

Fare-Free Mass Transit: A Case Study of What Is Now, and What Can Be In Any Large Metropolitan Region of the USA

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If a frog is placed in a pot of water that is slowly brought to a boil in such a way that the imperceptible heat change is not noticed by the frog, then it will not jump out of the pot. If a frog is dropped into a pot of boiling water, it will immediately jump out. In which state are we traffic-choked, urbanite frogs?

Abstract.

Urban transportation problems overwhelm every urban region on Earth. A list of the many existing problems associated with each of the current urban transportation systems includes:

- enormous waste and a staggering exhaustion of the rapidly diminishing non-renewable petroleum resources on Earth;
- unhealthful air quality, resulting in death and impaired health for tens of thousands;
- pervasive and constantly increasing daily gridlock traffic conditions extending well beyond rush hour time frames of 15 or more hours, resulting in millions of wasted hours daily by millions of passengers;
- high accident occurrences, resulting in death and injury and extensive, expensive property damage and medical costs for thousands;
- staggeringly expensive vehicle insurance, maintenance, operational and acquisition costs for the millions of licensed drivers who own millions of vehicles;
- enormous road/street maintenance costs;
- ubiquitous parking space/parking lot congestion and expense for millions;
- unhealthful high and constant noise pollution, especially damaging to those in the vicinity of freeways and main roads.

In particular, most of the petroleum consumption on Earth comes from these wasteful urban transportation systems. A concrete example of a region having the worst record on Earth relating to these problems is provided by the six county Southern California Region (SCR: Los Angeles, Orange, Ventura, San Bernardino, Riverside and Imperial counties, consisting of 188 cities, with a population of over 16.84 million [7/1/2001]). In this paper, we identify and analyze all of these problems and describe a solution for SCR, for the entire set of California urban regions, and, indeed, for the entire set of urban regions in the USA.

The core of the solution involves the creation of a *fare-free mass public transit system*. We show how such a system provides an optimum model for any large urban region.

In the urban regions of the USA, there is next to zero public transit: only 2% of the millions and millions of daily trips are made by public transit. Bus service is jammed and continues to deteriorate. For example, the bus fleet of the largest segment of SCR, the Metropolitan Transit Authority (MTA) of Los Angeles, has declined from a mere 2,600 in 1984 to a pitiful 1,800 in 1998! The rider ship on the few miles of the exorbitant \$300 million per mile subway is minuscule.

Almost all of the annual urban vehicle-miles and passenger-miles traveled (95.1%) in SCR occurs on the collection of interstate, other freeways and expressways, other principle arterials, minor arterial and collector roads (i.e., all roads except local; see Table 2 for a functional description of these types of roads) that comprises only 34.8% of the total urban road mileage in SCR; for California, the figures are 91.03% and 34.13%, respectively; and for the USA, the figures are 85.71% and 30.08%, respectively. Furthermore, in the USA, 95% of all urban vehicle-miles traveled emanates from personal vehicles (=all vehicles except commercial trucks).

The analysis to follow will show that this set of numbers is of utmost importance because it enables the creation of a fare-free all-bus system whose use will yield the required urban passenger miles at a very substantially lower cost and will solve all the problems listed at the outset (see Tables 3, 4, and 5).

The establishment of a mass transit, *fare-free*, system for urban regions can be financed easily by a method that literally involves *no cost to 99% of the citizens*. The proposed method for financing a *fare-free* mass transit system for SCR and, indeed, for all large urban regions in California and the USA, is simple and effective. The source of income is to come from a minuscule annual tax on the net wealth of the *wealthiest one percent of the appropriate adult population*. In California, the wealthiest one percent of the California adult population has over \$2.5 trillion in net wealth. An annual tax of only 0.42% on this amount would yield over \$10.5 billion annually; this is more than enough to finance a *fare-free* all-bus system that would yield the annual California passenger miles traveled for all urban regions in the state! (See Table 4). For the entire USA, the wealthiest one percent has over \$25 trillion in net wealth! An annual tax of only 0.28% on this amount would yield \$71 billion annually; this is more than enough to finance a *fare-free* all-bus system that would yield the annual USA passenger miles traveled for all urban regions in the USA! (See Table 5). Such minuscule assessments would pose little, if any, hindrance at undermining the staggering magnitude of this wealth. Even though a *fare-free* mass transit system may not sit well with the major reapers of profit (the petroleum, auto and insurance industries) in our drastically antiquated current mode of transportation, the enormity of our common, long-standing and exponentially worsening traffic problems demands a solution for the many rather than a status-quo subjugation to the powerful few.

No magical technology is required for the *fare-free* system to function right now! Current technology will do all of what is analyzed and proposed herein. The God of ever newer and more exotic technology can not possibly solve our horrendous transportation problems without the use of a mass transit system.

ONE THING IS ABSOLUTE: if the multi millions of personal vehicles in any urban region were instantaneously replaced by pollution-free vehicles, say electric or fuel cell powered vehicles, we would **not** eliminate the problems listed above, except to help with pollution!! **Ever-increasing gridlock is ever-increasing gridlock, enormous petroleum and energy waste is enormous petroleum and energy waste, enfeebling wasted time is enfeebling wasted time, and staggeringly expensive costs are staggeringly expensive costs by any other euphemisms.**

The proposed system allows the super wealthy to be the benefactors of urban mass transportation. The immediate and long term results will personally benefit everyone, including the super wealthy.

If we rigorously use our human reason both to discover and acknowledge the facts about our current transportation quagmire, and if we follow the logical implications for effective human action that such knowledge entails, then we can free ourselves of our plight. Failing this, we are doomed by mindless apathy, irrationality, ignorance and the stranglehold of the powerfully entrenched corporate interests to suffer our endlessly worsening transportation afflictions.

Analysis and Solution.

The solution to the aforementioned problems is to design a long range public transit system that **almost everyone** uses (except those who need use of a vehicle for commercial purposes, or for a long distance vacation, or for emergency purposes, and the like), leaving their personal vehicles at home most of the time while doing all or most of their trips on public transit. Though 100% use of public transit for non-commercial passengers may never happen, one can hope to create a system that enables and induces a substantial number (perhaps 80%, 90%, ...) to make their trips via public transit, and this in turn will eliminate or make inconsequential the aforementioned problems.

A transit system that enables and induces almost everyone to use it must have the following attributes:

- all must have quick access to it;
- for most passengers, the time required for each trip must be the same or **less than** that required by using one's private vehicle;
- the net cost to each public transit user should be much less than the cost incurred by using his/her private vehicle for trips;
- all of the problems described at the outset should be substantially alleviated or eliminated.

A public transit system that is fare-free for every user induces and enables everyone to use public transit for most or all of their trips. Its use eliminates the nuisance and unnecessary bureaucracy of fare transactions, transfers, and the other impediments of fare-based systems. As already mentioned above, the financial resources available in California and in the United States for this type of system, as well as the savings that would accrue to the body of all passengers (see Table 1), are staggering. Yet another mind-boggling example of enormous wealth will drive home the point. *In 1999, Forbes published the list of the 400 richest Americans; their net worth is \$1.1 trillion (led by Bill Gates \$132.6 billion on 23 December, 1999); in 2000, this figure jumped to over \$1.2 trillion!! The latter sum would finance a fare-free all-bus system (cost: \$71 billion annually - see Table 5) for the urban residents of the USA (=95% of the population) for 16.9 years; if only 5.92% of this sum were to be assessed annually, then that would finance this system for the indefinite future!*

For SCR, urban California, and urban USA, we give the analysis that compares the costs, fuel consumption and pollution output of the proposed all-bus system with the current (nearly)all-auto system (see Tables 3, 4, and 5).

