



**Public Transportation and
Petroleum Savings in the U.S.:
Reducing Dependence on Oil**

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"Public Transportation and Petroleum Savings in the U.S.: Reducing Dependence on Oil," January 2007

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Executive Summary

Public Transportation: The Smart Way to Cut Household Expenses and U.S. Foreign Oil Dependence

Public transportation provides greater freedom, access, opportunity and choice for Americans from all walks of life and from all across the country. Ridership is up 25.1 percent since 1995, and the millions of Americans who use public transportation each weekday know it saves money and gasoline.

This independent analysis looks for the first time at what public transportation saves – both for individual households and for the nation as a whole. In addition, it explores a possible future where many more Americans would have the choice to take public transportation. It was commissioned from ICF International by the American Public Transportation Association.

Public Transportation Reduces U.S. Foreign Oil Dependence

Using conservative assumptions, the study found that current public transportation usage reduces U.S. gasoline consumption by 1.4 billion gallons each year. In concrete terms, that means:

- 108 million fewer cars filling up – almost 300,000 every day.
- 34 fewer supertankers leaving the Middle East – one every 11 days.
- Over 140,000 fewer tanker truck deliveries to service stations per year.
- A savings of 3.9 million gallons of gasoline per day.

These savings result from the efficiency of carrying multiple passengers in each vehicle, the reduction in traffic congestion from fewer automobiles on the roads, and the varied sources of energy for public transportation.

Public transportation also saves energy by enabling land use patterns that create shorter travel distances, both for transit riders and drivers. We hope to estimate these savings in future research, but were not able to include them in this report.

Significant Household Savings

Households who use public transportation save a significant amount of money. A two-adult “public transportation household” saves an average \$6,251 every year, compared to an equivalent household with two cars and no access to public transportation service. We define “public transportation household” as a household located within ¾ mile of public transportation, with two adults and one car.

To put these household savings in perspective, we compared them to other household expenditures:

- The average U.S. household spent \$5,781 on food in 2004.
- The average U.S. homeowner with a mortgage spent \$6,848 on mortgage interest and fees in 2004, and paid off \$3,925 in mortgage principal.

Public Transportation and Petroleum Savings in the U.S.

These savings are attributable to three factors:

- *Driving less.* The average household in which at least one member uses public transportation on a given day drives 16 fewer miles per day compared to a household with similar income, residential location and vehicle ownership that do not use public transit – a savings of hundreds of dollars a year.
- *Walking more.* The 2001 National Household Transportation Survey reveals that households living near public transportation facilities tend to drive less in general, independent of their own public transportation use. That is because these areas tend to have characteristics allowing people to walk more, drive shorter distances when they do drive, and walk between destinations such as stores and workplaces.
- *Owning fewer cars.* The American Automobile Association (AAA) estimated the annual average cost of operating a vehicle in 2006 was \$5,586, including vehicle depreciation, insurance, finance fees and standard maintenance.

Expanding Public Transportation Would Double Petroleum Savings

The dramatic increase in ridership over the past decade demonstrates Americans' clear desire for more public transportation options. So what would happen if public transportation services were expanded so that ridership doubled? Total national fuel savings from public transportation would double to 2.8 billion gallons per year, or more if improved coordination between land use plans and public transportation could replace even more car travel.

About the Study

"Public Transportation and Petroleum Savings in the U.S.: Reducing Dependence on Oil" was prepared by ICF International, a leading global consulting firm that since 1969 has worked with government and commercial clients, and specializes in the connection between transportation and energy.

The study was commissioned by the American Public Transportation Association (APTA). APTA is a nonprofit international association of 1,500 member organizations including public transportation systems; planning, design, construction and finance firms; product and service providers; academic institutions; and state associations and departments of transportation. APTA members serve the public interest by providing safe, efficient and economical public transportation services and products. APTA members serve more than 90 percent of persons using public transportation in the United States and Canada.

Introduction

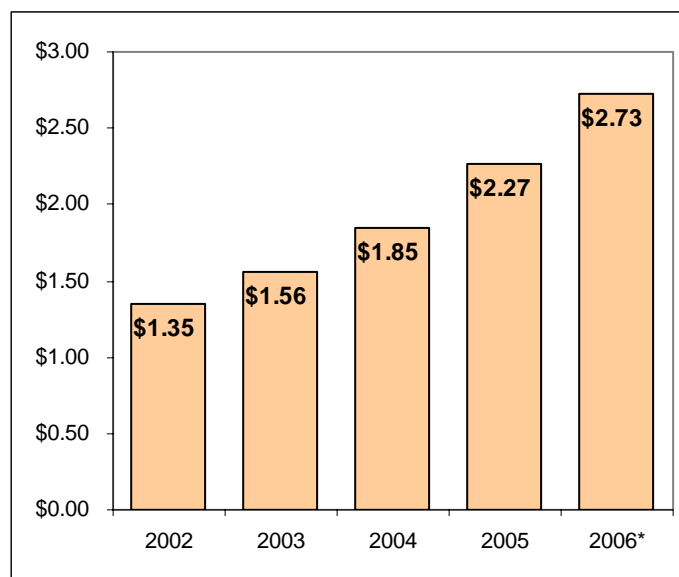
As gasoline prices reached new heights in 2006, a renewed interest in alternative ways to travel motivated APTA to commission this updated report on the impact of public transportation on the energy issues facing the country. This report quantifies the amount that households are saving on fuel costs by taking public transportation, and how their consumer choices affect total petroleum use for the country as a whole. The research team then hypothesized an increase in public transportation use and, based on that, estimated the increase in the number of households able to use public transportation for their travel needs, and how those savings would affect national petroleum use.

Petroleum consumption is a major issue for the household budget, and for our nation. Our dependence on petroleum imported from the Middle East makes fuel consumption a national security issue; our stores and manufacturers depend on diesel-powered freight movement, making it an economic issue; and individuals who have no other means to get to work must pay the market price for gasoline, making it a household budget issue. Public transportation is an important part of reducing oil dependence, and this report quantifies the role that public transportation is playing for households and the nation, and what role it could play.

The average price of gasoline in the U.S. was \$2.73 per gallon for the year through September, including taxes (EIA, September 4, 2006). The majority of Americans continue to have few choices but to pay at the pump to get where they need to go. According to the 2001 National Household Transportation Survey (NHTS 2001), only half of all households have access to public transportation. Of those residents, not all have service that can deliver them to their destinations for work, school, shopping, and socializing. Of those who can, many have seized the opportunity to save money on fuel consumption by taking public transportation.

Since 1995, public transportation ridership has gone up by 25 percent. In the first quarter of 2006, public transportation use increased by 4 percent over 2005, with light rail ridership growing in double digits (more than 11 percent). This trend was evident in regions with some of the country's largest bus systems – Los Angeles bus ridership grew by 8.8 percent, Detroit bus ridership rose by 18.7 percent, and Houston and Seattle bus riders grew by 10.8 and 10.0 percent, respectively. Households have been doing the math – the savings that households see when they use public transportation and live in the areas the systems support are significant, as discussed in this report.

Figure 1. Price for Gas, Regular Grade (National Average)



Source: U.S. Energy Information Administration

*Average retail price of regular gasoline through September 2006

Public Transportation and Petroleum Savings in the U.S.

Beyond the household level, the nation is collectively saving a significant amount of petroleum by using public transportation. Transit riders rode over 46 billion miles in 2004, reducing fuel use for private automobile travel proportionately. Public transportation generally saves energy by carrying multiple passengers in each bus or rail car. In addition, public transportation can displace travel-related energy demand from imported petroleum to other forms of energy that are generated using domestic resources, such as coal, wind, hydropower, and nuclear power.

This paper also presents a hypothetical scenario, in which public transportation service and use increase significantly. The analysis presented in this report estimates the number of households that would have new access to high-quality public transportation as an option for travel, as well as the predicted savings in U.S. petroleum consumption from an increase in public transportation use.

The remainder of this report presents the methodology and results for three analyses: first, the national impact of current public transportation use; secondly, the household impact of current public transportation use; and thirdly, the potential new impact of public transportation on household fuel expenditures and on national petroleum consumption under a hypothetical growth scenario on all modes of public transportation.

Methodology

The analysis presented here is based on a descriptive model of current public transportation use, a statistical analysis of household-level fuel use as it relates to public transportation availability, and a hypothetical model of future public transportation availability through an expanded public transportation system.

