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Metro Orange Line BRT Project Evaluation

OCTOBER 2011

FTA Report No. 0004
Federal Transit Administration

PREPARED BY

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National Bus Rapid Transit Institute
Center for Urban Transportation Research
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COVER PHOTO

Los Angeles County Metropolitan Transportation Authority

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SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC

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13. ABSTRACT In partnership with the Los Angeles County Metropolitan Transportation Authority (Metro) and the Federal Transit Administration (FTA), the National Bus Rapid Transit Institute (NBRTI) conducted an evaluation of the Metro Orange Line BRT service, which debuted in October 2005 as one of the first full-service BRT lines in the U.S. and the first exclusive busway in Los Angeles. The 14.5-mile Orange Line runs east-west through the San Fernando Valley, connecting the Warner Center mall and office complex in Woodland Hills to the Red Line subway in North Hollywood. The Orange Line runs almost entirely along an at-grade, dedicated busway within an abandoned rail right-of-way. The line's 14 stations are similar in design to light rail stations, with canopied platforms, real-time information, covered seating, lighting, bicycle parking, automated fare collection machines, and public art. The project also includes extensive native landscaping along the corridor and a bicycle and pedestrian path parallel to the busway. The Orange Line operates on a headway-based schedule and uses a pre-paid, proof-of-payment fare system. The final evaluation report contains a comprehensive overview of the Orange Line, including a historical narrative; a profile of project elements, project costs, issues in planning, design, and implementation; technology applications; and a "lessons learned" summary. The report also provides an evaluation of project performance by analyzing data on capacity, travel time, reliability, and safety and security. For the examination of travel-time performance, run-time data were collected and analyzed, providing insight into the directional and temporal components of running time, and producing a useful "before" dataset for future study of the project. The performance evaluation also includes an analysis of data from NBRTI's on-board survey of user perceptions and satisfaction and an assessment of the project's image and brand identity. The report concludes with an overall appraisal of the Orange Line's benefits, including assessments of ridership, financial feasibility, transit supportive land development, environmental quality, and overall performance of the Orange Line in meeting project goals.				
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EXECUTIVE SUMMARY

Project Context

Extending the regional rail system to the under-served San Fernando Valley in California was proposed in 1980 as a solution to rapidly increasing travel demand and congestion. However, legislative restrictions on rail funding soon halted the pursuit of either heavy or light rail in the Valley. In response, the Los Angeles County Metropolitan Transportation Authority (Metro) proposed the bus rapid transit (BRT) concept as a solution that would provide a premium, high-capacity rapid transit service in the Valley, at a lower cost than a light rail or subway line. The BRT project would operate along an exclusive busway and was designed to emulate a light rail line in urban design, decreased end-to-end travel time, and the ability to bypass congestion delays. The Metro Board of Directors officially adopted BRT as the Locally Preferred Alternative for the San Fernando Valley East-West Transit Corridor in 2001. In October 2005, after more than 20 years of planning for rapid transit in the San Fernando Valley, the Metro Orange Line debuted as one of the first full-service BRT lines in the U.S. and the first exclusive busway in Los Angeles.

Project Description

The 14.5-mile Metro Orange Line runs east-west through the San Fernando Valley, connecting the Warner Center mall and office complex in Woodland Hills to the Red Line subway in North Hollywood. The Orange Line runs almost entirely along a two-lane, dedicated busway within an abandoned rail right-of-way (ROW), traveling on-street for only half a mile between the last station and the route's western terminus at Warner Center. The busway is not grade-separated and passes through 38 signalized intersections, including 31 street crossings, 4 pedestrian crossings, and 3 limited-access road easements. The line's 14 stations, 6 of which have park-and-ride lots, are similar in design to light rail stations, with canopied platforms, a Transit Passenger Information System (TPIS), covered seating, lighting, bicycle parking, and automated fare collection machines. The facility also includes extensive native and drought-tolerant landscaping along the corridor and at stations and a bicycle and pedestrian path flanking the busway. The Orange Line operates on a pre-paid, proof-of-payment fare system. Passengers purchase one-way tickets for $1.50 or day passes for $6.00 at automated ticket vending machines.

The Orange Line operates on a headway-based schedule 7 days a week, 22 hours a day. Weekday headways are 4 to 5 minutes during peak travel times and 10 to 20 minutes during the early morning, late night, and on weekends. During weekly revenue service, 28 Orange Line vehicles operate along the corridor.

The Orange Line employs several forms of Intelligent Transportation Systems (ITS) to enhance the project's operations and image. These include the use of transit signal priority (TSP) along the route and global positioning systems (GPS) onboard the vehicles for automated vehicle location (AVL). GPS and AVL technologies enable TPIS at stations, which communicate real-time information to customers by way of visual message signs and a public address system.

A future extension of the Metro Orange Line, planned to open in 2012, will expand service four miles northward, from the western end of the busway at the Canoga Station Park-and-Ride lot to the Chatsworth Metrolink commuter rail station.

Project Costs

The capital cost of the Orange Line is $304.6 million in 2004 dollars, or $21.0 million per mile. Metro used state and local funds for the majority of project costs, while the recreational path was paid for primarily with federal funds.

Project Performance

Introduction of the Orange Line service has resulted in reduced travel times and improved levels of service reliability. Data collected by Metro and NBRTI show that the Orange Line has reduced average end-to-end travel time during peak hours in the corridor by approximately 7 minutes, equating to a 22 percent improvement over original travel times. TSP and a dedicated running way are contributing factors to the decrease in travel time. More than 70 percent of users perceived the Orange Line as faster than the previous service, with 43 percent of survey responses indicating that the service was at least 15 minutes faster.

However, travel time improvements within the corridor still fall short of Metro's original projected range of 28.8 to 40 minutes. Two primary factors explain this. First, as a safety measure after several accidents that occurred shortly after the Orange Line began service, Metro enacted a 10 mph slow order for buses traveling through intersections. This appears to have reduced some of the travel time benefit that normally would be expected from a segregated ROW such as the Orange Line. Second, although the cumulative time savings achieved by TSP over the entire Orange Line route are significant, an immediate green signal at every intersection cannot be guaranteed, due to the Orange Line's short headways and the signal spacing along the corridor. Thus, vehicles are inevitably delayed at red lights at certain points along the corridor, a fact that was not considered in early travel time projections.

Although the travel time savings of the Orange Line have not been as dramatic as originally predicted, the dedicated busway has resulted in highly reliable service, with virtually no difference between peak and non-peak running times. Customers are happy with reliability; most survey responses (82%) rated service reliability on the Orange Line as either "good" or "very good." The Orange Line also consistently meets its schedule, with an average end-to-end deviation of only 32 seconds from the time allotted by the schedule. The Orange Line performs well in terms of headway adherence (vehicle spacing), which is more important than schedule adherence for high-frequency transit service. An examination of APC data provided by Metro found that for weekday peak periods, vehicle bunching occurred on about 10 percent of trips, at most.

Metro has branded the Orange Line as part of the region's Metro Rail network by giving the line a color-coded name designation, including the route on the Metro Rail System Map, and using sleek, silver-gray vehicles that mimic the color schemes of Metro Rail vehicles. In addition, all stations have the same basic design and construction, ensuring a consistent, recognizable brand identity along the line. The majority of survey responses provided high ratings for all three elements related to service branding, with the majority of responses providing a "good" or "very good" rating for "Location of signage" (83%), "Ease of identifying service" (89%), and "The look/design of the vehicles" (89%). In general, overall satisfaction with the Orange Line received higher ratings than overall satisfaction with Metro, although the mean scores were very close, with values of 4.5 and 4.2, respectively.

During initial months of operation, the Orange Line experienced a series of collisions and near-miss incidents, primarily due to motorists running red lights at busway intersections. As of April 2010, the Orange Line has been involved in a total of 58 accidents at busway intersections since beginning operation. Only one of these reported accidents was due to negligence on behalf of an Orange Line operator; all other accidents were the fault of the other party involved. In response to these initial collisions, Metro reduced running speeds from 25 mph to 10 mph at all intersections. In addition, enhanced signage and warning signals were added, and photo-enforcement cameras were installed at many of the Orange Line's intersections to deter red-light running.

These additional safety measures appear to have had a positive impact on the overall safety of the busway by substantially lowering the occurrence of accidents and near-miss incidents. Over the course of the Orange Line's inaugural year, the number of near misses declined steadily, from 709 during the first month of service to only 72 by October 2006. Since June 2006, the Orange Line has maintained a lower accident rate than the Metro system as a whole. In terms of user perceptions, personal safety on Orange Line vehicles rated slightly higher than personal safety at stops, but both categories received high ratings, with 83 and 79 percent of responses rating personal safety on the vehicles and at stops as "good" or "very good," respectively.

In terms of capacity, Metro's current load standard policy and operating procedures stipulate a one-way peak-hour capacity on the Orange Line of 952 passengers. Because capacity is largely determined by maximum passenger loads, a sample of APC data from March 2009 was used to calculate the 95th percentile of peak-hour passenger loads on the Orange Line. As expected, passenger loads steadily increase during both AM and PM peaks in the eastbound direction as the Orange Line approaches its connection with the Red Line. However, the 68-passenger load standard is exceeded significantly only during the AM peak, creating a potential bottleneck at Van Nuys, Woodman, Valley College, and Laurel Canyon stations. The highest value observed during the AM peak was 84 at Woodman Station (124% of seated and standing capacity) and during the PM peak was 73 at North Hollywood Station (107% of seated and standing capacity).

Therefore, although the maximum operated carrying capacity per hour on the Orange Line is sufficient along most of the Orange Line, it is not adequate at maximum load points. However, with the exception of the highest observed loads during the eastbound AM peak, the demand-to-capacity ratio is very close to 1.0, even at the current load standard. Furthermore, Metro may increase the load standard on the Orange Line to 74 passengers in the near future. If this occurs, the demand-to-capacity ratio would slightly exceed 1.0 only in the eastbound AM peak at Van Nuys, Woodman, Valley College, and Laurel Canyon stations as the Orange Line nears its connection to the Red Line.

Approximately 63 percent of riders on the Orange Line rated the availability of seating on the vehicle as "good" or "very good. Only 4.3 percent of comments received through the onboard survey were related specifically to capacity, mentioning overcrowding onboard the vehicles and/or the need for more vehicles.

Project Benefits

Since the Orange Line began operating in October 2005, its ridership performance has dramatically exceeded forecasts. By May 2006, the line had attracted nearly 22,000 average weekday boardings, achieving in just seven months a ridership level not projected to occur until the year 2020. Ridership figures remained on a steady increase, reaching an all-time high of almost 28,000 average weekday boardings in September 2008. Despite slight decreases compared to 2008, ridership figures for 2009 and 2010 remained commensurate with the projections for 2020. Prior to the implementation of the Orange Line, the corridor averaged 41,580 weekday transit boardings. As of 2007, average weekday boarding reached 62,597, representing a 51 percent increase. However, it appears that the Orange Line's most impressive ridership growth occurred during the time period from its implementation in October 2005 through mid-2007 and may have since leveled off.

According to the 2009 NBRTI onboard survey, 32 percent of surveyed trips were made previously by using a non-transit mode. Of those, 25 percent were made by riders who previously drove, either alone (16%) or in a carpool (9%). Although more than one-third (36%) of responses indicated using some form of transit to make the trip prior to using the Orange Line, trips that previously were not made and those that previously were made by driving account for more than half (53%) of all responses when combined. This suggests that the Orange Line is not only attracting choice riders but is also helping to achieve one of the original project goals of improved overall mobility in the San Fernando Valley.

In terms of capital cost-effectiveness, the dollar investment per unit of service output on the Orange Line compared to the Ventura Metro Rapid was more than 100 times more per mile of running way and more than 25 times more per average weekday boarding, clearly reflecting the higher infrastructure investment in the full-service BRT elements of the Orange Line. In comparison to the Gold Line, however, the Orange Line cost 66 percent less per mile of running way, 71 percent less per annual hour of revenue service, 59 percent less per annual mile of revenue service, and 64 percent less per average weekday boarding. These figures are especially favorable for the Orange Line, considering that the two modes have very similar ridership. In terms of operating cost efficiency, the Orange Line also compares quite favorably to the Gold Line, costing 58 percent less per annual hour of revenue service, 41 percent less per annual mile of revenue service, 59 percent less per boarding, and 50 percent less per passenger mile.

The Orange Line also may be generating interest in land development. Some development along the Orange Line corridor has occurred recently, although it has not been determined if the development has occurred because of the implementation of the Orange Line. Metro has noted additional interest in property located along the route, although formal development plans have not yet been established.

In terms of environmental quality, the engine used for the Orange Line vehicles is powered by clean-burning compressed natural gas (CNG), which produces very low particulate matter and nitrous oxide emissions. Since May 2006, ridership has been commensurate with projections for the year 2020, and survey results have shown a growing trend of attracting "choice" riders; thus, the Orange Line potentially is lowering regional VMT and fuel consumption. Also, the first study of the Orange Line's impact on freeway volume found that U.S. 101, which runs adjacent to much of the Orange Line, is operating more efficiently since the opening of the Orange Line, potentially resulting in less smog and significant savings in fuel consumption. In addition, Metro's soil remediation efforts and ambitious landscape beautification project transformed a contaminated brownfield into a linear greenway. A bicycle and pedestrian path runs parallel to the busway, providing a community asset for surrounding neighborhoods.

SECTION

1

Project Context

Background

The Los Angeles County Metropolitan Transportation Authority (Metro) is the largest public transportation operating agency in Los Angeles County and also acts as the transportation planning agency for the region. Metro operates the third largest public transportation system in the U.S. by ridership, with 1.5 million average weekday boardings and an annual ridership of 478 million in FY09. The agency provides local fixed-route bus, subway, light rail, and bus rapid transit (BRT) service, as well as Metro Commute Services (vanpool, carpool ride-matching, and employer programs) within its 1,433-square-mile service area. Metro also supplies the majority of funding for a local 24-hour paratransit service for persons with disabilities, as well as partial funding for a wide array of transportation projects throughout the Los Angeles greater metropolitan area, including 16 municipal bus services, the Metrolink regional commuter rail system, bicycle and pedestrian facilities, freight transport, and improvements to local road and highway infrastructure.

Metro's Orange Line is the culmination of more than 20 years of planning for rapid transit in the San Fernando Valley, an effort that began in 1980 with Proposition A, a voter-approved half-cent sales tax dedicated to funding a regional rail system. In response to trends toward increasing travel demand, congestion, and transit dependency both in the Valley and the region, the San Fernando Valley East-West Transit Corridor was designated as one of six high-priority transit corridors in Los Angeles County. Following are some of the primary goals and objectives that were identified for a proposed transit improvement project within the corridor:

- Improve east-west mobility in the San Fernando Valley.
- Minimize total travel times.
- Provide an alternative to auto traffic passing through the Valley.
- Provide congestion relief on area streets and the 101 Freeway.
- Enable Valley residents to access the rapid transit system by providing a connection to the Metro Red Line's North Hollywood station.
- Support land use and development goals.
- Enhance and be compatible with the physical environment, where possible (1, 2, and 3].

The Southern Pacific Burbank Branch, an abandoned rail line paralleling the congested US 101 Freeway, was recommended as the preferred alignment for the corridor. In the years that followed, transit planners began developing concepts for a light rail line along this ROW, which Metro purchased in 1991. However, the passing of legislative restrictions on rail funding halted the pursuit of either heavy or light rail in the Valley. After a 1997 scanning tour of a renowned BRT system in

Curitiba, Brazil, Metro undertook a major investment study (MIS) to re-evaluate feasible alternatives for the corridor. In February 2000, the busway concept was proposed as a solution that would provide a premium, high-capacity rapid transit service in the under-served San Fernando Valley at a lower cost than a light rail or subway line. In July 2001, the Metro Board of Directors officially adopted BRT as the Locally Preferred Alternative for the San Fernando Valley East-West Transit Corridor.

The route was designed to emulate many of the features that have made BRT efficient and successful in Curitiba and elsewhere around the world. Exclusive bus lanes would remove buses from street traffic, eliminating queuing and congestion delays, while limited stops and transit signal priority (TSP) would decrease end-to-end travel time. The BRT alternative also was designed to be more than just an improvement over conventional on-street bus service. Similar to a rail alignment in terms of urban design, the corridor was conceptualized as "a multi-modal transportation facility within a greenway." Its key components include:

- Simple route configuration.
- Exclusive busway to eliminate queuing and congestion delays.
- Limited stops placed approximately every mile.
- Enhanced station infrastructure and amenities at stops.
- Transit priority implemented at all intersections.
- Headway-based scheduling, with high frequency during peak travel periods.
- High-capacity, low-floor buses featuring modern styling and multiple doors.
- Automated fare machines for fare prepayment.
- Transit Passenger Information System (TPIS).
- Strong brand identity.
- Landscape treatments to buffer surrounding areas from the busway.
- Parallel recreational path along the corridor, fenced from the busway for safety.

Metro did not pursue New Starts funding from the Federal Transit Administration (FTA), relying instead on a combination of state and local funds for the Orange Line. Planning and engineering of the busway took place from 2000 to 2003. Construction began in 2003 but experienced a significant delay due to a lawsuit filed by the local activist group Citizens Organized for Smart Transit (COST). COST argued that because buses must cross traffic at the busway's multiple at-grade intersections, actual travel time savings would be much lower than the projected time savings used to justify the Orange Line. COST claimed that travel time savings comparable to the Orange Line could be achieved at much lower cost by expanding the existing Metro Rapid system, a network of rapid bus lines with service in the Valley and throughout Los Angeles County. A July 2004 ruling by the California Court of Appeal ordered Metro to temporarily halt construction and to evaluate additional Metro Rapid lines as an alternative to the Orange Line.

In October 2004, Metro issued a Revised Final Environmental Impact Report (RFEIR), concluding that the Orange Line would yield greater benefits than additional Metro Rapid service. The RFEIR examined the environmental impacts, costs, and benefits of each alternative and determined that the Orange Line would:

- Result in faster end-to-end travel times (forecast between 28.8 and 40 minutes) than any of the rapid bus alternatives.
- Attract substantially more new transit riders than any of the rapid bus alternatives.
- Result in greater travel time consistency which, as a result of the dedicated busway, would not be compromised over time as the result of increasing traffic congestion.
- Be more cost-effective on a per-passenger basis.
- Better support local land use plans by encouraging transit oriented development (TOD) at and around stations.
- Operate for up to $10 million less annually than the rapid bus network alternative.

Construction of the busway resumed in 2003, and in October 2005, the Metro Orange Line debuted as the first exclusive busway in Los Angeles and one of the first full-service BRT lines in the U.S. Aside from the Orange Line, the only other significant increase to San Fernando Valley bus service outlined in Metro's current Long Range Transportation Plan is the expansion of the Metro Rapid Program, a regional network of rapid bus service throughout 35 cities and Los Angeles County.

Corridor Characteristics

The San Fernando Valley began growing as a major suburb of Los Angeles during the 1940s. Today, it is home to more than 1.3 million people and comprises more than half of the land area within the city of Los Angeles. Since the 1980s, the Valley theoretically has generated employment sufficient for supporting its own population, yet many residents continue to commute to jobs outside the Valley. Due to rapid population and employment growth and the heavy pattern of commuting throughout the Valley, many of the arterials, local streets, and five major freeways that serve the area operate at capacity during peak travel periods. The east-west arterials are projected to be the most congested in the Valley by the year 2020.

The San Fernando Valley East-West Transit Corridor is located in central Los Angeles County, approximately 20 miles northwest of the Los Angeles Central Business District. The Orange Line serves this corridor, which is primarily a single-family residential zone, with some three- and four-story multi-family housing. Most of the line's commercial activity is clustered around its two termini, Warner Center to the west and the North Hollywood neighborhood to the east.

The Valley's main commercial corridor is traversed by the Metro Rapid Ventura Line, which runs 1.5 miles to the south of the Orange Line. Prior to the construction of the Orange Line, the San Fernando Valley was served exclusively by local bus routes, with the Red Line subway terminating east of the Valley in North Hollywood.

Travelers from the Valley now are able to access the Metro Red Line via the 14.5-mile Orange Line busway, which was built along an abandoned portion of the Southern Pacific Railway, parallel to the congested US 101 Freeway. The line begins at the Warner Center mall and office complex, the third-largest employment center in Los Angeles County. It extends east through the San Fernando Valley communities of Tarzana, Encino, Sherman Oaks, and Van Nuys and terminates at the North Hollywood Station, providing a connection to the Metro Rail System via the Metro Red Line subway. However, to access the Red Line station, riders must cross Lankershim Boulevard via a pedestrian crosswalk. In addition to North Hollywood and Warner Center, major destinations throughout the corridor include Pierce College, the Sepulveda Basin Recreation Area, the Van Nuys Civic Center, the Valley Government Center, and Valley College.

The 14 stations, six of which have park-and-ride lots, are similar in design to light rail stations, with canopied platforms, covered seating, lighting, bicycle parking, automated fare collection machines, and public art. In addition, TPIS at stations communicates real-time information to customers by way of visual message signs and a public address system. Emergency telephones and closed circuit television (CCTV) cameras are provided for customer security at stations. In keeping with the Orange Line's urban design vision of a busway within a linear "greenway," the facility also includes a 14-mile recreational path, extensive native and drought-tolerant landscaping, and other aesthetic improvements to enhance the surrounding communities [1].

A future extension of the Metro Orange Line, budgeted at $215.6 million and scheduled to open in 2012, will expand service four miles northward, from the western end of the busway at the Canoga Station Park-and-Ride lot to the Chatsworth Metrolink commuter rail station. The future Orange Line Extension will serve Warner Center, several zones of high-employment concentration along Canoga Avenue, and the Chatsworth industrial area, and will provide a connection to the Metrolink system as well. The extension of the busway will be built along the Metro-owned railroad tracks paralleling Canoga Avenue. In addition, an extension of the existing Orange Line bicycle/pedestrian path will be constructed parallel to the new busway for its entire length [6]. It is hoped that the Orange Line Extension will 1) offer improved north-south mobility in the western San Fernando Valley by offering faster travel times and improved bus connections and 2) provide better access to destinations throughout Los Angeles County by linking activity centers along the corridor and connecting the Orange Line with Metrolink [5].

Projected ridership for the existing Orange Line in the year 2030 is 36,000 average weekday boardings; the extension, forecast to open in the summer of 2012, is expected to generate 9,000 new average weekday daily boardings by the year 2030, contributing to a projected 45,000 average weekday boardings for the full alignment from North Hollywood to Chatsworth. To accommodate the anticipated additional riders, Metro is considering different strategies, such as bus platooning, where multiple buses travel in a convoy; adding additional "tripper" buses that are deployed at times when passenger loads are high; and providing limited-stop trips [5].

Figure 1-1

Metro Orange Line Route Map with Extension to Chatsworth Station

Source: Metro Homepage at http://www.metro.net/

SECTION

2

Project Description

Running Ways

The 14.5-mile Orange Line runs almost entirely on an at-grade, dedicated busway that follows the inactive Southern Union Pacific Railroad alignment along the Chandler Boulevard corridor. At the line's western terminus, vehicles exit the busway at Canoga Avenue and travel briefly in mixed traffic to serve Warner Center. The busway passes through 38 signalized intersections, including 31 street crossings, four pedestrian crossings, and three limited-access road easements that allow official vehicles to access nearby municipal and military sites. Loop detectors are installed at all intersections to give Orange Line vehicles signal priority. The generous width of the ROW, which typically is 100 feet, provides the space needed to accommodate stations and other infrastructure. The busway has one lane running in each direction and a width of 26 feet, with the roadway widening at stations to afford passing capability in the event of a breakdown. The completion of the busway required the construction of three bridge crossings, including a 525-foot span over the Los Angeles River in the Sepulveda Basin.

Figure 2-1
Orange Line Busway

As an added benefit to the community, the design of the busway includes irrigated landscaping treatments and a 14-mile bicycle and pedestrian path, complete with fencing, crosswalks, and lighting to ensure safety. In addition to their recreational and aesthetic value, the path and landscaping treatments buffer adjacent homes and businesses from the busway. Also, an environmentally-friendly system of drainage swales, instead of traditional curb and gutter drainage, is used along certain portions of the busway to allow storm water run-off to percolate back into the soil, rather than flowing into pipes that would direct it to the ocean.

Figure 2-2

Metro Orange Line Recreational Trail

As an added measure to reduce ambient noise levels near homes, rubberized asphalt paving was installed along residential sections of the busway. However, significant deterioration of the rubberized asphalt in the form of cracking and rutting occurred during the line's first year of service. These maintenance issues, along with test results indicating that noise reduction from the rubberized asphalt was negligible, led to a decision by Metro to repave these portions of the busway with thicker, stronger "Super Pave" asphalt [7, 8].

Stations

The Orange Line has 14 stations, spaced approximately one mile apart. Stations are located at major intersections and at higher-density locations such as the Van Nuys Civic Center, Pierce and Valley Colleges, Warner Center, and North Hollywood. In addition to being a terminus for the Orange Line, North Hollywood is also a terminus for Metro's Red Line subway. Each Orange Line station area comprises two separate platforms along the busway, one for eastbound travel and another for westbound travel, with canopies covering portions of the platforms for shade and shelter. Stations are able to accommodate up to three Metro Liner vehicles.

Orange Line stations provide passenger amenities such as seating, telephones, lighting, and security cameras. TPIS communicates real-time information to customers by way of visual message signs and a public address system. To facilitate bicycle access to the Orange Line, bike racks or lockers are provided at every station except Warner Center.

Park-and-ride lots at six of the stations offer a total of 3,800 free parking spaces, indicated by the gray box with the letter "P" next to stations on the corridor map of the Orange Line in Figure 2-3.

Figure 2-3

Map of Orange Line Route Corridor with Stations

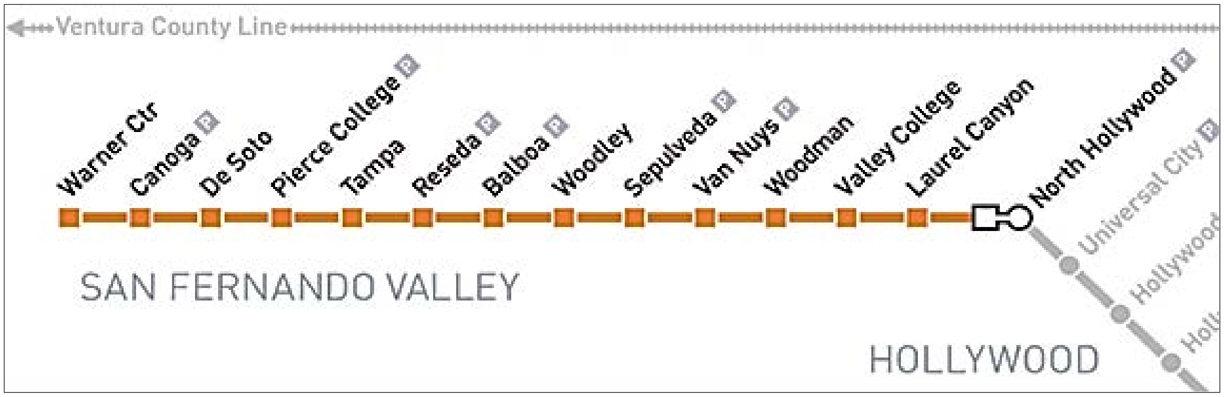


Figure 2-4

Seating at Laurel Canyon Station

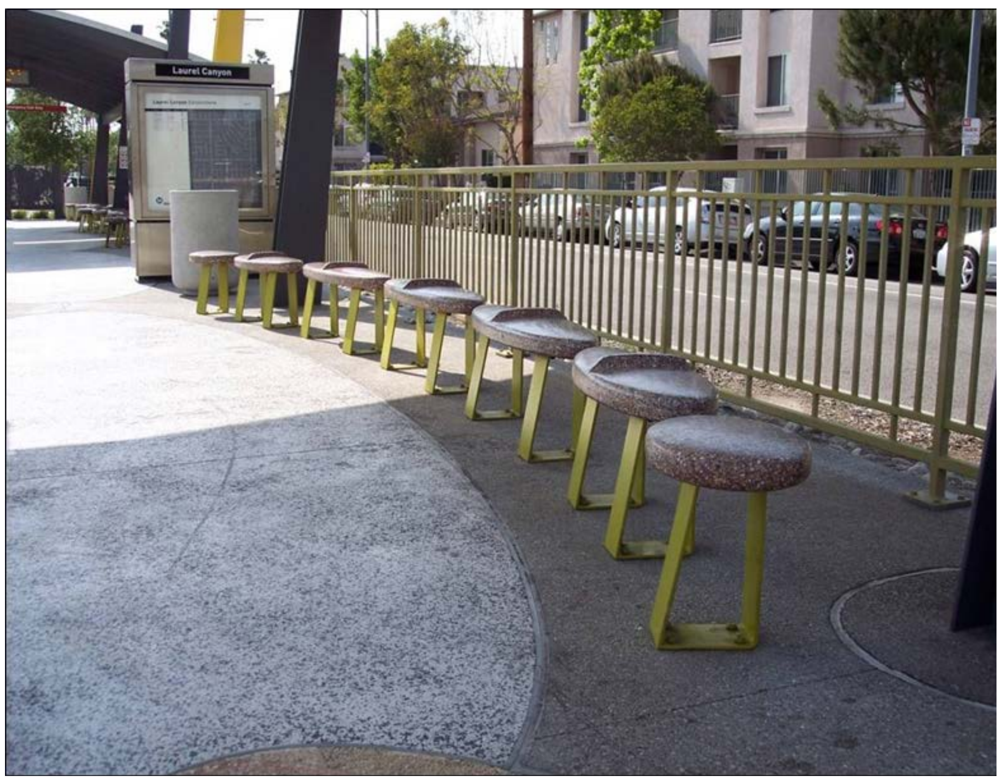


Figure 2-5
Bicycle Lockers at North Hollywood Station

As shown in the table below, which lists the number of park-and-ride spaces provided at each station, Sepulveda station offers approximately one fourth of the spaces along the entire route. The North Hollywood and Van Nuys stations have a significant number of spaces as well. During construction of the Orange Line, 22 spaces were added to the existing park-and-ride lot at the Red Line North Hollywood Station.

Table 2-1
Number of Park-and-Ride Spaces at Orange Line Stations

Station	Park and Ride Spaces
Canoga	608
Pierce College	394
Reseda	522
Balboa	273
Sepulveda	1,179
Van Nuys	824
Total	3,800

Figure 2-6

Terrazzo Paving and Sculpted Station Seating

In addition to the amenities mentioned previously, stations also feature unique artwork. Orange Line stations have a consistent design approach, with specialized artworks providing an element of variability for individual stations. A lead artist worked with the design team to identify opportunities for artwork commissions at each station and to develop elements of station continuity including standardized colors and materials, canopies, and seating elements. Each Orange Line station prominently displays terrazzo paving and porcelain enamel steel artwork created by a select California artist. Artwork at each station represents the unique culture of the Valley [9].

North Hollywood Station

The North Hollywood Station is the easternmost stop of the Metro Orange Line, located directly across the street from the Metro Red Line's North Hollywood Station. The Metro Red Line subway provides service from North Hollywood to Union Station in downtown Los Angeles and connects to other Metro Rail lines. The Orange Line's North Hollywood Station makes use of 915 parking spaces at the existing Metro Red Line North Hollywood park-and-ride lot. A total of 22 parking spaces were added to this lot at the time of the Orange Line's construction. The North Hollywood station has been a great asset to local area development, inspiring transit oriented development (TOD) including the NoHo Tower, a 15-story apartment complex; the NoHo Commons, a multi-use complex with retail on the ground floor and apartments on the floors above; and the largest TOD proposed in Los Angeles, the NoHo Art Wave. Initially proposed in 2007, the NoHo Art Wave project ultimately will consist of residential, retail, and office space equaling approximately $1.3 billion in development.

Warner Center Transit Hub

The western terminus of the Orange Line is located in the edge city of Warner Center, a mall and office complex in the Woodland Hills District of Los Angeles. A commercial shopping complex is directly across from the station and offers shopping, several dining options, and a movie theater. Three commercial-use skyscrapers also are located nearby. Construction of an extension to the Orange Line will result in a northern terminus at Chatsworth Station (see Figure 1-1).

Figure 2-7

View from Orange Line North Hollywood Station of Entry to Metro Red Line North Hollywood Station

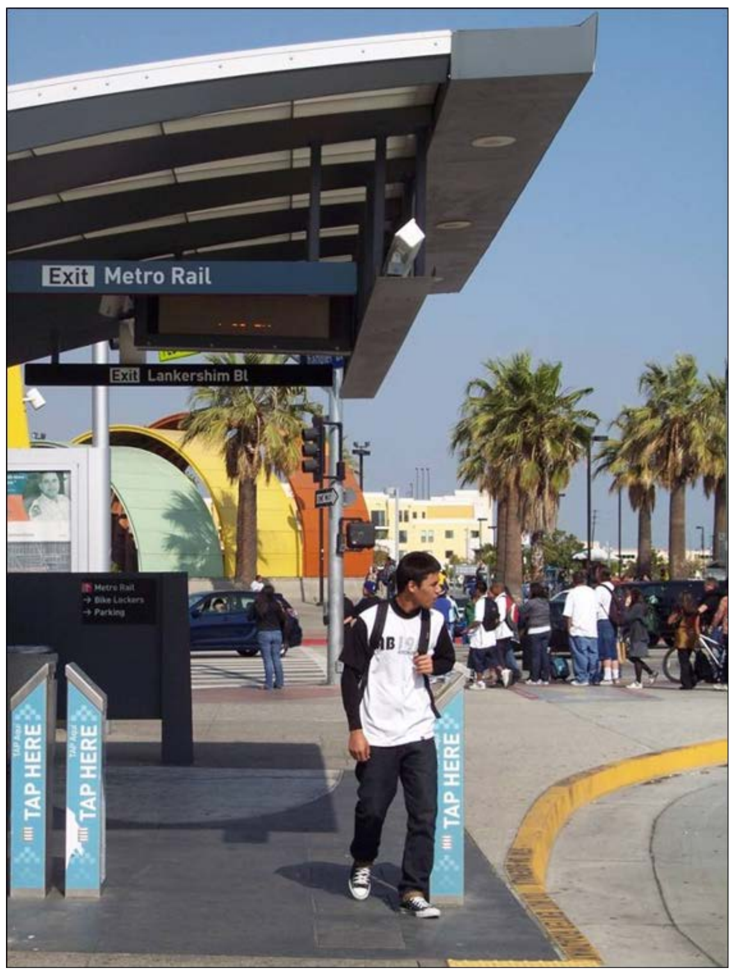


Figure 2-8

Orange Line Vehicle Traveling Eastbound from Warner Center

Vehicles

Orange Line service is provided exclusively by a new, specially-painted fleet of low-floor, 60-foot articulated "Metro Liners" manufactured by North American Bus Industries (NABI). In 2004, Metro made a strategic decision to consider vehicle aesthetics in the process of procurement. Although this would affect the future procurement of all vehicles, not just the BRT fleets, the Metro Liners were the first vehicles purchased using aesthetics as an evaluation criterion. Metro requested that bus manufacturers propose articulated bus designs that were sleek, streamlined, and aerodynamic in appearance [20]. Metro also wanted to incorporate several specific design features into the Orange Line vehicles, including graphics and color palettes, padded seating, and three extra-wide doors to support faster boarding/egress. There was also a substantially lower noise requirement for the vehicle (78db) than for Metro's other transit buses.

Metro eventually decided on the design concept submitted by NABI, which met all of Metro's vehicle design requirements and, with an initial cost of $633,000 per vehicle, was also priced about 20 percent lower than the competing proposals. Currently, there are 28 Metro Liners used for revenue service on the Orange Line;

8 are held in reserve. Total purchase price of the fleet was approximately $24.8 million, including tax, delivery, and other miscellaneous costs. This does not include the 65-foot demonstration vehicle (discussed in more detail below), which was built by NABI as a warranty settlement.

The Metro Liner vehicle is an articulated, low-floor bus designed specifically for use in bus rapid transit service. It is powered by a Cummins 6-cylinder 320 horsepower compressed natural gas (CNG) engine equipped with a 5-speed automatic transmission. Unlike most CNG engines, which are diesel conversions, the Cummins engines are designed from the ground up to run on CNG. This was the only certified CNG engine that met all applicable federal, state, and local emissions regulations. Furthermore, due to restrictions on the use of diesel fuel in transit vehicles by the South Coast Air Quality Management District (AQMD), as well as Metro's own alternative fuel policy, the Cummins CNG engine was the only practical alternative fuel propulsion option. Metro Liners have a fuel capacity of 27,088 cubic feet of CNG in 12 tanks and a range of more than 400 miles. The first pilot Metro Liner was delivered in the fall of 2004. After a 60-day review and testing period, Metro returned the pilot vehicle to NABI for final engineering and production. The entire fleet was delivered in late June 2005, allowing several more months of testing and training prior to the opening of the Orange Line in October 2005.

Figure 2-9

"Metro Liner" Vehicle

Metro Liners feature aerodynamic styling; panoramic windows; thickly padded, cantilevered seats; covered rear wheel wells; unobstructed, low floors for improved passenger maneuverability; and three extra-wide doors for ease of passenger boarding. Vehicles are painted in the same silver and gray color scheme as Metro rail vehicles and carry up to 57 seated passengers, an increase of 45 percent over the standard bus. To ensure accessibility for everyone, operators can deploy a simple ramp device at the front door for wheelchair and other mobility assistance. Accessibility is further enhanced by the low-floor entries and exits that align with the curb, eliminating the need for high steps. Vehicles also provide five fold-down priority seats for older adults and riders with disabilities, space for two wheelchairs onboard, an external bike rack with room for two bicycles, and automated visual and audio station announcements inside and outside the vehicle. On-board video monitors were recently installed for an added level of security. Because the Orange Line operates on a proof-of-payment system, vehicles are not equipped with fare boxes.

Figure 2-10

Rear Interior of Metro Liner

In September 2007, Metro introduced its new, super-sized 65-foot Metro Liner demonstration vehicle. The California Department of Transportation (CalTrans) granted a special permit for operational testing of the vehicle on the Orange Line busway during daily revenue service. Measuring five feet longer than the first-generation Metro Liner and just 10 feet shorter than a Metro Rail subway car, the extra-long vehicle (affectionately nicknamed "Longfellow") has the highest capacity of any articulated CNG bus currently operating in North America. It provides room for 66 seated passengers, representing a 16 percent gain in seating capacity over the 60-foot model's 57 seats.

New vehicle upgrades include frameless tinted windows for reduced glare and a more streamlined appearance, a relocated air conditioner to reduce interior noise, and an advanced exhaust system that further reduces exterior noise. For easier operator steering, the longer vehicle will have a tighter turning radius than many of Metro's existing 40-foot buses. Because the 65-foot Metro Liner uses four less CNG storage tanks, it is similar in weight to its 60-foot predecessor and is expected to be comparable in terms of acceleration and braking. Because the vehicle was built by NABI as a warranty settlement, no detailed cost information is available.

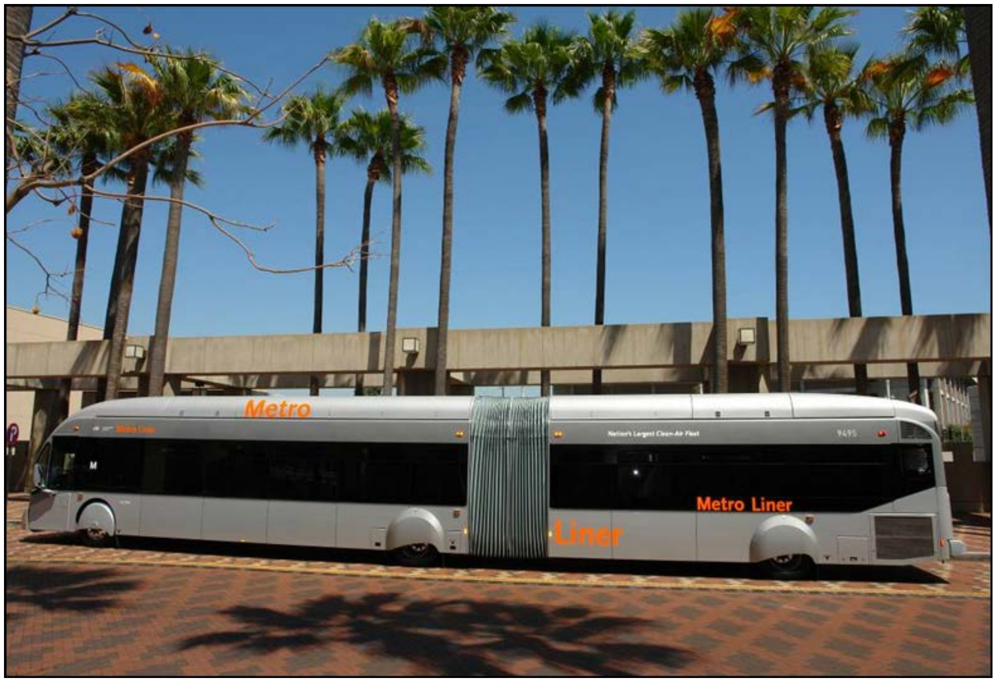


Figure 2-11

Metro Liner's 65-foot Demonstration Vehicle

Metro purchased the extra-capacity vehicle to meet growing ridership demand on the Orange Line without the increased operating costs of adding vehicles during peak periods. During a one-year testing period, Metro evaluated various performance factors including maneuverability, operating range, capacity, and passenger acceptance. The extra-long Metro Liner met all applicable performance requirements during testing and received positive feedback from operators. Due to its successful performance, the vehicle was put into daily revenue service on an experimental basis and could be flexibly phased into service with fleet replacements over time. However, unless there are changes to California law, which restricts the length of public transit buses to 60 feet, it is unlikely that Metro will purchase additional 65-foot vehicles in the near future.

Fare Collection

The Orange Line operates on a pre-paid, proof-of-payment fare system (see Figure 2-12). Before boarding, passengers use ticket vending machines (TVMs) to purchase single-ride tickets for $1.50 or day passes for $6.00. TVMs are located at all Metro Orange Line and Metro Rail station platforms and also may be used to load and reload transit access pass (TAP) cards. TAP is a recently-implemented universal fare system, enabled by contactless smart card technology, which reads and stores electronic information for repeated use. The credit card-sized TAP card must be tapped on electronic validators when entering and transferring within the system. For proof of payment, fare inspectors use wireless handheld units to make sure that TAP users have validated their cards. TAP cards may also be loaded and reloaded at Metro customer service centers or online. In addition to single-ride and stored-value features, monthly and weekly passes may be stored on the TAP. The current single-ride tickets for passengers not using TAP cards will be transitioned to limited-use paper smart cards. TAP will eventually replace the EZ Pass, which allows travel between Metro and other transit operators throughout the greater Los Angeles area.

Figure 2-12

Ticket Vending Machines (Left), TAP Card and Validator (Right)

Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) is the application of computer-based traffic management technology used to optimize freeway operations and signal timing, provide transit vehicles with TSP, provide real-time information to transit patrons, and assist in the management of transit operations. The Orange Line employs several forms of ITS technology to enhance the operation and image of the line. These include the use of TSP along the route, real-time vehicle displays at stations, ticket vending machines, and TAP card validation machines for faster boarding.

Transit Signal Priority

Active TSP is provided at every intersection along the Orange Line route, including the street-running segment near Warner Center. Each signal along the corridor is timed to accommodate specific bus speeds and dwell times but must be activated by either a detected bus or a pedestrian. If a signal is not activated, general-purpose traffic on cross-streets will be provided with a continuous green signal. Vehicles are detected at pre-determined locations using loop detectors. All priority requests and messages are then passed through a central system, allowing traffic managers to better coordinate and monitor the signals. Every signal uses advanced phase calling, in which the detection of a bus is transmitted to upcoming signals in order to clear intersections of pedestrians and cross traffic for the approaching bus.

