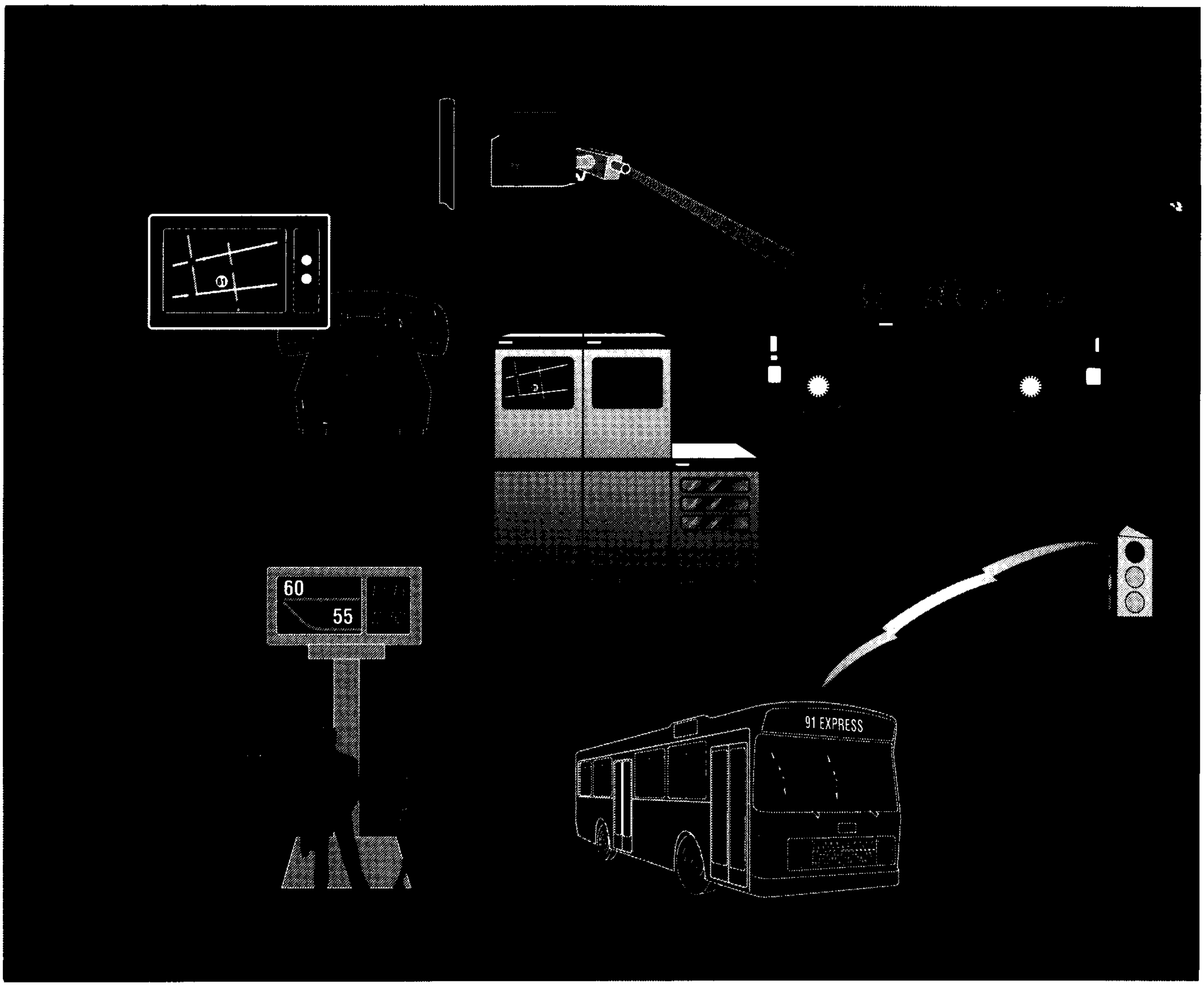
U. S. Department
of Transportation

Federal Transit
Administration

Cost Estimates for Selected California Smart Traveler Operational Tests

March 1993



ADVANCED PUBLIC TRANSPORTATION SYSTEMS PROGRAM
A Component of the Departmental IVHS Initiative

Office of Technical Assistance and Safety

This document was originally submitted by the contractor who prepared it with a number of technical appendices. These appendices have been edited from this printing to reduce the length of the summary document, and published in a second volume. Readers interested in the appendices may obtain them at cost from the National Technical Information Service (NTIS), Springfield, Virginia 22161. The order number for Volume 2, Technical Appendices through NTIS is PB 93-219608. The NTIS Order Desk can be reached by telephone at (703) 487-4600.

