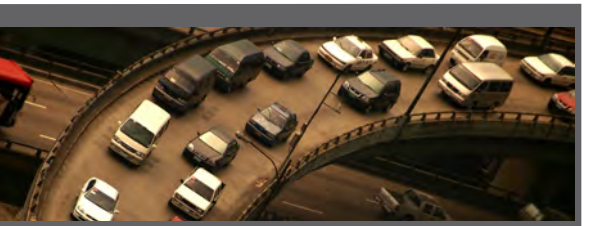
Changes in Transit Use and Service and Associated Changes in Driving Near a New Light Rail Transit Line

MTI Report 12-44



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REPORT 12-44

CHANGES IN TRANSIT USE AND SERVICE AND ASSOCIATED CHANGES IN DRIVING NEAR A NEW LIGHT RAIL TRANSIT LINE

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16. Abstract

Los Angeles is pursuing possibly the most ambitious rail transit investment program in the nation with plans to open six new rail transit lines between now and 2019. The report provides policy makes and planners a better understanding of the potential impacts of Los Angeles Metro's rail transit investment program by assessing the changes in transit use of nearby residents and nearby bus service associated with the Expo Line, the first of the six new lines. Our findings indicate that changes in bus service that are coincident with the introduction of new light rail transit can negatively affect the overall transit ridership in the corridor. In addition, we find that households living near new Expo Line light rail stations reduced their vehicle miles traveled (VMT), but those households living near bus stops that were eliminated as part of the service change increased their VMT.

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EXECUTIVE SUMMARY

Los Angeles is pursuing possibly the most ambitious rail transit investment program in the nation. This report provides policy makers and planners a better understanding of the potential impacts of Los Angeles Metro's major rail transit investment program by assessing the changes in transit use of nearby residents and nearby bus service associated with the Expo Line. This is a new Light Rail Transit (LRT) service in Los Angeles County, California that extends south and west from downtown Los Angeles. This study is one of the first that tracks changes in travel behavior before and after the opening of new light rail transit service. Findings suggest two important, and linked, lessons.

1. Changes in bus service that are coincident with the introduction of new light rail transit can negatively affect the overall transit ridership in the corridor. The immediate effect of bus service changes along the Gold Line extension appears to be related to net "bus plus rail" ridership declines in that corridor. The net transit ridership effect along the Expo Line corridor was an increase in ridership, possibly because bus service was not reduced by the same magnitude along the Gold Line extension.

2. Households living near new Expo Line light rail stations reduced their vehicle miles traveled (VMT), but those households living near bus stops that were eliminated increased their VMT. This is not definitive, but it suggests the possibility that bus service is a complement to rail transit service, at least for driving reduction.

The policy implications of this research start with the proposition that transit agencies should think more carefully about bus and rail transit service, particularly when new rail transit is introduced. The researchers suggest that transit agencies take a more holistic view of travel impacts, including driving as well as transit, and that changes to bus service should be carefully crafted not only to maximize use of new rail transit service, but also to facilitate changes in travel behavior consistent with a shift away from auto-mobility.

I. INTRODUCTION

Los Angeles is pursuing possibly the most ambitious rail transit investment program in the nation. The Los Angeles Metropolitan Transportation Authority's (Metro) long-range plan commits funds to six new rail transit lines scheduled to open between now and 2019, of which the Expo Line (along Exposition Boulevard) will be the first. In total, those six lines will increase the Los Angeles Metro rail network from 73 to approximately 120 miles (116.8 km to approximately 192 km), making it larger than the current Washington DC Metro system. This impressive commitment to transit infrastructure will play out in the context of ambitious state-level greenhouse gas emission reduction targets, making it important to have useful data regarding the impact of rail transit infrastructure on travel behavior.

This report provides policy makers and planners a better understanding of the potential impacts of Los Angeles Metro's major rail transit investment program by assessing the changes in transit use of nearby residents and nearby bus service associated with the Expo Line. This is a new Light Rail Transit (LRT) service in Los Angeles County, California that extends south and west from downtown Los Angeles. This report focuses on the first phase of the line's construction, which opened in two stages in April and June 2012. It runs 8.7 miles (13.9 km) from downtown Los Angeles westward to Culver City, near the junction of the 405 and 10 Freeways. This report has the following research objectives:

- Assessment of Ridership and Service Changes – To examine changes in Metro's LRT and bus service and ridership associated with the opening of the first phase of the Expo Line in April/June 2012 and the opening of the Gold Line Eastside extension in November 2009

- Assessment of Travel Pattern Changes – To assess potential changes in travel behavior associated with the new Expo Line service and corresponding changes to nearby bus service based on travel survey data collected for 193 households in late 2011 before the line opened and in late 2012 after the line opened

This report is structured as follows – in Chapter 2, review existing literature is reviewed to (a) provide insights from previous evaluations of the impact of LRT on travel behavior and (b) review previous empirical assessments of factors associated with household travel mode choice. Chapter 3 compares service and ridership changes associated with the opening of the Expo and Gold lines. Chapter 4 examines changes in travel patterns associated with the new Expo Line service. The report concludes and presents some policy considerations and identifies avenues for future research in Chapter 5.

II. FACTORS AFFECTING TRAVEL MODE CHOICE AND THE IMPACT OF LIGHT RAIL TRANSIT ON TRAVEL BEHAVIOR: A REVIEW OF THE LITERATURE

Urban environmental and public health problems associated with dependence on automobiles have led planners and researchers to seek ways to promote alternative travel modes. This section provides a brief overview of the existing literature on travel mode choice, highlighting the theory of planned behavior as a theoretical framework, along with a more detail analysis of "natural experiments" to evaluate the impact of light rail transit on travel behavior.

TRAVEL MODE CHOICE AND THE THEORY OF PLANNED BEHAVIOR

Much of the existing literature on travel mode choice uses an economic, utility-maximizing framework in which individuals select a particular mode that provides the highest preference or utility.[1] More recently, researchers have looked beyond objective economic factors, such as time and cost, to include the role of non-objective factors including attitudes, beliefs, and perceptions in travel mode decision-making. The theory of planned behavior (TPB) is a conceptual model of a rational choice process in which situational perceptions are distilled as attitudes that in turn inform an intention to perform a given behavior, such as choice of travel mode.

To identify and assess the role of attitudinal factors in influencing travel mode and residential choices, Hunecke et al. used the TPB to identify groups with sharply differentiated attitudes toward travel modes.[2] The results were found to hold promise for targeting pro-transit publicity to distinctive mode preference segments.

Habit plays an important role in mode choice. Verplanken et al. argued that where circumstances are stable, positive attitude toward mode choice is strong, and behavior is repetitive, evaluative faculties become dormant; over time, use of a car may become automatic (habitual) for any destination.[3] Taking issue with the idea of habitual travel mode choice behavior, Bamberg argued that the alleged predictive power of past behavior on present behavior is an interpretive fallacy that may simply reflect continuity of circumstances.[4] To test the effect of changed circumstances on travel mode behavior, the study centered on the introduction of pre-paid bus passes for university students. Bamberg found that attitudes identified in the first wave did not predict behavior in the second; rather, changes in attitude toward bus use were correlated with increased bus ridership, indicating that evaluative faculties are quickly engaged by new travel options. Similarly, Heath and Gifford found that personal beliefs had little correlation with increased ridership, indicating that environmental factors such as removal of practical and social impediments to behavior may be key aspects of revaluating attitude.[5]

Researchers are also closely examining the relationship between residential built environments and travel mode behavior. Contending that positive attitudes toward public transit use cannot be assumed where convenient access to transit does not exist, Van Wee et al. used surveys to determine whether travel mode preference data might add

predictive specificity to forecasts of transit use in particular built environments.[6] Results showed that adding mode preference survey information to socio-demographic and land-use data in cases where transit stops or lines were being introduced significantly improved accuracy of ridership forecasts.

EVALUATIONS OF THE IMPACT OF LRT ON TRAVEL BEHAVIOR: THE USE OF "NATURAL EXPERIMENTS"

A challenge of cross-sectional studies is that they are unable to resolve to what extent neighborhood characteristics influence travel mode behavior, or whether residential self-selection follows from pre-existing (travel mode and other) preferences. Recently, several studies have used the introduction of light rail or guided busway service into neighborhoods zoned as opportunities to conduct "natural experiments" examining the before-and-after change in transit usage, controlling for individual and neighborhood-level characteristics. The studies use surveys to collect subjective data concerning individuals' attitudes toward built environment and travel modes, as well as self-reported travel behavior data. In the following sections, the report provides detailed summaries for several of these natural experiments. While this research study did not focus specifically on health outcomes, as many of these natural experiments do, the investigators believe they provide a comprehensive review of how these experiments are conducted and what outcomes are found.

Before and After a New Light Rail Stop: A Natural Experiment in Salt Lake City

Brown and Werner used the introduction of a new light rail stop (on an existing light rail line) to conduct a natural experiment in a mixed-use, low income Salt Lake City neighborhood.[7] Their goal was to examine "whether transit riders are significantly different from non-riders in what they report about their own health, car rides, leisure walks, [and] residential attachment . . . before and after a new light rail stop is added to their neighborhood."

The study collected data during construction and nine months after the opening of the light rail stop. Surveys were used to record attitudinal data such as preferences for neighborhood types and transit modes, and self-reported travel-mode behavior and physical activity over the prior two weeks, before-and-after.

Surveys tested for four attitudinal composites: place attachment; neighborhood satisfaction; attitude toward suburbs; and favorable attitude toward transit-oriented development. Participants also described their travel behavior, reporting light rail use, pedestrian or bike travel, and automobile usage. The ridership data for the two surveys determined that 45.8% of respondents were continuing transit riders (walking roughly a half-mile [0.8 kilometers] to an existing light rail stop), 22.9% were new (from the opening of the new stop) transit riders, and 31.3% were non-riders.

The authors found that measured differences between study groups were significant and fairly consistent. Rail riders were more active, with "a lower prevalence of obesity" than non-riders; they also had more positive attitudes about neighborhood environment and TOD. With the exception of new riders, the main effect (data for both stages) for time was not significant, showing the new station did not change attitudes and behaviors for continuing

riders and non-riders. New riders had positive attitudes toward their neighborhoods and TOD prior to the opening of the new stop, but they did not elect to use light rail until the (closer) new stop made transit use convenient. Reported car rides for new riders also declined in stage 2.

The Effect of Light Rail Transit on Body Mass Index and Physical Activity: A Natural Experiment in Charlotte

McDonald et al. focused on the introduction of a light rail line in Charlotte, North Carolina.[8] The two-stage longitudinal study intended on one hand to examine cross-sectional associations "among objective and perceived measures of the built environment, physical activity, and obesity," and, on the other, to take advantage of "a natural experiment of the built environment" (a new light rail line) to assess the effect of transit use on obesity and physical activity levels.

The study used a pre-post intervention, longitudinal design to assess effects of LRT on physical activity and to control for residential location choice. Propensity score matching was used to reduce the effects of choice to use LRT. Telephone surveys at baseline and follow-up focused on perceptions of the physical and social environment of neighborhoods, socio-demographic factors, and self-reported daily travel and exercise patterns. Neighborhood physical and social environment questions focused on participants' positive or negative perception of neighborhood attributes within a 15-minute walk from their homes, including social order and safety; neighborhood aesthetics and cleanliness; and access to outdoor amenities (parks and commercial recreation facilities). Measures of the built environment included residential density, proximity of recreational parks, and density of food- and beverage-oriented commercial sites within a half-mile (0.8 kilometers) of subjects' homes, all factors associated with pedestrian activity.

Public transit use at baseline was assessed by asking how often subjects used bus or rail. Regular users were defined as those who used bus or rail at least once a week. To control (in part) for selection bias, a dichotomous indicator was established at baseline for those who planned to use LRT when it opened. During the follow-up, another dichotomous indicator was created for those who reported daily use of LRT for their commute to work, allowing distinction between transit riding ("treatment") and non-riding ("control") groups.

Results of the propensity score analysis showed a significant association between LRT use and reduction in body mass index (BMI) over time. LRT users were also found to be 81% less likely to become obese over time. The authors argued that because LRT users and non-users were living in the same neighborhood, with similar commuting patterns (to the central business district [CBD]) and perceptions of neighborhood environments, the findings suggested an independent weight control effect from daily use of LRT. Extrapolating from average weight loss estimates from the study data to probable daily increases in distances walked (based on estimates of transit commuting options – bus and LRT combinations), the authors suggested that increasing access to LRT transit can help to facilitate "daily utilitarian exercise."

Additional Research on Travel Behavior/Transit Ridership

In addition to the studies noted above, in recent years several other studies have commenced to investigate the impacts of light rail transit on travel behavior utilizing a natural experiment approach. These studies include work in Portland on the impacts of the Westside Max LRT line,[9] research in Seattle on the before-and-after effects of LRT on physical activity,[10] and a joint project between the Texas Transportation Institute and the University of Texas Health Science Center looking at the impacts of the Metropolitan Transit Authority of Harris County's LRT extension on physical activity and travel behavior of adults in Houston.[11] While not quasi-experimental research, some studies have focused only on ridership changes with the introduction of new or improved transit service that are relevant for this current research project, including work by Gomez-Ibanez on the ridership and operating cost for new light rail service in San Diego, Calgary, and Edmonton.[12]

III. RIDERSHIP AND SERVICES CHANGES: EXPO LINE VS. GOLD LINE

INTRODUCTION AND SECTION OBJECTIVES

The Los Angeles Metro's system has experienced significant ridership changes as the Gold Line was extended to East Los Angeles in November 2009 and the Expo Line service began in April/June 2012. These changes were associated with not only growth in rail ridership but also with changes in bus service and ridership. This section compares ridership between the Gold Line and Expo Line systems and documents similar patterns in ridership trends. Both the Gold eastside extension and the Expo Line experienced initial decreases in bus ridership after the light rail service began. However, there are some interesting differences in trends. The Expo Line opening in 2011 resulted in total system ridership increases despite the downturn in bus system ridership, while Gold Line extension in 2009 resulted in an overall ridership decrease despite the considerable increase in Gold Line ridership.

These patterns raise the following questions, which are addressed in this chapter of the report:

- How did the light rail opening/extension affect system-level ridership?
- How was the pattern of bus ridership affected by the light rail service change?
- What are the effects of the network restructure and service change on performance?

To answer these questions, this report analyzes key performance metrics of the transit systems between analogous months before and after the light rail opening at the route level. To conduct this analysis, Metro's transit data was reviewed for two periods: 2011 to 2012 (EXPO opening April 2012), and 2009 to 2010 (Gold Line extension opening November 2009). In the subsequent subsection, the report provides an overview of the Expo Line and Gold Line, examines how the pattern of bus ridership has been affected by the light rail service opening, reviews the system-level ridership changes after the LRT service began, and examines the route change after beginning of the services. Finally, the report compares demographic attributes of the station areas of the two lines and concludes with a summary of key issues and opportunities to increase ridership.