Figure 2-13

Traffic Signals Located Along the Busway

Each signal has the capability to provide priority to buses in the form of early green and green extension, although both cannot be used within the same cycle [21]. The Orange Line uses unconditional TSP, meaning that the system does not take into account whether or not a vehicle is behind schedule when deciding whether to grant a priority request. Priority is provided to the bus that first requests it, although more than one bus may benefit from the priority request since buses moving in opposite directions use the same green time. Although the small savings (five to ten seconds) achieved by TSP at an individual intersection may seem trivial, the cumulative result is a significant time savings to the customer [21]. However, because the use of TSP does not guarantee an immediate green signal at every intersection, it is not unusual for vehicles to encounter red lights. Further analysis of the TSP and its effect on travel time is discussed in Appendix C – Transit Signal Priority.

During the first few weeks of operation, a number of bus/car collisions occurred at intersections, caused by motorist error (see Section 4, subsection "Safety"). As a result, Metro restricted Orange Line vehicle speeds to 10 mph while traveling through intersections (see Section 4, subsection "Safety"). This has reduced the impact of the TSP system on travel times.

Automatic Vehicle Location and Real-Time Information Systems

Global Positioning Systems (GPS) onboard the vehicles relay information to the Bus Operations Center (BOC) for real-time information location status. This information is relayed every two minutes.

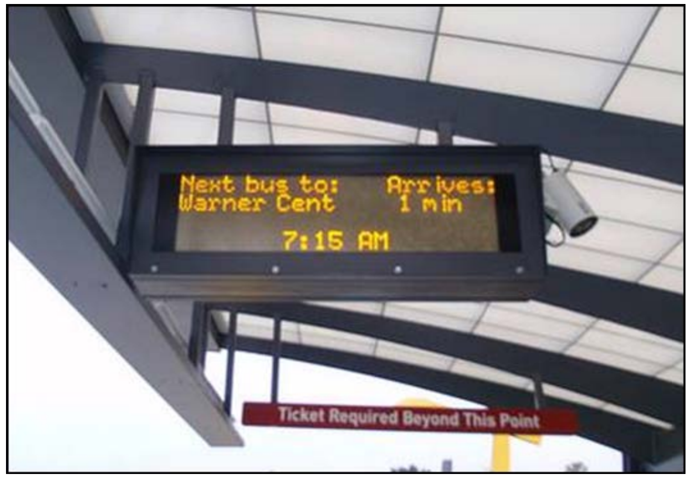


Figure 2-14

Real-time Information Display at North Hollywood Station

Real-Time Information provides travelers with timely information about the status of the BRT service. TPIS at Orange Line stations, enabled by GPS/AVL technologies, uses visual message signs and a public address system to communicate predicted bus arrival times and information about service delays and disruptions.

Figure 2-15

Oncoming Vehicle Notification along the Route

Service and Operations

The Metro Orange Line operates 22 hours a day, seven days a week. Schedules are based on headways of four to five minutes during peak operation and 10 to 20 minutes during the early morning, late evening, and on weekends.

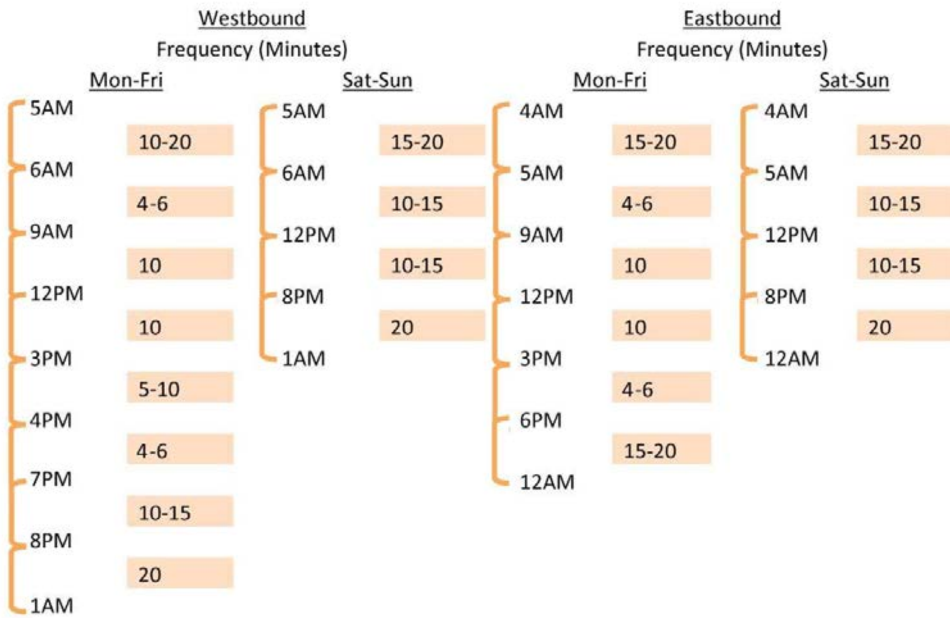


Figure 2-16
Operating Frequencies of the Orange Line

A total of 28 buses are used on the Orange Line during peak operating hours; 12 are required off-peak. The maximum end-to-end travel time along the corridor during peak operating hours is approximately 43 minutes, as compared to 50 minutes before the project was implemented. TSP and a dedicated running way are contributing factors to the decrease in travel time. Orange Line stations also connect to approximately 20 local and Metro Rapid bus lines, and schedules are coordinated with the Red Line subway to ease transfers from the North Hollywood terminus. Vehicle operators are allowed to minimize trip times by skipping stops if there are no passengers requesting the stop.

On high frequency systems such as the Orange Line, it is particularly important to maintain even headway spacing. An issue that sometimes can occur with such high frequency service is "bunching," whereby one vehicle essentially catches up with the vehicle in front of it. Bunching can occur as the result of unexpectedly long (or short) dwell times at a station or from signal issues, for example. To provide uniform service distribution, Metro has developed the following set of standard operating procedures for Orange Line vehicle operators:

- Always leave the terminal exactly at the scheduled depart time.
- Maintain a safe speed, but never exceed the posted speed limit.
- If another bus is encountered, fall back or slow down until the other bus is no longer visible.
- If directed to do so by the Bus Operations Control Center (BOC), reduce speed.

In addition, passing another Orange Line vehicle due to bunching is permitted at stations, where a third lane is provided for passing. Passing is allowed at all stations except the eastbound and westbound Laurel Canyon stations, which do not provide ample room for vehicles to maneuver around an object. Due to safety concerns, passing is strictly prohibited anywhere except at stations, unless otherwise directed by the BOC.

Another key factor in maintaining even headway spacing is the relationship between the TSP system and operator behavior. According to Metro officials, if an operator misses even one signal, bunching will occur almost immediately [22]. When the TSP system is operating, each signal is set to change based on the speed the operator should be using. Operators can maximize the benefit from the signal priority system, thereby ensuring more even headway spacing, if they abide by the following standard operating procedures:

- Maintain the posted speed limits between traffic signals.
- Reduce running speeds to 10 mph through all intersections (see Section 4, subsection "Safety and Security").
- Dwell for 15-20 seconds at station stops.

Branding, Marketing, and Community Outreach

Branding Elements and Marketing Strategy

A successful BRT brand can raise expectations of performance and service delivery by reinforcing impressions of BRT as a premium service. There are two major elements of branding for transit agencies to consider when developing a BRT system¬: marketing classification and branding devices [10].

Marketing classification describes how BRT fits within the rest of a transit system and reflects both functional differences in service attributes and differences in how the service is marketed. A BRT service with advanced features, especially dedicated running ways, can be classified and marketed as part of the larger regional rapid transit system. This typically involves the inclusion of BRT routes on regional rapid transit maps, as well as notation and naming of BRT lines in a manner similar to other rapid transit service and distinct from local bus service. Branding devices are attributes, usually visual, that define and reinforce the brand identity of a product. For BRT, a unified brand identity can also help to convey important customer information such as routing and stations served, as well as alerting infrequent customers as to where they can board. The most common branding devices for BRT are the use of special brand names, logos, and colors.

In terms of marketing classification, Metro's overall strategy was to present the Orange Line as an extension of the Metro Rail system. The approach has been to emphasize the Orange Line's link to the Red Line at North Hollywood and to subtly brand a "high-speed network" of rail lines and "bus lines that operate in a rail-like fashion" on dedicated ROWs [23]. The Orange Line is included in maps of the region's rapid transit network and, similar to other Metro Rail lines, has been given a color-coded name designation. To further differentiate the Orange Line from regular Metro bus service, marketing materials emphasize speed, ease-of-boarding, security, and the enticing image of the vehicle, which is painted in the same silver and gray color scheme as the newest Metro Rail vehicles.

Metro has worked to create a familiar and friendly brand for the Orange Line. From consistent use of identity elements such as name and logo to a unified typeface, color palettes and iconography, the Orange Line "look and feel" is coordinated across vehicles, stations, signs, maps, and other elements. As with other rail line openings, Metro sought to promote the Orange Line as a new option in the growing Metro system, rather than as its own unique, stand-alone brand. Another key element of brand continuity is the basic design of the stations, which is consistent throughout the entire line.

In promoting the Orange Line, Metro sought to inform and entice potential riders with information about the unique engineering of the line: sleek new articulated vehicles, stations that are similar to rail stations, a new recreation path, art installations, easy connections to other lines in the Metro system, and fast, frequent service. A full complement of outdoor, print, and radio advertising in the area as well as a direct mail campaign to local residents helped to drive anticipation and interest prior to and just after the official opening.

Figure 2-17

Metro Orange Line Promotional Materials

Source: Metro Orange Line promotional materials

To promote safety and help riders become familiar with the Orange Line, a series of web pages were created on Metro's website (www.metro.net). These pages contain station views and interactive maps where users can click on the various elements of the busway to learn more about the Line's amenities, special features and surroundings.

Figure 2-18

"Go Metro" Rapid Transit Map

Source: Los Angeles County Metropolitan Transportation Authority, www.metro.net

Figure 2-19

Billboard Advertisement for Orange Line

Source: Los Angeles County Metropolitan Transportation Authority

Figure 2-20

Promotional Banners for Orange Line

Source: Los Angeles County Metropolitan Transportation Authority

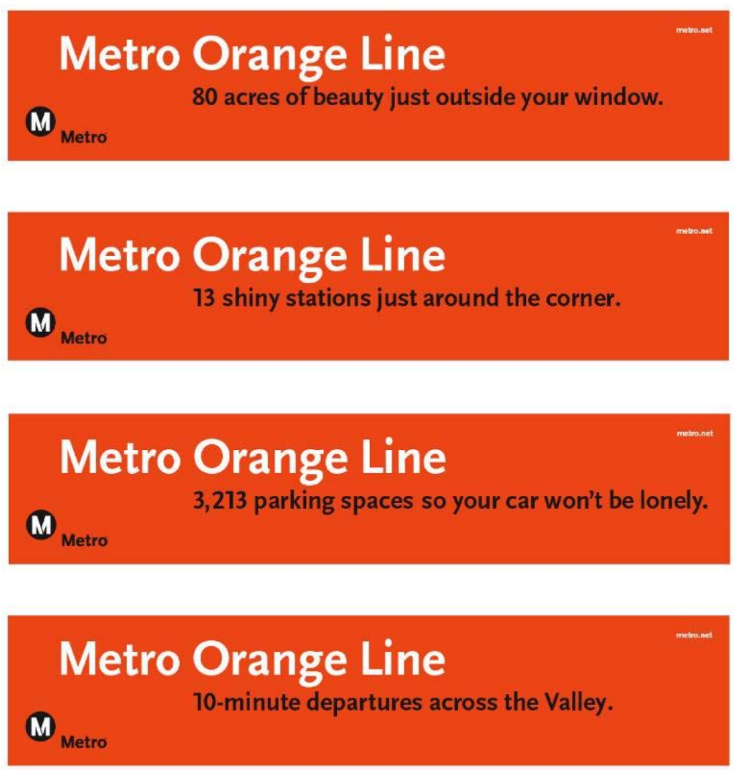
Figure 2-21

Pole Banners Promoting Orange Line

Source: Los Angeles County Metropolitan Transportation Authority

Figure 2-22

Promotional Banners Used During Orange Line Construction



Source: Los Angeles County Metropolitan Transportation Authority

Figure 2-23

Promotion of Orange Line at Metro bus shelters

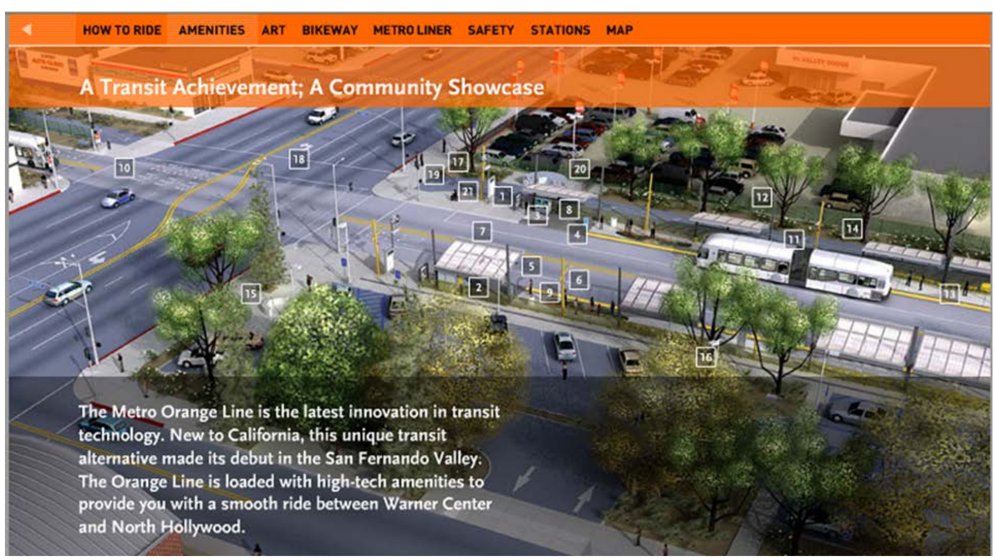
Source: Los Angeles County Metropolitan Transportation Authority

Community Outreach

To identify and involve various stakeholders in the project, an extensive public and agency outreach effort was undertaken, from the initiation of environmental studies through completion of preliminary engineering. Throughout the development of the Draft Environmental Impact Report and Environmental Impact Study (DEIR/EIS), a comprehensive community outreach program was conducted, including two formal public hearings. In addition to public hearings and open houses that were held to solicit citizen input during the planning process, the DEIR/EIS was released to private citizens, community groups, the business community, elected officials, and public agencies for a 45-day public review and comment period. Copies were made available at libraries near the corridor, and the DEIR/EIS was also published online. To respond to concerns voiced during the public review period, Metro held additional community meetings and included refinements and enhancements to the project in its Final Environmental Impact Report (FEIR) [1].

Figure 2-24

Selected Pages from Orange Line Interactive Website



Source: Los Angeles County Metropolitan Transportation Authority

In July 2001, the Metro Board formally adopted full BRT as the locally preferred alternative. However, in accordance with a 2004 California Court of Appeal decision (see Section 1, subsection "Background"), Metro prepared a Revised FEIR (RFEIR) analyzing three additional multiple-route rapid bus alternatives. The Draft RFEIR was circulated for 30 days for public comment. In October 2004, after evaluating and responding to issues raised during comment, Metro issued the RFEIR, which incorporated responses to comments and concluded that the Orange Line would yield greater benefits than additional rapid bus service.

In addition to the public outreach associated with the environmental documents, more than 200 meetings were held and nearly 11,000 contacts were identified in a public outreach database. This effort included station and landscape design workshops, newsletters, and meetings with a wide range of groups, organizations, and elected officials. During the preliminary engineering and final environmental phases of the Orange Line, Metro staff held a series of community meetings to address the concerns of adjacent neighborhoods and to refine project design features accordingly and where appropriate. Throughout the construction period, staff also worked closely with the contractor and Los Angeles City officials to effectively communicate street closures and minimize closure periods that would impact traffic flow. Status updates also were provided regularly through Metro press releases. The Metro Art Program also involved the community through an Arts Advisory Group, artist workshops, and various art program-related events.

As part of its safety program, Metro distributed an interactive Orange Line safety presentation to more than 30,000 residents within a one-mile radius of the busway. The DVD presentation, available in English and Spanish, urges drivers, pedestrians, and bicyclists to heed all traffic precautions. The presentation also provides instructions for operating ticket vending machines, directions for accessing parking along the line, and an overview of station security. Metro also delivered safety presentations to more than 100 schools within a 1.5-mile radius of the Orange Line. The school safety program provides school children with an overview of the busway and station intersections, and emphasizes the importance of obeying all signs, signals, and street striping on the busway. The presentation is followed by an eight-minute animated safety video for elementary-age children. Following Metro's visit to the schools, copies of the video were left with each school's library for administrators to share with new groups of students.

Figure 2-25

A Mobile Theater Travels to Communities to Offer Safety Presentations about the Metro Orange Line

During the test running phase in the weeks leading up to the Orange Line's opening, Metro provided safety tips through press releases and urged residents to strictly obey all signs and signals, both on the busway and at street intersections. Trespassing on the busway for any reason is strictly prohibited. Metro also worked closely with local law enforcement agencies to increase enforcement along the Orange Line during testing. The Los Angeles County Sheriff's Department and Los Angeles Police Department patrolled the busway and issued citations for violations.

To promote the Orange Line during the build-up to its inauguration, the Metro Liner vehicle was showcased at the 2005 RideFest, an annual event encouraging the use of transit and other congestion management strategies. Also, free rides were extended to the public during the weekend of the Orange Line's official opening and community celebrations took place at several stations along the route.

Lessons Learned

Meeting Agency Goals of Travel Time

Metro originally had projected that implementation of the Orange Line would result in a decrease of end-to-end travel time from 50 minutes to somewhere in the range of 28.8 to 40 minutes. According to the APC data provided by Metro and the travel time data collected by NBRTI, the average travel time achieved during peak travel hours is around 43 minutes. Although this represents a 22 percent improvement over original travel times within the corridor, it still falls short of agency projections. One of the main challenges for Metro has been the question of how to achieve the projected travel time savings while also complying with modifications that were implemented due to concerns with safety at intersections along the corridor. As a result of several accidents that occurred at intersections early in the project's operations, Metro required operators to decrease speeds to 10 mph while traveling through intersections (see Section 4, subsection "Safety"). In addition, due to the Orange Line's short headways and the signal spacing along the corridor, the use of TSP does not guarantee an immediate green signal at every intersection. Thus, vehicles will inevitably be delayed at red lights at certain points along the corridor (see Section 2; subsection "Intelligent Transportation Systems").

Corridor Noise and Asphalt

Metro built sound walls along some portions of the route, but noise was still an issue for many two-story buildings and for areas where the sound wall could not be built due to safety concerns regarding driver visibility. To further combat noise pollution, Metro modified vehicle exhaust pipes to open to the rear of vehicles and also met with residents to find other ways to buffer homes along the corridor from busway noise. Sound walls were extended where feasible, and several homes were retrofitted with additional insulation and sound-rated windows and doors.

Capacity

Orange Line ridership numbers were greater than originally anticipated. Prior to the implementation of the Orange Line, the corridor averaged 41,580 average weekday transit boardings [19]; the Orange Line itself attracted nearly 22,000 average weekday boardings by May 2006, surpassing the agency's stated ridership goal for 2020 in just seven months. In an effort to meet ridership needs, Metro reduced Orange Line headways to four minutes at peak hours. In 2007, the agency also ordered a prototype 65-ft bus that increases capacity by 20 percent to meet the demand. The axle weight of these vehicles, however, has delayed acquiring the regulatory waivers required to operate on the roadway. Although the maximum operated carrying capacity per hour on the Orange Line is sufficient along most of the route, it is not adequate at maximum load points. Even if Metro increases its current load standard, the demand-to-capacity ratio would still be approaching 1.0, indicating that system capacity may be maxing out (see Section 4, subsection "Capacity"). Reducing headways further is not a realistic option, as TSP would become ineffective. Other strategies that Metro may consider include bus platooning and providing limited-stop trips.

SECTION

3

Project Costs

Table 3-1 provides a capital cost summary of the Orange Line by element.

Table 3-1
Capital Costs Summary

	Original Budget	Actual Cost
Guideways	$ 124.2	$ 128.4
Professional Services	45.7	47.2
Stations	30.4	30.5
Special Conditions*	24.2	28.1
Vehicles and Buses	17.5	15.9
Canoga Station Busway Extension/Park-and-Ride	16.5	23.4
ROW Acquisition & Lease Relocation	24.9	12.5
Bicycle/Pedestrian Recreation Path	8.1	9.9
Systems/Equipment	12.7	8.2
Yards and Shops	1.2	1.2
Contingency	32.2	0.0
Project Revenue	0.0	(0.7)
Total	$ 337.6	$ 304.6

* Includes contractor-controlled insurance and risk, pre-revenue testing and operators, waste handling services, environmental mitigation, all third-party costs, and artists/artwork.

Source: Metro Orange Line Quarterly Project Status Report, June 2008.

Total capital costs for the Orange Line were determined to be $304.6 million in 2004 dollars, or $21.0 million per mile. It should be noted that this total does not include the original costs of the ROW for the busway, which was purchased more than a decade before the adoption of BRT as the Locally Preferred Alternative. Metro estimates the pro-rated cost of ROW acquisition for the Orange Line busway at roughly $73 million. If this cost is included, the cost is roughly $377.6 million, or $26.0 million per mile.

Metro used state and local funds for the majority of project costs, as shown in Table 3-2 below. Funds for the recreation path, shown separately in Table 3-3, were primarily from federal sources.

Table 3-2

Breakdown of Orange Line Funding

	Federal Funding	Other Funding
	Federal RSTP – $17.5 M	State TCRP – $145.5 M
	Section 5309 – $1.9 M	State STIP – $0.3 M
		Proposition C – $127.3 M
		City of Los Angeles – $1.8 M
Total	$19.4 M	$274.9 M
Percent Total	6.6%	93.4%

Table 3-3

Breakdown of Funding for Recreation Path

	Federal Funding	Other Funding
	TEA – 21 $6.0 M	City of Los Angeles – $2.1 M
	TEA-21 High Priority – $1.4 M	
	Federal STIP – $ 0.4 M	
Total	$7.8 M	$2.1 M
Percent Total	78.8%	21.2%

SECTION

4

Project Performance

Characteristics of Bus Rapid Transit for Decision-Making (CBRT) [10] identifies six key BRT performance areas: (1) travel time, (2) reliability, (3) image and identity, (4) passenger safety and security, (5) system capacity, and (6) accessibility. Each is discussed below.

Travel Time

Several performance indicators can be used to estimate travel time performance, as described in CBRT [10]. In the next subsection, the following indicators are discussed:

- Maximum Peak Hour End-to-End Travel Time – represents the maximum travel time required to complete a one-way trip from the beginning to the end of the line during weekday peak hours. This evaluation uses the average peak end-to-end travel times.
- Uncongested End-to-End Travel Time – represents the average travel time required to complete a one-way trip from the beginning to the end of the line during weekday non-peak hours of service.
- Average Speed in Peak Hour (mph) – determined by dividing the total one-way route length by the average peak-hour end-to-end travel time, multiplied by 60.
- Average Uncongested Speed (mph) – obtained by dividing the total one-way route length by the uncongested end-to-end travel time, multiplied by 60.

The performance indicators discussed in this subsection are based on APC data provided by Metro, as well as data collected by the National Bus Rapid Transit Institute (NBRTI) for its own independent travel time study. The travel time performance of the Orange Line is evaluated according to the project's original goals and objectives, taking into account any disadvantages or obstacles unique to the project. Data were analyzed to assess schedule adherence, reliability, on-time performance, and commercial speeds. In addition, NBRTI's travel time analysis provides insight into the directional and temporal components of the Orange Line's running time, and produces a useful "before" dataset for future study of the line. For full details of NBRTI's travel time analysis, please see Appendix B.

Metro Travel Time Data

End-to-end travel time data for the month of March 2009 were collected by the APC system on the Orange Line vehicles. Table 4-1 summarizes average travel times throughout the day with peak hours between 6:00am–9:00am and 4:00pm–7:00pm.

The table shows that the average travel time for the Orange Line during peak hours is 43 minutes, 24 seconds and during non-peak (uncongested) hours is 43 minutes, 4 seconds. As might be expected, because the service runs on an exclusive ROW there is little difference between the peak and non-peak running times.

Table 4-1

End-to-End Travel Times on the Orange Line (mm:ss)

Time of Day	4:00 am 6:00 am	6:00 am 9:00 am	9:00 am 12:00 pm	12:00 pm 2:00 pm	2:00 pm 4:00 pm	4:00 pm 7:00 pm	7:00 pm 10:00 pm	10:00 pm 12:00 am	Peak Avg	Non Peak Avg
Average	40:40	43:04	43:49	44:52	45:54	43:44	43:35	40:33	43:24	43:04

While Table 4-1 provides the peak hour and uncongested end-to-end travel times on the Orange Line, the average speed of the service during peak and off-peak hours is provided below:

- Average speed, peak hour – 20.05 mph
- Average uncongested speed (off-peak) – 20.20 mph

Because the Orange Line service operates in an exclusive ROW, the speeds do not differ significantly between the peak and uncongested (off-peak) periods.

NBRTI Travel Time Study

NBRTI conducted an analysis of travel time and reliability on the Orange Line. Data were collected in January and April 2010. Data collection involved surveyors riding the entire length of the route on inbound and outbound trips, documenting the time that each run began and ended, when each time point was reached, and the different components of travel time as the journey progressed. Data for a total of 64 runs were obtained, achieving the target of at least 20 runs in each of the three defined time periods (AM Peak, PM Peak, and Off-Peak). Data were analyzed to assess schedule adherence, reliability, on-time performance, and commercial speeds, and to identify the directional and temporal components of the line's running time (see Appendix B for detailed analysis).

Table 4-2

Metro and NBRTI Travel Time Data for Orange Line

	Metro Mar 2009	NBRTI Jan/Apr 2010	Time Difference	% Difference
Peak	43.4	42.6	0.8	1.8
Off-peak	43.1	43.2	0.1	0.0

Comparing the NBRTI analysis of the Orange Line with the APC data provided by Metro, it can be observed that both data sets produced similar results. Peak travel times recorded by APCs onboard the Orange Line vehicles showed an average of 43.4 minutes, compared to NBRTI's 42.4, a 1.8 percent difference between the two datasets. For off-peak trips, the two datasets produced virtually identical results.

Travel Time Savings

Introduction of the Orange Line service has resulted in reduced travel times and improved levels of service reliability. One of the original goals of the San Fernando Valley East-West Transit Corridor Project was to reduce travel times from 55 minutes to approximately 35 minutes for bus riders in the corridor [3]. Metro originally projected that implementation of the Orange Line would result in peak hour travel times between 29 and 40 minutes, with the variation "depending on the range of reasonable assumptions about signal delay developed during preliminary engineering" [1, 2]. According to the APC data provided by Metro and the travel time data collected by NBRTI, the average travel times achieved during peak travel hours are approximately 43 minutes, representing a 22 percent improvement over original travel times within the corridor. Yet, it must be noted that the Orange Line's improved travel times within the corridor still fall short of agency projections.

Two primary factors contribute to this shortfall. The first factor relates to the issue of "reasonable assumptions about signal delay" that were used in early estimates of Orange Line travel times. The accumulation of the savings achieved by TSP at each individual intersection (five to ten seconds) results in a significant time savings to the customer. However, owing to the Orange Line's short headways and the signal spacing along the corridor, the use of TSP does not guarantee an immediate green signal at every intersection. Thus, vehicles inevitably will be delayed at red lights at certain points along the corridor, a fact that was not considered in early travel time projections [21]. For more detailed information on TSP, please refer to Section 2, subsection "Intelligent Transportation Systems," and Appendix C, "Transit Signal Priority."

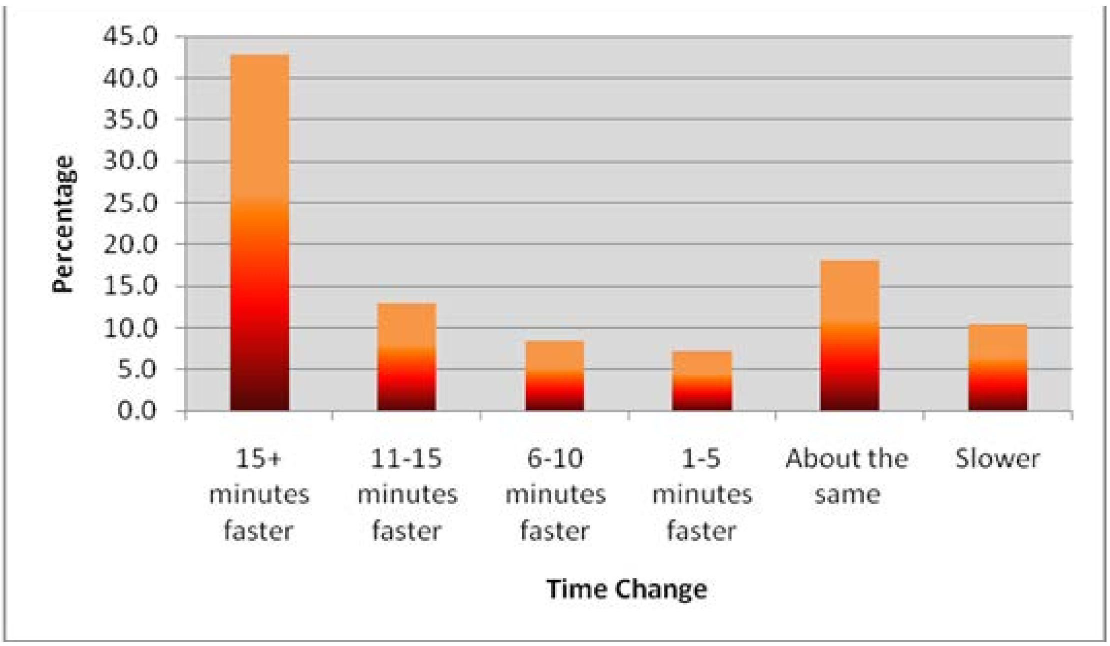
Second, Metro has been challenged by the issue of how to achieve the projected travel times while also complying with safety modifications at the busway's intersection crossings. As a result of several accidents that occurred at intersections early in the project's operations, Metro requires operators to decrease speeds to 10 mph while traveling through intersections (see Section 4, subsection "Safety"). This appears to have reduced some of the travel time benefit that normally would be expected from a segregated busway such as the Orange Line. Indeed, the issue of at-grade crossings may be a trend in the data. According to CBRT, busways that include some at-grade intersections have lower time savings than busways with total grade separation. However, although the travel time savings of the Orange Line have not been as dramatic as originally predicted, the dedicated busway has nonetheless resulted in highly reliable service, with virtually no difference between peak and non-peak running times (see Section 4, subsection "Reliability").

User Perceptions of Travel Time Savings

The NBRTI onboard survey asked respondents if their travel time changed with the implementation of the Orange Line. Figure 4-1 shows that the majority (71.3%) of respondents stated that using the Orange Line had reduced their travel time, while 18.8 percent stated that their travel time had remained unchanged, and approximately 10.5 percent stated that their travel time was now slower. Thus, more than 70 percent of riders perceived that their travel time had improved as a result of the Orange Line, with 43 percent reporting a travel time savings of 15 minutes or more.

Figure 4-1

User Perceptions of Change in Travel Time on Orange Line



The survey also asked respondents to rate "Travel time on this bus" on a five-point scale. Table 4-3 shows that the Orange Line received a mean score of 4.2. More than 83 percent of respondents rated travel time on the Orange Line as either "good" or "very good," while only 2 percent rated it as "poor" or "very poor."

Table 4-3

Consumer Ratings of Travel Time on Orange Line

Travel Time on this Bus	Orange Line Value
Very Poor	0.5%
Poor	1.6%
Fair	14.9%
Good	39.4%
Very Good	43.7%
Mean Score	4.2

Data presented in Table 4-4 compare responses received to the questions "If you previously made this trip, how has the Orange Line affected the length of this trip?" and "Before the Orange Line opened, how did you make this trip?" As shown, the vast majority of responses for trips that were previously completed by using some form of transit (80% for Metro Rail Line, 71% for MetroLink, 85% for other Metro bus routes, 100% for Muni Bus) reported a faster travel time than before. Although 28 percent of responses for trips that previously were made by driving alone indicated an increase in travel time, the majority (73%) reported the same or better travel time; nearly 39 percent indicated a travel time improvement, with more than 21 percent reporting a travel time savings of 15 minutes or more. For trips previously taken by carpooling, cycling, walking, or "Other," the majority of responses indicated that the trip was completed faster on the Orange Line than on the previous mode.

Table 4-4

Impact of Orange Line on Travel Time for Prior Modes Used

Travel Time Impact	Mode Used Prior to Orange Line									
	Drove Alone	Car pooled	Bicycled	Metro Link	Walked	Metro Rail Line	Metro Bus Route	Muni Bus Route	Didn't make trip	Other
15+ min faster	21.3	29.5	30.0	42.3	34.8	55.0	58.0	50.0	41.8	47.6
11–15 min faster	7.5	11.4	30.0	13.0	8.7	10.0	12.6	50.0	13.9	23.8
6–10 min faster	5.0	6.8	10.0	8.5	13.0	0.0	9.8	0.0	11.4	4.8
1–5 min faster	5.0	9.1	10.0	7.5	17.4	15.0	4.2	0.0	7.6	0.0
About the same	33.8	29.5	10.0	18.3	8.7	10.0	11.9	0.0	20.3	4.8
Slower	27.5	13.6	10.0	10.5	17.4	10.0	3.5	0.0	5.1	19.0
Total	100	100	100	100	100	100	100	100	100	100

To examine the perception of travel time among survey participants who previously made the trip by motor vehicle, an analysis was conducted of those who responded that they had previously driven alone or carpooled prior to using the Orange Line. Table 4-5 shows that approximately 77 percent of riders who switched from private motor vehicle to using the Orange Line experienced the same or better travel time. Forty-five percent reported an improvement in travel time, with nearly a quarter stating that their travel time improved by 15 minutes or more.

Riders who indicated that they had either driven or carpooled prior to the implementation of the Orange Line were also asked if they had previously used the 101 Freeway. Responses from participants who answered affirmatively were cross-tabulated with responses to the question, "If you previously made this trip, how has the Orange Line affected the length of this trip?"

Table 4-5

Perceived Travel Time Change According to Prior Motor Vehicle Use

Perceived Change in Travel Time	Orange Line Value
15+ min faster	23.8%
11–15 min faster	9.0%
6–10 min faster	5.7%
1–5 min faster	6.6%
About the same	32.0%
Slower	23.0%

As shown in Table 4-6, 44.2 percent of those who previously had not used the 101 Freeway indicated that using the Orange Line had improved their travel time, with 18.6 percent reporting a travel time saving of 15 minutes or more. In comparison, a nearly equal proportion (45%) of the respondents who previously used the 101 Freeway indicated that using the Orange Line had improved their travel time, though a larger share (nearly a third) reported saving 15 minutes or more of travel time.

Overall, the majority (75%) of the respondents who previously used the 101 Freeway indicated that their travel time was either about the same or had improved with the Orange Line. Of those who had not previously used the 101 Freeway, an even larger majority (79.1%) indicated that their travel time was either about the same or had improved with the Orange Line.

Table 4-6

Perceived Travel Time Change According to Prior Use of Freeway 101

Perceived Change in Travel Time	Did you use Freeway 101?
15+ min faster	29.2%
11–15 min faster	9.7%
6–10 min faster	1.4%
1–5 min faster	4.2%
About the same	30.6%
Slower	25.0%

Reliability

In CBRT, three types of reliability are addressed. Running time reliability and station dwell time reliability are related to the ability to consistently meet scheduled times or specified travel times. The third type, service reliability, describes system characteristics that contribute to rider perceptions of overall availability and dependability of the service. This evaluation focuses on running time reliability.

Running Time Reliability

CBRT outlines three performance indicators that have been developed to measure running time reliability. These are shown in Table 4-7 and include:

- *Ratio of Minimum to Maximum Travel Time* – this ratio is the travel time differential between peak and non-peak travel times computed by dividing peak hour travel time by non-peak hour travel time; a higher ratio represents a greater impact from peak hour traffic conditions on travel times.
- *Running Time Reliability (Coefficient of Variation)* – computed by dividing the standard deviation of running time by the average running time.
- *Survey of Customer Perception of Reliability* – this measure is discussed in Section 4, subsection "User Perceptions of Reliability."

Table 4-7 provides the mean and standard deviation of travel times on the Orange Line, calculated from the March 2009 APC data provided by Metro. Table 4-8 includes the performance indicators developed from the information in Table 4-7. The ratio of peak to non-peak travel time represents the impact of peak-hour traffic conditions on total end-to-end travel times. The ratio for the Orange Line is approximately 1, which indicates negligible variability between peak and non-peak travel time. Specifically, the peak/non-peak ratio for both directions combined is 1.008. Because the Orange Line service travels on an exclusive ROW, the travel times are not significantly impacted by varying traffic conditions and can maintain consistent levels of performance throughout the day.

Table 4-7

Mean and Standard Deviation of Travel Time on the Orange Line

Mean Travel Time (mm:ss)			Standard Deviation of Travel Time (mm:ss)		
Peak	Off-Peak	Total	Peak	Off-Peak	Total
43:24	43:04	43:14	04:02	04:22	04:13

The coefficient of variation is a performance indicator used to measure running time reliability and is the ratio of the standard deviation of the travel time to the mean travel time. Table 4-8 shows that the coefficient of variation is approximately 0.1 for both directions, providing further evidence of low variability in travel times.

Table 4-8

Orange Line Running Time Reliability Performance Indicators

Mean Peak (mm:ss)	Mean Off Peak (mm:ss)	Ratio (Peak/Off Peak)	Coefficient of Variation
43:24:00	43:04:00	1.008	0.098

Table 4-9 provides the difference between scheduled and actual travel times on the Orange Line recorded during NBRTI's 2010 travel time data collection effort. Travel in the direction of North Hollywood adhered more closely to the schedule, deviating an average of 15 seconds from the allotted travel time, compared to an average deviation of 51 seconds when traveling toward Warner Center. During PM peak operation, trips in both directions experienced travel times more than 60 seconds longer than scheduled, with North Hollywood bound taking 1 minute, 11 seconds more than the allotted travel time, and Warner Center bound taking 2 minutes, 31 seconds longer than scheduled. Overall, the Orange Line operates on time, deviating an average of 32 seconds from the time allotted by the schedule.

Table 4-9

Difference between Scheduled and Actual Travel Times

	Mean Difference between Scheduled and Actual Travel Times (sec)				Standard Deviation of Mean Difference between Scheduled and Actual Travel Time (sec)			
	AM	OFF	PM	Total	AM	OFF	PM	Total
North Hollywood Bound	-00:13	00:06	01:11	00:15	02:41	01:54	02:40	02:26
Warner Center Bound	-01:00	00:50	02:31	00:51	01:47	03:09	01:56	02:43
Both Directions	-00:32	00:28	01:52	00:32	02:20	02:34	02:16	02:34

Schedule Adherence

While the previous analysis of the Orange Line's reliability focused on end-to-end travel time, this subsection examines reliability over the length of the route. Schedule adherence, often assessed in terms of on-time performance, refers to the ability of a transit service to consistently meet its schedule.

Table 4-10 provides a directional summary of on-time performance data collected by NBRTI, expressed as the percentage of early, on-time (within one minute of scheduled time), or late arrivals at time points. For both directions of travel, approximately 70 percent of trips were between one minute early and three minutes late. However, it should be emphasized that for high frequency transit service such as the Orange Line, headway adherence is a more important indicator of reliability than schedule adherence. Headway adherence is discussed in the next subsection. (For a detailed summary of on-time performance by time point, please refer to Appendix B.)

Table 4-10
On-time Performance Assessment of the Orange Line

	North Hollywood Bound	Warner Center Bound
> 1 min early	18.8%	13.5%
On time	34.9%	41.1%
1 to 3 min late	35.4%	29.8%
3 to 5 min late	4.7%	11.4%
> 5 min late	6.0%	4.3%

As an anecdotal note, the first published schedules for the Orange Line originally were based on average runtimes for the entire route, with running boards containing only departure times from the near terminal and free running time to the far terminal. Due to the lack of any intermediate time points for regulating speed and trip spacing, these schedules were not very accurate; on-time performance lagged behind that of local bus service and vehicle bunching was an issue. On-time performance was elevated to top priority in April 2009, resulting in the addition of three intermediate time points to the Orange Line running boards. The introduction of the time points improved on-time performance on the Orange Line from 55 percent to approximately 90 percent, compared to the Metro local bus service's on-time performance of 75 percent. Metro considers a vehicle to be on time if it is between one minute early and five minutes late [24].

Headway Adherence

For high-frequency service, typically defined as service operating at headways of ten minutes or less, headway adherence is the most important indicator of reliability. Headway adherence is the ability of a transit service to maintain uniform vehicle spacing. A problem that sometimes can occur with high frequency service is "bunching," whereby one vehicle essentially catches up with the vehicle in front of it. Bunching can result from unexpectedly long (or short) dwell times at a station or from signal issues, for example. Once it occurs, bunching tends to propagate as vehicles travel along a route, causing uneven passenger loading and additional delay, which ultimately requires the use of more vehicles to serve a given number of passengers. When buses are evenly spaced, passenger loading is more uniform and cumulative passenger wait times are reduced.

An examination of the March 2009 APC data was conducted to determine how often vehicles arrived at stations within one minute of each other. The assumption was that if another vehicle arrived at a station less than one minute behind another vehicle, bunching was occurring. According to this definition, the data indicated that for weekday peak periods, bunching occurred on about 10 percent of trips at most. The data also showed that in the eastbound direction, bunching generally begins to occur at Reseda Station. However, the most bunching was found to occur in the westbound direction beginning at Van Nuys Station.

This information was confirmed by discussions with Metro staff, who further noted that Van Nuys Boulevard is the busiest north-south corridor along the Orange Line alignment, with many government services, businesses, and connections to other transit services. In addition, the signal at Van Nuys Boulevard has a relatively short green for the Orange Line [22].

As a further note in regard to bunching, the addition of the intermediate time points previously mentioned in Section 4, subsection "Schedule Adherence" not only improved on-time performance, but significantly reduced the occurrence of bunching [24]. To maintain even headway spacing, Metro also developed a set of standard operating procedures for Orange Line vehicle operators. For a detailed description of these, please refer to Section 2, subsection "Service and Operations."

User Perceptions of Reliability

The NBRTI on-board survey asked respondents to rate "Dependability of the Bus (on-time performance)" on a five-point scale. Their responses are shown in Table 4-11.

Table 4-11 shows that the Orange Line received a mean score of 4.3, higher than the average rating (4.2) for other aspects of service (see Appendix A, Table A-8). Most respondents (82.2%) rated service reliability on the Orange Line as either "good" or "very good," while only 2.5 percent rated the service as "poor" or "very poor."

Table 4-11
Consumer Ratings of Orange Line Reliability

Dependability of Bus (on time performance)	Orange Line Value
Very Poor	0.9%
Poor	1.6%
Fair	15.4%
Good	34.5%
Very Good	47.7%
Mean Score	4.3

Image and Identity

Research has shown that if transit is to attract choice riders, it must not only offer competitive travel times and high-quality service, but also convey an attractive image. To increase its appeal to choice riders, an important objective of BRT is to establish an image and identity separate from local bus operations. This discussion focuses on two key aspects of image and identity—brand identity and contextual design—followed by a summary of recent research on the importance of image and perception to BRT.