The average all-inclusive cost for non-commercial vehicles (fuel, oil, maintenance, tires, insurance, depreciation, finance charges, license/registration/taxes) is 50 cents per mile, and the average fuel consumption is 20 miles per gallon (source: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics). The all-inclusive cost of running a diesel bus (administrative, labor, capital, fuel, oil, maintenance, tires, insurance, depreciation, finance charges, license/registration/taxes) is \$93 per hour (we round this out to \$100 per hour), and the average fuel consumption is 4.649 miles per gallon (source: analysis section of the Metropolitan Transit Authority (MTA)). The following Table 1 summarizes the analysis in Tables 3 to 5:

Table 1

Comparison of Modes of Urban Transportation: All auto* versus all fare-free bus modes						
Annual cost						
Urban region(s)	All auto mode	All fare-free bus mode	Ratio: bus cost to auto cost	For every \$1 of bus cost, auto cost is:	Annual Cost Savings: annual auto cost minus annual bus cost	
SCR	\$ 52,815,967,200	\$ 5,562,309,692	10.53%	\$9.50	\$ 47,253,657,508	
California	\$ 99,833,340,000	\$ 10,531,553,253	10.55%	\$9.48	\$ 89,301,786,747	
USA	\$ 640,696,740,000	\$ 70,936,082,388	11.07%	\$9.03	\$ 569,760,657,612	
Annual fuel consumption (gallons)						
Urban region(s)	All auto mode	All fare-free bus mode	Ratio: bus fuel use to auto fuel use	For every gallon of bus fuel use, auto fuel use is:	Annual Fuel Savings: annual bus use minus auto use	Equivalent savings in barrels of crude***
SCR	5,740,866,000	500,764,044	8.72%	11.464	5,240,101,956	275,794,840
California	9,983,334,000	946,197,938	9.48%	10.551	9,037,136,062	475,638,740
USA	64,069,674,000	6,109,602,297	9.54%	10.487	57,960,071,703	3,050,530,090
*Here, "auto" means "non-commercial vehicle"						***1 barrel crude yields 19 gals gasoline
Annual pollution comparison						
Urban region(s)	Annual bus miles	Annual auto miles	Ratio**			
SCR	2,328,052,039	114,817,320,000	10.14%			
California	4,398,874,215	217,029,000,000	10.13%			
USA	28,403,541,077	1,392,819,000,000	10.20%			
**Assumes a bus pollutes 5 times as much as an auto per mile; the ratio of the annual bus pollution to the annual auto pollution is 5 x #annual bus miles traveled / #annual auto miles travelled						

The comparison between the two modes of transportation is mind-boggling:

For the SCR, California and USA urban cases:

- 1). **The annual cost of the all-bus mode is only 10.53% to 11.07% of the annual cost of the current all-auto mode! For every \$1 spent for the all-bus mode, the average motorist spends \$9.03 to \$9.50!**
- 2). **The annual fuel consumption for the all-bus mode is only 8.72% to 9.54% of that of the all-auto mode! For every one gallon of fuel used in the all-bus mode, the all-auto mode requires 10.487 to 11.464 gallons!**
- 3). **For SCR, California and the USA, respectively, the annual fuel savings that accrue by use of the all-bus system are 5.24 billion, 9.04 billion, and 56.96 billion gallons, respectively; the annual savings in equivalent barrels of crude petroleum are 276 million, 476 million, and 3.05 billion barrels, respectively; the 10 year savings are 2.76 billion, 4.76 billion, and 30.5 billion barrels, respectively! The last figure for the USA far exceeds the wildest, most optimistic estimation of petroleum reserves in the Arctic National Wildlife Refuge!!**
- 4). **The annual pollutants from the all-bus mode are 10.14% to 10.20% of those for the all auto mode! If natural gas buses are used instead of diesel, then the ratio drops to near zero!**

Clearly, the all-bus system is far superior to the current (nearly) all-auto system of transportation because its use would result in far lower costs for the entire body of passengers (especially vehicle owners), far lower fuel consumption and consequent fuel conservation, far less wasted energy, far lower pollution (noise and environmental), far less wasted travel time for almost everyone (see next paragraph and Tables 6 to 7), and a substantial alleviation or elimination of all of the problems described at the outset.

It will now be shown that the all-bus system greatly reduces the travel time for the vast majority of the population. (See also the hypothetical example given at the end of the list of **Mathematical Relations** below).

Consider a frequently encountered scenario on any of our freeways during the usual extended time frame (at least 15 hours daily) of gridlock conditions. Suppose there are four lanes (one direction) and that the all-auto mode prevails; suppose further that a 20 mile one-way stretch contains 16,896 autos (4,224 each lane) traveling 20mph with an *unsafe* separation of only 10 feet (safe separation requires at least 30 feet). There will, of course, be frequent stops followed by the accordion/wave phenomenon inherent in such unsafe traffic conditions. It will take each of the 16,896 passengers (average auto occupancy is only slightly more than one per auto) *one hour* to travel the 20 mile distance. The fuel used will be 16,896 gallons (assuming the average fuel consumption is 20 m/gal for each auto) and the cost for each motorist (@ \$0.50 per mile) will be \$10.00! Let us examine the consequences of the requirement that the travel time for transporting 16,896 passengers in the all-bus mode (50 per bus) for the 20 mile stretch shall be *only 20 minutes* (not one hour!). This will require only 338 buses, each traveling 60mph with a safe separation of 262.5 feet (more than the safe separation amount of $1.5 \times 60 = 90$ feet), with a total fuel consumption of only 1,454 gallons (4.649 m/gal average) – only 8.6% of the fuel used by the fleet of 16,896 autos– and with a cost for each of the 16,896 bus passengers of only \$0.62 – 6.3% of what it would cost if each passenger used an auto!! The waiting time for each bus is 3 seconds.

Tables 6 and 7 give cost comparisons for various cases of both modes traveling at the same speed and carrying the same number of passenger miles per hour. **Note the many cases where it is impossible for the all auto mode to carry large amounts of passenger miles per hour but always possible for the all bus mode to do so for any speed from 10 to 70 mph and for any passenger mile per hour amount from 1,000 to 25,000! Also notice the short waiting times between buses for every case!**

Summary of Tables

Mathematical Relations	Formulas needed for the analysis
Table 1	Comparison of modes of transportation: all-bus versus all-auto
Table 2	Federal Highway Administration [FHWA] Functional System
Table 3	Bus carrying capacity and cost for SCR urban roads
Table 4	Bus carrying capacity and cost for California urban roads
Table 5	Bus carrying capacity and cost for USA urban roads
Table 6	One way, 4 lane roadway: number of autos, N_A, per lane-mile, equally spaced in each of the 4 lanes, and the number of buses, N_B, per lane-mile, equally spaced in one lane, needed to carry P passengers past a fixed point in one hour, the maximum waiting time between each bus, and the cost comparison (one passenger per auto, 50 passengers per bus, auto length 15 feet, bus length 50 feet; buses and autos at same speed)
Table 7	One way, 2 lane roadway: number of autos, N_A, per lane-mile, equally spaced in each of the 2 lanes, and the number of buses, N_B, per lane-mile, equally spaced in one lane, needed to carry P passengers past a fixed point in one hour, the maximum waiting time between each bus, and the cost comparison (one passenger per auto, 50 passengers per bus, auto length 15 feet, bus length 50 feet; buses and autos at same speed)
Table 8	U.S. Public Road and Street Mileage by Functional System and Distribution of U.S. Public Road and Street Mileage by Functional System
Table 9	Annual Vehicle - Miles of Travel, 1980 - 1995 by Functional System (National Summary) and Distribution of Annual Vehicle-miles by Functional System
Table 10	December 31, 1998 Six County (SCAG) Mileage Summary and Travel Estimate

Mathematical Relations

p_c = number of passengers per car

p_b = number of passengers per bus

s_c = speed of each car in miles per hour (mph)

s_b = speed of each bus in miles per hour (mph)

t_c = average number of hours each car operates

t_b = average number of hours each bus operates

l_c = average distance each car travels = $s_c t_c$

l_b = average distance each bus travels = $s_b t_b$

d_p = average distance each passenger travels

L_c = length of each car (feet)

L_b = length of each bus (feet)

S_c = separation between each car (feet)

S_b = separation between each bus (feet)

d_c = density per unit of length for all-car mode (number of passengers per mile for all-car mode)

d_b = density per unit of length for all-bus mode (number of passengers per mile for all-bus mode)

N_c = number of passengers passing by a fixed point per hour in the all-car mode

N_b = number of passengers passing by a fixed point per hour in the all-bus mode

V_c = number of cars passing by a fixed point in one hour

V_b = number of buses passing by a fixed point in one hour

P_c = number of passenger miles carried by each car at speed, s_c , with p_c passengers, and operating for t_c hours = $s_c t_c p_c$

P_b = number of passenger miles carried by each bus at speed, s_b , with p_b passengers, and operating for t_b hours = $s_b t_b p_b$

The following equations (1) through (7) hold for one lane of a thoroughfare in one direction.