The principles of this analysis are presented in this section. In the following section on results, actual calculations are presented with more detail on each procedure.

National Analysis

To obtain national figures estimating the impact of public transportation use on petroleum consumption, we began with several key assumptions:

- When public transportation travel is hypothetically replaced by automobile* travel, passenger-miles are replaced one for one.
- Travel to work has different characteristics than other travel, and is treated separately.
- Public transportation is one mode choice among several options for those who are served by bus or rail transit.
- All current land use patterns currently extant would remain the same, even if public transportation service were changed significantly.

These are conservative assumptions. Research has shown generally that public transportation users travel fewer miles than their automobile-driving counterparts (Newman and Kenworthy, 1999, p. 87). Land use patterns, such as store and office locations, residential building patterns, residential preferences, and employment center formation have been shown to correlate closely with travel patterns and transportation facility provision. The market forces on mode choice have been researched extensively, and the different characteristics of trips for various purposes have been described in detail based on national surveys.

National data on petroleum used by public transportation is taken from the Public Transportation Fact Book for 2006 (APTA, 2006), which consolidates information collected by the National Transit Database for the Federal Transit Administration. Petroleum sources are specified for each energy source used by public transportation, and the petroleum used is converted to gasoline equivalent gallons so that it can be compared against gasoline used by most automobiles.

Passenger miles on public transportation are similarly taken from the APTA Fact Book. A “passenger mile” is defined as a mile traveled by an individual passenger, as opposed to vehicle miles or other measures of fuel consumption. The passenger mile is key

* “Automobile” is used here for all personal vehicle travel, including sedans, pick-ups, sport-utility vehicles, and other light-duty vehicles.

because it allows the calculations to account for buses, trains, and automobiles with multiple passengers.

Generally, data used represents 2004, except where noted.

In addition to fuel savings because of individual mode choice, the fuel benefits of reduced traffic congestion on roads was included in the total fuel savings from public transportation. The Texas Transportation Institute estimates congestion costs and savings annually, as well as the impact of public transportation on congestion and costs. Public transportation has a net benefit in this calculation because it removes automobiles from congested routes. This analysis uses the total fuel savings from public transportation use in 85 cities, from the 2005 Mobility Report.

Household Analysis

For the household calculations, survey data from the 2001 National Household Transportation Survey (NHTS 2001) is used. Over 69,000 households nationwide were surveyed, with sampling techniques and weighting to promote accurate representation of different regions and rural, suburban and urban areas across the country. Households were asked to report on general transportation behaviors and preferences, and to fill out a travel diary for one specific day. The days assigned to the respondents were selected to be representative of all days of the week, and times of the year.

In estimating household expenditures for gasoline, the average fuel economy of personal vehicles was taken from Highway Statistics, published by the Federal Highway Administration. While automobiles vary in their fuel economy, this is an average estimate of the fuel cost associated with driving an automobile. We also assumed that average fuel economy remained the same across different driving terrains, although individual automobile performance differs significantly between high-speed conditions, low-speed conditions, and stop-and-go conditions. This is a conservative measure since fuel economy is generally worse on city and suburban streets than on the interstate, and public transportation is generally used in cities and suburbs.

Household savings from public transportation are calculated primarily by using a multivariate regression on vehicle miles. This statistical procedure controls for other factors on vehicle miles traveled per household besides public transportation, such as income, working status of adults in the household, vehicles available in the household, and residential building patterns around each household. The regressions are conducted to control for the complex sample structure of the data, and weighted to be representative of the population.

The statistical analysis is presented in its raw form, but also in the form of real-world examples of how much fuel households use based on their mode choices and proximity to public transportation. Because household-level behavior is tracked using a 2001 survey, estimates of the extent of public transportation use in the groups described are conservative relative to current public transportation use, which has increased since 2001, very significantly in some metropolitan areas.

Growth Scenario

A final analysis was completed to estimate the effect of an expansion of public transportation service and use. Total ridership, as measured in unlinked trips, was doubled. Growth in public transportation use was assigned to two major sources: improvements to an existing route or system, and extensions and new routes. By conducting an analysis of growth on public transportation systems from 1999 to 2004, the research team found that approximately one-third of ridership growth is associated with improvements to existing routes, while two-thirds has resulted from new routes and modal extensions.

The necessary growth in route miles and modal extensions was estimated using recent improvements to public transportation systems in the U.S., using the average increase in ridership relative to the route miles built. Figures from several recent rail and high-quality bus projects were collected directly from public transportation agencies. Most major improvements and extensions to public transportation systems currently operate either light rail, commuter rail, or high-quality bus systems.

For households, an increase in the number of route miles served by high-quality public transportation service would increase the total number of households with the option to use public transportation, as well as the total number of employment sites served by public transportation networks. The number of households that would have improved or new public transportation service is estimated using some basic assumptions about the distribution of residences:

- Residential density is assumed to be the average for urbanized areas across the U.S. Current urbanized areas were defined by the 2000 Census, and generally represent cities and suburbs that have a combined population of over 50,000 people. This is a conservative estimate because public transportation alignments are generally targeted to areas that have been zoned and built up at a higher density than other areas in the city.
- The area served by new routes are assumed to overlap with areas served by parallel or nearby routes by 25 percent.

Existing public transportation availability was estimated using the NHTS 2001 data. NHTS 2001 staff provided a special data set to the research team that uses the geographic location of each respondent and a 1994 database of bus lines and rail stops to calculate the distance between each respondent and public transportation services. Relative increases in total public transportation route mileage is based on existing services from 2004.

National Scale Analysis Results

The estimated total amount of fuel saved from public transportation use currently is equal to 1.4 billion gallons of gasoline (based on 2004 figures), as discussed in the calculations below. In terms of total barrels of crude oil, this would be the equivalent of 33.5 million barrels of crude oil.*

Overall, public transportation use represents a savings in petroleum proportionate to the number of riders using each unit of public transportation. While public transportation service types differ across the country, from the subways of New York City to rural bus service around small towns in Michigan to bus rapid transit in Los Angeles, this analysis represents aggregate savings.

In order to calculate the petroleum savings from public transportation, we first calculate how much petroleum would have been used to provide the same amount of passenger travel using automobiles. This is the first source of petroleum savings: direct savings through the substitution of public transportation trips for automobile trips. The second major source of petroleum savings comes from avoiding excess fuel use in congested traffic by replacing automobiles on the roadway with public transportation trips.

The table below shows the number of passenger miles traveled on public transportation, by mode. The two main modes of public transportation are clearly bus and rail, which continue to carry the bulk of all travel on public transportation. Paratransit, service for the elderly and disabled, has been growing in recent years but remains a small percentage of total passenger miles.

* If every part of crude oil could be processed into gasoline, 1.4 billion gallons of gasoline would equal 33.5 million barrels. In practice, only about 44 percent of crude oil can be easily refined into gasoline, depending on the source of the crude oil. This means that the U.S. imports or extracts more than two barrels of crude oil for every 42 gallons (the volume of one barrel) of gasoline that is marketed. However, because gasoline consumption is a strong driver of total imports, an increase in demand for gasoline would result in higher overall levels of petroleum imports, possibly lowering prices on non-gasoline petroleum products.

Table 1. Passenger Miles by Mode 2004

Mode	Travel by Mode (Thousand Passenger Miles)
All Rail	25,822,000
Bus	21,377,000
Paratransit	962,000
Other	911,000
Total	49,072,000

Source: Federal Transit Administration, National Transit Database 2004.

These trips are then distributed onto automobile trips through a calculation that accounts for trip purpose. The purpose of a trip typically correlates significantly with its distance. For example, most people shop at a grocery store close to their home, but many people work relatively far from their home because their choice of employment is more selective and less likely to be found close to their home. Trip type distribution is shown below.

Table 2. Distribution of Person-Miles for Automobiles and Public Transportation

Trip Purpose	Automobile	Public Transportation
Work Trips, Work-related	24.7%	55.6%
Other	75.3%	44.4%
Total	100%	100%

*NHTS 2001, ICF analysis

In order to calculate public transportation's direct effect on petroleum use, rail and bus trips are distributed onto automobile trips using the above figures. In order to calculate the gasoline that would be consumed by the replacement automobile trips, we use the average fuel economy of personal automobiles in the U.S., 19.6 miles per gallon (2004), based on total mileage and gasoline consumption figures from Highway Statistics 2004. The analysis also accounts for vehicle occupancy in automobiles, since increasing the passengers in an automobile also affects the fuel efficiency of automobile travel. The table below shows how many automobile miles would be generated by replacing passenger miles on public transportation. Vehicle occupancy is based on survey responses from the NHTS 2001. Passenger-miles for public transportation are used from 2004.