Brand Identity

According to CBRT, brand identity is the combination of elements that identifies and distinguishes a brand and forms its overall perception in the consumer's mind [10]. Brand identity can be thought of as the outward expression of a brand, including not only visual elements, but all things encompassing the senses. In addition to physical design and aesthetics, identity and image also relate to aspects of service quality. For BRT, brand identity involves the holistic "packaging" of a broad range of attributes into an attractive product.

A BRT service with a well-designed brand identity will more likely be perceived as an enhanced transit service that caters to a niche travel market. As discussed in Section 2, subsection "Branding, Marketing, and Community Outreach," the Orange Line has a color-coded name designation, appears on the map of the regional Metro Rail network, and features sleek, modern vehicles painted in the same silver-gray color pattern as the newest Metro Rail vehicles. These elements distinguish the Orange Line from the local bus service and contribute to the line's brand identity as part of a premium "high-speed network."

Figure 4-2

Rail-Inspired Design of Orange Line Vehicle

A unified BRT brand identity also can help to convey important customer information such as routing and stations served, as well as alerting infrequent customers as to where they can board. To ensure a consistent, recognizable brand identity along the Orange Line, graphics, color palettes, and icons are coordinated across vehicles, stations, signs, maps, and other project elements. These same branding devices are also incorporated into the basic design of the stations, which is consistent throughout the entire line, with integrated art elements developed in a fashion similar to the art in Metro rail stations.

In addition to physical design and aesthetics, elements of the Orange Line's brand identity also relate to aspects of service quality such as reliability, comfort, and convenience. For instance, the Orange Line's 14.5-mile exclusive busway may reinforce the perception of reliable service, while the sleek-looking Metro Liner vehicles, fully-appointed stations, TPIS, off-board fare payment, and near-level boarding may enhance the customer's sense of comfort and convenience.

Figure 4-3

Various Branding Devices of Orange Line

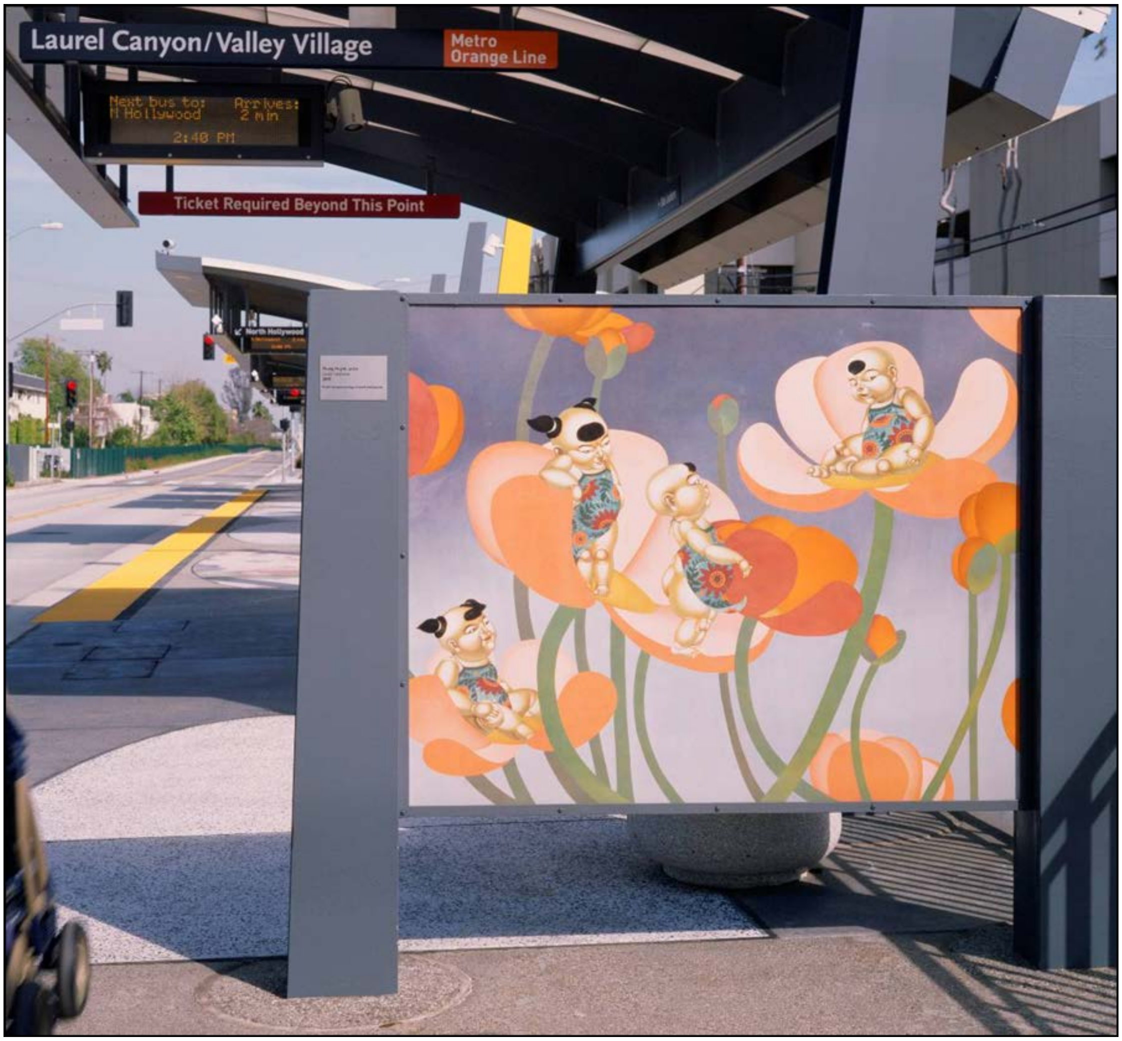
Contextual Design

Contextual design is the integration of the physical design elements of a BRT project into a singular design aesthetic that complements the urban environment. Good contextual design can channel a wide spectrum of benefits relating to the environment, public health and safety, accessibility, and aesthetics. Quality of life is enhanced when systems are designed to complement the scale and character of the surrounding area and create a sense of place for the communities they serve. Accessibility and connectivity to the broader urban fabric should be emphasized as crucial elements of contextual design. Because transit facilities serve as a transition between different modes, they must be carefully tailored to balance the needs of pedestrians, bicyclists, transit riders, motorists, and people with disabilities [10].

To create a sense of place, the uniformly designed Orange Line stations each feature artwork by a different California artist. Artworks are positioned in the same locations at each station, creating a consistent and recognizable design aesthetic with a series of unique identifiers. Large, elliptical terrazzo paving is visible from the vehicle as well as the platform. Porcelain enamel steel art panels are placed to greet customers as they arrive. These artworks reflect the character of the surrounding communities and incorporate aspects of San Fernando Valley history. Other artist-designed amenities include seating and several landscaping elements. Additional features such as the bicycle and pedestrian path, sound walls, and irrigated landscaping soften the look of the busway and add aesthetic and recreational value to surrounding neighborhoods.

Figure 4-4

Steel Art Panel at Laurel Canyon Station



Source: Los Angeles County Metropolitan Transportation Authority

The Orange Line's Metro Liner vehicles have space for two bicycles and two wheelchairs. On-board video monitors recently were installed for an added level of security. Each station offers bicycle racks and lockers, covered seating, ticket vending machines, telephones, enhanced lighting, spacious sidewalks, and security cameras. Six stations have lighted park-and-ride lots, supplying a total of 3,800 free parking spaces.

Land use in San Fernando Valley was also a key consideration in selecting the Orange Line running way and stations over simpler BRT configurations. The long-term development plan for Los Angeles includes high-capacity transit at certain major activity centers to encourage transit oriented development (TOD). Please refer to Section 5, subsection "Transit Supportive Land Development," for more detailed information on the subject of land use.

Figure 4-5

Community Bike Path Adjacent to Orange Line

Research on the Importance of Image and Perception

Research has shown that if transit is to attract discretionary riders, it must not only offer competitive travel times and high-quality service but also be complemented by an attractive image. Although BRT is designed to emulate the high-quality service of rail-based transit, little quantitative evidence exists regarding BRT's ability to replicate the premium image and associated ridership attraction benefits of rail. NBRTI recently completed a study to address this question and to quantify the tangible and intangible factors that drive perceptual differences between alternative transit modes [11]. "Tangible" service attributes refer to those that are functional and objectively quantifiable, whereas "intangible" attributes are abstract, subjective, and more difficult to measure and quantify. NBRTI conducted a series of focus groups in late 2007, followed in 2008 with an attitudinal survey of 2,400 transit users and non-users. Research was fielded in Los Angeles due to the range of different rapid transit modes in the area.

- Metro Local is the conventional bus service that operates throughout the city. Buses are distinguished by their bright orange color or an orange stripe. Weekday boardings in FY 2008 averaged 1,153,758.
- Metro Rapid (BRT-Lite) represents the lower-investment approach to BRT that typically runs in mixed traffic, using relatively low-cost applications such as TSP, intersection queue jumps, headway-based schedules, and far-side stops to provide improved commercial speeds and reliability. The Metro Rapid consists of a 450-mile network of routes throughout the city, has a unified brand identity and enhanced stops with lighting, canopies, and

real-time information. In FY 2008, average weekday boardings for the 25 Rapid lines operated by Metro were estimated at 242,000.

- Metro Orange Line (Full-Service BRT) operates on an exclusive busway, representing the high end of the BRT investment and performance spectrum. For a full description, see Section 2 of this report. The Orange Line averaged 23,352 weekday boardings in FY 2008.
- Metro Blue Line (Light Rail) serves 22 stations and traverses much of the densely populated area through South Los Angeles, Watts, Willowbrook, Compton, and Long Beach, which includes some of the most economically-deprived areas of the city. The average weekday boarding for FY 2008 was 75,564.
- Metro Gold Line (Light Rail) spans 13.7 miles from downtown Los Angeles to eastern Pasadena, adjacent to the heavily-congested Pasadena and Foothill freeways. Weekday boardings in FY 2008 averaged 20,514.
- Metro Red Line (Heavy Rail) operates solely underground and provides high-speed service to the city's most densely populated areas. Weekday boardings in FY 2008 averaged 134,665, making it the busiest rail line in Los Angeles.

Analysis of the focus group transcripts revealed a large number of potential service attributes that affect overall perceptions. These were separated into tangible and intangible variable groups and then synthesized into 14 core variables that were incorporated into the attitudinal survey. These variables are described in Table 4-12.

Table 4-12

Tangible and Intangible Factors Identified in Focus Groups

Tangible Variables	Intangible Variables
Travel cost – transit fares, plus related costs like parking	Safety while riding the service – safety from accidents and/or crime
Door-to-door travel time	Comfort while riding – seats available, temperature, smooth ride, cleanliness, etc.
Frequency of service – how often the service runs	Safety at the station/stop – safety from accidents and/or crime
Hours of service – how early or late service runs, and/or weekend hours	Comfort at the station/stop – shelter from weather, amenities, etc.
Convenience of service – goes where you need to go/parking availability	Customer service – provided by drivers and other transit service staff
Reliability of service – does the service run on time?	Ease of service use – clear service info, routes easy to figure out, etc.
	Other riders – feeling secure/at ease/compatible with others using the service
	Avoidance of stress/cost of car use – traffic, parking, accidents, tickets, etc.

Approximately 400 respondents from each of the six identified transit modes were sampled for the attitudinal survey, as were 400 non-transit users. Because the six transit services are dispersed throughout greater Los Angeles, respondents living in different areas could not provide valid information on the likelihood of using the different services. Thus, rating each service from 1 (very poor) to 5 (very good) was used as a proxy for ridership attraction.

Study Findings

Survey data analysis showed that statistically significant differences existed in the overall ratings of the alternative transit modes, which were separated into four different tiers, ordered lowest to highest in overall rating:

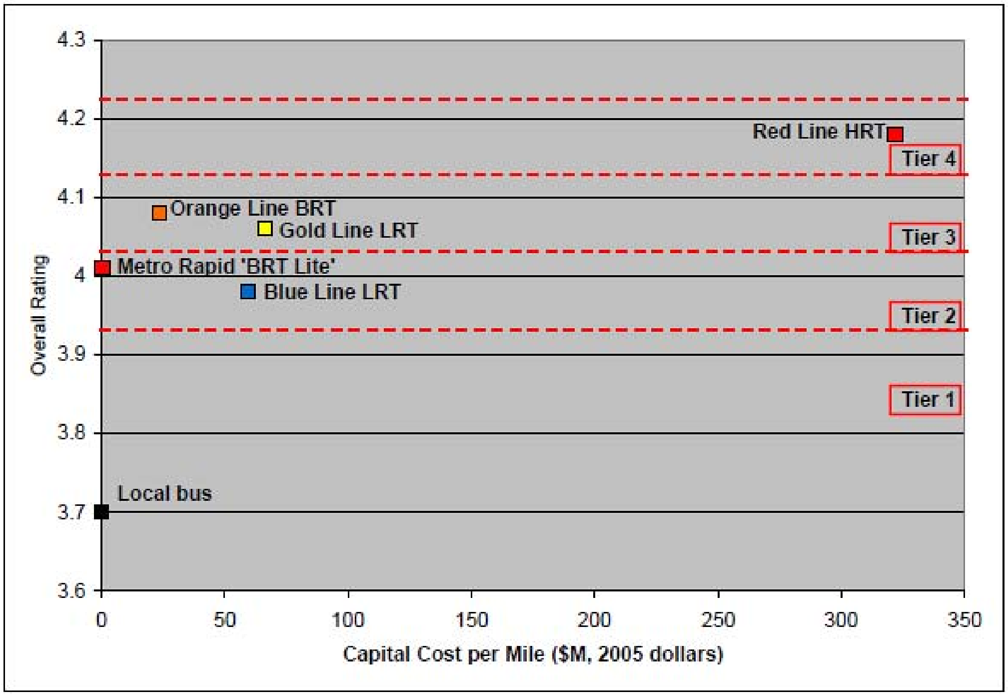
- Tier 1: Local bus service (mean overall rating of 3.70)
- Tier 2: Metro Rapid BRT and Blue Line LRT (mean overall ratings of 4.01 and 3.98, respectively)
- Tier 3: Orange Line BRT and Gold Line LRT (mean overall ratings of 4.08 and 4.06, respectively)
- Tier 4: Red Line HRT (mean overall rating of 4.18)

These findings show that people do perceive alternative rapid transit modes differently; moreover, differences in perception appear to be independent of any particular mode or technology. However, overall ratings generally followed the relative level of investment required to provide each service. To investigate this issue further, the actual level of investment of each mode, defined as capital cost per mile in 2005 dollars, was considered. Figure 4-6 compares each mode in terms of overall rating and actual level of investment, and also shows the four tiers described above.

This analysis showed a large disparity in investment level, with the Red Line costing approximately 1,000 times more than the local bus service. Yet, aside from these two obvious extremes, the ratings achieved by the remaining transit services did not directly correspond to investment levels. For Tiers 2 and 3, both the Metro Rapid "BRT-Lite" and Orange Line "Full-Service" BRT outperform their investment costs, achieving a slightly higher rating than the light rail systems grouped within the same tier. For example, the Metro Rapid achieved a rating equivalent to the Blue Line LRT for a fraction of the investment cost per mile ($0.355 million vs. $59.1 million). Given that the investment level associated with the Metro Rapid is much closer to the local bus than to any of the other modes, it was concluded that the Metro Rapid performs remarkably well in terms of overall rating achieved per dollar of investment, and therefore represents a very cost effective form of BRT. The Orange Line achieved an overall rating that was equivalent to the Gold Line and significantly higher than the Blue Line, for approximately one-third the capital investment. This indicates that the Orange Line also performs well in terms of overall rating achieved per dollar of investment, although not to the dramatic level associated with the Metro Rapid.

Figure 4-6

Overall Rating of Each Transit Mode vs. Capital Cost per Mile



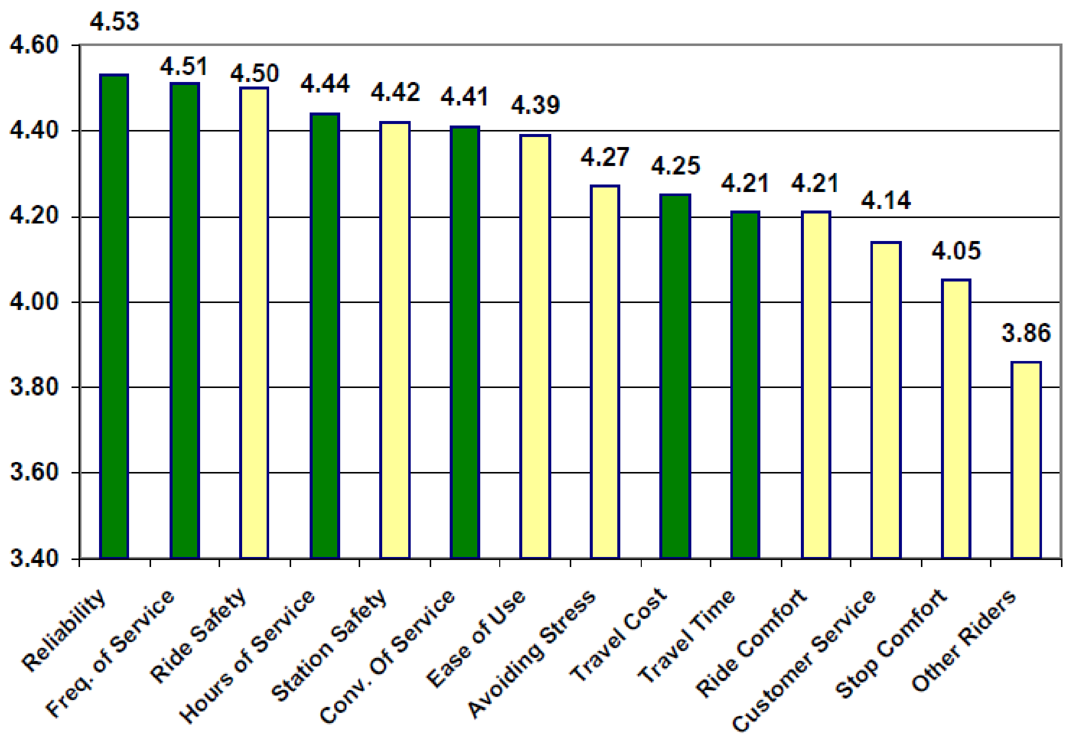
It was found that intangible service attributes have a significant influence on modal perceptions. While the Orange, Gold, and Blue Lines received comparable tangible attribute ratings, the Orange and Gold Lines achieved significantly higher ratings for the key intangible attributes of safety while riding, safety while at the station, station comfort, and perceptions of other riders. Qualitative analysis of the focus group transcripts suggested that urban context exerts a significant influence on the relative attractiveness of transit services by directly impacting intangible service attributes such as perceptions of safety. While the Blue Line runs through some of the most economically-deprived areas of the city, the Gold and Orange Lines serve relatively affluent areas; thus, it may be these differences in urban context that are largely responsible for the discrepancy in overall rating between these modes. Indeed, urban context may be more influential in determining overall perceptions than whether a service is based on rail or bus technology.

When comparing the Orange Line and the Metro Rapid, which represent opposite ends of the BRT investment spectrum, it was found that the Orange Line's significantly higher overall rating originated in higher ratings on both the tangible and intangible attributes, though by far the largest single difference was in relation to station comfort. The fact that the Orange Line received superior ratings both for tangible and intangible attributes implies a greater likelihood of success in attracting the coveted "potential rider" market (those that could ride transit but choose to travel by private auto instead). However, while the Orange Line is perceived as superior, it should be noted that the Metro Rapid achieved an overall rating that was only slightly lower, while costing around 100 times less, per mile, to provide.

By assessing the influence of the different tangible and intangible attributes on the overall ratings of each mode, it was hoped that the source of perceptual differences could be determined. Figure 4-7 illustrates the average importance rating assigned to each tangible and intangible factor.

Figure 4-7

Aggregate Importance Rating for Each Tangible and Intangible Factor



Clearly, a mix of tangible and intangible attributes combine to determine modal perceptions. In terms of importance, the tangible attributes of reliability and service frequency received the highest ratings, along with the intangible attribute of ride safety. These were closely followed by the tangible attribute of service span and the intangible attribute of station safety.

Overall, the study findings show that Full-Service BRT can replicate both the functionality standards (tangible attributes) and image qualities (intangible attributes) normally associated with the higher-investment LRT mode. Nevertheless, even a lower-investment BRT-Lite service such as the Metro Rapid performs remarkably well in terms of overall rating achieved per investment dollar, and therefore represents a highly cost-effective form of BRT. However, the authors emphasize that the findings of this study were obtained in one U.S. city and cannot be generalized to other urban areas until further research has been conducted. It should also be noted that this study used overall modal ratings as a proxy for ridership attraction potential. Further research is required to verify whether this is a reasonable assumption, and whether the study findings may be generalized to other urban areas.

User Perceptions of Identity and Image

On-board survey respondents were asked to rate the following aspects of the Orange Line branding efforts:

- Ease of identifying Orange Line service
- Location of Orange Line signage
- The look / design of the new vehicles used for the Orange Line

The ratings received for these service aspects are shown in Table 4-13, along with overall ratings for the Orange Line and other services provided by Metro.

Table 4-13

Consumer Ratings for Different Aspects of the Orange Line

Orange Line Service Element	Response Category (%)						Mean Score
	Very Poor (1)	Poor (2)	Fair (3)	Good (4)	Very Good (5)	TOTAL	
Ease of identifying Orange Line service	0.5	1.6	9.5	37.6	50.9	100	4.4
Location of Orange Line signage	0.9	1.8	14.0	39.7	43.6	100	4.2
Look/design of the vehicles	0.5	0.9	9.4	37.2	52.1	100	4.4
Overall satisfaction w/Orange Line	0.4	0.9	7.0	34.2	57.5	100	4.5
Overall satisfaction w/ Metro	2.0	2.3	13.3	36.9	45.5	100	4.2

The majority of survey responses provided high ratings to all three elements related to service branding, with the majority of responses providing a "good" or "very good" rating for "Location of signage" (83.3%), "Ease of identifying service" (88.5%), and "Look/design of the vehicles (89.3%). The ratings given for "Ease of identifying Orange Line service" and "Look/design of the Orange Line vehicles" were the highest, each with a mean score of 4.4. Also, overall satisfaction with the Orange Line was rated higher than overall satisfaction with Metro, although the mean scores were close, with values of 4.5 and 4.2, respectively.

Table A-7 in Appendix A summarizes the additional comments on the Orange Line. Approximately 48 percent of the comments were positive in general as compared to approximately 12 percent of generally dissatisfied comments. The majority of the comments were made on the theme of service provision (38.3%).The most frequently cited comment was the great service received by the riders (10.5%), followed by the need for more stops and better routes (9.9%) and the need for better timing / synchronization (6.2%). The need for improvements on the vehicles made up the second largest group of comments (11.7%). The comment cited most frequently in this section was the need for improved safety and security (3.7%).

A variety of comments were made about the Orange Line vehicle operators. Only one respondent (0.62%) gave a positive comment (good drivers/courteous drivers), while 11 respondents (6.79%) gave negative comments. Criticisms included not waiting for people, poor driving (too fast/jerky/leave before people can sit down), and not enforcing the rules (for example, controlling rowdy student passengers).

Safety and Security

Safety

Safety is the level of freedom from hazards experienced by passengers, employees, pedestrians, occupants of other vehicles, and others who interact with the transit system. Investment in BRT elements offers the potential to positively influence safety relative to conventional bus operations. A key expected safety implication from partially-separated or exclusive running ways is that vehicle collision rates tend to decrease as the degree of running way exclusivity increases. However, given the small number of U.S. BRT systems and the short time period most have been in operation, the actual safety characteristics of BRT have not been fully determined. In general, two performance measures reflect the quality of a transit agency's safety management: accident rates and public perception of safety [10].

During construction of the Orange Line, Metro worked closely with LADOT to build the following safety infrastructure into all busway intersections:

- To prevent motorists from blocking an intersection or placing their vehicle in the path of an approaching bus, many street intersections are marked as "Keep Clear" zones.
- Turning on a red or yellow light at intersections is strictly prohibited.
- "Do Not Enter" signs and other directional signs are located on both sides of busway entrances to deter motorists from accidentally driving onto the busway.
- When buses approach the intersection, flashing electronic "Bus Coming" signs are activated.
- Crosswalks at busway intersections and mid-block pedestrian crossings allow pedestrians and bicyclists to safely access stations.
- Metro also constructed four signalized pedestrian crossings to help members of the community to safely access the other side of the busway.

As part of a safety program created specifically for the Orange Line, Metro also distributed an interactive safety presentation to more than 30,000 residents within a mile radius of the busway and delivered safety presentations to more than 100 schools in the area. The safety program is described in more detail in Section 2, subsection "Branding Elements and Marketing Strategy."

Despite the implementation of these safety measures, a series of collisions and near-miss incidents occurred during initial months of operation, primarily due to motorists running red lights at busway intersections. As of April 2010, the Orange Line was involved in a total of 58 accidents at busway intersections since beginning operation. Only one of these reported intersection accidents was due to negligence on behalf of an Orange Line operator; all other accidents were the fault of the other party involved. Although existing policy already restricted speeds to a maximum of 55 mph along the busway and 25 mph at intersections, these accidents prompted Metro to issue a "slow order" that further reduced running speeds at all intersections to 10 mph until further notice.

In addition, Metro convened a Safety Task Force composed of key members from Metro, the City of Los Angeles, and the Los Angeles Police and Sheriff Departments. Upon the recommendation of the Task Force, Metro installed red light photo enforcement cameras at 12 high-risk intersections to deter red light running. Improvements also included additional motorist signage regarding right turn restrictions, increased signal timing at red lights to give buses more time to clear intersections, and green arrow right-turn signals to decrease confusion on the part of motorists. To improve bus visibility and clarify roadway rules, additional signage and warning signals were installed, including:

- Directional "arrow" traffic signals that specify the exact direction of travel, to emphasize the prohibition of turning right on red
- "Bus Xing," "No Right Turn on Red" signs at intersections
- "Keep Clear" and "Wait Here" pavement markings at intersections
- "Look Both Ways" pedestrian warning signs
- Flashing "Bus Coming" signs lowered to be immediately adjacent to "No Right Turn on Red" signs

Figure 4-8

Pedestrian Warning Sign (left) and Directional Traffic Signal at Busway Intersection (right)

Accident Rates

The additional safety features described above appear to have had a positive impact on the overall safety of the busway by substantially lowering the occurrence of reported accidents and near miss incidents. Over the course of the Orange Line's inaugural year, the number of near misses declined steadily, from 709 during the first month of service to only 72 by October 2006. Since June 2006, the Orange Line has maintained a lower accident rate than the Metro system as a whole, as shown in Table 4-14. It should be noted that the accident rates shown in the table include incidents that occurred while Orange Line vehicles were operating off the dedicated busway and while out of service.

Table 4-14
Metro Orange Line Collision Rates per 100,000 Scheduled Miles

Fiscal Year	Orange Line	All Metro Lines
2006	2.23	3.37
2007	1.55	3.69
2008	1.90	3.43
2009	1.13	3.03
2010*	1.04	2.82

* Fiscal Year to date through August 2009 (Source: Metro)

According to CBRT, at-grade crossings are a key aspect of safety performance that should be addressed during the development of a BRT project, especially on segregated or off-street rights-of-way [10]. The Orange Line experience reinforces the notion that safety incidents are likely to occur on at-grade systems soon after deployment, when drivers are not yet accustomed to the busway but that educational outreach and comprehensive safety measures can effectively address these issues. However, despite dramatic improvements to accident rates since the opening of the Orange Line, the 10 mph intersection speed restrictions remain in place, contributing to longer travel times than originally projected.

Security

The objective of transit system security is to minimize the frequency and severity of potential or perceived criminal threats to passengers, employees, and property. Physical design elements, service and operational characteristics, advanced technologies, surveillance, and enforcement all contribute to the level of passenger security. However, as with safety, the lack of available data means that it is not yet possible to determine the impact of particular BRT elements on transit system security [10].

Metro has contracted with the Los Angeles Sheriff's Department to provide 24-hour security on the busway and at stations, including motor, cruiser, and horse-mounted patrols. Trespassing on the busway is strictly forbidden and offenders may be issued a fine up to $500. Orange Line stations and key busway intersections are well-lit and are equipped with CCTV surveillance cameras, which are monitored 24 hours a day by Metro's BOC in downtown Los Angeles. In addition to the public telephones installed at each station, customers are able to use the emergency assistance telephone to report safety or security concerns directly to a live operator at the BOC. The BOC operator can make special safety and security announcements to all station patrons through the public address system.

Figure 4-9

Live Video Feed of Orange Line at Metro BOC

All Metro buses, including Metro Liners, are equipped with a silent alarm system. The silent alarm can be activated by the operator when a crime is in progress and activation of an obvious alarm would put the operator in danger. Vehicles are equipped with Automatic Transportation Monitoring Systems (ATMS), which use terrestrial communications and GPS technologies to integrate video monitoring, mobile voice and data communications, computer aided dispatch (CAD), and AVL. ATMS gives a controller the ability to find a potential problem, confirm it with an operator, and identify the vehicle's exact location. Although on-board digital cameras record only video events, discreet voice monitoring can occur during a silent alarm event.

Enforcement of proof-of-payment systems is essential for preventing fare evasion and maintaining low crime rates. Although there are no barriers to pass through on the Metro Orange Line, customers must have proof of payment in their possession at all times while riding. The Los Angeles Sheriff's Department and Metro's Transit Security/Fare Collection Inspectors conduct random fare inspections to verify payment. A passenger who is unable to produce a valid fare instrument may receive a citation for fare evasion and a fine of $250. Fare inspectors use a wireless handheld unit to verify that TAP users have validated their cards.

User Perceptions of Safety and Security

On-board survey respondents were asked to rate two different aspects of safety in relation to the Orange Line: safety while on the vehicles, and safety while waiting at stops.

The survey showed that personal safety on the Orange Line vehicle rated slightly higher than personal safety at stops, but both categories received a "good" rating. Only 4.3 and 3.9 percent of respondents rated personal safety on the vehicles and at stops as "poor" or "very poor," respectively. Overall, this suggests that user perceptions of personal safety while using the Orange Line are high.

Table 4-15

Customer Ratings of Safety of Orange Line Service

	Response Category (%)					
Service Element	Very Poor (1)	Poor (2)	Fair (3)	Good (4)	Very Good (5)	Mean Score
Personal safety on bus	1.1	3.2	12.9	39.9	42.9	4.2
Personal safety at stops	0.5	3.4	18.3	37.2	40.6	4.1

Capacity

System capacity refers to the maximum number of people or transit vehicles that can be moved past a point by a BRT line or system. Capacity is limited by the critical link, or bottleneck, within the BRT system. According to CBRT, the most appropriate measure of capacity for BRT systems is a concept called person capacity. Person capacity is the maximum number of passengers that can be moved along the critical section of the BRT route during a given period of time, under specific operating conditions, without unreasonable delay, hazard, or restriction and with reasonable certainty [10].

Different aspects of capacity are addressed in CBRT [10]. Maximum capacity is the unconstrained theoretical maximum capacity as determined by physical characteristics, such as size of the vehicles or the BRT facility. Design capacity is determined by operating policies and effectively scales down the maximum capacity to ensure passenger comfort, safety, and reliability. Operated capacity is based on the vehicles and service frequency that are actually operated, and tends to be less than maximum capacity because operation is scaled to passenger demand. This section discusses the design capacity of the Orange Line according to Metro operating policies, as well as the line's operated capacity.

Operating Policies and Capacity

The Orange Line operates with NABI 60-foot stylized articulated vehicles that have a seated capacity of 57 passengers. In terms of design capacity, Metro has adopted a peak-hour load standard of 120 percent, which is equivalent to the fully seated load plus 20 percent standees. The load standard is calculated as the ratio of the maximum number of passengers on board a vehicle at a given time to the number of seats and is expressed as a percentage (68 passengers/57 seats = 120%).

Accordingly, Orange Line vehicles are scheduled at a level not to exceed an average load of 68 passengers. However, Orange Line bus operators may continue to add passengers above the 68-passenger threshold if they determine that it is safe to do so.

Passenger loads are monitored at various times throughout the year and service levels are adjusted as required. When a load exceeds the 120 percent standard, a trip is added or other trips are adjusted to bring the loads into compliance. The load standard can also be adjusted in order to manage capacity. Metro may increase the current load standard to 1.3 in the near future, which would translate to a 74-passenger target.

The Orange Line operates at peak hour frequencies of 4 to 5 minutes, which equates to a one-way peak hour maximum of 14 vehicles. With each vehicle carrying up to 68 passengers, the operated one-way peak hour capacity is 952 passengers (68 * 14). According to a sample of APC data from March 2009, PM peak loads average 56 passengers along the line in the westbound direction and 43 in the eastbound direction. This translates to approximately 784 passengers per peak hour in the westbound direction (82% of seated and standing capacity) and 602 passengers per peak hour in the eastbound direction (63% of seated and standing capacity). Therefore, maximum operated carrying capacity per hour on the Orange Line is sufficient for the average passenger load experienced during peak-hour travel times.

Passenger Demand

Passenger demand characteristics such as the distribution of passengers over time and the distribution of passenger boardings and alightings among stations can impact capacity by affecting dwell times and by defining where maximum load points create potential bottlenecks. As described in the previous subsection, the maximum operated carrying capacity per hour on the Orange Line is sufficient for the average peak-hour passenger load. However, because capacity is largely determined by maximum passenger loads, the 95th percentile is a more useful statistic for evaluating capacity than the average passenger load. A percentile is the value of a variable below which a certain percent of observations fall. The 95th percentile is the passenger load value below which 95 percent of the observations fall. The 95th percentile yields a very accurate picture of maximum passenger loads because 95 percent of observations fall below it, while the top 5 percent of observations are eliminated. Thus, infrequent spikes in the data are ignored. The sample of APC data from March 2009 was used to calculate the 95th percentile of peak-hour passenger loads on the Orange Line.

Figure 4-10 shows the 95th percentile of peak-hour passenger loads by station in the eastbound direction (toward North Hollywood Station). As expected, for both AM and PM peak trips, passenger loads steadily increase in the eastbound direction as the Orange Line approaches its connection with the Red Line. However, only during the AM peak at Van Nuys, Woodman, Valley College, and Laurel Canyon Stations is the 68-passenger load standard significantly exceeded. The highest passenger load observed in the AM peak was 84 at Woodman Station, and in the PM peak was 69 at Van Nuys and Valley College Stations.

Figure 4-10

95th Percentile of Peak-Hour Loads by Station (Eastbound)

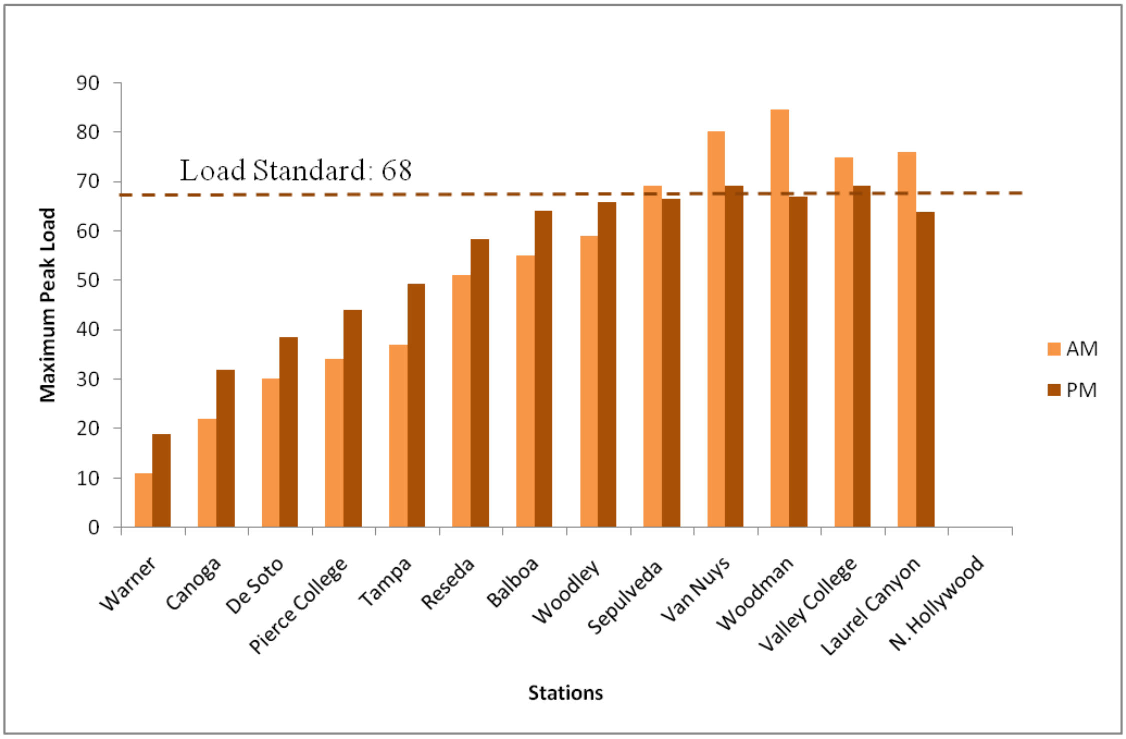


Figure 4-11 shows the 95th percentile of peak-hour passenger loads by station in the westbound direction (toward Warner Center). As an overall pattern, peak-hour passenger loads decrease in the westbound direction, although there is a slight increase at Woodley Station during the AM peak. The highest passenger load observed in the AM peak was 74 at Woodley Station, and in the PM peak was 73 at North Hollywood Station.

The 95th percentile values of peak-hour passenger loads by station are shown in Table 4-16 for both directions of travel. Values that exceed the 68-passenger load standard are shown in bold. A potential bottleneck in the system is created at maximum load points that occur in the AM peak in the eastbound direction at Sepulveda, Van Nuys, Woodman, Valley College, and Laurel Canyon stations, as the Orange Line nears its connection to the Red Line. For both directions of travel, loads in the PM peak are more moderate than in the AM peak. The highest value for the AM peak was 84 at Woodman Station (124% of seated and standing capacity). The highest value for the PM peak was 73 at North Hollywood Station (107% of seated and standing capacity).

Figure 4 -11

95th Percentile of Peak-Hour Loads by Station (Westbound)

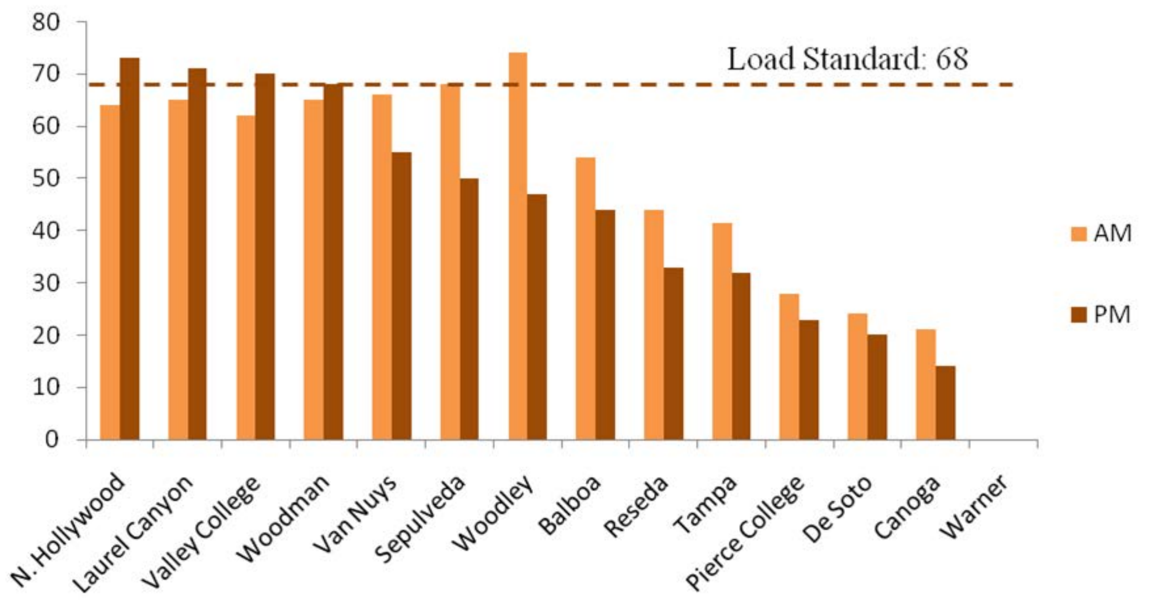


Table 4 -16

95th Percentile of Peak-Hour Loads by Station

	Eastbound		Westbound	
Station	AM	PM	AM	PM
Warner Center	11	19	--	--
Canoga	22	32	21	14
De Soto	30	39	24	20
Pierce College	34	44	28	23
Tampa	37	49	42	32
Reseda	51	58	44	33
Balboa	55	64	54	44
Woodley	59	66	74	47
Sepulveda	69	66	68	50
Van Nuys	80	69	66	55
Woodman	84	67	65	68
Valley College	75	69	62	70
Laurel Canyon	76	64	65	71
N. Hollywood	--	--	64	73

Table 4-17 shows the percentage of all peak-hour passenger load observations (including the top 5%) that exceeded Metro's 68-passenger load standard. Stations that did not exceed the load standard are not shown in the table. As expected, the stations with the highest percentages generally correspond to the AM "bottleneck" mentioned above, that occurs as the Orange Line approaches its connection to the Red Line at North Hollywood Station. Of particular note are Van Nuys and Woodman stations, where the current load standard was observed to be exceeded more than 15 percent of the time.

Table 4-17

Percent of Total Observations Exceeding Load Standard of 68

	Eastbound		Westbound	
Station	AM	PM	AM	PM
Balboa	1.20%	3.70%	--	--
Woodley	1.60%	4.80%	9.20%	--
Sepulveda	6.10%	4.70%	5.60%	--
Van Nuys	16.20%	6.30%	4.20%	0.60%
Woodman	20.80%	5.00%	3.30%	5.20%
Valley College	12.10%	5.60%	2.20%	8.80%
Laurel Canyon	12.10%	3.40%	3.40%	9.40%
N. Hollywood	--	--	3.70%	11.90%

Using the 95th percentile as an indicator, it can be concluded that although the maximum operated carrying capacity per hour on the Orange Line is sufficient along most of the route, it is not adequate at maximum load points. However, as previously mentioned, Metro may increase the current load standard to 1.3 in the near future, which would translate to a 74-passenger target. Table 4.18 shows the demand to capacity ratio for the current 68-passenger load standard, as well as for the possible future load standard of 74 passengers. The demand to capacity ratio is a standard measure used to determine capacity utilization. The highest observed 95th percentile load points (from Table 4-16) were used to calculate the demand to capacity ratios.

Table 4-18

Demand to Capacity Ratio at Highest Observed 95th Percentile Load Points

	Eastbound		Westbound	
Load Standard	AM	PM	AM	PM
1.2 (68 passengers)	1.24	1.01	1.09	1.07
1.3 (74 passengers)	1.14	0.93	1.00	0.99

At the current load standard, the demand to capacity ratio exceeds 1.0 during both of the peak travel periods and in both directions; however, PM peak loads are more moderate than in the AM peak for both directions of travel. If Metro were to increase the load standard to 1.3, the demand to capacity ratio for eastbound trips during the AM peak would exceed 1.0. With the exception of Sepulveda Station, this would occur primarily at the "bottleneck" stations described previously. For all other trips, the demand to capacity ratio would be equal to or approaching 1.0, indicating that system capacity may be maxing out. To increase capacity, Metro may consider bus platooning and limited-stop trip strategies. Reducing headways further is not a realistic option, as TSP would become ineffective. (For more detailed information on capacity, please see Appendix D.)

