-of-payment decreases delay times at stops and increases on/off boarding capacity times.

**System Performance and Operation**

The Red Line operates seven days a week at five minute intervals during the weekday and increasing to twenty minutes during evenings and weekends. The Red Line had a total of 11,613,720 passenger boardings, with average daily ridership of 38,769 in 2009. During this same period, the system completed 27,051,371 Passenger Miles and 915,836 Vehicle Miles. Based on the performance data for the system, some additional measures of service effectiveness, productivity, and efficiency can be calculated; these are presented below in Table 9. In addition, similar performance data is presented for the Metro bus system for overall comparison purposes. Based on the total population of the Houston MSA in 2009, passenger

![Figure 41: METRO Red Line Platform Stop](Source: RideMetro.org)
trips per capita for the Red Line and Metro bus were 2.67 and 12.24, respectively. Passenger miles per vehicle mile was 29.54 for the Red Line and 9.74 for the bus system.

Table 9: Operational Performance Measurements for METRO Light Rail and Bus System (FY2009)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Light Rail</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headway Time (minutes)</td>
<td>5.38</td>
<td>13.16</td>
</tr>
<tr>
<td>Operating Speed (mph)</td>
<td>12.11</td>
<td>14.42</td>
</tr>
<tr>
<td>Annual Vehicle Mile</td>
<td>915,836</td>
<td>37,889,442</td>
</tr>
</tbody>
</table>

**Ridership**

<table>
<thead>
<tr>
<th></th>
<th>Light Rail</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily (average)</td>
<td>38,769</td>
<td>161,500</td>
</tr>
<tr>
<td>Annual –Passenger Trips</td>
<td>11,613,720</td>
<td>58,947,679</td>
</tr>
<tr>
<td>Annual – Passenger Mile</td>
<td>27,051,371</td>
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**Effectiveness**

<table>
<thead>
<tr>
<th></th>
<th>Light Rail</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger mile per capita</td>
<td>6.21</td>
<td>79.73</td>
</tr>
<tr>
<td>Passenger trip per capita</td>
<td>2.67</td>
<td>12.24</td>
</tr>
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</table>

**Productivity**

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<thead>
<tr>
<th></th>
<th>Light Rail</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger miles per vehicle mile</td>
<td>29.54</td>
<td>9.74</td>
</tr>
<tr>
<td>Passenger trip per vehicle mile</td>
<td>12.58</td>
<td>1.50</td>
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</tbody>
</table>

**Efficiency**

<table>
<thead>
<tr>
<th></th>
<th>Light Rail</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of carrying passenger 1 mile</td>
<td>$0.58</td>
<td>$0.72</td>
</tr>
</tbody>
</table>

Source: NTD, 2010

Overall, both the bus system and the light rail system seem to be performing at high levels. The Red Line outperforms the bus system when looking at the “Efficiency” measurement which looks at the cost of carrying one passenger one mile; the bus is 24% more costly. The bus system far outpaces the light rail for annual passenger miles and vehicles miles. This is due to the short light rail line and the extensive number of bus routes that cover most of the Houston metropolitan area.

**System Cost**
The total capital cost of the Red Line was $324 million. A detailed breakdown of this number is currently unavailable as the Red Line, along with San Diego’s first light rail line, was one of the few light rail lines to be constructed using only local funds. In 1978, Houston-area voters created METRO and approved a one-cent sales tax to fund METRO’s operations. In addition, voters granted METRO the authority to issue up to $640 million in bonds to fund the next phase of projects. Based on the 7.5 miles constructed, the cost per mile was $43.2 million, excluding vehicle cost.

The system’s total O&M costs was $24,069,761 in 2009. In terms of service efficiency, operating expenses per vehicle mile were $17.22. For cost effectiveness, the Cost-to-Ridership Ratio (operating expense per passenger trip) was $1.35, meaning that it costs METRO $1.35 for each passenger who boards the light rail.

**Bus Transit Integration**

The Red Line conveniently connects to Houston’s bus system. Because the transit systems are owned and operated by the same entities, transit integration has become a major focus for METRO. The hours of operation for the light rail line and the buses are coordinated. The METRO Q card works on both buses and light rail and fares are transferrable for up to three hours in the same direction.

The bus stops are located along the east/west corridors as all buses have been removed from traveling along Main Street. Approximately eighty-six bus routes interact with the Red Line. Further efforts at transit integration reduced the number of bus trips into the midtown/downtown area by six hundred trips every weekday. This is an effort to reduce redundant bus routes along the fixed light rail line in the city center.

**Impact on Economic Development**

As with most transit projects, the vision of METRORail was to shape and support economic growth by providing a new urban mobility option that would enhance the city and regional transportation system. The Red Line services major cultural, educational, medical and commercial districts, and connects to the bus system, which makes it extremely attractive for further economic development. Downtown was already a popular area for projects during the construction of the Red Line. Cotswold, the Entertainment District street reconstruction project, Minute Maid Park (home of the Houston Astros), the Toyota Center (home of the Houston
Rockets), and the Hilton Americas Hotel were all under construction at the same time. These projects may not have been influenced by the presence of the Red Line, but these types of projects are an indication of economic development many would like to see after the construction of a new transit system/line.

Numerous businesses have opened along the Red Line since operations began in 2004. These include numerous restaurants and bars, two hotels, and a CVS Pharmacy. In addition to the small scale projects above, major developments have occurred along the Red Line corridor. St. Luke’s Hospital, at 300,000 square feet, opened along the line, but this is more than likely due to the existing location of the Texas Medical Center and not the presence of the light rail line. The University of Houston Downtown (where the Red Line originates) constructed its College of Business building. BG Group Place is a new one million-square-foot, forty-six story premier office tower located on Main Street and Houston Pavilions, a mixed-use project labeled as “the premier entertainment, dining, retail and office hub in downtown,” spans three blocks and is comprised of 300,000 square feet of retail space, 260,000 square feet of office space and a 1,600-space parking garage. Figure 42 looks at the Houston Pavilions from Main Street, the location of the existing Red Line.

**Expansion Plans**

Existing construction projects and future plans show that METRORail has proven to be beneficial and is seen as a viable transit option for Houston area residents. In June 2005, METRO announced its $2 billion Phase 2 Implementation Plan to provide more rapid transit for the Houston region. This plan includes an expansion of the light rail system by nearly thirty miles. The North Line, a 5.3 mile extension of the Red Line, is currently under construction as are the Southeast Line and the East End Line. The Southeast Line goes through the center of one of Houston’s oldest African-American communities and connects downtown Houston with the local universities: Texas Southern University (TSU) and the University of Houston (UH). The
East End Line will allow riders to travel all the way to the UH campus. The University and Uptown Lines are still in the final design stage, but will connect even larger areas of Houston when completed. The University Line is the only true east/west light rail line and is much needed within the system. Figure 43 shows the fully expanded light rail system in Houston.

The light rail expansion has already faced numerous setbacks delaying the anticipated completion date for the new lines. The most recent estimates have the lines currently under construction beginning operations in 2014. It is also important to note that the extension lines are the first lines built using state and federal funds; METRO was awarded $150 million by the Federal Transit Administration.

Figure 43: METRORail’s Proposed Expansion Network Map
Source: GoMetroRail.org

PHOENIX, ARIZONA

Introduction

METRO light rail and Valley Metro bus operates throughout Maricopa County, Arizona, and in particular, the Phoenix-Mesa Urban Area. Maricopa County has a population of 3,817,117, with a population density of nearly 415 people per square mile, making it the fourth largest county in the United States. The Phoenix-Mesa Urban Area itself is 799 square miles,
with an estimated population of 3,243,920, and a population density of over 4,059 people per square mile.154 Part of the reason the urban area has such high density is that it includes such major cities as Phoenix, Tempe, Mesa and Glendale.

Of the over three million people in the Phoenix-Mesa Urban Area, 2,476,000 (76 percent of the population) are age sixteen and older. Within this working age population sixteen and over, 1,635,564 people are in the labor force, with 1,495,546 of these workers commuting to work.155 The largest employers in Maricopa County include the State of Arizona, Wal-Mart, Banner Health Systems, the City of Phoenix, Maricopa County, Wells Fargo, and Arizona State University.156

As of 2000, there were 61,803 persons employed within a quarter-mile of a METRO station, as well as 22,931 people residing within a quarter-mile of a METRO station.157 Compared to the total population and employment of the MSA, the system captures less than one percent (0.71) of the total population and 4.21 percent of the MSA employment. The METRO provides nearly direct access to the major employers in the area including City and County government offices, Chase Field and US Airways Center.158

The Regional Public Transportation Authority (RPTA) has operated a regional transit system, focused on bus transit, under the name Valley Metro since 1993. From the mid-1990s through to the early 2000s, Valley Metro buses averaged between 127 and 150 million passenger miles, as well as thirty to forty million passenger trips each year (Figure 44). By the mid-2000s these numbers began to increase, and by 2009 service had nearly doubled with Valley Metro

![Figure 44: METRO Trend Graph for Bus and LRT (1995 to 2010)](Source: FTIS, 1995 - 2010)
buses reporting 281 million passenger miles and sixty-nine million passenger trips (See Appendix B).\textsuperscript{159}

When METRO light rail opened in late December 2008, the system reported forty-seven million passenger miles, and five million passenger trips in its first six months of operation. Light rail accounted for about fifteen percent of the system’s passenger miles. Metro’s bus passenger miles dropped to 221 million and passenger trips dropped to fifty-four million.\textsuperscript{160} Total transit trips and passenger miles increased over this time period (see Appendix B). Light rail now accounts for twenty-eight percent of the total passenger miles, and eighteen percent of the total passenger trips for the transit system (Figure 45) as many former bus riders switch to the more efficient light rail line.\textsuperscript{161}

**Light Rail System**

METRO, or the Valley Metro Light Rail, is a twenty mile starter line light rail system, which runs throughout the Phoenix-Mesa Urban Area. The route travels between the Phoenix area in the west and continues east through Tempe before finishing in Mesa (Figure 46). Of the total twenty mile line, 13.34 miles are in Phoenix, 5.5 miles are in Tempe, and 0.97 miles are in Mesa. Total trip time from one end to the other is about sixty-five minutes, with a trip from Downtown Phoenix to Downtown Tempe of twenty-five minutes, and Downtown Phoenix to Downtown Mesa of forty minutes.\textsuperscript{162}

The origins of regional public transportation in Maricopa County began in October of 1985 when voters approved a one-half cent sales tax for freeway construction, with a
small portion of the money also going towards expanding regional transit. These sales tax funds were designed to help create a true regional transit system, and the funds were guaranteed through 2005. The foundation for a new light rail system began in September 1996 when voters in the City of Tempe approved a half-cent sales tax dedicated solely to transit. During that same year, the RPTA began work on a Major Investment Study of the Central Phoenix/East Valley corridor to create a twenty-two mile light rail starter line, including a thirteen-mile minimum operating segment, to connect the cities of Phoenix, Tempe, and Mesa. The study was completed in Spring 1998, and a few months later the Federal Transit Administration gave the RPTA the authority to begin a PE/EIS on twenty miles of the proposed twenty-two mile corridor. Around this same time, the Maricopa Association of Governments officially adopted the plan to create the light rail system, and included the light rail project in the Long Range Transportation Plan.

In March of 2000, the City of Phoenix approved a four-tenths cent sales tax increase, in addition to the County tax, to support transit for a twenty-year period, with light rail funding beginning in 2008. Although property would be purchased for the system during 2001 and initial work on the line started in 2002, it was not until October of 2002 that the project truly began to take shape. At this time, METRO, a non-profit corporation, was formed between the cities of Phoenix, Tempe, Mesa, and Glendale for the purposes of designing, building, and operating the new light rail system. Under this agreement, the Regional Public Transportation Authority, Valley Metro, maintained control of the local bus system, while also gaining responsibility for connectivity between the Valley Metro buses and the new METRO light rail.

In November 2004, Maricopa County voters extended the original half-cent Countywide sales tax originally approved in 1985. This allocated one-third of the sales tax to transit improvement plans, including a 27.7 mile extension of the planned light rail system. With local funding mechanisms in place for the system, METRO entered into a Full Funding Grant Agreement with the FTA in January 2005, which provided slightly over $587 million in New Starts funding to build the twenty mile starter segment. On December 27, 2008, the METRO starter line began service, and on January 1, 2009, official revenue service on the system started.

METRO uses fifty light rail vehicles manufactured by Kinkisharyo International of Osaka, Japan (Figure 47). Initially thirty six vehicles were purchased at a cost of $3,258,680 per
In February of 2006, METRO purchased an additional fourteen light rail vehicles for $3,013,285 per vehicle. Total costs for all the vehicles were $159,498,495 million, for an average cost of $3,189,969 per vehicle. Each vehicle has a length of 91.5 feet, seating for sixty-six passengers, a comfort capacity of 175, and a maximum capacity of 226. Three vehicles can be linked into a single train to increase capacity and boost system efficiency. All vehicles are handicap accessible and utilize low boarding for ADA compliance.

The line was designed with trains operating in an exclusive trackway taken from existing road ROW. This trackway is separated from vehicular traffic by six-inch curbing, with motor traffic only able to cross the track at specially designated intersections, complete with left turn lanes and signals. Due to this exclusive trackway, trains are able to maintain an average speed of twenty-two mph; METRO can run up to thirty-five mph on city streets, with vehicles designed to reach a maximum of fifty-eight mph.

The METRO includes twenty-eight stations, at an average spacing of ¾ of a mile, with a total of thirty-three platforms; five stations in the Downtown Phoenix operate on a one-directional basis as part of an east/west split. Stations are three hundred feet long and sixteen feet wide, approximately as long as a downtown city block, and are located either in the center median or along outer curbs (Figure 48). The stations located in the downtown area that serve as unidirectional stations are almost entirely located along the outer curb, meaning that pedestrians do not need to cross the road to enter or exit the station. The stations located in the center median require passengers to cross
high traffic roadways to enter or exit the station. To provide for a safe crossing, stations are accessible only via signalized crosswalks complete with countdown signals, while approaching and departing trains utilize bells, headlight flashes and operator controlled horns to warn pedestrians of moving trains. Because trains operate in an exclusive trackway and vehicles may only cross the tracks at specially marked intersections, passengers are well protected from adjacent traffic while at a station.¹⁷⁶

The Phoenix-Mesa Urban Area includes two major branches of Arizona State University: the flagship campus in Tempe (Figure 49), as well as the Downtown Phoenix Campus. The main branch of Arizona State University had 58,371 enrolled students, while the downtown Phoenix campus had 13,567 for the Fall of 2010.¹⁷⁷ The METRO provides access to both of these campuses with two stops in Tempe, and one stop in Downtown Phoenix. Although walking distances from either of the two university stops in Tempe are often over a half mile, there are connecting Valley Metro Bus routes and campus shuttles which provide service around the perimeter of the campus. Arizona State University Downtown Phoenix is an estimated 0.08 miles from two light rail stations, meaning it is easily accessible by walking (Figure 50).¹⁷⁸

Even more relevant to Tallahassee, particularly in light of Florida State University, the METRO route also travels to Sun Devil Stadium. As the home stadium of
Arizona State University’s football team, Sun Devil Stadium hosts six to seven major college football games a year and can seat 71,706 fans. By using the campus stops (Figures 49 and 51), gameday fans, as well as stadium workers, can travel almost directly to the stadium for a game. Furthermore, since both of these stops are also serviced by Valley Metro bus service, fans can use a combination of public transit options to attend games. 2010 ridership data suggests that both campuses are being reached via METRO with weekday averages of on/offs at the two university Tempe stations reaching 1,952 and 2,762 passengers respectively, higher than any other METRO station with the exception of the beginning and end of the line. The ASU Downtown Phoenix station saw average weekday on/offs of about 1,405 passengers, but it should be noted that there are many other destinations located in the vicinity of the stations (Figure 51).