OVERVIEW OF THE LIGHT RAIL TRANSIT LINES

The Expo Line

The Expo Line is a light rail transit line in the Los Angeles metropolitan area that extends south and west from downtown Los Angeles, reaching downtown Santa Monica upon completion. The line is scheduled for completion in two stages. Phase I, opened in early 2012, runs 8.7 miles (14 km) from downtown Los Angeles westward to Culver City, near the junction of the 405 and 10 Freeways (Figure 1). Service began on the eastern portion of the Phase I section on April 28, 2012, and service was extended to Culver City on

June 20, 2012. Phase I of the Expo Line stops at a total of 12 stations, ten of which were newly constructed. It shares track with the Metro Blue Line light rail over 1.2 miles (1.9 km) near downtown Los Angeles (LA), and it also runs on the same route as the Metro Silver rapid bus and other Metro bus lines for 2.7 miles (4.3 km) between the 7th Street/Metro Center station in downtown LA and the Expo Park/USC station. The Expo Line operates from 5 a.m. to 12:30 a.m., with approximate headways of 12 minutes during the day and 20 minutes at other times. The system could run at headways as low as six minutes, depending on demand and system capacity. In addition to downtown LA and Culver City, the Expo Line serves the area south and east of the University of Southern California campus, as well as the neighborhoods of Exposition Park, Leimert Park, Crenshaw, Jefferson Park, Baldwin Hills, and West Adams. Phase II, which will extend the line into downtown Santa Monica, is currently under construction (as of this publication). According to the Exposition Construction Authority, the line is scheduled to be complete in 2015.

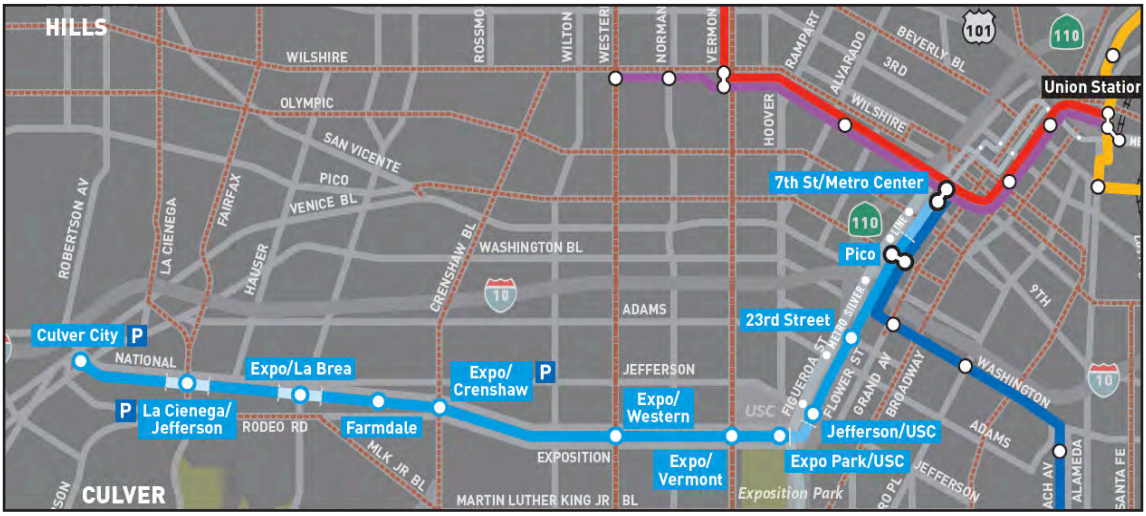

Figure 1. Exposition Line Vicinity Map (in blue)

Source: Los Angeles County Metropolitan Transportation Authority, "Metro Expo Line Fact Sheet," http://media.metro.net/projects_studies/exposition/images/expo_ph1_fact_sheet.pdf (Accessed September 23, 2014).

The Gold Line

The Gold Line is an LRT line that runs from Pasadena to East Los Angeles via downtown Los Angeles, including Little Tokyo, Union Station, and Chinatown. The line began service in 2003 and is operated by the Los Angeles Metro. Phase I opened June 16, 2003 and runs from Union Station in downtown Los Angeles to east Pasadena. The length of route is a 13.7-mile (22 km) stretch of rail that uses a previous Southern Pacific rail line and has 13 stops. In November 2009, Metro opened the second phase of the Gold Line that connects the eight-station Metro Gold Line and links Los Angeles' Union Station to Atlantic Boulevard near Monterey Park. The extended route serves Little Tokyo, Boyle Heights, and East LA Civic Center (Figure 2).

Figure 2. Gold Line Extension Vicinity Map

Source: Hatch Mott MacDonald, "Gold Line Extension," http://www.hatchmott.com/projects/gold-line-extension-ventilation-system (Accessed September 23, 2014).

BUS RIDERSHIP CHANGE AFTER LRT OPENING/EXTENSION

The data for transit ridership analysis comes from the Los Angeles County Metropolitan Transportation Authority (Metro) and represents estimated ridership (Los Angeles County Metropolitan Transportation Authority, n.d.). Metro is the largest bus and urban rail transit provider in the Los Angeles area. Other transit service providers, such as Culver City Bus and Big Blue Bus, also operate in the study area. However, due to limitations of data availability, this analysis of transit ridership relies on Metro data. In this analysis, all ridership records contain the total unlinked passenger trips for every month.

The Expo Line

There are 66 Metro bus lines traversing a one-mile (1.6 km) area around the Expo Line Phase I (which opened April 2012), including four types of Metro services: local, rapid, express, and shuttle buses (Figure 3). Metro local bus services entail frequent stops. Metro local buses currently operate 41 routes across the area. Among these 41 local bus lines, 30 lines run through downtown Los Angeles and connect the CBD area to Beverly Hills, Santa Monica, West LA, and Los Angeles International Airport (LAX)/South Bay area. The other 11 local bus lines offer eastbound-westbound and northbound-southbound services, and they connect the non-CBD area to West Hollywood, Culver City, Inglewood, Norwalk, Athens, South Gate, Hawthorne, etc. Fifteen rapid buses, eight express buses, and two shuttle buses run through the Expo Line area.

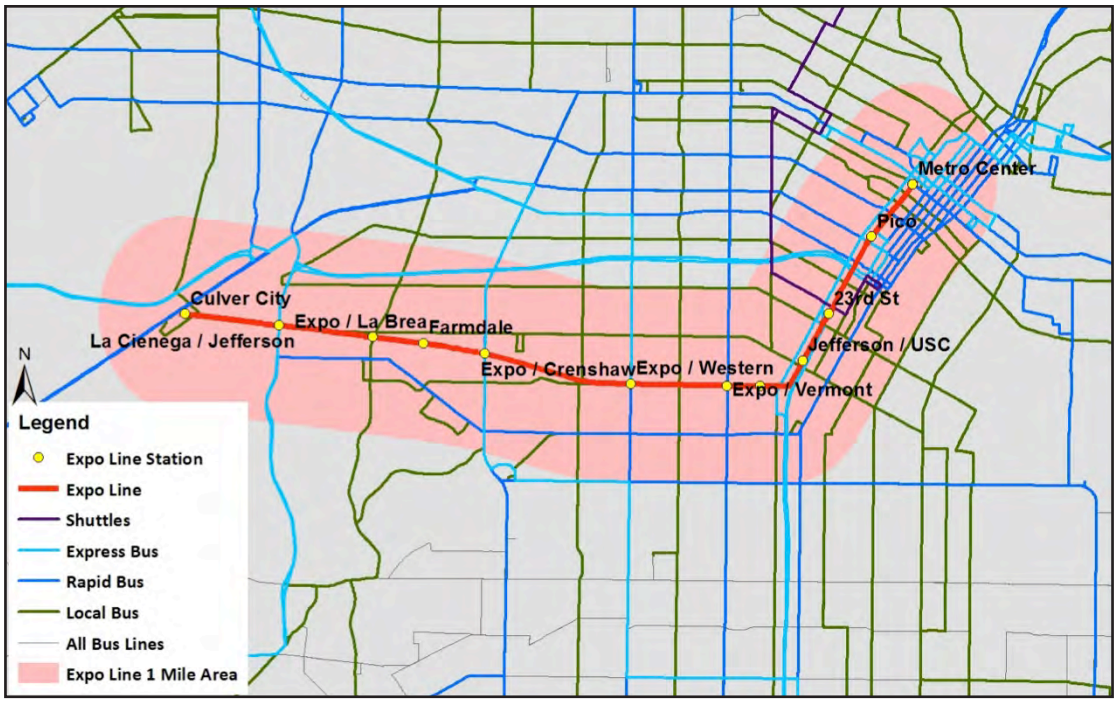

Figure 3. Bus Lines Traversing the Expo Line Area

Figure 4 shows that there has been a change in total ridership since Expo Line service began on April 28, 2012. The ridership of the Expo Line has gradually increased from an average per weekday of approximately 18,000 in July 2012 to 22,000 per weekday during November 2012. The graph shows that the Expo Line contributes to increased overall transit ridership in the area, but ridership fluctuations result from the normal seasonal pattern.

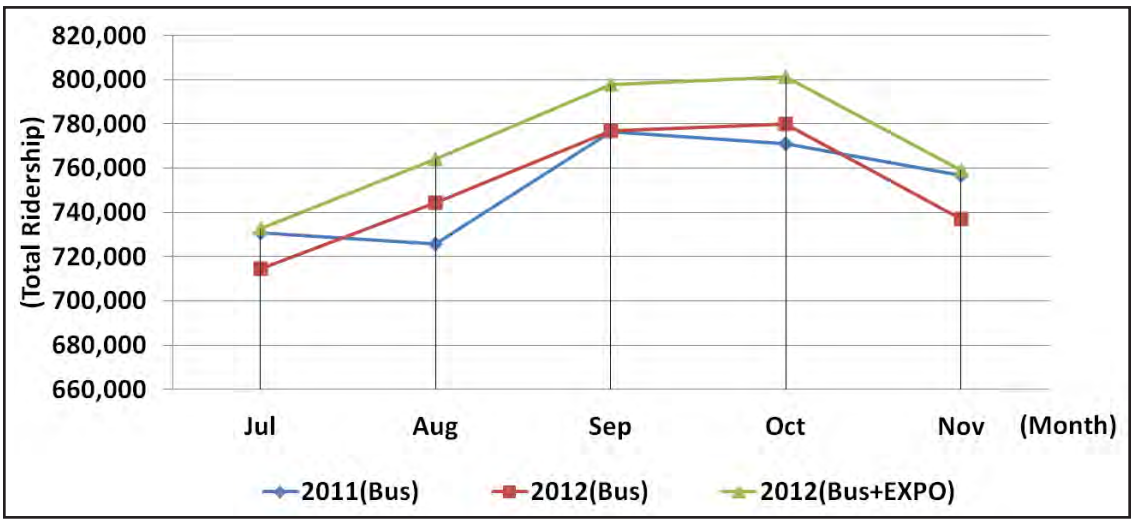

Figure 4. Change in Total Ridership for Bus Lines that Traverse the Expo Line Area (within 1 Mile [1.6 km] of the Expo Line)

Table 1 in Appendix A presents detailed ridership data for the bus lines traversing the Expo Line service. Comparing total bus ridership with Expo Line ridership for the months before and after the Expo Line's opening (July-November 2011, July-November 2012), total transit ridership for bus lines traversing the one-mile vicinity area of the Expo Line increased by approximately 18,800 riders per day, which implies a reduction in bus ridership of approximately 1,600 riders per day.

Four bus lines had the largest changes in ridership after the opening of the Expo Line. These are the 30 and 102, local lines that had an increase in ridership, and the 550 and 740, respectively an express and rapid bus line that had decreases in ridership.

The Gold Line

There are 64 Metro bus lines traversing a one-mile (1.6 km) radius around the Gold Line that was extended in November 2009. Figure 5 shows four types of Metro services: local, rapid, express, and shuttle buses that traverse the Gold Line extension area. Metro local buses currently operate 38 routes across this area. Among these 38 routes, 31 lines run through downtown Los Angeles and connect the CBD to West LA, Santa Monica, Burbank, Sun Valley, etc. The other seven local bus lines serve north-south routes in non-CBD areas, and they connect the East Los Angeles, Compton, Pasadena, and Lynwood areas. Ten express bus lines, three shuttle lines, and 13 rapid lines run through the extension part of Gold Line area.

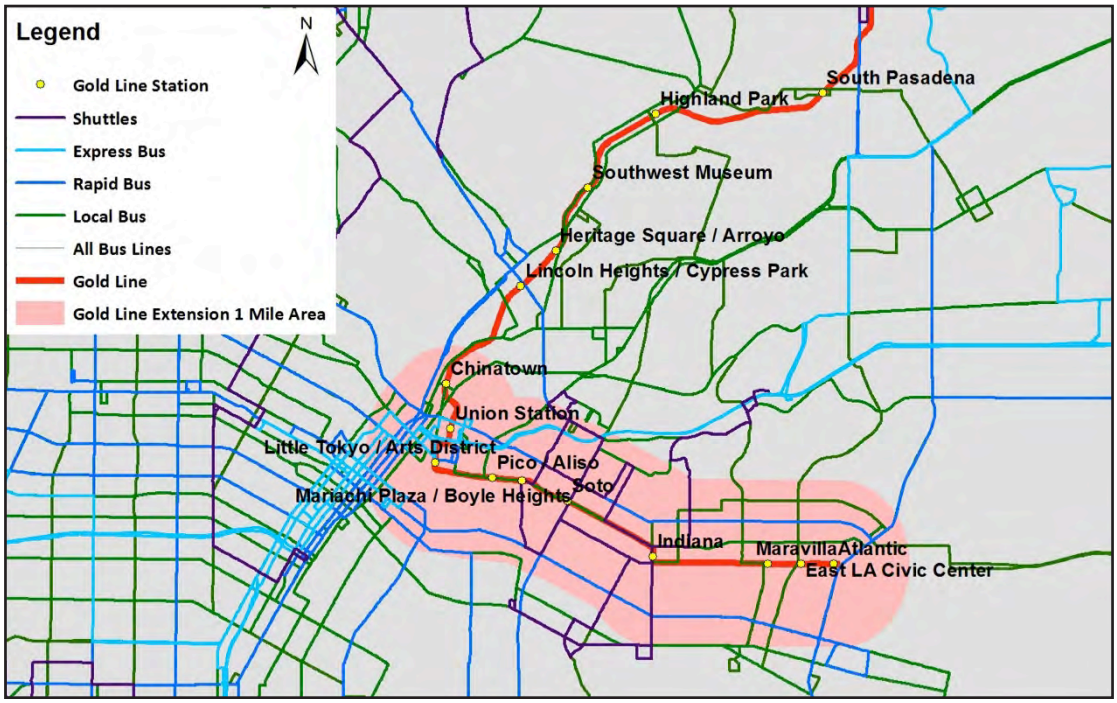

Figure 5. Bus Lines Traversing the Gold Line Extension Area

Figures 6 and 7 show the change in total bus and total transit ridership in the Gold Line Area before and after the extension. (Table 2 in Appendix A presents detailed ridership data.) Ridership of the Gold Line has gradually increased from an average per weekday of

approximately 22,000 in 2009 to 35,000 per weekday in 2010. However, the graph shows that total transit (bus plus rail) ridership in the Gold Line extension corridor decreased despite the increase (35%) in Gold Line ridership. Total transit ridership for lines traversing the area (one-mile buffer of the Gold Line) decreased by approximately 51,800 riders per day, which implies a reduction in bus ridership of about 64,400 riders per day.