The safe separation rule requires that the distance, S , between vehicles must satisfy

(1) **$S > 1.5s$, where s is the vehicle speed in mph.**

We have the following relations:

$$(2) d_c = 5280p_c / (L_c + S_c)$$

$$(3) d_b = 5280p_b / (L_b + S_b).$$

Note that S_c and S_b must satisfy (1) if there is to be safe separation.

The maximum density under safe separation occurs when equality holds in (1), and so we have

$$(2') d_{cMAX} = 5280p_c / (L_c + 1.5s_c)$$

$$(3') d_{bMAX} = 5280p_b / (L_b + 1.5s_b).$$

We further have:

$$(4) N_c = d_c s_c = 5280s_c p_c / (L_c + S_c) = V_c p_c$$

$$(5) N_b = d_b s_b = 5280s_b p_b / (L_b + S_b) = V_b p_b$$

$$(6) V_c = 5280s_c / (L_c + S_c)$$

$$(7) V_b = 5280s_b / (L_b + S_b).$$

The maximum number of passengers (respectively, vehicles) passing by a fixed point in one hour under the safe separation rule occurs when equality holds in (1), and so we have

$$(4') N_{cMAX} = d_{cMAX} s_c = 5280s_c p_c / (L_c + 1.5s_c) = V_{cMAX} P_c$$

$$(5') N_{bMAX} = d_{bMAX} s_b = 5280s_b p_b / (L_b + 1.5s_b) = V_{bMAX} P_b$$

$$(6') V_{cMAX} = 5280s_c / (L_c + 1.5s_c)$$

$$(7') V_{bMAX} = 5280s_b / (L_b + 1.5s_b).$$

Now let T_c be the total daily number of passengers in the all-car mode, each traveling an average distance, a_c , and all to be carried by C cars with each traveling at speed, s_c , each with p_c passengers, and each operating for t_c hours. Then

$$(8) T_c = C p_c$$

$$(8') (TPM)_c = \text{total number of passenger miles in all-car mode} = T_c a_c = C P_c = C s_c t_c p_c.$$

Analogously, let T_b be the total daily number of passengers in the all-bus mode, each traveling an average distance, a_b , and all to be carried by B buses with each traveling at speed, s_b , each with p_b passengers, and each operating for t_b hours.

Then

$$(9) T_b = B p_b$$

$$(9') (TPM)_b = \text{total number of passenger miles in all-bus mode} = T_b a_b = B P_b = B s_b t_b p_b.$$

If we assume $T_c = T_b$ and $a_c = a_b$, then we obtain (see (8') and (9')) **the ratio of buses to cars**

$$(10) B/C = (s_c t_c p_c) / (s_b t_b p_b).$$

For a hypothetical example, let $p_c = 1$ and $p_b = 50$ and assume the conditions in (10). This means one passenger per car, fifty passengers per bus, the total number of daily passengers are the same for both modes, and the average distance for each passenger is the same for both modes. If $s_c = 30$ mph (average car speed), $t_c = 1$ hr (average time of car travel), $s_b = 60$ mph (average bus speed), $t_b = 3$ hrs (average bus time of travel), then $B/C = 1/300$. Furthermore, if $C = 10,000,000$ cars, then $B = 33,333$ buses.

Summarizing this hypothetical example, only 33,333 buses, each traveling at 60 mph for 3 hours, and each with 50 passengers, produces 300,000,000 passenger miles, but it takes 10,000,000 cars, each traveling at only 30 mph for 1 hour, and each with only one passenger, to produce the same!! In such a hypothetical scenario, the travel time for each of the 10,000,000 people would be one-half as much in the all-bus mode as it would be in the all-car mode!

Table 2

FEDERAL HIGHWAY ADMINISTRATION [FHWA] FUNCTIONAL SYSTEM

The functional classification of public streets and highways is grouped into systems according to the services they provide.

PRINCIPAL ARTERIALS (PA)

RURAL: A road classified as Principal Arterial (PA) serves corridor movements having trip length and travel density characteristics of statewide or interstate travel. A PA Rural route provides an integrated network without stub connections except under certain conditions such as coastal city or international boundary connections.

URBAN: A PA Urban route carries the major portion of trips entering and leaving urban areas as well as the majority of through movements bypassing the central city. PA serves intra-area travel (such as between major inner-city communities, between central business districts and residential areas or between major suburban centers).

MINOR ARTERIALS (MA)

RURAL: Rural MA roads link cities, larger towns and other important traffic generators such as resort areas into an integrated network of arterial highways. This network provides intrastate and inter-county service connecting to rural collector or local roads.

URBAN: Urban MA streets and roads interconnect and expand the PA system and provide service for moderate distance and lower mobility travel. The MA system distributes travel to smaller geographic areas than the PA system. The Urban MA system may carry local bus routes and provide intra-community continuity but does not penetrate neighborhoods.

COLLECTORS

RURAL: Rural Collector routes generally serve travel of primarily intra-county importance rather than statewide importance. Predominant travel distances are shorter than on Arterial routes.

RURAL MAJOR COLLECTORS (MJC): Rural MJC routes provide service to county seats and larger towns not served by Arterials. Rural MJC routes also link other important intra-county traffic generators such as consolidated schools, shipping points, county parks and important mining and agricultural areas.

RURAL MINOR COLLECTORS (MNC): Rural MNC routes serve the more important intra-county corridors and developed areas within a reasonable distance of a major collector road. Rural MNC routes also link the locally important traffic generators in the rural areas.

URBAN COLLECTORS (COL): Urban COL routes provide land access service and traffic circulation within residential neighborhoods, commercial and industrial areas.

LOCAL STREETS AND ROADS

Local Streets and Roads are technically not functionally classified.

RURAL LOCAL (LOC): Rural LOC routes provide access to adjacent land and provide service to short distance travel.

URBAN LOCAL (LOC): Urban LOC routes provide access to neighboring land or to functionally classified routes. These routes offer the lowest level of mobility and usually contain no bus routes. Through traffic movement is usually discouraged.

POPULATION GROUPS

The United States Bureau of Census divides communities into groups by volume of population. These groupings are used for further analysis by many agencies such as the Environmental Protection Agency (EPA) and are an important part of HPMS (Highway Performance Monitoring System) data items and analysis.

RURAL (R) AREAS are those areas outside the boundaries of small urban and urbanized areas. The Bureau of Census defines rural areas as having a population of less than 5,000.

SMALL URBAN (S) areas are defined by the Bureau of Census as having a population of 5,000 to 49,999.

URBANIZED (U) areas are defined as having a population of 50,000 to 199,999.

LARGE URBANIZED (L) areas pertain to larger urban areas having a population of over 200,000.