The results of the 2010-11 on-board travel survey suggest a large number of college students are utilizing the METRO to reach campus. Thirty-four percent of light rail only passengers used METRO for home-based college trips, compared to fifteen percent for the overall transit system. Twenty-three percent of light rail only passengers were likely to finish their trip at a college or university, compared to eight percent for bus only and nine percent for the overall system. With the influx of students using METRO, light rail is actually bringing new passengers to the transit system as forty-four percent of light rail only passengers and thirty-four percent of light rail/bus passengers have been using public transit for less than two years.

Fares for the METRO start at $1.75 for a one-ride fare, and can be purchased using fare vending machines at light rail stations, transit centers, retail outlets, or online. In addition to the one-ride fare, patrons can also purchase passes in increments of all-day, three day, seven day, and thirty-one day. Passengers may make unlimited trips on both the light rail and the local bus service for the duration of these passes although extra fees apply for use of the Express/RAPID express buses. METRO uses a proof-of-payment system to keep the system moving. This means passengers are expected to keep their receipt as they may be subject to random inspections from
fare inspectors, with fines ranging from $50 to $500. Using a proof-of-payment system helps keep the system running smoothly since random inspections at the station platform allows passengers to board the train from all open doors as opposed to only from the front as is often the case with a bus.

In addition to traditional passes, METRO also has special Arizona State University issued ASU U-Passes as well as other employer-issued passes. The ASU-U Pass is available to all students enrolled for at least one-credit hour at Arizona State University for $150 and provides unlimited service on the METRO and Valley Metro buses throughout the academic year. The ASU-Platinum Pass is available for Arizona State University faculty and staff, which provides unlimited service for the entire year. Costs for this pass are $390 for a local pass and $520 for an express pass.

**System Performance and Operation**

To provide maximum service for passengers, METRO operates about twenty hours per day, 365 days a year. For Fiscal Year 2009-2010, METRO had a total of 12,112,733 passenger boardings, with average ridership of 38,030 on Weekdays, 27,779 on Saturdays, and 17,097 on Sundays. During this same period, the system completed 87,661,755 passenger miles, 2,736,091 Vehicle Miles and 2,652,759 Revenue Miles, during 186,419 Vehicle Hours and 182,780 Revenue Hours. Based on the total passenger miles and unlinked passenger trips, the average passenger trip length was slightly over seven miles at 7.23 miles.

Table 10 shows information from both the METRO light rail and Valley Metro bus system. In comparison, the bus system completed 221,592,625 passenger miles and had 54,326,139 passenger trips in 2010. Additionally, Valley Metro reported 38,027,120 Vehicle Revenue Miles and 2,964,478 Revenue Hours for the bus system. Average passenger trip length for the bus system was 4.07 miles. Based on these totals from 2010, and only factoring in both light rail and bus data, the METRO light rail completed twenty-eight percent of the region’s public transit passenger miles, and had eighteen percent of the total passenger boardings.
### Table 10: Operational Performance Measurements for Light Rail and Valley Metro Bus System

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Light Rail</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headway Time (minutes)</td>
<td>9.66</td>
<td>30.55</td>
</tr>
<tr>
<td>Operating Speed (mph)</td>
<td>14.31</td>
<td>12.99</td>
</tr>
<tr>
<td>Annual Vehicle Revenue Miles</td>
<td>2,652,759</td>
<td>38,027,120</td>
</tr>
<tr>
<td><strong>Ridership</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekday (average)</td>
<td>38,030</td>
<td>148,839</td>
</tr>
<tr>
<td>Annual – Passenger Trips</td>
<td>12,112,733</td>
<td>54,326,139</td>
</tr>
<tr>
<td>Annual – Passenger Mile</td>
<td>87,661,755</td>
<td>221,592,625</td>
</tr>
<tr>
<td><strong>Effectiveness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger mile per capita</td>
<td>27</td>
<td>86.28</td>
</tr>
<tr>
<td>Passenger trip per capita</td>
<td>3.73</td>
<td>68.31</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger mile per revenue mile</td>
<td>33.04</td>
<td>5.83</td>
</tr>
<tr>
<td>Passenger trip per revenue mile</td>
<td>4.57</td>
<td>1.43</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of carrying passenger 1 mile</td>
<td>$0.38</td>
<td>$1.25</td>
</tr>
</tbody>
</table>

**Source:** NTD, 2010, Metro Fast Facts  
**Notes:** All data is for FY2009-2010, with the exception of headway information and operating speed, which are FY2008-2009. All bus data is based on combined data reported from RPTA, Valley Metro, City of Phoenix Public Transit Department, and City of Tempe Transit Division.

Based on the performance data for the METRO system, some additional measures of service effectiveness can be calculated. Passenger trips per capita (based on the estimated population of the Phoenix-Mesa Urban Area) were 3.73. Passenger trips per vehicle revenue mile were 4.57 and passenger trips per vehicle revenue hour were 66.27 for FY 2009-2010. Passenger miles per capita were twenty-seven, while passenger miles per vehicle revenue miles and passenger miles per vehicle revenue hour were 33.04 and 479.60 respectively. These final numbers are quite impressive, as it shows that, on average, there are thirty-three passengers on board a train at any given time. The light rail system definitively outperforms the bus system in terms of passenger miles per revenue mile.
Again, compared to the local bus system, there are noticeable differences between the performance of the light rail and the buses. Passenger trips per capita for the bus system were 16.7, while passenger trips per vehicle revenue mile and passenger trips per vehicle revenue hour were 1.43 and 18.33 respectively. Passenger miles per capita were 68.31, with passenger miles per vehicle revenue mile and passenger miles per vehicle revenue hour of 5.83 and 93.12. These last two numbers are in stark contrast to the light rail data, as buses are only carrying 5.83 passengers at any time. This compares to an average of thirty-three passengers at any given time for the light rail.

**System Cost**

The total capital cost of the twenty-mile starter line was $1.4 billion including $112 million in financing costs. Based on the twenty miles constructed, this means that the cost per mile was $70,606,267. The $1.4 billion cost includes all forecasted expenses for the project including ROW acquisition ($133 million), the initial thirty-six light rail vehicles ($117 million) and facilities ($545 million) among others. Table 11 shows the breakdown of the capital costs for METRO. It is important to note that although forecasted costs for various items within the system budget increased from initial forecasts, the overall project cost remained on target throughout.
Table 11: METRO Capital Cost Breakdown

<table>
<thead>
<tr>
<th>Project Contract Unit</th>
<th>Project Budget</th>
<th>Expenditures To Date</th>
<th>Forecast Cost to Complete</th>
<th>Forecast At Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Management &amp; Administration</td>
<td>$61,109,298</td>
<td>$60,177,844</td>
<td>$1,472,404</td>
<td>$61,650,248</td>
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<td>Program Management Consultant</td>
<td>$52,653,279</td>
<td>$51,622,985</td>
<td>$377,015</td>
<td>$52,000,000</td>
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<td>City Administration</td>
<td>$22,185,439</td>
<td>$21,956,479</td>
<td>$228,960</td>
<td>$22,185,439</td>
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<tr>
<td>ROW Acquisition</td>
<td>$133,100,000</td>
<td>$133,438,573</td>
<td>$61,427</td>
<td>$133,500,000</td>
</tr>
<tr>
<td>PE/FEIS Engineering</td>
<td>$25,054,938</td>
<td>$25,169,700</td>
<td>$0</td>
<td>$25,169,700</td>
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<td>Engineering</td>
<td>$107,647,240</td>
<td>$108,241,397</td>
<td>($1,083)</td>
<td>$108,240,314</td>
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<td>Owner Furnished Equipment/Materials</td>
<td>$33,460,104</td>
<td>$33,195,541</td>
<td>$166,977</td>
<td>$33,362,518</td>
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<td>Light Rail Vehicles</td>
<td>$118,422,565</td>
<td>$110,163,878</td>
<td>$7,148,617</td>
<td>$117,312,495</td>
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<td>Facilities</td>
<td>$544,692,507</td>
<td>$540,776,377</td>
<td>$4,798,919</td>
<td>$545,575,296</td>
</tr>
<tr>
<td>Systems</td>
<td>$114,436,312</td>
<td>$108,159,001</td>
<td>$6,106,671</td>
<td>$114,265,672</td>
</tr>
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<td>Construction Administration Services</td>
<td>$57,281,460</td>
<td>$57,136,747</td>
<td>$144,713</td>
<td>$57,281,460</td>
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<tr>
<td>Testing &amp; Startup</td>
<td>$23,000,000</td>
<td>$22,491,351</td>
<td>$8,649</td>
<td>$22,500,000</td>
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<td>Art Program</td>
<td>$6,283,133</td>
<td>$5,956,268</td>
<td>$326,865</td>
<td>$6,283,133</td>
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<td>Unallocated Design Contingency</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
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<tr>
<td>Project Reserve</td>
<td>$481,071</td>
<td>$0</td>
<td>$481,071</td>
<td>$481,071</td>
</tr>
<tr>
<td>Financing Costs</td>
<td>$112,318,000</td>
<td>$64,524,701</td>
<td>$47,793,299</td>
<td>$112,318,000</td>
</tr>
<tr>
<td><strong>Total Project:</strong></td>
<td><strong>$1,412,125,346</strong></td>
<td><strong>$1,343,010,842</strong></td>
<td><strong>$69,114,504</strong></td>
<td><strong>$1,412,125,346</strong></td>
</tr>
</tbody>
</table>

Source: Hillary Foose, METRO Light Rail

The total operating expenses for the Regional Bus Service during FY 2009-2010 were $276,039,612. Operating expenses per vehicle revenue mile were $7.26, and operating expenses per vehicle revenue hour were $93.12. In terms of cost effectiveness, the bus system appears to cost more to operate per passenger mile and passenger trip than the light rail. The operating expense per unlinked passenger trip for bus was $5.08, while the operating expense per passenger mile was $1.25.\(^{194}\)
Bus Transit Integration

METRO was designed to help connect the cities of Phoenix, Tempe and Mesa, and from the beginning it was determined that any light rail system needed to operate within the context of the larger regional transportation system. In fact, part of the initial Major Investment Study initiated in 1996 called for “a supporting bus system to provide the required mobility in the Central Phoenix/East Valley corridor and the region” in addition to the light rail system. One of the ways in which the light rail is integrated with the larger transit network is through the six transit centers located along the METRO light rail line. These transit centers (Figure 52) are located within walking distance of the light rail stations and provide passengers with multiple bus connection options as well as additional amenities such as enclosed waiting areas and public restrooms. Some of these transit centers, including Central Station and the 44th Street/Washington Street Transit Center, provide more than four connecting bus routes for passengers.

Figure 52: METRO Transit Centers
Source: Valley Metro
Passengers who wish to drive to a light rail station may do so by using one of nine park and rides located along the light rail route. These park and rides are free to passengers. In total, the park and rides located along the METRO provide over 3,600 parking spaces and are in addition to the park and rides located elsewhere on the Valley Metro bus system.\textsuperscript{198}

Based on the final METRO system design, as well as a recently completed on-board travel survey, METRO seems to have been successful in this aspect for two reasons. First, METRO passes, with the exception of one-ride fares, are valid for unlimited transfers between light rail and bus service. Second, twenty-six of the twenty-eight light rail stations have connecting bus routes. All but two of these twenty-six stations have at least two connecting routes, with many, especially in the Downtown Phoenix area, having over six connecting bus routes.\textsuperscript{199} The inclusion of eight park and rides on the light rail route and the over forty park and rides connected to the bus system helps passengers easily travel from one system to the other.\textsuperscript{200}

According to the 2010-11 Valley Metro Transit On-Board Survey, fifty-two percent of all public transit users transferred at least once during their trip. Of this fifty-two percent, thirty-nine percent made one transfer, eleven percent two transfers, and two percent three or more transfers. More importantly, of those transit users who transferred between bus and light rail, sixty-one percent made one transfer, thirty-three percent made two and six percent made three or more.\textsuperscript{201}

**Impact on Economic Development**

Due to the relatively short time frame for which the METRO has been operating, as well as the recent economic downturn which has hit the Phoenix area particularly hard, it is difficult to quantify the true economic development benefits of the METRO system. Since 2004, 169 projects have been either planned, under construction, or recently completed along the light rail line. These projects represent over $5 billion in private capital investment and $1 billion in public investment.\textsuperscript{202} While this is evidence of economic development along the light rail route, it is impossible to determine whether these developments came about following the creation of the METRO or if they would have been built regardless. In terms of the types of development built, the two largest categories of development are commercial, with 129 million square feet, and Residential, with nine million square feet representing 16,670 residential units.\textsuperscript{203} Two of the more interesting developments along the light rail route include CityScape, in Downtown Phoenix, and the Domain at Tempe. CityScape is a planned 1.8 million square foot mixed-use...
development located in the heart of Downtown Phoenix, and adjacent to two METRO stations. 620,000 square feet of office, retail, and restaurant space was completed as part of the first phase. Additional phases include hotel and residential units, but development is currently on hold until market demands are suitable for the project. A second development, the Domain at Tempe, is a mixed-use development centered around student rental housing, located on Apache Boulevard only minutes away from the Smith-Martin/Apache Blvd METRO station which is three stops from Arizona State University. One of the most interesting aspects of the Domain at Tempe (Figure 53) is that in addition to the standard amenities associated with student housing complexes such as restaurants, the property makes an effort to advertise the proximity to the METRO. Ultimately, it is difficult to ascertain whether the same sort of development would have occurred without the METRO, but it is clear that light rail is at least playing a large role in the marketing strategies of this complex.

Expansion Plans

Due in large part to the tremendous growth experienced throughout the Maricopa County region over the past decade, the Maricopa Association of Governments’ Regional Transportation Plan has designated six future high-capacity transit corridors, representing thirty-seven total miles, for expansion (Figure 54). Ultimately METRO will be responsible for determining not only the location details of each additional expansion corridor, but also which transit mode is best equipped to serve the new corridors. The following are the six corridors (shown in Figure 54):

- Central Mesa Light Rail Extension- A three-mile extension running east from the current end of the line through downtown Mesa: expected completion in 2016.
- Tempe Streetcar- A 2.6 mile line in the Mill Avenue corridor with expected completion in 2016.
Phoenix West- An eleven-mile extension running west from downtown Phoenix with expected completion in 2021.

Northwest Light Rail Extension- A five-mile extension from the current end of the line toward Peoria Avenue. The expansion will be built in two phases: expected completion for Phase I is 2023, and Phase II is 2026.

Glendale- A five-mile extension into downtown Glendale with expected completion in 2026.

Northeast Phoenix: A twelve-mile extension towards Paradise Valley Mall with expected completion in 2031.206

Figure 54: METRO Future Transit Corridors
Source: Valley Metro

SALT LAKE CITY, UTAH

Introduction

Salt Lake City is the capital of Utah and the most populous city in the state, with a 2010 population of 186,440 persons. Brigham Young founded Salt Lake City in 1847 and mining, the transcontinental railroad, and Young’s Mormon followers provided the city with its initial economic boon. Today, Salt Lake City is known for its service-oriented economy and tourist
industry, which is based heavily on outdoor recreation. Major employers in the area include Delta Airlines, the University of Utah, and the Church of Jesus Christ of Latter-day Saints. Salt Lake City is also the industrial banking center of the United States.\textsuperscript{207}

These industries help maintain a Salt Lake City-Ogden metropolitan statistical area (MSA) employment force of 591,940 people.\textsuperscript{208} Salt Lake City’s business environment and cultural attractions have contributed to it being one of the highest-income MSAs in the United States with a median household income of $48,594 and a total population of 1,333,914.\textsuperscript{209} There are numerous higher education locations in Salt Lake City with at least nine universities and numerous trade and technical schools.

The Utah Transit Authority (UTA) provides bus service, commuter rail line, and light rail. These vehicles have an annual ridership of sixty-eight million within a 1,295 square mile area.\textsuperscript{210} The light rail system, TRAX, is a three-line, thirty-five mile system. The subject of this case study, the University Line, began operating in 2001 and was recently expanded in the first half of 2011. The remaining lines are currently undergoing an expansion to increase TRAX’s reach throughout Salt Lake City.