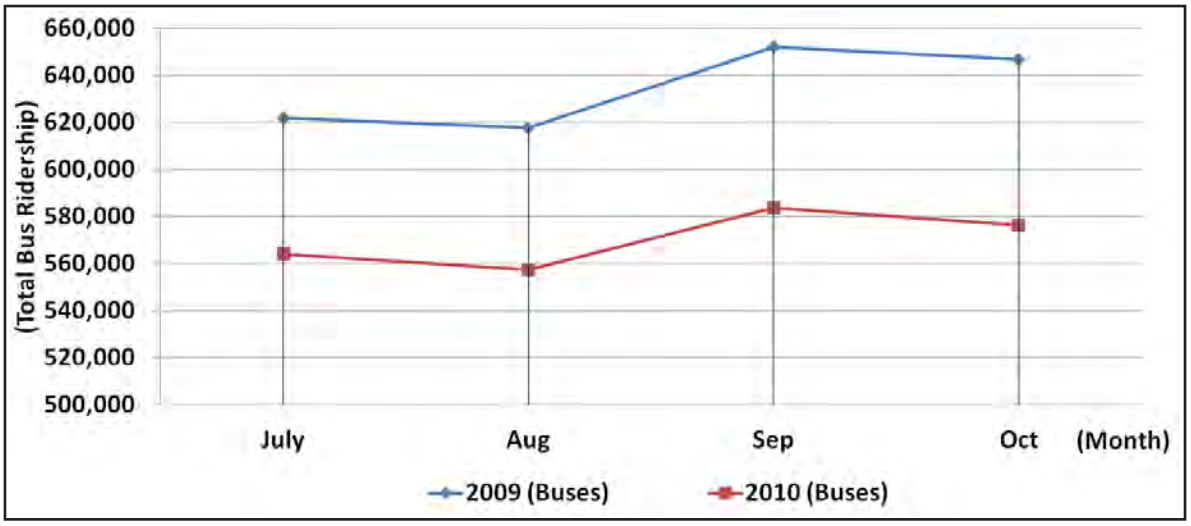

Figure 6. Total Bus Ridership Change in Gold Line Area, 2009 Versus 2010

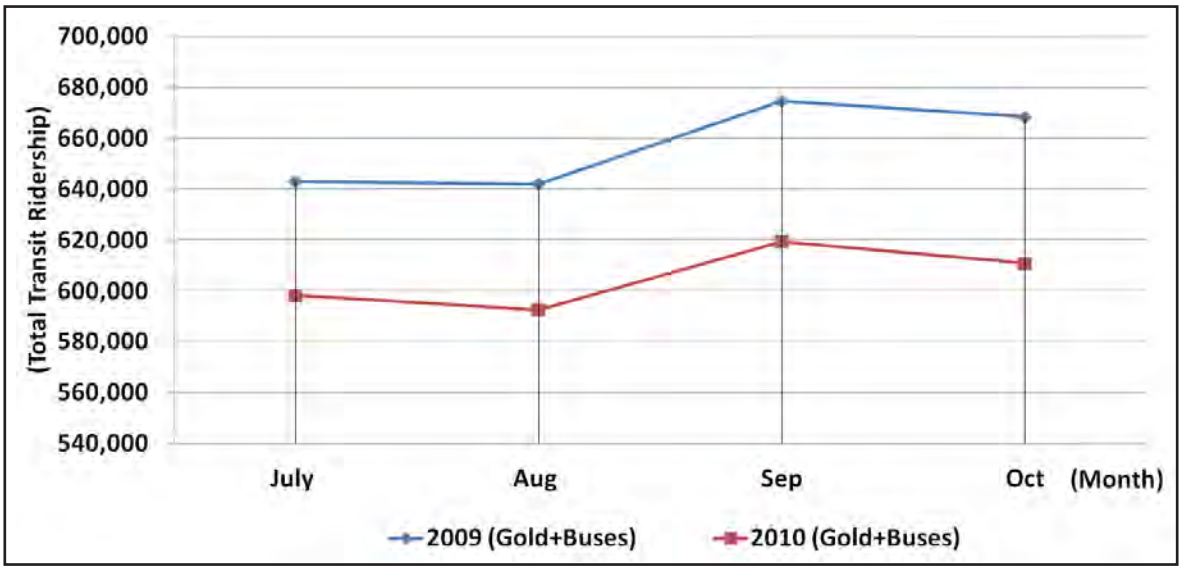

Figure 7. Total Transit Ridership Change in Gold Line Area, 2009 Versus 2010

SYSTEM-WIDE RIDERSHIP TRENDS

Table 1 summarizes the annual ridership of the Metro bus, rail, and total system from 1991 through 2012. During these two decades, Metro built six rail lines, including four light rail lines (Blue, Green, Gold, and Expo Lines) and two subway lines (Red and Purple). The Blue Line opened in July 1990. Following the Blue Line, the Red, Green, and Purple Lines opened during the 1990s. The Gold and Expo Lines opened in 2003 and 2012, respectively.

Table 1. System-wide Average Weekday Boardings, 1991-2012

Year	Bus	Rail	Total
1991	1,281,630	20,291	1,301,921
1992	1,270,096	34,242	1,304,338
1993	1,169,786	49,047	1,218,833
1994	1,179,619	52,364	1,231,983
1995	1,082,946	58,669	1,141,615
1996	1,048,056	83,505	1,131,561
1997	1,074,040	108,029	1,182,069
1998	1,129,895	114,636	1,244,531
1999	1,074,558	122,753	1,197,311
2000	1,067,778	174,554	1,242,332
2001	1,123,013	211,184	1,334,197
2002	1,147,254	207,668	1,354,922
2003	1,100,281	195,841	1,296,122
2004	1,085,908	217,378	1,303,286
2005	1,141,138	227,703	1,368,841
2006	1,202,888	273,829	1,476,717
2007	1,230,989	277,464	1,508,453
2008	1,153,758	292,344	1,446,102
2009	1,155,000	312,469	1,467,469
2010	1,047,441	302,046	1,349,487
2011	1,110,353	325,930	1,436,283
2012	1,085,223	399,175	1,484,398
Δ (2012 – 1991)	-196,407 (-15.32%)	378,884 (1,867.25%)	182,477 (14.02%)

Figure 8 shows that rail systems have experienced significant ridership growth from 1991 through 2012. Metro's rail system's annual ridership increased from just over 20,000 unlinked[1] passenger trips in 1991 to almost 400,000 unlinked passenger trips in 2012. Metro's bus ridership during the same period slightly decreased from about 1.3 million unlinked passenger trips in 1991 to almost 1.1 million unlinked passenger trips in 2012, a decrease of almost 15% (Figure 9). Metro's total system ridership has increased from just over 1.3 million unlinked passenger trips in 1991 to about 1.5 million unlinked passenger trips in 2010, an increase of about 182,000 riders per day, which implies a reduction in bus ridership of approximately 196,000 riders per day (Figure 10).

1 The available data from LA Metro were on boardings, or unlinked trips. An anonymous reviewer suggested that linked trips might have increased along the rail corridors in ways that unlinked trips did not increase, suggesting that the opening of rail lines made it possible to combine several transit trips into one trip by rail. The research team could not examine that, given the unavailability of linked trip data, but they note that this conjecture is the opposite of what has appeared in the literature. Kain (1990, footnote 4), criticized early planning studies for the Dallas light rail system for using unlinked trips. Kain noted that the evidence at the time suggested that the opening of new light rail created more transfers, and hence would increase unlinked trips more than linked trips, citing evidence that in the early years of Atlanta's MARTA, total transit (rail plus bus), unlinked trips increased 47%, while linked transit trips increased only 2.3% The common assumption in the literature has been that unlinked trips are more favorable to light rail than are linked trips (Kain, 1990).

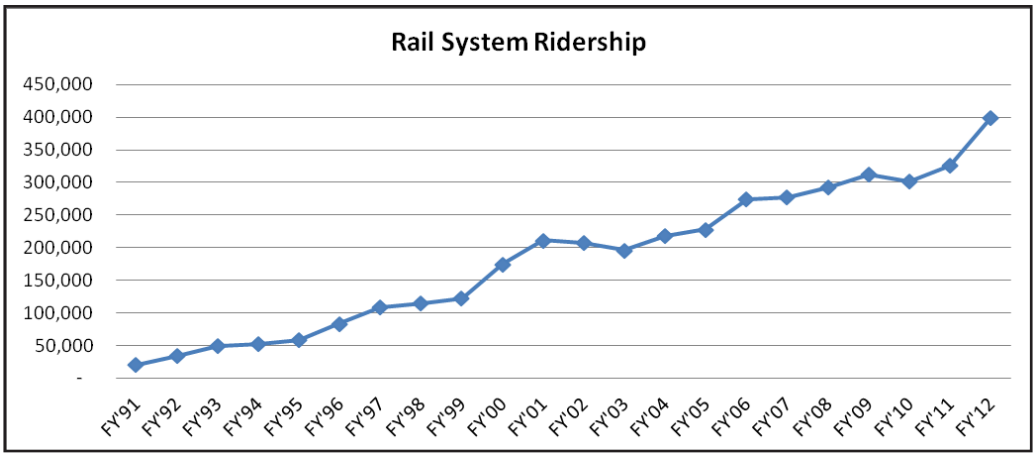

Figure 8. Annual Unlinked Rail Passenger Trips (Average Weekday Boardings), 1991-2012

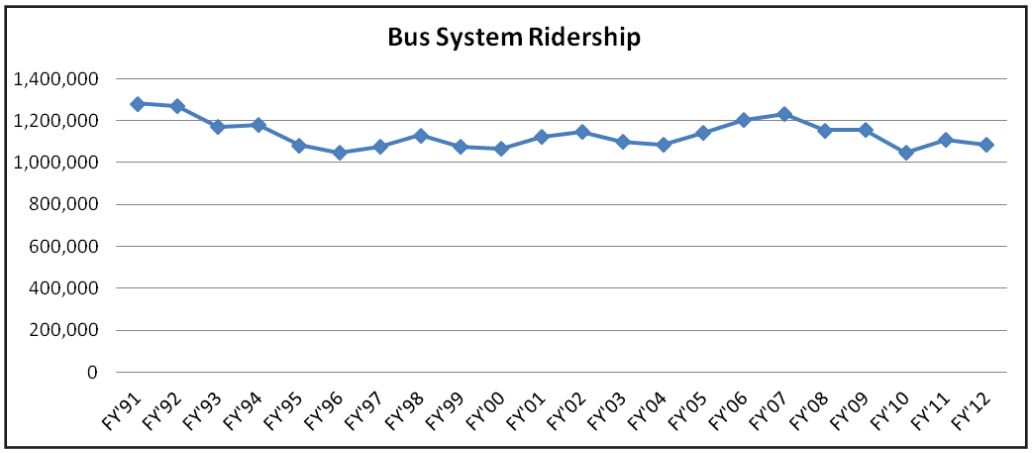

Figure 9. Annual Unlinked Bus Passenger Trips (Average Weekday Boardings), 1991-2012

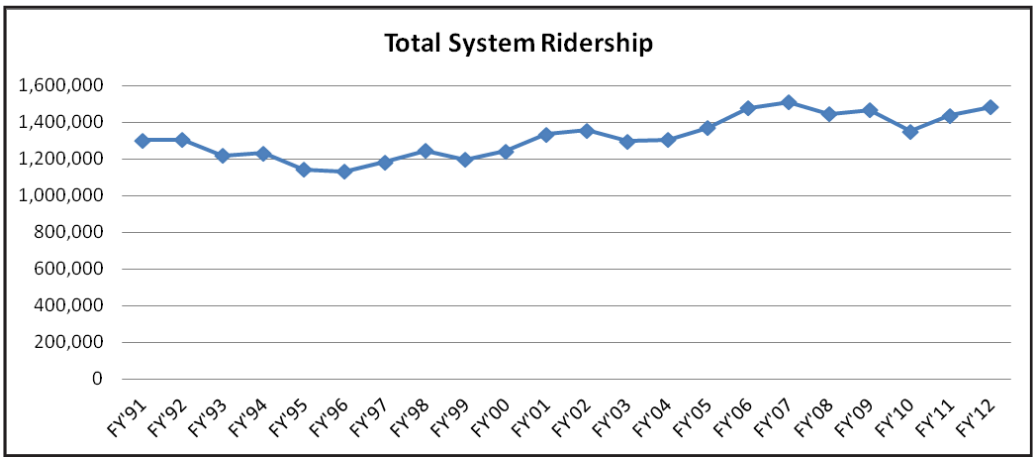

Figure 10. System-wide Annual Unlinked Passenger Trips (Average Weekday Boardings), 1992-2012

SERVICE LEVEL CHANGE AFTER LRT OPENING/EXTENSION

The Expo Line: June 2011-June 2012

During the periods before and after the Expo Line opened, Metro's level of bus service on weekdays slightly decreased, but the system-wide service level was almost identical in terms of service frequency. Table 2 presents the system-wide service changes for bus lines. Metro retained almost the same number of runs across all bus lines during morning peak, whereas Metro decreased afternoon peak and owl service vehicles system wide by about 2%. Table 3 shows the service changes for bus lines traversing the Expo Line area (one-mile radius around the line). Metro decreased the number of buses traversing the Expo area at morning and afternoon peak by 2%, while Metro increased the number operated during base time on weekdays by almost 2%. Metro also decreased owl service buses in the same area by 2%. Table 4 presents the change in service level for individual bus lines traversing the one-mile radius area around the Expo Line.