RURAL	URBAN
(PAI)Principal Arterial Interstate	(PAI)Principal Arterial Interstate
(OPA)Other Principal Arterial	(OFE)Principal Arterial – Other FWY / EXP
(MA)Minor Arterial	(OPA)Other Principal Arterial
(MJC)Major Collector	(MA)Minor Arterial
(MNC)Minor Collector	(COL)Collector
(LOC)Local	(LOC)Local

Table 3

MT = miles travelled; V = vehicle; P = passenger; D = daily; A = annual						
BUS CARRYING CAPACITY AND COST FOR SCR URBAN ROADS EXCLUDING LOCAL (50 PASSENGERS PER BUS)						
18 HOUR OPERATING PERIOD: 5AM TO 11PM						
Hourly capacity (i.e., passenger miles per hour), C, at v mph (each bus), b buses per mile: C = 50 x b x # bi-directional road miles x v						
	Int	OFE	OPA	MA	Col	TOTALS
Total miles	525,915	451,325	3,196,137	5,226,955	4,553,461	13,953,793
Bi-directional road miles	1,051,830	902,650	6,392,274	10,453,910	9,106,922	27,907,586
v (mph)	55	55	40	30	30	
b	1.75	1.36	0.37	0.23	0.069	
C	5,061,932	3,375,911	4,730,283	3,606,599	942,566	
18 hour (=daily) capacity	91,114,774	60,766,398	85,145,090	64,918,781	16,966,196	318,911,238
Wait time between buses						
in minutes	0.62	0.80	4.05	8.70	28.99	
#buses operating for 18 hrs	1,841	1,228	2,365	2,404	628	8,466
#buses operating in 6 hour segments (three shifts)	5,522	3,683	7,095	7,213	1,885	25,399
#bus hours over 18 hour period	33,133	22,097	42,573	43,279	11,311	152,392
18 hour cost at \$100/hr	\$ 3,313,264	\$ 2,209,687	\$ 4,257,254	\$ 4,327,919	\$ 1,131,080	\$ 15,239,205
Annual cost	\$ 1,209,341,542	\$ 806,535,828	\$ 1,553,897,887	\$ 1,579,690,340	\$ 412,844,095	\$ 5,562,309,692
1998 URBAN SCR ALL VEHICLE DATA						
DVMT = DPMT (approximately)	90,876,300	60,419,100	83,945,800	62,603,000	16,723,800	314,568,000
AVMT = APMT (approximately)	33,169,849,500	22,052,971,500	30,640,217,000	22,850,095,000	6,104,187,000	114,817,320,000
Annual bus travel						
=365 x v x #buses operating 18 hrs x 18	665,137,848	443,594,705	621,559,155	473,907,102	123,853,229	2,328,052,039
Annual bus fuel consumption (gallons)						
=annual bus travel/4.649mpg	143,071,165	95,417,231	133,697,388	101,937,428	26,640,832	500,764,044
92% of all-vehicle URBAN VMT is from non-commercial vehicles; \$0.50 per mile is average cost for non-commercial vehicle; Annual non-commercial vehicle cost = 0.92xAVMTx\$0.50 = \$52,815,967,200				Fare-free bus system costs:	Average annual cost per SCR capita (16.84 million):	\$330.30
					Average daily cost per capita:	\$0.90
Urban non-commercial vehicles average 20 miles per gallon; Annual urban non-commercial fuel consumption=0.92xAVMT/20 =5,740,866,000 gallons					Annual cost as a percentage of the \$2.5 trillion of net wealth held by the richest 1% of Californians	0.22%

Table 4

BUS CARRYING CAPACITY AND COST FOR CA URBAN ROADS EXCLUDING LOCAL (50 PASSENGERS PER BUS)						
18 HOUR OPERATING PERIOD: 5AM TO 11PM						
Hourly capacity (i.e., passenger miles per hour), C, at v mph (each bus), b buses per mile: C = 50 x b x # bi-directional road miles x v						
	Int	OFE	OPA	MA	Col	TOTALS
Total centerline miles (1998)	1,069,184	1,397,345	5,843,989	10,235,916	9,973,415	28,519,849
Bi-directional road miles	2,138,368	2,794,690	11,687,978	20,471,832	19,946,830	57,039,698
v (mph)	55	55	40	30	30	
b	1.57	0.93	0.34	0.22	0.08	
C	9,232,404	7,147,420	7,947,825	6,755,705	2,393,620	
18 hour capacity (=daily capacity)	166,183,269	128,653,554	143,060,851	121,602,682	43,085,153	602,585,509
Wait time between buses						
in minutes	0.69	1.17	4.41	9.09	25.00	
#buses operating for 18 hrs	3,357	2,599	3,974	4,504	1,596	16,030
#buses operating in 6 hour segments (three shifts)	10,072	7,797	11,922	13,511	4,787	48,089
#bus hours over 18 hour period	60,430	46,783	71,530	81,068	28,723	288,536
18 hour cost (=daily cost) at \$100/hr	\$ 6,043,028	\$ 4,678,311	\$ 7,153,043	\$ 8,106,845	\$ 2,872,344	\$ 28,853,571
Annual cost	\$ 2,205,705,208	\$ 1,707,583,537	\$ 2,610,860,526	\$ 2,958,998,597	\$ 1,048,405,385	\$ 10,531,553,253
1999 URBAN CALIFORNIA ALL VEHICLE DATA:						
DVMT = DPMT (approximately)	165,575,342	127,517,808	141,920,548	120,057,534	39,528,767	594,600,000
AVMT = APMT (approximately)	60,435,000,000	46,544,000,000	51,801,000,000	43,821,000,000	14,428,000,000	217,029,000,000
Annual bus travel						
=365 x v x #buses operating 18 hrs x 18	1,213,137,865	939,170,945	1,044,344,210	887,699,579	314,521,615	4,398,874,215
Annual bus fuel consumption (gallons)						
=annual bus travel/4.649mpg	260,945,981	202,015,691	224,638,462	190,944,199	67,653,606	946,197,938
92% of all-vehicle URBAN VMT is from non-commercial vehicles; \$0.50 per mile is average cost for a non-commercial vehicle; Annual urban non-commercial vehicle cost = 0.92xAVMTx\$0.50 = \$99,833,340,000				Fare-free bus system costs:	Average annual cost per capita (34 million):	\$309.75
					Average daily cost per capita:	\$0.85
Urban non-commercial vehicles average 20 miles per gallon; Annual urban non-commercial fuel consumption=0.92xAVMT/20 =9,983,334,000 gallons					Annual cost as a percentage of the \$2.5 trillion of net wealth held by the richest 1% of Californians	0.42%

Table 5

BUS CARRYING CAPACITY AND COST FOR USA URBAN ROADS EXCLUDING LOCAL (50 PASSENGERS PER BUS)						
18 HOUR OPERATING PERIOD: 5AM TO 11PM						
Hourly capacity (i.e., passenger miles per hour), C, at v mph (each bus), b buses per mile:						
C = 50 x b x # bi-directional road miles x v						
	Int	OFE	OPA	MA	CoI	TOTALS
Total miles	13,343.000	9,125.000	53,206.000	89,399.000	88,008.000	253,081.000
Bi-directional road miles	26,686.000	18,250.000	106,412.000	178,798.000	176,016.000	506,162.000
v (mph)	55	55	40	30	30	
b	0.8	0.53	0.29	0.18	0.079	
C	58,709,200	26,599,375	61,718,960	48,275,460	20,857,896	
18 hour (=daily) capacity	1,056,765,600	478,788,750	1,110,941,280	868,958,280	375,442,128	3,890,896,038
Wait time between buses						
in minutes	1.36	2.06	5.17	11.11	25.32	
#buses operating for 18 hrs	21,349	9,673	30,859	32,184	13,905	107,970
#buses operating in 6 hour segments (three shifts)	64,046	29,018	92,578	96,551	41,716	323,909
#bus hours over 18 hour period	384,278	174,105	555,471	579,306	250,295	1,943,454
18 hour cost at \$100/hr	\$ 38,427,840	\$ 17,410,500	\$ 55,547,064	\$ 57,930,552	\$ 25,029,475	\$ 194,345,431
Annual cost	\$ 14,026,161,600	\$ 6,354,832,500	\$ 20,274,678,360	\$ 21,144,651,480	\$ 9,135,758,448	\$ 70,936,082,388
1998 URBAN USA ALL VEHICLE DATA						
DVMT = DPMT (approximately)	1,049,276,712	470,035,616	1,075,947,945	860,098,630	360,583,562	3,815,942,466
AVMT = APMT (approximately)	382,986,000,000	171,563,000,000	392,721,000,000	313,936,000,000	131,613,000,000	1,392,819,000,000
Annual bus travel						
=365 x v x #buses operating 18 hrs x 18	7,714,388,880	3,495,157,875	8,109,871,344	6,343,395,444	2,740,727,534	28,403,541,077
Annual bus fuel consumption (gallons)						
=annual bus travel/4.649mpg	1,659,365,214	751,808,534	1,744,433,501	1,364,464,496	589,530,552	6,109,602,297
92% of all-vehicle URBAN VMT is from non-commercial vehicles; \$0.50 per mile is average cost for non-commercial vehicle;			Fare-free bus system costs:	Average annual cost per USA capita (285 million):		\$248.90
Annual non-commercial vehicle cost = 0.92xAVMTx\$0.50 = \$640,696,740,000				Average daily cost per capita:		\$0.68
Urban non-commercial vehicles average 20 miles per gallon; Annual urban non-commercial fuel consumption=0.92xAVMT/20 =64,069,674,000 gallons				Annual cost as a percentage of the \$25 trillion of net wealth held by the richest 1% of the US population:		0.28%