User Perceptions Relating to Capacity

Table 4-19 shows that approximately 63 percent of riders on the Orange Line rated the availability of seating on the vehicle as "good" or "very good." The Orange Line also received very few responses in the "poor" and "very poor" categories (5% and 3%, respectively). This is consistent with the results of the onboard survey, where only 4.3 percent of the comments received were related specifically to capacity, mentioning overcrowding on the vehicles and/or the need for more vehicles (see Table, A.7, Appendix A).

Table 4-19

Customer Ratings of Availability of Seating on Bus

Response Category (%)					
Very Poor (1)	Poor (2)	Fair (3)	Good (4)	Very Good (5)	Mean Score
2.9	5.0	29.3	34.5	28.2	3.8

Accessibility

Accessibility refers to how easily individuals with disabilities can use the transit system. The implementation of many BRT elements can significantly improve the accessibility of transit for people with disabilities, as well as for the general public. The accessibility of a transit system can be assessed based upon whether it has been designed to meet the overall mobility needs of all customers, including people with disabilities and older adults. According to CBRT, there are three major ways that elements of BRT can affect accessibility:

- Physical accessibility – removing physical barriers and facilitating entry into stations and vehicles.
- Accessibility of information – making information available to all passengers, especially those with vision and hearing impairments.
- Safety – providing enhanced safety treatments and preventing susceptibility to hazards through warnings and other design treatments.

In terms of physical accessibility, the Orange Line is configured for "near-level" boarding, with low-floor entries and exits that align with raised platforms designed to minimize the step-up into the vehicles. To facilitate boarding for passengers who use wheelchairs or other mobility aids, ramps at the front door of the vehicle can be deployed in 25 seconds. Access and circulation is enhanced by three extra-wide doors and unobstructed, low floors throughout the interior of the vehicle. In addition, five fold-down priority seats are provided for seniors and riders with disabilities, and there is space for two wheelchairs on-board. All station features are compliant with ADA (Americans with Disabilities Act of 1990) regulations.

Figure 4-12

Priority Seating Area for Older Adults and People with Disabilities

For enhanced access of information, automated voice annunciator (AVA) messages alert passengers of the next station, and external speaker and bus header screens at the front of the bus announce next-station arrivals.

Safety treatments at stations include enhanced lighting, emergency telephones, and security cameras, as well as visual and audio "bus approaching" warning messages communicated via the TPIS. Tactile warning strips (detectable by cane or underfoot) are used to alert people with vision impairments of their approach to the edges of boarding and alighting areas. The recreational path also has safety features such as fencing, crosswalks, and lighting. For an added level of security, video monitors were recently installed on vehicles.

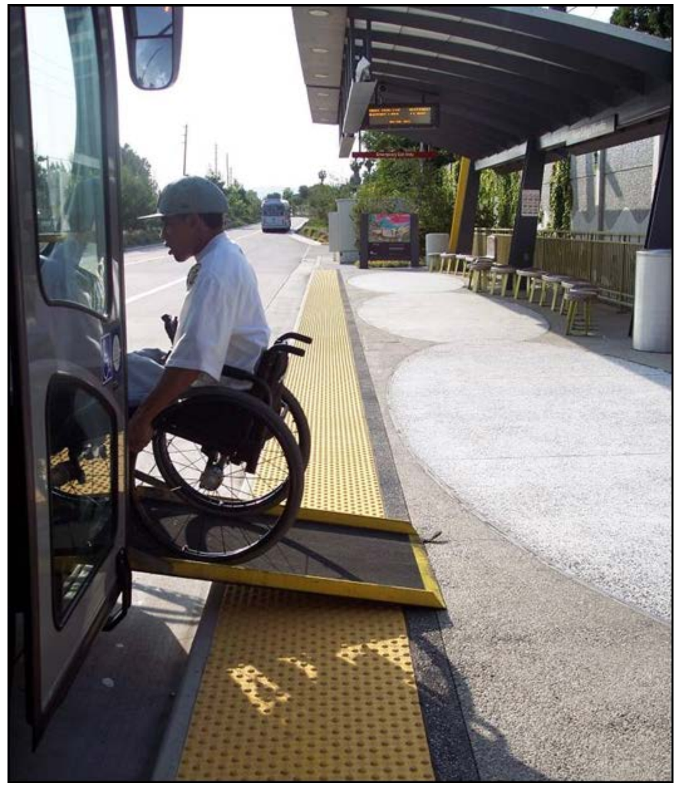


Figure 4-13
Wheelchair Ramp Deployed Over Tactile Warning Strip at Station

User Perceptions Relating to Accessibility

Survey participants who indicated personal use of a wheelchair when traveling on the Orange Line were asked to grade their experience of various aspects of the Orange Line's accessibility from 1 (very poor) to 5 (very good). As shown in Table 4-20, wheelchair securement (both rear- and front-facing) and boarding times for wheelchair users achieved ratings of "good," while ease of boarding and exiting vehicles and accessibility of vehicles to people with disabilities were rated just above or at "fair" levels of service, respectively. However, due to the small sample of participants who indicated use of a wheelchair (4 people), no conclusions should be drawn from the results shown below.

Table 4-20
Ratings of Orange Line Accessibility by Patrons Who Use Wheelchairs

	Response Category (%)					
Service Element	Very Poor (1)	Poor (2)	Fair (3)	Good (4)	Very Good (5)	Mean Score
Ease of getting on and off vehicles	0.0	0.0	50.0	50.0	0.0	3.5
Vehicle accessibility to people with disabilities	0.0	0.0	50.0	0.0	0.0	3.0
Rear-facing wheelchair securement	0.0	0.0	33.3	33.3	33.3	4.0
Front-facing wheelchair securement	0.0	0.0	33.3	33.3	33.3	4.0
Time it takes to board vehicles	0.0	0.0	33.3	33.3	33.3	4.0

Summary of Project Performance

In regard to safety, the Orange Line experienced a series of collisions and near-miss incidents during initial months of operation, primarily due to motorists running red lights at busway intersections. As of April 2010, the Orange Line has been involved in a total of 58 accidents at busway intersections since beginning operation. Only one of these reported accidents was due to negligence on behalf of an Orange Line operator; all other accidents were the fault of the other party involved. In response to these collisions, Metro reduced running speeds from 25 mph to 10 mph at all intersections. In addition, enhanced signage and warning signals were added and photo-enforcement cameras were installed at many of the Orange Line's intersections to deter red-light running. These additional safety measures have had a positive impact on the overall safety of the busway by substantially lowering the occurrence of reported accidents and near miss incidents. The number of near misses declined by 88 percent over the course of the Orange Line's inaugural year, and since June 2006 the Orange Line has maintained a lower accident rate than the Metro system as a whole.

Introduction of the Orange Line service has resulted in reduced travel times and improved levels of service reliability. Data collected by Metro and NBRTI show that the Orange Line has reduced average end-to-end travel time during peak hours in the corridor by approximately 7 minutes, equating to a 22 percent improvement over original travel times. TSP and a dedicated running way are contributing factors to the decrease in travel time. More than 70 percent of users perceive the Orange Line as faster than the previous service, with 43 percent of surveyed respondents indicating that the service was at least 15 minutes faster.

However, travel time improvements within the corridor still fall short of Metro's original projected range of 28.8 to 40 minutes. Two primary factors explain this. First, as a safety measure in response to several accidents that occurred shortly after the Orange Line began service, Metro enacted a 10 mph slow order for buses traveling through intersections. This appears to have reduced some of the travel time benefit that would normally be expected from a dedicated ROW such as the Orange Line. Second, although the cumulative time savings achieved by TSP over the entire Orange Line route are significant, an immediate green signal at every intersection cannot be guaranteed, due to the Orange Line's short headways and the signal spacing along the corridor. Thus, vehicles are inevitably delayed at red lights at certain points along the corridor, a fact that was not considered in early travel time projections.

Although the travel time savings of the Orange Line have not been as dramatic as originally predicted, the dedicated busway has resulted in highly reliable service, with virtually no difference between peak and non-peak running times. Customers are happy with reliability; most (82.2%) of survey responses rated service reliability on the Orange Line as either "good" or "very good." The Orange Line also consistently meets its schedule, with an average end-to-end deviation of only 32 seconds from the time allotted by the schedule. With respect to headway adherence, which is more important than schedule adherence for high frequency transit service, an examination of APC data provided by Metro found that vehicle bunching occurred at most on about 10 percent of weekday peak trips.

Metro has branded the Orange Line as part of the region's rail network by giving the line a color-coded name designation, including the route on the Metro Rail System Map, and using sleek, silver-gray vehicles. In addition, all stations have the same basic design and construction, ensuring a consistent, recognizable brand identity along the line. The majority of survey respondents provided high ratings to all three elements related to service branding, with the majority of survey respondents providing a "good" or "very good" rating for "Location of signage" (83.3%), "Ease of identifying service" (88.5%), and "The look/design of the vehicles (89.3%). Customers rated their overall satisfaction with the Orange Line higher than their overall satisfaction with Metro, although the mean scores were very close, with values of 4.5 and 4.2, respectively.

In terms of capacity, Metro's current load standard policy and operating procedures stipulate a one-way peak hour capacity on the Orange Line of 952 passengers. Because capacity is largely determined by maximum passenger loads, a sample of APC data from March 2009 was used to calculate the 95th percentile of peak-hour passenger loads on the Orange Line. As expected, passenger loads steadily increase during both AM and PM peaks in the eastbound direction as the Orange Line approaches its connection with the Red Line. However, the 68-passenger load standard is significantly exceeded only during the AM peak, creating a potential bottleneck at Van Nuys, Woodman, Valley College, and Laurel Canyon stations. Loads in the PM peak are more moderate than in the AM peak for both directions of travel. The highest value observed during the AM peak was 84 at Woodman Station (124% of seated and standing capacity), and during the PM peak was 73 at North Hollywood Station (107% of seated and standing capacity).

Therefore, although the maximum operated carrying capacity per hour on the Orange Line is sufficient along most of the Orange Line, it is not adequate at maximum load points. At the current load standard, the demand to capacity ratio exceeds 1.0 during both travel periods and in both directions. If Metro goes forward with plans to increase the load standard on the Orange Line to 74 passengers, the demand to capacity ratio for eastbound trips during the AM peak would exceed 1.0. For all other trips, the demand to capacity ratio would be equal to or approaching 1.0, indicating that system capacity may be maxing out. To increase capacity, Metro may consider bus platooning and limited-stop trip strategies. Reducing headways further is not a realistic option, as TSP would become ineffective.

SECTION

5

Project Benefits

Higher Ridership

In terms of ridership, the Orange Line's performance has been impressive. Before the Orange Line opened, Metro estimated 5,000 to 7,000 average weekday boardings for the first year of service and 22,000 average weekday boardings by 2020. As illustrated in Figure 5-1, the Orange Line had attracted nearly 22,000 average weekday boardings by May 2006, achieving in just seven months a ridership level not projected to occur until the year 2020. Ridership continued to increase, with September 2008 marking an all-time high of 27,596 average weekday boardings, representing an increase of 11,000 average weekday boardings since the October 2005 opening. Despite a slight decrease compared to 2008, ridership in 2009 and 2010 remained commensurate with, if not above, the projections for 2020. The future Chatsworth extension is expected to generate an additional 9,000 average weekday daily boardings by the year 2030, contributing to a projected 45,000 average weekday boardings for the full alignment from North Hollywood to Chatsworth.

Although ridership growth on the Orange Line itself has surpassed expectations, the overall ridership impact that has resulted from the Orange Line's implementation is not as straightforward. First, the Orange Line did not replace an existing route; prior to its implementation, there were a variety of routes and connections that had to be made to complete the same trip. This means there is no pre-Orange Line ridership data that directly correspond to the Orange Line ridership data. In addition, travel patterns in the San Fernando Valley have changed since the opening of the Orange Line, and modifications were made to several local bus lines in the corridor to reduce service duplication and improve transfer connections with the Orange Line.

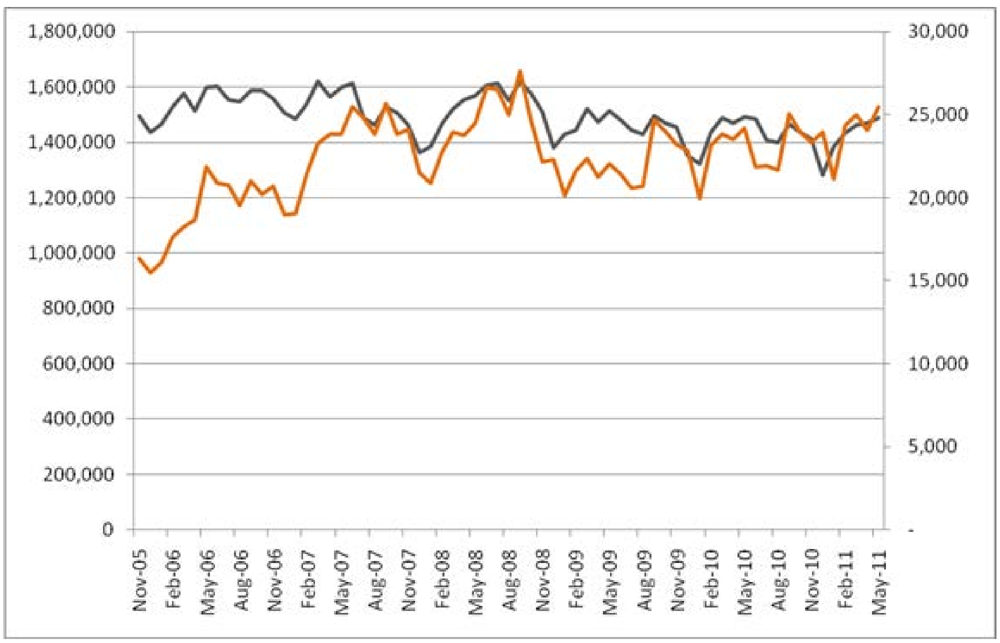
In cases such as this, where there are no directly equivalent pre- and post-condition data, an assessment of overall corridor ridership can be used to measure the ridership impact of BRT implementation [10]. An early analysis undertaken by Metro to assess the Orange Line's ridership impact found that total boardings in the San Fernando Valley had increased by 16,900 between the line's opening in October 2005 and February 2006. The majority of new boardings were found to occur on the Orange Line and connecting north/south routes. As expected, several east/west routes (or partial route segments) parallel to the Orange Line experienced reductions in boardings; however, most of these boardings were recaptured on alternate Metro lines, including the Orange Line. Other available data show that prior to the implementation of the Orange Line, the corridor averaged 41,580 weekday boardings. As of 2007, average weekday boarding reached 62,597, representing a difference of 21,017, an increase of 51 percent [10]. In both instances the estimated ridership increase is comparable to the average weekday ridership of the Orange Line at the time of the analyses; however, it should be noted that some Orange Line riders transfer to and from connecting line service and are likely recorded as multiple boardings. It also appears that the Orange Line's most impressive ridership growth occurred during its early years (see Figure 5-1).

Regional Ridership Trends

As shown in Figure 5-1, system-wide ridership at Metro (shown in gray) has remained relatively steady throughout the duration of the Orange Line's existence. While total Orange Line ridership (shown in orange) increased by 55.8 percent from its inception in October 2005 until May 2011, total system ridership decreased by 0.4 percent. During the same time period, rail ridership increased by 22.7 percent, and total system bus ridership increased by 0.1 percent. (Note: Beginning July 2009, Metro bus ridership figures include ridership on the Orange Line.) However, it appears that the Orange Line's most impressive ridership growth occurred during the time period from its implementation in October 2005 through mid-2007 and may have since leveled off.

Figure 5-1

Orange Line Ridership (Average Weekday Boardings)

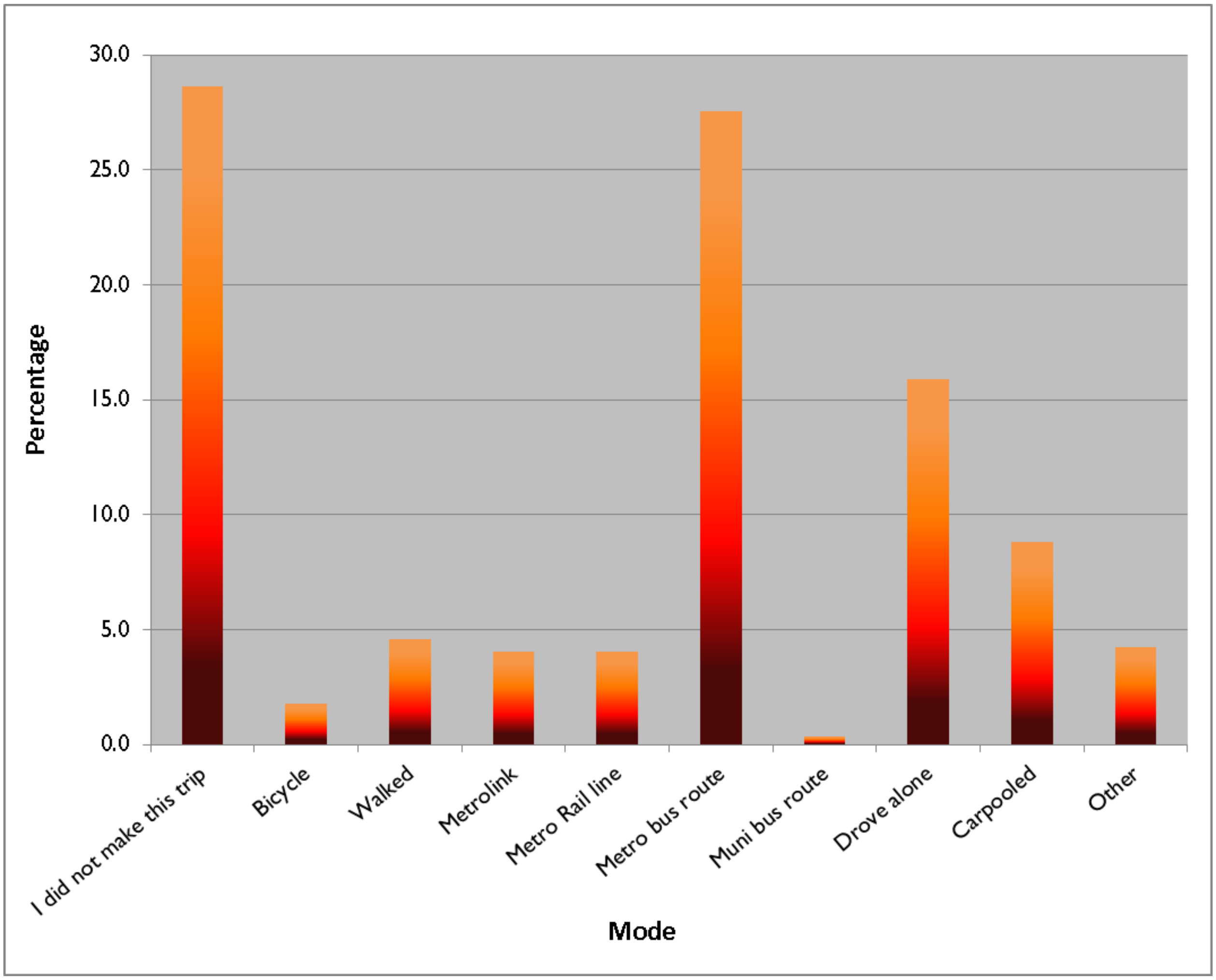


Sources of Orange Line Ridership

In response to the question, "Before the Orange Line opened, how did you make this trip?" the largest share of riders indicated that they did not make the trip (28.6%), closely followed by those who stated that they previously completed their trip onboard another Metro bus route (27.6%). Approximately 25 percent of Orange Line riders previously drove, either alone (15.9%) or in a carpool (8.8%). Although more than one-third (36.2%) of survey respondents previously used some form of transit to make their trip, those riders who did not previously make the trip or who switched from driving account for more than half (53.3%) of all responses when combined. This suggests that the Orange Line is not only attracting choice riders but also is helping to achieve one of the original project goals of improved overall mobility in the San Fernando Valley.

Figure 5-2

Mode Used Before Introduction of Orange Line



Capital Cost Effectiveness

As described in CBRT, cost-effectiveness is defined as the cost per unit of service output [10]. Section 3 of this document, "Project Costs," contains detailed information on costs for the Orange Line. Total capital costs for the Orange Line were determined to be approximately $304,600,000, as outlined in Table 3-1 in CBRT.

Table 5-1 includes a set of capital cost-effectiveness measures for the Orange Line. Also provided in the table are capital cost-effectiveness measures for the Metro Rapid BRT Line that runs in the Ventura Boulevard corridor, as well as the Gold Line LRT operated by Metro. The Ventura Metro Rapid line is part of a 450-mile arterial rapid bus network that uses limited BRT features such as increased stop spacing and signal priority to improve travel times. The Ventura line lends itself to comparison with the Orange Line because it is of similar length, running parallel and about 1.5 miles south of the Orange Line. The Gold Line is a good comparison case because it was roughly the same length as the Orange Line when the relevant data were collected and, like the Orange Line, it also connects with the Red Line subway.

In terms of capital cost-effectiveness, the dollar investment per unit of service output on the Orange Line compared to the Ventura Metro Rapid was greater than 100 times more per mile of running way and greater than 25 times more per average weekday boarding. The higher capital cost measures of the Orange Line clearly reflect the higher investments in infrastructure of a full-service BRT project. In comparison to the Gold Line, however, the Orange Line cost 66 percent less per mile of running way, 71 percent less per annual hour of revenue service, 59 percent less per annual mile of revenue service, and 64 percent less per average weekday boarding. These figures are especially favorable for the Orange Line, considering that the two modes have very similar ridership. In FY 2009, the Orange Line generated 7,188,152 passenger trips and averaged 23,093 weekday boardings, while the Gold Line produced 7,510,300 passenger trips and averaged 23,681 weekday boardings.

Table 5-1

Capital Cost-Effectiveness: Orange Line, Ventura Metro Rapid, and Gold Line

Cost Efficiency Measure	Orange Line	Ventura Metro Rapid	Gold Line LRT
Capital Cost per Mile of Running Way	$21,007,000	$201,500	$62,701,000
Capital Cost per Annual Hour of Revenue Service	$3,049.02	$70.18	$10,410.23
Capital Cost per Annual Mile of Revenue Service	$189.36	$4.68	$463.71
Capital Cost per Annual Unlinked Passenger Trip	$42.38	n/a	$114.38
Capital Cost per Average Weekday Boarding	$13,190.14	$507.75	$36,273.81

Note: Service and ridership data are from FY 2009, Metro and Metro FY10 Adopted Budget. Capital cost data and Ventura Metro Rapid data from Metro.

Operating Cost Efficiency

According to CBRT, important attributes of BRT include its flexibility in being able to meet the unique needs of a transit network and its ability to achieve high levels of operational efficiency at relatively low capital costs [10]. This section provides some measures of operating cost efficiency for the Orange Line, the Ventura Metro Rapid BRT, the Gold Line LRT, and the transit system as a whole for all bus and rail modes operated by Metro. These measures are shown in Table 5-2.

Table 5-2

Operating Cost Efficiency:
Orange Line, Ventura Metro Rapid, Gold Line, and Systemwide

Cost Efficiency Measure	Orange Line	Gold Line LRT	Ventura Metro Rapid	System wide
Operating Cost per Annual Hour of Revenue Service	$226.40	$535.84	$94.24	$146.65
Operating Cost per Annual Mile of Revenue Service	$14.20	$23.87	$6.29	$10.86
Operating Cost per Boarding (Passenger Trip)	$3.13	$7.71	n/a	$2.52
Operating Cost per Passenger Mile	$0.53	$1.06	n/a	$0.61

Source: Metro FY10 Adopted Budget, FY09 Budget and Metro staff.

As mentioned previously, the Orange Line and the Gold Line have similar ridership; however, the Orange Line compares quite favorably in terms of operating cost efficiency, as indicated in Table 5-2. On the other hand, based on available measures, the Ventura Metro Rapid achieves much higher levels of operational efficiency than the Orange Line. Operating cost measures for the Orange Line are also somewhat higher than the systemwide figures, according to Table 5-2. This is expected, given that Metro's bus services (excluding the Orange Line) comprise more than 80 percent of the systemwide ridership, thus increasing the system total operating cost efficiency.

Another measure of operating cost efficiency is the farebox recovery ratio, which represents the proportion of operating expenses that are covered by fare revenue. It should be noted that farebox recovery is not a strong metric for operating cost efficiency but can be used as a general indicator. Table 5-3 indicates that the heavy rail mode and the bus mode (excluding the Orange Line) are the most cost-efficient modes for Metro in terms of farebox recovery. The light rail mode has the lowest farebox recovery, at 17.6 percent. It should be noted that fare information was not available for the individual light rail lines. The Orange Line covers approximately one-fifth (21.2%) of its operating expenses with revenue from the farebox.

Table 5-3

Farebox Recovery Ratio by Mode, Metro

Mode	Value
Orange Line BRT	21.2%
Bus (excluding Orange Line)	27.6%
Light Rail (Blue, Green, and Gold Lines)	17.6%
Heavy Rail (Red and Purple Lines)	28.9%
System Total	26.3%

Metro FY10 Adopted Budget Document, FY09 Budget

Because it operates on its own dedicated ROW, the Orange Line arguably has greater potential than the Metro Rapid for generating development interest. In addition to the higher investment in infrastructure for the route, there is also a greater amount of undeveloped land along the corridor than in the more dense areas in which the Metro Rapid operates. Although there are many incentives available to developers, public demand and marketability determine which areas receive the development and incentives.

A Revised Final Environmental Impact Report (RFEIR) for the Metro Orange Line concluded that the Orange Line was superior to each of the three Rapid Bus Alternatives that were studied in the revised report. The RFEIR examined:

- Three east-west Rapid Bus route alternatives (Sherman Way, Vanowen Street, Victory Blvd.)
- Five east-west Rapid Bus route alternatives (Sherman Way, Victory Blvd., Oxnard St., Burbank Blvd., Chandler Blvd.)
- Rapid Bus network alternative (nine Rapid Bus routes: three east-west routes, six north-south routes).

The RFEIR examined the impacts, costs and benefits of each Rapid Bus alternative and concluded the Metro Orange Line would:

- attract substantially more riders than any other Rapid Bus alternative
- result in the greatest system-wide travel time savings
- maintain the most consistent travel time, which will not be affected by increased traffic congestion over time [2]

The RFEIR also concluded that the exclusive busway operation of the Orange Line has potential land use benefits that would encourage TOD at or around stations and is consistent with adopted local planning documents [1].

Some development along the Orange Line corridor has occurred recently, although it has not been determined if the development has occurred because of the implementation of the enhanced transit service. Metro has noted additional interest in property located along the route, although formal development plans have not yet been established.

The North Hollywood community area originally was a farming community and eventually became a convenient residential area. Due to freeway construction during the 1960s and 1970s, the area experienced decline. Redevelopment efforts have been made since 1979. Significant changes have occurred since the opening of the Red Line Metro subway station in 2000. This, in combination with the addition of the Metro Orange Line, has resulted in an increase in revitalization efforts. Commercial and residential investments have been made, and developers have continued to express interest as well. NoHo Commons, a multi-phased mixed-use complex several blocks east of the North Hollywood Metro Rail Station, features 220,000 square feet of office space, 228,000 square feet of shops and restaurants, 810 units of housing, a community health center, and a child-care center. The NoHo Art Wave is another proposed project that will include more than 500 residential units, more than 1,000 square feet of office space, approximately 150,000 square feet of retail, and 35,000 square feet of community space

The Lankershim Core is the high-density area of North Hollywood that encompasses both sides of Lankershim Boulevard from Burbank Boulevard to Weddington Street and is anchored by a proposed multimodal, mixed-use transit center. Residents and commuters can use the Orange Line, the subway, or local bus service at this location. Currently, stations and stops for each of these transit modes are not consolidated, although recommendations have been made to consider the consolidation of bus and rail facilities. The benefits for doing this would include ease of use for transfers and the ability to use land that would become available for higher-value uses. Additionally, the consolidation would eliminate the duplication of "kiss-and-ride," ticketing, and information facilities for fare and trip-planning

Figure 5-3

New Multi-Family Housing along Orange Line Corridor

Figure 5-4

Construction at Orange Line Terminus and Red Line Connection at North Hollywood Station

Figure 5-5

Newer Development at North Hollywood Red Line Station

Environmental Quality

Environmental quality encompasses a variety of indicators that gauge a region's quality of life in terms of public health and well-being, as well as the attractiveness and sustainability of both the natural and urban environment. BRT can improve environmental quality in a variety of ways, the most significant impacts being reduced emissions of local air pollutants from vehicles, greenhouse gas reductions, and increased vehicle fuel efficiency [10]. BRT systems may produce these impacts by three related mechanisms that affect the emissions and fuel consumption of both the BRT vehicles and other vehicles operating in the vicinity of the transit corridor:

Environmental quality encompasses a variety of indicators that gauge a region's quality of life in terms of public health and well-being, as well as the attractiveness and sustainability of both the natural and urban environment. BRT can improve environmental quality in a variety of ways, the most significant impacts being reduced emissions of local air pollutants from vehicles, greenhouse gas reductions, and increased vehicle fuel efficiency [10]. BRT systems may produce these impacts by three related mechanisms that affect the emissions and fuel consumption of both the BRT vehicles and other vehicles operating in the vicinity of the transit corridor:

- Vehicle technology – Low emission or alternative propulsion systems may benefit the environment by reducing pollutant emissions and improving energy efficiency.
- Ridership and mode shift – By shifting low-occupancy private vehicle trips to high-capacity public transit, BRT can decrease regional vehicle miles traveled (VMT), thereby reducing pollutants, greenhouse gases, and fuel consumption.
- Traffic system effects – In some cities, BRT has reduced congestion and improved overall traffic speeds and flow, which can in turn improve vehicle fuel economy and reduce regional transportation emissions.

Although the most direct impact on environmental quality stems from the reduction of emissions of local air pollutants, BRT investments also can have similar positive impacts on other forms of pollution (such as noise), overall livability, and other environmental objectives.

Vehicle Technology

According to CBRT, BRT vehicle technology has the most direct impact on environmental quality. Low-emission alternative-fuel engines can reduce overall greenhouse gas emissions. Under rules adopted by both the California Air Resources Board and the South Coast Air Quality Management District, Metro worked to develop a plan for purchasing only non-diesel, alternative fuel buses, a policy that went into effect in 2000. The engine used for the Orange Line's Metro Liner vehicles, the Cummins 320 L-Gas Plus, is powered by clean-burning compressed natural gas (CNG). CNG has been used in revenue service on buses for well over a decade, and it is well-established that CNG produces very low particulate matter (PM) and nitrous oxide (NOx) emissions. By diversifying the fuel sources of the transportation sector, CNG also provides an important energy security benefit.

The L-Gas Plus, which was designed specifically for large transit vehicles, is ultra-low emissions-certified to U.S. Environmental Protection Agency (EPA) 2005 standards. At the time of the Metro Liner fleet purchase, the L-Gas Plus engine offered the best-in-class emissions performance, emitting 40 percent less NOx and non-methane hydrocarbons and 90 percent less PM than the levels required by EPA standards [12].

Other vehicle design and technology elements provide environmental benefits by directly reducing fuel consumption and pollutants emitted by BRT vehicles. For instance, the extra capacity provided by the larger, 60-foot Metro Liners (an increase of 45% over standard 40-foot buses) means that passenger demand can be met with fewer vehicles in revenue service. In addition, off-coach fare collection, multiple doors, and low floors improve dwell times, which in turn reduces engine idling.

Ridership and Mode Shift

There is a direct relationship between VMT and air pollution. In urbanized regions such as the Los Angeles Metropolitan area, mobile emissions are the primary source of air pollution [1]. Shifting trips from private cars to BRT lowers regional VMT and reduces total fuel consumption, which can significantly improve regional air quality [10].

Survey results show a growing trend of the Orange Line attracting "choice" riders (people who have access to a private vehicle but choose to take transit instead). A January 2006 on-board survey [4] found that more than one-third of responses indicated that a car was available for the trip. According to the on-board survey conducted by NBRTI in June 2009, the proportion of responses reporting regular daily access to a car had increased to 41 percent. Results from the earlier survey also indicated that, as planners had hoped, the Orange Line is attracting riders who are new to transit, with 31 percent of responses stating that they were new to Metro or had been using Metro for less than one year. The 2009 survey did not ask participants how long they had been using public transit; however, on 44 percent of surveyed trips riders reported using the Orange Line for less than one year.

Despite the high ridership on the Orange Line, there have been questions about whether it has had a significant impact on mode shift from private cars, and Metro has acknowledged that many Orange Line riders are existing transit users. The 2006 on-board survey showed that 73 percent of respondents already were using transit for their travel needs prior to the Orange Line's opening, while 18 percent previously drove, either alone (14%) or in a carpool (4%). According to the 2009 NBRTI survey, the proportion of respondents already using transit before the opening of the Orange Line had dropped to 36 percent, while the proportion of respondents who previously drove increased to 25 percent; however, most of this increase was due to a more than twofold increase in respondents who reported previously carpooling (9%), with only a slight rise in those reporting that they previously drove alone (16%).

Shortly after the Orange Line's opening, critics also noted that park-and-ride lots usually were filled only to 25 percent or less of their capacity. The 2009 NBRTI survey found that approximately half of riders (49%) used public transit to reach the Orange Line, 35 percent arrived by bike or on foot, and 14 percent arrived by car (either driving alone, carpooling, or being dropped off). Responses for how riders reached their final destinations were similar to how they had arrived at the Orange Line, with half of riders using some form of transit, 40 percent walking or using a bike, and only about 8 percent using a car (see Appendix A, tables A-7 and A-8). This indicates that, for half of its riders, the Orange Line does not provide a single-seat trip, but serves instead as a feeder to other transit services. Also, although the proportion of respondents accessing the Orange Line by car may seem low, these figures are not inconsistent with Metro forecasts predicting that 81 percent of riders would access the line by a mode other than a private motor vehicle [1].

Traffic System Effects

BRT can reduce local vehicle emissions and improve vehicle fuel economy by:

- reducing conflicts between BRT vehicles and other traffic
- improving overall traffic speeds and flow
- reducing overall system congestion

Since it is problematic to measure and predict the associated impacts of emissions changes due to improved traffic flow, quantifying traffic system improvement benefits is difficult.

The first study attempting to gauge the Orange Line's impact on freeway volume found that traffic between 7:00 a.m. and 10:00 a.m. has been slightly lighter on the U.S. 101 Freeway where it parallels the busway. Researchers at the California Center for Innovative Transportation (CCIT) found a 14 percent decrease in total time spent in congestion (defined as traffic slower than 35 mph) since the Orange Line began operating. As a result, the onset of morning peak hour congestion on the heavily-traveled freeway was beginning about 11 minutes later, shifting on average from 6:55 a.m. to 7:06 a.m. The CCIT study also found a 7 percent increase in traffic flow during morning rush hour, from an average of 43 mph to 46 mph [13].

These findings are corroborated by NBRTI's 2009 on-board survey, which found that in 25 percent of the trips that were surveyed, riders previously drove alone (16%) or in a carpool (9%) to make their trip before the opening of the Orange

Line. Of the responses that indicated having previously driven, about 55 percent reported previously using U.S. 101.

Approximately 45 percent of riders who previously used the U.S. 101 Freeway perceived that their travel time had improved as a result of the Orange Line, with approximately 29 percent reporting a travel time savings of 15 minutes or more. However, since the Orange Line does not operate in mixed traffic, survey responses are not an accurate indicator of traffic system effects.

Table 5-4

Perception of Orange Line Travel Time Compared to Previous Use of U.S. 101 Freeway

Perceived Change in Travel Time	Orange Line Value
15+ min faster	29.2%
11-15 min faster	9.7%
6-10 min faster	1.4%
1-5 min faster	4.2%
About the same	30.6%
Slower	25.0%

The authors of the CCIT study acknowledge that the Orange Line's impact is reducing commute times by only a few minutes and having only a moderate effect on mode shift from private autos. However, their overall conclusion was that the freeway is operating more efficiently because of the Orange Line and that saving even a minute or two a day in travel time has a cumulative effect that results in less smog and significant savings in fuel consumption.

Noise

According to CBRT, noise and vibration from vehicles are the primary sources of potential noise impacts from BRT. The level of noise depends on:

- vehicle size
- propulsion system and configuration
- frequency of service
- paving material of the running way

Noise impacts, which result from both the engine noise and the sound of the tires on the running way, may be intensified by the larger engines needed to power high-capacity articulated buses. Also, although CNG buses are typically quieter than diesel buses, some have demonstrated increased vibration.

In response to noise complaints since the opening of the busway, Metro modified exhaust pipes on the Metro Liner vehicles to point to the rear instead of blowing sideways toward residences. Although Metro built sound walls to reduce noise levels near homes, some apartment buildings are higher than the sound walls, and certain parts of the busway do not have sound walls because of the potential for interference with motorist visibility on intersecting streets. To address individual complaints regarding noise, Metro has worked with the community to find additional solutions, such as retrofitting homes with additional insulation and dual-pane, sound-rated windows and doors [15].

Other Pollutants

Metro purchased the former Southern Pacific Railroad ROW with the goal of transforming the contaminated brownfield into usable property that would provide a transportation alternative to the highway gridlock of the San Fernando Valley. Under a voluntary cleanup agreement, staff of the Department of Toxic Substances Control (DTSC) supervised the identification and removal of lead- and arsenic-contaminated soil. Periodic air monitoring and dust control measures were implemented during soil excavation activities to ensure that the public was protected from particulate emissions. The site was certified as clean in May 2004. To date, Metro has excavated and transported approximately 55,000 cubic yards of contaminated soil for proper disposal [16].

Visual Impacts and Livability

Metro undertook a landscape beautification project to transform the vacant Southern Pacific railroad parcel into a linear greenway stretching from North Hollywood to Woodland Hills, recognizing it as a one-time opportunity to add thousands of plants and trees to the urban landscape. To build upon local input from the community, Metro created a Landscape Advisory Committee to help oversee the project. The $20 million project was one of the largest plantings ever in Southern California, with 850,000 plants, 5,000 trees, and six landscape art areas installed on 80 acres along the Orange Line busway [17].

To reflect the San Fernando Valley's heritage, California native and other water-wise plants were selected, including some trees and shrubs found in the Valley before it was developed. In addition to enhancing the overall appearance of the corridor, native plants help to create habitat for native wildlife and lend a unique, Southern California sense of place to the Orange Line. The hardy, drought-tolerant plants need little water, fertilizer, or maintenance, and since no mowing is required, there is less use of gasoline and less air pollution. Metro also agreed to spend $2 million to install a special irrigation system capable of using recycled water from a nearby wastewater treatment facility. Part of the beautification project also included planting leafy, climbing vines along the busway's sound walls to deter graffiti.

A 14-mile recreational path runs parallel to the busway, helping to fulfill the Orange Line's urban design vision of a busway within a linear "greenway." Metro has also started incorporating sustainability design guidelines using Leadership in Environmental Energy and Design (LEED) principles in major capital projects, beginning with the extension of the Metro Orange Line [18].

Figure 5-6

Native Landscaping Along Orange Line Busway

Figure 5-7

Vine Plantings on Sound Walls to Deter Graffiti

Summary of Project Benefits

Since it began operation in October 2005, the Orange Line's ridership performance has been impressive. By May 2006, the Orange Line had attracted nearly 22,000 average weekday boardings, achieving in just seven months a ridership level not projected to occur until the year 2020. Ridership continued to increase, with

September 2008 marking another ridership milestone of 27,987 average weekday boardings, an all-time high for the Orange Line. Despite a slight decrease compared to 2008, ridership in 2009 remained commensurate with the projections for 2020. Prior to the implementation of the Orange Line, the corridor averaged 41,580 weekday transit boardings. As of 2007, average weekday boarding reached 62,597, representing a 51 percent increase. However, it appears that the Orange Line's most impressive ridership growth occurred during the time period from its implementation in October 2005 through mid-2007 and may have since leveled off.

According to the 2009 NBRTI onboard survey, 32 percent of survey respondents previously made their trip using a non-transit method. Of those, 25 percent drove, either alone (16%) or in a carpool (9%). Although more than one-third (36.2%) of survey respondents already used some form of transit to make their trip prior to using the Orange Line, riders who did not previously make the trip or who switched from driving account for more than half (53.3%) of all responses when combined. This suggests that the Orange Line is not only attracting choice riders but is also helping to achieve one of the original project goals of improved overall mobility in the San Fernando Valley.

The capital cost of the Orange Line was determined to be $304.6 million in 2004 dollars, or $21.0 million per mile. In terms of capital cost-effectiveness, the dollar investment per unit of service output on the Orange Line compared to the Ventura Metro Rapid was greater than 100 times more per mile of running way and greater than 25 times more per average weekday boarding. The higher capital cost measures of the Orange Line clearly reflect the higher investments in infrastructure of a full-service BRT project. In comparison to the Gold Line, however, the Orange Line cost 66 percent less per mile of running way, 71 percent less per annual hour of revenue service, 59 percent less per annual mile of revenue service, and 64 percent less per average weekday boarding. These figures are especially favorable for the Orange Line, considering that the two modes have very similar ridership.

In terms of operating cost efficiency, the Orange Line also compares quite favorably to the Gold Line, costing 58 percent less per annual hour of revenue service, 41 percent less per annual mile of revenue service, 59 percent less per boarding, and 50 percent less per passenger mile. On the other hand, based on available measures, the Ventura Metro Rapid achieves high levels of operational efficiency, costing 42 percent as much as the Orange Line per annual hour of revenue service and 41 percent as much per annual mile of revenue service. Operating cost measures for the Orange Line are also somewhat higher than the systemwide figures, which is to be expected, given that Metro's bus services (excluding the Orange Line) comprise more than 80 percent of the systemwide ridership. (Interestingly, the operating cost per passenger mile is 13 percent less on the Orange Line than the systemwide figures.)

The heavy rail mode and the bus mode (excluding the Orange Line) are the most cost-efficient modes for Metro in terms of farebox recovery, while the light rail mode has the lowest farebox recovery, at 17.6 percent. The Orange Line covers approximately one-fifth (21.2%) of its operating expenses with revenue from the farebox.

The Orange Line also may be generating interest in land development. Some development along the Orange Line corridor has occurred recently, although it has not been determined if the development has occurred because of the implementation of the Orange Line. Metro has noted additional interest in property located along the route, although formal development plans have not yet been established.

In terms of environmental quality, the engine used for the Orange Line vehicles is powered by clean-burning CNG, which produces very low PM and NOx emissions. Since May 2006, ridership has been commensurate with projections for the year 2020, and survey results have shown a growing trend of attracting "choice" riders; thus, the Orange Line is potentially lowering regional VMT and fuel consumption. Also, the first study of the Orange Line's impact on freeway volume found that U.S. 101 is operating more efficiently since the opening of the Orange Line, potentially resulting in less smog and significant savings in fuel consumption. To reduce noise pollution near homes, Metro built sound walls, modified exhaust pipes on the Metro Liner vehicles to point to the rear instead of blowing sideways toward residences, and retrofitted several homes with additional insulation and sound-rated windows and doors. In addition, Metro's voluntary toxic soil cleanup and ambitious landscape beautification project transformed a contaminated brownfield into a linear greenway. A bicycle and pedestrian path runs parallel to the busway, providing a community asset for surrounding neighborhoods.