Table 2. System-wide Bus Line Service Change, June 2011-June 2012

DATE	AM PEAK		BASE		PM PEAK		OWL		Total	
	Runs	% Change '11-'12	Runs	% Change '11-'12	Runs	% Change '11-'12	Runs	% Change '11-'12	Runs	% Change '11-'12
June 2011	1847	0.1%	1008	0.6%	1940	-2.2%	60	-1.7%	4855	-0.8%
June 2012	1848		1014		1897		59		4818	

Table 3. Service Change for Bus Lines Traversing Expo Line Area (within 1 mile of line), June 2011-June 2012

DATE	AM PEAK		BASE		PM PEAK		OWL		Total	
	Runs	% Change '11-'12	Runs	% Change '11-'12	Runs	% Change '11-'12	Runs	% Change '11-'12	Runs	% Change '11-'12
June 2011	1188	-1.6%	647	1.9%	1223	-2.2%	51	-2.0%	3109	-1.1%
June 2012	1169		659		1196		50		3074	

Table 4. Service Change for Individual Bus Lines Traversing Expo Line Area (within 1 mile of line), June 2011-June 2012

Bus #	Number of runs for the route (2011-2012)					Ridership Change	
	DATE	AM PEAK	BASE	PM PEAK	OWL	Average difference	% difference
# 30	June 2011	15	10	19	2	5,791	44.4%
	June 2012	23	19	25	2		
# 71	June 2011	7	3	3		213	11.5%
	June 2012	7	3	3			
# 83	June 2011	8	6	9	2	-614	-15.2%
	June 2012	7	5	8	2		

Bus #	Number of runs for the route (2011-2012)					Ridership Change	
	DATE	AM PEAK	BASE	PM PEAK	OWL	Average difference	% difference
# 102	June 2011	3	3	3		860	52.7%
	June 2012	6	6	6			
# 450	June 2011	7	1	10		212	14.3%
	June 2012	8	2	10			
# 550	June 2011	7	5	9		-1,527	-47.4%
	June 2012	5	2	5			
# 728	June 2011	12	5	13		-715	-10.7%
	June 2012	15	5	14			
# 740	June 2011	17	7	16		-3,760	-48.1%
	June 2012	12	6	13			
# 910	June 2011	22	10	24		2,125	20.6%

The Gold Line: June 2009-June 2010

During the period after the Gold Line opened, bus service frequencies significantly decreased. The system-wide service level decreased almost 5% when compared with the service level in June 2009 and the service level in June 2010 (Table 5). Table 6 shows the service changes of bus lines traversing the Gold Line extension area (one-mile radius around line extension). Overall, Metro decreased the number of buses traversing the Gold Line extension area by 13%. For morning and afternoon peak, Metro decreased the number of vehicles by 13% to 14%, while the number of buses during base time decreased 11%. Table 7 presents the change in service level for individual bus lines traversing the one-mile radius area around the Gold Line extension.

Table 5. System-wide Bus Line Service Change, June 2009-June 2010

DATE	AM PEAK		BASE		PM PEAK		OWL		Total	
June 2009	2206	-5.4%	1125	-6.0%	2333	-3.7%	61	-3.3%	5725	-4.8%
June 2010	2087		1057		2247		59		5450	

Table 6. Service Change for Individual Bus Lines Traversing Gold Line Area (within 1 mile of the line), June 2009-June 2010

DATE	AM PEAK		BASE		PM PEAK		OWL		Total	
June 2009	1214	-14.3%	636	-10.8%	1285	-13.0%	45	-4.4%	3180	-13.0%
June 2010	1040		567		1118		43		2768	

Table 7. Service Change for Individual Bus Lines Traversing Gold Line Area (within 1 mile of the line), June 2009-June 2010

Bus #	Service change					Ridership Change	
	DATE	AM PEAK	BASE	PM PEAK	OWL	Average difference	% difference
# 28	June 2009	17	9	19		-1,121	-11.8%
	June 2010	18	8	20			
# 30	June 2009	20	13	24	2	-3,487	-21.2%
	June 2010	16	10	19	2		
# 33	June 2009	47	22	51	5	-11,684	-50.7%
	June 2010	18	11	20	3		
# 66	June 2009	51	14	50		-2,890	-12.4%
	June 2010	38	14	38			
# 70	June 2009	22	15	19	2	-1,740	-12.8%
	June 2010	16	12	15	2		
# 83	June 2009	13	10	15	2	-999	-17.2%
	June 2010	11	8	12	2		
# 94	June 2009	29	9	24		-732	-10.6%
	June 2010	19	8	18			
# 176	June 2009	3	2	3		-189	-15.5%
	June 2010	3	2	4			
# 439	June 2009	8	3	7		143	14.9%
	June 2010	5	3	7			
# 485	June 2009	9	6	10		-465	-15.4%
	June 2010	9	4	7			
# 665	June 2009	3	1	3		-149	-16.2%
	June 2010	4	1	2			
# 687	June 2009	7	5	7		-542	-23.3%
	June 2010	4	4	5			
# 714	June 2009	12	4	12		-643	-16.0%
	June 2010	12	4	11			
# 745	June 2009	23	7	21		-851	-10.4%
	June 2010	23	7	21			
# 753	June 2009	10	6	9		-363	-11.4%
	June 2010	10	4	9			
# 762	June 2009	15	10	17		-684	-11.8%
	June 2010	10	9	11			
# 794	June 2009	17	10	17		-742	-11.6%

ROUTE CHANGE AFTER LRT OPENING/EXTENSION

The Expo Line: June 2011-June 2012

After the Expo Line opening, Metro implemented several bus route service changes. The following section discusses the impacts on four separate route changes along the Expo Line.

Figures 11 and 12 depict the changes to local bus Line 30 before and after the Expo Line opening. Metro made some changes to Line 30 after the Expo Line opening, extending the route from West Adams to West Hollywood and increasing the number of vehicles serving Line 30 (Figures 11 and 12). Ridership on Metro local Line 30 has increased nearly 45% since the Expo Line service began.

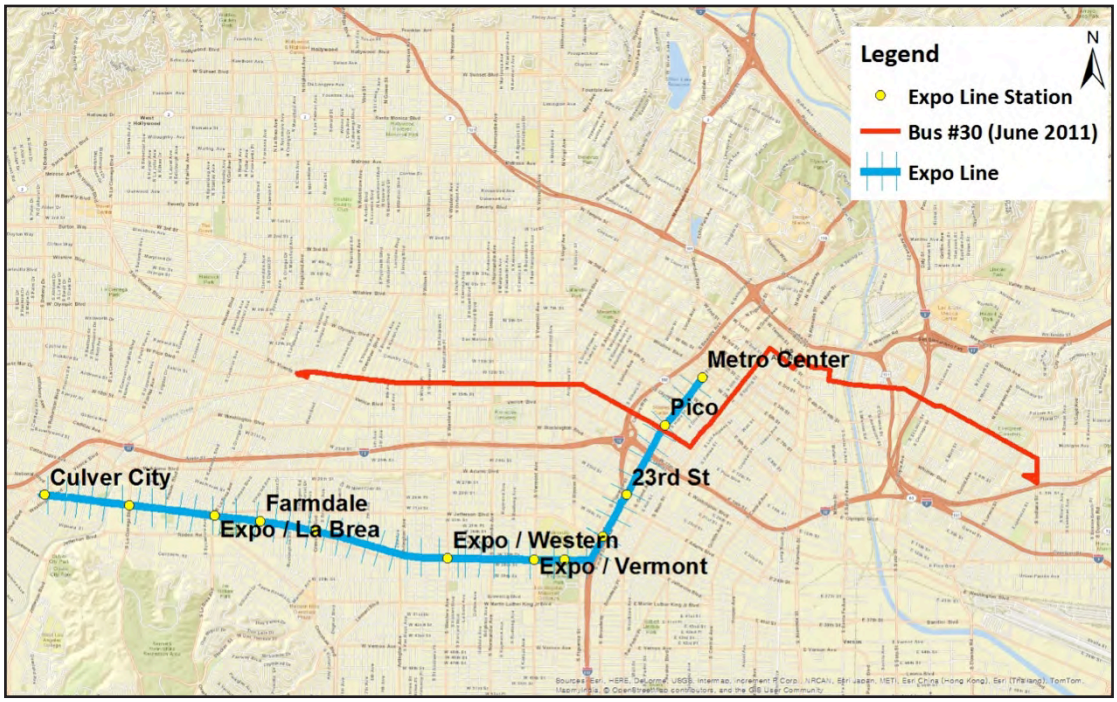

Figure 11. Bus Route 30 Before Expo Line Opening (June 2011)

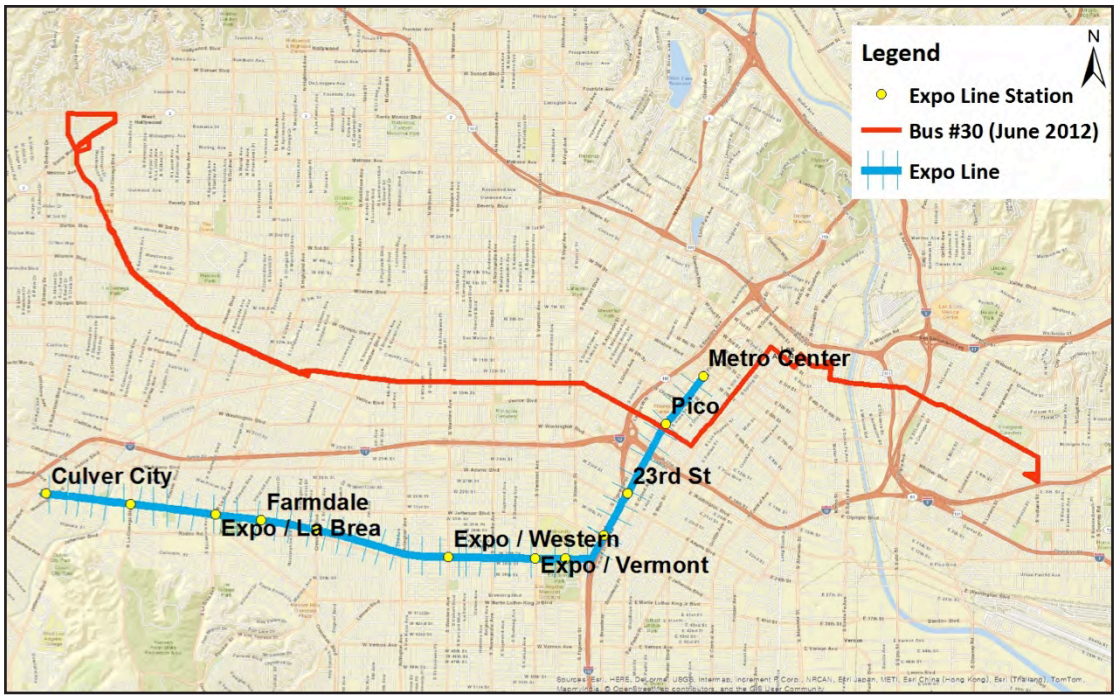

Figure 12. Bus Route 30 After Expo Line Opening (June 2012)

Another bus route with significant service changes after the Expo Line opening is Line 102. The route has been extended from Expo/Western station to Los Angeles International Airport (LAX) with double the number of vehicles serving the line (Figures 13 and 14). Ridership has increased 53% since the Expo Line service began.

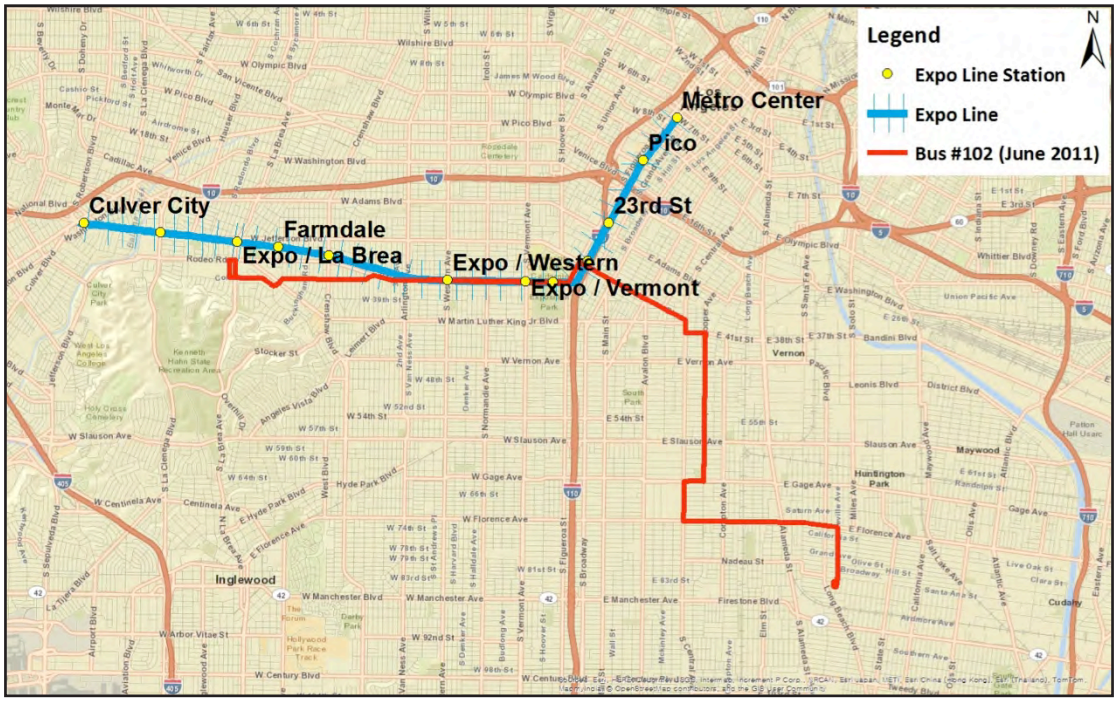

Figure 13. Bus Route 102 Before Expo Line Opening (June 2011)

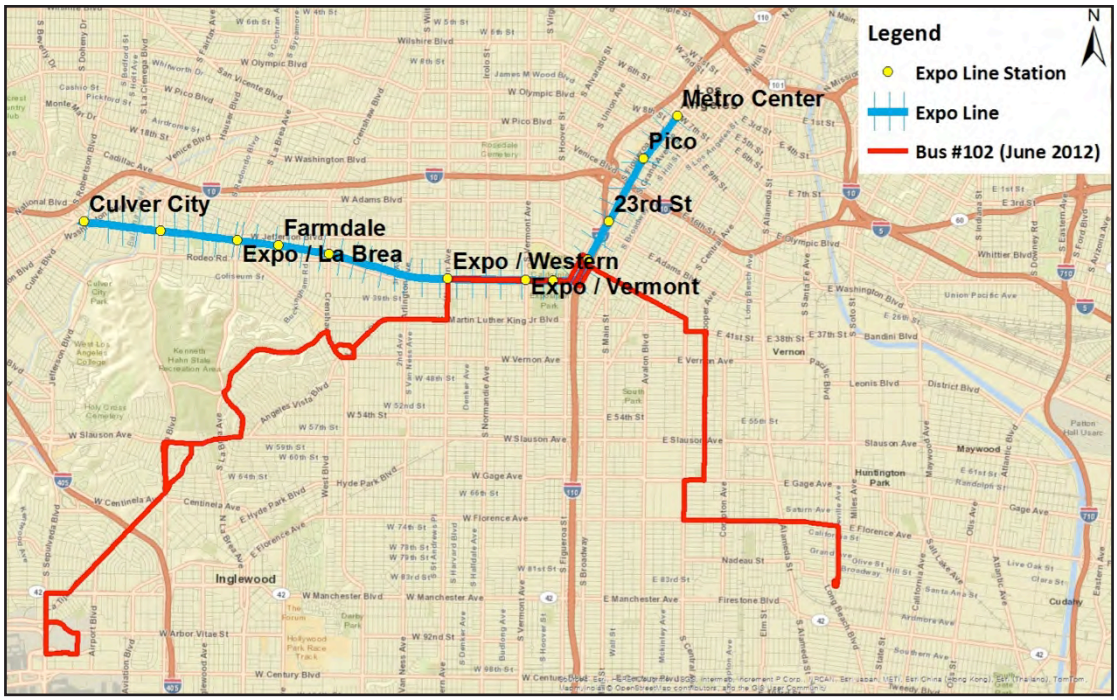

Figure 14. Bus Route 102 After Expo Line Opening (June 2012)

Metro local Line 550 has lost almost 47% of its ridership after the Expo Line service began. Metro made a route change of Line 550 after the Expo Line opening, eliminating service into West Hollywood (Figures 15 and 16). Metro has also decreased the number of vehicles that serve Line 550.