The annual passenger miles in 2009 for the TRAX were 60,857,298.\textsuperscript{211} When compared to the total bus system of the area, which had an annual passenger miles of close 105 million in 2009, the TRAX system accounts for about thirty-one percent of the total transit system (Figure 55) passenger miles.\textsuperscript{212} The light rail’s impact is further illustrated when looking at passenger miles and trips of the bus and light rail system over time as depicted in Figure 56. The bus system experienced a decline in ridership in 1999, the same year the first TRAX line opened. The light rail system experienced steady growth since 2002 and only recently saw a downturn in both passenger miles and trips. Figure 56 clearly shows the positive impact the TRAX system had on the overall transit system in Utah. TRAX was heavily used at the very beginning and it has become a successful part of the public transportation system.
transportation system and current expansion plans ensure the system will continue to play an integral part. Exact data used to develop the trend graph is presented in Appendix B.

**Light Rail System**

During the late 19th and early 20th centuries, an extensive streetcar system was constructed throughout Salt Lake City. As was the trend throughout the country, the automobile replaced the streetcar and the system was abandoned in 1945. Rail transit was re-introduced in 1999 when the first TRAX line opened. Planning for light rail began in 1983 when relieving traffic congestion on Interstate 15 became a major focus of the Utah Department of Transportation due to a growing population and increased vehicle miles. However, support and funding were initially hard to come by and it was not until Salt Lake City won the bid to host the 2002 Winter Olympics that a future for light rail in the city could be seen.
The subject of this case study is the initial University Line (the red route shown in Figure 57) and the MCE (green route). The blue route is the North/South line; the first TRAX line that opened in 1999. The University Line is an east/west line specifically designed to target University of Utah students. The initial University Line began at the Delta Center in the west and terminated in the east at Eccles Stadium (Figure 58). Eight stops along the 2.5 mile line provided easy access to the University of Utah and the downtown area. In 2003, the Medical Center Expansion (MCE) extended the University Line 1.5 miles to the University Medical Center and included the addition of three more stops. Upon completion of the initial University Line, University of Utah students immediately became one of UTA’s “most significant market segments.”

The University Line runs at the same elevation as the roadway using embedded double track on a reserved alignment. Motor vehicles are allowed to crossover at two locations along the route. The alignment of the guideway was shifted from the center of the roadway to side for the MCE, due to the high cost of continuing the line in the center of the road. The TRAX system uses a total of forty vehicles. Five Siemens SD100 vehicles were purchased for the initial University Line and seven SD 160 vehicles were added after the MCE. Siemens is a German company with corporate headquarters in Washington, D.C. Each vehicle is 81.4 feet long and has a carrying capacity of 205 persons with a top speed capability of
sixty-five mph. The light rail vehicles have eight low-level sliding doors. Four doors are equipped with manually-operated bridge-plates for easy entry from ramps. The low floor design and multiple door arrangement, along with a proof of payment fare system, enable passengers to board and alight easier and faster (Figure 59). This reduces potential delays for both the light rail and surrounding automobile traffic.

Fares for the light rail system start at $2.25 for a one-way fare and can be purchased using cash, credit or debit card at any MAX TVM at the various platforms, online, and at any Pass Sales Outlet. In addition to the one-ride fare, patrons can purchase a roundtrip pass, day pass, monthly pass, student 30-day pass, or minor monthly pass. There are special passes and fares for seniors, premium/express routes, and route deviations.

Of particular importance to this study is the EdPass Program operated by UTA. All faculty, staff, and students at the University of Utah qualify for a free EdPass allowing them to ride the entire UTA system for free. UTA charges the university a yearly fee based on expected ridership for the passes. A 2006 survey of University of Utah faculty, staff, and students indicated that the EdPass was well-known and heavily used. Three out of four students and staff indicated they had a pass, with two out of three faculty agreeing. Virtually everyone that did not have a pass said they were aware they were eligible for one and seventy-five percent of students and fifty percent of faculty and staff said they used the EdPass to commute to and from the university campus.

TRAX uses an electronic fare collection (EFC) system that keeps the system moving efficiently since passengers can board through multiple doors instead of having to enter the door nearest the driver to pay as they enter. Passengers must “tap” their card against the card reader when entering and exiting a light rail station; the card reader deducts the fare from the card and tracks passenger behavior. This method decreases delay times at stops and increases on/off boarding capacity times.
System Cost

The total capital cost of the University Line was $118,500,000, which included $74.5 million in purchasing land and design/construction of the line and structures, and another $12.7 million in rolling stock purchases. Costs labeled as “other” totaled $29.6 million. Based on the initial 2.5-miles constructed, the cost per mile was $47.4 million, including vehicle cost. The MCE cost $83.2 million, or $54.4 million per mile. The funding for the University Line came from New Start Funds, Formula Funds, and Local Match Funds.

O&M costs for the University Line and MCE are unavailable as it is difficult to track costs for a specific line. The system’s total O&M costs were $28,006,024 million in 2009. In terms of service efficiency, operating expenses per vehicle mile were $8.62. For cost effectiveness, the Cost-to-Ridership Ratio (operating expense per passenger trip) was $2.09, meaning it costs $2.09 for each passenger who boards the light rail. Data available from the 2006 Before and After Study shows revenue generated by the entire UTA system, the TRAX system, and the University Line before and after the MCE. Figure 60 shows the three years before and after the extension and the increase in revenue due to an increase in ridership. The total fare revenue of the TRAX system in 2009 was $10,413,625.

![Figure 60: Revenue Comparison](source: UTA Before and After Study)
Bus Transit Integration

As shown in Figure 61 and Figure 62, the change in ridership on bus routes serving the University of Utah in the before and after periods is a decrease of 370 and 325 boardings (2004 and 2005, respectively). This is a decrease of eighty-five revenue trips. Ridership increased on other routes during the same period and only minor changes in bus service (the discontinuation of two routes serving the university) were implemented so this decrease can be explained almost entirely as ridership shifting from bus to light rail. This would account for between ten and fifteen percent of the new boardings on the MCE. Thus most of the ridership on the MCE is from new riders.

The greatest decrease in bus boardings between 2002 and 2004 occurred on routes that serve suburban areas of Salt Lake County. Based on the geographic service areas of these routes, it is expected that nearly all of these riders shifted to TRAX as a result of the added light rail service to the Medical Center. Similarly, ridership on buses that serve downtown Salt Lake City and the historic Avenues suburb on route to the Medical Center decreased by 347 boardings, or nine percent.

Figure 61: Boardings on Bus Routes serving the University, 2002-2004
Source: UTA Before and After Study

Figure 62: Boardings on Bus Routes serving the University, 2002-2005
Source: UTA Before and After Study
Project Impact

The 2006 Before and After Study conducted by UTA focused on the impacts of the MCE. The impacts studied centered on the results of the expanded transit system and not on secondary impacts such as economic development. For this reason, only project impacts are discussed in this section.

After the MCE was completed, boardings and linked trips increased throughout the UTA system, but the increase was the most pronounced on the MCE project. Approximately fourteen percent of the new boardings were on the MCE project.

Another important impact that the MCE project had on UTA ridership is the change in the proportion of choice riders. A 2005 on-board survey indicated that sixty percent of riders on the MCE had a car available for that trip, but chose to take transit. This is a slight improvement over the 2002 survey results, in which fifty-seven percent of riders on the University Line indicated that they had a car available.223

One of the most significant impacts of the project was relief of the growing demand for parking on the University of Utah campus. The University Line greatly reduced demand for parking when it was built in 2001. The MCE further improved the situation, with 500 fewer parking passes sold than in the previous year. Analysis of changes in enrollment, transit trips, and available parking indicate that 200 additional parking passes would have been sold if the MCE had not been built.224

The MCE project also provided direct light rail access to the Jon M. Huntsman Center. Basketball games and gymnastics meets at the Huntsman Center are two of the largest generators of special events ridership on TRAX. Gymnastics meets at the Huntsman center regularly attract over 10,000 fans. Over five percent of the fans ride the light rail to the Huntsman Center, which was not accessible by TRAX prior to construction of the MCE.225

According to the UTA Before and After Report, the increase in ridership after the construction of the MCE project was not accompanied by an equally dramatic increase in revenue. The University Line experienced a fifty-seven percent increase in ridership between 2002 and 2004, while revenue increased by only forty-four percent during this period. This gap had widened by 2005, when ridership had increased by one hundred eight percent and revenue by only sixty-one percent.226 One explanation given for this discrepancy is the EdPass program in place at the University of Utah. Many of the new riders on the project were probably using the
passes they already had, but had not previously used. Because UTA negotiates EdPass contracts with the university on a yearly basis, revenues from these contracts are not as sensitive to market shocks or improvements to the system. To a lesser degree, the same is true for monthly passes. Riders often respond to system improvements by using their passes more frequently, rather than buying more passes. The added value can eventually be reflected in a higher price, but the increase in revenue is not as immediate as would be seen if all riders were paying a fare per trip. A major advantage of the EdPass program is that it helps students establish the habit of using transit.

In general, the construction of the Medical Center Extension successfully made transit more convenient and attractive to new riders without adverse effects for current riders.

**Expansion Plans**

UTA is working on several new extensions that will connect the existing light-rail lines to the Salt Lake International Airport, Draper, Mid-Jordan, and West Valley areas. Transit studies and planning are also underway in the four other areas. The following two lines are currently under construction with work yet to begin on the remaining extensions:

- The Salt Lake International Airport extension (Figure 63) is fifty percent complete. This extension is six-miles of imbedded double track with both separate and in-street along roadways ROW that will connect the airport to the rest of the system. There will be a direct transfer from a light rail stop to the FrontRunner Commuter Train, which will eventually connect all towns from Ogden to Provo. This project also

![Figure 63: Salt Lake International Airport Extension](source: Utah Transit Authority)
includes the construction of a Welcome Center just outside terminal one of the airport and five new stations.

- The Draper Line (Figure 64) is a 3.8-mile extension of the existing Sandy-Salt Lake Line south from its current termination point. The Draper extension is being built in the UTA-owned rail corridor, and will feature three new stations. Construction is underway along the entire length of the line.

![Figure 64: Draper Line Extension](source: Utah Transit Authority)

**KEY FINDINGS FROM THE U.S. LIGHT RAIL CASE STUDIES**

Below are key findings that have been identified based on the operations and performance of the three U.S. light rail case studies:

- **System Performance** – The case study systems show higher speed, efficiency, and performance (in terms of passenger miles per vehicle mile) than the bus networks in the case study cities.

- **Exclusive Right-of-Way** – A large part of light rail systems’ success is the exclusive ROW taken from streets the systems use throughout the route. This maximizes operating speed and efficiency by reducing interference from automobile and allows high capacity trains making stops at important destinations to operate much faster than buses.
• Boarding and Alighting- The systems are designed to board and alight large passenger volumes quickly through large, multiple door vehicle design, platform design, and proof of payment fare collection system

• Access to Universities – A major factor of two light rail systems is that the systems travel directly to major universities. With direct access to universities, light rail systems have been successful in attracting college students, a group who otherwise may not have been riding public transit.

• Integration with Transit System – An additional factor in light rail success is the light rail’s interconnectivity with the overall transit system. All the light rail systems have routes that provide access to many connecting bus routes.

• Student Fares – Both METRO light rail and UTA TRAX have made conscious efforts to promote free or heavily discounted transit passes for university students. The use of dedicated university passes can entice the university community to use the enhanced public transit mode since it can greatly lower transportation costs.

• Park and Rides – To further help feed the enhanced transit mode, all three light rail case study systems used park and rides located along the routes. Dedicated light rail park and rides allow passengers to drive to various stations along the light rail line route and park their car for free before using the system.

• Connections to Large Populations – All three light rail systems involved in the study are part of large metropolitan areas. The large population sizes and densities of these regions have all contributed to high ridership levels since there are enough people to support an enhanced travel mode.
FRENCH TRAM CASE STUDIES

This section of the report presents the French Case Studies of Le Mans, Orléans, and Reims. A brief background on the application of streetcar systems in France is included as well as the reasoning for selecting the three system/cities.

STREETCAR/TRAM SYSTEMS IN FRANCE

In the early 1980s, cities in France began to plan and construct what are now known as modern tramways. As of 2011, over nineteen cities in France have one or more modern tramway lines. Tramways in France are designed first and foremost as a “transport tool”, with a primary goal of enhancing the existing public transportation system and increasing transit ridership and productivity. Rather than being downtown circulators or focused only on the city center, tramways in France are designed to connect various parts of the city together, in some cases reconnecting far-flung satellite communities to the city center or revitalizing “disadvantaged neighborhoods”. Integration with the overall transit system and a prioritization of the tramway over automobiles is a key component of French tramways. Tramways have priority at all intersections and extensive dedicated ROW. Vehicle lanes are frequently removed to be used for the tramway ROW, and are not replaced in an effort to relieve congestion through restricting vehicle traffic in French cities, and “reconquer part of the public space that cars have monopolized in cities”. French tramways are planned and constructed in a relatively quick period of time, often timed to coincide with the six-year term of office for French mayors. All levels of government in France provide capital funding for tramway projects. Local funding primarily comes from the versement transport, which is a payroll tax, usually up to 1.75 percent, that is levied on all businesses with nine or more employees.

For the purpose of this report, three case study cities were chosen: Le Mans, Orléans, and Reims (Figure 65). These cities were chosen...
based on their relatively comparable population size to Tallahassee, the presence of a college or university along the tramway alignment, and most importantly, potential data availability and contact information.

French tramways are also distinctive in that there is tremendous attention paid to the urban design of the tramway alignment, an example of which is shown in Figure 66. According to Tom Parkinson, “excellent urban design integration” is a hallmark of French tramways. The reason that such close attention is paid to urban design is that tramways are highly visible from the city street, meaning there is an opportunity to use the visibility of the tramway to “enhance the urban space” through providing “immediate environmental improvements: silence and absence of air pollution, tree planting, grass trackbeds” and to generally “enhance the urban space.” Excellent integration with the urban environment not only enhances the quality of life of the city, but also increases “the overall acceptance of and regard for public transport.”

Figure 66: Reconstruction of an “Urban Highway” in Strasbourg
Source: Münchner Verkehrsgesellschaft, “The Modern Tram in Europe”
Table 12: Snap-shot of All Available Tram/Streetcar Systems and Bus System in France
Source: SETRAM, CERTU, and email message from Christian Buisson

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As shown by Table 12, despite relatively limited available data, the impact that French tramway systems have on the overall transit network is striking. Out of the ten cities examined, the tramway systems carried at least thirty-seven percent of all trips on the public transit network. In Nantes, fifty-seven percent of all transit boardings were on the tramway with Le Mans, Strasbourg and Montpellier also having over fifty percent of their total public transit system’s boardings on the tramway lines. One of the characteristics of the French tramways model is the large transit share the French tramways are able to capture. High tramway ridership further translates into excellent productivity compared to the bus system. As measured by
passenger boardings per revenue mile, all of the tramway systems displayed significantly higher levels of productivity compared to the bus system.

It is important to note that with the exception of Le Mans, Reims and Orléans, only tramway passenger boardings, and tramway revenue miles were provided along with the percentage of tramway boardings and tramway revenue miles compared to the rest of the transit system. Using these statistics, ridership and revenue mile statistics were calculated for the bus system. With the exception of Le Mans, Orléans and Reims, operating costs were calculated using the operating cost per capita multiplied by the system’s service area population.

Figure 67 displays the effect that the implementation of tramways has had on transit ridership per capita. This graph displays ridership per capita for the cities of Mulhouse (M2A) Clermont-Ferrand, Nancy, Caen, and Orléans over a ten year period. The small train icons designate when tramway systems were implemented. All of the above systems have seen at least some increase in transit ridership per capita with the implementation of tramways, and in some cases (such as Clermont-Ferrand) dramatic increases in riding habit corresponding with the implementation of tramway systems.