Table 3. Public Transportation Travel Replacements by Trip Type

Trip Purpose	Millions of Passenger Miles (APTA 2004)	Purpose of Trip for Passenger Miles (NHTS 2001)	Automobile Occupancy by Trip Purpose** (NHTS 2001)	Replacement Automobile Vehicle Miles (millions)	Gallons of Gasoline Consumed for Replacement Vehicle Miles (000's)
To/From work	27,263*	55.6%	1.14	24,003	1,223,376
All Other	21,809*	44.4%	1.92	11,368	579,416
TOTAL	49,072	100.0%		35,371	1,802,792

*Work and non-work mileage for public transportation are calculated using total passenger miles from APTA and trip purpose distribution from NHTS 2001.

**Automobile Occupancy is calculated based on person-miles rather than trips. This is a more accurate representation of trip distribution by purpose because work trips tend to be longer than other trips.

Note: The table shows rounded figures.

In the calculation table shown above (Table 3), the “replacement” total automobile mileage is lower than the public transportation miles that are being replaced. This is because the public transportation mileage is shown relative to each individual person (“passenger miles”), whereas automobile travel is defined relative to each vehicle (“vehicle miles”). When more than one person travels in an automobile, the occupancy is higher and passenger miles are replaced by fewer vehicle miles.

In order to calculate the total net savings in fuel from public transportation, we must offset the gasoline consumption in Table 3 by fuel used by public transit vehicles. Vehicles that use electric power, including most rail service and some buses, use much less petroleum than similar trips would take using private automobiles. Only 3 percent of electricity is currently produced using petroleum products, meaning that electric vehicle public transportation reduces the national consumption rate of petroleum. However, it is important to note that electric public transportation does consume energy from other sources in addition to petroleum.

Total petroleum use by public transportation is shown in Table 4 below. The latest year for which full data are available is 2004.

Table 4. Petroleum Fuel Used by Public Transportation (gasoline equivalents), 2004

Mode	Gasoline Gallon Equivalents (000's)*
Bus	610,797
Commuter Rail	84,172
Heavy Rail	10,888
Light Rail	1,634
Trolley Bus	201
Paratransit	80,969
Ferry Boat	38,969
Other	28,472
Total	856,102

*Includes gasoline used, gasoline equivalents of diesel fuel & propane used, and petroleum used for electricity generation.

Source: American Public Transportation Factbook 2006 (data from Federal Transit Administration, National Transit Database 2004)

In total, public transportation consumed the equivalent of 856 million gallons of gasoline in 2004. With a total of 49 billion passenger miles on transit, the average passenger miles per gallon equivalent was 57. This varies to some extent between the different modes, depending on fuel use and vehicle occupancy. Rail tends to use more electricity than other modes, and therefore has the highest fuel efficiency in terms of petroleum use. Paratransit, a special public transportation service for disabled and elderly persons, has a relatively low efficiency because it has low-capacity vehicles, carries passengers on individualized trips, and serves only those trips which bus and rail cannot serve because of access limitations.

Subtracting fuel used by public transportation from the gasoline fuel that would be required to replace public transportation travel, we calculate the total savings from current public transportation use (Table 5, below). Included below is also the savings from reduced congestion because of public transportation. This figure is from the Texas Transportation Institute, which calculates an overall congestion impact rate for 85 major urban areas in the U.S., and estimates the effect of removing transit riders from automobile trips on that congestion.

Table 5. Current Petroleum Consumption Benefits from Public Transportation

	Gasoline Gallon Equivalents (000s)
Changes in Fuel Use Without Public Transportation	
Fuel Used Directly for Replacement Vehicle Miles	1,802,792
(Less Fuel Currently Used by Public Transportation)	-856,102
Secondary Fuel Use because of Congestion without Public Transportation ¹	461,000
Total Additional Fuel to Replace Public Transportation	1,407,690

¹Texas Transportation Institute, *2005 Urban Mobility Report*, accessed at: <http://mobility.tamu.edu/ums/report/>. Data from TTI is for calendar year 2003.

All figures are for 2004 unless otherwise noted. The tables for the 85 areas can be found at http://mobility.tamu.edu/ums/congestion_data/.

As shown above in Table 5, an estimated 1.4 billion additional gallons of gasoline would be needed to replace travel on public transportation with automobile trips in the U.S. For the reasons discussed in the methodology section, this is a conservative estimate. Some of the other effects of public transportation service are discussed below as they relate to land use, specifically in the mix of residential and commercial areas, and the extended effects on household travel that relate to public transportation.

Household Analysis Results: Reduced Fuel Expenditures with Public Transportation

This section will present the impact of public transportation use and availability on the household budget. First, the costs of fuel in household budgets is described, then a statistical analysis is presented to describe the effect of public transportation use and availability on total vehicle miles traveled in households. Finally, these figures are used to estimate the total impact of public transportation on household budgets.

Household Expenditures on Fuel Relative to Household Budget

As a background to the discussion of fuel expenditures relative to public transportation, the cost of fuel relative to the household budget is described below. This is based on the Consumer Expenditure Survey, conducted by the Bureau of Labor Statistics. This survey provides more detail on actual expenditures for fuel than the National Household Transportation Survey for 2001, which is used for the remaining analyses at the household level below. In 2004, households spent an average \$1,598 on transportation fuel. This amounted to 3.7 percent of total household expenditures. The average price of gasoline in 2004 was \$1.895 per gallon, or \$2.04 per gallon in 2006 dollars. An updated estimate of current household expenditures based on current fuel prices is provided in Table 6, below.

Table 6: Household Fuel Expenditures Based on Current Higher Fuel Prices

Year	Gasoline Price (incl. taxes)	Transportation Fuel Expenditures	Percent of Household Expenditures (using 2004 total)
2004*	\$2.04	\$1,718	3.7%
2006	\$2.73	\$2,161	4.6%

*Adjusted for Inflation using the Consumer Price Index.

2006 gasoline price is the national average for 2006 through August. Source: U.S. Energy Information Administration Petroleum Navigator, updated 9/5/2006.

For this calculation, we assume a short-run price elasticity of demand for gasoline to be -0.19.* This means that if the price of gasoline increases by 50 percent, the demand for gasoline will decrease by 9.5 percent. All figures for 2004 are adjusted for inflation using the Consumer Price Index.

Similarly, if 2006 gasoline prices were to rise to new heights, we would expect the total household expenditures on gasoline to increase even though total gasoline use would decrease. Those figures are shown below in Table 7.

* Daniel J. Graham and Stephen Glaister, (2004). "Road Traffic Demand Elasticity Estimates: A Review." In: Transport Reviews, Vol. 24, No. 3, 261–274, May 2004.

Table 7. Household Fuel Expenditures Based on Hypothetical Higher Prices

Year	Gasoline Price (incl. taxes)	Transportation Fuel Expenditures	Percent of Household Expenditures (using 2004 total)
2006**	\$3.50	\$2,570	5.5%
2006**	\$4.00	\$2,788	6.0%
2006**	\$4.50	\$2,969	6.4%

**Hypothetical gas prices for the 2006 calendar year.

This analysis also assumes a -0.19 price elasticity for gasoline.

Adjusting for the elasticity of gasoline consumption is key here, despite the fact that the lay understanding of gasoline consumption is that it is almost completely inelastic, or unresponsive to fuel prices. This comes from the belief that every trip a household makes by automobile is necessary and inevitable. The response of households to fuel prices has been documented in many studies, however. Households are able to reduce trips to some extent, for example by replacing multiple trips to the grocery store each week with one trip, by carpooling with friends to school or class, and by taking public transportation. These are short-term responses. In the longer term, people may move closer to work, move to a place with public transportation access, or buy a new vehicle with better gas mileage.

However, public transportation, which would be an efficient short-term way for a household to save on fuel expenditures, is often unavailable for the trips that a household makes every day because of the limited network and service levels in the U.S. The analysis below examines the effects of public transportation availability and use on household driving patterns, and thus on fuel expenditures.