Figure 15. Bus Route 550 Before Expo Line Opening (June 2011)

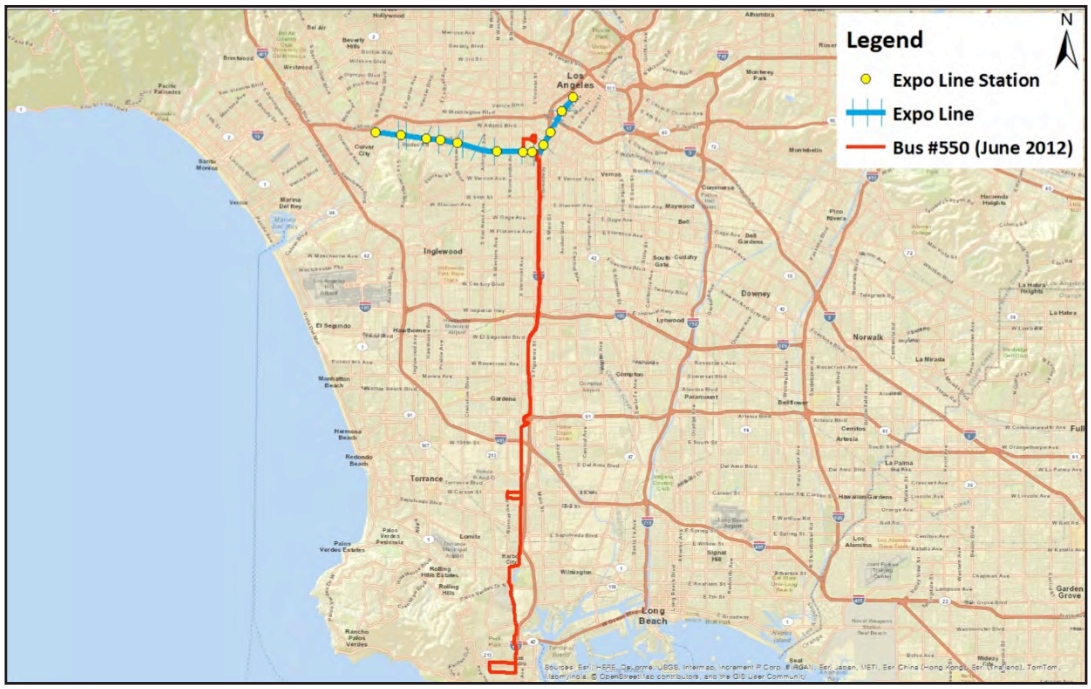

Figure 16. Bus Route 550 After Expo Line Opening (June 2012)

Another bus route with significant changes after the Expo Line opening is Metro local Line 740. This route connects to the Expo Line at Farmdale and no longer serves downtown Los Angeles. Ridership has decreased almost 48% since the Expo Line opened.

Figure 17. Bus Route 740 Before Expo Line Opening (June 2011)

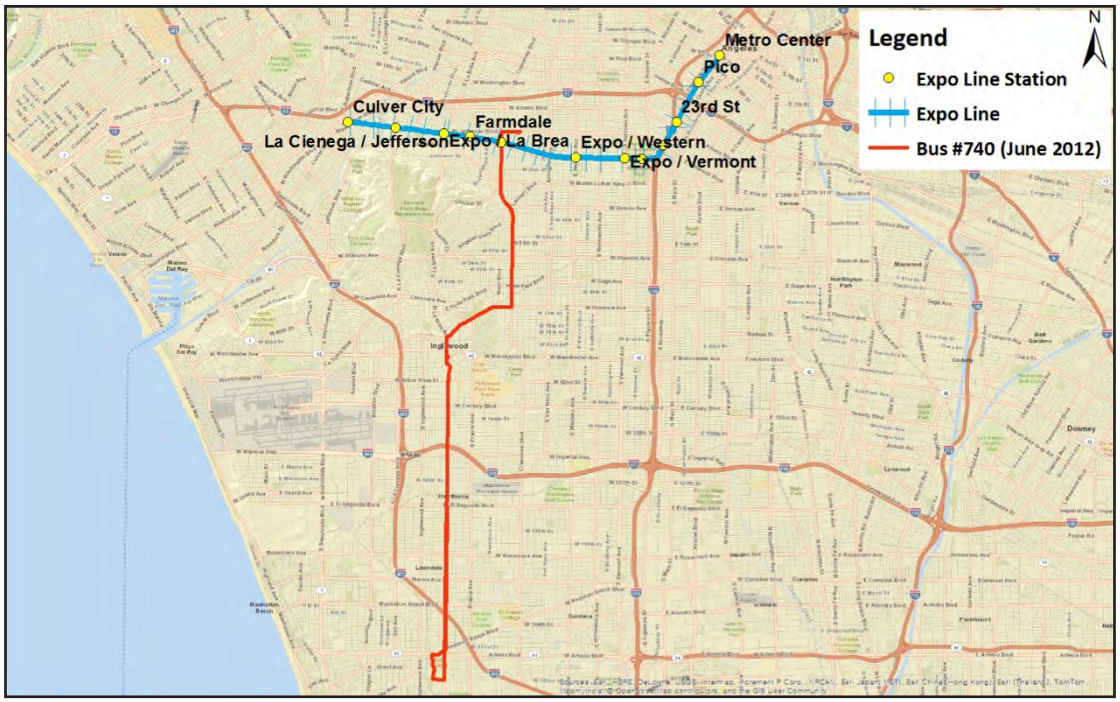

Figure 18. Bus Route 740 After Expo Line Opening (June 2012)

The Gold: June 2009-June 2010

With the Gold Line extension, Metro made a route change to Line 30, cutting the route west of Indiana station, modifying the route near downtown, and reducing the number of vehicles serving Line 30 (Figures 19 and 20). Ridership along Line 30 decreased 22% after the Gold Line service extension opened.

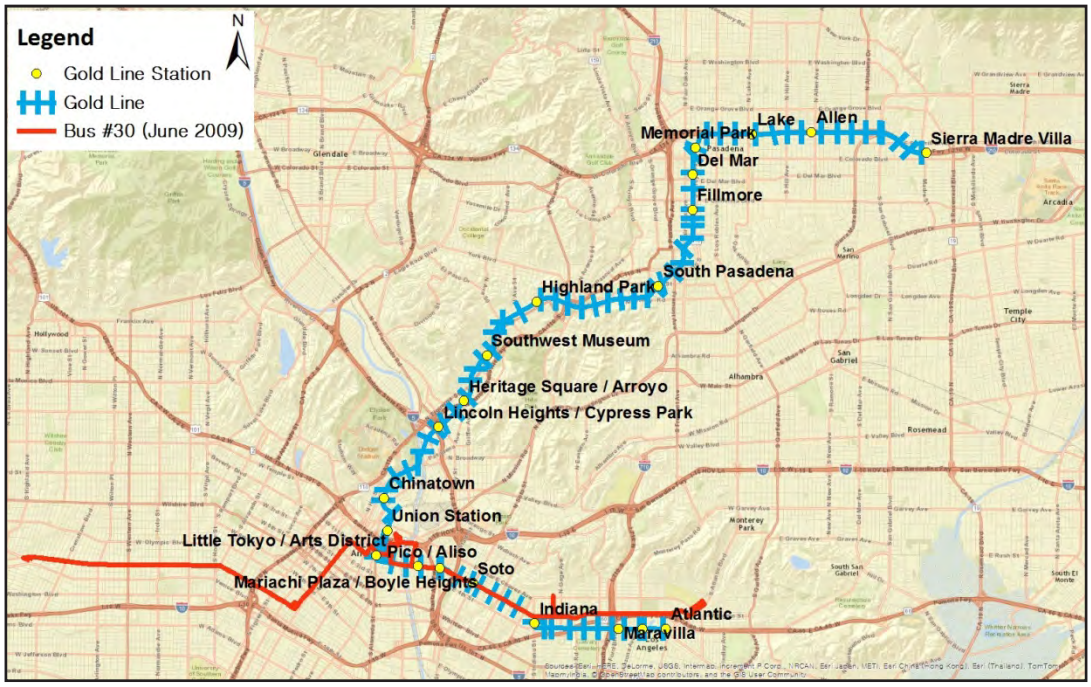

Figure 19. Bus Route 30 Before Gold Line Extension (June 2009)

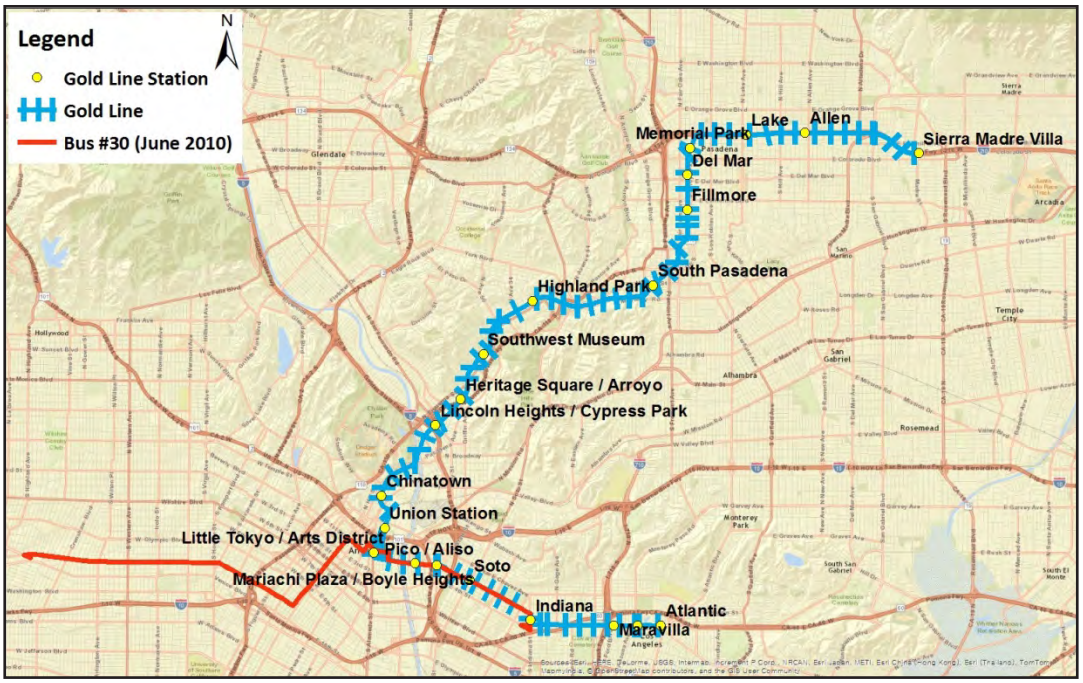

Figure 20. Bus Route 30 After Gold Line Extension (June 2009)

POPULATION DENSITY AND INCOME NEAR LRT

So far, the evidence shows that total transit (bus plus rail) boardings increased slightly after the Expo Line opened but decreased after the Gold Line extension opened. That effect appears to be explained by changes in bus service levels coincident with the opening of both light rail lines. Yet the researchers wanted to rule out the possibility that the characteristics of the neighborhoods traversed by the lines might have been associated with these changes. In particular, do the lines traverse neighborhoods that differ in ways that might be associated with transit ridership? While it is beyond the scope of this study to conduct a detailed statistical analysis of this question, it examined population density and household income along both the Expo and Gold Line extension corridors. Briefly stated, the results find no difference in population density or household income across the two corridors, reinforcing the conclusion that the change in transit boardings was due to changes in bus service coincident with the opening of the light rail lines. Figures 21 and 22 depict the half-mile (0.8 km) radius buffer areas used for this analysis. Tables 8 and 9 present the population and annual household income data for each station along the Gold Line extension and Expo Line, respectively.

The average population of the half-mile radius areas around each Gold Line station was almost 11,000 people. This is only a slightly higher population density than that of the Expo Line area. The average annual household median income of the Gold Line area was approximately $35,000, about $2,000 higher than that of the Expo Line. For the Expo Line station buffer areas, half had annual median household income levels below $30,000 per year. All of these lower income areas are located in the eastern part of the line. The westernmost station, Culver City, has an annual median household income of $67,000. While the income levels for the Expo Line station areas show significant differences

between eastern and western areas of the line, annual household income levels for the Gold Line station areas are relatively consistent, ranging between $29,000 and $40,000.