Table 6

One way, 4 lane roadway: number of autos, N_A , per lane-mile, equally spaced in each of the 4 lanes, and the number of buses, N_B , per lane-mile, equally spaced in one lane, needed to carry P passengers past a fixed point in one hour, the maximum waiting time between each bus, and the cost comparison (one passenger per auto, 50 passengers per bus, auto length 15 feet, bus length 50 feet; buses and autos at the same speed)

P number of passengers per hr	s speed (mph)	safe separation in feet: =1.5 x s	all auto mode			all bus mode		maximum waiting time between each bus (minutes)	total cost for one hour of all auto operation (\$0.50 per mile per auto)	total cost for one hour of all bus operation (\$100 per hour per bus)	for one hour of operation, ratio of all bus cost to all auto cost	
			actual separation in feet	N_A	total number of autos in a one mile segment of 4 lanes	actual separation in feet	N_B					
1,000	10	15	196.2	25.00	100.00	2,590.0	2.00	3.00	\$ 5,000.00	\$ 2,000.00	40.00%	
1,000	20	30	407.4	12.50	50.00	5,230.0	1.00	3.00	\$ 10,000.00	\$ 2,000.00	20.00%	
1,000	30	45	618.6	8.33	33.33	7,870.0	0.67	3.00	\$ 15,000.00	\$ 2,000.00	13.33%	
1,000	40	60	829.8	6.25	25.00	10,510.0	0.50	3.00	\$ 20,000.00	\$ 2,000.00	10.00%	
1,000	50	75	1,041.0	5.00	20.00	13,150.0	0.40	3.00	\$ 25,000.00	\$ 2,000.00	8.00%	
1,000	60	90	1,252.2	4.17	16.67	15,790.0	0.33	3.00	\$ 30,000.00	\$ 2,000.00	6.67%	
1,000	70	105	1,463.4	3.57	14.29	18,430.0	0.29	3.00	\$ 35,000.00	\$ 2,000.00	5.71%	
2,000	10	15	90.6	50.00	200.00	1,270.0	4.00	1.50	\$ 10,000.00	\$ 4,000.00	40.00%	
2,000	20	30	196.2	25.00	100.00	2,590.0	2.00	1.50	\$ 20,000.00	\$ 4,000.00	20.00%	
2,000	30	45	301.8	16.67	66.67	3,910.0	1.33	1.50	\$ 30,000.00	\$ 4,000.00	13.33%	
2,000	40	60	407.4	12.50	50.00	5,230.0	1.00	1.50	\$ 40,000.00	\$ 4,000.00	10.00%	
2,000	50	75	513.0	10.00	40.00	6,550.0	0.80	1.50	\$ 50,000.00	\$ 4,000.00	8.00%	
2,000	60	90	618.6	8.33	33.33	7,870.0	0.67	1.50	\$ 60,000.00	\$ 4,000.00	6.67%	
2,000	70	105	724.2	7.14	28.57	9,190.0	0.57	1.50	\$ 70,000.00	\$ 4,000.00	5.71%	
5,000	10	15	27.2	125.00	500.00	478.0	10.00	0.60	\$ 25,000.00	\$ 10,000.00	40.00%	
5,000	20	30	69.5	62.50	250.00	1,006.0	5.00	0.60	\$ 50,000.00	\$ 10,000.00	20.00%	
5,000	30	45	111.7	41.67	166.67	1,534.0	3.33	0.60	\$ 75,000.00	\$ 10,000.00	13.33%	
5,000	40	60	154.0	31.25	125.00	2,062.0	2.50	0.60	\$ 100,000.00	\$ 10,000.00	10.00%	
5,000	50	75	196.2	25.00	100.00	2,590.0	2.00	0.60	\$ 125,000.00	\$ 10,000.00	8.00%	
5,000	60	90	238.4	20.83	83.33	3,118.0	1.67	0.60	\$ 150,000.00	\$ 10,000.00	6.67%	
5,000	70	105	280.7	17.86	71.43	3,646.0	1.43	0.60	\$ 175,000.00	\$ 10,000.00	5.71%	
#	10,000	10	15	6.1	250.00	1,000.00	214.0	20.00	0.30	\$ 50,000.00	\$ 20,000.00	40.00%
#	10,000	20	30	27.2	125.00	500.00	478.0	10.00	0.30	\$ 100,000.00	\$ 20,000.00	20.00%
	10,000	30	45	48.4	83.33	333.33	742.0	6.67	0.30	\$ 150,000.00	\$ 20,000.00	13.33%
	10,000	40	60	69.5	62.50	250.00	1,006.0	5.00	0.30	\$ 200,000.00	\$ 20,000.00	10.00%
	10,000	50	75	90.6	50.00	200.00	1,270.0	4.00	0.30	\$ 250,000.00	\$ 20,000.00	8.00%
	10,000	60	90	111.7	41.67	166.67	1,534.0	3.33	0.30	\$ 300,000.00	\$ 20,000.00	6.67%
	10,000	70	105	132.8	35.71	142.86	1,798.0	2.86	0.30	\$ 350,000.00	\$ 20,000.00	5.71%
#	15,000	10	15	-0.9	375.00	1,500.00	126.0	30.00	0.20	\$ 75,000.00	\$ 30,000.00	40.00%
#	15,000	20	30	13.2	187.50	750.00	302.0	15.00	0.20	\$ 150,000.00	\$ 30,000.00	20.00%
#	15,000	30	45	27.2	125.00	500.00	478.0	10.00	0.20	\$ 225,000.00	\$ 30,000.00	13.33%
#	15,000	40	60	41.3	93.75	375.00	654.0	7.50	0.20	\$ 300,000.00	\$ 30,000.00	10.00%
#	15,000	50	75	55.4	75.00	300.00	830.0	6.00	0.20	\$ 375,000.00	\$ 30,000.00	8.00%
#	15,000	60	90	69.5	62.50	250.00	1,006.0	5.00	0.20	\$ 450,000.00	\$ 30,000.00	6.67%
#	15,000	70	105	83.6	53.57	214.29	1,182.0	4.29	0.20	\$ 525,000.00	\$ 30,000.00	5.71%
#	20,000	10	15	-4.4	500.00	2,000.00	82.0	40.00	0.15	\$ 100,000.00	\$ 40,000.00	40.00%
#	20,000	20	30	6.1	250.00	1,000.00	214.0	20.00	0.15	\$ 200,000.00	\$ 40,000.00	20.00%
#	20,000	30	45	16.7	166.67	666.67	346.0	13.33	0.15	\$ 300,000.00	\$ 40,000.00	13.33%
#	20,000	40	60	27.2	125.00	500.00	478.0	10.00	0.15	\$ 400,000.00	\$ 40,000.00	10.00%
#	20,000	50	75	37.8	100.00	400.00	610.0	8.00	0.15	\$ 500,000.00	\$ 40,000.00	8.00%
#	20,000	60	90	48.4	83.33	333.33	742.0	6.67	0.15	\$ 600,000.00	\$ 40,000.00	6.67%
#	20,000	70	105	58.9	71.43	285.71	874.0	5.71	0.15	\$ 700,000.00	\$ 40,000.00	5.71%
#	25,000	10	15	-6.6	625.00	2,500.00	55.6	50.00	0.12	\$ 125,000.00	\$ 50,000.00	40.00%
#	25,000	20	30	1.9	312.50	1,250.00	161.2	25.00	0.12	\$ 250,000.00	\$ 50,000.00	20.00%
#	25,000	30	45	10.3	208.33	833.33	266.8	16.67	0.12	\$ 375,000.00	\$ 50,000.00	13.33%
#	25,000	40	60	18.8	156.25	625.00	372.4	12.50	0.12	\$ 500,000.00	\$ 50,000.00	10.00%
#	25,000	50	75	27.2	125.00	500.00	478.0	10.00	0.12	\$ 625,000.00	\$ 50,000.00	8.00%
#	25,000	60	90	35.7	104.17	416.67	583.6	8.33	0.12	\$ 750,000.00	\$ 50,000.00	6.67%
#	25,000	70	105	44.1	89.29	357.14	689.2	7.14	0.12	\$ 875,000.00	\$ 50,000.00	5.71%