Household Savings on Fuel from Public Transportation

The following statistical analysis investigates the interaction between public transportation and household vehicle miles traveled. The NHTS 2001 is used here because it contains detailed information about public transportation use, driving behavior, the neighborhood around each household, and other demographics such as workforce participation and income that correlate with vehicle miles traveled. The variables in the model are listed below, in Table 8.

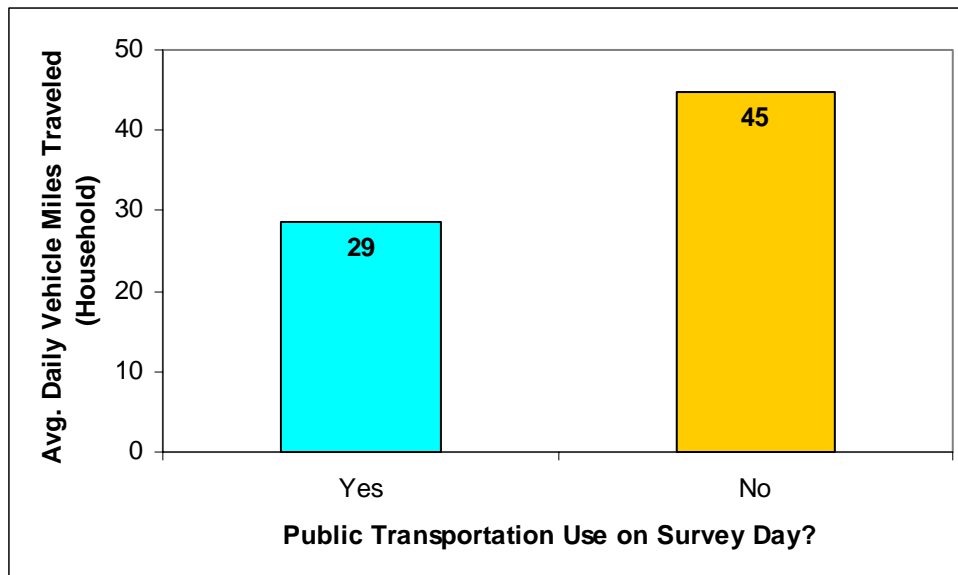
Table 8. Variables Used in Household Model

	Mean	Minimum	Maximum
Dependent Variable:			
Daily Household Vehicle Miles Traveled	43.2	0	1600
Independent Variables:			
Count of Workers in Household	1.3	0	10
Ratio of Adults to Vehicles	1.0	0	6
Residential Density (000s per square mile)	2.7	0	100
Household Income [Ordinal Categories]	9.3	1	18
Zero Vehicle Households [Binary]	0.1	0	1
Bus or Rail Available within $\frac{3}{4}$ mile [Binary]	0.5	0	1
Used Public Transportation on Travel Day [Binary]	0.06	0	1
Travel Day was a Weekday [Binary]	0.7	0	1

The analyses presented here are linear regressions to predict vehicle miles traveled for the entire household. The regression accounts for the complex sample design of the NHTS and allows for isolation of the correlation between public transportation availability and use and total vehicle miles traveled in the household. This is important because for many households, public transportation is only part of the household travel pattern. Some households have two workers, and one uses a personal vehicle for the work commute, while the other uses public transportation. Or a single worker may own a automobile but use it for only some trips. “Zero vehicle household” is entered separately from the number of vehicles per adult, since there is a threshold relationship between owning at least one vehicle in terms of driving behavior.

Controlling for other factors, the use of public transportation on a given day in a household corresponds to fewer vehicle miles traveled in a household overall on that day. As shown in Figure 2, below, this reduction in driving corresponds to an average 16 mile reduction in travel on the survey day.

Figure 2. Average Daily Vehicle Miles Traveled per Household, by Public Transportation Use



Source: NHTS 2001, ICF International analysis.

The regression results behind Figure 2 are shown below, in Table 9. For this first model, only public transportation use is included, regardless of public transportation availability.

Table 9. Regression Results – Model of Public Transportation Use
Response Variable: Household Vehicle Miles Traveled

	Estimated Coefficient	Std. Error	t value	PR > t
Constant	3.06	1.13	2.7	0.0069
Household Income	1.34	0.07	18.5	<.0001
Zero Vehicle Household	-9.80	1.17	-8.35	<.0001
Any Public Transit Use on Travel Day	-16.07	1.36	-11.86	<.0001
Count of Workers in Household	14.49	0.45	32.37	<.0001
Vehicles per Adult in Household	5.91	0.71	8.33	<.0001
Residential Density (000s per square mile)	-0.68	0.04	-17.56	<.0001
Travel Diary was on a Weekday	9.54	0.74	12.87	<.0001
R ² = 0.1867				

As shown above, public transportation use on the travel day is correlated with a significant reduction in total vehicle miles traveled in the household. Not owning a vehicle and living in an area with higher housing density also correlate with lower household vehicle miles traveled.

This first model only evaluated the effect of using public transportation on the household travel pattern. Another important issue is the way that public transportation availability interacts with how neighborhoods are built, and from that, how people travel. Often, public transportation infrastructure coincides with a building pattern that encourages walking with sidewalks and crosswalks, has a mix of retail near residential areas, and places destinations closer together than in other neighborhoods. Public transportation is

an important part of this type of built environment because it allows for these uses to coincide without creating prohibitive congestion levels.

The second regression shows the correlation between public transportation availability for each household and the average miles driven, controlling for public transportation use. This analysis also controls for density and other factors that are associated with total vehicle miles traveled. The independent variables and their effects are listed in the table below.

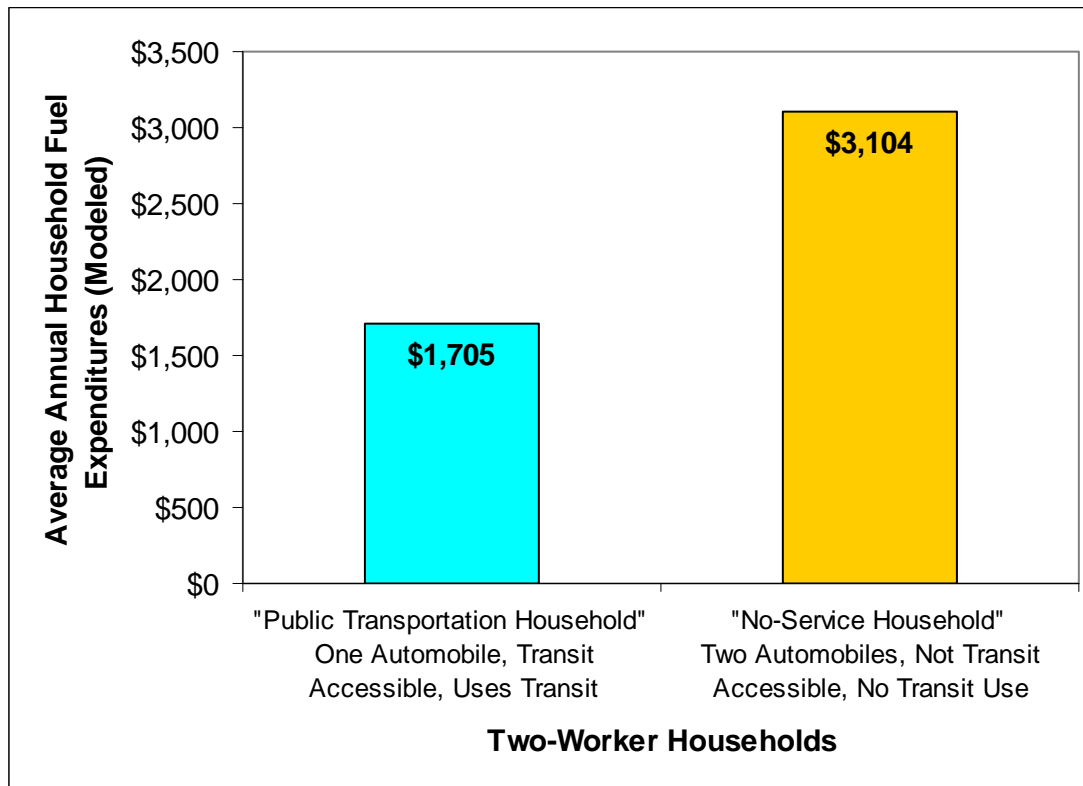
Table 10. Regression Results – Model Including Public Transportation Within ¾ Mile
Response Variable: Household Vehicle Miles Traveled