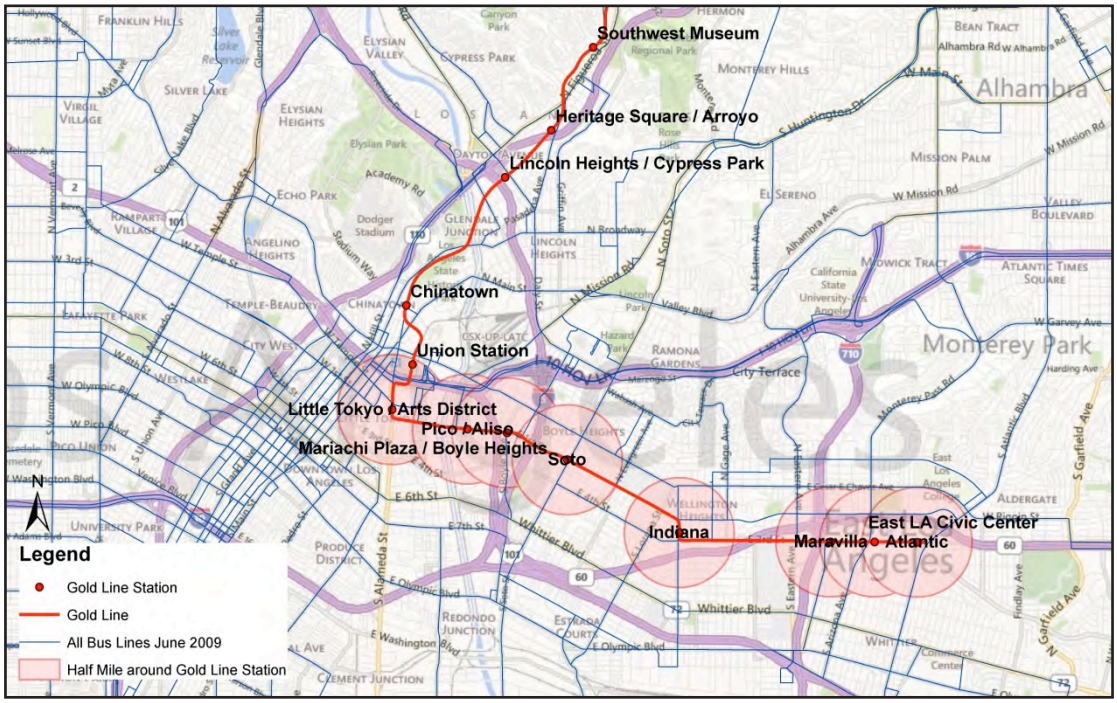

Figure 21. Half-mile (0.8 km) Radius Buffer Areas Along the Gold Line Extension

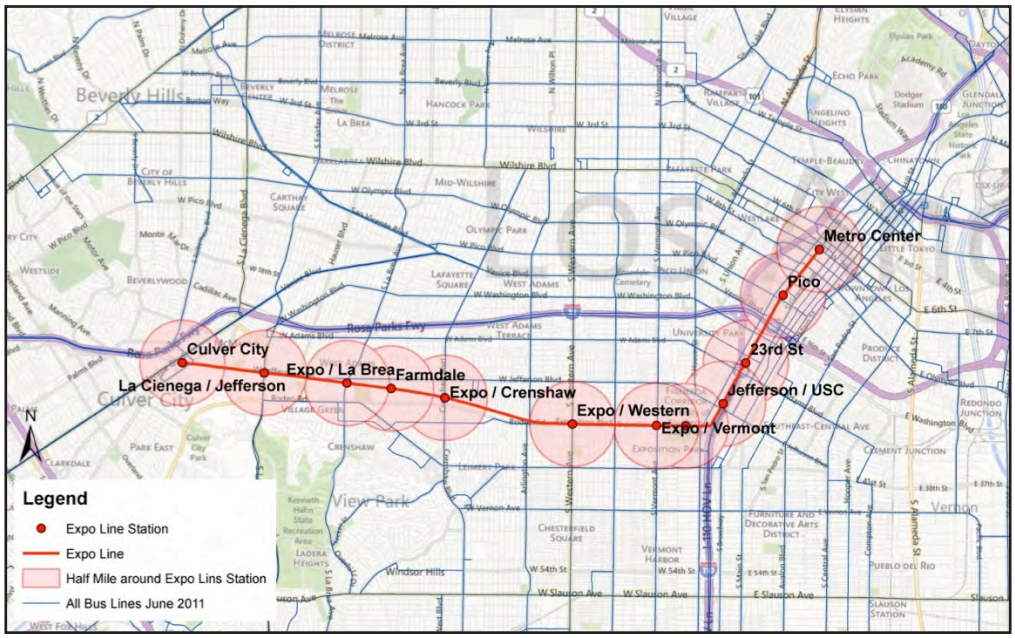

Figure 22. Half-mile (0.8 km) Radius Buffer Areas Along the Expo Line

Table 8. Population and Income for Half-mile Radius Buffer Areas Along the Gold Line Extension (2010)

Station #	Station Name	Population	Annual Household Median Income ($)
14	Little Tokyo / Arts District	7,658.1	40,304.8
15	Pico / Aliso	6,792.2	32,522.0
16	Mariachi Plaza / Boyle Heights	10,189.6	29,196.7
17	Soto	18,310.6	29,130.7
18	Indiana	14,737.4	40,577.6
19	Maravilla	11,043.3	38,345.8
20	East LA Civic Center	10,629.0	35,856.4
21	Atlantic	8,607.2	36,624.4
	Average	10,995.9	35,319.8

Data Source of Population: DEC_10_SF1_P1 (2010 Decennial Census, Summary File 1)
Data Source of Household Median Income: ACS_10_5YR_S1903 (2006-2010 American Community Survey 5-Year Estimates)

Table 9. Population and Income for Half-mile Radius Buffer Areas Along the Expo Line (2010)

Station #	Station Name	Population	Annual Household Median Income ($)
1	Culver City	8,465.4	67,041.0
2	La Cienega / Jefferson	6,354.8	47,433.6
3	Expo / La Brea	11,791.6	35,375.7
4	Farmdale	11,215.7	36,926.5
5	Expo / Crenshaw	8,989.1	43,691.7
6	Expo / Western	15,390.9	36,219.8
7	Expo / Vermont	12,367.5	21,198.6
8	Expo Park / USC	9,597.7	18,626.4
9	Jefferson / USC	10,935.5	20,923.7
10	23rd St	9,374.3	23,168.8
11	Pico	7,487.4	24,753.6
12	Metro Center	11,486.2	21,766.5
	Average	10,288.0	33,093.8

Data Source of Population: DEC_10_SF1_P1 (2010 Decennial Census, Summary File 1)
Data Source of Household Median Income: ACS_10_5YR_S1903 (2006-2010 American Community Survey 5-Year Estimates)

SUMMARY OF FINDINGS FOR RIDERSHIP AND SERVICE CHANGES

The experience along the Expo and Gold Lines differed in ways that can be traced to changes in bus service levels coincident with the opening of light rail transit. After the Gold Line extension opened in 2009, Metro decreased the number of buses along the corridor in the morning and afternoon peak by 14% and 13%, respectively, in addition to an 11% reduction in base (off-peak) buses serving the corridor. These reductions are larger than the reductions in system-wide bus service at the time. In contrast, bus service along

the Expo Line corridor was only modestly changes, with the number of buses reduced by approximately 2% in the morning and afternoon peak but with an approximate 2% increase in base service. The researchers hypothesize that those service changes are a factor in the different “bus plus rail” ridership along the two corridors. The opening of the Gold Line extension saw a combined reduction in bus and rail transit ridership, while the increase in rail ridership exceeded the drop in bus ridership along the Expo Line corridor.

Transit agencies typically change bus service coincident with the opening of new rail service, and such changes are appropriate. The lesson here is that the service reductions along the Gold Line extension occurred coincident with a large drop in bus ridership. While this report does not have specific recommendations about alternative routing strategies, it suggests some caution in bus service realignments when light rail transit is introduced.

IV. TRAVEL PATTERNS AND CHANGE ASSOCIATED WITH THE NEW EXPO LINE SERVICE

INTRODUCTION AND SECTION OBJECTIVES

This chapter assesses potential changes in travel behavior associated with the new Expo Line service and corresponding changes to nearby bus service based on travel survey data collected for 193 households in late 2011 before the line opened and late 2012 after the line opened.

SURVEY DATA AND METHODS

Data for this study were obtained through a seven-day survey of residents of south Los Angeles, conducted in two phases, one before (September 2011-February 2012) and one after (September 2012-January 2013) the Expo LRT service began in April/June 2012. The study area covers about 12 square miles (19.2 sq km) along the Exposition and Crenshaw corridors in south Los Angeles (Figure 23). The study area's population was about 9% non-Hispanic white, 41% Hispanic, and 43% African-American. According to 2010 Decennial Census data, about one-fifth of residents lived in households with income below the federal poverty level, about one-third were foreign-born, and about one-quarter had an educational attainment of a bachelor's degree or higher.

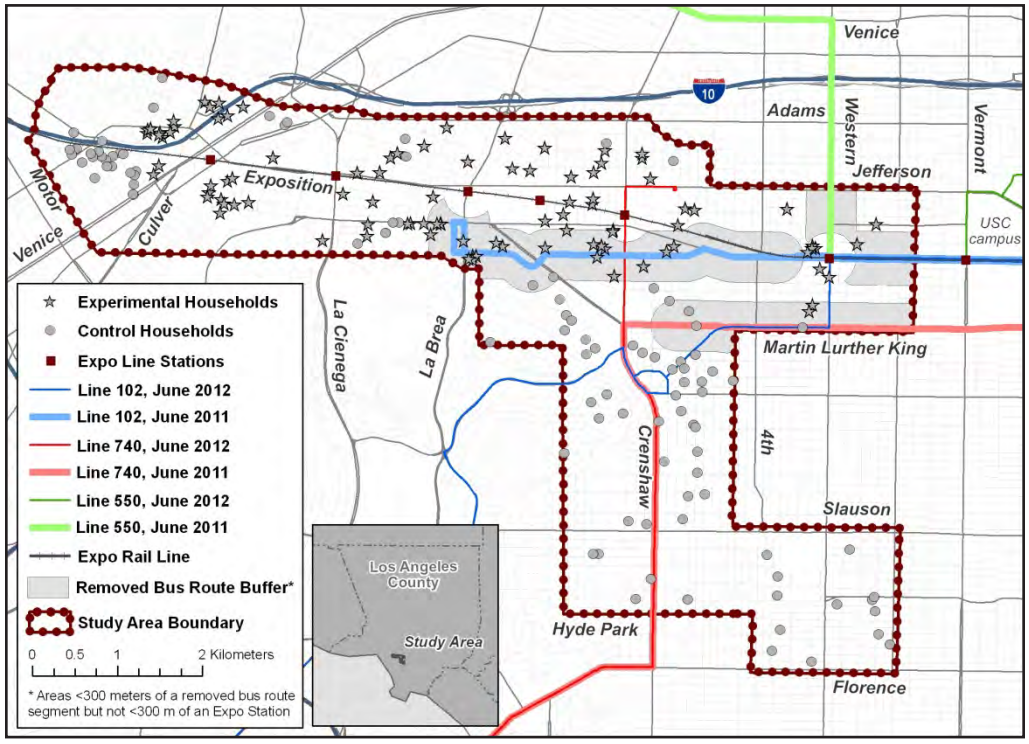

Figure 23. Expo Line Study Area, Approximate Participant Household Locations, and Bus Route Service Changes

To identify potential participants in the first phase of data collection, the research team purchased a list of all household addresses within the study area (27,275) from a marketing firm, InfoUSA. Invitation letters were mailed to each household, and all households who indicated they were interested in participating (651) were invited into the study. A total of 279 households submitted a complete set of responses for at least one household member age 12 or older for the baseline survey, which included questions about demographics, household composition, and transportation resources, as well as a seven-day travel log, which required each participant to record his or her daily number of trips by travel mode (passenger vehicle, public transit, walking, and cycling) and the number of minutes walking and cycling. The researchers re-contacted the households who participated in the first phase of data collection into the second phase of data collection, which required the participants to complete the same survey protocol. The sample for the current analysis included the 193 households for which complete survey responses were obtained for at least one day in each phase of data collection. Appendix B presents the relevant survey questions and travel log.

Households within 1 kilometer (0.8 mile) network distance of an Expo station were classified into the "experimental" group given the hypothesis that participants living within this distance of the new service would be able to walk to the service and would be more likely to be impacted by its availability. Households farther from this distance were classified as "control" neighborhoods given the hypothesis they were far enough away to be unaffected by the new LRT service. The experiment and control areas generally had similar demographic, land use, and transit service patterns before LRT service began. Participating households were provided a grocery gift as an incentive for completing the survey in each phase. The 1 kilometer (0.8 mile) distance was chosen because it corresponds with a walking time of approximately 15 minutes to a station, and because of previous research that indicates that one-half and three-quarter-mile radius circles produce the best fitting models of residence-based transit catchment areas (Guerra, Cervero, and Tischler 2012).[13] However, data obtained for this study in the after-opening period clearly indicates that a 1 kilometer (0.8 mile) catchment area better captures actual train use in the vicinity of Expo Line stations.

The analysis is structured to identify potential differences in travel patterns and transit usage across the experimental households who live within walking distance of the new service and control households who live farther from the new service. In addition, the study assesses potential differences in travel patterns and transit usage based on whether households were near a removed bus route segment (defined as an area within 300 meters of a removed bus route segment but not within 300 meters of an Expo Station).

RESULTS

Study Area, Participant Characteristics, and Bus Service Changes

Figure 23 shows the study area, and the approximate residential location of participating households by experimental and control groups. Experimental households are defined as households within a roadway network distance of 1 kilometer (1.6 mi) of an Expo Line station. Of 193 households in the sample, just under half were Black (46%) and

over half (55%) had a household annual income under $55,000 (Table 10). Control households included a higher percentage of households with a main respondent who was Black compared to Experimental households (52% vs. 41%), in part because the control areas along Crenshaw Boulevard had a higher composition of Black residents overall. Experimental household had a higher percentage of households who owned their home compared to control households (50% vs. 36%).

The 29 households who were in an area near a removed bus route segment (defined as residing within 300 meters of a removed bus route segment but not within 300 meters of an Expo Station) had a higher composition of Black residents compared with all other survey households (55% vs. 45%), a higher percentage of households who had lived in their homes for 10 or more years (55% vs. 41%), and a higher percentage of home ownership (59% vs. 40%).

Table 10. Descriptive Characteristics of Sample, by Groups (Control/Experimental and Proximity to a Removed Bus Route Segment)

	All	Control	Experimental	All	Not Near Removed Bus Route	Near Removed Bus Route
Total	***193***	***95***	***98***	***193***	***164***	***29***
Household Composition by Age						
Household Member 18 years or older	1.70	1.74	1.66	1.70	1.73	1.54
Household Member under 18 years old	0.24	0.27	0.21	0.24	0.23	0.29
Race/Ethnicity of Main Adult Respondent						
Asian/Asian-American	0.12	0.12	0.12	0.12	0.13	0.07
Black/African-American	0.46	0.52	0.41	0.46	0.45	0.55
Hispanic/Latino	0.07	0.05	0.09	0.07	0.07	0.07
Other	0.05	0.03	0.06	0.05	0.04	0.07
White/Caucasian	0.28	0.27	0.29	0.28	0.30	0.17
Household Annual Income						
Under $15,000	0.14	0.13	0.15	0.14	0.13	0.17
$15,000-$34,999	0.23	0.23	0.22	0.23	0.23	0.24
$35,000-$54,999	0.18	0.18	0.18	0.18	0.20	0.10
$55,000-$74,999	0.15	0.17	0.12	0.15	0.15	0.14
$75,000 or higher	0.25	0.23	0.27	0.25	0.25	0.24
Housing Tenure						
Under 5 years	0.36	0.37	0.35	0.36	0.37	0.31
6-10 years	0.16	0.12	0.20	0.16	0.18	0.07
10 or more years	0.43	0.46	0.40	0.43	0.41	0.55
Housing Ownership						
Own	0.43	0.36	0.50	0.43	0.40	0.59
Rent	0.52	0.58	0.46	0.52	0.55	0.34
Household vehicles (N)	1.35	1.38	1.32	1.35	1.38	1.18

Travel Change by Phase and Control/Experimental Groups

When examining differences between groups for the Phase I period before the Expo Line began service, mean travel patterns between experimental and control households were not statistically different except for the number of walking trips (Table 11). Experimental households had 0.56 more walking trips than control households. This difference was also significant in Phase II after the Expo Line opened. In addition, in Phase II experimental households have on average 8.7 fewer vehicle miles traveled (13.9 km) compared with control households. Experimental households also had significantly more train trips after the line opened, but overall transit usage was not significantly different between experimental and control groups in Phase II.