The application and performance of the streetcar/tram in France is further analyzed and discussed in the three case studies presented below.

Figure 67: Transit Ridership per Capita in Select French Cities.
Source: Mulhouse Agglomeration, “Mulhouse Annual Mobility Report 2010”
ORLÉANS, FRANCE

Introduction

The City of Orléans is located in the north central section of France, along the Loire River. Orléans is the capital of the Loire region of France. The urban area of Orléans has a population of approximately 279,518 individuals and 187,609 employees. Public transportation in Orléans is operated by the Setao organization (contracted to Veolia Transdev), which is branded as the TAO. The TAO operates in a service area covering 208 square miles and provides public transportation service to twenty-two municipalities in the Orléans urban area (Figure 68). The TAO provides a network of one tramway line and thirty-two bus lines, in addition to four shuttle and seven demand response lines in the system, with a total of 1,280 bus stops in the network. The TAO employs 715 people, of whom 482 are transit operators. In addition to the fixed route and demand response services, the TAO also provides paratransit service for individuals with limited mobility. To provide these services, the TAO utilizes twenty-two tramsets and 220 buses.

Tramway Line

The Orléans tramway, labeled Line A began service on November 20, 2000 along an 11.2 mile alignment (shown below in Figure 68, the system map for the region). The line is a single alignment, without any branching or spurs. Line A serves twenty-four stations, spaced approximately 0.3 miles apart. Of the twenty-four stations, eighteen use a side platform configuration, while six use a single center platform between tracks. The stations along the tramway are of a simple and uniform design. Every station platform has a large sized shelter, with TVMs and system information, providing a protected waiting area for patrons. The station platforms along Line A also have real time arrival information displays.
The tramway line runs from north to south through Orléans and its surrounding municipalities. As shown by Figure 69, the line begins at its northern terminus, Jules Verne station before heading to serve the Aubrais and Orléans rail stations, traveling through the city center of Orléans, crossing the River Loire. After crossing the river, the tramway travels through Orléans and its southern suburbs. It stops at a major

Figure 68: Orléans TAO System Map  
Source: Le réseau TAO

Figure 69: Orléans Tramway Line A  
Source: Le réseau TAO
exposition park, travels through the Université d’Orléans campus before reaching its terminus station at the La Source Hospital. Several miles of the alignment through this section are in relatively undeveloped areas, which are expected to gradually infill with development centered around the tramway stations over time. Line A is operated using 22 Alstom Citadis tramsets, which were acquired in preparation for the lines opening in 2000.

Line A provides an important connection from Orléans to the campus of the Université d’Orléans, south of the city center. The Université d’Orléans has 15,000 students on its campus. Line A serves the university at three stations: Université Chateau, Université Parc Floral, and Université L’indien (Figure 70). Line A runs directly through the heart of the Université d’Orléans campus. Rather than being relegated to peripheral roads, the tramway line runs through the middle of the campus in primarily pedestrian areas, winding its way around the campus buildings, as shown by Figure 71, Figure 72, and Figure 73. The integration between Line A and the University could potentially be a good example of how rail transit and a university campus can be well integrated in a way that both maintains the character of the university and provides for transit-supportive urban design. Two bus lines also serve the Université d’Orléans: thirteen and twenty, which run from early morning to late evening.

Figure 70: Route of Line A through Université d’Orléans Campus
Source: Université d’Orléans
Figure 71: Tramway in front of the Faculté Lettres-Langues, Sciences Humaines Building
Source: Google Maps

Figure 72: Tramway Running Through Center of Université d'Orléans Campus
Source: Google Maps

Figure 73: Tramway between Université Chateau and Université Parc Floral
Source: Google Maps
Schedule/Timetable

On Weekdays and Saturdays, Line A runs from 4:00 am until 1:00 am, while on Sundays, the line runs from 6:00 am until 1:00 am. Frequency is an important component of the tramway. The tramway runs every five to seven minutes Monday through Friday. On Saturday, the tramway runs every eight to ten minutes. Sunday and holiday service is the exception to this high frequency standard, as service is significantly reduced to every twenty to thirty minutes. The tramway runs every five to seven minutes Monday through Friday. On Saturday, the tramway runs every eight to ten minutes. Sunday and holiday service is the exception to this high frequency standard, as service is significantly reduced to every twenty to thirty minutes. Line A runs at a scheduled speed of thirteen mph, though this varies considerably depending where along the route the tramway is running. In the city center, the tramway has an estimated scheduled speed of between five and six mph, a slow speed that is likely due to high levels of boardings and alightings in this area. Outside of the city center, where there are in some cases distances of up to one mile between stations, the tramway travels at a scheduled speed of eighteen or twenty plus mph. Line A averages a scheduled speed of eleven mph while traveling through the campus of the Université d’Orléans.

Park & Ride

There are six park and rides along Line A: Libération station with two hundred parking spaces, Zenith-Parc des Expositions with two hundred spaces, Victor Hugo station with 150 spaces, Les Aulnaies station with 150 spaces, Bustière station with fifty-five spaces, and Jules Verne station with forty-five spaces. Patrons wishing to park must purchase a special pass ($3 per day) in order to get access to the first four park and ride lots (which have security surveillance). To use the Bustière park and ride, drivers must have a validated TAO fare or transit pass in order to exit the lot. The Jules Verne lot is free.

Integration with the TAO Bus Network

In contrast to the SETRAM network in Le Mans, the Orléans network does not have a few well-defined transfer points where many bus routes connect to the tramway line. Rather, there are many stations along Line A which connect to one or two lines in the bus system. Out of twenty-four total stations, nineteen of them connect to at least one bus line. The one central hub in the network is the Gare d’Orléans central train station, where the tramway and intercity trains connect with twelve bus lines to create a multimodal transit center.

The TAO bus system is set up to complement Line A of the tramway system. Unlike the systems in Reims and Le Mans, Orléans does not actively brand a few bus lines as “core routes”. The TAO system is made up of an extensive network of bus lines, the majority of which radiate
out from the city center to the edges of the Orléans urban area. Many of these routes do not terminate in the city center, but continue as “cross-town” routes, travelling from one edge of the Orléans area to the other via the city center. Buses travel along the city center focused in an east-west pattern along Boulevard Alexandre Martin, complementing the north-south travel pattern of the tramway. There are several options to transfer while in the city center, but the system focuses most bus-bus and bus-tram transfers in this part of Orléans at the central train station (Gare d’Orléans). It is important to note that not every route is focused through the center of Orléans. Many routes are designed to feed into the tramway line at peripheral stations, particularly routes that travel from suburbs of Orléans to a tramway stop. Other routes are focused on connecting these suburbs to each other in a more decentralized fashion. The frequency of the bus routes in the TAO system varies widely, with some routes running every ten to fifteen minutes, and others running every thirty minutes during off-peak.

**System Performance and Operation**

The Orléans tramway system is an excellent example of how the successful introduction of a tramway line can lead to significant ridership gains through the entire public transportation network. The opening of Line A in late 2000 had a significant impact on the overall public transit system in Orléans. Between 1995 and 2000, before the opening of the line, the system experienced a slow decline in bus patronage from 17,200,000 boardings in 1995 to 15,998,000 boardings in 2000. Operating trips per capita decreased from sixty-six passenger trips per capita (service area population) in 1996 to fifty-nine passenger trips per capita in 1999 and 2000. Implementation of the tramway system has resulted not only in annual gains in tramway ridership, but also in increased ridership in the overall system. Line A ridership has steadily increased since service began in 2000. From 2002 to 2007, tramway boardings increased by thirty percent. Total boardings on the tramway have increased every year since 2000 from 9.2 million boardings in 2002 to twelve million boardings in 2007.

As shown by the table Table 13 and Figure 74, while bus ridership decreased with Line A’s opening, ridership has steadily increased since that initial decline, with a twenty-two percent increase in ridership between 2002 and 2007. The result of the introduction on overall system ridership has been significant. While system-wide ridership decreased every year between 1996 and 2000, this trend has been dramatically reversed. System-wide boardings have steadily increased since 2000, with a twenty-six percent in overall system-wide ridership between 2002
and 2007, from 20.4 million boardings to 25.7 million boardings. When compared to pre-tramway ridership levels, there has been a nearly sixty percent increase in ridership from 1999 to 2007\textsuperscript{259} from sixteen million annual boardings to 25.7 million annual boardings (or roughly 40,000 passengers per day).\textsuperscript{260} Riding habit, measured by system-wide passenger trips per capita, has also increased over this time period from fifty-nine in 1999 to ninety-four in 2007. Boardings per vehicle mile (system-wide), a measure of productivity, have increased steadily since the introduction of the tramway. After declining to 2.71 boardings per vehicle mile, this measure of productivity has increased every year since the tramway was introduced in 2000, reaching 3.81 in 2007.\textsuperscript{261} Boardings per vehicle mile are not comparable to passenger miles per vehicle mile, and are generally smaller in terms of magnitude.

### Table 13: Orléans System Performance 1995-2007

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</tr>
<tr>
<td>Total Vehicle Miles (thousands)</td>
</tr>
<tr>
<td>Boardings per capita</td>
</tr>
<tr>
<td>Operating Cost thousands (€)</td>
</tr>
<tr>
<td>Operating Cost thousands (Francs)</td>
</tr>
<tr>
<td>Boardings per Vehicle Mile</td>
</tr>
</tbody>
</table>

| 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|-----------------------------------------------------|
| Service Area Population | 273,781 | 273,781 | 273,781 | 273,781 | 273,781 | 273,781 |
| Number of lines | 22 | 22 | 22 | 22 | 22 | 22 |
| Total Line length (km) | 474 | 453 | 381 | 380 | 380 | 380 |
| No. Vehicles | 259 | 256 | 246 | 241 | 249 | 237 |
| Total Trips (thousands) | 20,405 | 22,030 | 23,876 | 23,355 | 24,819 | 25,685 |
| Bus Trips | 11,159 | 11,760 | 12,459 | 12,012 | 12,969 | 13,622 |
| Tramway Trips | 9,246 | 10,270 | 11,417 | 11,343 | 11,850 | 12,063 |
| Total Vehicle Kilometers (thousands) | 11,222 | 11,397 | 11,393 | 10,664 | 10,850 | 10,860 |
| Total Vehicle Miles (thousands) | 6,973 | 7,082 | 7,079 | 6,626 | 6,742 | 6,748 |
| Boardings per capita | 75 | 81 | 87 | 85 | 91 | 94 |
| Operating Cost thousands (€) | 37,550 | 41,674 | 45,523 | 47,049 | 50,077 | 54,098 |
| Operating Cost thousands (Francs) | 144,701 | 149,052 | 157,557 | 160,992 | 170,545 | 195,128 |
| Boardings per Vehicle Mile | 2.93 | 3.11 | 3.37 | 3.52 | 3.68 | 3.81 |

*2001 data not available*
Figure 74: Orléans Transit Network Ridership 1995-2007
*2001 Data not available
Source: Christian Buisson, email message to authors

**ROW Treatments/Urban Design**

The Orléans tramway displays several ROW treatments that are typical of many tramway systems in France, as shown by Figure 75 and Figure 76. These include grassed sections in the median of the roadway, some limited sections of shared ROW, as well as ROW well isolated from the roadway in the outlying areas of the tramway alignment. Figure 75 is an example of how the tramway is integrated into the existing

Figure 75: Orléans Protected Right of Way
Source: Google Maps

Figure 76: Grass Median ROW
Source: Google Maps
urban fabric of the city center of Orléans. In this example, the tramway has its own ROW protected from vehicle traffic, but vehicle traffic can go into the tramway ROW in emergency situations.

The grass median ROW (Figure 76) treatment is seen throughout French tramway systems. In this case, it creates a path of travel for the tramway that is separated from vehicle traffic, while enhancing the aesthetic look of the tramway alignment through the use of the natural grass elements. In the case of the Orléans tramway, speeds along this ROW treatment are typically ten to fifteen mph.\textsuperscript{263} \textsuperscript{264}

Figure 77 shows a median ROW treatment similar to the grassed median, but with paving instead. In the case of Line A, this median ROW treatment results in roads with one vehicle travel lane in each direction with the tramway in the middle, rather than high speed multi-lane streets with tramways in the middle. In this image, a typical center platform station is also visible.

In Figure 78, Line A is completely segregated from automobile traffic, and is in its own ROW. A typical side platform for Line A is also visible to the left. It is important to note that the ROW treatment used along the alignment combined with the spacing between stations can significantly impact the speed of the tramway operation. For example, between Les Aulnaies station and Lorette station, the tramway runs essentially through greenspace, with no auto conflict. Along this isolated section, the tramway reaches scheduled speeds of over twenty mph.\textsuperscript{265} \textsuperscript{266}
Fares and Passes

The TAO system uses the proof-of-payment system for the tramway line, meaning that users must purchase their fares in advance before boarding the tramway. When boarding, patrons may use any door, which speeds boarding and alighting. Fares and passes may be purchased on board buses, at TVMs located at each station, and at the TAO’s offices. The TAO offers a myriad of passes, including day passes, weekly passes, and monthly passes. The TAO also offers a contactless RFID card, as well as passes for special groups such as students, senior citizens, and employer sponsored pass programs.267

Future Expansion

The success of tramway Line A has led to a proposed expansion of the tramway system in Orléans. This new east-west line (Line B) will link with Line A in the center of Orléans and, according to the Orléans municipality, will serve about twenty percent of the urban area’s population.268 Construction began in 2009 and the tramway is scheduled to open in June 2012.269 Line B will serve twenty-five stations and is approximately 6.8 miles long, connecting Orléans to its eastern and western suburbs.270 Line B is expected to cost approximately $425 million.271

LE MANS, FRANCE

Introduction

Located an hour southwest of Paris by rail in the Pays de la Loire region of France, Le Mans is one of the smallest cities in France to have a tramway system. The Le Mans metropolitan agglomeration has an urban population of 291,765,272 with the city of Le Mans at its center. The city of Le Mans has a population of 168,966 and a total employment population of 122,120.273 Other communities included in the urban area include: La Chapelle-Saint Aubin; Coulaines; Sargé; Yvré-l’Évêque; Mulsanne; Arnage; Allonnes; and Rouillon (Figure 80).

Public transportation in Le Mans is operated by the Soceite d’Economie Mixte des Transports en Commun de l’Agglomeration Mancelle (SETRAM). This organization is a part of the Keolis Company, which operates multiple transit systems across France.274 The French railway operator, SNCF, owns a majority stake of Keolis. SETRAM also provides special shuttle service to and from primary and secondary schools in the Le Mans urban area.275 SETRAM
provides paratransit service for Le Mans\textsuperscript{276} and a limited demand response community shuttle service to limited parts of its service area\textsuperscript{277} In addition to operating the bus and tramway network, SETRAM operates a bike rental service for residents of Le Mans\textsuperscript{278} The bike share system began operation in January 2010\textsuperscript{279}

**Tramway System**

As shown by the Figure 79, the Le Mans tramway consists of one line with two branches. The tramway operates as a single line between the Université terminus station and Saint Martin station. At Saint Martin station, the line splits into two branches, one terminating at Espalarche de La Nature, with the other terminating at Antarés-MMArena. The northwest terminus of the line serves the Université du Maine, which has a population of approximately 10,000 students\textsuperscript{280} Leaving the campus, the tramway continues into Le Mans, serving the main hospital before entering the city center. The tramway line crosses over the Sarthe River, and from the city center, it travels to the Gare du Mans SNCF TGV rail station in Le Mans. From the rail station, the line continues through Le Mans to Saint Martin, before splitting into its two branches. The south branch terminates at the famous Le Mans raceway track and a major sports arena at Antarés-MMArena, while the east branch continues through a primarily residential area to its terminus at Espalarche de La Nature. The Le Mans tramway uses twenty-three tramsets, all of the Alstom Citadis model like many other French cities.