Cost Estimates for Selected California Smart Traveler Operational Tests

Volume 1, Technical Report
March 1993

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Distributed in Cooperation with

Technology Sharing Program
U.S. Department of Transportation
Washington, D.C. 20590

DOT-T-93-31

ABSTRACT

The original "California Smart Traveler" report describes how telephone-based information systems can be used to develop new types of public transportation services (e.g. single-trip carpools) and to integrate these new services with conventional transit, paratransit and ridesharing modes.

This report provides estimates of the costs of conducting operational tests of California Smart Traveler concepts in 1) San Ramon/Pleasanton/Livermore, 2) UCLA/Westwood, and 3) San Diego's North City area. These cost estimates were based in large measure on data from Germany and on discussions with German and Australian transit experts who are now conducting an operational test of a "smart-bus" system in Shellharbour, New South Wales.

This report also compares the costs of using "smart-traveler" approaches with the costs of expanding conventional transit services to reduce traffic congestion, air pollution and mobility problems in suburban areas, where most people in U.S. metropolitan areas now live and work. The Executive Summary outlines why "smart-traveler" systems should be recognized as an outstanding business opportunity by on-line information service providers.

This report was designed to be a working document. It is anticipated that schedules, cost estimates, ridership projections, etc. will be modified in the future as hardware and software prices decline and as more experience is gained from operational tests of "smart traveler" concepts in the U.S. and in other countries.

ACKNOWLEDGEMENTS

The author appreciates the assistance of Patrick Conroy and Robert Ratcliff of the Advanced Transportation Management and Information Systems-Office of Caltrans and Ronald J. Fisher and Ronald Boenau of the Advanced Public Transportation System (APTS) Program Office of the Federal Transit Administration (FTA).

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It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more difficult to manage than the creation of a new system. For the initiator has the enmity of all who would profit by the preservation of the old institution and merely lukewarm defenders in those who would gain by the new ones.

(Machiavelli, The Prince)

EXECUTIVE SUMMARY

(An IVHS Business Opportunity for YOURCORP*)

YOURCORP has an opportunity to become an active participant, if not a leader, in the use of telephone-based information systems to reduce traffic congestion, gasoline consumption, air pollution and mobility problems in urban, suburban and rural areas. This is a multi-million dollar business opportunity. For example, it appears that telephone-based Advanced Traveler Information Systems (ATIS) could double the annual revenues of the U.S. telephone industry within the next 25 years, while improving the quality of life of almost all Americans. Both the U.S. Department of Transportation (DOT) and California's Department of Transportation (Caltrans) are interested in teaming with the private sector and local governments to test ATIS concepts.

BACKGROUND

According to the 1992 Statistical Abstracts of the United States (1988 data), there are 53.5 million (41%) more automobiles (including vans and small trucks) in the U.S. than telephone access lines (i.e. unique telephone numbers). In addition, the average spending per automobile ($173/month) in the U.S. is almost six times higher than the average spending per telephone access line ($30/month). As a result, Americans spend eight times as much on their automobiles ($371 billion) as they spend on their telephones ($47.2 billion) each year. In fact, Americans spend 64 percent more on gasoline for their automobiles ($77.3 billion) than they spend on their telephones each year.

If a strategy could be developed that would transfer thirteen percent (13%) of the spending on automobiles to Advanced Traveler Information Systems (ATIS), it would create a new industry with annual revenues equal to those of the U.S. telephone industry. The "California Smart Traveler System" report (DOT-T-92-16) outlines how this could be done. This report describes the costs of conducting operational tests of three Smart Traveler systems in suburban areas of San Diego, Los Angeles and San Francisco.

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* YOURCORP is any company that provides on-line information systems or services.

STATEMENT OF THE PROBLEM

Jane Hall, an economist at Cal State-Fullerton, estimates that dirty air in the Los Angeles area kills 1,600 people and costs $10 billion a year. The American Public Health Association estimates the medical problems caused by gasoline pollution cost Americans $40 billion each year. USDOT estimates that traffic congestion now costs motorists more than $100 billion per year in wasted time and wasted fuel. Furthermore, traffic congestion is growing much faster than the population in most U.S. metropolitan areas.

State and local governments also spend billions of dollars more each year on highway construction and maintenance than they collect in gasoline taxes and other highway user fees. In 1985, for example, governments spent $58 billion on highway and other roadway construction and maintenance projects but collected only $36 billion in gas taxes, tolls and highway user fees,. Several environmental analysts estimate that Americans subsidize automobiles, vans and small trucks by over $200 billion each year when environmental, health and other factors are considered. Some favor raising gasoline taxes by $3 - $4 per gallon to eliminate these subsidies, to discourage the use of single-occupant automobiles, and to increase the general funds.