#Impossible or very unsafe cases for the all auto mode because actual separation is less than safe separation; but possible in ALL CASES for the all bus mode because the actual separation exceeds the safe separation by at least a factor of 3.7

Table 7

One way, 2 lane roadway: number of autos, N_A , per lane-mile, equally spaced in each of the 2 lanes, and the number of buses, N_B , per lane-mile, equally spaced in one lane, needed to carry P passengers past a fixed point in one hour, the maximum waiting time between each bus, and the cost comparison (one passenger per auto, 50 passengers per bus, auto length 15 feet, bus length 50 feet; buses and autos at same speed)

P number of passengers per hr	s speed (mph)	safe separation in feet: =1.5 x s	all auto mode			all bus mode			maximum waiting time between each bus (minutes)	total cost for one hour of all auto operation (\$0.50 per mile per auto)	total cost for one hour of all bus operation (\$100 per hour per bus)	for one hour of operation, ratio of all bus cost to all auto cost
			actual separation in feet	N_A	total number of autos in a one mile segment of 2 lanes	actual separation in feet	N_B					
1,000	10	15	90.6	50.00	100.00	2,590.0	2.00	3.00	\$ 5,000.00	\$ 2,000.00	40.00%	
1,000	20	30	196.2	25.00	50.00	5,230.0	1.00	3.00	\$ 10,000.00	\$ 2,000.00	20.00%	
1,000	30	45	301.8	16.67	33.33	7,870.0	0.67	3.00	\$ 15,000.00	\$ 2,000.00	13.33%	
1,000	40	60	407.4	12.50	25.00	10,510.0	0.50	3.00	\$ 20,000.00	\$ 2,000.00	10.00%	
1,000	50	75	513.0	10.00	20.00	13,150.0	0.40	3.00	\$ 25,000.00	\$ 2,000.00	8.00%	
1,000	60	90	618.6	8.33	16.67	15,790.0	0.33	3.00	\$ 30,000.00	\$ 2,000.00	6.67%	
1,000	70	105	724.2	7.14	14.29	18,430.0	0.29	3.00	\$ 35,000.00	\$ 2,000.00	5.71%	
2,000	10	15	37.8	100.00	200.00	1,270.0	4.00	1.50	\$ 10,000.00	\$ 4,000.00	40.00%	
2,000	20	30	90.6	50.00	100.00	2,590.0	2.00	1.50	\$ 20,000.00	\$ 4,000.00	20.00%	
2,000	30	45	143.4	33.33	66.67	3,910.0	1.33	1.50	\$ 30,000.00	\$ 4,000.00	13.33%	
2,000	40	60	196.2	25.00	50.00	5,230.0	1.00	1.50	\$ 40,000.00	\$ 4,000.00	10.00%	
2,000	50	75	249.0	20.00	40.00	6,550.0	0.80	1.50	\$ 50,000.00	\$ 4,000.00	8.00%	
2,000	60	90	301.8	16.67	33.33	7,870.0	0.67	1.50	\$ 60,000.00	\$ 4,000.00	6.67%	
2,000	70	105	354.6	14.29	28.57	9,190.0	0.57	1.50	\$ 70,000.00	\$ 4,000.00	5.71%	
#	5,000	10	15	6.1	250.00	500.00	478.0	10.00	0.60	\$ 25,000.00	\$ 10,000.00	40.00%
#	5,000	20	30	27.2	125.00	250.00	1,006.0	5.00	0.60	\$ 50,000.00	\$ 10,000.00	20.00%
	5,000	30	45	48.4	83.33	166.67	1,534.0	3.33	0.60	\$ 75,000.00	\$ 10,000.00	13.33%
	5,000	40	60	69.5	62.50	125.00	2,062.0	2.50	0.60	\$ 100,000.00	\$ 10,000.00	10.00%
	5,000	50	75	90.6	50.00	100.00	2,590.0	2.00	0.60	\$ 125,000.00	\$ 10,000.00	8.00%
	5,000	60	90	111.7	41.67	83.33	3,118.0	1.67	0.60	\$ 150,000.00	\$ 10,000.00	6.67%
	5,000	70	105	132.8	35.71	71.43	3,646.0	1.43	0.60	\$ 175,000.00	\$ 10,000.00	5.71%
#	10,000	10	15	-4.4	500.00	1,000.00	214.0	20.00	0.30	\$ 50,000.00	\$ 20,000.00	40.00%
#	10,000	20	30	6.1	250.00	500.00	478.0	10.00	0.30	\$ 100,000.00	\$ 20,000.00	20.00%
#	10,000	30	45	16.7	166.67	333.33	742.0	6.67	0.30	\$ 150,000.00	\$ 20,000.00	13.33%
#	10,000	40	60	27.2	125.00	250.00	1,006.0	5.00	0.30	\$ 200,000.00	\$ 20,000.00	10.00%
#	10,000	50	75	37.8	100.00	200.00	1,270.0	4.00	0.30	\$ 250,000.00	\$ 20,000.00	8.00%
#	10,000	60	90	48.4	83.33	166.67	1,534.0	3.33	0.30	\$ 300,000.00	\$ 20,000.00	6.67%
#	10,000	70	105	58.9	71.43	142.86	1,798.0	2.86	0.30	\$ 350,000.00	\$ 20,000.00	5.71%
#	15,000	10	15	-8.0	750.00	1,500.00	126.0	30.00	0.20	\$ 75,000.00	\$ 30,000.00	40.00%
#	15,000	20	30	-0.9	375.00	750.00	302.0	15.00	0.20	\$ 150,000.00	\$ 30,000.00	20.00%
#	15,000	30	45	6.1	250.00	500.00	478.0	10.00	0.20	\$ 225,000.00	\$ 30,000.00	13.33%
#	15,000	40	60	13.2	187.50	375.00	654.0	7.50	0.20	\$ 300,000.00	\$ 30,000.00	10.00%
#	15,000	50	75	20.2	150.00	300.00	830.0	6.00	0.20	\$ 375,000.00	\$ 30,000.00	8.00%
#	15,000	60	90	27.2	125.00	250.00	1,006.0	5.00	0.20	\$ 450,000.00	\$ 30,000.00	6.67%
#	15,000	70	105	34.3	107.14	214.29	1,182.0	4.29	0.20	\$ 525,000.00	\$ 30,000.00	5.71%
#	20,000	10	15	-9.7	1,000.00	2,000.00	82.0	40.00	0.15	\$ 100,000.00	\$ 40,000.00	40.00%
#	20,000	20	30	-4.4	500.00	1,000.00	214.0	20.00	0.15	\$ 200,000.00	\$ 40,000.00	20.00%
#	20,000	30	45	0.8	333.33	666.67	346.0	13.33	0.15	\$ 300,000.00	\$ 40,000.00	13.33%
#	20,000	40	60	6.1	250.00	500.00	478.0	10.00	0.15	\$ 400,000.00	\$ 40,000.00	10.00%
#	20,000	50	75	11.4	200.00	400.00	610.0	8.00	0.15	\$ 500,000.00	\$ 40,000.00	8.00%
#	20,000	60	90	16.7	166.67	333.33	742.0	6.67	0.15	\$ 600,000.00	\$ 40,000.00	6.67%
#	20,000	70	105	22.0	142.86	285.71	874.0	5.71	0.15	\$ 700,000.00	\$ 40,000.00	5.71%
#	25,000	10	15	-10.8	1,250.00	2,500.00	55.6	50.00	0.12	\$ 125,000.00	\$ 50,000.00	40.00%
#	25,000	20	30	-6.6	625.00	1,250.00	161.2	25.00	0.12	\$ 250,000.00	\$ 50,000.00	20.00%
#	25,000	30	45	-2.3	416.67	833.33	266.8	16.67	0.12	\$ 375,000.00	\$ 50,000.00	13.33%
#	25,000	40	60	1.9	312.50	625.00	372.4	12.50	0.12	\$ 500,000.00	\$ 50,000.00	10.00%
#	25,000	50	75	6.1	250.00	500.00	478.0	10.00	0.12	\$ 625,000.00	\$ 50,000.00	8.00%
#	25,000	60	90	10.3	208.33	416.67	583.6	8.33	0.12	\$ 750,000.00	\$ 50,000.00	6.67%
#	25,000	70	105	14.6	178.57	357.14	689.2	7.14	0.12	\$ 875,000.00	\$ 50,000.00	5.71%