The tramway is approximately 9.6 miles in length, serving twenty-nine stations\textsuperscript{281} Of these twenty-nine stations, twenty-three use side platform configurations, while the remaining six stations use a single center platform design. Stations are placed on average approximately 0.34 miles apart.

![Figure 79: 2011 SETRAM Bus & Tram Network](source: SETRAM)
The design of the Le Mans tramway stations (Figure 80) is simple, uniform, and relatively utilitarian. The platforms are partially enclosed by a large Plexiglas-type shelter, with advertising panels on one side of the shelter. TVMs and system information are located at every station. Some small graphic art elements are placed on the bottom of the panels of each shelter.

An important element of the tramway is its service to the Université du Maine. The Université du Maine is the northeast terminus of the tramway line. The tramway passes along the circumference of the university campus, using existing ROW along roads, rather than passing directly through the heart of the campus. The university is served by two tramway stops: Université and Campus-Ribay.

**Schedule/Timetable**

The tramway operates seven days a week from 5:00 am to 1:00 am Monday through Saturday, and from 6:00 am to 1:00 am on Sundays and holidays. As with practically all French tramway systems, high frequency is a very important component of the Le Mans tramway. Along the main spine of the system between Université and Saint Martin, the tramway runs every five minutes during peak hours and every six minutes during off peak hours. The scheduled speed of the tramway is an average of fourteen mph, with travel times significantly faster along some sections of the alignment, and slower through the city center, where there are large volumes of boardings and alightings. The tramway has priority at all intersections.

**Park & Ride**

There are three Park and Ride lots along the tramway line, located at the terminus stations of Antarés, Université, and Espalarche de La Nature. There are 926 total Park and Ride spaces with Antarés holding 359 vehicles, Université 450 vehicles, and Espalarche de La Nature holding 117 vehicles. Parking is free for users who have a SETRAM smart card (La carte Moovéa), while for all other users it costs approximately $4 per day.
Construction of the Tramway and Funding

The Le Mans tramway was constructed relatively quickly over a three-and-a-half year period, opening on November 18, 2007.\textsuperscript{285} The total capital cost of the tramway is estimated at $423 million,\textsuperscript{286} which places the Le Mans tramway on the lower end of the capital cost spectrum for French tramways. This results in capital cost per mile of approximately $44 million per mile for the 9.6 mile alignment.\textsuperscript{287} Planning for the tramway project began in 1998, with actual construction beginning in June 2004. The tramway was built in a two-stage process. The first step involved diverting and reconstructing utilities in the way of the tramway line in preparation for construction.\textsuperscript{288}

The second stage was the construction of the Maintenance and Operations Control Center as well as construction of the tramway track.\textsuperscript{289} The track construction involved the installation of concrete track slabs, the completion of the track surface, installation of the overhead wiring system to power the tramway, the construction of nine electrical sub-stations, the construction of the tram stops, as well as the installation of approximately six miles of grass track along the main avenues of Le Mans.\textsuperscript{290} 180 different firms were involved in the construction process, totaling 2.5 million hours of labor.\textsuperscript{291}

The Le Mans tramway was funded by a variety of sources. This included some funding from the French Government via the “Agence de Financement des Infrastructures de Transport” (four percent of the project’s capital funding), and some funding from the regional government (accounting for five percent of the project’s funding). About ninety percent of the tramway project’s capital funding came locally via the Versement payroll tax assessed to all employers with nine or more employees.\textsuperscript{292} At a capital cost of roughly $27 million per kilometer, the Le Mans tramway is one of the lowest cost tramway systems in France.\textsuperscript{293}

Integration with the SETRAM System

When the tramway opened in November 2007, the existing bus network was reorganized to fully integrate with the new tramway line. The “new” system was branded the SETRAM “Bus + Tram” network.\textsuperscript{294} As of 2011, the bus system is organized to connect to the transit system at four well-defined transfer stations, in addition to four other tramway stations where one bus line connects to the tramway (Figure 81).\textsuperscript{295} These transfer stations (Eperon, République, Gare du Mans, Saint Martin) are designed to facilitate transfers between the tramway and the bus lines that make up the rest of the network.
Figures 81 and 82 provide an overview of how bus-tram transfers are facilitated in the city center of Le Mans, centered around the main square of Le Mans (République). Rue Gambetta and the République Square and tramway stop are restricted to vehicle traffic, so patrons must cross the square or Rue Gambetta to reach bus services.

Figure 81: République and City Center Service
Source: SETRAM

Gare du Mans, the central railway station in Le Mans (Figure 83) is an important transfer location for patrons transferring between the tramway, bus, and French national railways intercity or TGV high speed trains in the main station. Transfers are facilitated by placing the tramway station directly outside the entrance to the rail station.

Saint Martin station, Figures 84 and

Figure 82: Eperon and République Transfer Stations

Figure 83: Gare du Mans (rail) Transfer Station
Source: SETRAM
85, is the only station in the system where buses and trains share the station platforms, allowing for easy transfers. At other transfer points in the system, buses remain on the street. This station is also important in the system because it is where the line branches off to Antarés-MMArena and Espalarche de La Nature.

Figure 84: Saint Martin Bus and Tramway Station
Source: Google Maps

The SETRAM bus system is designed to complement the tramway system. The bus system is comprised of three primary or core bus lines and seventeen other bus lines. Service is provided to each of the nine municipalities seven days a week. The three core bus lines, lines 3, 4, and 16, run at a span of service and frequency comparable to the tramway. These lines operate from 5:00 am until 12:30 am, with buses running every eight minutes during peak hours and every twelve minutes during off peak hours. These routes in combination with the tramway form a network of frequent transit service from early morning until night. The rest of the bus lines in the system provide service from 6:30 am to 12:30 am throughout the SETRAM system. These auxiliary lines serve a variety of roles: acting as feeder routes to the tramway, connecting destinations in the outer municipalities to Le Mans and to each other, as well as providing additional cross town connections in Le Mans.

Figure 85: Saint Martin Transfer Station
Source: SETRAM
System Operations and Performance

While the data that is available is somewhat limited compared to the United States light rail and streetcar systems, the Le Mans case study still provides valuable insight into the impact the French approach can have on transit systems. As shown by Figure 86 and Table 14, in 2010 the SETRAM system had a total of 24 million boardings, with 12.4 million on the tramway (fifty-one percent of all boardings) and 11.6 million by bus.297

Table 14: Le Mans System Performance 1995-2010

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</thead>
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<tr>
<td></td>
<td>Service Area Population</td>
<td>187,737</td>
<td>188,108</td>
<td>188,480</td>
<td>188,852</td>
<td>188,852</td>
<td>188,852</td>
<td>188,852</td>
<td>188,852</td>
<td>188,852</td>
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<td>188,852</td>
<td>188,852</td>
<td>188,852</td>
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<tr>
<td></td>
<td>Number of lines</td>
<td>19</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>25</td>
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<td>Line length (km)</td>
<td>168</td>
<td>182</td>
<td>180</td>
<td>178</td>
<td>183</td>
<td>183</td>
<td>210</td>
<td>217</td>
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<td>210</td>
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<tr>
<td></td>
<td>Vehicles</td>
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<td>153</td>
<td>157</td>
<td>157</td>
<td>155</td>
<td>156</td>
<td>156</td>
<td>164</td>
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<td>156</td>
<td>164</td>
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<td></td>
<td>Total Trips (thousands)</td>
<td>23,635</td>
<td>21,711</td>
<td>22,087</td>
<td>22,359</td>
<td>23,098</td>
<td>22,582</td>
<td>22,505</td>
<td>22,633</td>
<td>22,505</td>
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<td>Tramway Trips (thousands)</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>Total Vehicle Km (thousands)</td>
<td>5,597</td>
<td>5,397</td>
<td>5,810</td>
<td>5,825</td>
<td>5,926</td>
<td>5,807</td>
<td>5,866</td>
<td>5,912</td>
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<tr>
<td></td>
<td>Boardings per capita</td>
<td>126</td>
<td>115</td>
<td>117</td>
<td>118</td>
<td>122</td>
<td>120</td>
<td>119</td>
<td>120</td>
<td>119</td>
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<td>119</td>
<td>120</td>
<td>119</td>
<td>120</td>
</tr>
<tr>
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<td>Operating Cost (000s) (€)</td>
<td>16,656</td>
<td>16,976</td>
<td>18,082</td>
<td>18,790</td>
<td>19,768</td>
<td>20,241</td>
<td>21,085</td>
<td>22,257</td>
<td>21,085</td>
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</tr>
<tr>
<td></td>
<td>Operating Cost (000s) ($)</td>
<td>22,169</td>
<td>22,595</td>
<td>24,067</td>
<td>25,009</td>
<td>26,311</td>
<td>26,941</td>
<td>28,064</td>
<td>29,624</td>
<td>28,064</td>
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<tr>
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<td>Cost per boarding (€)</td>
<td>0.70</td>
<td>0.78</td>
<td>0.82</td>
<td>0.84</td>
<td>0.90</td>
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<td>0.98</td>
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</tr>
<tr>
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<td>Cost per boarding ($)</td>
<td>1.04</td>
<td>1.04</td>
<td>1.09</td>
<td>1.12</td>
<td>1.19</td>
<td>1.25</td>
<td>1.31</td>
<td>1.31</td>
<td>1.25</td>
<td>1.31</td>
<td>1.25</td>
<td>1.31</td>
<td>1.25</td>
<td>1.31</td>
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</tbody>
</table>

Note: *2010 Bus 3604, Tram 870
         Tramway Begins 11/07
According to SETRAM, the public transit system has an average of 100,000 boardings per day, with about half of those boardings (51,000) on the tramway.\textsuperscript{298} This represents a huge shift from bus patronage to tramway patronage since the tram was introduced in 2007. As shown by Figure 87, the Le Mans public transit system before the introduction of the tramway in 2007 was experiencing a gradual decline in ridership since 2005, with fluctuating ridership between 1995 and 2005.

This shift from the bus to the tramway reveals several advantages of the French model of operations. In contrast to many U.S. streetcar systems, the tramway in Le Mans was able to capture such a large amount of system-wide patronage, that bus service has been reduced while maintaining overall system ridership. According to SETRAM, the level of service provided by the bus has been reduced from a high of 4,000 vehicle miles in 2006 down to 2001 levels (3,600 vehicle miles).\textsuperscript{299, 300} The shift in patronage from the tramway to the bus allows for a more productive operation. In 2010, the tramway carried approximately 14.25 boardings per vehicle mile, in stark comparison to the 2.59 boardings per vehicle mile on the bus system that same year and the 5.5 boardings per vehicle mile in 2006, the year before the tramway opened. It should be noted that boardings per vehicle mile are not comparable to passenger miles per vehicle mile. It is also important to note that the cost per boarding has not decreased over this time period.\textsuperscript{301, 302}

**ROW Treatments/Urban Design**

A variety of ROW treatments can be seen along the alignment of the Le Mans tramway that are typical of the French approach to tramway construction, including exclusive ROW taken from existing road space (in some cases entire roads were converted to tramway-only configurations), ROW shared with vehicles, and ROW that is located in the median of roadways. One constant that remains throughout this variety is close attention paid to the urban design, ensuring that the tramway fits neatly into the existing urban fabric. In Figure 87, the tramway is given its own ROW separated from vehicles, but still using what was road space. Care is taken to incorporate principles of urban design, such as wide sidewalks for tramway patrons.
Figure 88 shows an example of where the tramway and private automobiles use the same roadway. It is important to note that this is not a high traffic street, nor it is a particularly wide multi-lane road. In Le Mans, the occasions where this mixed traffic situation is seen is very rare, and only occurs along two-lane, low traffic roads. Vehicles on this particular street are restricted to thirty km/h, or about twenty mph. Figure 89 shows the tramway along the Université du Maine Campus.

**Figure 88: Le Mans Mixed Right of Way**
Source: Google Maps

**Figure 89: Université du Maine Campus**
Source: Google Maps
Urban Design Through the Tram: Place de la République

The reconstruction of the République Square (Figure 90) during the tramway construction process is a good overview of how both urban design and the restriction of auto traffic were taken into consideration during the planning and construction of the Le Mans tramway. In this case, the main square in the center of Le Mans was converted from a plaza ringed by a road to an attractive pedestrian area completely restricted to automobiles. In fact, the tramway is the only “vehicle” of any type that enters the newly designed République Square on a regular basis. Steps to restrict the movement of automobiles during the implementation of the tramway, such as the refurbishment of République, are in part credited with a drop in auto traffic in the center of Le Mans since the tramway opened in 2007.303

In the case of Le Mans, the construction of the streetcar in these older, well-developed urban areas creates two opportunities to enhance the urban aesthetic of Le Mans. First, the tramway provided an opportunity to create a reconstructed streetscape with an excellent, transit supportive urban design and aesthetic.304 Secondly, the tramway provided an opportunity to remove ROW for automobiles and shift ROW to pedestrians and tramways in the city center of Le Mans, thereby reducing automobile traffic in the city center. This was achieved through the closure of République Square and sections of Rue Gambetta to automobile traffic.305

Fare information

The SETRAM transit network uses a unified fare system in that passes can be used on both the tramway and bus systems. An hour pass is good for unlimited travel on the tram and bus system after validation.306 On the tramway, a proof-of-payment system is used. Fares must be purchased before boarding the tramway, which allows for tramway patrons to board through any door. Patrons must display proof-of-fare payment when requested by a fare inspector. A variety of fare media and passes are available to tramway patrons, including hourly passes (approximately $1.80),307 day passes, ten ride passes, weekly passes, group passes, as well as
standard monthly and annual passes. Passes are also available for special categories such as students, the elderly and disabled, and employer sponsored transit pass programs.\textsuperscript{308} Fares and passes are available from SETRAM’s offices, onboard SETRAM buses, and available from TVMs located at each station along the tramway line.

In conclusion, the Le Mans tramway is a good example of a tramway system built in a small-medium sized city relatively quickly and at comparatively low cost. The tramway over the past two to three years has been quite successful at capturing a significant percentage of the SETRAM transit system’s overall patronage, with ridership on the tramway accounting for fifty-one percent of all patronage on the SETRAM network.\textsuperscript{309} While the tramway has not led to extremely dramatic increases in public transportation usage overall in Le Mans at this point in time, it seems to have helped to stop the slow decline in transit patronage the SETRAM bus-only system had experienced in recent years and has helped to dramatically enhance the urban design of Le Mans and its surrounding municipalities along the tramway route.

**REIMS, FRANCE**

**Introduction**

Reims is located in northern France within the Champagne-Ardenne region. The city has a population of 188,078, with an urban area population of 291,735 making it one of France’s medium sized cities. An important element of the city is the Université de Reims Champagne-Ardenne. According to the university, during the 2007-2008 academic year there was a student population of 22,220.\textsuperscript{310} The city of Reims is one of six cities that constitute the Reims Métropole organization. The Reims Métropole organization is responsible for setting policies and objectives for urban transport within the six municipality region.\textsuperscript{311} The Reims Métropole was created in November 2005 after the previous organization, the Urban Community of Reims, was disbanded. Citura is the new name for the bus and tram system within Reims, which are operated by a private company, Veolia Transdev under contact to Reims Métropole. Alstom is the company that has a contract to provide the rolling stock for the tram system.

**Tramway System Characteristics**
The tram system is a very new component of the public transit system within Reims. The tram system began operations in April of 2011 and is integrated with the previously existing bus system and is 11.2 kilometers (6.9 miles) in length. The Reims tram system consists of the A and B lines (Figure 91). The tram system is a very new component of the public transit system within Reims. The tram system began operations in April of 2011 and is integrated with the previously existing bus system and is 11.2 kilometers (6.9 miles) in length. The Reims tram system consists of the A and B lines (Figure 91). There are eighteen trams, a total of twenty-three tram stations, and three park and ride facilities. Lines A and B run along a common alignment for much of the tramway route. The two lines diverge after the Arago station and the A line continues to pass through the Mediatheque Croix Rouge Station and terminates at the Reims Hopital Debré Station whereas the B line continues to the southwest and passes through the Leon Blum station and terminates at the Bezannes Gare Champagne TGV station.