	Estimated Coefficient	Std. Error	t value	PR > t
Constant	9.44	1.19	7.92	<.0001
Household Income	1.38	0.07	19.14	<.0001
Zero Vehicle Household	-10.52	1.16	-9.04	<.0001
Any Public Transportation Use on Travel Day	-13.92	1.35	-10.33	<.0001
Public Transportation Available within ¾ Mile	-11.30	0.69	-16.28	<.0001
Count of Workers in Household	14.37	0.45	32.28	<.0001
Vehicles per Adult in Household	4.57	0.69	6.59	<.0001
Residential Density (000s per square mile)	-0.45	0.04	-12.63	<.0001
Travel Diary was on a Weekday	9.36	0.74	12.67	<.0001
R ² = 0.1975				

All variables in this model are statistically significant at the $p < .01$ level. The other variables listed allow this model to isolate the effect of public transportation availability, which corresponds to 11.3 fewer miles traveled on a given day, aside from related factors such as actual public transportation use on a given day, housing density, and the number of vehicles available in the household. The distance of three-quarters of a mile, approximately a 15-minute walk, is considered the maximum distance that an average person will travel on foot to get to a bus line or a rail transit station. The areas around these stations and bus service lines appear to generally have shorter distances between destinations and may also have better infrastructure for walking, reducing total miles driven.

To put the results above in a more concrete context, we used two household profiles, modeling their travel patterns and annualized fuel expenditures. The first household is a “public transportation household.” This household has two workers, is located within three-quarters of a mile of public transportation, has one automobile, and uses public transportation on a given day. The second household is the “no-service household.” This household lives more than three-quarters of a mile from public transportation, has two workers, two automobiles, and did not use public transportation on a given day. The difference between the two households is illustrated in Figure 3 below.

Figure 3. Average Annual Rate of Fuel Expenditures per Household, Two Profiles



Source: NHTS 2001, ICF International analysis. Assumes average fuel economy of 19.6 miles per gallon and gasoline priced \$2.73 per gallon.

The total fuel savings of the “public transportation household” relative to its “no-service” counterpart average \$1,399 on an annual basis. The savings are a compounding of the effects of both public transportation availability and use, as well as the reduction in household vehicles. These are based on the model above, which controls for the influence of other important factors such as household income.

Net Household Savings from Public Transportation Use

Average household savings based on reduced vehicle miles traveled are one part of the picture. Public transportation also charges a fare, which does increase overall cost. Conversely, reducing the need to own a car significantly reduces household expenditures on vehicles. This is discussed in more detail below. A 2003 study conducted by the Bureau of Transportation Statistics found that those who use public transportation save approximately 40 percent of the expenditures made by those who commuted by automobile, just for the commute (BTS Issue Brief 1, 2003, “Commuting Expenses: Disparity for the Working Poor”). The results found here are similar in magnitude.

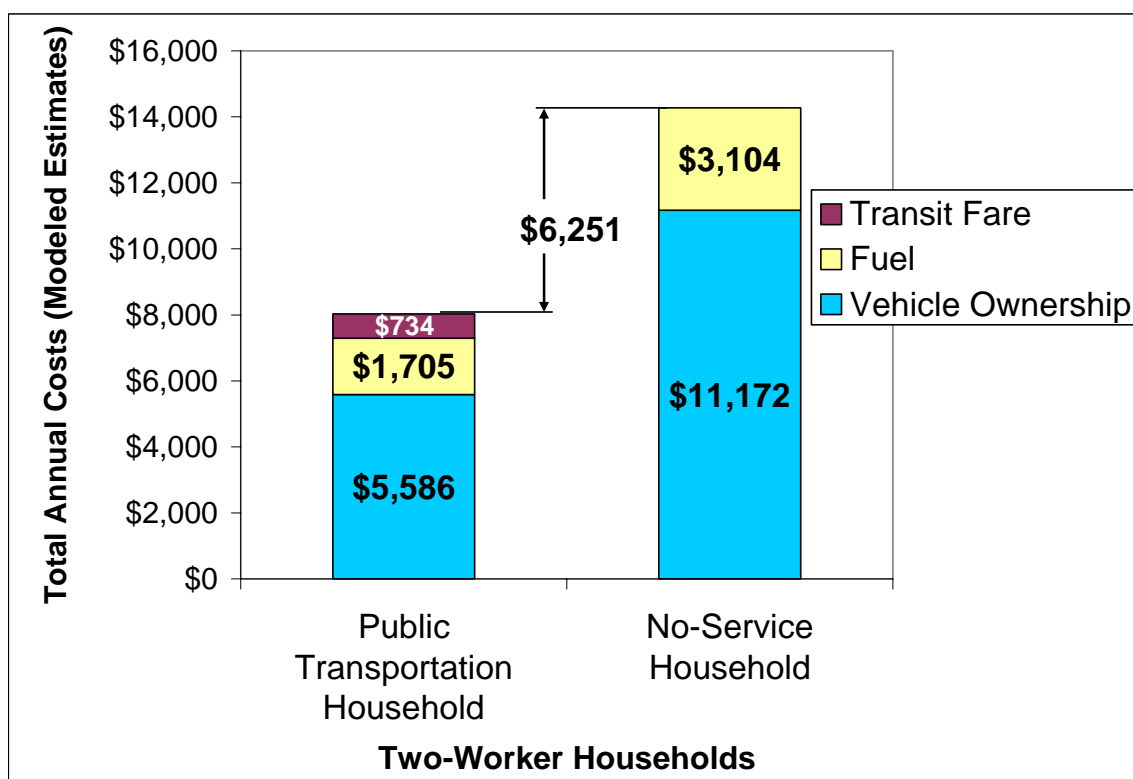
Transit fares average \$1.02 per unlinked trip, according to 2004 figures from the National Transit Database. Estimating a total of 240 work days per year, and a transfer rate of 1.5 segments per trip, the total transit fare for travel to and from work would cost \$734 per year. On average, public transportation users take one roundtrip each day they take the bus or train. For public transportation users on non-work trips, this is a

conservative estimate since they are unlikely to travel as many days a year as a commuter.

Using the results of the two household profiles described above, the “public transportation household” would save \$1,399 per year over its automobile-oriented counterpart, before transit fares. Taking the total estimated cost of using public transportation regularly for a commute, we estimate the total net savings on daily expenditures for fuel, less transit fares, to be \$665 per year.

We have not yet taken the cost of automobile ownership into account. While cost can vary, the AAA estimated the annual average cost of operating a vehicle in 2006 at \$5,586, including vehicle depreciation, insurance, finance fees, and standard maintenance. The “public transportation household” profiled above would save these costs in addition to fuel used since it has one fewer vehicle than its “no-service” household. The total annual savings, counting cost of vehicle ownership, would be \$6,251, as shown below in Figure 4.

Figure 4. Total Modeled Savings for Two-Worker Households With and Without Public Transportation Service

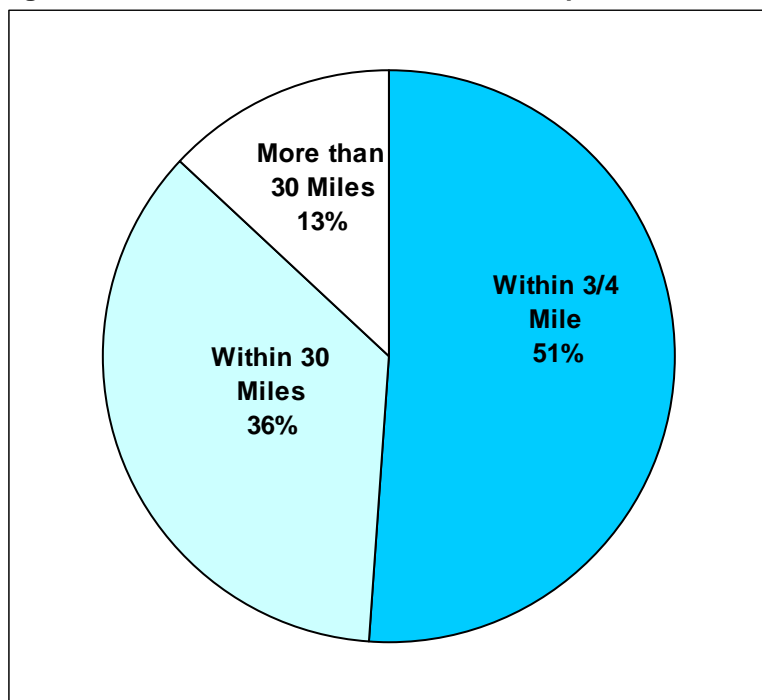


Data based on AAA estimates of average annual vehicle ownership costs for 2006, ICF analysis of NHTS 2001 data on driving behavior, and average annual transit fares from APTA for 2004.