Others favor using some or all of the additional revenue generated by raising gasoline taxes to expand conventional transit services. Unfortunately, expanding conventional transit services has not proven to be a cost-effective way to reduce the use of single-occupant vehicles in most U.S. cities in recent years. Although federal, state and local governments have spent over $150 billion (in 1992 dollars) to subsidize bus and rail transit services during the past 25 years, per capita transit ridership has continued to decline. Transit's share of work commuting trips in U.S. urbanized areas has also continued to decline during this period, from 24.6% in 1960, to 13.6% in 1970, to 9.5% in 1980, to approximately 7% in 1990.

One reason for the decline of transit's market share is the subsidies provided to the automobile. Drivers, particularly single-occupant vehicle drivers, are not paying for the full costs of traffic congestion and other problems they cause. A second reason is the dramatic shift of residences and jobs from the central cities to suburban communities of most U.S. metropolitan areas. The 1990 Census shows that more than two-thirds of all workers in U.S. metropolitan areas now have their homes in the suburbs and more than two-thirds of these workers also have their jobs in the suburbs. Journey-to-work data collected by the Census Bureau show that less than two percent of suburb-to-suburb commuting trips in the U.S. are made by public transportation. Fixed-route bus and rail transit services tend to have very high costs-per-passenger-trip in low-density areas and it would be prohibitively expensive to provide high-quality, fixed-route transit services for suburb-to-suburb or rural-to-rural travel.

Nevertheless, political and other pressures have led many transit agencies to expand bus and rail transit services in suburban and rural areas. This approach increased transit's share of work and non-work trips very little, but it reduced the productivity of transit operations significantly because transit vehicles operating in low-density areas tend to carry fewer passengers per vehicle-mile. Chasing the suburban market also increased the costs of bus and rail services for passengers, taxpayers and transit operators. In real terms, fares per passenger trip are 60 percent higher, subsidies per passenger trip are 120 percent higher and total costs per passenger trip are 180 percent higher today than they were 25 years ago in the United States.

Last year, U.S. highway officials formally acknowledged that the U.S. can't pave (or build) its way out of traffic congestion, air pollution and mobility problems. Within the next year or two, U.S. transit officials will probably acknowledge that the U.S. can't talk (or plan) its way out of these problems using only conventional transit, paratransit (e.g., taxis, jitneys, dial-a-ride) and ridesharing modes. Something else is needed.

DISCUSSION

To this end, innovative highway and transit agencies throughout the United States are now looking for ways that new technologies can help them develop more cost-effective transportation systems in urban, suburban and rural areas. The Intelligent Vehicle-Highway System (IVHS) program was established in 1991 to marry telecommunications, computers and other electronics technologies with the U.S., transportation infrastructure. This program is expected to be considerably larger than the U.S. Interstate Highway program, which President Eisenhower once described as the "greatest public works program in the history of the world."

Dr. James Costantino estimates that the public and private sectors will spend over $222 billion on IVHS technologies during the next 20 years. Dr. Costantino is Executive Director of IVHS-America, a public-private partnership of nearly 300 organizations that advises the U.S. Department of Transportation (USDOT) on IVHS. One of the major components of the IVHS program is Advanced Traveler Information Systems (ATIS). Another is Advanced Public Transportation Systems (APTS).

ATIS may be defined as the use of IVHS technologies to provide drivers and riders with better information on which to make local and regional travel decisions. APTS may be defined as the use of IVHS technologies to improve the cost-effectiveness of transit, paratransit and ridesharing services. The California Smart Traveler System includes ATIS, APTS and other IVHS components.

European countries are further along in ATIS/APTS activities than the United States. The following are several examples of European ATIS/APTS concepts that soon will be tested with federal, state and local funds in the United States:

1. Minnesota's Department of Transportation (MnDOT) is planning to distribute transit and traffic information to the public via videotex. US WEST will provide MnDOT with both outdoor kiosks and Minitel terminals. Telephone-based transportation information services have proven to be popular in France, which now has more than 6 million videotex service subscribers.

2. The Ann Arbor Transportation Authority (AATA) in Michigan is planning to use "smart-cards" to develop a cashless, distance-based fare collection system. Cities in France and Germany that have installed these systems have seem their ridership increase and their costs per passenger trip decline. It appears that fixed-fares discouraged people from making short trips via transit. The fares per passenger-mile for short trips were too high. "Smart-cards" may also be used for pay phones, parking meters, automatic teller machines, etc. They are also used in some new micro-cellular (PCN) phones to reduce billing fraud.

3. The Chicago Transit Authority (CTA) is expected to award a contract by the end of 1992 for 2,200 on-board computers and an integrated digital data transmission system. This system will give managers and the public better information about bus arrival times, passenger loads, etc. Similar "smart bus" systems are operating successfully in a number of European cities.