![Reims Tram System](image)

**Figure 91: Reims Tram System**

Source: Citura

The trams are made by the French company Alstom and are the Citadis model. The Citadis model trams possess a low floor platform, multiple doors, and wide gangways. In order for the trams to be completed for the Reims tram system, six Alstom plants throughout France were involved. Each plant added a different component to the trams such as electrical parts or motors, but the trams were designed and assembled at the La Rachelle plant.
The city of Reims made many efforts to ensure the tramway system would be both efficient and functional at providing its citizens with a new mode of transportation and that the trams’ designs would fit in with the character of the city. These efforts resulted in a color scheme and a nose design on the lead car that reflected a prominent characteristic of the Champagne-Ardenne Region, champagne. A team was comprised of Alstom company members and members of the Reims Métropole (representing the city of Reims) decided the lead car of all trams will have the design of a champagne flute because of the region’s prominence in the champagne industry (Figure 92). Eighteen trams are one of eight possible color hues, yellow, orange, pink, red, purple, blue, turquoise, and green, of which pink was chosen as the color of the first tram to be showcased in the Reims plaza in March of 2010 before the system opened in 2011.315

System Ridership and Performance

Due to the tram system being in operation for only a short time, the data available on system ridership is very limited. According to notes from a meeting with representatives familiar with the Reims transit system, patronage data is a problem for them due to consistency issues associated with measuring patronage before and after the tram system and difficulties with the electronic “smart card” ticketing system. Even though there are difficulties in obtaining patronage data it was stated that in June of 2011 there were 35,000 boardings per day.316

Tram Schedule and Fare Information
The tram is in operation from 5 AM to midnight seven days a week and operates 364 days per year. Prior to the integrated bus and tram system the buses had a headway of one to six minutes during peak hours and a headway of ten minutes during off peak hours. After the initiation of the tram system in April of 2011, there is a headway of five minutes throughout the entire system.\(^{317}\)

After the trams were introduced, a new form of electronic ticketing was introduced in order to make moving between the buses and trams easier. The new system requires obtaining a ticket that can be reloaded that must be validated by passing it in front of a validating machine located at the front of the buses and trams. According to Currie, the new ticketing system is proving to be problematic because it does not provide accurate passenger counts in some instances because “they concentrated on making it work instead of on how it counted passengers.”\(^{318}\)

**System Costs**

The construction costs of the tram system were estimated at $550 million and the cost to buy the vehicles from the tram provider was estimated to be $4 million each. The current operating costs of the integrated bus and tramway system are estimated to be $60 million, with eight to nine million Euros being the cost of operating the tram system and $48 million being the operating costs of the bus system. Prior to the introduction of the tram system, the 2010 operating costs of the bus system alone was estimated to be $50 million.\(^{319}\)

**Conclusion**

The Reims tramway appears to be working as an efficient transportation mode for the citizens of Reims. However, due to the newness of the system’s operation, there is not a large amount of long-term data available to make statements regarding the patronage or operation and maintenance costs of the tramway system. There are elements of the system that are still being perfected, such as the new electronic integrated bus-tram ticket system. Thus, until the system has been operating for a longer amount of time and has corrected its issues, it will be rather difficult to make assumptions about what future impacts the tram system will have on Reims.
KEY FINDINGS FROM THE FRENCH TRAM CASE STUDIES

Below are key findings that have been identified based on the operations and performance of the three modern French tramway case studies:

- **High Ridership** – Some of the French tram systems have an overall system ridership in excess of fifty percent of total transit ridership. Characteristics that contribute to the systems’ high ridership include high operational speeds, high frequencies, extended service hours, and high connectivity with the city center and surrounding areas, directly serving many destinations with one or two lines.

- **Integration with Transit Network** – French tramway systems are generally well integrated with the overall transit network and function as the core of the transit network. Various systems, such as Reims, restructure their bus networks into frequent, core routes and feeder routes to tramway stations in order to create a complete network centered around the tramway line(s).

- **Urban Design** – Care is taken to ensure that the tramways fit into the existing urban fabric and character of the city and they enhance the urban design of the corridors along which they run.

- **ROW Separation and Priority at Intersections** – French tramways, when possible, are placed in a ROW that is protected from vehicle traffic, rather than being mixed in with vehicle traffic. Tramway ROW is often taken from existing street space without replacement for vehicles. French tramways have priority at all times at all intersections in most cases. These characteristics allow for faster travel times, higher operating speed, and prevent the tramways from being delayed by vehicles.
**KEY FINDINGS**

The section summarizes the key findings from each of the case study types. The U.S. Streetcar findings are presented first, followed by the U.S. Light Rail, and then concluded by the French Tramway.

**MODERN STREETCAR (UNITED STATES)**

The following section presents the key findings that have been derived from the four modern circulator streetcar case studies in the areas of Little Rock, Arkansas, Memphis, Tennessee, Tampa, Florida and Seattle, Washington. There are seven focus areas for this: service area, low efficiency, operating speed, operating costs, vehicle design and capacity, transit system integration and enhanced mode option.

**Limited Coverage**

In terms of the service area, all of the case studies appear to service a very small area of the cities and as a result, a small portion of the total population. In three out of four case studies, the total route length was less than five miles long. Memphis has the longest route length at over ten miles, and this also leads to a higher ridership, which was almost tripled in count compared to the other systems. Having a longer line results in reaching out to more of the population in terms of capturing ridership. This also correlates to the destinations along the streetcar lines. Streetcars that go to areas where there is nighttime activity as well as attraction areas are a plus. This shows that the more access to various destinations a system provides, the better; one main street is not enough.

**Low Ridership**

The experience of the case studies have demonstrated low ridership compared to the French tramways and modern light rail vehicles. While streetcars have exhibited ridership ranging from 600 to 3,000 boardings per day, light rail (roughly 38,000 per day in Houston and Phoenix) and the French tramways have shown considerably higher ridership, up to 51,000 boardings per day.

**Poor Efficiency**

The streetcars have poor efficiency in terms of cost. The average cost of carrying one passenger one mile on a streetcar in all four case studies was $5.21. In comparison, the average cost of carrying one passenger one mile on the bus systems in all four case studies was $0.89.
The newest modern streetcar line (Seattle) had the highest cost at $7.21, while Tampa had the lowest with $3.07. An explanation for Tampa’s lower cost could be the scheduled operating hours for the system. The scheduled hours of operations are less, leading to a lower cost. Longer hours are better for the streetcar system, starting in the morning and going to the late evening.

**Low Operating Speeds**

All four systems have low operating speeds. The average operating speed for the streetcars is 5.6 mph while for buses it was 13.52 mph. Memphis has the highest operating speed for both buses and streetcars at 14.72 mph and 6.48 mph, respectively. In addition to this, it has the most dedicated ROWs of any of the systems reviewed. The lack of mixing with traffic appears to have an impact on operating speed overall.

**Operating Costs**

All expenditures, such as capital costs and operations and maintenance (O&M) cost are directly related to the size of the system in terms of length of the line and number of vehicles. The longer the line and the more vehicles there are, the higher the expenditures for the system. However, as the size of the system increases, the “Cost-to-Ridership” ratio decreases which means it costs less per rider. This shows an increase in efficiency of the system. Memphis is the largest system out of the four case studies and has the largest Capital and O&M Costs with $102 million and $4.01 million, respectively; however, the “Cost-to-Ridership” ratio is the smallest at $3.67 since it is able to capture more ridership with the larger system. A way to keep costs down is by increasing the revenue stream.

**Vehicle Design and Capacity**

Modern streetcar vehicles have several distinct advantages over their heritage counterparts. It has been noted that vehicle design and capacity improves productivity. Seattle, with a modern streetcar design, has the fewest number of vehicles in operation with only three, but has the highest passenger trips per vehicle mile at 7.47. This shows that the larger capacity modern streetcar vehicles are carrying more passengers per mile than their heritage counterparts, which increases the productivity of the whole system. Thus, if a system utilizes heritage-type vehicles, more vehicles will need to be in operation to achieve the same level of productivity. Cost comparisons need to be made based on the length of the line as well as the type of car, in relation to expenditures. The average cost of a heritage-type trolley is $700,000 while the Inekon cars used by Seattle cost $3.06 million. Modern streetcar vehicles are also seen more favorably
by passengers than heritage design vehicles, and offer greater accessibility to patrons with disabilities. In terms of performance, modern streetcars also offer the potential for higher acceleration and higher operating speeds than their heritage counterparts.

**Integration with the Transit Network**

In terms of contributing to transit ridership, streetcars show a very low contribution to the system as a whole. This is in part due to a lack of full integration with the existing transit system in terms of both fare transferability and network design. Total streetcar ridership makes up for its area averages to be less than 2.5 percent of total public transit ridership. The use of the streetcars in the United States mostly reveals a philosophy that does not consider the streetcar as a viable option to meet major transit demands. Streetcars are seen more as a novelty and a tourist attraction to the city, often with no consideration to the transit rider.

**LIGHT RAIL (UNITED STATES)**

The following are the key findings that have been derived from the case studies presented on the light rail systems located in the cities of Phoenix, Houston, and Salt Lake City. The key findings can be arranged into several focus areas, including exclusive ROW, access to universities, integration with the transit system, student fares, park and rides, and connections to large populations in the service area.

**Exclusive Right-of-Way**

A large part of light rail systems’ success is the exclusive ROW the systems use throughout the route. For example, whether in the center of the road or along the outer curbs, all three systems operate in an exclusive trackway, whereby cars are separated from light rail vehicles. The exclusive track allows the system to operate by a set schedule and maximize on-time performance. Any enhanced transit mode should operate without interference from cars, because it is one of the best ways to maximize speed and efficiency through minimizing interference from other vehicle traffic, which allows for faster operating speeds than in-street running.

**Access to Universities**

A second major factor of two of the light rail systems is that the systems travel directly to major universities. In the case of Phoenix, the METRO is accessible to two branches of Arizona State University, while in the case of Salt Lake City the University Line (current Red Line)
travels through the University of Utah. With direct access to two large state universities, the system has been quite successful in attracting college students, a group who otherwise may not have been riding public transit. Access to a major university is by far the greatest advantage StarMetro has in applying an enhanced transit mode to Tallahassee. West of North Macomb Street, a large portion of Tennessee Street runs parallel to Florida State University. An enhanced transit mode on that street or on parallel Call Street, especially if it can operate in an exclusive trackway, could provide efficient service to a destination which is already highly traveled.

**Integration with Transit System**

Along with access to a university, an additional factor involved in light rail success is the light rail’s interconnectivity with the overall transit system. All three light rail routes provide access to many connecting bus routes. More importantly, the majority of fare options allow passengers to make unlimited free transfers between the two travel modes. This creation of an integrated system can be implemented in Tallahassee by making sure that any new enhanced transit mode is compatible with traditional StarMetro buses. For example, if a new streetcar or bus rapid transit system is created along Tennessee Street, the fixed route buses could continue to serve as feeders for the new system.

**Student Fares**

An additional factor that has led to great success for both the METRO light rail and UTA’s University Line has been the conscious effort to promote free or heavily discounted transit passes for university students. Arizona State University students and faculty can purchase discounted transit passes for unlimited service on the light rail and bus, while the University of Utah’s Ed Pass provides a pass good for unlimited service to all eligible students and faculty with payment of a school transportation fee. The use of dedicated university passes can entice the university community to use the enhanced public transit since it greatly lowers transportation costs. StarMetro currently has a student fare program with its bus system. Thus, a similar type of transit pass with FSU should be extended to any new enhanced transit mode traveling to the FSU campus.

**Park and Rides**

To further help feed the enhanced transit mode, all three light rail case study systems use park and rides located along its routes. In the case of the METRO, in addition to the bus system’s park and rides, dedicated light rail park and rides allow passengers to drive to various
stations along the light rail route and park their car for free before using the system. Park and rides could be beneficial in Tallahassee as a way to assist passengers in reaching the enhanced transit mode while also keeping additional cars from entering the downtown area. Passengers would drive to park and rides located throughout the area served by StarMetro and subsequently board a StarMetro vehicle. Assuming system integration is created, both via free transfers and connecting routes, passengers can park at a park and ride and then travel throughout downtown using both StarMetro buses and the new enhanced transit.

**Connections to Large Populations**

All three light rail systems involved in this study are part of large metropolitan areas. The large population sizes and densities of these three regions have all contributed to high ridership levels since there are enough people to support an enhanced transit mode. Furthermore, the transit agencies have adapted to these large, decentralized urban areas by (for the most part) constructing light rail systems that cover a significantly larger service area than their U.S. streetcar counterparts, and (in the case of Salt Lake City and Phoenix) that connect to multiple destinations in both the city center and outside of the Downtown areas.

**TRAMWAYS (FRANCE)**

The following are the key findings that have been derived from the case studies presented on the tramway systems located in the cities of Le Mans, Reims, and Orléans. The key findings can be arranged into several focus areas, including high ridership, integration with transit network, urban design, right of way separation and priority at intersections.

**High Ridership**

A prominent characteristic of the French tramway systems is that they possess very high levels of system ridership. Some of the French tram systems have an overall system ridership in excess of fifty percent of total transit ridership. The characteristics that contribute to the systems’ high ridership are the high operational speeds, high frequencies, extended service hours, and that they possess a high connectivity with the city center and surrounding areas, directly serving many destinations. The French tramway systems overall have a fairly high scheduled speed when compared to their U.S. streetcar counterparts. A high scheduled speed (and higher operational speed while carrying large numbers of passengers and large volumes of boardings and alightings) seems to be an important factor in the success of the French tramways. These allow for systems that are as fast (if not faster) than buses and even competitive with automobile
traffic. French tramways are uniformly very frequent systems, with headways of well under ten minutes in many cases. This creates a system where riders do not have to consult a schedule, and allows for easy travel. French tramways typically operate from early morning (6:00 am or earlier) until late at night (midnight or later), which creates a system that riders can depend on and that is attractive for many different types of trips. The last characteristic that results in these systems possessing such a high ridership is that they are not solely focused on the city center. Rather, they connect large portions of the city and its suburbs to each other, often passing through the city center. They connect to many destinations through the city, both in and outside of the city center, such as universities, hospitals, and rail stations.

**High Integration with the Transit Network**

Another important characteristic of the French tramway system is they are generally well integrated with the overall transit network, and function as the core of the transit network. Various systems, such as Reims, restructure their bus networks into frequent, core routes, feeder routes to tramway stations, and other routes in order to create a complete network centered around the tramway line(s). Multiple bus lines connect with the tramways and various points along their routes, often these bus lines are also very frequent, allowing for easy transfers, and forming a comprehensive, integrated, and frequent transit network. Fare and transfer policies improve the tram systems’ integration with the transit network. The transfers are relatively easy between the bus system and the tram system because the French tramways uniformly have a proof-of-payment system. These policies allow for the overall transportation network to function at its full potential because it increases the integration between the two systems.