#Impossible or very unsafe cases for the all auto mode because actual separation is less than safe separation, but possible in ALL CASES for the all bus mode because the actual separation exceeds the safe separation by at least a factor of 3.7

Table 8

U.S. Public Road and Street Mileage by Functional System*										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Urban mileage										
INT	11,527	11,602	12,516	12,877	13,126	13,164	13,217	13,247	13,312	13,343
OFE	7,668	7,709	8,491	8,841	8,994	8,970	9,027	9,063	9,127	9,125
OPA	51,968	52,515	51,900	52,708	53,110	52,796	52,983	53,223	53,132	53,206
MA	74,659	74,795	80,815	86,821	87,857	88,510	89,020	89,185	89,496	89,399
COL	78,254	77,102	82,784	84,854	86,089	87,331	87,790	88,049	88,071	88,008
LOC	520,568	526,139	548,560	559,776	564,609	568,935	574,728	583,973	588,504	592,978
Total	744,644	749,862	785,066	805,877	813,785	819,706	826,765	836,740	841,642	846,059
Rural mileage										
INT	33,547	33,677	32,951	32,631	32,457	32,580	32,820	32,817	32,813	32,974
OPA	83,802	86,747	94,947	96,770	97,175	97,948	98,131	98,257	98,852	98,856
MA	144,774	141,795	137,685	137,577	138,120	137,151	137,359	137,497	137,308	137,463
MJC	436,352	436,746	434,072	432,222	431,115	431,712	432,117	432,714	432,408	432,954
MNC	293,922	293,511	284,504	282,182	282,011	274,081	273,198	272,362	272,140	271,690
LOC	2,129,885	2,141,582	2,131,856	2,117,952	2,111,932	2,119,048	2,119,262	2,135,485	2,091,127	2,097,244
Total	3,122,282	3,134,058	3,116,015	3,099,334	3,092,810	3,092,520	3,092,887	3,109,132	3,064,648	3,071,181
TOTAL urban and rural mileage	3,866,926	3,883,920	3,901,081	3,905,211	3,906,595	3,912,226	3,919,652	3,945,872	3,906,290	3,917,240
*Includes the 50 states and the District of Columbia. When states did not submit reports, data were estimated by the U.S. Department of Transportation, Federal Highway Administration.										
Distribution of U.S. Public Road and Street Mileage by Functional System*										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Urban mileage										
INT	1.55%	1.55%	1.59%	1.60%	1.61%	1.61%	1.60%	1.58%	1.58%	1.58%
OFE	1.03%	1.03%	1.08%	1.10%	1.11%	1.09%	1.09%	1.08%	1.08%	1.08%
OPA	6.98%	7.00%	6.61%	6.54%	6.53%	6.44%	6.41%	6.36%	6.31%	6.29%
MA	10.03%	9.97%	10.29%	10.77%	10.80%	10.80%	10.77%	10.66%	10.63%	10.57%
COL	10.51%	10.28%	10.54%	10.53%	10.58%	10.65%	10.62%	10.52%	10.46%	10.40%
LOC	69.91%	70.16%	69.87%	69.46%	69.38%	69.41%	69.52%	69.79%	69.92%	70.09%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Rural mileage										
INT	1.07%	1.07%	1.06%	1.05%	1.05%	1.05%	1.06%	1.06%	1.07%	1.07%
OPA	2.68%	2.77%	3.05%	3.12%	3.14%	3.17%	3.17%	3.16%	3.23%	3.22%
MA	4.64%	4.52%	4.42%	4.44%	4.47%	4.43%	4.44%	4.42%	4.48%	4.48%
MJC	13.98%	13.94%	13.93%	13.95%	13.94%	13.96%	13.97%	13.92%	14.11%	14.10%
MNC	9.41%	9.37%	9.13%	9.10%	9.12%	8.86%	8.83%	8.76%	8.88%	8.85%
LOC	68.22%	68.33%	68.42%	68.34%	68.29%	68.52%	68.52%	68.68%	68.23%	68.29%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 9

ANNUAL VEHICLE - MILES OF TRAVEL, 1980 - 1995 1/ BY FUNCTIONAL SYSTEM NATIONAL SUMMARY 2/ (MILLIONS)															TOTAL
YEAR	RURAL							URBAN							TOTAL RURAL & URBAN
	INT	OPA	MA	MJC	MNC	LOC	TOTAL	INT	OFFE	OPA	MA	COL	LOC	TOTAL	
1980	135,084	132,958	129,816	150,186	39,282	84,704	672,030	161,242	79,690	229,469	175,030	83,043	126,791	855,265	1,527,295
1981	139,304	135,029	132,191	152,428	41,080	88,276	688,308	166,479	81,454	231,610	170,220	80,598	136,639	867,000	1,555,308
1982	142,546	134,042	135,979	154,476	40,582	81,601	689,226	175,879	90,054	242,138	182,195	83,726	131,792	905,784	1,595,010
1983	145,250	140,104	133,304	156,913	43,736	81,210	700,517	192,470	87,299	256,914	188,791	86,827	139,970	952,271	1,652,788
1984	149,139	144,056	136,761	158,956	42,922	86,298	718,132	204,304	93,810	271,403	195,400	87,893	149,327	1,002,137	1,720,269
1985	154,357	145,881	136,922	163,297	43,372	86,899	730,728	216,188	97,408	279,121	201,741	89,578	160,062	1,044,098	1,774,826
1986	159,498	149,405	140,724	164,852	43,123	90,178	747,780	232,017	105,480	287,660	208,728	89,967	163,240	1,087,092	1,834,872
1987	170,493	155,446	146,543	174,301	44,535	89,132	780,450	244,836	109,961	304,684	224,144	95,970	161,159	1,140,754	1,921,204
1988	181,315	160,244	151,749	183,541	47,023	93,662	817,534	258,695	116,983	319,344	231,802	99,211	182,393	1,208,428	2,025,962
1989	191,085	165,859	156,646	187,195	48,714	97,726	847,225	270,735	122,024	327,173	234,769	101,871	192,690	1,249,262	2,096,487
1990	200,173	175,133	155,733	190,512	49,948	97,379	868,878	278,901	127,465	335,543	236,225	106,297	191,053	1,275,484	2,144,362
1991	205,011	179,202	155,553	193,998	51,632	98,157	883,553	285,325	128,220	339,954	239,344	107,281	188,373	1,288,497	2,172,050
1992	205,557	196,816	147,246	184,845	50,065	99,568	884,097	303,265	138,312	345,047	262,259	116,065	198,106	1,363,054	2,247,151
1993	208,308	203,113	146,454	178,170	48,126	102,535	886,706	317,399	142,063	354,976	276,939	117,887	200,408	1,409,672	2,296,378
1994	215,568	207,569	149,760	182,000	48,529	104,915	908,341	330,577	147,534	364,200	286,165	120,088	200,683	1,449,247	2,357,588
1995	223,382	215,567	153,028	186,212	49,936	105,164	933,289	341,528	151,560	370,338	293,272	126,929	205,907	1,489,534	2,422,823

1/ Data are based on State highway agency estimates reported for the various functional systems.