Future Scenario: Public Transportation Growth and Fuel Savings

This section explores the effects of a dramatic expansion of public transportation service and usage across the U.S. Public transportation currently provides a significant opportunity for households in the U.S. to reduce their petroleum consumption, and for the nation to reduce its dependence on petroleum as a fuel source. However, that opportunity is limited by the lack of public transportation services in many areas of cities, suburbs, and rural regions. The figure below shows the current distribution of households in terms of proximity to public transportation (defined as within three-quarters of a mile), within the larger area (defined as within 30 miles), and far from any public transportation (beyond 30 miles).

Figure 5. 2001 Households with Public Transportation Availability in the U.S.



Source: NHTS 2001, ICF Analysis.

The NHTS 2001 showed that approximately 51 percent of households have access to public transportation within $\frac{3}{4}$ mile of their home. The research team constructed a hypothetical extension and improvement of public transportation services that would double public transportation use in an undefined time frame from 2004 levels. We then examined the effect of this expansion on total service level and on residential access to public transportation, focusing on the effects at the household level.

Fuel savings from this expansion are hypothesized to parallel the fuel savings currently, as presented above. Total national fuel savings depend on how new services are provided – whether through diesel, electricity, or other fuel sources. Efficiency per railcar mile or vehicle mile would also depend on how consistently service provision matches up with consumer demand. This is discussed in more detail below.

Doubling Public Transportation Usage: A Profile of Expanded Services

The research team hypothesized an expansion of public transportation ridership to double its 2004 levels. This growth in ridership would fall into two categories: the first would be an increase in frequency or capacity of service, and the second would be an expansion of high-quality public transportation routes. The relative distribution of the two types of growth is 1/3 on improvements to existing routes, and 2/3 on new high-quality public transportation service. This distribution was based on an assessment of the ridership growth patterns from 1999 through 2004, from the National Transit Database. Ridership growth from expanded service on an existing line was found to account for a third of total growth, and new route miles accounted for another two-thirds.

The ratio of ridership to new public transportation routes is based directly on the ridership experience of recent extensions, both on high-quality bus routes and rail-based public transportation. The extensions used are from a range of cities, including Los Angeles, Kansas City, Portland, Minneapolis, Dallas, Denver, and Salt Lake City. Some were completed as late as 2005, while others have been operational since the 1990s. The ridership figures for each extension were taken for the year after operations began. This is a conservative ridership measure, since ridership typically grows over time as services mature, and as stores, offices and homes are built near stations. Table 11, below, lists the extensions researched for the analysis.

Table 11. New Public Transportation Services Used to Model System Expansion

Mode	Line	Year Opened	Miles of Track Added
Bus	LA Orange Line	2005	14.0
	Kansas City MAX	2005	9.5
Rail	Portland MAX-Red Line	2001	5.5
	Portland MAX-Yellow Line	2004	5.8
	Minneapolis Hiawatha	2004	12.0
	Dallas 1997 Opening	1997	20.0
	Dallas 2002 Expansion	2002	19.5
	Denver-Central Corridor	1994	5.3
	Denver-Southwest Corridor	2000	8.7
	Salt Lake City (north/south line)	1999	15.0
	LA Blue Line	1990	22.0
	LA Green Line	1995	20.0
LA Gold Line	2003	13.7	

Each of the extensions is described in more detail in Appendix A.

We calculate that for this sample, for each directional mile of new route created, there are an average of 274,475 unlinked trips per year. We assume that new routes hypothesized under this scenario achieve the same ridership on average, which is a conservative measure; the better a route is laid out and coordinated with local land use, the higher the ridership. The public transportation planners of the future are thus expected to do no better and no worse than their recent counterparts. The average of

existing rail systems in 2004 is actually higher (315,991 unlinked trips per directional route mile, unweighted), but since this includes some very well-established rail systems, using a new system average was considered a better prediction of future extensions.

Because there were few high-quality bus line extensions in our sample, we amalgamated all the extensions listed above to create an average number of unlinked trips relative to the size of the extension. This may overstate the potential ridership of these new bus systems, depending on the level of quality in the new bus systems. Of the two high-quality bus extensions in our sample, one was in the same range as the rail extensions (Los Angeles Orange Line), while the other, in Kansas City, fell at the low end of the range.

Next, we made the following calculations to distribute the ridership growth onto improvements to existing routes and new routes.

Calculations

In this hypothetical public transportation expansion plan, the goal is to double ridership across the country. Ridership is defined as unlinked trips per year. In 2004, there were approximately 9.6 billion unlinked trips per year. One-third of the growth in ridership would occur on existing routes; this is discussed in more detail below. First, we begin with the two-thirds of new ridership (6.4 billion unlinked trips) that would be taken on new routes.

New routes would serve both additional residences and additional offices, stores, and other destinations. For this analysis, however, we focus on how new services affect residences. Based on the experiences of the sampled new routes, we find an average of 274,475 unlinked trips per new directional route mile. We assume that 20 percent of the trips taken on the new route would actually be former public transportation users who are moving from another route or service to the new one. This deficit in users of existing routes is accounted for below, in the growth in ridership on existing routes.

Dividing the number of new unlinked trips per year (6.4 billion) by the average new unlinked trips per directional route mile (274,475), we find that the expansion would require 23,401 new directional route miles. We assume that directional route miles (e.g., one going north, another going south) are generally paired. The total number of route miles would then be half the directional route miles, or 11,700 total route miles. The area served by these new routes is calculated by multiplying the linear miles of route length by a 1.5-mile buffer, meaning that the buffer extends three-quarters of a mile around each stop. Assuming that no stops would be more than 1.5 miles apart, this covers the entire area around each station. The total area served would then be 17,550 square miles.

Assuming that existing areas would overlap with the new route areas to some extent – for example, when a rail line runs parallel to another for a portion of its route, or parallel to a bus line – the *new* area served is calculated as a portion of the total service area of the new route. We assume that there would be a 25 percent overlap rate. This reduces the total new area served by the new routes by 25 percent, to 13,163 square miles.

The average residential density of the 452 urbanized areas in the U.S., as defined by the 2000 Census, was 1,073 dwelling units per square mile in 2000. This equates to

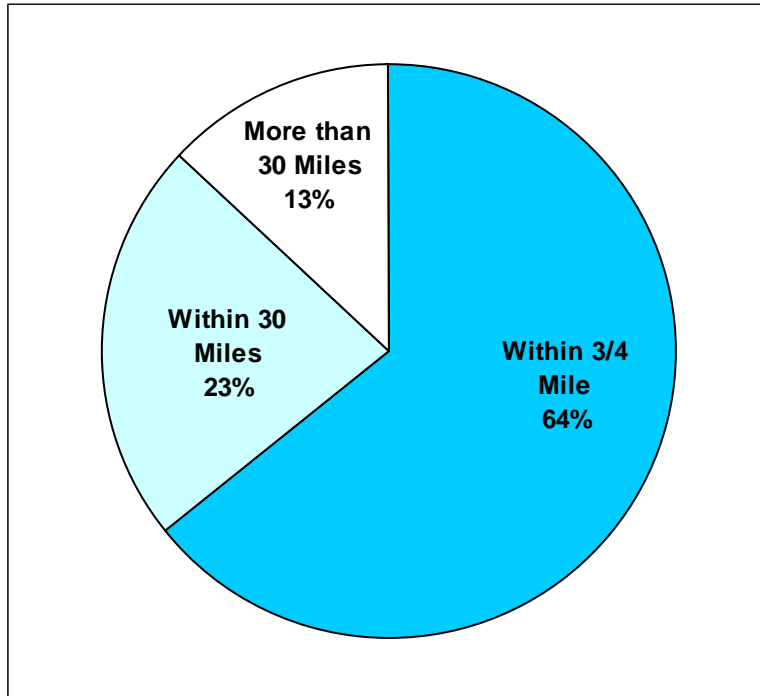
approximately 2.4 dwelling units per buildable acre (30 percent of land is set aside for roads and other public space), or housing lots of approximately 18,200 square feet each. This is a fairly low density for an area served by public transportation, and so gives a conservative estimate of the number of households served. Multiplying this density by the new area that would be served by the new routes, we find that an additional 14.1 million households would have public transportation service within $\frac{3}{4}$ mile of their home with these extensions.