**Urban Design**

Another characteristic of the French tramway systems is that care is taken to ensure that the tramways fit into the existing urban fabric and character of the city and that they enhance the urban design of the corridors along which they run. For instance, the tramway in Reims was designed so that it would fit the character of the city by designing the lead cars to have the shape of champagne glasses because the city is prominent within the champagne making industry in France. Additionally, in all three case studies, the tramway alignment was designed to create an enhanced urban environment along the corridor through various enhanced right of way treatments and street reconfigurations that restrict vehicle traffic.
ROW Separation and Priority at Intersections

French tramways, when possible, are placed in a ROW that is protected from vehicle traffic, rather than being mixed in with vehicle traffic. In the case of the case study cities, it was found that the tramways are generally not placed on large, multi-lane streets, but rather in the median of two lane roads (this can involve reducing four lane roads to two lane roads during construction). French tramways have priority at all times at all intersections in most cases. This allows for faster travel times, and prevents the tramways from being delayed by vehicles. These two components allow for faster travel times and a higher operating speed.
SYSTEM CRITERIA ANALYSIS

GOALS AND OBJECTIVES

Defining the criteria necessary for alternative evaluation requires clear goals and objectives for an enhanced transit mode and the specification of indicators appropriate to those goals and objectives. Identifying the goals and objectives of StarMetro’s enhanced transit alternatives along the TSC for this analysis was done by the SPT based on the scope of work, meetings with Studio Director, discussion with StarMetro, and guidance received from the Studio Advisory Committee during the review period. Two broad goals were identified during the process; one primary and one secondary.

- **Primary Goal:** Transit System Improvement and Efficiency
- **Secondary Goal:** Economic Development

The primary goal is based upon the knowledge that any enhanced transit mode alternative for the TSC must be designed to enhance and integrate into the existing transit system in Tallahassee. The objectives needed to achieve these goals were determined based on research, observations, and performance data collected during the case studies presented in this report as well as the Literature Review. The following objectives for any enhanced transit mode were determined to be paramount to achieving the primary goal of StarMetro:

- Ensure enhanced system operates efficiently and cost effectively;
- Improve system reliability and frequency;
- Increase transit mobility;
- Maximize system integration and connectivity with existing bus system;
- Reduce safety risks by incorporating appropriate safety and design features; and
- Ensure adequate service area and ridership.

The secondary goal is based upon perception that transit projects are a catalyst for economic development once constructed. Due to the substantial capital investment required to implement an enhanced transit mode, additional economic development is often used as a resulting benefit of the investment. However, as identified in the Literature Review section and outlined in many of the case studies, the empirical evidence does not substantiate the assumption by many that transit causes economic development. What was identified in this report is that
economic development and growth does occur around transit lines when accompanied with other factors, such as a growing real estate market (Seattle), improved urban design along the corridor (France), and favorable zoning policies. Thus, a transit project can enhance and increase economic development if implemented in the right area in conjunction with other plans, policies, and/or projects. This report identifies the factors needed on the transit side as well as the outside factors identified in many of the case studies which will be part of the Recommendation section of this report. The following objectives for any enhanced transit mode were determined to be paramount to achieving the **secondary goal** of StarMetro:

- Promote economic development in Tallahassee;
- Increase residential and commercial development along the TSC; and
- Increase employment and population densities along the TSC.

**EVALUATIONS CRITERIA AND DEFINITIONS**

The general approach for evaluating enhanced transit projects involves assessing each alternative against a set of goal and objective-based criteria and determining project importance. This report includes such an approach, as well as using observations and performance data collected during the case studies to identify key criteria and assign a weighted level of importance to those criteria. The evaluation criterion presented are based on various performance and operation indicators identified during the research that the proposed enhanced transit alternatives along the TSC should be analyzed against in order for StarMetro’s transit objectives to be achieved. The following are the evaluation criteria identified:

- Passenger miles
- Passenger miles per vehicle mile
- O&M Cost
- Schedule Reliability
- Headway Times/ Frequency
- ¼ mile Employment Served
- ¼ mile Population Served
- Density of Service Area
- Number of Key Destinations Served
- Ownership
- Span of Service
- Operating Speed
- Fare Costs/Payment Method
- Transfer Policy
- Vehicle Design and Capacity
- ROW Design
- Park and Rides
- Boarding Times
- Length of Route
- Transfer Stations/Shared Stops
- Stop Design
- Stop Spacing
After identifying the goals, objectives, and evaluation criteria, an organizational tree, shown in Figure 93, was developed as a visual tool to aid in the analysis. Organizing the criteria and objectives facilitates weighting the criteria and examining the overall results at the level of the objectives.

![Organizational Tree of Goals, Objectives, and Criteria for the TSC Enhanced Transit Evaluation](image)

**Figure 93: Organizational Tree of Goals, Objectives, and Criteria for the TSC Enhanced Transit Evaluation**
The evaluation criteria identified below are based on various performance and operation characteristics identified in the case studies and are generally accepted throughout the transit profession. These proposed enhanced transit alternatives along the TSC should be analyzed against these criteria in order for StarMetro’s transit objectives to be achieved.

**Criteria Descriptions**

The following describes each of the criteria in more detail as well as how it relates to the objectives previously identified.

**Boarding/Alighting Time** - The amount of time that it takes passengers to board and alight from transit vehicles can have a significant impact on schedule speed and reliability. Steps can be taken to decrease boarding times through the use of proof-of-payment fare systems which allow for boarding through all available doors, expediting the process. This is especially important at heavily used stops.

**Density of Service Area (Population)** - This is an important measurement of the ridership potential of an area. The greater the population density, the higher the ridership a transit investment is likely to obtain.

**Percent Employment Served** - This is also an important measurement of the ridership potential of an area. The greater the employment density, the higher the ridership a transit investment is likely to obtain. The more people that can access a mode of transit going to useful areas, the more people may want to use it. This also increases accessibility for people going from home to work, or moving between employment centers. This is important for system integration, accessibility/mobility and having an adequate service area.

**Fare Payment Method** - With traditional fixed route bus systems, the operator is responsible for the collection of fares. Proof-of-payment systems require that riders purchase their fares before boarding the vehicle, and retain proof of fare payment for inspection while riding the vehicle. Proof-of-payment allows for all-door boarding, and removes fare collection responsibility from the operator, which can lead to a faster operation.

**Headway Times/Frequency** - Headway can be defined as the amount of time (e.g. minutes) patrons must wait between transit vehicles) while frequency refers to the number of vehicles in a given time frame, (e.g. buses per hour). This is extremely important to the system’s reliability
and attractiveness to patrons. Generally, the higher the frequency, the higher the ridership and almost all “enhanced” modes of transit demonstrate frequent service (typically defined as every fifteen minutes or better). Frequency is also critical to transfers in a decentralized system, where transfers are untimed.

**Integration** - Promote and install policies and procedures for both modes of transportation leading to a better, more efficient transit system. Both the bus and enhanced modes of transportation are well connected to each other through transfer points along the enhanced mode’s alignment, with schedules designed for maximum transfer connectivity.

**Length of Route** - Distance the alignment covers. A route that is very short will not reach an adequate population or number of destinations in order to achieve increased ridership. Adequate route length can significantly impact transit accessibility and is very important for integration into the overall transit systems in regards to providing connections to other transit modes.

**Number of Key Destinations** - In order for the system to serve as an effective enhanced transit mode, it must carry passengers to key destinations such as the Central Business District and Colleges and/or Universities better than existing transit modes. To gain more ridership, the systems must have routes that service these areas or potential passengers will find other means of transportation that carry them to those destinations. The number of destinations a system serves is directly related to the accessibility provided at each of its stops, with the greater the number of destinations, the greater the accessibility provided at each stop.

**Operation and Maintenance (O&M) Cost** - Refers to the cost of operating and maintaining the system in everyday service. Using this cost measure can aid in evaluating the success of the system, with a more efficient system having a lower O&M cost per passenger.

**Operating Speed** - The speed in which a transit line operates, including dwell time for stops. This is an extremely important measure, as the slower the operating speed, the less attractive the service will be. Conversely, transit options that offer significantly higher operating speeds than other alternatives are likely to be well patronized. A system with low operating speed could also be operating inefficiently, in addition to likely having low ridership.

**Ownership** - An important element of system design is who owns the enhanced transit mode and who owns the bus network. If both are owned by the same agency, they can be well coordinated and very well integrated. If separate agencies control the planning and/or operation of each
system, then the prospect of true network integration becomes much more difficult due to various issues (communication between the parties involved, political considerations, the priorities or mission of each respective agency, etc.) and coordination and transfers can be made much more difficult.

**Park and Rides** - Provides a location for riders to drive their vehicles to a station, park it, and then take transit to their final destination. Park and rides can provide enhanced accessibility to individuals who are not directly served by transit.

**Passenger Mile per Vehicle Mile** - Measure of system productivity in terms of how many people on board a vehicle per mile that vehicle runs. In this case, vehicle miles also include the number of miles a bus travels out of service, not picking up or dropping off passengers. This is a measure of operating efficiency and ridership productivity.

**Right of Way (ROW) Design** - The right of way design of an enhanced transit mode alignment (in mixed traffic, grade separated, priority at intersections, etc.) has an important impact on the safety of the alignment for transit users, other vehicles, and pedestrians. It also affects system efficiency, cost effectiveness, and system reliability by (depending on the design) reducing the potential for delays due to conflict with other vehicles.

**Schedule Reliability** - On time performance and other measures of reliability of an enhanced mode are important for an efficient and cost effective operation. Schedule reliability is very important to potential riders, and consistent on time performance could lead to increased ridership.

**Span of Service** - The hours during the day that service is offered. Span of service is important for riders to be able to depend on the system to be available to them when they need it. It is an important measure of accessibility and system reliability, which in turn can translate into increased ridership.

**Stop Spacing** – The distance that stops or stations are spaced apart from each other is an important consideration for any enhanced transit mode. Stops placed too closely together can lead to slow operating speeds due to increased boarding and alighting. Stops spaced too far apart can lead to a decreased potential service area.

**Transfer Policy** - Requiring an additional fare for transfers between the existing bus network and an enhanced mode can discourage usage, and greatly reduces the effectiveness of the transit system.
network (especially if it is decentralized). Allowing for free transfers between the bus and enhanced transit modes allows for the maximum utilization of the transit system and greatly enhances the integration of the transit network.

**Transfer/Shared Stops** – These are stops designed to facilitate transfers between the bus system and enhanced transit line. They can be either a shared station, or can be bus stops placed within close walking distance of the enhanced transit stop. Effective integration of buses and enhanced transit through the use of well-designed transfer facilities is critical to overall system connectivity and integration.

**Vehicle Design** - Vehicle design can have an important impact on the capacity of the enhanced mode, ease and speed of passenger boarding and alighting, and overall operating speed. Low floor vehicles with multiple doors can facilitate faster boarding and alighting. Additionally, a floor plan with extensive open space allows for increased capacity and passenger circulation.
RECOMMENDATIONS AND CONCLUSION

This study examined what factors and criteria that should be considered and analyzed when defining the TSC enhanced transit alternatives. The SPT’s recommendations presented in this report will ensure that the enhanced transit mode selected will yield substantial benefits to the TSC and be well integrated into StarMetro’s current bus network. The recommendations are based on the key findings and the extensive analysis of the case study cities in the United States and France previously presented.

RECOMMENDATIONS

Recommendations for Transit System Improvement and Efficiency

The following are SPT’s recommendations to StarMetro to ensure that the preferred enhanced transit alternative for the TSC improves Tallahassee’s overall transit system and makes it operate efficiently:

- The preferred route of the alternative should be located so that the population and employment within a quarter-mile buffer of the corridor is maximized to the fullest extent possible. This will have a direct correlation with the amount of ridership the alternative will capture. The larger the population and employment within that buffer, the more ridership the alternative will attract.

- The route length of the alternative should be sufficiently long enough to capture enough population and employment necessary for the system to operate efficiently. Longer routes result in reaching more of the population in terms of capturing ridership. The SPT recommends a route length of at least five miles; thus, the eight-mile segment of TSC that extends from Capital Circle Northwest to Capital Circle Northeast would seemingly be sufficient. However, a more thorough population and employment assessment should be conducted during the siting study.

- The alternative should cover a route that connects to key destinations both inside and outside the city center, and should connect outlying areas of Tallahassee to the city center. The alternative should not be focused solely on the city center of Tallahassee (e.g. a Downtown circulator). Downtown-centric streetcar systems have demonstrated to be low performing and have significantly lower ridership compared to the French or United States light rail case study examples. In contrast, both French tramways, the Phoenix light
rail, and the Utah light rail systems exhibit alignments that connect to multiple destinations in the city center, outside the city center, and in outlying communities or suburbs and are experiencing high ridership and high productivity.

- The preferred alternative should be routed as to maximize the number of key destinations it services with coordinated stops to provide greater accessibility and attraction to potential riders. Key destinations in Tallahassee to consider include, but are not limited to, the Capitol, FSU, FAMU, TCC, museums, the Donald L. Tucker Civic Center, football and baseball stadiums, Gaines Street, and Midtown. The greater number of key destinations an alternative can service usually equates to a greater number of riders it can capture. As stated above, these destinations should not be limited to the center of Tallahassee, but should reflect the decentralized nature of the urban area.

- The preferred alternative should serve the Florida State University campus if at all feasible, and should either directly serve or connect to frequent (every fifteen minutes or better) bus service to the FAMU and TCC campuses. All three French case study alignments directly serve university campuses, and the experience of Salt Lake City and Phoenix provide further evidence that direct service to universities has the potential to greatly enhance ridership along the alignment.

- The preferred alternative’s operating speed end to end should be no less than ten mph. The preferred alternative’s operating speed should be faster than the existing bus service along the corridor in order to be considered an “enhanced” transit mode, and preferably should be competitive with automobile travel times along the corridor. The higher the operating speed, the better the alternative will operate in terms of attracting additional ridership, maximizing trips, and increasing system capacity, reliability, shorter headway times, and overall productivity. The French tramway case study systems demonstrate much greater operating speeds than modern America streetcars, and light rail systems are even faster. Low speed modern streetcar systems in the United States have shown to be ineffectual at increasing transit ridership.

- The stops of the preferred alternative should be placed at an average of approximately one-third to one-half mile apart. Based on case study analyses, this appears to be an ideal distance – any shorter, and operating speeds are negatively impacted. Any longer, and the alternative does not capture as much of the potential ridership in the area. This
average distance has been successful for all three French tramway systems. Like the French tramway and United States light rail systems, the exact stop spacing will depend on the context of the situation, with less distance between stops in the city center and more populated areas and greater distance between stops in less densely populated areas.

- Headway times of the alternative should be ten minutes or less. Shorter headway times signify a more frequent transit service and availability. Headways are directly proportional to changes in ridership. A reduction in transit headway times correlates to an increase in ridership. The case of the French tramway systems is illustrative, in that headway times significantly better than this standard (five to seven minutes) have led to very high ridership levels.

- The preferred alternative’s span of service should ideally be early morning until late at night in order to accommodate many different riders, travel patterns, and types of trips. French tramways typically operate from at least 6:00 am until after midnight in order to create a mode that patrons can rely upon to travel to and from their destinations when needed, even early in the morning or late at night. Frequencies during very early and very late service segments may be reduced based on demand and operating efficiency.

- The preferred route of the alternative should be located within an exclusive ROW in road or campus setting. First, this design feature has been shown to increase safety by reducing the likelihood of collisions with other motor vehicles, and second by clearly identifying the transit route to potential riders, which increases awareness. In addition, the taking of dedicated ROW allows for greater enhancement of the urban design of the corridor during construction, which can impact perception and economic development. Lastly, a dedicated right of way reduces potential delays and increases operating speeds by alleviating traffic conflicts with automobiles. The slow operating speeds of the United States streetcar case studies (five to six mph) compared to the significantly higher scheduled speeds of the French tramways (twelve to fourteen mph) can be in part attributed to operating in mixed traffic versus operating in a dedicated right of way.

- The preferred route of the alternative should have priority over other vehicular traffic at all intersections. This feature, as shown by the French tramway systems and light rail systems, expedites travel time and operating speeds leading to increased operating efficiency, decreased travel time and potentially increased ridership.
The fare payment method of the enhanced transit alternative should be a proof-of-payment system to facilitate faster and easier usability of the alternative. This payment method reduces delay times at stops and transfer stations by not requiring each passenger to pass through the driver for payment. Additionally, this method allows the full benefits of a multiple door vehicle to be obtained by allowing faster boarding/exit alighting times with greater capacity. Lastly, this payment method supports greater system integration between modes.