2/ Includes the 50 States and the District of Columbia

DISTRIBUTION OF ANNUAL VEHICLE-MILES BY FUNCTIONAL SYSTEM														
YEAR	RURAL							URBAN						
	INT	OPA	MA	MJC	MNC	LOC	TOTAL	INT	OFFE	OPA	MA	COL	LOC	TOTAL
1980	20.10%	19.78%	19.32%	22.35%	5.85%	12.60%	100.00%	18.85%	9.32%	26.83%	20.47%	9.71%	14.82%	100.00%
1981	20.24%	19.62%	19.21%	22.15%	5.97%	12.83%	100.00%	19.20%	9.39%	26.71%	19.63%	9.30%	15.76%	100.00%
1982	20.68%	19.45%	19.73%	22.41%	5.89%	11.84%	100.00%	19.42%	9.94%	26.73%	20.11%	9.24%	14.55%	100.00%
1983	20.73%	20.00%	19.03%	22.40%	6.24%	11.59%	100.00%	20.21%	9.17%	26.98%	19.83%	9.12%	14.70%	100.00%
1984	20.77%	20.06%	19.04%	22.13%	5.98%	12.02%	100.00%	20.39%	9.36%	27.08%	19.50%	8.77%	14.90%	100.00%
1985	21.12%	19.96%	18.74%	22.35%	5.94%	11.89%	100.00%	20.71%	9.33%	26.73%	19.32%	8.58%	15.33%	100.00%
1986	21.33%	19.98%	18.82%	22.05%	5.77%	12.06%	100.00%	21.34%	9.70%	26.46%	19.20%	8.28%	15.02%	100.00%
1987	21.85%	19.92%	18.78%	22.33%	5.71%	11.42%	100.00%	21.46%	9.64%	26.71%	19.65%	8.41%	14.13%	100.00%
1988	22.18%	19.60%	18.56%	22.45%	5.75%	11.46%	100.00%	21.41%	9.68%	26.43%	19.18%	8.21%	15.09%	100.00%
1989	22.55%	19.58%	18.49%	22.10%	5.75%	11.53%	100.00%	21.67%	9.77%	26.19%	18.79%	8.15%	15.42%	100.00%
1990	23.04%	20.16%	17.92%	21.93%	5.75%	11.21%	100.00%	21.87%	9.99%	26.31%	18.52%	8.33%	14.98%	100.00%
1991	23.20%	20.28%	17.61%	21.96%	5.84%	11.11%	100.00%	22.14%	9.95%	26.38%	18.58%	8.33%	14.62%	100.00%
1992	23.25%	22.26%	16.65%	20.91%	5.66%	11.26%	100.00%	22.25%	10.15%	25.31%	19.24%	8.52%	14.53%	100.00%
1993	23.49%	22.91%	16.52%	20.09%	5.43%	11.56%	100.00%	22.52%	10.08%	25.18%	19.65%	8.36%	14.22%	100.00%
1994	23.73%	22.85%	16.49%	20.04%	5.34%	11.55%	100.00%	22.81%	10.18%	25.13%	19.75%	8.29%	13.85%	100.00%
1995	23.93%	23.10%	16.40%	19.95%	5.35%	11.27%	100.00%	22.93%	10.17%	24.86%	19.69%	8.52%	13.82%	100.00%

Table 10

December 31, 1998 Six County (SCAG) Mileage Summary and Travel Estimate								
(NHS = National Highway System; DVMT = Daily Vehicle-Miles Traveled)								
		INT	OFE	OPA	MA	COL	LOC	TOTALS
URBAN TOTALS	NHS Miles	525.915	409.701	165.232	6.836	2.000	0.000	1,109.684
	DVMT	90,876,300	58,496,500	3,083,800	121,700	6,200	0	152,584,500
	Other Miles	0.000	41.624	3,030.905	5,220.119	4,551.461	25,663.027	38,507.136
	DVMT	0	1,922,600	80,862,000	62,481,300	16,717,600	27,562,300	189,545,800
	Total Miles	525.915	451.325	3,196.137	5,226.955	4,553.461	25,663.027	39,616.820
	DVMT	90,876,300	60,419,100	83,945,800	62,603,000	16,723,800	27,562,300	342,130,300
RURAL & URBAN TOTALS	NHS Miles	1,091.854	820.061	191.449	26.574	2.000	0.000	2,131.938
	DVMT	105,793,900	66,123,300	3,412,300	216,000	6,200	0	175,551,700
	Other Miles	0.000	79.796	4,213.871	7,803.490	5,972.773	31,130.316	49,200.246
	DVMT	0	2,249,800	85,256,200	67,500,100	17,630,400	28,664,300	201,300,800
	Total Miles	1,091.854	899.857	4,405.320	7,830.064	5,974.773	31,130.316	51,332.184
	DVMT	105,793,900	68,373,100	88,668,500	67,716,100	17,636,600	28,664,300	376,852,500
RURAL TOTALS	NHS Miles	565.939	410.360	26.217	19.738	0.000	0.000	1,022.254
	DVMT	14,917,600	7,626,800	328,500	94,300	0	0	22,967,200
	Other Miles	0.000	38.172	1,182.966	2,583.371	1,421.312	5,467.289	10,693.110
	DVMT	0	327,200	4,394,200	5,018,800	912,800	1,102,000	11,755,000
	Total Miles	565.939	448.532	1,209.183	2,603.109	1,421.312	5,467.289	11,715.364
	DVMT	14,917,600	7,954,000	4,722,700	5,113,100	912,800	1,102,000	34,722,200
RURAL & URBAN TOTALS	NHS Miles	1,091.854	820.061	191.449	26.574	2.000	0.000	2,131.938
	DVMT	105,793,900	66,123,300	3,412,300	216,000	6,200	0	175,551,700
	Other Miles	0.000	79.796	4,213.871	7,803.490	5,972.773	31,130.316	49,200.246
	DVMT	0	2,249,800	85,256,200	67,500,100	17,630,400	28,664,300	201,300,800
	Total Miles	1,091.854	899.857	4,405.320	7,830.064	5,974.773	31,130.316	51,332.184
	DVMT	105,793,900	68,373,100	88,668,500	67,716,100	17,636,600	28,664,300	376,852,500
URBAN DISTRIBUTION (ACROSS)	NHS Miles	47.39%	36.92%	14.89%	0.62%	0.18%	0.00%	100.00%
	DVMT	59.56%	38.34%	2.02%	0.08%	0.00%	0.00%	100.00%
	Other Miles	0.00%	0.11%	7.87%	13.56%	11.82%	66.64%	100.00%
	DVMT	0.00%	1.01%	42.66%	32.96%	8.82%	14.54%	100.00%
	Total Miles	1.33%	1.14%	8.07%	13.19%	11.49%	64.78%	100.00%
	DVMT	26.56%	17.66%	24.54%	18.30%	4.89%	8.06%	100.00%
RURAL DISTRIBUTION (ACROSS)	NHS Miles	55.36%	40.14%	2.56%	1.93%	0.00%	0.00%	100.00%
	DVMT	64.95%	33.21%	1.43%	0.41%	0.00%	0.00%	100.00%
	Other Miles	0.00%	0.36%	11.06%	24.16%	13.29%	51.13%	100.00%
	DVMT	0.00%	2.78%	37.38%	42.70%	7.77%	9.37%	100.00%
	Total Miles	4.83%	3.83%	10.32%	22.22%	12.13%	46.67%	100.00%
	DVMT	42.96%	22.91%	13.60%	14.73%	2.63%	3.17%	100.00%
RURAL & URBAN DISTRIBUTION (ACROSS)	NHS Miles	51.21%	38.47%	8.98%	1.25%	0.09%	0.00%	100.00%
	DVMT	60.26%	37.67%	1.94%	0.12%	0.00%	0.00%	100.00%
	Other Miles	0.00%	0.16%	8.56%	15.86%	12.14%	63.27%	100.00%
	DVMT	0.00%	1.12%	42.35%	33.53%	8.76%	14.24%	100.00%
	Total Miles	2.13%	1.75%	8.58%	15.25%	11.64%	60.64%	100.00%
	DVMT	28.07%	18.14%	23.53%	17.97%	4.68%	7.61%	100.00%