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APPENDIX

A

On-Board Survey Analysis

Introduction and Methodology

To understand rider perceptions of the Orange Line, NBRTI analyzed data that were collected from an on-board survey. The survey was conducted on the Orange Line between the hours of 6:00 a.m. and 7:00 p.m. on Tuesday, Wednesday, and Thursday during the week of June 21, 2009, and on Tuesday and Wednesday the week of June 28, 2009. The dates of the survey were chosen to capture midweek data, as Mondays and Fridays generally do not follow typical commuting patterns. Specific bus duties were selected to ensure adequate service coverage during morning peak, off-peak, and evening peak travel times. Each selected run included a minimum of four one-way trips lasting approximately one hour each. Surveying occurred along the entire length of the route, from Warner Center to the North Hollywood Station. Of the 889 Orange Line patrons who were offered the survey, 578 accepted and returned it with some portion of the instrument completed, for an overall response rate of 65 percent. The total completion rate was 62 percent, producing 551 fully complete surveys.

Survey distribution was conducted by Applied Management and Planning Group (AMPG), a Los Angeles-based market research firm specializing in public transportation. In all cases, two surveyors were assigned to the bus being surveyed. To notify passengers of the survey activities and to encourage participation, a sign reading "Survey Today/Encuesta Hoy" was placed behind the driver. Surveys were offered to every passenger after he or she boarded and was settled. Surveyors walked through the bus to collect surveys as they were completed by patrons. In addition, a heavy-duty envelope reading, "Place Surveys Here/Entreguela Aquí" was placed at the front of the bus. AMPG employed bilingual English/Spanish-speaking surveyors, and in some instances, surveyors assisted some riders with disabilities in the completion of their surveys. Riders were asked to complete a survey each time they boarded a bus, regardless of whether they had previously completed a survey on a previous day or earlier trip.

Surveys were printed double-sided on 11x17 card stock, with both English and Spanish versions available for patrons. The instrument contained approximately 25 questions, some with multiple components. The majority of questions were close-ended in nature, simply requiring customers to select from a list of provided responses. Since answering every question was not a requirement for the survey to be included in this analysis, many of the records in the final survey database had missing values for various questions. This report presents the analysis of results obtained from the survey. The survey instrument is provided in Appendix E.

Comparison of Sample and Population Demographics

In Table A-1, the rider demographics from the NBRTI on-board survey are compared to the population characteristics of the city of Los Angeles obtained from the 2008 U.S. Census.

Table A-1 shows that the demographic characteristics of the survey sample are similar to the overall census data of the city of Los Angeles. Riders between the ages of 25 and 54 account for more than half of the trips surveyed on the Orange Line, a share similar to the nearly 45 percent of the Los Angeles population that fall within this age group. Interestingly, the youngest and oldest age groups comprise a smaller fraction of the Orange Line sample than for the city of Los Angeles population. However, the share of Orange Line riders falling into the "20 to 24" age range is nearly double the proportion reported for the city of Los Angeles population.

In terms of vehicle ownership, 87 percent of those within the city of Los Angeles population own one or more vehicles, compared to nearly 40 percent of the trips that were surveyed on the Orange Line. The largest differences between the two population samples in terms of annual household income lie at the lower and upper extremes. Those making less than $10,000 per year account for the largest single category of Orange Line survey respondents (32.4%), compared to only 7.7 percent of the city of Los Angeles. Conversely, only 9.2 percent of Orange Line riders make $75,000 or more per year, compared to nearly one-third of the population of Los Angeles.

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Table A-1
Sample and Population Demographics

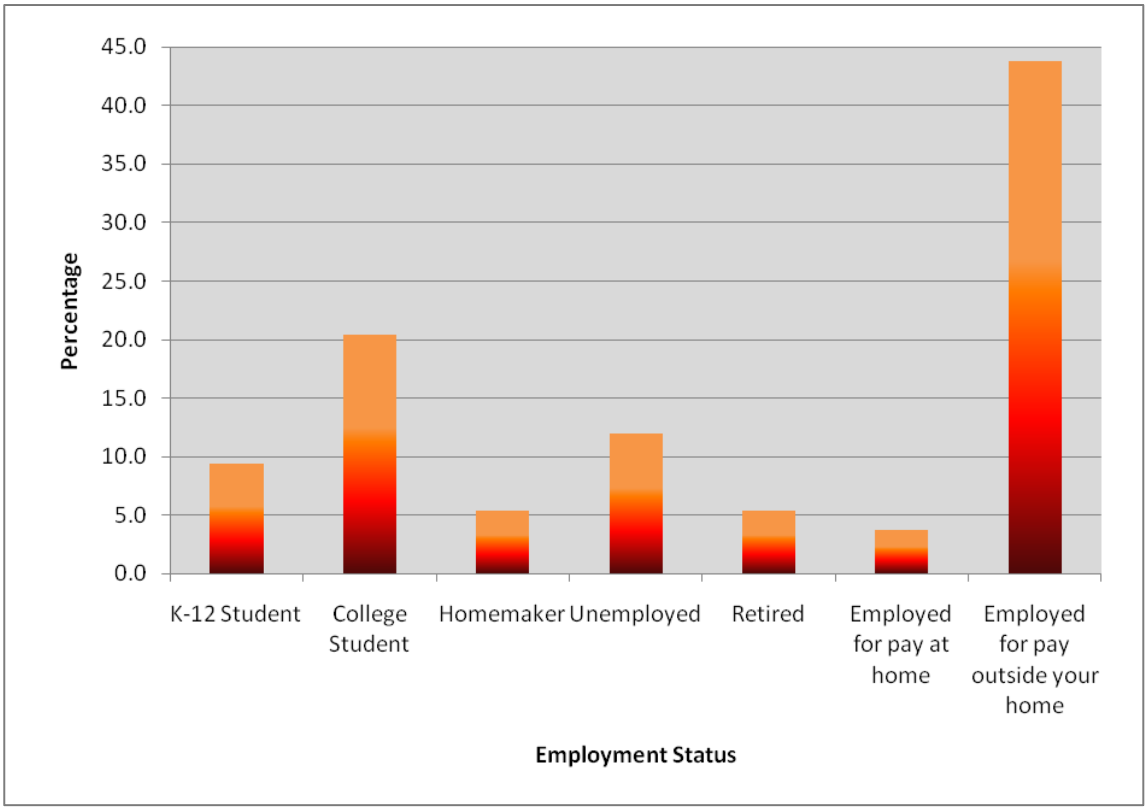
		Orange Line	U.S. Census
Demographic Variable	Categories	Survey Results (%)	Los Angeles City (%)
N (Population / Sample Size)		550	3,749,058
Age	Under 20	19.5	27.8
	20 to 24	15.2	7.9
	25 to 34	20.9	15.8
	35 to 54	30.8	29.1
	55 to 64	10.3	9.0
	65 and Older	3.4	10.2
N (Population / Sample Size)		495	3,749,058
Gender	Male	47.5	49.9
	Female	52.5	50.1
N (Population / Sample Size)		495	1,275,534
Household Vehicles	None	60.8	12.70
	One	17.1	39.62
	Two	13.1	32.55
	Three	6.8	10.31
	Four or more	2.2	4.81
N (Population / Sample Size)		435	1,275,534
Annual Household Incomes	Less than $10,000	32.4	7.7
	$10,000 to $14,999	16.1	6.9
	$15,000 to $24,999	12.4	12.3
	$25,000 to $34,999	11.0	11.0
	$35,000 to $44,999	6.2	13.2
	$45,000 to $74,999	12.6	16.7
	$75,000 to $99,999	4.4	10.3
	$100,000 or more	4.8	21.3

Type of Employment

Respondents were asked to choose any of the seven provided options for employment status. Multiple responses were permitted. Figure A-1 shows that the majority of responses indicated employment for pay outside the home (43.8%), followed by students (29.8%) and those who are unemployed (11.9%). Homemakers (5.3%), retired (5.3%), and employed for pay at home (3.8%) comprise the remainder of the responses.

Figure A-1

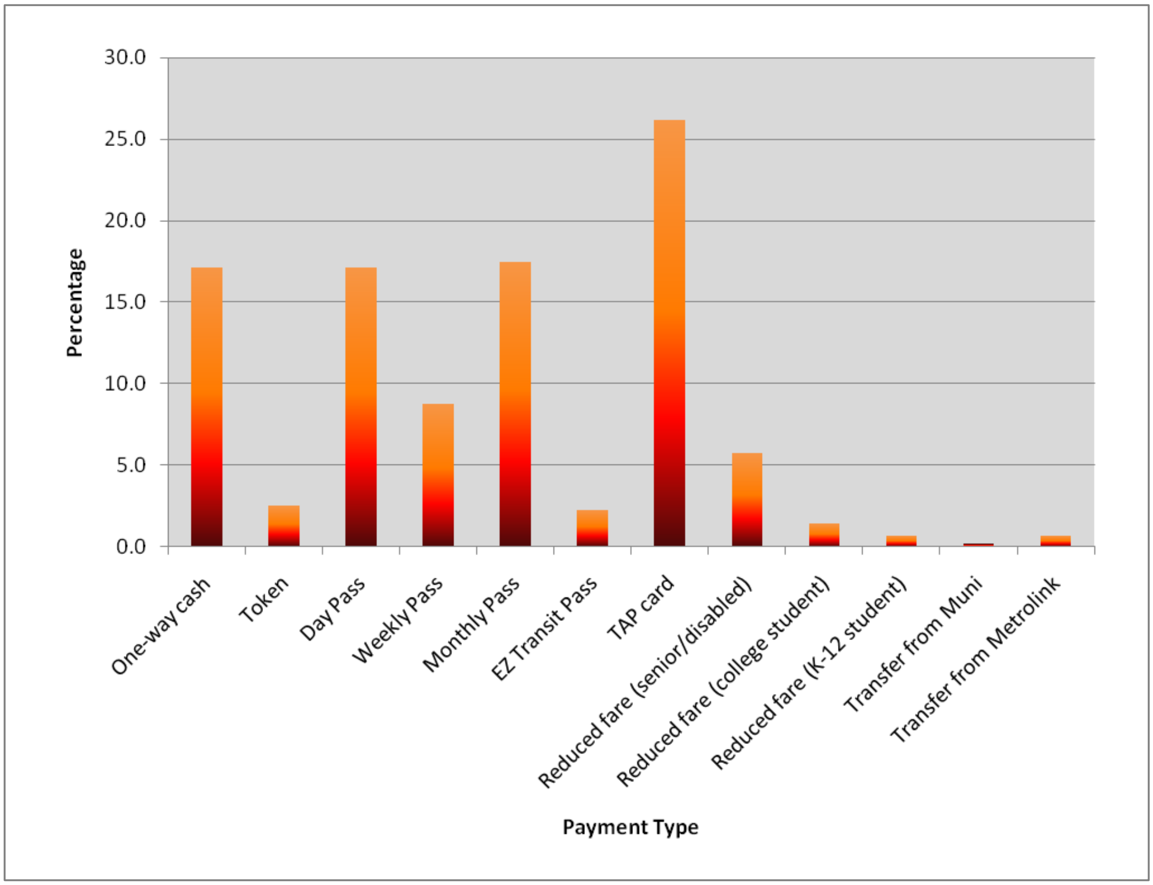
Employment/Educational Status of Orange Line Patron



Survey respondents were asked which type of fare system they used to ride the Orange Line. The largest group of respondents (26.2%) use the transit access pass (TAP) card, followed by the monthly pass (17.5%), the day pass (17.1%), and one-way cash fare (17.1%). It should be noted that the small proportion (1.4%) of "Reduced fare (college student)" responses has no direct correlation to the share of college students who use the Orange Line.

Figure A-2

Type of Payment Used to Ride Orange Line



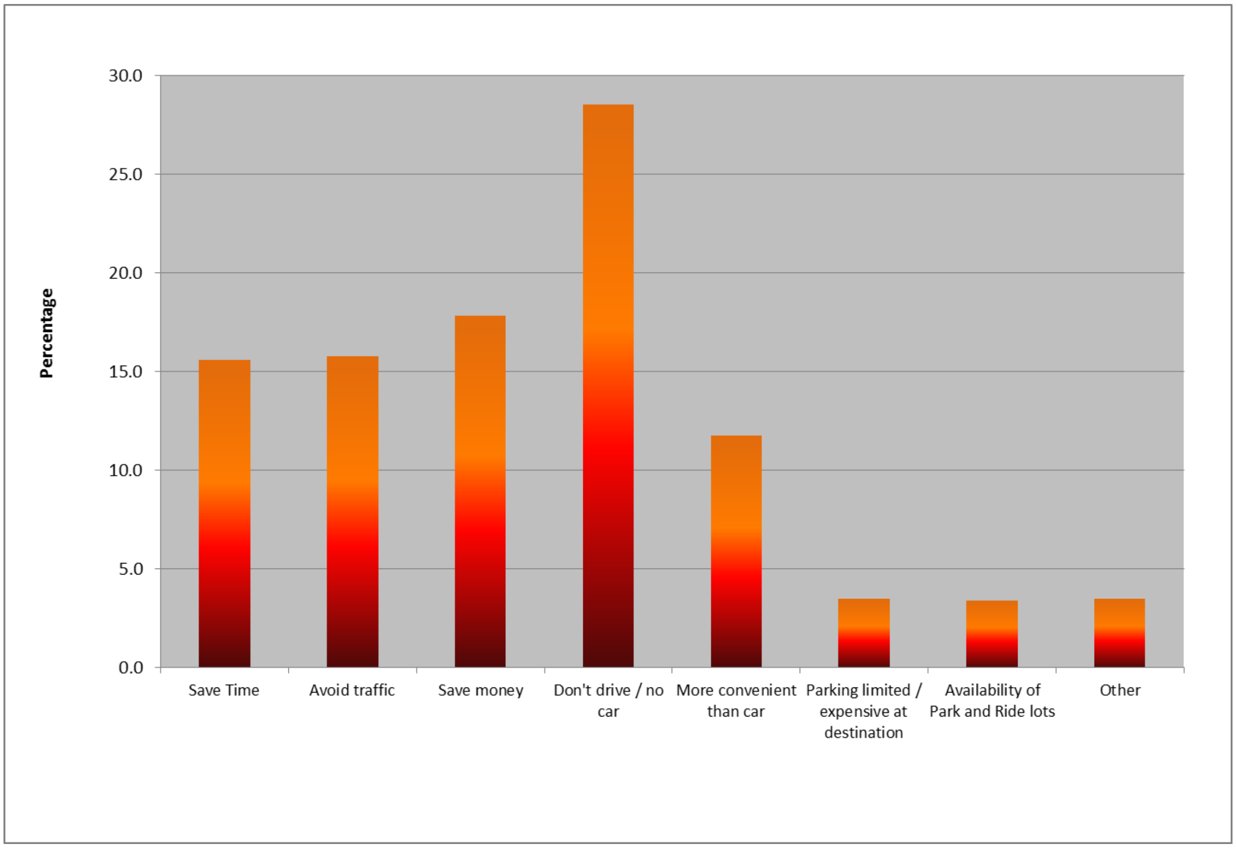
Characteristics of Current Orange Line Use

Reasons for Riding the Orange Line

Survey respondents were given eight response options for the question, "Why are you riding the bus today?" Multiple responses were permitted. Approximately 29 percent of responses reported riding the Orange Line due to lack of access to an automobile, while 17.9 percent cited the need to save money. Approximately 16 percent of responses indicate using the Orange Line to avoid traffic, and 15.6 percent used the service to save time. Close to 12 percent of responses reported the Orange Line as more convenient than using a car. The results of the survey suggest that the Orange Line is considered by many to be a reliable, convenient, economical and rapid mode of transportation.

Figure A-3

Why Are You Riding The Bus Today?



Trip Purpose

Figure A-4 shows the stated purposes for trips taken on the Orange Line. The figure shows that approximately half of the trips taken on the Orange Line are for work commuting, while the other half are for other purposes such as school, recreation, job seeking, medical appointments, shopping, and other activities. This indicates that the Orange Line not only provides its riders with a commuting service, but also the day-to-day mobility necessary to be active in the community.

As shown in Figures A-5 and A-6, boarding and alighting patterns suggest that the Orange Line is extending the reach of the Red Line into the San Fernando Valley via the North Hollywood Station. Survey participants were asked to identify the stop at which they boarded the vehicle as well as which stop they were to get off to complete their trip. More than 35 percent of surveyed trips were taken by riders who boarded the bus at the North Hollywood station. This can be attributed to the station's close proximity to the Metro Red Line's North Hollywood Station. The Van Nuys station was the second most used station (10.3%), which is likely due to the fact that Van Nuys Boulevard is the busiest north-south corridor along the Orange Line alignment, with many government services, businesses, and connections to other transit services including the Metro Rapid. In general, locations where riders debarked from the bus mirror boarding locations.

Figure A-4

What Is The Main Purpose of Your Trip Today?

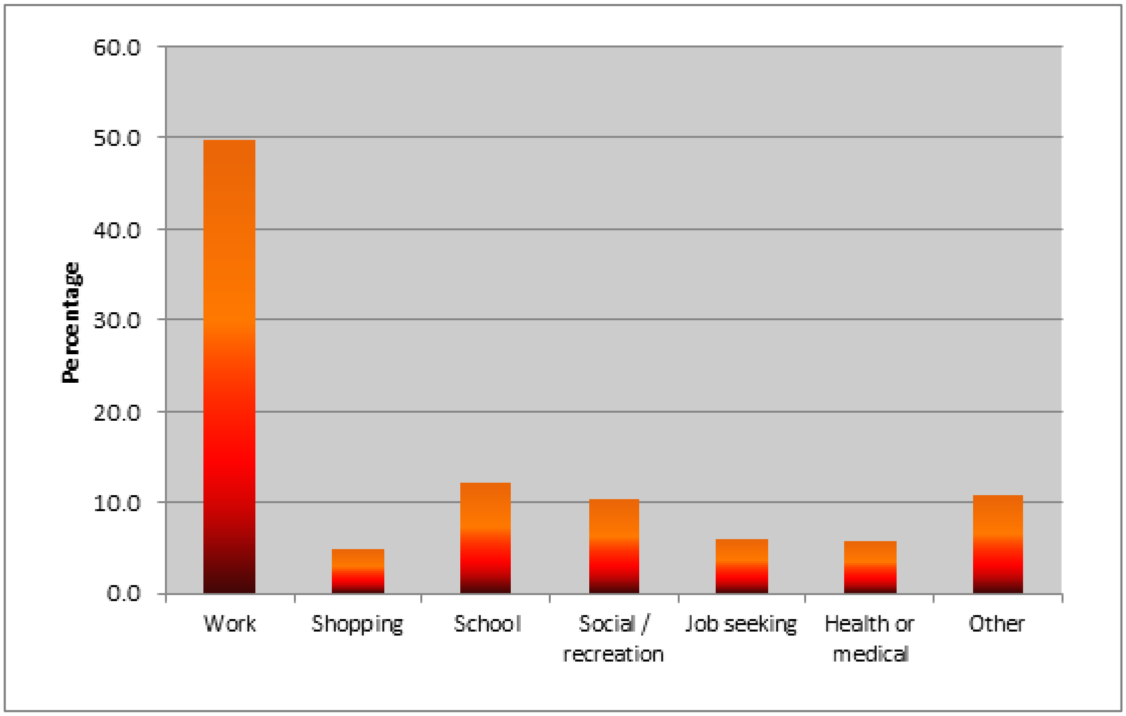


Figure A-5

Where Did You Get on This Bus?

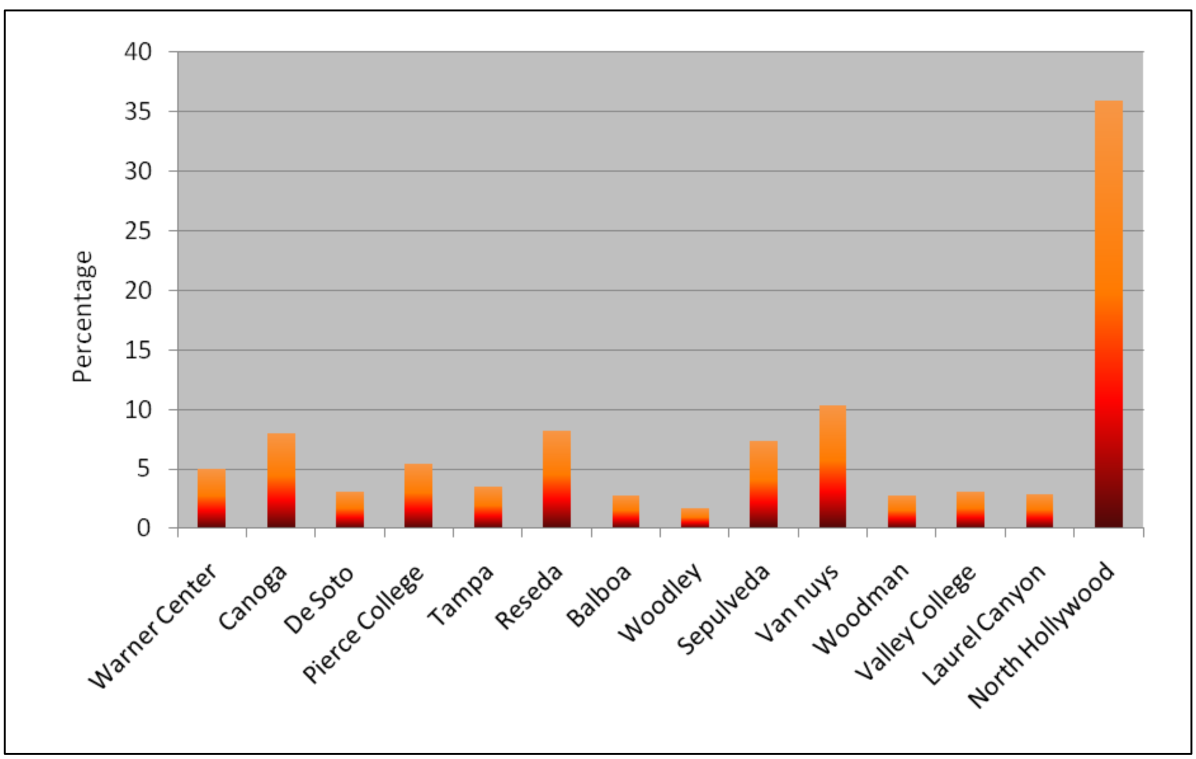
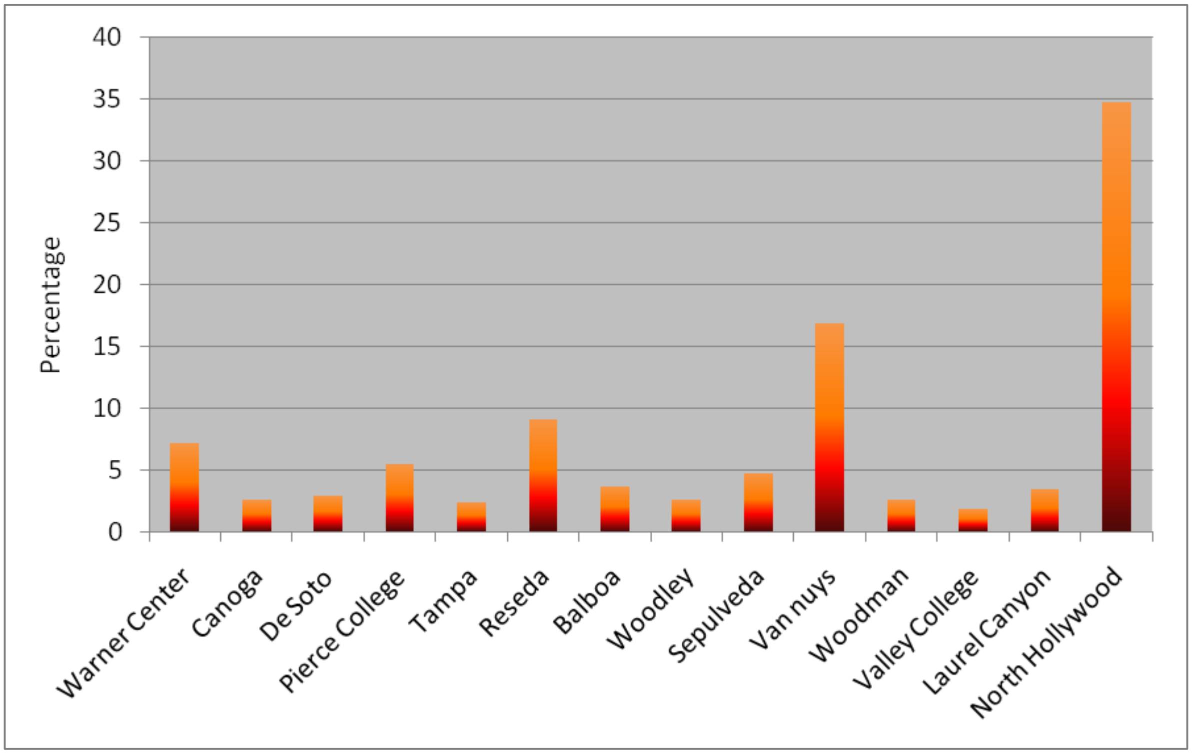


Figure A-6

Where Will You Get Off This Bus?



Mode of Access to and from the Orange Line

Figure A-7 and A-8 show mode of access to and from the Orange Line as reported by survey participants. To access the Orange Line, approximately half of all surveyed trips (49%) used public transit, 35 percent arrived by bike or on foot, and 14 percent arrived by car (driving alone, carpooling, or being dropped off). Responses were similar in regard to how final destinations were reached, with half of the surveyed trips using some form of transit, 40 percent walking or using a bike, and only about 8 percent driving alone, carpooling, or being picked up. This indicates that about half of all trips taken on the Orange Line are not single-seat rides, but instead feed into other transit services. Also, although the proportion of respondents accessing the Orange Line by car may seem low, these figures are not inconsistent with forecasts in the FEIR, which predicted that 81 percent of riders would access the line by a mode other than a private motor vehicle (1).

Figure A-7

How Did You Get to the Orange Line Bus?

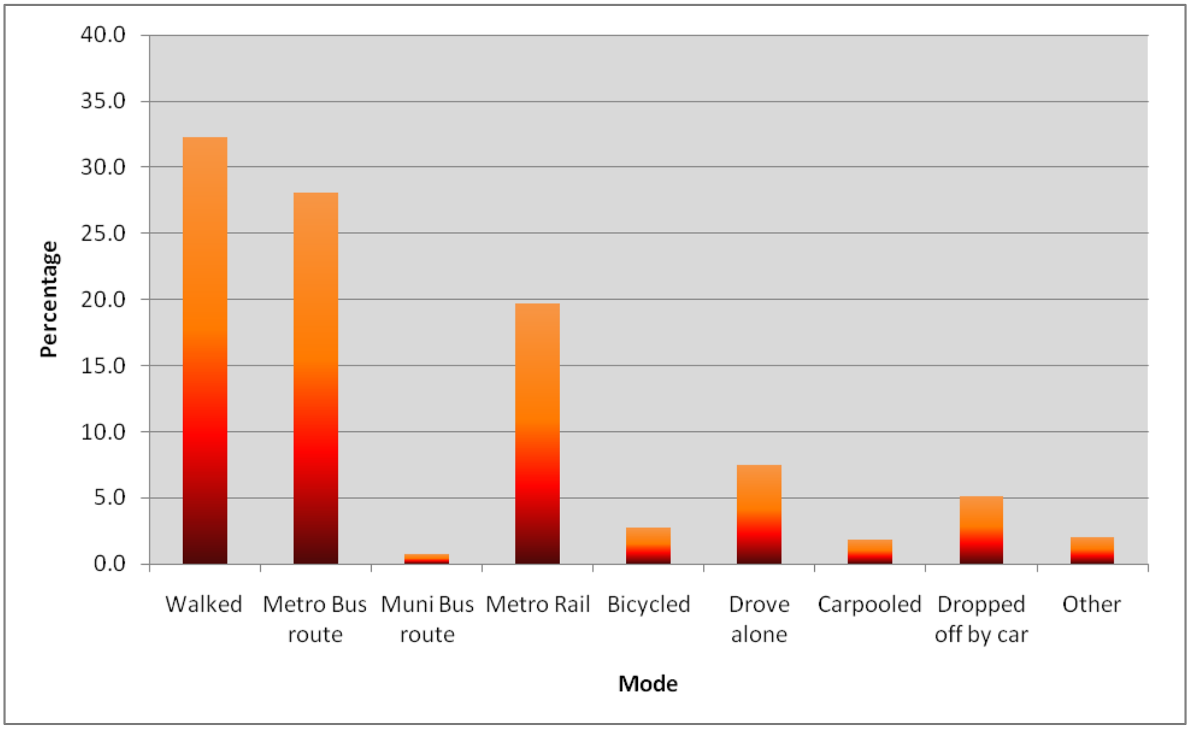
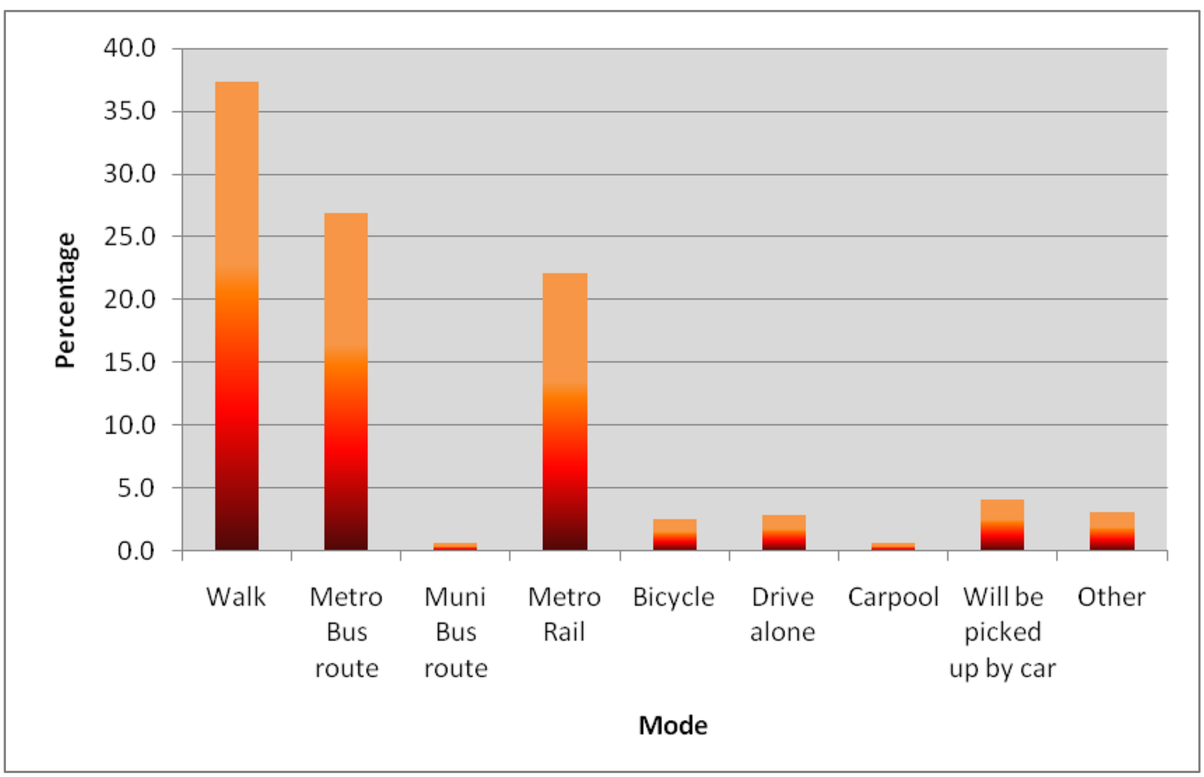


Figure A-8

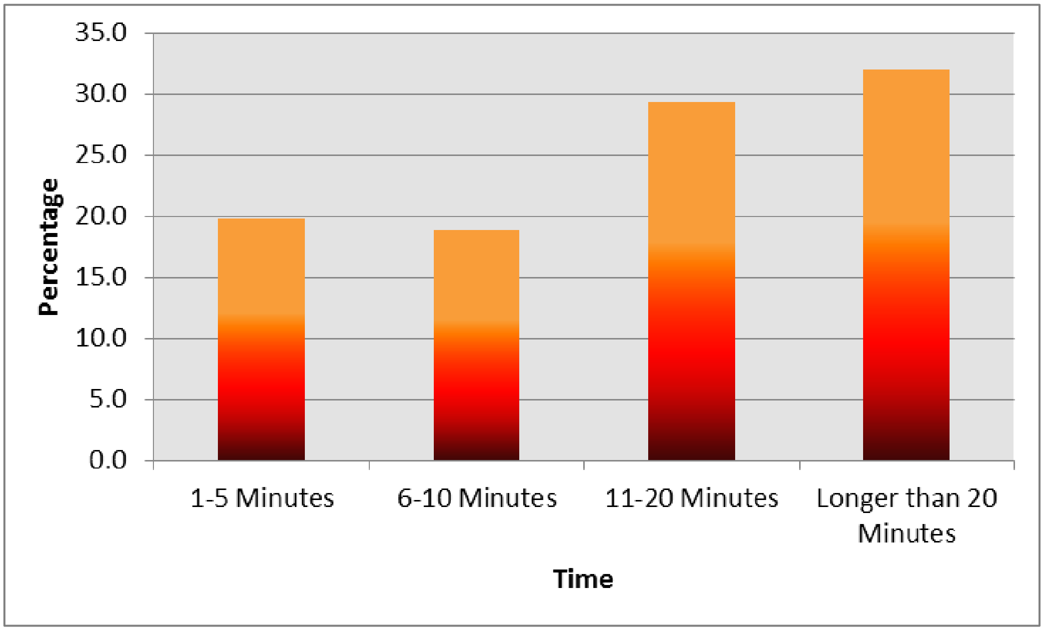
How Will You Get to Your Final Destination?



Riders also were asked "How long will it take you to reach your final destination?" Figure A-9 shows that approximately one-third of riders on the Orange Line took longer than twenty minutes to get to their destination. The interval of 11-20 minutes was the second most commonly-reported time to the rider's final destination, accounting for more than 29 percent of survey responses. Time intervals of one to five and six to 10 minutes had the next greatest percentage of respondents among riders on the Orange Line, (19.8% and 18.9%, respectively).

Figure A-9

How Long Will it Take You to Reach Your Final Destination?



User Perceptions of Orange Line's Impact on Travel Time

The Orange Line survey asked if respondent's travel time changed with the implementation of the Orange Line. Figure A-10 shows that the majority of respondents thought that the Orange Line had reduced their travel time, with 71 percent of riders reporting a decrease in travel time. Approximately 18 percent stated travel time had remained about the same, and only 10.5 percent reported an increase in travel time.

Data presented in Table A-2 compare responses received to the questions "If you previously made this trip, how has the Orange Line affected the length of this trip?" and "Before the Orange Line opened, how did you make this trip?" In the case of individuals who drove alone, nearly 73 percent perceived their travel time on the Orange Line to be the same or better than before, with 21 percent reporting a travel time improvement of 15 minutes or more. Approximately 28 percent perceived their travel time on the Orange Line as slower than before.

Figure A-10

How Has Your Travel Time Changed With The Orange Line?

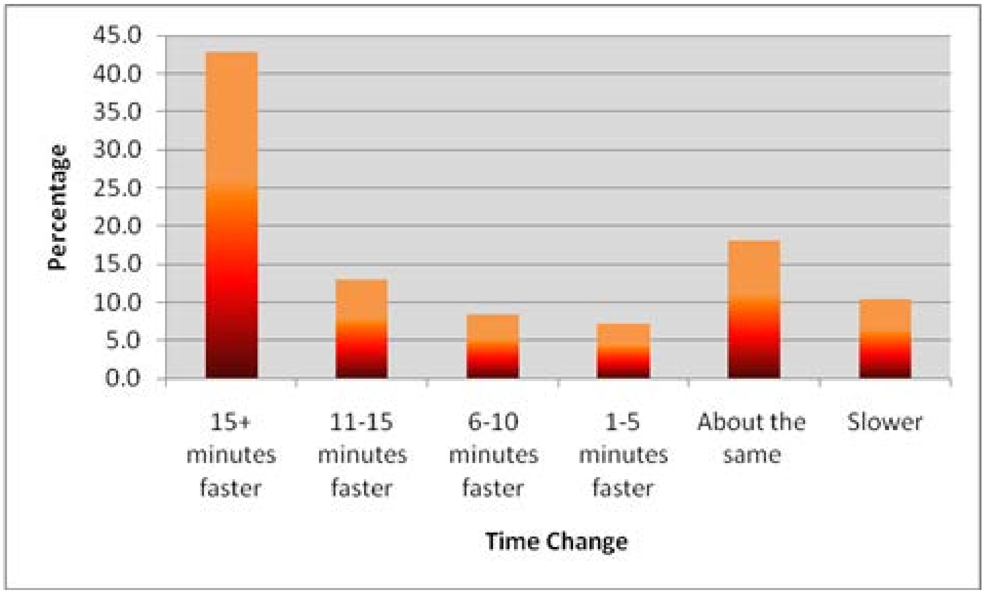


Table A-2

Impact of Orange Line on Travel Time for Prior Modes Used

Travel Time Impact	Mode Used Prior to Orange Line								
	Drove Alone	Car pooled	Bicycled	Metro Link	Walked	Metro Rail Line	Metro Bus Route	Muni Bus Route	Other
15+ min faster	21.3	29.5	30.0	42.3	34.8	55.0	58.0	50.0	47.6
11-15 min faster	7.5	11.4	30.0	13.0	8.7	10.0	12.6	50.0	23.8
6-10 min faster	5.0	6.8	10.0	8.5	13.0	0.0	9.8	0.0	4.8
1-5 min faster	5.0	9.1	10.0	7.5	17.4	15.0	4.2	0.0	0.0
About the same	33.8	29.5	10.0	18.3	8.7	10.0	11.9	0.0	4.8
Slower	27.5	13.6	10.0	10.5	17.4	10.0	3.5	0.0	19.0
TOTAL	100	100	100	100	100	100	100	100	100

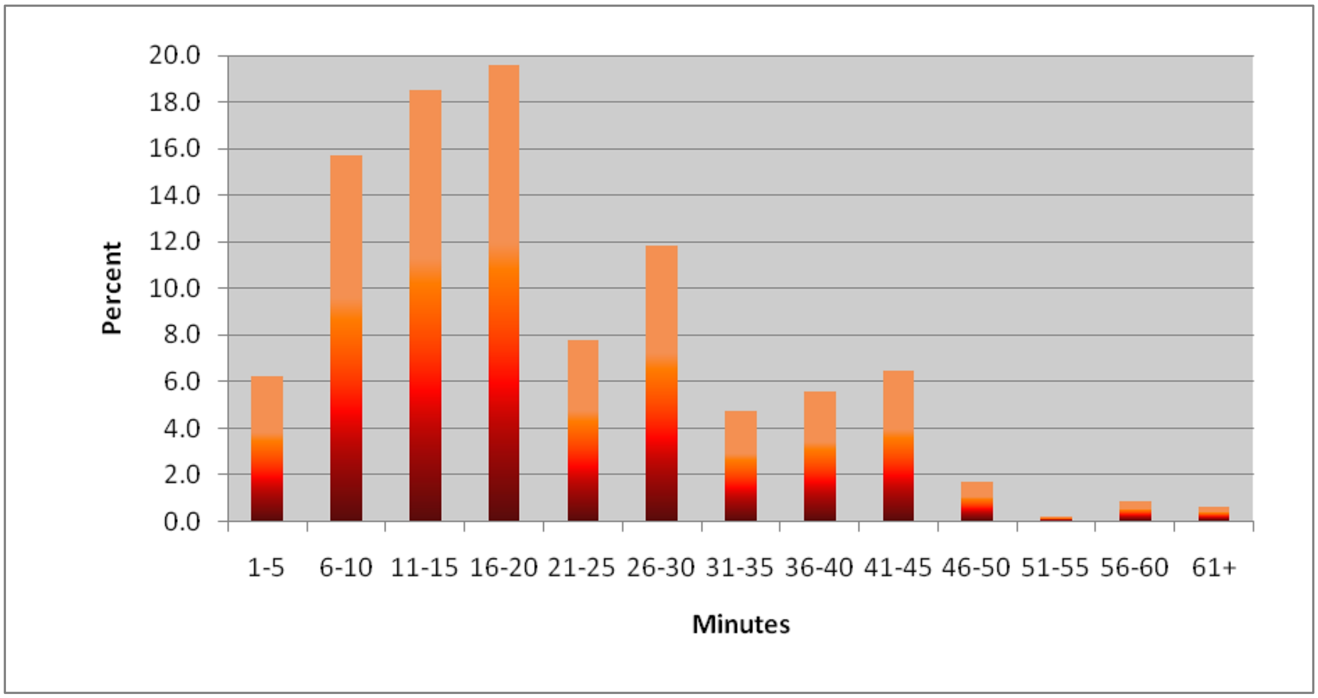
The overwhelming majority of riders that used a form of public transit prior to the Orange Line said that their travel time is now faster than before (80% of previous Metro Rail riders, 71% of previous MetroLink riders, 85% of previous Metro Bus route riders, and 100% of previous Muni Bus riders). An impressive number of these previous transit users reported a travel time savings of 15 minutes or more (55% of previous Metro Rail riders, 42% of previous MetroLink riders, 58% of previous Metro Bus route riders, and 50% of previous Muni Bus riders).

For those who rode with someone else, cycled, walked, or selected "other," the majority responded that the Orange Line completes the trip faster than their previous mode.

According to NBRTI's travel time analysis, the Orange Line takes approximately 42 minutes, on average, to travel from North Hollywood Station to Warner Center. To understand the length of time that most riders were onboard an Orange Line vehicle, riders were asked "Approximately how long will you be on this bus?" The time interval of 16 to 20 minutes was the most frequently chosen response (19.6%), with 11 to 15 and 6 to 10 minutes the next highest chosen intervals at 18.5 percent and 15.7 percent respectively. Only 16.8 percent of riders reported trip lengths between 31 and 45 minutes, and very few respondents (3.4%) reported being onboard the vehicle 46 minutes or more.

Figure A-11

Approximately How Long Will You Be on This Bus?

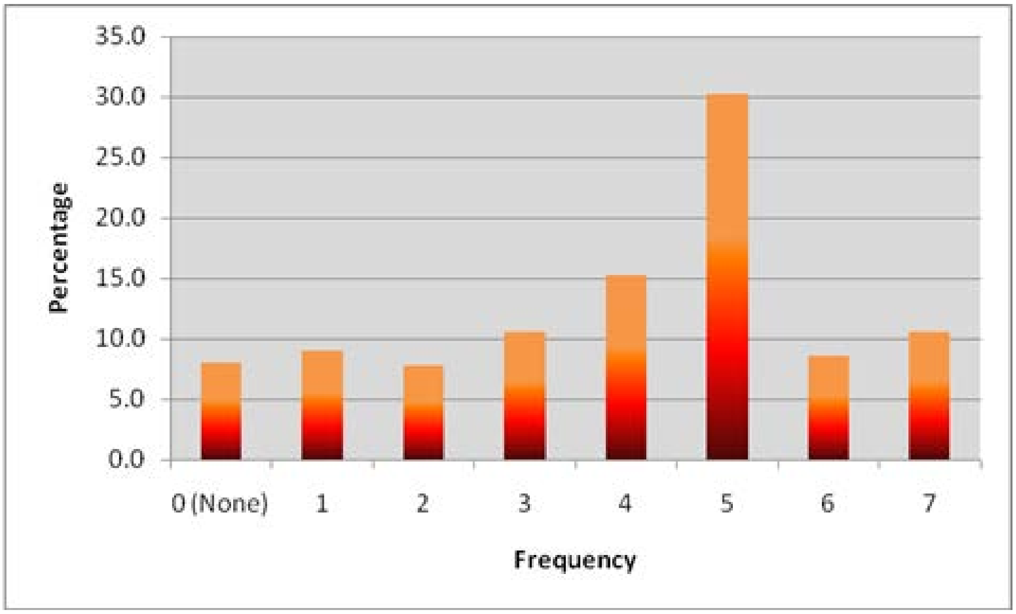


Characteristics of Transit Use

In an effort to understand the frequency of use among riders, survey participants were asked how many days per week they rode the Orange Line (Figure A-12). The group with the largest percentage of respondents was for five days per week (30.3), followed by four days (15.2) and seven days (10.6). This is indicative that the majority of riders use the Orange Line to travel to and from work and school.