Fares should be transferable between the existing StarMetro bus system and the alternative mode. This is a key component of total system integration, and it is easily achieved since StarMetro will own and operate both systems. Fare transferability promotes and invites riders to utilize both systems.

To further achieve system integration with the current transit system, the preferred alternative should be designed to have station/stops adjacent to other transit modes’ station/stops to facilitate transfers between modes. In addition shared stops should be utilized or constructed. These measures will increase accessibility and ease of use as well as reduce redundancy. Both the French and United States light rail case studies have multiple examples of facilities designed to facilitate near seamless transfers between the bus network and rail system.

To further achieve system integration, the schedules of buses that are connecting to the preferred alternative should be coordinated with the preferred alternative’s schedule. High ridership or other key bus routes that connect to the preferred alternative should have frequent service (every fifteen minutes or better) if possible in order to facilitate transfers and minimize passenger wait times in a decentralized system. French tramway systems, such as Reims, utilize frequent bus routes that connect with the tramway to create an integrated frequent transit network that allows for maximum ease of travel and minimum travel times for passengers and enables travel throughout the urban area.

The alternative should be designed in a manner that makes provisions for future expansion, and allows for expansions of enhanced transit to be seamlessly integrated into the already constructed enhanced mode from both an operational and rider perspective. For example, a system may by planned to run initially from west of FSU to Downtown Tallahassee, with provisions made for further expansions east and west along the corridor.
that will allow for the alternative to operate as a single east-west line within an integrated transit network.

**Recommendations Contingent on Type of Mode**

- If a streetcar alternative is the preferred mode, the modern streetcar vehicles should be utilized instead of the smaller vintage vehicles. The modern vehicles have a larger capacity which means they can carry more people with fewer vehicles increasing the productivity of the whole system. Their bi-directional, multiple door, and low floor design improves boarding times, increases operating speed, increases accessibility, and eliminates some infrastructure requirements. Fewer vehicles required to achieve the same capacity equates to lower O&M costs. However, the modern vehicles require additional capital investment over the vintage type, so a more thorough cost-benefit analysis needs to be done. Another factor contributing to this recommendation is based on public perception of the two streetcar vehicles which can affect ridership. Based on our research, there seems to be a more favorable perception of the modern vehicle. Vintage vehicles are perceived as a novelty and a tourist attraction to the city; thus, they tend not to attract a large proportion of the local ridership.

**Recommendations for Economic Development**

The following are SPT’s recommendations to StarMetro to facilitate additional economic development along the TSC:

- If funding is available, the urban design of the corridor should be enhanced through the implementation of French-style ROW treatments, such as grass or pavers. French tramway systems have shown to be greatly enhanced aesthetically through these design treatments, which in turn are attributed to enhancing the overall urban design of the corridor into a more pedestrian and transit oriented environment.

- The preferred alternative route should be situated so that transit stops are located adjacent to pre-existing or planned development projects.

- The preferred alternative route should be located in areas with adequate zoning and land use to support increased densities and mixed-use development. Consideration should also be made to rezone areas along the corridor to increase density levels and stimulate additional mixed-use development.
Land use planning and regulations should be carefully coordinated to concentrate development along the corridor to ensure that development is designed to complement the preferred alternative and enhance the urban design of the corridor.

**RECOMMENDATIONS IN BULLETED LIST FORM WITH PERFORMANCE MEASURES**

The above recommendations have been consolidated into a list of key recommendations and where applicable, specific performance measures have been tied to each specific recommendation.

- Route Length: The end to end route length of the alignment should be at least five miles long.
- The enhanced mode should serve **both the city center and outside the city center**. It should not solely be focused on downtown Tallahassee.
- The enhanced mode should **maximize connections to key destinations**.
- The enhanced mode should **serve the FSU campus**.
- Operating Speed: End to end scheduled operating speed should be **greater than an average of 10 MPH** or than existing fixed route bus service (whichever is faster).
- Stop spacing: The average stop spacing from end to end along the alignment should be **1/3 to 1/2 mile apart**.
- Headways: AM peak, mid-day, PM peak and evening headways should be **every 15 minutes of better**.
- Span of Service: early morning to late evening/night, **14-16 hours a day during weekdays**.
- ROW: The enhanced mode should have a **dedicated ROW** wherever possible.
- Priority: The enhanced mode should have **priority over all other traffic at intersections**.
- Proof of payment: The enhanced mode should use a **proof of payment fare system**.
- Transferability: **Fares should be transferable** between the enhanced mode and regular fixed route buses.
System interconnectivity: The overall transit network should be designed to create ample connections between fixed route buses (particularly north-south crosstown routes) and the enhanced mode.

Bus-enhanced mode transfer: **bus stops and enhanced mode stations should be located in close proximity to each other** to facilitate seamless transfers between modes.

**CONCLUSION**

It is anticipated that the information and evaluation criteria presented in this report will increase the understanding of the operations and performance of the enhanced transit alternatives being considered for the TSC. Additionally, it will serve to aid StarMetro in identifying and selecting the alternative that maximizes its goals and objectives as well as improves overall transit system performance. The recommendations presented are based on the key findings and the extensive analysis of the case study cities in the United States and France. There are many positive aspects of these systems identified in the case studies and key findings. Based on the analysis, these aspects have successfully increased transit ridership and enhanced the overall transit system, particularly in the case of the French tramways and United States light rail examples. The SPT is confident that these elements could potentially be applied to the TSC in Tallahassee and other cities across the United States with success. Additionally, weaknesses in the current approach towards modern streetcar transit that have hindered its potential have been identified in the key findings. The recommendations presented above are designed to provide parameters that incorporate into a potential TSC preferred alternative the best aspects of the examined enhanced transit modes that have contributed to their success. The recommendation’s parameters are also framed in a way so as to avoid the weaknesses of less successful systems. For any transit mode to be considered “enhanced”, it must outperform the existing modes available while also enhancing and adding value to the overall transit system. The SPT strongly believes that the above recommendations will lead to the development of a preferred alternative that is indeed better than the status quo and that in the future, if successfully implemented, will serve as the core of the StarMetro transit network.
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ENDNOTES

1 NTD Database.
2 Ibid.
4 Florida Transit Information System.
6 Shawhyde, "Davis Streetcar Feasibility Report," University of California-Davis, 16.
7 Ibid.
8 Ibid.
10 Ibid.
11 Ibid, 11.
12 Ibid, 16.
15 Ibid.
16 Ibid.
17 Ibid.
18 Ibid.
20 Ibid.
22 Ibid, 10.
23 Ibid, 9.
26 “Downtown Largo Multimodal Plan: City of Largo Multimodal Transportation System Plan,”10.
31 Ibid, 34.
33 Ibid, 44.
34 Ibid, 43.
37 Ibid, 258.
42 TCRP Synthesis 86, 11.
43 Gloria Ohland and Shelley Poticha, *Street Smart*, 36.
46 Ibid.
48 Ibid, E-4.
49 Ibid, 5-2.
50 Ibid, E-3, 5-3.
51 Ibid, E-3, 5-4.
52 Ibid, 5-3.
53 Ibid.
54 Ibid, E-6.
55 Ibid, E-6, 5-6.
56 Ibid, E-6, 5-4.
57 Ibid, 5-5.
58 Ibid, 5-5.
59 Ibid, 5-5.
60 Ibid, E-7.
61 Ibid.
63 Ibid.
64 Ibid.
68 “2010 American Community Survey.”
69 “Memphis: Transportation.”
72 National Transit Database, 2009.
A Vision for an Enhanced Transit Application in Tallahassee

71 Ibid.
72 American Public Transportation Association, “Planning for Introduction of Modern Light Rail.”
73 Ibid.
74 Ibid.
75 Ibid.
76 Ibid.
77 Ibid.
78 Ibid.
80 Ibid.
81 Ibid.
82 National Transit Database, 2009.
83 American Public Transportation Association, “Planning for Introduction of Modern Light Rail.”
84 Ibid.
85 Ibid.
86 “Relationships Between Streetcars and the Built Environment,” accessed October 11, 2011,
87 American Public Transportation Association, “Planning for Introduction of Modern Light Rail;”
88 “Relationships Between Streetcars and the Built Environment.”
89 National Transit Database, 2009.
90 Ibid.
91 Ibid.
92 Ibid.
93 American Public Transportation Association, “Planning for Introduction of Modern Light Rail.”
94 Ibid.
95 Ibid.
96 “Relationships Between Streetcars and the Built Environment.”
97 Ibid.
98 Ibid.
100 City of Little Rock. Economic Development. Online: http://www.littlerock.org/citymanager/divisions/economicdevelopment/
101 CAT. River Rail System. Online: http://www.cat.org/rrail/
102 Ibid.
103 Ibid.
104 Virginia Fry, River Rail Manager
105 Hillsborough County. Online: http://hillsboroughcounty.org/about/.
106 Census. Hillsborough County. Online: http://quickfacts.census.gov/qfd/states/12/12057.html/
107 Ibid.
109 TECO Online. Who We Are. Online: http://www.tecolinestreetcar.org/board/who/index.htm
110 Ibid.
111 Ibid.
113 TECO Online. Whitting Street Exenstion Project. Online: http://www.tecolinestreetcar.org/extension/index.htm
114 CNN Money, “Fortue 500 States,” accessed September 2011,
117 “2010 American Community Survey.”
120 National Transit Database, 2009.
121 Ibid.
123 Ibid.
125 National Transit Database, 2009.
126 Seattle Streetcar Fact Sheet.”
127 Ibid.
128 Ibid.
129 The Seattle Times, 2011. “Employers near South Lake Union streetcar offer to fund increased service.” Originally published May 18, 2011
130 National Transit Database, 2009.
132 “Street Smart: Streetcars and Cities in the Twenty First Century.”
133 Ibid.
134 Ibid.
136 “2010 American Community Survey.”
137 “2010 Census”
138 “2010 American Community Survey.”
139 “Florida Transit Information System.”
140 “National Transit Database.”
141 Ibid.
143 “Center For Transit Oriented Development.”
144 Ibid.
146 “National Transit Database”
147 Ibid.
Endnotes

A Vision for an Enhanced Transit Application in Tallahassee

151 GoMetroRail, “University Line.”
152 GoMetroRail.
153 County 2011
154 Bureau 2009
155 Bureau 2009
156 Valley Metro Rail, Inc 2009, 30
157 “Center For Transit Oriented Development.”
158 METRO Light Rail 2011
159 Florida Department of Transportation 2011
160 National Transit Database 2009
161 National Transit Database 2010
162 METRO 2011, 9
163 Valley Metro 2011
164 National Transportation Library 1998
165 Valley Metro 2011
166 Valley Metro 2011, 5
167 Valley Metro 2011
168 Valley Metro 2011
169 METRO n.d.
170 Hillary Foose, Public Information Officer METRO Light Rail, e-mail message to author, October 26, 2011
171 METRO 2011, 9
172 METRO 2008
173 METRO 2011, 8
174 KINKISHARYO International, LLC 2009, 2
175 METRO 2011
176 METRO 2008
177 Office of Institutional Analysis 2010
178 Google Earth 2011
179 Sun Devil Athletics 2011
180 METRO Light Rail 2011
181 ETC Institute 2011, 53
182 ETC Institute 2011, 54
183 ETC Institute 2011, 49
184 METRO Light Rail 2011, 2
185 Ibid.
186 Valley Metro 2011, 4
187 Arizona State University 2011
188 Ibid.
189 METRO Light Rail FY09-10
190 National Transit Database.
191 Ibid.
192 National Transit Database 2010
193 METRO n.d.
194 National Transit Database 2010
195 Federal Transit Administration 1999
196 METRO Light Rail 2011
197 METRO Light Rail 2011, 3
198 METRO Light Rail 2011
199 METRO Light Rail 2011
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Endnotes

200 METRO Light Rail 2011
201 ETC Institute 2011, 57
202 METRO Light Rail 2011, 3
203 METRO Light Rail 2011, 3
204 CityScape 2011
205 Student Housing 2011
206 METRO Light Rail 2011
208 “2010 American Community Survey.”
209 “2010 Census.”
210 “Florida Transit Information System.”
211 “National Transit Database.”
212 Ibid.
213 Utah Transit Authority, “Medical Center LRT Project, Before and After Study,” December 2006, 2.
214 Ibid, 4.
215 Siemens, 2011.
216 Ibid.
218 Utah Transit Authority, “University of Utah Students, Staff & Faculty Summary Report,” January 2006, 3-4.
220 “Before and After Study,” 3-5.
221 “National Transit Database.”
223 “Before and After Study,” 4-51
224 Ibid.
225 Ibid.
226 Ibid.
227 Ibid.
231 Gouin, “Urban Planning and LRT Systems in France”.
232 Gouin, “Urban Planning and LRT Systems in France”.
233 Parkinson, “French Tramways”.
234 Parkinson, “French Tramways”.
235 Parkinson, “French Tramways”.
236 Gouin, “Urban Planning and LRT Systems in France”.
237 Münchner Verkehrsgesellschaft, “The Modern Tram in Europe”.
238 “Annual Mobility Report”, Mulhouse Agglomeration
241 “Chiffres-cles”.
242 “Chiffres-cles”.
243 “Chiffres-cles”.

151
247 “Vos lignes”.
250 “P+R”.
251 “Vos lignes”.
252 “Vos lignes”.
253 “Vos lignes”.
254 “Vos lignes”.
255 “Vos lignes”.
256 Christian Buisson, e-mail message to authors, November 16, 2011.
257 Christian Buisson, e-mail message to authors, November 16, 2011.
258 Christian Buisson, e-mail message to authors, November 16, 2011.
259 Christian Buisson, e-mail message to authors, November 16, 2011.
260 Christian Buisson, e-mail message to authors, November 16, 2011.
261 Christian Buisson, e-mail message to authors, November 16, 2011.
264 “Vos lignes”.
266 “Vos lignes”.
269 “CLEO sur les rails”.
271 “CLEO en chiffres”.
273 “Le Mans Chiffres Clés Emploi- Population Active”.
279 “Vélo”.
283 “Les P+R”.
284 “Les P+R”.
285 Harrison, “Planning, construction, and financing of a tramway project in France, example of the town of Le Mans”.
286 Source: Le Mans tramway memorandum
287 Calculated by authors
288 Harrison, “Planning, construction, and financing of a tramway project in France, example of the town of Le Mans”.
289 Harrison, “Planning, construction, and financing of a tramway project in France, example of the town of Le Mans”.
290 Harrison, “Planning, construction, and financing of a tramway project in France, example of the town of Le Mans”.
291 Harrison, “Planning, construction, and financing of a tramway project in France, example of the town of Le Mans”.
292 Harrison, “Planning, construction, and financing of a tramway project in France, example of the town of Le Mans”.
294 “Le réseau SETRAM”.
295 “Le réseau SETRAM”.
296 SETRAM Service Clients, e-mail message to authors, November 21, 2011.
297 SETRAM Service Clients, e-mail message to authors, November 21, 2011.
298 SETRAM Service Clients, e-mail message to authors, November 21, 2011.
299 Christian Buisson, e-mail message to authors, November 16, 2011.
300 Christian Buisson, e-mail message to authors, November 21, 2011.
301 Harrison, “Planning, construction, and financing of a tramway project in France, example of the town of Le Mans”.
302 Christian Buisson, e-mail message to authors, November 16, 2011.
303 Harrison, “Planning, construction, and financing of a tramway project in France, example of the town of Le Mans”.
304 Harrison, “Planning, construction, and financing of a tramway project in France, example of the town of Le Mans”.
309 SETRAM Service Clients, e-mail message to authors, November 21, 2011.
313 Citura Powerpoint Presentation made by Citura provided by Tom Larwin
316 Graham Currie, email message to Greg Thompson, October 16, 2011.
317 Graham Currie, email message to Greg Thompson, October 16, 2011.
318 Graham Currie, email message to Greg Thompson, October 16, 2011.
319 Graham Currie, email message to Greg Thompson, October 16, 2011.