Table 12. Calculated Values for Households with New Public Transportation Service

Description	Value
Average new unlinked trips per directional route mile	274,475
Ridership growth on new routes	6,422,890,680 unlinked trips
Directional route miles of new routes (directions are generally assumed to be paired)	23,401 miles
Route miles (bidirectional)	11,700 miles
Area served by new routes ($\frac{3}{4}$ mile buffer)	17,550 square miles
Rate of overlap between existing service areas and new route service areas	25 percent
New route service area previously outside a $\frac{3}{4}$ mile buffer	13,163 square miles
Residential density	1,073 dwelling units/square mile
Households with new routes within $\frac{3}{4}$ mile	14,123,742 households

The additional households served are assumed to come mainly from areas that are somewhat close to public transportation currently (i.e., within 30 miles). By adding these services, we would see a new distribution of households close to public transportation, as shown in the graph below.

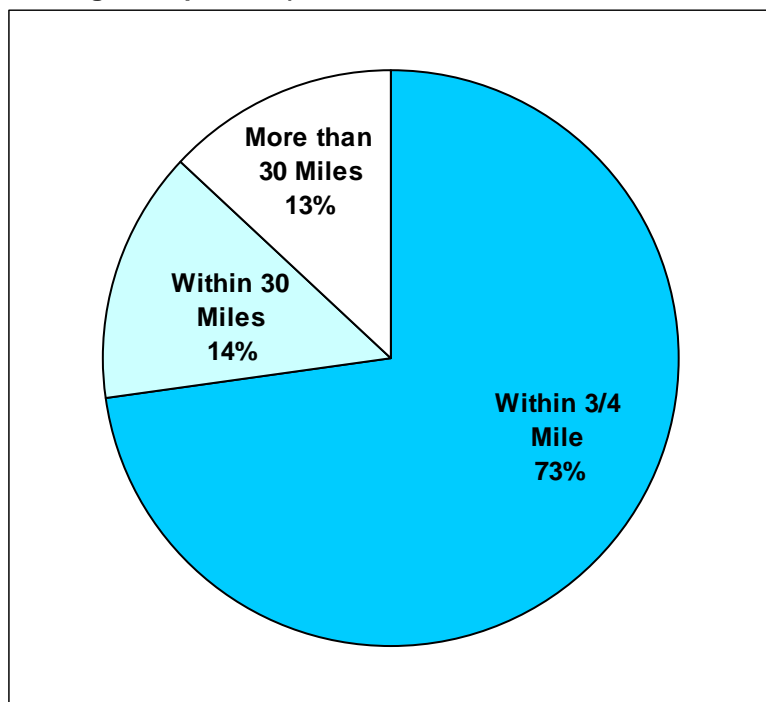
Figure 6. New Total Household Service Levels Under Public Transportation Growth Scenario



Our assumption about housing density near public transportation services was quite conservative here. The standard of practice in public transportation planning, and Federal Transit Administration requirements, dictate that land use plans in the areas served by public transportation be molded to provide more housing units near stations, and more development in general around those stations. The standards of “transit-oriented development” are not set in stone, but building housing in a more efficient way near public transportation stations could dramatically change the number of households with access to public transportation under this scenario.

Below, we show the new household distribution based on an assumption that housing near public transportation stations is built at 65 percent higher density, or one house on each quarter acre. With this assumption of density, an additional 23 million households would have public transportation available to them within three-quarters of a mile, or a total of 73 percent of households.

Figure 7. Household Service Levels with Moderate Density Housing Near Stations (four dwelling units per acre)



This graph shows that coordinating land use planning with this large and coordinated expansion of public transportation services would dramatically increase the number of households with public transportation service options. In addition to the availability of public transportation to households as a place of origin, the expansion described here would also expand the number of destinations that could be reached by public transportation, which would in turn increase the likelihood that households currently within the three-quarter mile buffer could replace automobile trips with public transportation regularly or when gas prices are at higher levels.

Expanding Service on Existing Public Transportation Routes

In order to double total ridership, the model hypothesizes an increase of 33 percent in service and ridership on existing routes, and a growth of 67 percent in ridership on new routes. Additionally, some portion of the new services hypothesized here would take riders from parallel existing routes on a different mode or a route that may now be further away from a residence than the new route. To reiterate, the 33 percent growth on existing routes was found to be the case generally in public transportation system growth from 1999 to 2004, relative to growth associated with new services.

Ridership on existing routes occurs regularly as a function of population growth, increased economic activity along routes, and homebuilding activities. Generally, service must increase at roughly the same rate, in terms of frequency or number of railcars, as ridership growth. Controlling for the rate of displaced riders from the new route in this scenario, we hypothesize an actual growth rate, in new riders on existing routes, of 4.4 billion annual unlinked trips. Distributing these riders evenly onto existing rail services and existing bus services, this would represent an increase of 72 percent per directional

route mile of existing rail services and 60 percent per directional route mile of existing bus services.

Improved service on existing lines would be necessary to generate this increase in ridership. We have not calculated here exactly how improved services would be provided, whether on new buses and railcars, improved technology, or staff time. All of these should be considered, however – including both capital and operational improvements. Public transportation agencies can also increase ridership by partnering with local governments to increase the number of residences and businesses served close to public transportation facilities to allow higher density building near stations and bus lines.

Table 13. Calculated Values for Improved Services on Existing Public Transportation Routes

Description	Value
Actual ridership increase (1/3 of total growth under scenario)	3,163,513,320 unlinked trips
Ridership loss from migration of passengers to new service	1,284,578,136 unlinked trips
Total ridership increase from improved service (1/3 of total increase and replacing ridership loss)	4,448,091,456 unlinked trips
Ridership increase on rail routes	72 percent
Ridership increase on bus routes	60 percent

New Routes in Growth Scenario: Bus and Rail Split

If new services were exactly as efficient in terms of consumer services as existing public transportation service, increasing total ridership by 67 percent through new routes would require both rail and bus service grow by 67 percent as well. However, we have postulated here that the new services would be high-quality public transportation, either rail or bus, that would have a higher average ridership per route mile than existing services. This is especially true for the high-quality bus services postulated here.

Assigning new services to bus and rail services would rest on policy decisions about the costs and benefits of each mode. We offer here one scenario under which new routes could be provided, without estimating the fiscal implications at this time.

Total growth under this scenario is 11,700 route miles (bi-directional). We assign 65 percent of those route miles to high-quality bus systems, or 7,605 miles. Rail systems would represent a total of 35 percent of the new route growth, or 4,095 miles.

Table 14. Route Mile Growth by Mode

Description	Value
Total route mile growth	11,700 miles
Rail route mile growth	4,095 miles
Bus route mile growth	7,605 miles

As a comparison, the rail route mile increase described here represents an 84 percent increase over current systems. The bus route mile increase represents a 7 percent increase over current bus route miles, although this is a deceptive comparison since most bus routes do not have high-quality service currently.

There are currently approximately 3,858 route miles of rail service in some stage of engineering, construction, planning, or proposal. The total number of route miles of high-quality bus service proposed is unknown.

Fuel Savings from New Growth Scenario

The new growth scenario is estimated here to roughly double the total national fuel savings from public transportation, to 2.8 billion gallons per year. However, as has been shown above, improved coordination between land use plans and public transportation services could improve the ratio between services provided (and the fuel they use) and the amount of personal automobile travel replaced.

An important note is that in terms of fiscal management, operations costs relative to frequency of service for public transportation agencies will generally rise relative to fuel prices. Therefore, if public transportation provides some measure of fiscal relief for households during times of high fuel prices, operations costs must account for the increased need at a time when their existing services also cost more for each unit of service provided to customers.