Figure A-12

How Many Days per Week Do You Usually Ride the Orange Line?



Riders also were asked how many days they usually ride on Metro buses or trains. As shown in Figure A-13, the most frequently chosen response was five days per week (29.0%). This closely mirrors responses provided for use of the Orange Line (30.3%). Approximately 18 percent of riders access public transit seven days of the week.

Figure A-13

How Many Days A Week Do You Usually Ride Metro Buses/Trains?

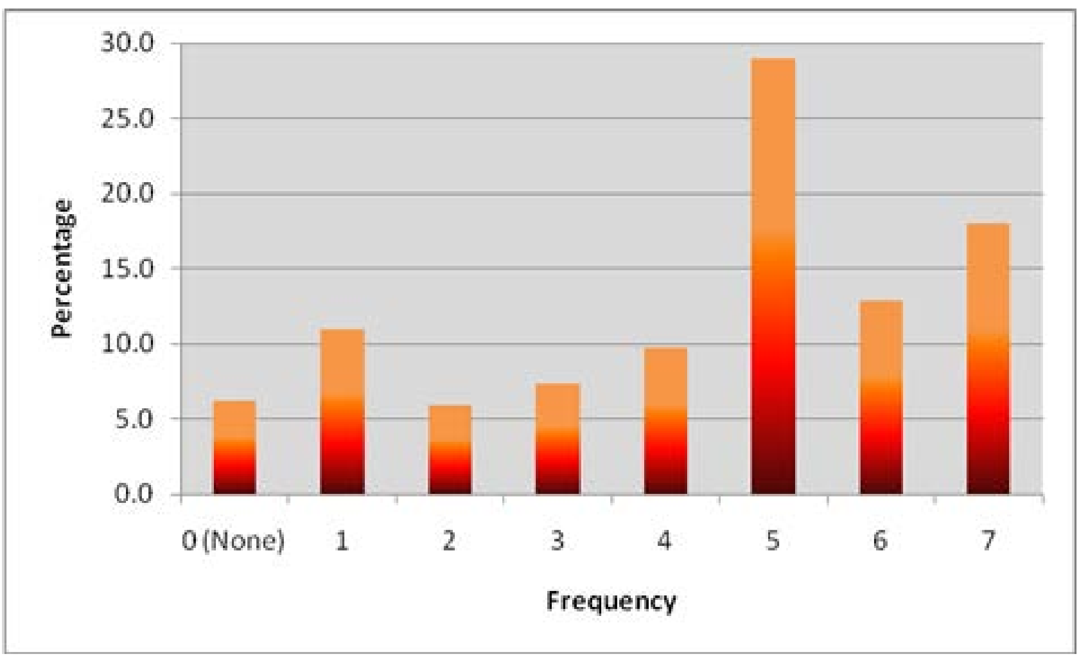


Table A-3 shows the results of a cross tabulation of the survey questions "What is your annual household income?" and "How many days per week do you usually ride the Orange Line?" Approximately 37 percent of respondents who use the service five days a week live in a household with an annual income of $35,000 or more.

Table A-3

Percent of Riders by Annual Household Income and Days Riding Orange Line/Week

	Days Per Week (%)							
Annual Household Income	0 (None)	1	2	3	4	5	6	7
Less than $10,000	27.6	31.4	48.6	31.8	38.6	22.6	37.5	36.6
$10,000 to $14,999	3.4	11.4	20.0	27.3	15.8	12.9	25.0	17.1
$15,000 to $24,999	13.8	17.1	14.3	9.1	8.8	9.7	12.5	19.5
$25,000 to $34,999	13.8	11.4	8.6	11.4	10.5	17.7	0.0	4.9
$35,000 to $44,999	6.9	11.4	2.9	0.0	3.5	8.1	10.0	7.3
$45,000 to $59,999	6.9	2.9	2.9	9.1	8.8	9.7	7.5	7.3
$60,000 to $74,999	0.0	2.9	0.0	2.3	3.5	9.7	7.5	0.0
$75,000 to $99,999	20.7	0.0	2.9	4.5	5.3	4.8	0.0	2.4
$100,000 or more	6.9	11.4	0.0	4.5	5.3	4.8	0.0	4.9
TOTAL	100	100	100	100	100	100	100	100

*Zero days per week was a provided response, as the question asked about usual travel behavior.

Riders were also asked "How many times will you board a bus/train today?" Figure A-14 shows that most riders (31.06%) use buses or trains twice a day, which can be attributed to the particular origin and destination trip completed by the respondent that day. Approximately 49 percent responded that they would board a transit vehicle four or more times, indicating that almost half of Orange Line riders access the line as only part of their trip. As with the results for mode of access/egress (see Figures A-7 and A-8), this suggests that the Orange Line serves in large part as a feeder to other transit modes, rather than as a single-seat ride.

In responses to the question, "How long have you been riding the Orange Line?" more than 74 percent of responses reported using the Orange Line for 6 months or more, with 19.1 percent reporting use for six months to one year, 25.7 percent for one to two years, 13.5 percent for two to three years, and 16.2 percent for 3 or more years. In addition, 17.2 percent have been accessing the service for six months or less, indicating that the Orange Line has been successful in attracting new riders.

Figure A-14

How Many Times Will You Board A Bus/Train Today?

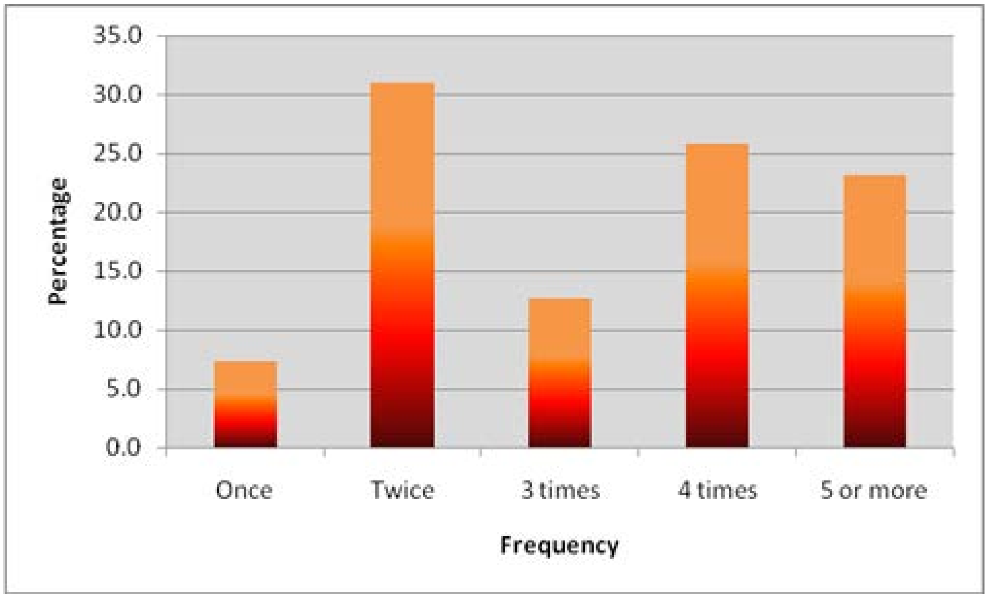
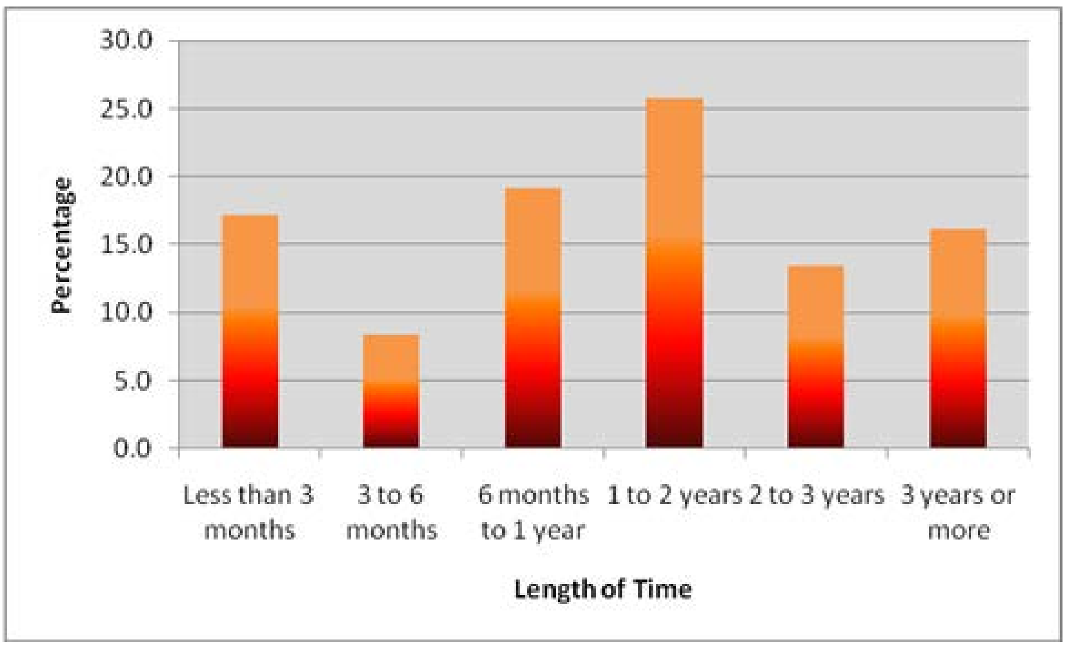


Figure A-15

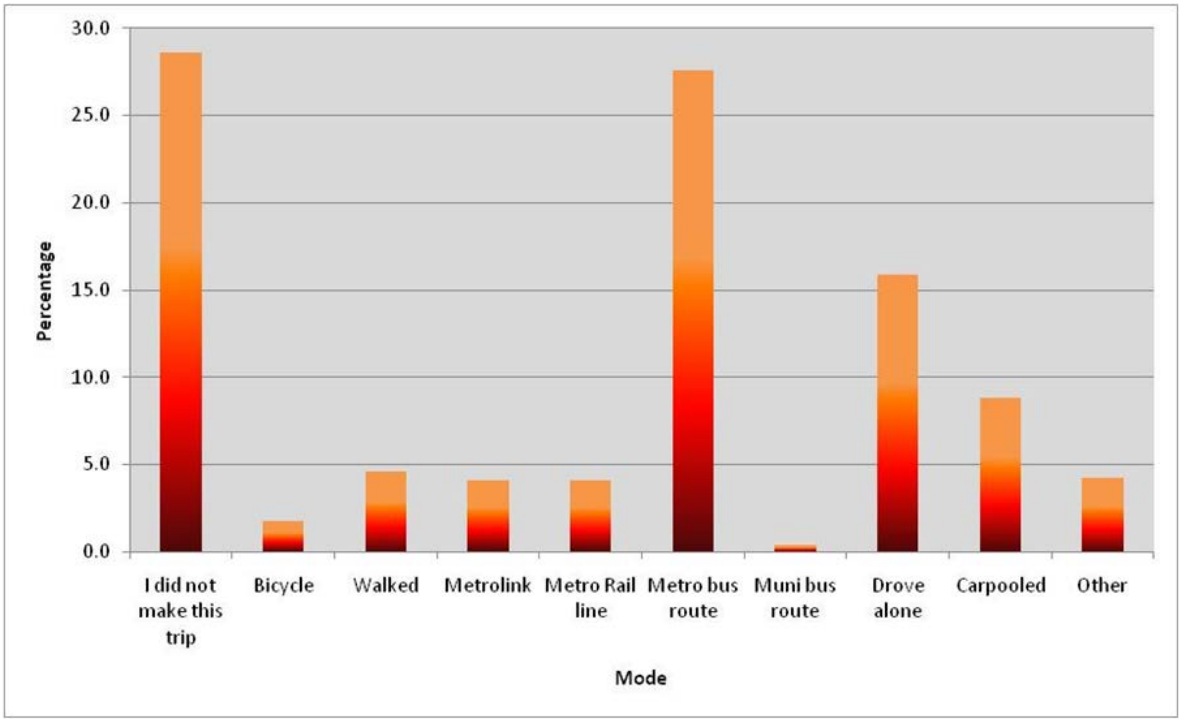
How Long Have You Been Riding the Orange Line?



Based on responses to the question, "Before the Orange Line opened, how did you make this trip?" it is apparent that the most frequent response among survey participants was that they did not previously make the trip (28.6%). As shown in Figure A-16, almost as many participants responded that they had previously used a Metro bus route (27.6%). Approximately 25 percent of riders responded that they previously drove alone or carpooled, showing that the Orange Line has been effective in attracting choice riders. Other reported responses were making the trip by foot (4.6%), using MetroLink (4.1%), riding Metro Rail lines (4.1%), using other means (4.2%), biking (1.8%), and using Muni bus routes (0.4%).

Figure A-16

Before the Orange Line Opened, How Did You Make This Trip?



In an effort to further understand the group of respondents that stated that they have been using the Orange Line over specific amounts of time, a cross tabulation was completed between the length of ridership data (Figure A-15) and data from the question, "Do you own a car or other motor vehicle, or have access to one?"

As shown in Table A-4, of those that had been using the Orange Line for less than three months, slightly more than half responded that they had access to a car or other motor vehicle. Aside from the "3 to 6 months" category (in which only 22% reported having access to a motor vehicle), there appears to be a moderate but steady decline in motor vehicle access with increased length of time using the Orange Line

Table A-4

Motor Vehicle Ownership by Length of Time Using Orange Line

	Own a Car or Other Motor Vehicle		
Length of Time	Yes %	No %	Total %
Less than 3 months	53.6	46.4	100.0
3 to 6 months	22.0	78.0	100.0
6 months to 1 year	43.3	56.7	100.0
1 to 2 years	41.1	58.9	100.0
2 to 3 years	36.8	63.2	100.0
3 or more years	34.1	65.9	100.0

Another cross tabulation compared car ownership and the number of days per week respondents rode Orange Line. The information presented in Table A-5 shows that approximately 39 percent of respondents with access to a motor vehicle ride the Orange Line five days a week compared to 23.5 percent that do not have access.

Table A-5

Number of Days/Week Riding Orange Line and Motor Vehicle Ownership

	Own a Car or Other Motor Vehicle	
Days per Week	Yes %	No %
0	13.9	4.2
1	5.7	10.3
2	4.1	10.7
3	8.3	12.8
4	16.1	14.6
5	38.9	23.5
6	8.3	9.3
7	4.7	14.6
TOTAL	100	100

Rating of Different Aspects of Orange Line Use

Survey respondents were asked to rate different aspects of the Orange Line service on a scale of 1 (very poor) to 5 (very good). The final two questions related to public perceptions of Orange Line service overall, and other Metro bus services overall. Table A-6 provides the analysis of these responses showing, for each service element, the sample proportions in each response category and the overall mean score. The service elements have been sorted based on the overall mean score that they achieved.

The results shown in Table A-6 indicate that the Orange Line is highly regarded by its customers, with 93.8 percent of responses rating the Orange line overall as either "good" or "very good." Furthermore, the Orange Line's overall satisfaction mean score of 4.5 compares favorably with Metro's overall satisfaction rating, which received a mean score of 4.2. None of the service elements of the Orange Line were rated "poor" or "very poor" by more than 6 percent of the sample, with only a few elements receiving more than 5 percent of their total responses in these two categories. It also can be seen that the responses were relatively consistent across the different service elements. "Additional door in the middle of the vehicle" received the highest mean score, 4.5. Service elements receiving a 4.4 rating included hours of service, ease of identifying Orange Line service, accessibility of vehicles to people with disabilities, the look and design of the Orange Line vehicles, and connectivity to other Metro services.

Additional Comments and Suggestions

The final section of the on-board survey provided space for respondents to write any other comments or suggestions about the Orange Line service. These comments have been categorized to facilitate a quasi-quantitative analysis. Table A-7 provides the results of this analysis.

The table shows that a total of 162 separate comments were coded. While the majority of respondents only made one comment, some commented on a range of different issues, and were thus assigned multiple codes. The comments were separated into seven major themes: service provision, drivers, vehicles, fares, shelters, bike racks, and overall.

Of the comments on overall satisfaction with the Orange Line, 34.6 percent were categorized as "overall satisfied," as compared to 0 percent of "overall dissatisfied" comments. The majority of the comments were made on the theme of service provision (Table A-7). The most frequently cited comment was that the Orange Line had overall "great service" (10.5%). Some of the generally negative comments on the service were made in regard to the need for more stops (9.9%), the need for better timing (6.2%), the need for more buses due to overcrowding (4.3%), and the need for extended service hours (3.1%).

The need for improvement to the vehicles made up the second largest group of comments. The largest portion of responses (3.7%) expressed concern about the need for improved safety aboard Orange Line vehicles, while 3.1 percent indicated a need for more bike racks or better bike securement. Other concerns about the Orange Line vehicles included cleanliness, with 1.2 percent saying that the buses were dirty, 1.2 percent having concerns about wheelchair ramp safety, and 0.6 percent reporting unpleasant odors.

A variety of comments were made about the Orange Line bus drivers. One person (0.6%) gave positive comments (good drivers/courteous drivers), while the rest of the comments were negative (6.8%). Criticisms included not waiting for people, poor driving (too fast/jerky/leave before people can sit down), not enforcing the rules (controlling rowdy passengers), and general rudeness by the bus drivers (tone of voice/lack of concern for users).

Table A-6

Customer Ratings of Different Aspects of Orange Line Service

	Response Category (%)					
	Orange Line					
Service Element	Very Poor (1)	Poor (2)	Fair (3)	Good (4)	Very Good (5)	Mean Score
Hours of service	0.8	0.6	9.9	33.9	54.7	4.4
Frequency of the bus (how often buses run)	0.7	2.6	14.9	34.2	47.6	4.3
Convenience of the bus (where buses go)	0.4	0.9	13.3	35.6	49.8	4.3
Dependability of the bus (on-time performance)	0.9	1.6	15.4	34.5	47.7	4.3
Wait time at station/stop for the bus	0.7	3.1	16.3	38.8	41.2	4.2
Travel time on this bus	0.5	1.6	14.9	39.4	43.7	4.2
Cost of riding the bus (value for what you pay)	2.0	4.0	15.7	31.8	46.4	4.2
Availability of bus information/maps at stations	2.0	5.4	15.3	31.5	45.7	4.1
Availability of seats on bus	2.9	5.0	29.3	34.5	28.2	3.8
Parking cost/availability	1.0	2.8	22.0	34.3	39.9	4.1
Ticket vending machines	1.2	3.1	13.6	38.3	43.9	4.2
Personal safety on vehicles	1.1	3.2	12.9	39.9	42.9	4.2
Personal safety at stations	0.5	3.4	18.3	37.2	40.6	4.1
Quality of stations	0.5	1.4	14.2	39.8	44.2	4.3
Smoothness of ride on vehicles	0.9	3.0	17.9	40.4	37.8	4.1
Ease of getting on and off vehicles	0.9	2.3	14.4	36.9	45.5	4.2
Location of Orange Line signage	0.9	1.8	14.0	39.7	43.6	4.2
Ease of identifying Orange Line service	0.5	1.6	9.5	37.6	50.9	4.4
Accessibility of vehicles to handicapped	0.5	1.0	9.1	38.2	51.3	4.4
Rear-facing wheelchair securement on vehicles	0.5	1.0	13.2	35.7	49.6	4.3
Front-facing wheelchair securement on vehicles	1.0	1.5	11.8	37.1	48.6	4.3
Time it takes for wheelchair users to board vehicles	1.7	5.4	25.3	31.9	35.8	3.9
Operator courtesy	2.1	2.5	18.9	37.8	38.7	4.1
Operator driving competence	0.9	1.4	13.5	41.9	42.3	4.2
Cleanliness of vehicles	0.7	2.0	13.9	38.9	44.5	4.2
Cleanliness of stations	1.1	1.8	13.6	38.5	45.0	4.2
Amenities at stations (benches, trash bins, etc.)	1.1	2.3	13.4	36.6	46.6	4.3
Availability of bike racks on vehicles	1.7	3.6	15.6	34.1	45.0	4.2
Look/design of the Orange Line vehicles	0.5	0.9	9.4	37.2	52.1	4.4
Additional door in the middle of vehicle	0.5	0.7	8.8	32.6	57.5	4.5
Connectivity to other Metro service	1.2	1.4	10.5	34.5	52.4	4.4
Your overall satisfaction with the Orange Line	0.4	0.9	7.0	34.2	57.5	4.5
Your overall satisfaction with Metro	2.0	2.3	13.3	36.9	45.5	4.2
Average score of each category	1.0	2.3	14.5	36.5	45.7	4.2

Table A-7

Additional Comments/Suggestions on Orange Line

Comment Category		N	%
Service Provision	Great service	17	10.49
	Need better service	4	2.47
	Need more buses/overcrowded	7	4.32
	Need better timing/synchronization	10	6.17
	Needs to be on time	3	1.85
	Need more stops and better routes	16	9.88
	Needs extended hours	5	3.09
Drivers	Satisfied with drivers	1	0.62
	Dissatisfied with drivers	11	6.79
Vehicles	Need stroller strap	1	0.62
	Needs trashcans onboard	1	0.62
	Needs improved interior	1	0.62
	Needs better maps	1	0.62
	Vehicles are clean	3	1.85
	Need air-conditioning	1	0.62
	Dirty	2	1.23
	Smell bad	1	0.62
	Need improved safety and security on vehicles	6	3.70
	Concerned with wheelchair ramp	2	1.23
Fares	Keep it free/cheap	1	0.62
	Too expensive	2	1.23
Shelters	Needs better shelters	2	1.23
	Needs bathroom at stations	1	0.62
Bike Racks	Like the bike racks	0	0.00
	Need more bike racks/bikes need better securement	5	3.09
Overall	Overall satisfied with Orange Line	56	34.57
	Overall dissatisfied with Orange Line	0	0.00
	Should have been Rail/Reinstate Rapid 724	2	1.23
Total		162	100.00

APPENDIX

B

Travel Time Component Analysis

Introduction and Methodology

This document presents the assessment of travel time and reliability on the Orange Line Bus Rapid Transit service in Los Angeles, California. Data on the Orange Line were collected on Tuesday, Wednesday, and Thursday during the week of January 25, 2010, and on Tuesday, Wednesday, and Thursday during the week of April 5, 2010. Data collection involved surveyors riding the entire length of the route, from Warner Center to the North Hollywood station, recording the time that each run began and ended, when each time point was reached, and the different components of travel time as the journey progressed. Data for a total of 64 runs were collected, achieving the target of at least 20 runs in each of the three defined time periods (AM peak, PM peak, and off-peak).

To assist in the proper collection of data and limit the need for key punch and additional data cleaning, a travel time data collection instrument was programmed onto hand-held Treo units using Entryware software designed by Techneos. The use of hand-held devices and the unique data entry software allowed for the proper recording of arrival and departure times at each stop, the calculation of time delays to the second, and total time elapsed from the beginning to the end of each trip. The programming of the units required surveyors to enter the weather for the day and reason for any reroute delays and to provide notes on reasons for delays, such as wheelchair boarding, pedestrian delays, bike loading and unloading, and other delays.

Data were analyzed to assess schedule adherence, reliability, on-time performance, and commercial speeds. Since no directly-corresponding transit service existed prior to the implementation of the Orange Line, there is no pre-Orange Line dataset to compare to the travel time data collected by NBRTI. Therefore, a direct before and after comparison describing travel time achievements attributable to the Orange Line is not possible. Nonetheless, this effort provides insight into the directional and temporal components of the Orange Line's running time, and produces a useful "before" dataset for future study of the line.

Travel Time Component Analysis

Total Travel Time

Figure B-1 shows the mean travel time (in minutes) of the Orange Line service, as well as how the different travel time components (time spent in transit, signal delay, dwell time, and other delays) contribute to total travel time.

Figure B-1

Aggregate Mean Total Travel Time of Orange Line

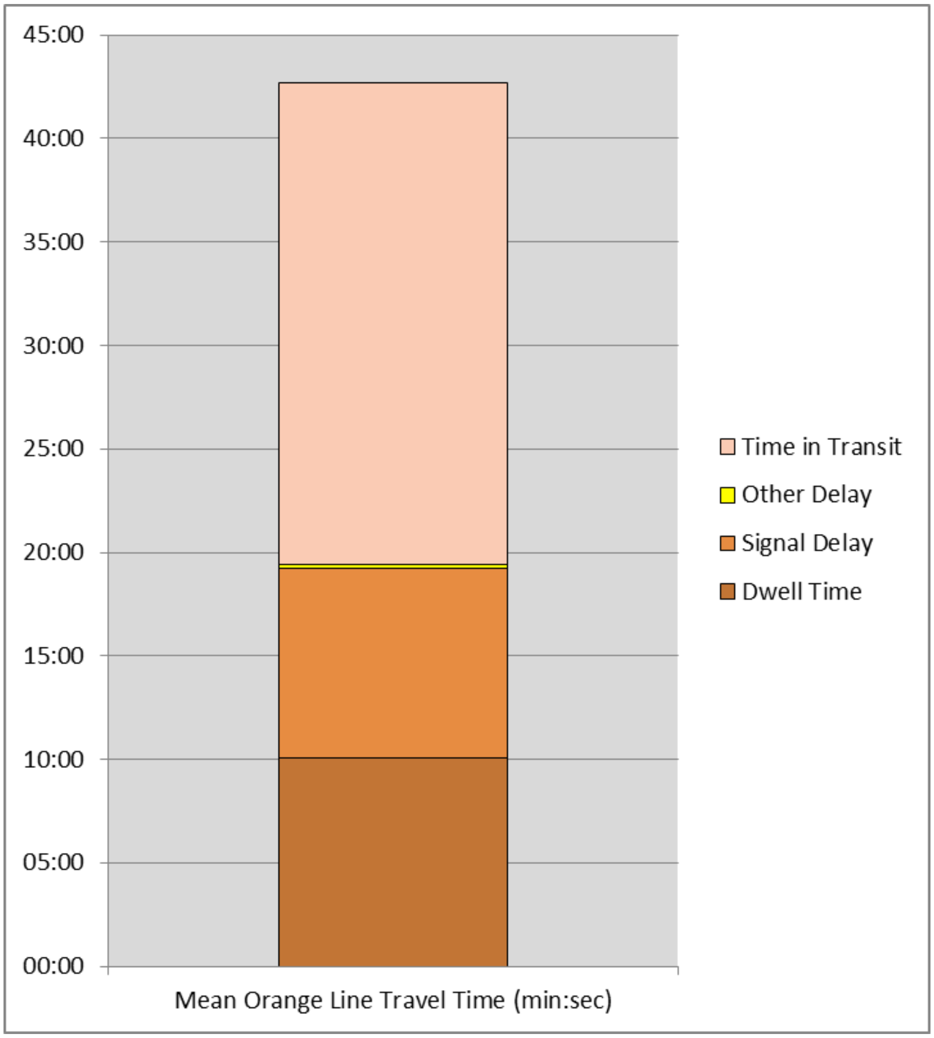


Table B-1 provides the mean for each component of travel time, along with a breakdown by time period (morning and evening peaks and off-peak). The mean travel time of the Orange Line was 42 minutes, 46 seconds. More than half (55%) of mean travel time was spent in-transit, while the remainder was fairly evenly split between dwell time (23%) and signal delay (21%). On average, PM peak trips took 3.7 minutes longer than trips in the AM peak. This increase was primarily due to time in transit (dwell time actually decreased), indicating that average travel speeds are slower in the PM peak. According to staff at Metro, travel speeds in the PM peak may be impacted by heavy traffic along the on-street segment extending from Warner Center to Canoga Station.

Table B-1

Orange Line Travel Time Comparison

Travel Time Components	Mean			
	AM	OFF	PM	All Time Periods Combined
Dwell Time	10:33	09:30	10:13	09:59
Signal Delay	09:25	08:57	09:51	09:14
Other Delays	00:04	00:23	00:09	00:13
In-Transit	20:30	24:20	24:13	23:20
Total Travel Time	40:45	43:10	44:25	42:46

Travel Time by Direction and Time Period

Figure B-2 and B-3 and Tables B-2 and B-3 compare the mean travel time (in minutes) of the Orange Line in each direction and by time period, as well as how the different travel time components contribute to total travel time.

Figure B-2

Comparison of Mean Total Travel Time, North Hollywood and Warner Center-Bound

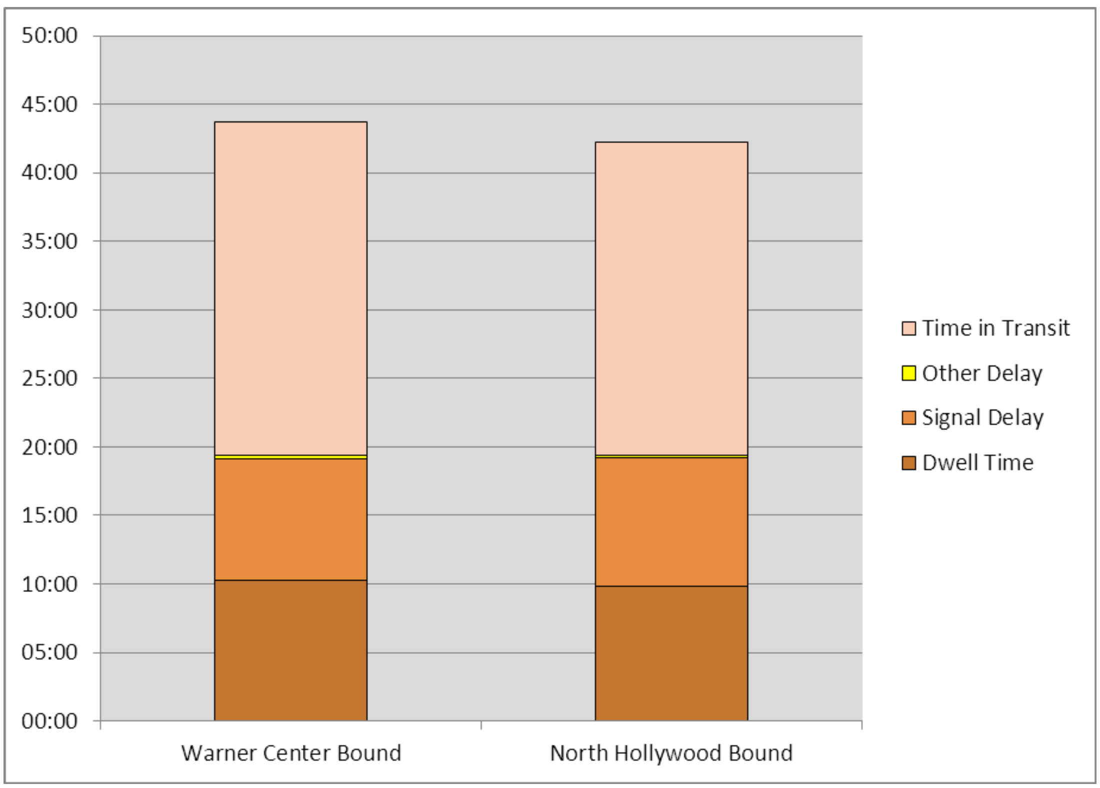


Figure B-3

Comparison of N. Hollywood and Warner Center-Bound Based on Peak Operation Travel Time Component

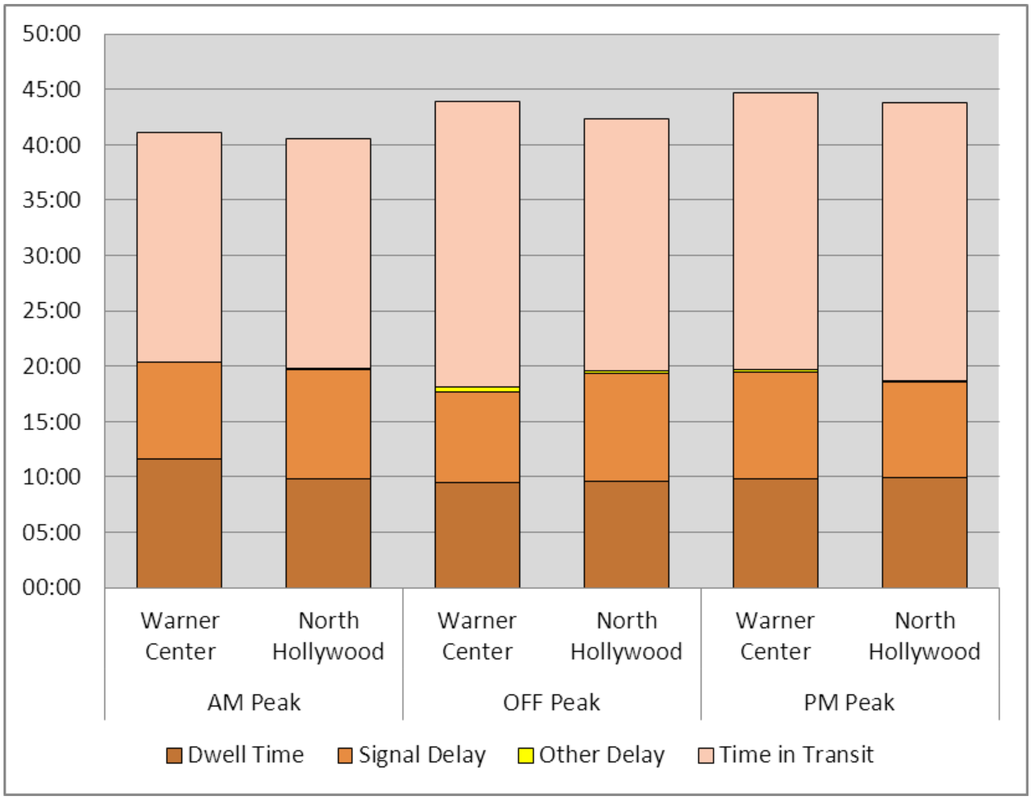


Table B-2

Orange Line Travel Time Comparison, Warner Center Bound

Travel Time Components	Mean			
	AM	OFF	PM	All Time Periods Combined
Dwell Time	11:39	09:26	10:11	10:06
Signal Delay	08:40	08:17	10:11	08:40
Other Delays	00:00	00:28	00:13	00:17
In-Transit	20:45	25:44	24:09	24:16
Total Travel Time	41:04	43:55	44:44	43:20

Table B-3

Orange Line Travel Time Comparison, North Hollywood Bound

Travel Time Components	Mean			
	AM	OFF	PM	All Time Periods Combined
Dwell Time	09:51	09:35	10:14	09:47
Signal Delay	09:53	09:45	09:32	09:26
Other Delays	00:06	00:17	00:05	00:10
In-Transit	20:42	22:41	24:17	22:30
Total Travel Time	40:32	42:18	43:45	42:16

For each time period, mean travel time in the direction of Warner Center was greater than in the direction of North Hollywood, although only slightly so. The largest variation (1 minute, 37 seconds) occurred during off-peak operation; most of this variation was due to time spent in transit, which was approximately 3 minutes greater when traveling toward Warner Center. For all time periods combined, mean total travel time in the direction of Warner Center was approximately one minute greater than when traveling toward North Hollywood, with most of the difference again coming from time in transit. Overall, these results indicate that average travel speeds are slower when traveling westward.

There are two likely explanations for this. First, the design of the route itself is slightly longer in the westbound direction, where the final layover at Warner Center is two-thirds of the way around the loop. A second factor is the design of the signal progression, which, as a result of the various cycle lengths and signal spacing, is slightly favorable for eastbound travel. Thus, it is possible that westbound vehicles are more likely to encounter a signal that is red upon the vehicle's approach, but that turns green before the vehicle needs to come to a complete stop. This would result in higher levels of deceleration for westbound travel, and hence slightly slower average travel speeds.

Reliability/Schedule Adherence

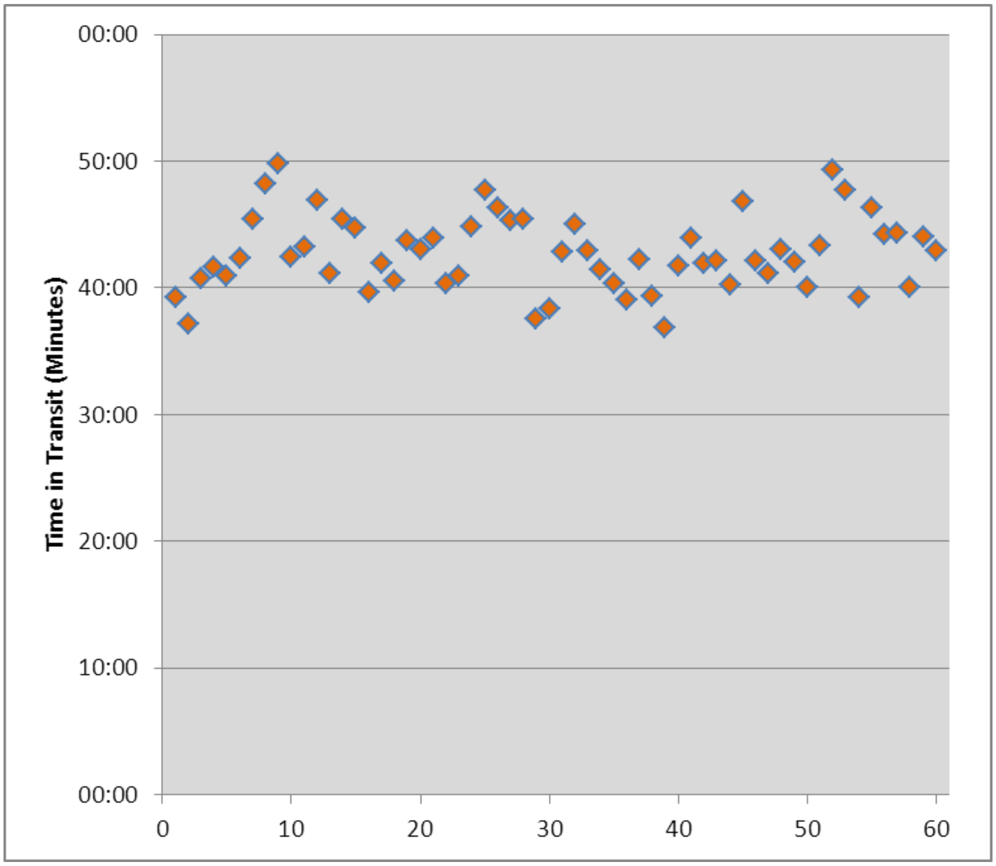
Overall Impact of Orange Line on Reliability

Assessment of the reliability of the Orange Line service was initiated with a scatter plot analysis of total travel time. This is shown in Figure B-4.

The figure shows that the observed running time on the Orange Line ranged from 36 minutes, 53 seconds to 50 minutes. The average run time is 42 minutes, 46 seconds, with a standard deviation of +/- 2 minutes, 57 seconds.

Figure B-4

Orange Line Travel Time Dispersion



Schedule Adherence

Figures B-5 and B-6 compare the scheduled travel times versus actual travel times on the Orange Line in each direction. Both directions of travel more closely adhere to the scheduled time in the AM peak. The North Hollywood bound direction of travel is more consistent, with an average scheduled end-to-end travel time of approximately 42 minutes, 16 seconds.

Table B-4 summarizes the average difference between scheduled and actual travel times between the two directions of the corridor. Differences in average travel time show that North Hollywood-bound adhered more closely to the schedule, deviating an average of 15 seconds from the allotted travel time, compared to an average deviation of 51 seconds when travelling toward Warner Center. During PM peak operation, trips in both directions experienced travel times more than 60 seconds longer than scheduled, with North Hollywood bound operating an average of 1 minute, 11 seconds behind schedule and Warner Center bound operating an average of 2 minutes, 31 seconds behind schedule. Overall, the Orange Line operates on time, deviating an average of only 32 seconds from the scheduled travel time.

Figure B-5

Orange Line Schedule Adherence, North Hollywood-Bound

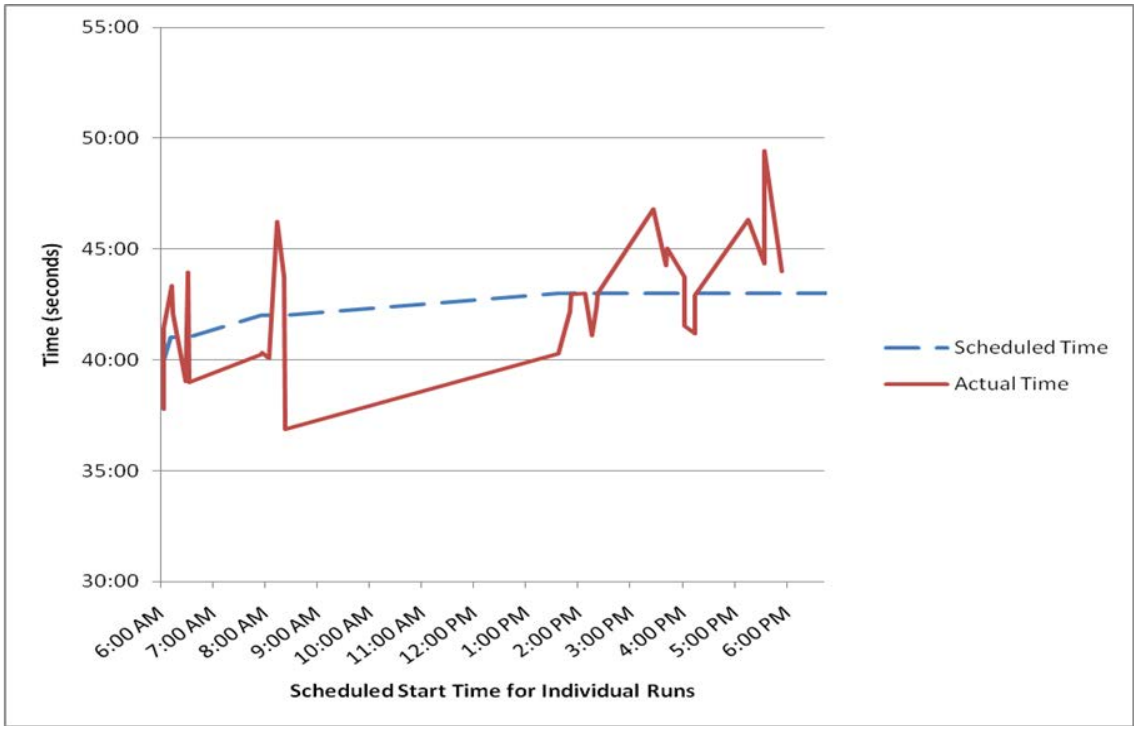


Figure B-6

Orange Line Schedule Adherence, Warner Center-Bound

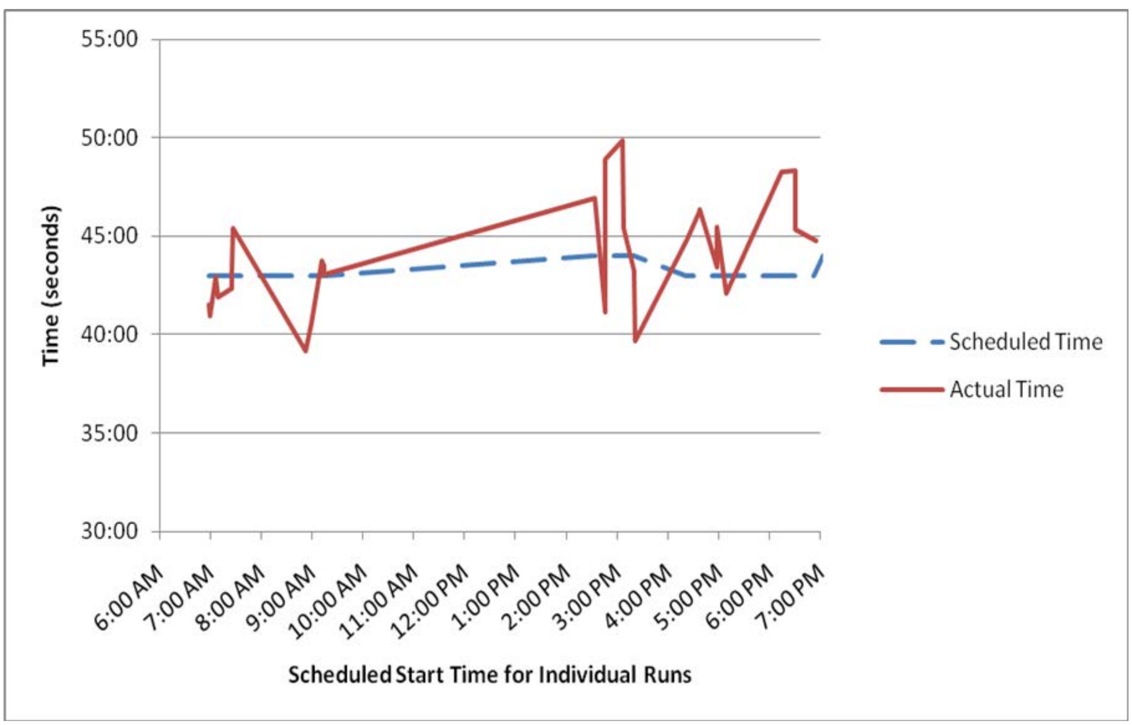


Table B-4

Difference between Scheduled and Actual Travel Times

	Mean Difference Between Scheduled and Actual Travel Times (Sec)				Standard Deviation Of Mean Difference Between Scheduled and Actual Travel Time (Sec)			
	AM	OFF	PM	Total	AM	OFF	PM	Total
North Hollywood Bound	-00:13	00:06	01:11	00:15	02:41	01:54	02:40	02:26
Warner Center Bound	-01:00	00:50	02:31	00:51	01:47	03:09	01:56	02:43
Both Directions	-00:32	00:28	01:52	00:32	02:20	02:34	02:16	02:34

On-time Performance

Tables B-5 and B-6 provide a summary of on-time performance of the Orange Line for each direction of travel, expressed as the percentage of runs early, on-time (within one minute of scheduled time), and late for each time-point.