Experimental households near the Expo Line reduced their household daily VMT by 6.3 miles (10 km) from Phase I to Phase II, and control households farther from the Expo Line increased their household daily VMT by 3.6 miles (5.8 km) from Phase I to Phase II. This suggests that the new Expo Line service was associated with an overall reduction of VMT for the experimental household of about 10 miles (16 km), and this difference is statistically significant. Experimental households also had a statistically significant increase in train trips, but there was no significant difference across the groups in terms of overall transit usage (bus and train combined).

Travel Change by Phase and Proximity to a Removed Bus Route Segment

Table 12 presents a comparison of the 29 households in the sample who were in an area near a removed bus route segment (defined as residing within 300 meters of a removed bus route segment but not within 300 meters of an Expo Station) with all other sample households. Results indicate that these households had a statistically significant increase in the number of overall household trips and the number of household walking trips from Phase I to Phase II compared with other sample households.

Table 11. Travel Patterns and Change by Phase and Control/Experimental Groups

	Phase 1 Means (Before)				Phase 2 Means (After)				Difference in Means, Phase 1 vs. Phase 2			
	Control	Experimental	Diff.	Sig.	Control	Experimental	Diff.	Sig.	Control	Experimental	Diff.	Sig.
Households (N)	*95*	*98*			*97*	*96*			*95*	*98*		
VMT	25.85	28.82	2.97		30.27	21.54	-8.73	**	3.64	-6.34	-9.99	**
All Trips	6.65	7.30	0.65		6.43	7.13	0.70		-0.19	-0.21	-0.02	
Car Trips	4.77	4.59	-0.18		4.36	4.15	-0.21		-0.38	-0.47	-0.09	
Bus Trips	0.52	0.69	0.17		0.54	0.50	-0.04		0.01	-0.17	-0.18	
Train Trips	0.05	0.07	0.02		0.10	0.25	0.15	**	0.05	0.18	0.12	*
Transit (Bus and Train) Trips	0.56	0.76	0.20		0.63	0.76	0.13		0.06	0.00	-0.06	
Walking Trips	1.14	1.70	0.56	**	1.19	1.87	0.68	**	0.05	0.16	0.10	

Significance: * p < .1. ** p < .05. Denotes the difference in means between the subgroups is significant.

Table 12. Travel Patterns and Change by Phase and Proximity to a Removed Bus Route Segment

	Wave 1 Means				Wave 2 Means				Difference in Means, Wave 1 vs. Wave 2			
	Not Near Removed Bus Route	Near Removed Bus Route	Diff.	Sig.	Not Near Removed Bus Route	Near Removed Bus Route	Diff.	Sig.	Not Near Removed Bus Route	Near Removed Bus Route	Diff.	Sig.
Households (N)	*164*	*29*			*164*	*29*			*164*	*29*		
VMT	28.32	21.93	-6.39		25.78	26.77	0.99		-2.54	4.84	7.37	
All Trips	7.04	6.61	-0.43		6.62	7.68	1.06		-0.42	1.07	1.49	**
Car Trips	4.72	4.48	-0.24		4.22	4.45	0.24		-0.50	-0.02	0.48	
Bus Trips	0.62	0.53	-0.09		0.52	0.55	0.03		-0.10	0.01	0.11	
Train Trips	0.06	0.05	-0.01		0.16	0.27	0.11		0.10	0.22	0.12	
Transit (Bus and Train) Trips	0.68	0.58	-0.10		0.67	0.81	0.14		0.00	0.23	0.24	
Walking Trips	1.42	1.41	-0.01		1.41	2.17	0.76	*	-0.01	0.76	0.77	*

Significance: * p < .1. ** p < .05. Denotes the difference in means between the subgroups is significant.

SUMMARY OF FINDINGS FOR TRAVEL BEHAVIOR CHANGE

Households living within a one-kilometer (1.6-mile) road network distance of a new Expo Line light rail station reduced their driving by almost 10 miles (16 km) per day relative to control group households. This is a substantial driving reduction, and it provides evidence that travel behavior is malleable and that travel habits can change rapidly after the provision of new transportation infrastructure. The report notes, however, that those households near bus stops that were removed ended up driving more – almost 5 miles (8 km) per day more. This may not be surprising. Possibly those households either drove to park-and-ride bus or rail stations after a nearby bus stop was removed, or they may have substituted car trips for bus trips. Yet this is a caution that changes in bus service can influence the effectiveness of new rail transit, possibly in unexpected ways. Eliminating bus stops not only attenuates the VMT reduction observed in experimental households who lived within one kilometer of new light rail stations, it also reverses the effect.

V. CONCLUSION AND POLICY CONSIDERATIONS

This study is one of the first that tracks changes in travel behavior before and after the opening of new light rail transit service. It combines the results of a detailed household travel survey along the Expo Line in Los Angeles with aggregate bus and rail ridership data along corridors for the two most recently opened light rail lines in the city – the Expo Line and the Gold Line extension. The results give two important, and linked, lessons.

1. Changes in bus service that are coincident with the introduction of new light rail transit can negatively affect the overall transit ridership in the corridor. The immediate effect of bus service changes along the Gold Line extension appears to be related to net "bus plus rail" ridership declines in that corridor. The net transit ridership effect along the Expo Line corridor was an increase in ridership, possibly because bus service was not reduced by the same magnitude along the Gold Line extension.

2. Households living near new Expo Line light rail stations reduced their VMT, but those households living near bus stops that were eliminated increased their VMT. This is not definitive, but it suggests the possibility that bus service is a complement to rail transit service, at least for driving reduction.

The policy implications of this research start with the proposition that transit agencies should think more carefully about bus and rail transit service, particularly when new rail transit is introduced. Light rail runs along the street, often along heavily traveled bus routes, and it is natural to eliminate some bus routes to optimize the system after new light rail service commences. This study does not argue against that, but based on its results, the study suggests some caution. The changes in bus service, on net, can be consistent with increases in transit ridership (as in the Expo Line corridor) or decreases in transit ridership (as in the Gold Line corridor). More importantly, system optimization might extend to a full range of travel behavior. If driving behavior is considered, eliminating bus stops (or possibly other reductions in service) may be less attractive, based on the increases in driving among households near eliminated bus stops in the Expo Line study area. This study suggests that transit agencies take a more holistic view of travel impacts, including driving as well as transit, and that changes to bus service should be carefully crafted to maximize use of not only new rail transit service but also to facilitate changes in travel behavior that are consistent with a shift away from auto-mobility.

The results of this study point to two different, but related, effects. Changes in bus service can have negative or positive effects on system ridership, and agencies should take care when introducing light rail or any service that prompts system-wide reconfigurations of existing service. Changes in service, particularly those associated with new light rail, can change travel behavior. How might agencies best combine these two insights?

The study argues that future research should be alert to informing this question. First, transit agencies and researchers should be more alert to before-and-after evaluations of new service. The insights from this study can stand as an example of the importance of such before-and-after evaluations. Along those lines, the research team suggests that transit agencies can easily implement some of these studies, including comparisons of

boardings before and after the introduction of new service, and they suggest that such studies become a standard part of agency operations. That would include reporting the results to the public, which is possible on web pages. Second, the large reductions in VMT observed after the opening of the Expo Line suggest several possibilities in travel behavior research. The research team has an incomplete view of how travelers interact with new technologies that provide real-time information about the network, use social media to encourage travel change, and can now promote mobility services of the type that are rapidly gaining a foothold in the market (e.g., shared rides, bicycle sharing, or the like). Future research might examine how new infrastructure interacts with information and with innovative mobility services, and whether such interactions provide ways to obtain even more leverage from rail transit investments.

Overall, the results of this research suggest that travel behavior may change more rapidly and more substantially than many people likely previously thought. This report suggests that future research deepen that insight by examining the conditions under which new light rail can most effectively achieve broader transportation goals.

APPENDIX A: DETAILED RIDERSHIP DATA FOR EXPO AND GOLD LINES

Table 13. Ridership Data for Bus Lines Traversing the Expo Line Area (within 1 mile of the line)

	Line #	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Jul-Nov 2011	Jul-Nov 2012	Average Difference	Difference (%)
Local through CBD	2	19,417	18,868	20,324	20,380	19,523	19,249	19,838	20,515	20,779	19,345	19,702	19,945	243	1.2%
	4	20,582	20,294	21,573	21,645	21,315	20,963	22,200	22,388	22,254	21,036	21,082	21,768	686	3.3%
	10	11,994	11,785	13,914	13,868	13,295	11,463	12,924	13,919	13,959	12,890	12,971	13,031	60	0.5%
	14	19,166	19,476	21,919	22,112	21,458	19,040	20,595	22,244	22,376	20,498	20,826	20,951	124	0.6%
	16	25,509	25,214	26,739	27,103	26,924	24,415	25,506	25,995	26,082	25,089	26,298	25,417	-880	-3.3%
	18	24,678	24,314	25,695	25,528	24,901	23,654	24,554	24,821	24,827	23,996	25,023	24,370	-653	-2.6%
	20	17,161	17,177	17,558	17,409	16,792	17,215	17,684	17,773	17,791	16,654	17,219	17,423	204	1.2%
	28	7,902	7,784	8,148	8,047	7,942	8,535	8,571	8,793	8,834	8,371	7,965	8,621	656	8.2%
	30	13,045	13,090	13,237	13,048	12,868	18,511	18,703	19,317	19,377	18,337	13,058	18,849	5,791	44.4%
	33	12,418	12,173	12,906	12,700	12,586	12,744	13,546	13,727	13,686	12,874	12,557	13,315	759	6.0%
	35	12,050	11,872	13,627	13,441	13,279	10,655	11,655	12,877	12,932	12,004	12,854	12,025	-829	-6.5%
	40	24,022	23,790	25,133	25,254	25,126	22,546	23,521	24,408	24,010	22,728	24,665	23,443	-1,222	-5.0%
	45	21,908	21,668	22,901	22,641	22,366	20,296	21,107	22,026	22,207	21,126	22,297	21,352	-944	-4.2%
	51	27,074	27,606	29,068	28,905	28,639	27,509	28,459	29,517	30,080	28,743	28,258	28,862	603	2.1%
	53	13,342	13,299	14,623	14,536	14,338	13,408	14,102	15,122	15,300	14,339	14,028	14,454	427	3.0%
	55	9,094	9,034	10,270	10,308	9,934	8,501	9,520	10,682	10,657	9,759	9,728	9,824	96	1.0%
	60	19,809	19,864	20,749	20,252	19,992	20,093	20,918	21,163	21,610	20,767	20,133	20,910	777	3.9%
	62	4,851	5,041	5,190	5,103	5,076	5,056	5,189	5,339	5,380	5,113	5,052	5,215	163	3.2%
	66	19,684	19,314	19,516	19,442	19,246	18,394	18,765	18,828	18,782	17,812	19,440	18,516	-924	-4.8%
	70	12,368	12,341	12,731	12,606	12,443	12,371	12,443	12,916	13,064	12,229	12,498	12,605	107	0.9%
	71	1,663	1,670	1,879	2,037	2,010	1,839	1,959	2,128	2,284	2,113	1,852	2,065	213	11.5%
	76	10,829	10,711	11,231	11,078	10,963	10,429	10,206	10,740	10,690	10,174	10,962	10,448	-515	-4.7%
	78	11,573	11,465	12,113	11,885	11,710	11,690	11,767	12,425	12,515	12,053	11,749	12,090	341	2.9%
	81	15,870	15,987	17,357	17,161	16,757	15,374	16,112	17,336	17,276	16,543	16,626	16,528	-98	-0.6%
	83	4,034	3,918	4,189	4,107	3,996	3,368	3,406	3,514	3,581	3,306	4,049	3,435	-614	-15.2%
	84	9,182	8,612	9,691	9,524	9,360	8,559	8,730	9,565	9,593	8,963	9,274	9,082	-192	-2.1%
	90	5,911	6,113	6,982	6,772	6,626	6,406	6,478	7,791	7,589	7,084	6,481	7,070	589	9.1%
	92	5,771	5,661	5,855	5,827	5,916	5,468	5,525	5,714	5,747	5,597	5,806	5,610	-196	-3.4%
	94	6,644	6,517	6,669	6,553	6,522	6,221	6,242	6,545	6,492	6,142	6,581	6,328	-253	-3.8%
	96	1,631	1,607	1,651	1,628	1,516	1,676	2,030	1,743	1,690	1,533	1,607	1,734	128	8.0%

	Line #	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Jul-Nov 2011	Jul-Nov 2012	Average Difference	Difference (%)
Local through non-CBD	102	1,556	1,590	1,752	1,685	1,579	2,274	2,442	2,609	2,605	2,532	1,632	2,492	860	52.7%
	105	11,668	11,833	12,746	12,557	12,850	12,496	13,265	13,569	13,725	13,032	12,331	13,217	887	7.2%
	200	14,790	14,846	15,714	15,752	15,231	15,170	15,852	16,235	16,063	15,405	15,267	15,745	478	3.1%
	204	26,770	26,616	29,340	29,259	28,810	25,772	27,904	29,287	28,949	26,899	28,159	27,762	-397	-1.4%
	206	12,940	12,738	14,083	14,149	13,688	12,951	13,767	14,341	14,057	13,289	13,520	13,681	161	1.2%
	207	23,766	22,945	24,847	24,093	23,455	21,491	22,855	23,738	23,252	21,761	23,821	22,619	-1,202	-5.0%
	209	850	875	1,040	1,049	1,033	895	1,034	1,177	1,173	1,044	969	1,065	95	9.8%
	210	14,576	14,359	15,931	15,404	14,897	14,772	15,398	16,840	16,942	15,967	15,033	15,984	950	6.3%
	212	13,132	13,249	14,181	14,395	14,125	14,303	14,935	15,492	15,402	14,645	13,816	14,955	1,139	8.2%
	217	8,063	8,132	8,336	7,994	8,022	8,545	8,889	9,066	9,160	8,699	8,109	8,872	762	9.4%
	220	289	267	269	252	264	280	301	295	307	273	268	291	23	8.6%
Limited Ex-press	305	2,606	2,580	2,762	2,651	2,775						2,675			
	439	428	443	470	453	429						445			
	442	228	241	268	277	256	249	252	274	283	281	254	268	14	5.4%
	450	1,389	1,396	1,495	1,567	1,545	1,635	1,618	1,704	1,771	1,723	1,478	1,690	212	14.3%
	460	4,586	4,683	4,620	4,528	4,432	4,862	4,874	4,950	4,896	4,637	4,570	4,844	274	6.0%
	487	3,825	3,779	4,103	4,285	4,092	3,840	3,798	4,198	4,437	3,982	4,017	4,051	34	0.9%
	534	3,002	3,015	3,114	2,975	2,908	2,853	3,005	3,094	3,032	2,873	3,003	2,971	-31	-1.0%
	550	3,176	3,136	3,316	3,289	3,190	1,618	1,664	1,789	1,747	1,655	3,221	1,695	-1,527	-47.4%
Shuttle	603	6,555	6,455	7,014	6,921	7,111	6,403	7,330	7,435	7,279	6,764	6,811	7,042	231	3.4%
	607	42	43	50	51	61	63	52	75	67	66	49	65	15	30.8%