Households may also save fuel costs because of land use plans that accommodate public transportation service. As shown in the regressions in the previous section above on household savings, many households living within $\frac{3}{4}$ mile of public transportation services spend less on fuel independent of their own use of public transportation. These fuel savings may overshadow direct savings on replaced mileage on public transportation in reality, since only a portion of the households living within the three-quarter mile buffer around public transportation services use them. The building patterns that likely enable lower household mileage include proximity of stores and services to one another, increased walking access to commercial services and even office districts from homes, and shorter distances between destinations because of the increased footprint of each structure in areas with high parking space requirements for commercial buildings.

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Appendix A: Overview of New Service Data Sources

Public Transportation and Petroleum Savings in the U.S.

Kansas City MAX High Quality Bus

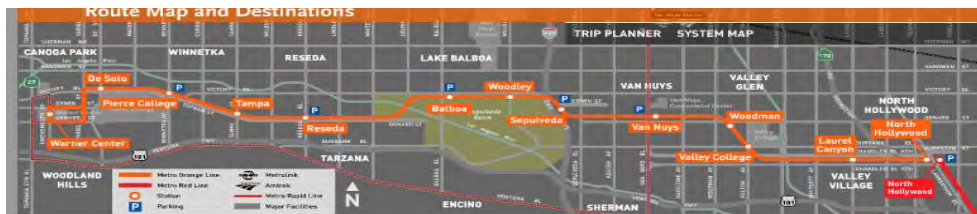
Transit Agency: Kansas City Area Transportation Authority
Line: MAX
Opening Date: July 24, 2005
Length: 9.5 miles
Funding: \$21 million

The Kansas City MAX is the first high quality bus service in the greater Kansas City area. The line runs from River Market, through downtown, and ends at the Plaza. Ridership in unlinked trips from July 2005 through July 2006, the first twelve months of operation, was collected from the Kansas City Area Transportation Authority. The new line eliminated the #56-Country Club route on the same corridor. Previously, the annual ridership on this corridor was 1,075,143, while annual ridership on the new high quality bus was 1,435,013—a 33.5% increase.

Los Angeles High Quality Bus

Transit Agency: Los Angeles Metropolitan Transit Agency
Line: Orange
Opening Date: October 29, 2005
Length: 14 miles
Funding: n/a

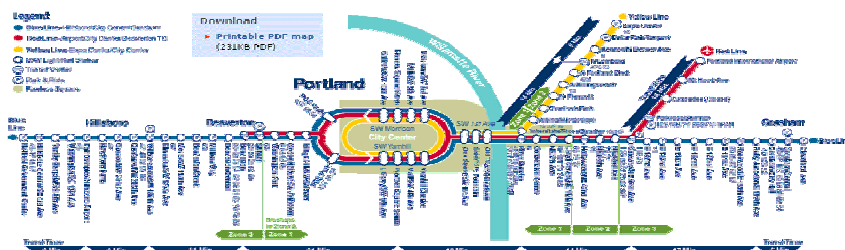
The Orange line is the first high quality bus line in the greater Los Angeles metro area. It connects the communities of North Hollywood, Valley Village, Valley Glen, Van Nuys, Tarzana, Winnetka and Woodland Hills in the San Fernando Valley to downtown Los Angeles. Annual passenger trips were calculated from the first eight months of operation, November 2005 through June 2006. This number was multiplied by one-and-a-half to get a prediction of passenger trips in the first full year of service.



Portland, Oregon MAX Light Rail- EXTENSIONS

Transit Agency: Tri-County Metropolitan Transit District of Oregon- TriMet
 Lines: Red (Airport) & Yellow Lines
 Opening Dates: September 10, 2001, May 1, 2004
 Length: 5.5 miles & 5.8 miles
 Funding: \$125.8 million and \$350 million

TriMet opened its first light rail line, the MAX Blue Line, in 1986. Following an extension of the Blue line in 1998, the Red line to the Portland International Airport opened in September 2001. The most recent addition to the MAX light rail was the Yellow line, which was completed in May of 2004. The data set from TriMet includes annual ridership in unlinked trips by line for the first twelve full months of operation.



Map provided courtesy of TriMet, Portland, Oregon

Minneapolis Light Rail- NEW

Transit Agency: Metro Transit
 Line: Hiawatha Line
 Partial service: June 26, 2004
 Full service: December 4, 2004
 Length: 12 miles
 Funding: \$715.3 million

Minneapolis opened its first Light Rail service in 2004 with a line that connects three of the Twin Cities' most popular destinations—downtown Minneapolis, the Minneapolis/St. Paul International Airport and the Mall of America in Bloomington. Unlinked trips data was collected from the first twelve full months of operation, January 2005 through December 2005.



Dallas DART Light Rail- NEW & EXTENSION

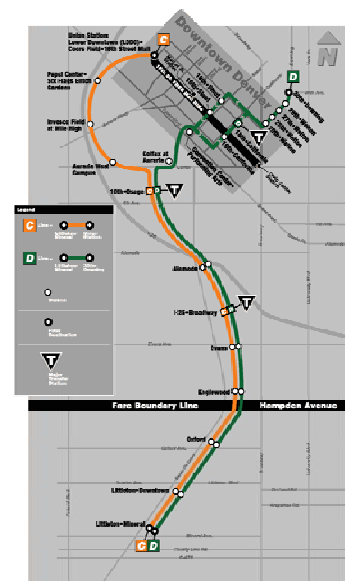
Transit Agency: Dallas Areas Rapid Transit
 Lines: Red/Blue Line opening & extensions
 Opening Dates: July 1997 & December 2002
 Length: 20 miles & 19.5 miles
 Funding: n/a



The first phase of the Dallas DART Light Rail was completed in 1997. These twenty miles of track are broken down into two lines, the Red and the Blue, through downtown Dallas. In 2002, an expansion project was completed to expand both lines into the Dallas suburbs. The data provided by the agency contains unlinked trips numbers from each new station for the first twelve months of operation.

Denver Light Rail- NEW & EXTENSION

Transit Agency: Regional Transportation District Denver
 Lines: Central & Southwest Corridors
 Opening Dates: October 7, 1994 & July 14, 2000
 Length: 5.3 miles & 8.7 miles
 Funding: \$100 million & \$177.4 million



The Denver light rail opened in 1994 with a line originating in the City of Denver, running through the Five Points Business District and the heart of downtown, and terminating south of downtown. The Southwest Corridor, which opened 6 years later, connects at the southern end of the Central corridor and extends into the Southwestern suburbs of Denver. Annual ridership numbers were collected from the transit agency for the whole system. Ridership during the first full calendar year of operation, 1995, was 4,054,403 unlinked trips. Since unlinked trips by station were not available, the difference in ridership between 1999 and 2001 was used to represent an increase in ridership after the opening of the Southwest corridor. These numbers do not take natural growth on the existing line into account. There was a 91.3% total increase in ridership between 1999 and 2001.

Los Angeles Light Rail- NEW & EXTENSIONS

Transit Agency:	Los Angeles Metropolitan Transit Agency
Lines:	Blue, Green, & Gold Lines
Opening Dates:	July 14, 1990, August 12, 1995, & July 26, 2003
Length:	22 miles, 20 miles, 13.7 miles
Funding:	\$877 million, \$718 million, and \$859 million

In 1990, Los Angeles opened its first light rail line since the closing of the Yellow line in the 1960s. The Blue line runs north/south through downtown Los Angeles. Green line opened in 1995 and runs east/west across the Blue line and out to the Los Angeles International Airport and the South Bay area. The most recent addition to the Los Angeles light rail was the Gold Line in 2003, which offers service from the Pasadena area into downtown. Annual passenger trips were collected from the first full year of operation on each line.



Salt Lake City TRAX Light Rail -NEW

Transit Agency:	Utah Transit Authority
Lines:	North/South Line
Opening Date:	December 4, 1999
Length:	15 miles
Funding:	n/a

Salt Lake City's first light rail line opened in late 1999. The North/South Line runs from downtown Salt Lake City, through South Salt Lake, Murray, and Midvale en route to Sandy. The University Line extension opened in 2001 with stops at the University of Utah and the University Medical Center. Unfortunately, data availability has been limited. Annual unlinked trips were collected for the calendar year 2000 from the National Transit Database (NTD) on the first line opened. For the University Line addition, data released to the media after its opening are used for ridership.