Table B-5

Orange Line On-time Performance Assessment, North Hollywood Bound

	Warner Center	Pierce College Station	Balboa Station	Van Nuys Station	North Hollywood
> 1 min early	22.58%	3.33%	13.79%	7.14%	45.16%
On time	58.06%	23.33%	48.28%	35.71%	9.67%
1 to 3 min late	16.13%	60.00%	27.59%	35.71%	38.01%
3 to 5 min late	0.00%	3.33%	6.90%	10.71%	3.23%
> 5 min late	3.23%	10.00%	3.45%	10.71%	3.23%
Observations	31	30	29	28	31

Table B-6

Orange Line On-time Performance Assessment, Warner Center Bound

	North Hollywood	Valley College Station	Sepulveda Station	Reseda Station	Warner Center
> 1 min early	3.33%	7.14%	7.69%	11.11%	36.67%
On time	46.67%	39.29%	57.69%	51.85%	13.33%
1 to 3 min late	43.33%	46.43%	26.92%	22.22%	10.00%
3 to 5 min late	3.33%	7.14%	3.85%	11.11%	30.00%
> 5 min late	3.33%	0.00%	3.85%	3.70%	10.00%
Observations	30	28	26	27	30

While the previous analysis of the Orange Line schedule adherence focused on end-to-end travel time, this analysis measures adherence over the length of the route. The majority of the Orange Line trips arrived on time or between one and three minutes late. However, some stations, specifically the eastbound Van Nuys and Pierce College Stations and the westbound Reseda Station, fell behind schedule.

It should be noted that the first published schedules for the Orange Line were originally based on average runtimes for the entire route, with running boards containing only departure times from the near terminal and free running time to the far terminal. Due to the lack of any intermediate time points for regulating speed and trip spacing, these schedules were not very accurate; on-time performance lagged behind local service and vehicle bunching was an issue. On-time performance was elevated to top priority in April 2009, resulting in the addition of three intermediate time points to the Orange Line running boards. The introduction of the time points improved on-time performance on the Orange Line from 55 percent to approximately 90 percent and had the added benefit of reduced bus bunching (personal correspondence with George Trudeau, Assistant Manager of Vehicle Operations, November 2, 2010).

Travel Time Ratios

This ratio compares the travel time during unconstrained travel conditions (typically off-peak) with travel time during peak periods, in order to assess the impact of peak hour travel conditions on end-to-end travel times. Because the mean AM peak travel time was actually lower than the mean off-peak travel time, only the PM peak has been used in this calculation (see Tables B-5 and B-6). Table B-7 table provides the ratio for the Orange Line service in each direction of travel.

Table B-7
Travel Time Ratios

Mean End to End Travel Time	North Hollywood Bound	Warner Center Bound
Unconstrained (Off-Peak)	42:18	43:55
Constrained (PM Peak)	43:45	44:44
Ratio	1.03	1.02

The table shows that the ratios for the Orange Line in both directions were close to 1.0 which shows that speeds do not differ significantly between the peak and uncongested (off-peak) periods. Because the Orange Line service operates on an exclusive busway, it is expected that peak hour travel conditions would have little impact on the Orange Line's end-to-end travel time.

Commercial Speeds

Route lengths were obtained in each direction for the Orange Line services, allowing commercial speeds to be calculated. As shown in Table B-8 below, average commercial speeds in both directions fall within 1 mile per hour of one another, showing consistency between directions.

Table B-8

Commercial Speeds

	North Hollywood Bound			Warner Center Bound		
	Peak	Off Peak	Total	Peak	Off Peak	Total
Mean End-to-End Travel Time (sec)	42:20	43:55	43:20	42:54	42:18	42:16
Distance (mi)	14.5	14.5	14.5	14.5	14.5	14.5
Commercial Speed (MPH)	20.55	19.81	20.08	20.28	20.57	20.58

Conclusions

The mean travel time of the Orange Line was 42 minutes, 46 seconds. More than half (55%) of mean travel time on the Orange Line was spent in transit, while the remainder was fairly evenly split between dwell time (23%) and signal delay (21%).

In general, average travel times were found to be greater during the PM peak and when traveling westward toward Warner Center. However, travel time ratios were close to 1.0, showing that travel times are not significantly impacted by varying traffic conditions and can maintain consistent levels of performance throughout the day. Because the Orange Line service operates on an exclusive busway, it is expected that peak hour travel conditions would have little impact on end-to-end travel time. Average commercial speeds also show consistency by direction and time period, falling within 1 mile per hour of one another.

It was found that both directions of travel more closely adhere to schedule in the AM peak and in the eastbound direction. Overall, however, the Orange Line was found to operate on time, deviating an average of only 32 seconds from the scheduled travel time. The Orange Line also performed well in terms of on-time performance, with the majority of trips arriving at time points on time or between one and three minutes late.

APPENDIX

C

Transit Signal Priority

Introduction

Transit signal priority (TSP), as defined by ITS America, is a cost effective method of increasing the reliability of transit and improving travel time efficiency through adjustments in traffic signals (C17). The National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP) further defines transit signal priority as providing "preferential treatment of one vehicle class (such as transit vehicles) over another vehicle class at a signalized intersection without causing the traffic signal controllers to drop from coordinated operations (C15)." The three major types of signal priority methods include active priority, passive priority, and pre-emption, although pre-emption is generally reserved for emergency vehicles and is generally not used for buses. Each type of signal priority has associated strengths and weaknesses and should be selected based on the goals and resources of the implementing agency.

Types of Transit Signal Priority

Passive priority relies on coordinating signal timing with transit vehicle schedules to minimize travel times along the corridor. By utilizing a passive signal priority methodology, travel times and reliability of transit vehicles can be improved by creating a good signal progression, without the need for additional hardware or software (C17). By accounting for average dwell times, dwell time variability, and average travel speeds, signal timing can be implemented to provide transit vehicles with better signal progression (C17). To reduce costs, transit agencies may want to consider first using passive priority to improve service before implementing an active priority system.

Active signal priority can be divided into three categories: early green, green extension, and phase insertion. Both early green and green extension actively detect the transit vehicle at a pre-determined location or through automatic vehicle location (AVL) technologies and either trigger a green phase (shorten the red phase), extend the green phase, or some combination of both, based on guidelines set by the controlling agency (C17). Phase insertion, on the other hand, will change the signal timing phases and provide a phase specifically for the transit vehicle, such as a queue jump, or an additional turning phase (C17). Traffic volumes, transit service characteristics, and the goals of the signal priority project are all contributing factors in deciding the type of signal priority to be implemented. Active signal priority may be provided to transit vehicles either conditionally or unconditionally, depending on the desired results. Generally, conditional priority is used to increase reliability by allowing vehicles running behind schedule the opportunity to "catch up" to schedule. When the objective is to decrease travel times, unconditional priority is used to ensure the transit vehicle is not impeded by traffic signals and is able to maintain a higher average speed (C17).

Motivations

TSP can be a cost-effective method for enhancing the perception and efficiency of transit with little construction cost. As much as 25 percent of all bus travel time consists of delay at intersections (C7). By controlling for this large portion of potential variability in travel time, TSP results in greater efficiency in terms of both reliability and travel times. Improving reliability through TSP can save the operating agency on inefficient scheduling (C11), thus reducing costs. In addition to more efficient scheduling, transit agencies can also see some improvement in fuel efficiency as a function of the reduced dwell time at traffic signals. TSP has been shown to improve fuel efficiency by 1.1 to 2.7 percent (C7).

While a TSP system will generally improve reliability and travel times, the true benefits and costs depend on how the system is employed and the characteristics of the corridor in which it is implemented. Evaluations of new and existing TSP systems will increase the body of knowledge regarding these benefits, and provide valuable information for agencies that may be considering TSP.

Literature Review

TSP is a well-documented area of research within the field of transportation planning and engineering, although there is still a need for additional evaluative studies to determine the effectiveness of the service within the context of different systems. This literature review will summarize two of the main topics within the literature: evaluation methodology and previous case-studies.

Methodology for Evaluating TSP

Evaluation of TSP is a vital part of the implementation process and provides an opportunity to further refine the system to best meet the stated objectives, as well as providing insight for future projects. Individual case studies and evaluations have identified costs and benefits in a variety of ways, as can be seen within the literature. Travel times, reliability, and traffic impacts are all evaluated in different ways, based on the needs and goals of the transit agency. Each corridor has its own unique characteristics and cannot be evaluated in the same way using a "cookie-cutter" formula. This leads to some difficulty in comparing the results of different TSP systems, as well as extrapolating results from one corridor to another corridor.

Selecting the proper metrics for evaluation is vital for understanding the true impacts of TSP. There are many different ways TSP can be measured, depending on the objectives of the system and the needs of the riders. Researchers from Virginia Tech outlined a framework for determining the types of metrics to be used for an evaluation, based on what element of TSP is being evaluated, and the goals of the system (C4). The framework is broken into three objectives: bus service reliability, bus efficiency, and other traffic impacts. These objectives are further broken into individual measures such as on-time performance, 95th percentile running time, or overall delay (C4). By evaluating the metrics that are important for a particular corridor, the benefits of the transit priority system can be maximized by focusing on improving these specific items.

In addition to the measures to be used for evaluation, the methodology is just as important, each with its own strengths and weaknesses. There have been numerous studies using both simulation techniques (C4, C7, C19) and empirical analysis (C16) to evaluate transit priority systems. While empirical analysis is more convincing to stakeholders, as it is a "real-world" analysis, it is both costly and time consuming (C6). Policy-makers may be less likely to trust a simulation that does not exist in the "real world" when they are considering the benefits of a system such as TSP, in which they may have limited experience. Cost is one thing that should certainly be considered when deciding on evaluation techniques. As much as 79 percent of the cost can be saved by using a simulation study (C6). The trade-off between cost and the effectiveness in convincing policy-makers should be taken into account when deciding the evaluation methodology to be used.

Previous Evaluations

Table C-1 provides a selected overview of TSP evaluations within the United States. This selection is not comprehensive, but provides a good mix of evaluation types and locations. Overall, TSP does improve travel times and reliability, with mostly insignificant impacts on traffic. As can be seen within the table, comparing the benefits from each system is difficult at best due to the major differences in corridor type, priority type (conditional vs. unconditional), number of intersections, reporting methods, etc. Travel time savings range from 2.3 percent to 20 percent (C6, C14), while reliability improvements range from 0.9 percent to 16.3 percent (C4, C20). All of the evaluations presented in the table used a combination of early green and green extension protocols.

Using simulation software, it is possible to determine the effects of different types of TSP within the same corridor. A group of studies conducted in the Virginia/Washington, D.C. area evaluated the effects of both conditional and unconditional TSP treatments on the same corridor (C4, C6). Both studies found statistically significant improvements to both travel time and reliability over no TSP; however, the conditional priority methodology provided less impact to travel time savings and had a smaller impact on non-transit traffic. Using the conditional priority system, buses were provided with a travel time savings of 2.3 to 4.8 percent and reliability improvement of 3.7 to 7.6 percent, with minimal impacts to other traffic during the morning and mid-day peak hours (C6). The unconditional priority system provided a 3.2 percent decrease in travel times and 0.9 percent improvement in reliability, with an increased vehicle delay of 1.0 percent during the morning peak for this particular corridor (C4).

Case Study — Los Angeles Orange Line

Description of Orange Line

The Los Angeles Orange Line is a bus rapid transit route that was designed to be a "light rail on rubber tires." The Orange line operates on a 14-mile dedicated busway between Warner Center and North Hollywood. There are a total of 14 stations, each approximately 1 mile apart, including the two terminal stations. The Orange Line crosses 38 signalized intersections, so providing some signal priority was necessary (C18). The Orange Line operates 22 hours per day, seven days per week with headways of four to five minutes during the peak periods, 10 minutes during the middle of the day, 15 to 20 minutes overnight, and 10 to 20 minutes on Saturday and Sunday. The bus is scheduled to complete the route in 40 to 45 minutes throughout most of the day, which equates to travel speeds of 19 to 21 miles per hour. During early morning and late night service, scheduled travel times are reduced somewhat to 35 to 40 minutes, which equates to travel speeds of 21 to 28 miles per hour.

Design of the Transit Signal Priority System

The Orange Line signal priority system is based on the active TSP system built for Metro Rapid in 2000 and is modified to work on a dedicated busway crossing major streets. By using the same TSP system already deployed throughout the rest of Los Angeles, the Orange Line corridor could be better integrated with the existing system. The National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP) is used between the loop detectors and controller in the field. Communication between the controller and the traffic management center is handled using a proprietary/legacy protocol. All priority requests and messages are passed through a central system which controls the entire system. This allows traffic managers to better coordinate and monitor the signals.

To improve travel times and reliability, the decision was made to provide TSP along the entire route, including the non-busway segment near Warner Center. In order to effectively reduce travel times, priority must be provided at every intersection. While the Metro Rapid bus service receives priority only for late buses (conditional priority), Orange Line vehicles receive the same level of unconditional priority afforded to light rail vehicles. LADOT chose to use unconditional priority for the Orange Line in order to achieve the best possible travel times and to meet the project's design objective of a "light rail on rubber tires." Although the small savings (five to ten seconds) achieved by TSP at an individual intersection may seem trivial, the cumulative result is a significant time savings to the customer (C22).

Table C-1

Previous Evaluation Studies on Transit Signal Priority

City / Agency	Year	Author	Eval. Type	TSP Type	Changes
Arlington, VA	2003	Chang, J. Collura, J. Dion, F. Rakha, H.	Simulation	Early green and green extension Unconditional	Significantly reduced travel time during morning peak by 3.2%.
					Significantly improved bus reliability during morning peak by 0.9%.
					Increased vehicle delay of other traffic during morning peak by 1.0%.
Arlington, VA	2004	Dion, F. Rakha, H. Zhang, Y.	Simulation	Early green and green extension Conditional	During the morning peak, significantly reduced travel time of express bus by 2.3 to 2.5%, delay by 3.7 to 4.1%, number of stops by 1.3 to 2.7%, and fuel consumption by 1.1 to 2.7%.
					During the morning peak, significantly reduced travel time of all buses by 4.8%, delay by 7.6%, stops by 1.8%, and fuel consumption by 1.9%.
					Minimal impact on other traffic during morning and mid-day peak.
Sacramento, CA	2006	Rephlo, J. Haas, R.	Empirical	Early green and green extension	14 to 71 second decrease in travel time on corridor, although travel-time is 40 minutes.
					No significant impact on reliability was found.
Minneapolis, MN	2006	Liao, C. Davis, G.	Simulation	Early green and green extension	12 to 15% reduction in average travel time during AM peak and 4 to 11% reduction during PM peak.
					16 to 20% reduction in average bus delay during AM peak and 5 to 14% during PM peak.
					Some impacts on non-transit travel times – 6 seconds per vehicle during the AM peak and 22 seconds per vehicle during the PM peak.
San Pablo, CA	2007	Zhou, K. Meng, L. Johnston, S. Zhang, W. Sun, S. Leung, K. Lau, J. Chiu, P.	Empirical	Early green and green extension	Significantly reduced average stop time at TSP-enabled signals by 8.2% (2.4 seconds) in the northbound direction and 10.1% (3.1 seconds) in the southbound direction.
					Significant improvements in travel time, running time, dwell time, total intersection stop time, and number of stops at red signals, although mostly during the AM and mid-day peaks.
					Delays for both major and minor movements are minimal with less than 2 seconds delay per vehicle on average.
Newark, NJ	2007	Muthuswamy, S. McShane, W. Daniel, J.	Simulation	Early green and green extension	10 to 20% reduction in travel time for transit.
					5 to 10% reduction in travel time for private car.
					Some impact on side streets when signals were optimized and green time taken away.

City / Agency	Year	Author	Eval. Type	TSP Type	Changes
South Snohomish County, WA	2008	Wang, Y. Hallenbeck, M. Zheng, J. Zhang, G. Corey, J. Ma, X.	Empirical and Simulation	Early green and green extension	16.3% (1'34") improvement for reliability on phase 1 corridor (3,600 feet/4 intersections)
					6% (15") improvement for reliability on phase 2 corridor (5.3 miles/13 intersections)
					4.9% (6.7") travel time reduction for phase 1 corridor
					4.93% (54") travel time reduction for phase 2 corridor
					Using simulation software, no significant impacts on side streets were found.

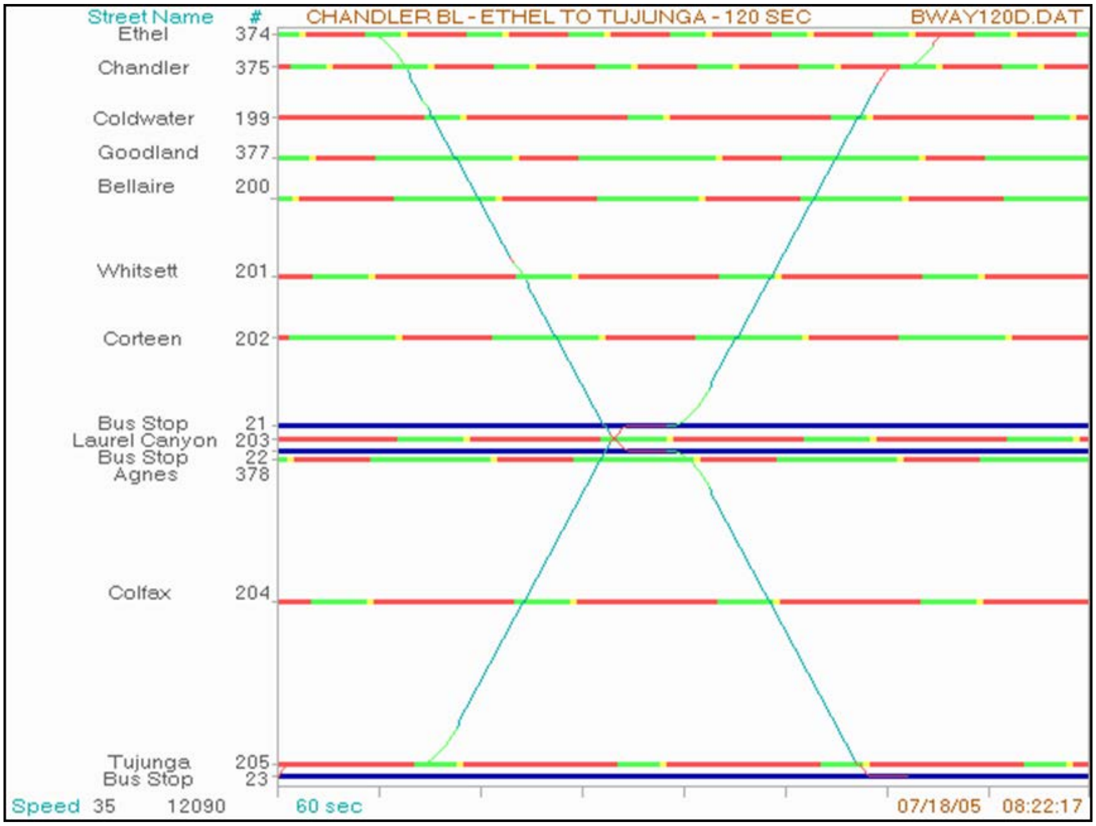
Each signal along the corridor is timed, but must be activated by either a detected bus or a pedestrian. If a signal is not activated, general-purpose traffic on cross-streets will be provided with a continuous green signal. To limit the impacts to general street traffic crossing the Orange Line busway, the TSP was designed to allow for a very small temporal gap in which the bus can travel. Because bus speeds and dwell times were incorporated into the design of the TSP system, buses operate most efficiently when drivers are able to maintain these planned speeds and dwell times (C22). Also, to further limit additional congestion on the cross streets, the major streets parallel to the busway were timed to avoid traffic interference from turning movements into the cross streets (C22).

An example of the time-space diagram used for planning purposes can be found in Figure C-1. The horizontal bars represent the signal phase, with the colors corresponding to the signal colors. The diagonal lines represent the movement of two buses moving in opposite directions through the signals. Generally, the buses are able to progress through each intersection without stopping, although a green signal cannot be provided to the bus 100 percent of the time.

Each signal has the capability to provide early green and green extension priority to buses, although both cannot be used within the same cycle (C22). Priority is provided to the bus that first requests it, although more than one bus may benefit from the priority request since buses moving in opposite directions utilize the same green time. The amount of priority provided to a bus is based on the cycle length. Up to 10 percent of the total cycle length is available for either early green or green extension priority; this translates to between nine and 12 seconds, considering that cycle lengths are 90 to 120 seconds throughout the corridor (C22). Every signal uses advanced phase calling, in which the detection of a bus is transmitted to the central system and relayed to upcoming signals in order to clear intersections of pedestrians and cross traffic for the approaching bus. Since advanced phase calling does not interfere with the cycle itself, there is no limit to how often or when it can be used.

Figure C-1

Time–Space Diagram for Select Portion of the Orange Line



As shown in Appendix B of this report, it was found that westbound travel times were 30 seconds to 2.5 minutes longer than eastbound travel times. This is due to two primary factors. First, the design of the route itself is slightly longer in the westbound direction, where the final layover at Warner Center is two-thirds of the way around the loop. It is also due to the design of the signal progression which, as a result of the various cycle lengths and signal spacing, is slightly favorable for eastbound travel. This configuration was chosen as the best option for attaining the lowest possible travel time for both directions combined.

Issues Encountered

One of the largest issues encountered after the opening of the Orange Line was safety at the major street crossings (C22). Driver confusion and red light running led to several major accidents between buses and private vehicles (see Section 4, subsection "Safety and Security"). A bus does not arrive during every cycle; however, when it does, the light is designed to turn green prior to the arrival to minimize the amount of acceleration and deceleration necessary. To improve safety at the intersections, bus operators must now slow down to 10 mph while passing through intersections. Because the TSP was designed to accommodate specific bus speeds and dwell times, the system had to be adjusted to account for the deceleration at intersections. In addition, LED signs were deployed that flash when the light is red and a bus is approaching.

Impacts of Transit Signal Priority on the Orange Line

Evaluating the impacts of transit signal priority on the Orange Line is difficult; the TSP system has been in place since the initial deployment of the Orange Line, which eliminates the possibility of a before-after evaluation. During the early concept stages of the Orange Line, there were some studies on the impacts of TSP using assumptions on travel times and typical travel time savings of the Metro Rapid routes. The early estimates for travel times were 29 to 30 minutes, although the best times achieved were closer to 33 minutes, due to signal spacing and changes in route geometry that reduced speeds along certain segments of the line (C22). After implementation, travel times further increased to closer to 40 minutes, due to the new requirement that buses reduce speed to approximately 10 mph through intersections.

A previous evaluation of the Orange Line by Stanger found that on average, the bus encounters 11 red lights, or one-third of the signals, per trip (18). The report also found that each bus spends approximately 9 minutes per run waiting at a red light. LADOT estimates that approximately 85 percent of all priority requests are granted; however, that is not to say that buses will encounter an immediate green signal 85 percent of the time. For instance, a bus may come upon a red light while receiving priority in the form of an early green, which reduces the red light dwell time from what it otherwise would have been. It is important to emphasize that signals along the Orange Line are regulated to provide just enough priority to keep buses moving at the design speed. Granting an immediate green light in response to every bus priority request is simply not feasible. This would result in unregulated movement along the corridor, which would (1) drastically increase the impacts on cross-street traffic and (2) lead to bus bunching, since encountering a red signal at some point is unavoidable. It should also be noted that, although operator speeds and driving styles vary, those who know the system well can drive it very efficiently and make the most of the signal timing (C22.)

Especially for a high-frequency service such as the Orange Line, bunching must be avoided in order to make the most efficient use of TSP. When buses become bunched together, one of two scenarios may happen: either cross street traffic will suffer from additional delays as priority is granted to consecutive buses, or some of those buses will be forced to wait at additional red lights when their priority requests are eventually denied. Due to the cycle length of 90 to 120 seconds throughout the corridor, bunching usually occurs when headways reach approximately two minutes and buses are not spaced properly between signals (C22). By managing the amount of time spent at each signal, the route can function as efficiently as possible.

Recommendations and Successes of the Orange Line

The TSP system utilized by the Orange Line is generally successful at reducing signal delay. While there are some issues (such as safety at intersections) that have reduced the impact of the system on travel times, there are successes that can be generalized for other systems.

The infrastructure used to communicate between the transit vehicle and the traffic signal controller is vital for a successful TSP system. Along the Orange Line, all messages are fed through a centralized system which oversees the entire corridor, rather than using peer-to-peer communication. This results in better advanced phase calling, which in turn allows for better signal progression (C22). Since there is not competition with general-purpose traffic on the busway, the speed of the bus is more easily controlled, making advanced phase calling more practical. Using advanced phase calling, rather than providing priority immediately before the signal, allows pedestrians and cross-street traffic to be sufficiently cleared before a bus arrives.

As an at-grade busway, safety at intersections is essential. In addition to slowing down the vehicles through the intersection, LED bus signs were installed next to the signals on the cross-streets. As mentioned previously, one of the issues encountered was confusion by motorists as they approached the busway. The signal would be red, but with no apparent traffic and a short window for the bus to pass, several accidents involving buses and private vehicles occurred. The LED bus signs provided a more clear indication that a bus was coming by flashing and attracting the attention of motorists, similar to the flashing bulbs at a railroad crossing.

Conclusions and Future Work

Implementation of transit signal priority is best done on a case-by-case basis rather than using a cookie-cutter methodology. Variables such as the type of running way, number of signals, density, headway, and cross-street traffic volumes all impact effectiveness of transit signal priority methods. Using evaluations of TSP, such as those found within this appendix, allow professionals to look at the failures and successes of previous projects and make the best decisions for future implementations.

While TSP is generally a well-documented area of research, there is still much to be done to gain a complete understanding of the topic. The headway of the Orange Line is as small as four to five minutes during peak times, while bunching occurs when headways reach approximately 2 minutes, due to the cycle length and amount of green time allowed per cycle for the bus (C22). In future studies, the relationship between transit headway and the efficiency of TSP needs to be found. Theoretically, there should be an optimal headway range for which TSP provides the greatest benefit. By determining this range, transit professionals can best make the decision on when TSP is ideal and when some other technique should be used.

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APPENDIX

D

Capacity

In Section 4, subsection "Capacity", the 95th percentile of observed peak-hour passenger loads on the Orange Line was calculated from a sample of APC data from March 2009 and analyzed to assess capacity on the Orange Line. The 95th percentile was used because (1) capacity is largely determined by maximum passenger loads, and (2) the 95th percentile yields a very accurate picture of maximum passenger loads because 95 percent of observations fall below it, while the top 5 percent of observations are eliminated.

The information presented in this appendix includes all observations from the APC data, including the top 5 percent of observations. The maximum observed peak-hour loads are shown in Table D-1 below. Table D-2 shows the percentage of peak-hour passenger load observations that exceeded Metro's 68-passenger load standard. The two tables are followed by frequency distributions of observed loads by station, direction, and peak travel time.

Table D-1

Maximum Peak-Hour Loads by Station

	Eastbound		Westbound	
Station	AM	PM	AM	PM
Warner Center	29	30	21	14
Canoga	61	44	35	23
De Soto	66	55	40	35
Pierce College	68	65	44	41
Tampa	71	78	69	50
Reseda	82	81	71	46
Balboa	83	92	84	62
Woodley	85	93	103	63
Sepulveda	86	96	96	66
Van Nuys	103	96	90	79
Woodman	103	89	90	87
Valley College	100	83	82	90
Laurel Canyon	102	84	87	92
N. Hollywood	35	36	80	90

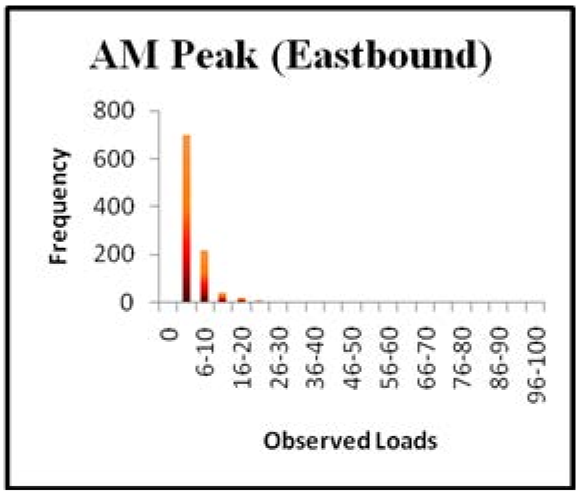
Table D-2

Percent of Observations Exceeding Load Standard of 68

	Eastbound		Westbound	
Station	AM	PM	AM	PM
Balboa	1.2%	3.7%	--	--
Woodley	1.6%	4.8%	9.2%	--
Sepulveda	6.1%	4.7%	5.6%	--
Van Nuys	16.2%	6.3%	4.2%	0.6%
Woodman	20.8%	5.0%	3.3%	5.2%
Valley College	12.1%	5.6%	2.2%	8.8%
Laurel Canyon	12.1%	3.4%	3.4%	9.4%
N. Hollywood	--	--	3.7%	11.9%