	Line #	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Jul-Nov 2011	Jul-Nov 2012	Average Difference	Difference (%)
	705	7,561	7,741	8,519	8,418	8,208	7,347	7,626	8,099	8,241	7,892	8,089	7,841	-248	-3.1%
	710	6,977	6,930	8,155	8,044	7,905	7,179	7,605	8,846	8,873	8,428	7,602	8,186	584	7.7%
	720	41,601	41,215	41,800	41,098	40,115	42,240	42,819	42,728	42,108	40,014	41,166	41,982	816	2.0%
	728	6,747	6,563	6,833	6,723	6,551	5,724	5,771	6,102	6,236	6,009	6,683	5,968	-715	-10.7%
	730	4,695	4,606	4,800	4,644	4,673						4,684			
	733	13,119	12,621	13,146	12,975	12,507	12,085	12,730	12,861	12,885	11,785	12,874	12,469	-404	-3.1%
	740	7,520	7,541	8,097	8,073	7,894	3,643	3,868	4,270	4,368	4,175	7,825	4,065	-3,760	-48.1%
Rapid	745	6,843	6,727	7,316	7,302	7,172	6,430	6,615	6,923	7,080	6,736	7,072	6,757	-315	-4.5%
	754	20,304	20,137	22,390	22,271	21,793	20,049	20,890	22,263	22,468	21,108	21,379	21,356	-23	-0.1%
	757	12,527	12,730	13,702	13,700	13,754	12,897	13,486	14,497	14,861	13,829	13,283	13,914	631	4.8%
	760	6,486	6,594	6,855	6,723	6,589	5,816	6,082	6,304	6,198	5,978	6,649	6,076	-574	-8.6%
	770	8,786	8,554	9,207	9,037	8,982	8,527	8,405	9,188	9,292	8,836	8,913	8,850	-64	-0.7%
	780	9,854	9,534	10,837	10,881	10,614	10,100	10,246	11,266	11,425	10,495	10,344	10,706	362	3.5%
	794	4,953	5,105	5,438	5,462	5,144	5,120	5,334	5,421	5,598	5,480	5,220	5,391	170	3.3%
	910	9,480	9,730	10,414	11,234	10,648	11,206	11,449	12,197	13,765	13,515	10,301	12,426	2,125	20.6%
EXPO	806						18,181	19,776	20,656	21,382	22,066				
Buses		730,872	725,814	776,398	771,071	756,721	714,483	744,416	777,004	779,989	737,025	752,175	750,583	-1,592	-0.2%
Total		730,872	725,814	776,398	771,071	756,721	732,664	764,192	797,660	801,371	759,091	752,175	770,996	18,820	2.5%

Table 14. Ridership Data for Bus Lines Traversing the Gold Line Area (within 1 mile of the line)

Line #		Jul-09	Aug-09	Sep-09	Oct-09	Jul-10	Aug-10	Sep-10	Oct-10	Jul-Oct 2009	Jul-Oct 2010	Average Difference	Difference (%)
Local through CBD	2	22,080	21,620	22,595	22,626	19,656	20,105	20,348	20,654	22,230	20,191	-2,040	-9.2%
	4	20,630	20,404	21,651	21,418	19,375	19,031	19,548	19,313	21,026	19,317	-1,709	-8.1%
	10	12,902	12,810	14,567	14,387	11,934	11,666	13,302	13,060	13,667	12,491	-1,176	-8.6%
	14	16,346	16,187	18,158	18,285	16,477	16,251	17,561	17,322	17,244	16,903	-341	-2.0%
	16	26,511	26,311	27,332	27,485	25,169	24,974	26,101	26,248	26,910	25,623	-1,287	-4.8%
	18	26,783	26,533	27,869	27,740	24,853	24,581	25,590	25,192	27,231	25,054	-2,177	-8.0%
	20	17,569	17,550	18,128	17,794	16,789	16,689	16,812	17,036	17,760	16,832	-929	-5.2%
	26	27,413	27,259	28,363	28,777	27,744	27,495	28,450	28,167	27,953	27,964	11	0.0%
	28	9,470	9,581	9,545	9,520	8,400	8,092	8,317	8,656	9,529	8,366	-1,163	-12.2%
	30	16,898	16,565	16,574	16,202	13,221	12,843	13,042	12,913	16,560	13,005	-3,555	-21.5%
	33	23,214	22,931	23,475	22,922	11,637	11,299	11,430	11,396	23,136	11,441	-11,695	-50.6%
	35	8,853	8,503	9,911	10,011	7,919	7,857	9,008	9,085	9,320	8,467	-852	-9.1%
	38	5,779	5,758	6,460	6,476	5,459	5,393	6,092	5,887	6,118	5,708	-411	-6.7%
	40	17,677	17,344	18,409	18,449	17,551	17,038	17,722	17,115	17,970	17,357	-613	-3.4%
	42	4,859	4,703	5,120	5,122	4,589	4,529	4,755	4,813	4,951	4,672	-280	-5.6%
	45	20,841	20,594	21,751	21,351	20,922	20,728	21,883	21,530	21,134	21,266	132	0.6%
	53	10,389	10,348	11,226	10,922	10,603	10,423	10,970	10,914	10,721	10,728	6	0.1%
	55	10,358	9,827	11,265	11,454	9,487	9,538	10,411	10,340	10,726	9,944	-782	-7.3%
	60	17,642	17,585	17,704	17,767	18,096	18,094	18,163	17,649	17,675	18,001	326	1.8%
	62	4,244	4,367	4,404	4,472	4,647	4,727	4,874	4,724	4,372	4,743	371	8.5%
	66	23,231	23,285	23,489	23,489	20,769	20,518	20,617	20,429	23,374	20,583	-2,790	-11.9%
	70	13,301	13,365	13,916	13,743	11,922	11,781	12,215	11,693	13,581	11,903	-1,679	-12.4%
	76	10,679	10,553	11,047	10,894	10,439	10,387	10,884	10,708	10,793	10,605	-189	-1.7%
	78	11,457	11,402	11,806	11,589	11,341	11,241	11,777	11,345	11,564	11,426	-138	-1.2%
	81	16,903	16,727	17,815	17,742	15,961	15,859	16,903	16,816	17,297	16,385	-912	-5.3%
	83	5,710	5,548	5,958	5,965	4,770	4,618	4,952	4,862	5,795	4,801	-995	-17.2%
	84	9,222	9,119	10,181	9,834	8,777	8,329	9,121	9,100	9,589	8,832	-757	-7.9%
	90	6,034	6,011	6,541	6,496	5,883	5,753	6,579	6,225	6,271	6,110	-161	-2.6%
	92	5,675	5,720	5,966	5,989	5,783	5,767	5,890	5,764	5,838	5,801	-37	-0.6%
	94	6,837	6,849	6,987	6,924	6,135	6,105	6,314	6,108	6,899	6,166	-734	-10.6%
	96	2,407	2,389	2,339	2,098	2,334	2,307	2,501	2,455	2,308	2,399	91	3.9%

Line #		Jul-09	Aug-09	Sep-09	Oct-09	Jul-10	Aug-10	Sep-10	Oct-10	Jul-Oct 2009	Jul-Oct 2010	Average Difference	Difference (%)
Local through non-CBD	251	10,073	10,064	10,294	10,123	9,631	9,691	9,781	9,378	10,139	9,620	-518	-5.1%
	252	2,786	2,590	3,274	3,231	2,722	2,817	3,025	3,210	2,970	2,944	-27	-0.9%
	254	599	662	727	691	725	715	759	763	670	741	71	10.6%
	256	1,497	1,384	2,038	1,735	1,426	1,359	1,667	1,658	1,664	1,528	-136	-8.2%
	258	1,612	1,651	1,776	1,730	1,499	1,542	1,689	1,626	1,692	1,589	-103	-6.1%
	260	11,447	11,264	12,475	12,185	11,688	11,616	12,951	12,629	11,843	12,221	378	3.2%
	287	1,775	1,751	1,875	1,900	1,976	1,926	2,008	1,923	1,825	1,958	133	7.3%
Limited Express	439	914	972	971	1,006	1,111	1,095	1,144	1,105	966	1,114	148	15.3%
	442	209	209	240	242	205	214	219	237	225	219	-6	-2.8%
	444	2,982	3,008	3,026	3,024					3,010		-3,010	
	445	1,314	1,339	1,361	1,380	1,200	1,173	1,226	1,228	1,349	1,207	-142	-10.5%
	446	4,122	4,023	4,324	4,386					4,214		-4,214	
	460	4,238	4,412	4,367	4,171	4,516	4,375	4,323	4,172	4,297	4,347	50	1.2%
	484	6,975	7,021	7,415	7,884					7,324		-7,324	
	485	2,931	2,818	3,042	3,283	2,447	2,270	2,541	2,810	3,019	2,517	-502	-16.6%
	487	3,862	3,743	4,179	4,185	3,553	3,461	3,856	3,869	3,992	3,685	-308	-7.7%
	490	5,548	5,690	6,283	6,517					6,010		-6,010	
Shuttle	605	2,339	2,371	2,847	2,533	1,998	1,950	2,376	2,378	2,523	2,176	-347	-13.8%
	620	646	657	761	774	731	716	709	740	710	724	15	2.0%
	665	813	789	949	1,025	711	674	791	844	894	755	-139	-15.5%

Line #		Jul-09	Aug-09	Sep-09	Oct-09	Jul-10	Aug-10	Sep-10	Oct-10	Jul-Oct 2009	Jul-Oct 2010	Average Difference	Difference (%)
	704	12,479	12,384	13,311	12,628	12,171	12,071	12,818	12,798	12,701	12,465	-236	-1.9%
	714	3,866	3,729	4,206	4,197	3,207	3,224	3,502	3,541	4,000	3,369	-631	-15.8%
	720	38,405	38,367	38,370	37,141	37,787	37,798	38,003	36,898	38,071	37,622	-449	-1.2%
	728	8,428	8,562	8,873	8,611	8,124	7,900	8,267	8,323	8,619	8,154	-465	-5.4%
	730	4,951	4,900	5,458	5,262	4,814	4,558	4,914	5,031	5,143	4,829	-314	-6.1%
	740	9,110	9,039	9,656	9,705	8,570	8,404	8,890	8,640	9,378	8,626	-752	-8.0%
Rapid	745	7,935	8,003	8,229	8,288	7,126	6,974	7,523	7,422	8,114	7,261	-853	-10.5%
	751	5,967	6,229	6,350	6,335	6,256	6,060	6,395	6,068	6,220	6,195	-26	-0.4%
	753	3,149	3,042	3,166	3,320	2,877	2,844	2,820	2,840	3,169	2,845	-324	-10.2%
	760	8,513	8,536	8,952	8,764	8,716	8,754	8,831	8,619	8,691	8,730	39	0.4%
	762	5,267	5,251	6,257	6,165	4,954	4,647	5,447	5,274	5,735	5,081	-655	-11.4%
	770	9,217	9,151	10,134	10,153	9,068	8,718	9,344	9,188	9,664	9,080	-584	-6.0%
	794	6,084	6,387	6,432	6,442	5,518	5,676	5,829	5,643	6,336	5,667	-670	-10.6%
GOLD	804	21,065	24,175	22,476	21,322	34,285	35,247	35,649	34,440	22,260	34,905	12,646	56.8%
Buses		621,967	617,746	652,170	646,959	563,969	557,240	583,780	576,374	634,711	570,341	-64,370	-10.1%
Total		643,032	641,921	674,646	668,281	598,254	592,487	619,429	610,814	656,970	605,246	-51,724	-7.9%

APPENDIX B: SURVEY QUESTIONS AND TRAVEL LOG

Information About Your Household

How long have you lived in your current home?

□ less than 1 year

□ 1 to 5 years

□ 6 to 10 years

□ more than 10 years

□ all of my life

Do you own or rent your residence?

□ Own

□ Rent

□ Don't know

□ Other. If other, please describe:_____

What is your average annual household income?

□ Less than $15,000

□ $15,001 to $35,000

□ $35,001 to $55,000

□ $55,001 to $75,000

□ $75,001 to $100,000

□ More than $100,000

What is your race or ethnicity?

□ Asian/Pacific Islander

□ Black/African-American

□ White/Caucasian

□ Hispanic

□ Native American/Alaska Native

□ Other/Multi-Racial

Individual Demographic Survey and 7-Day Travel Log

Please enter the following information for the person whose trips are recorded on this log.

First Name: _____

What is this person's gender?

□ Male □ Female

How old is this person?

_____ years

Is this person employed?

□ No □ Yes, part time □ Yes, full time

Is this person a student?

□ No.

□ Yes, in a college or university.

□ Yes, in high school.

□ Yes, in another type of school.

If they are a student, do they attend school full time or part time?

□ Part time □ Full time

What is the highest level of education this person has completed?

□ 12th grade or less

□ Graduated high school or equivalent

□ Some college, no degree

□ Associate degree

□ Bachelor's degree

□ Post-graduate degree

Trip Log

Neighborhood Travel and Activity Study **Travel Log**

Person Name:

	Car Driver	Car Pass-enger	Motor-cycle/ Scooter	Bus	Train	Bicycle		Walk		Other	Notes? Problems? Please describe below.
						# of Trips	Total Minutes	# of Trips	Total Minutes		
Monday											
Tuesday											
Wednesday											
Thursday											
Friday											
Saturday											
Sunday											

Instructions

- Count each trip you take during each day
- Include walk/bike trips over 5 minutes
- Count trips you take for recreation or exercise
- Log the total minutes you walk or bicycle each day
- Count each trip mode as a separate trip (car, walk, etc)

Suggestions

- Carry and complete the log as you travel
- Or you can complete the log at the end of each day
- Note any problems each day (forgot to fill out one day)
- See the back of this log for examples

Vehicle Mileage Log

Neighborhood Travel and Activity Study

Vehicle Mileage Log

Vehicle Year: _____

Make (Ford, Honda, etc): _____

Model (Focus, Accord, etc): _____

	Start	End
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		
Saturday		
Sunday		

Instructions

- Place one log in each vehicle in a visible location
- Enter vehicle year, make, and model
- Log mileage at the start and end of each day
- Obtain mileage from the *odometer* near the speedometer

ABBREVIATIONS AND ACRONYMS

BMI	Body Mass Index
CBD	Central Business District
km	kilometer
LA	Los Angeles
LAX	Los Angeles International Airport
LRT	Light Rail Transit
MARTA	Metropolitan Atlanta Rapid Transit Authority
TOD	Transit-oriented Development
TPB	Theory of Planned Behavior
VMT	Vehicle Miles Traveled

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