Figure D-1

Frequency Distribution of Observed Loads at Warner Center Station



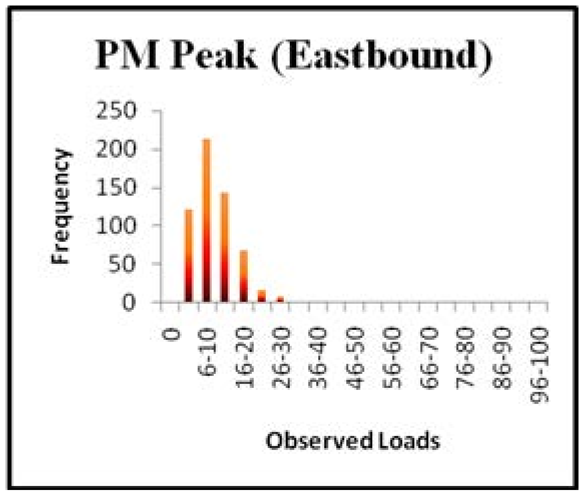


Figure D-2

Frequency Distribution of Observed Loads at Canoga Station

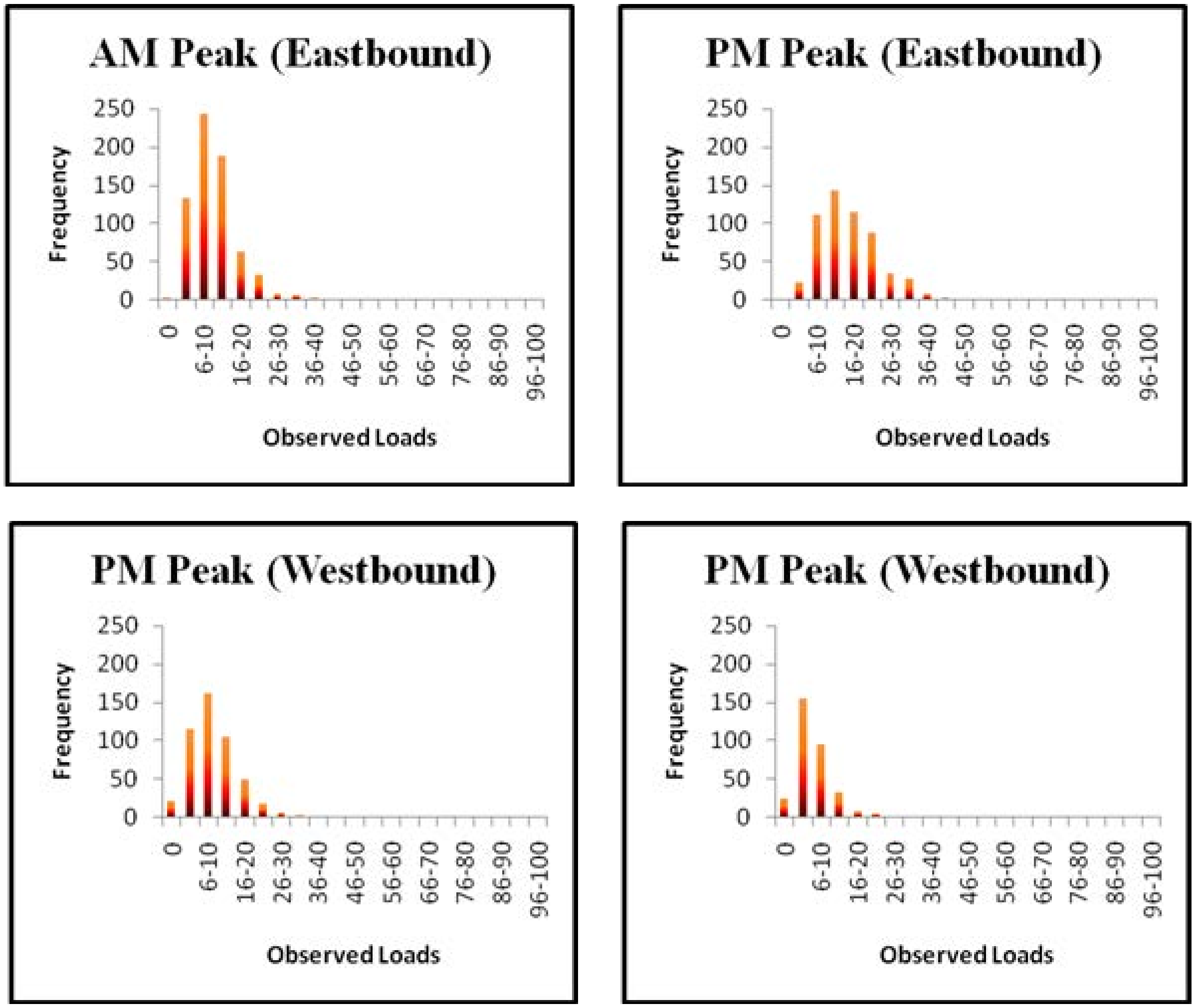


Figure D-3

Frequency Distribution of Observed Loads at De Soto Station

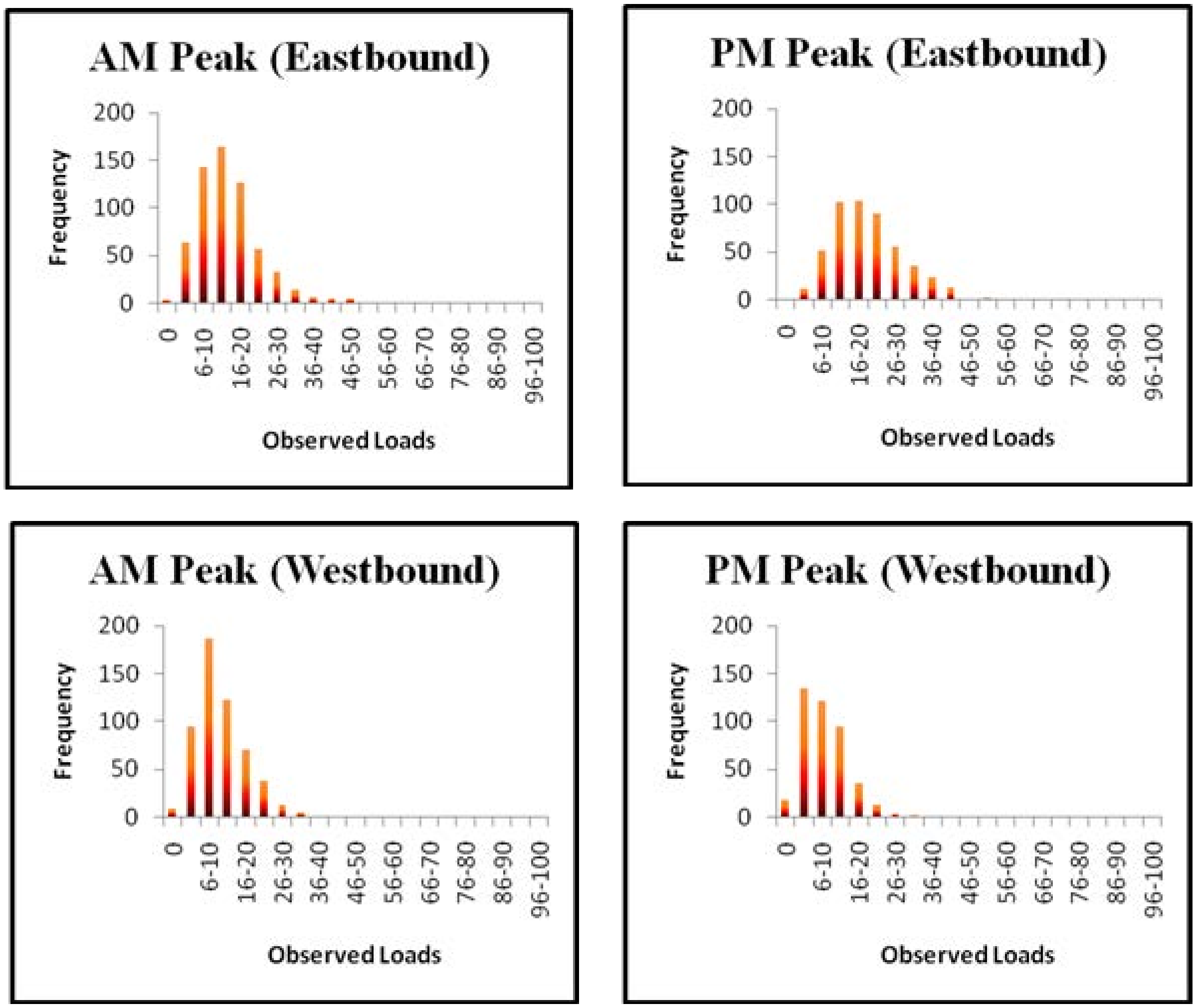


Figure D-4

Frequency Distribution of Observed Loads at Pierce College Station

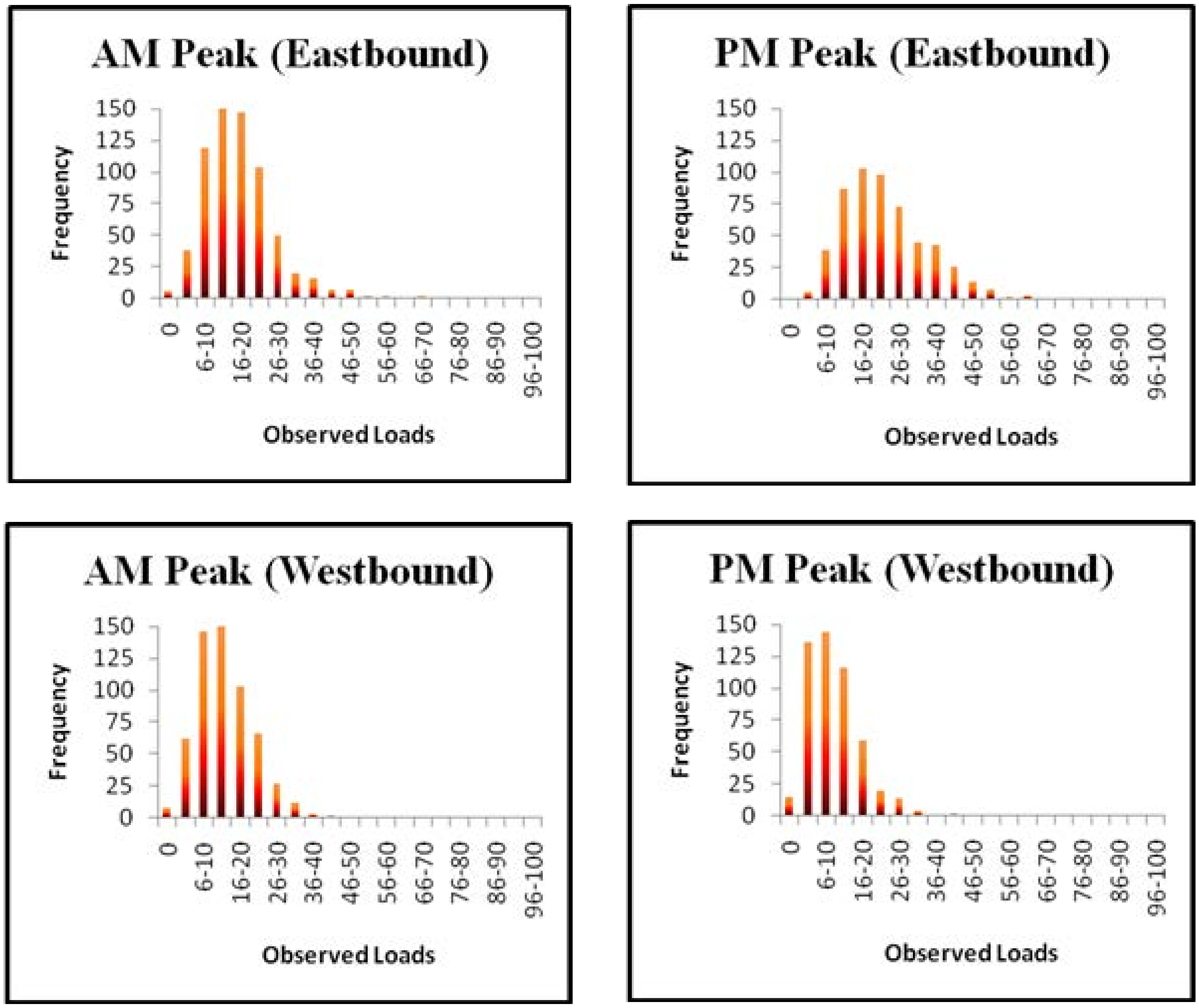


Figure D-5

Frequency Distribution of Observed Loads at Tampa Station

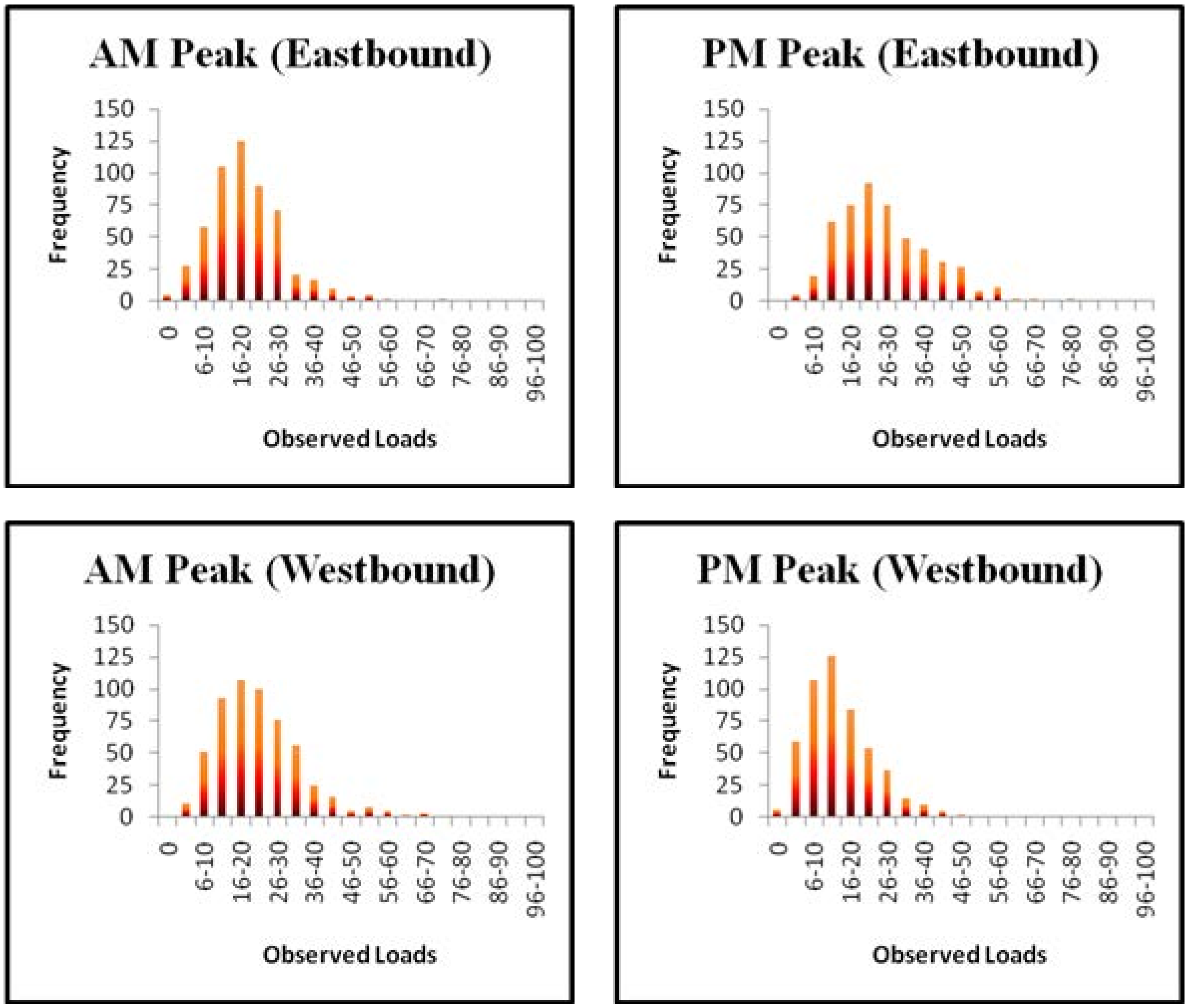


Figure D-6

Frequency Distribution of Observed Loads at Reseda Station

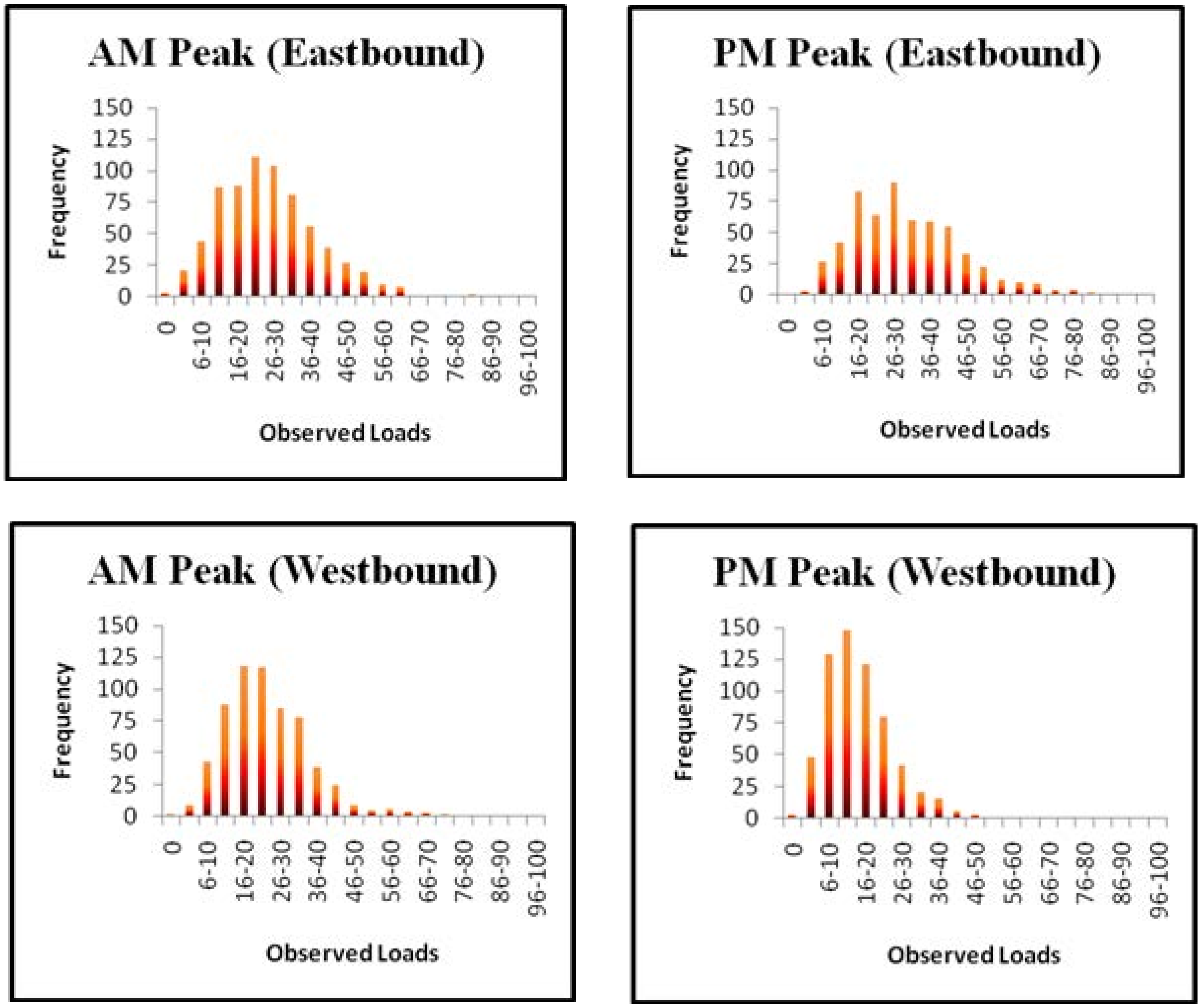


Figure D-7

Frequency Distribution of Observed Loads at Balboa Station

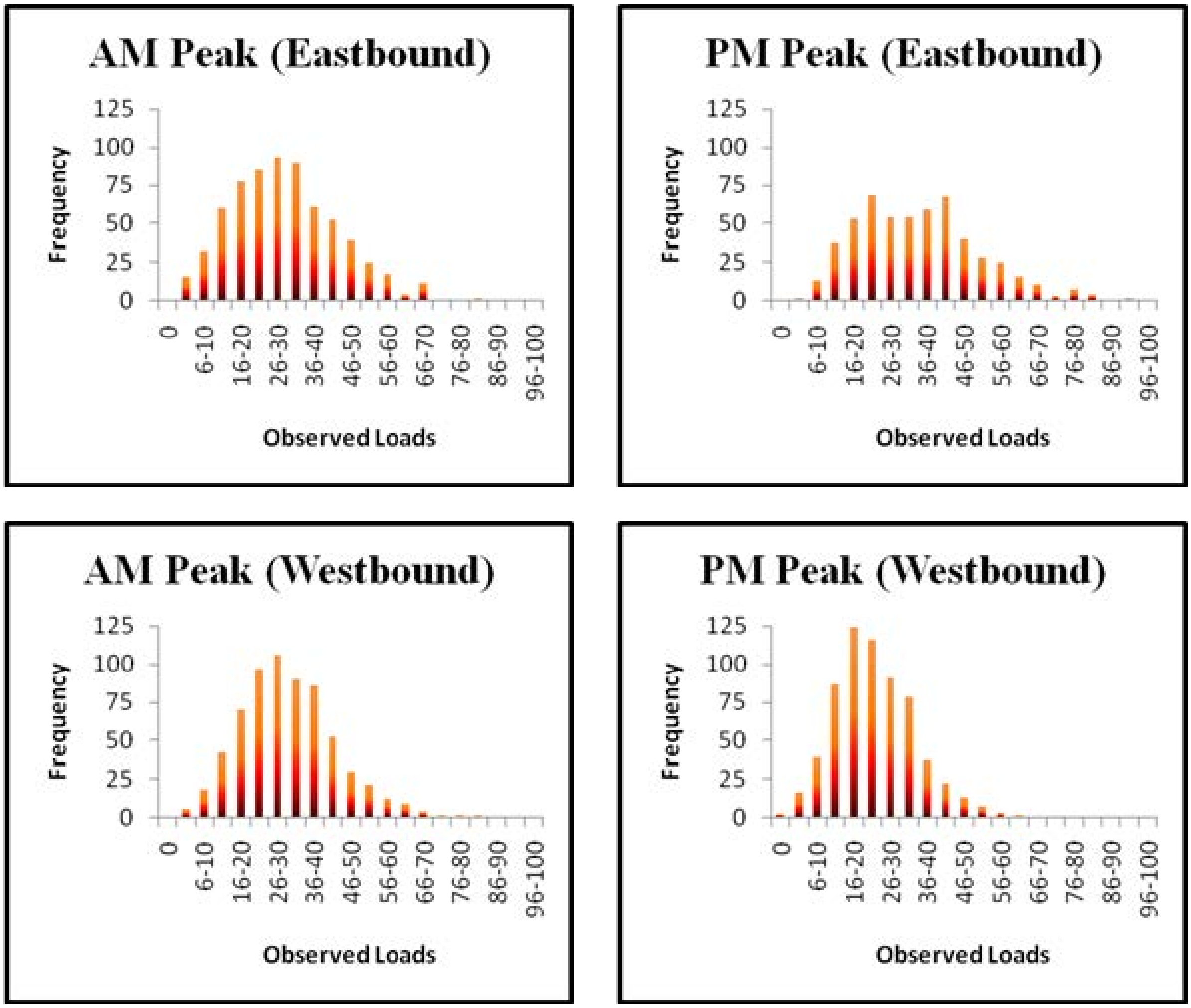


Figure D-8

Frequency Distribution of Observed Loads at Woodley Station

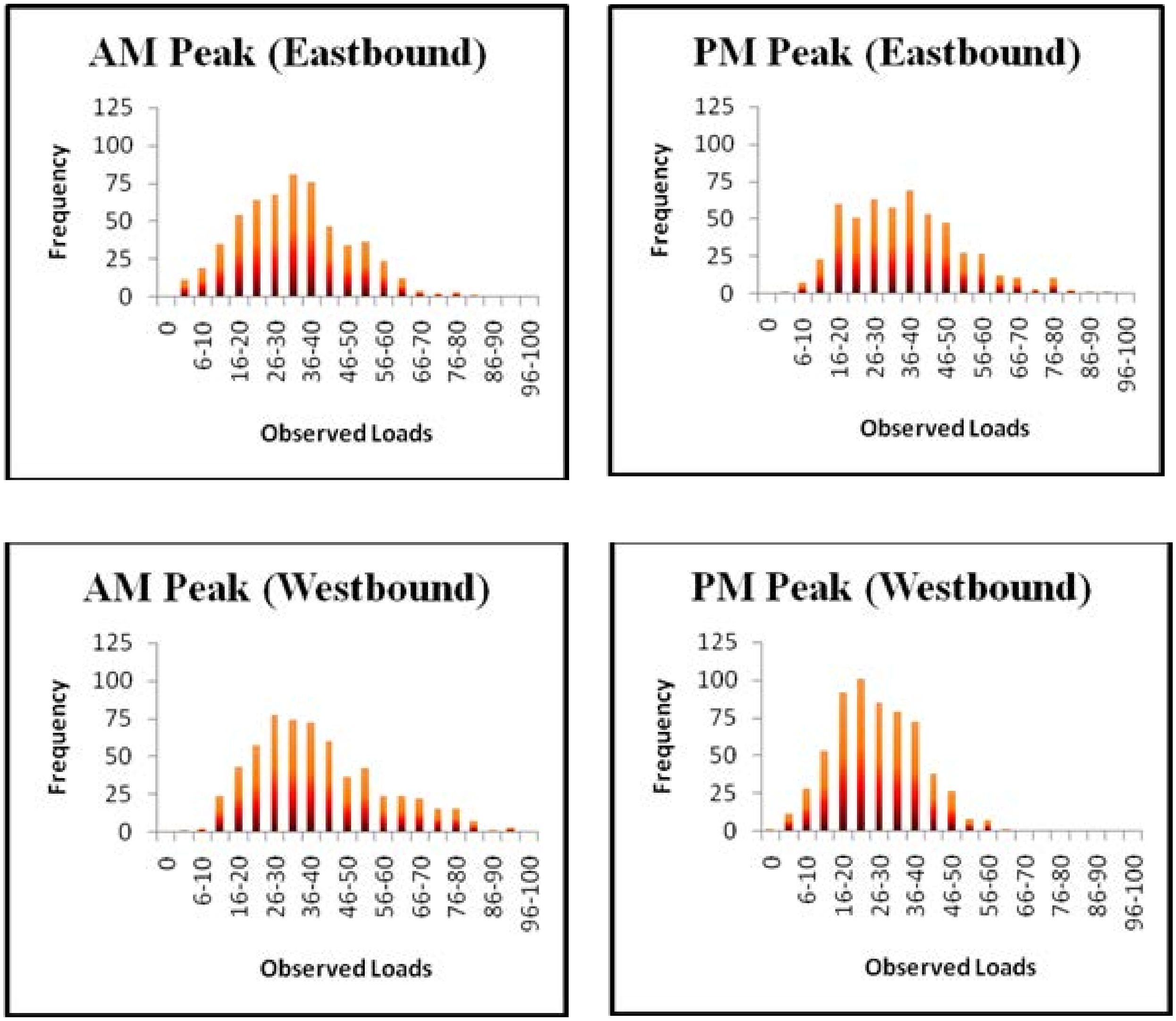


Figure D-9

Frequency Distribution of Observed Loads at Sepulveda Station

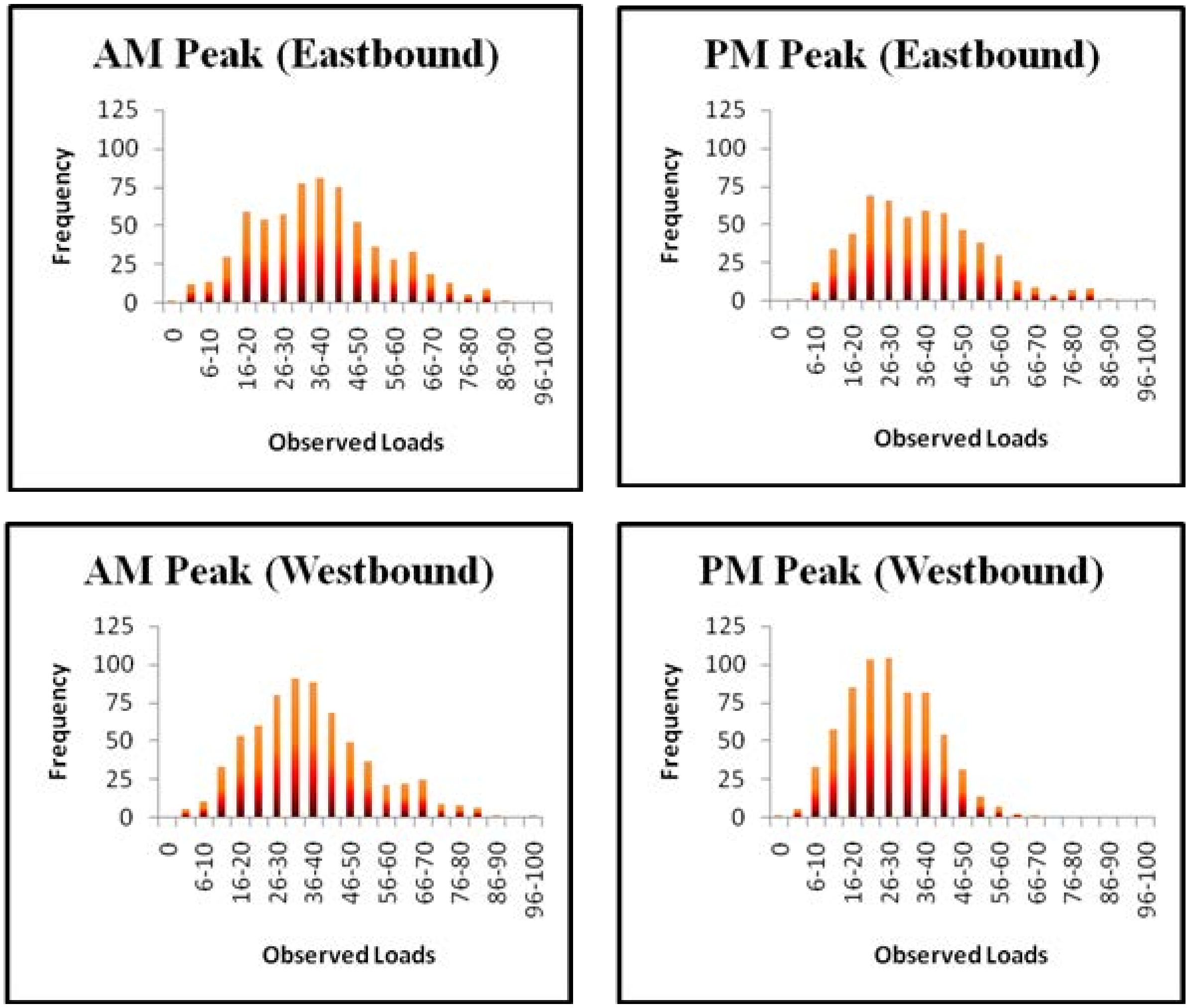


Figure D-10

Frequency Distribution of Observed Loads at Van Nuys Station

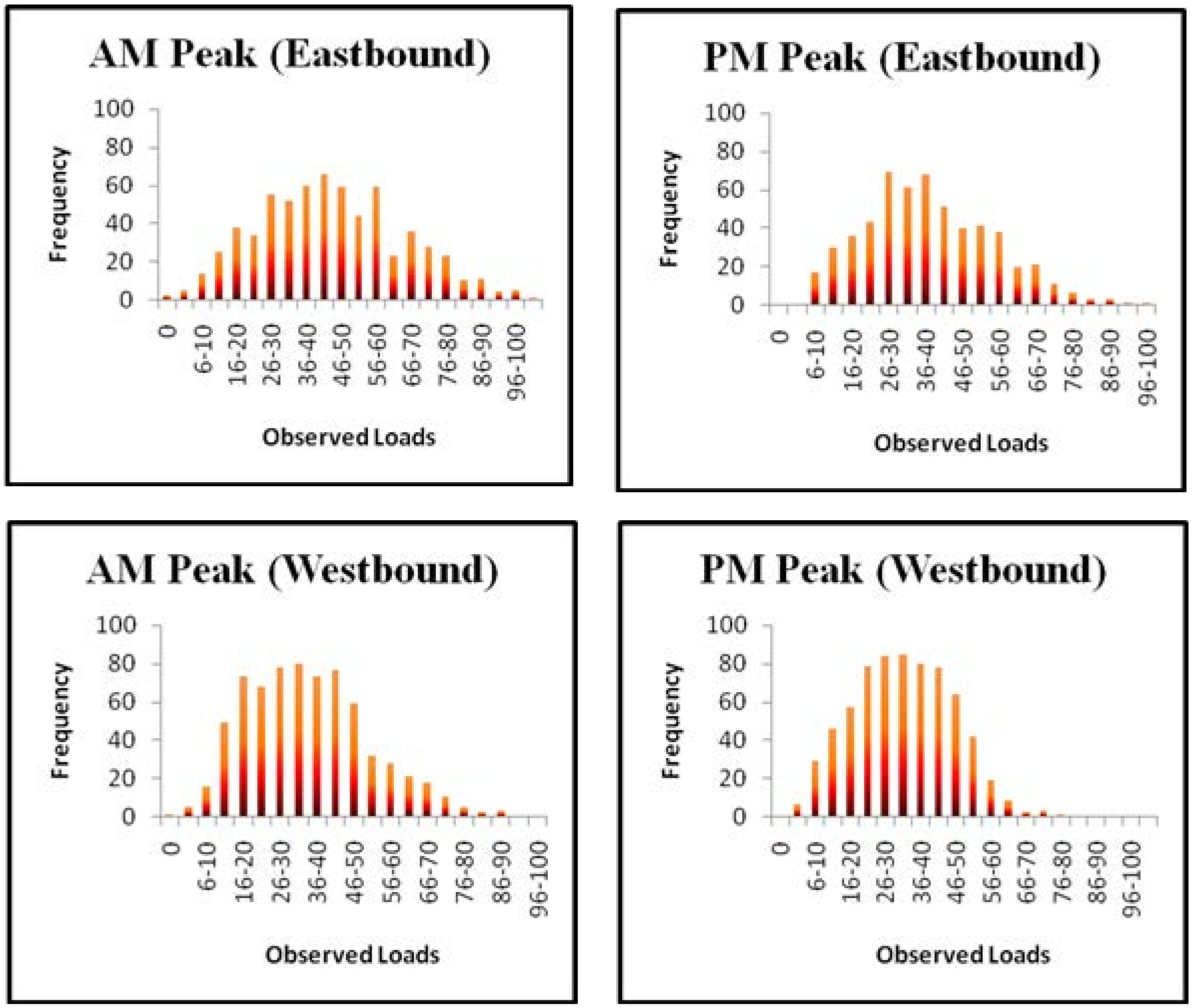


Figure D-11

Frequency Distribution of Observed Loads at Woodman Station

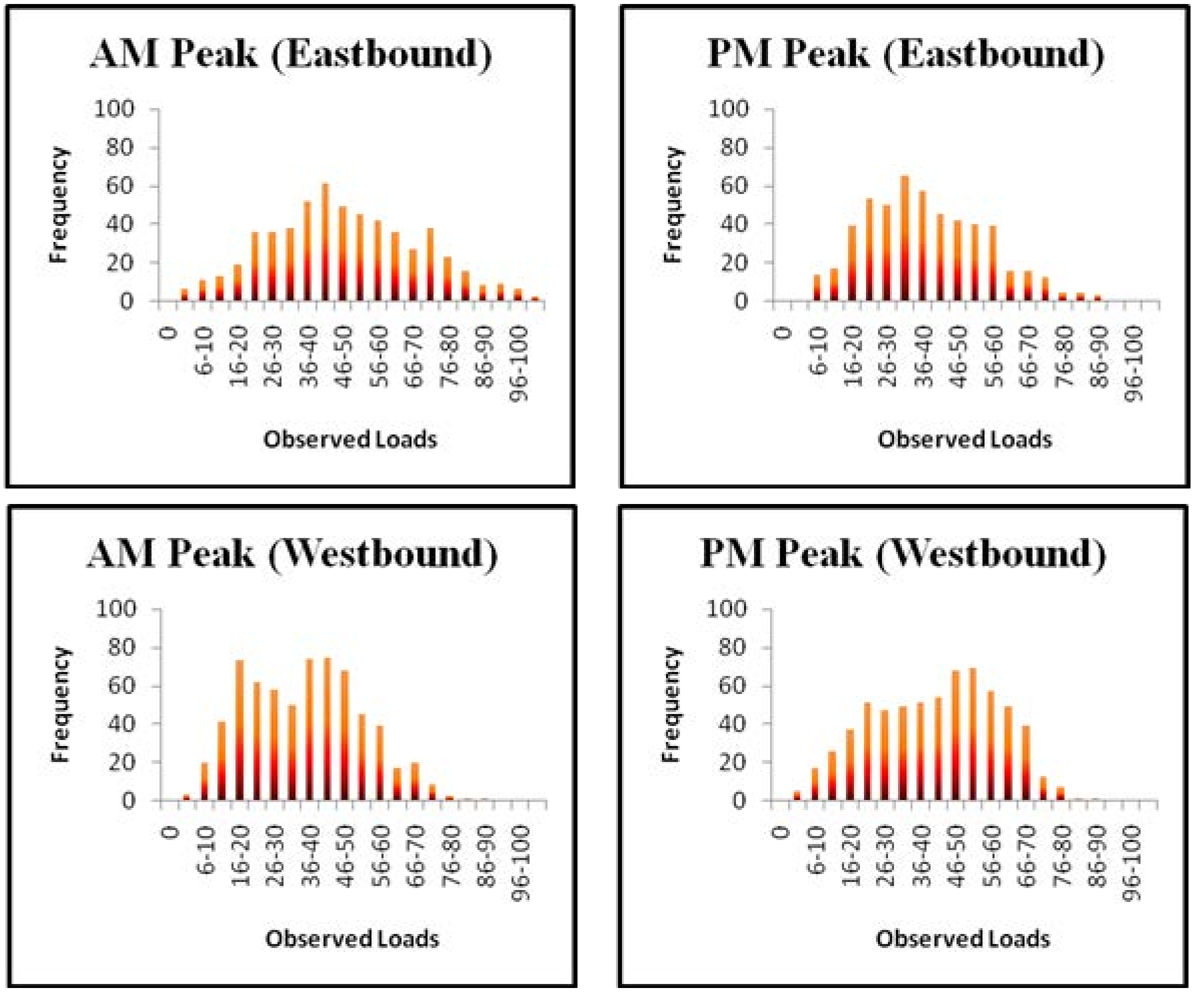


Figure D-12

Frequency Distribution of Observed Loads at Valley College Station

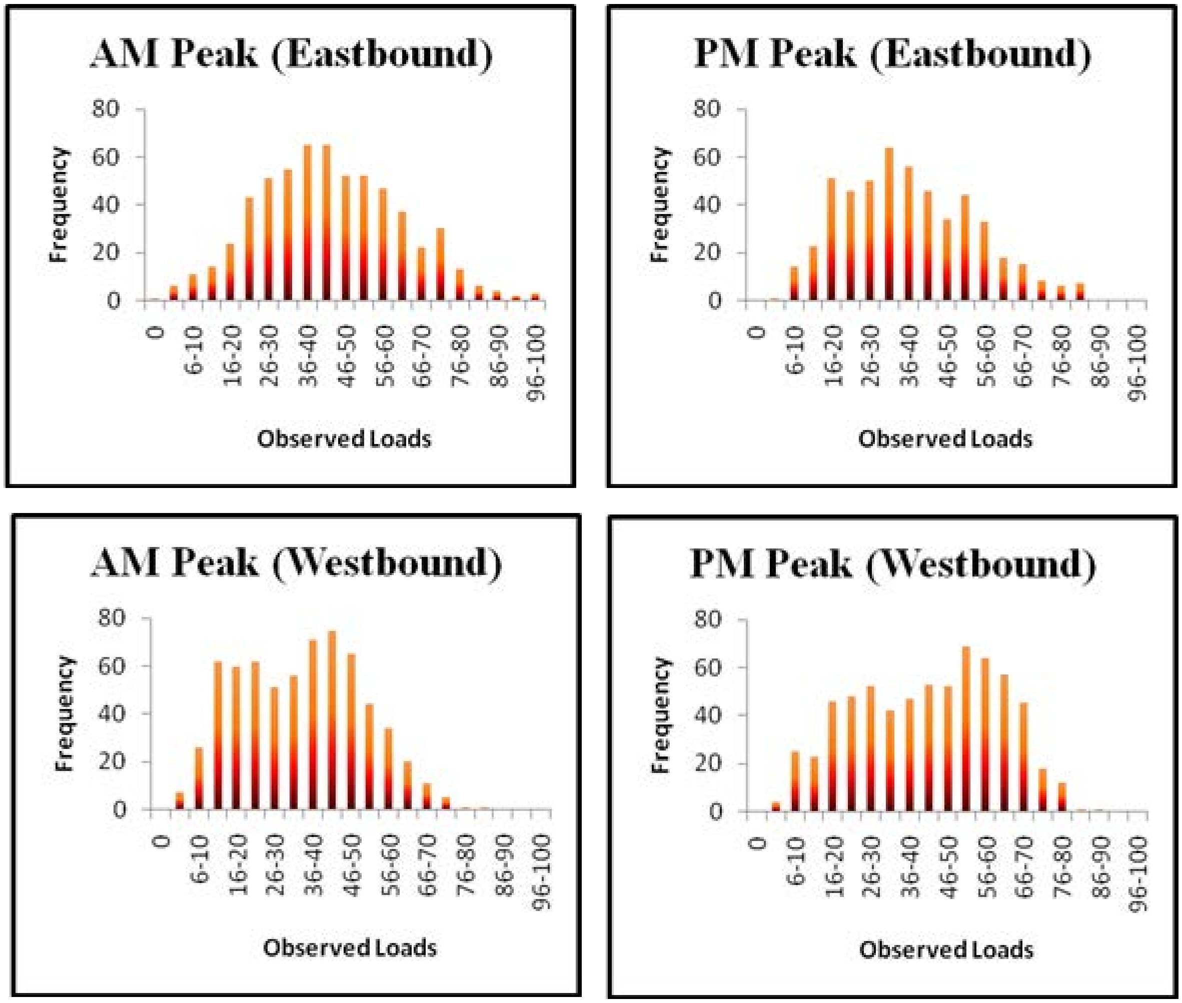


Figure D-13

Frequency Distribution of Observed Loads at Laurel Canyon Station

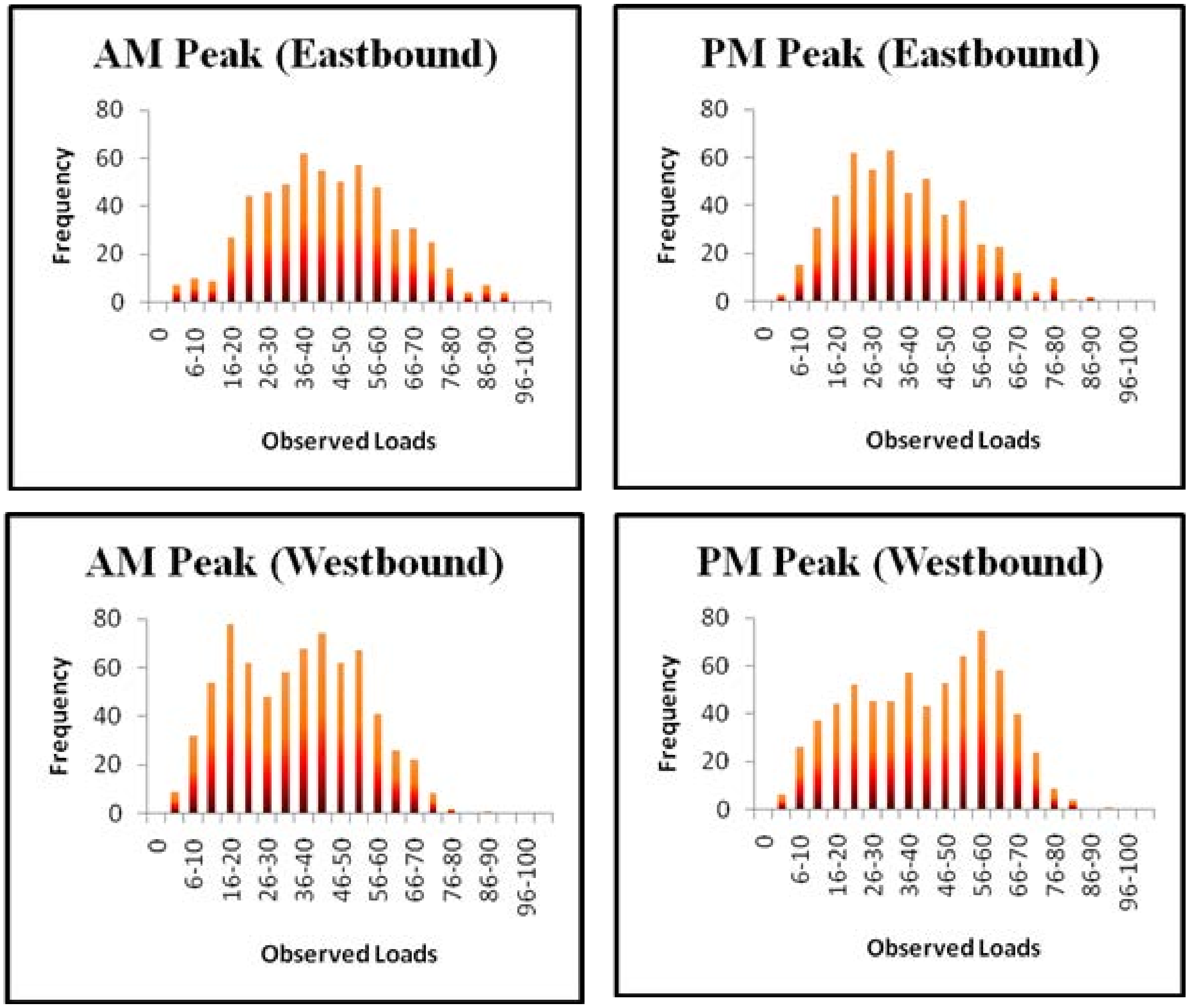
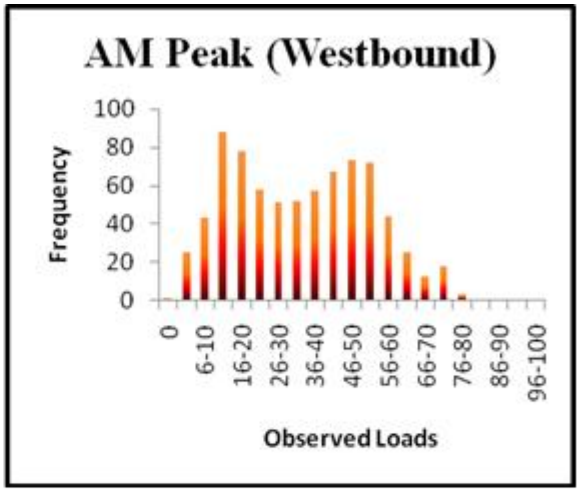
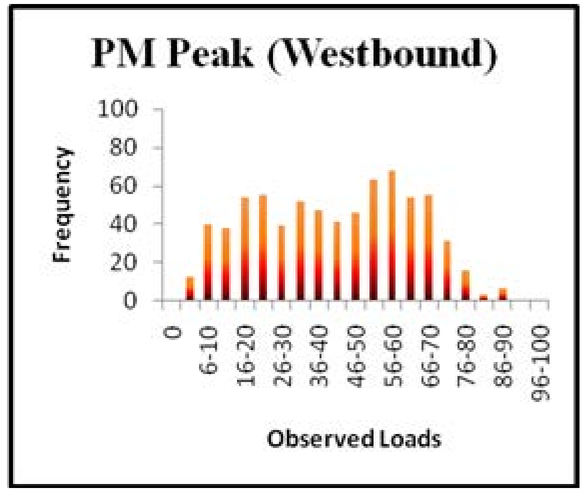


Figure D-14

Frequency Distribution of Observed Loads at N. Hollywood Station





APPENDIX

E

Survey Instrument

DEAR VALUED METRO CUSTOMER:

We are trying to get the opinions of people who are 18 and older for a research study of the Orange Line. Your participation is totally voluntary. If you do not wish to take part, please return this form to the surveyor. If you would like to take part, check (✓), write out, or circle your responses as appropriate. This is an anonymous survey—please do not put your name or other identifying marks on the survey. Even if you do not complete the survey, please return it to a surveyor or leave it in your seat as you exit the bus. Thank you for helping the Orange Line to serve you better!

1. Where did you get on this bus?
1___North Hollywood 6___Laurel Canyon 11___Valley College
2___Woodman 7___Van Nuys 12___ Sepulveda
3___Woodley 8___Balboa 13___ Reseda
4___Tampa 9___Pierce College 14___ De Soto
5___Canoga 10___Warner Center

2.Why are you riding this bus today? (Please check **ALL** that apply)
1 ___Save time 5 ___More convenient than car
2 ___Avoid traffic 6 ___Parking limited / expensive at destination
3 ___Save money 7 ___Availability of Park and Ride lots
4 ___Don't drive / no car 8 ___ Other (Specify): ____________________

3.What is the main purpose of your bus trip today? (Please check only ONE)
1 ___Work 5 ___Job seeking
2 ___Shopping 6 ___Health or medical
3 ___School 7 ___Other (Specify): _____________________
4 ___Social / recreation

4.How did you get to this Orange Line bus? (Please check only ONE)
1___Walked (#___ blocks) 4___Metro Rail 7___Carpooled
2___Metro Bus route #___ 5___Bicycled 8___Dropped off by car
3___Muni Bus route #___ 6___Drove alone `9___ Other (Specify):
____

5.Where will you get off this bus?
1___North Hollywood 6___Laurel Canyon 11___Valley College
2___Woodman 7___Van Nuys 12___ Sepulveda
3___Woodley 8___Balboa 13___ Reseda
4___Tampa 9___Pierce College 14___ De Soto
5___Canoga 10___Warner Center

6. After you get off this bus, how will you get to your final destination? (Please check only ONE)
1___Walk (#___ blocks) 4___Metro Rail 7___Carpool
2___Metro Bus route #___ 5___Bicycle 8___Will be picked up by car
3___Muni Bus route #___ 6___Drive alone 9___Other (Specify): ___________

7. After you get off this bus, how long will it take you to reach your final destination?
1___1-5 minutes 3___11-20 minutes
2___6-10 minutes 4___Longer than 20 minutes

8. Approximately how long will you be on this bus? ______ minutes

9. Before the Orange Line opened, how did you make this trip?
1___I did not make this trip5___Metro Rail line____ 9___Carpooled
2___Bicycle 6___Metro bus route #___ 10___Other (specify):_______
3___Walked 7___Muni bus route#___
4___Metrolink 8___Drove alone

10. If you previously made this trip, how has the Orange Line affected the length of this trip?
1___15+ minutes faster 4___1-5 minutes faster
2___11-15 minutes faster 5___About the same
3___6-10 minutes faster 6___Slower

11. If you previously drove or carpooled, did you use the 101 Freeway?
1___Yes 2___No

12. How did you pay your fare for this trip? (Please check ALL that apply to you)
1___One-way cash 6___EZ Transit Pass 11___Transfer from Muni
2___Token 7___TAP Card 12___Transfer from Metrolink
3___Day Pass 8___Reduced fare (senior/disabled)
4___Weekly Pass 9___Reduced fare (college student)
5___Monthly Pass 10___Reduced fare (K-12 student)

13. How many times will you board a bus/train today?
1___ once 2___ twice 3___ 3 times 4___ 4 times 5___ 5 or more

14. How many days per week do you usually ride Metro buses/trains?
0 (None) 1 2 3 4 5 6 7

15. How many days per week do you usually ride the Orange Line?
0 (None) 1 2 3 4 5 6 7

16. In general, how would you rate each of the following aspects of ORANGE LINE service?

Please circle the number that best reflects your opinion		Very Good	Good	Fair	Poor	Very Poor
a.	Hours of service	5	4	3	2	1
b.	Frequency (how often vehicles run)	5	4	3	2	1
c.	Convenience (where vehicles go)	5	4	3	2	1
d.	Dependability (on-time performance)	5	4	3	2	1
e.	Wait time at station for the vehicle	5	4	3	2	1
f.	Travel time on this vehicle	5	4	3	2	1
g.	Cost to ride (value for what you pay)	5	4	3	2	1
h.	Availability of information/maps at stations	5	4	3	2	1
i.	Availability of seats on vehicle	5	4	3	2	1
j.	Parking cost/availability	5	4	3	2	1
k.	Ticket vending machines	5	4	3	2	1
l.	Personal safety on vehicle	5	4	3	2	1
m.	Personal safety at stations	5	4	3	2	1
n.	Quality of stations	5	4	3	2	1
o.	Smoothness of ride on vehicles	5	4	3	2	1
p.	Ease of getting on and off vehicles	5	4	3	2	1
q.	Location of Orange Line signage	5	4	3	2	1
r.	Ease of identifying Orange Line service	5	4	3	2	1
s.	Accessibility of vehicles to handicapped	5	4	3	2	1
t.	Rear-facing wheelchair securement on vehicles	5	4	3	2	1
u.	Front-facing wheelchair securement on vehicles	5	4	3	2	1
v.	Time it takes for wheelchair users to board vehicles	5	4	3	2	1
w.	Operator courtesy	5	4	3	2	1
x.	Operator driving competence	5	4	3	2	1
y.	Cleanliness of vehicles	5	4	3	2	1
z.	Cleanliness of stations	5	4	3	2	1
aa.	Amenities provided at stations (benches, trash bins, etc.)	5	4	3	2	1
bb.	Availability of bike racks on vehicles	5	4	3	2	1
cc.	The look/design of the Orange Line vehicles	5	4	3	2	1
dd.	Additional door in the middle of the vehicle	5	4	3	2	1
ee.	Connectivity to other Metro service	5	4	3	2	1
ff.	Your overall satisfaction with the Orange Line	5	4	3	2	1
gg.	Your overall satisfaction with Metro	5	4	3	2	1

17. How long have you been riding the Orange Line?
1___Less than 3 months 3___6 months to 1 year 5___2 to 3 years
2___3 to 6 months 4___1 to 2 years 6___3 years or more

18. What are the most important reasons you ride the Orange Line?

____

____

____

Please tell us a little about yourself. All replies are strictly confidential.

19. How old are you? _______

20. Do you own a car or other motor vehicle, or have regular daily access to one?
1___Yes 2___No

If yes, what is the total number of cars or other motor vehicles owned or leased by your household? (Circle a number.) 1 2 3 4 5 or more

21. Are you female or male? 1___Female 2___Male

22. Please check ALL of the following that apply to you. Are you:
1 ___K-12 student 4 ___Unemployed 7 ___ Employed for pay outside your home
2 ___College student 5 ___Retired
3 ___Homemaker 6 ___ Employed for pay at home

23. Do you use a wheelchair?
1___Yes 2___No

24. What is your total annual household income (before taxes)?
1 ___Less than $10,000 4 ___$25,000 to $34,999 7 ___$60,000 to $74,999
2 ___$10,000 to $14,999 5 ___$35,000 to $44,999 8 ___$75,000 to $99,999
3 ___$15,000 to $24,999 6 ___$45,000 to $59,999 9 ___$100,000 or more

25. What is your home zip code? ____________________

26. If you have any other comments or suggestions about the Orange Line, please write them below:

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