The California Smart Traveler project, as part of Caltran's IVHS program, has been evaluating the best ways to add conventional carpool matching, single-trip carpool matching, audiotex/videotex inquiry, and door-to-door dispatching capabilities to the European "smart-bus" designs.

The resulting system could look and operate very much like a 9-1-1 Emergency Vehicle Dispatching System. Instead of dispatching, fire trucks, ambulances and police cars, however, the California Smart Traveler computers would dispatch buses, minibuses and automobiles (e.g., taxis, single-trip carpools) to pick up passengers who had "called" for rides via touch-tone telephones, videotex terminals, PCs, cellular phones or PCN phones, kiosks, cable TV sets, etc. The flexible-route vehicles would be integrated with fixed-route buses, trains and ferries to form a new personalized public transportation system.

Market research studies indicate that these Advanced Public Transportation Systems (APTS) could reduce the use of single-occupant automobiles by 20 percent and traffic congestion delays by 50 percent in U.S. metropolitan areas without major increases in government (i.e. taxpayer) subsidies. Subsidies for California Smart Traveler systems will be low because these systems will make extensive use of single-trip carpools (aka parataxis) and other innovative ridesharing services.

Parataxis are a new mode of public transportation that offer the comfort and convenience of a taxi and the economic and environmental benefits of a carpool. Although parataxi drivers will be paid for some of their travel expenses, their role in providing affordable local transportation services will be similar to the role played by volunteers in providing affordable fire, police and ambulance services in many communities. California Smart Traveler Systems will also be able to generate revenues by providing information services for drivers, riders and advertisers.

CONCLUSIONS

Many transportation researchers have pointed out that the traffic congestion, gasoline consumption, air pollution and mobility problems of the United States are not caused by a shortage of transportation resources. Most U.S. communities have enough buses, vans and automobiles to transport all their residents at the same time, using only the front seats of the automobiles.

Most U.S. communities also have enough roadways to transport all these residents at the same time without traffic congestion. Most of our transportation and transportation-related energy and environmental problems in the U.S. are a direct result of not managing our available transportation resources very well. On-line, telephone-based information systems can provide the tools necessary and sufficient to manage local and regional transportation resources in a cost-effective manner.

Based on market research surveys conducted in Honolulu, it appears that millions of American families would be willing to pay $10, $15 or more each month for transportation information services that could save them $50 to $250 per month by eliminating the need for a second (or third) car or by sharing driving expenses with neighbors and co-workers. Information services that would permit them to bank-at-home, shop-at-home, send and receive electronic mail, take training courses, etc., would be "icing on the cake". These on-line, telephone-based information services would not only help reduce traffic and parking congestion by reducing the need to travel, they would also help pay for some of the costs of the common information "highway".

One of the reasons for the success of videotex information services in France was the availability of government funds to underwrite the development of electronic telephone directory services. This "anchor" application provided the critical mass of users necessary to gradually attract thousands of other privately-operated information services to the Minitel videotex system. The availability of government funds to underwrite the development of telephone-based Advanced Traveler Information Systems (ATIS) and Advanced Public Transportation Systems (APTS) could provide the "anchor" application necessary to stimulate the rapid growth of the U.S. videotex (including audiotex) industry.

RECOMMENDATIONS

Corporations interested in learning more about Advanced Traveler Information Systems (ATIS) and Advanced Public Transportation Systems (APTS) should read the Department of Transportation's "IVHS Strategic Plan - A Report to Congress". Corporations interested in learning more about the Caltrans ATIS and APTS programs should read "California Smart Traveler System". It contains functional specifications for a user-friendly, on-line, traveler information system. Both are available from the U.S. Department of Transportation in Washington D.C. (Telephone: (202) 366-6394)

Corporations interested in learning more about the objectives and the estimated costs of operational tests of California Smart Traveler systems in the San Diego, Los Angeles and San Francisco metropolitan areas, should read the rest of this report. Caltrans is now developing a strategic plan for the California Smart Traveler program. It should be available by the end of 1993. For additional information contact Robert Ratcliff at (916) 323-2644.

BACKGROUND

The Advanced Public Transportation Systems (APTS) program is a high-priority program, established by the Federal Transit Administration (FTA), to use computers, telecommunications and other electronic technologies to improve the cost-effectiveness of public transportation services in urban, suburban and rural areas.

APTS is part of the much-larger Intelligent Vehicle-Highway System (IVHS) program, often called the "smart-cars, smart-highways" program. IVHS uses new information systems technologies to develop better ways to reduce traffic congestion, gasoline consumption, air pollution and other ground transportation problems.

It is estimated that public and private organizations in the U.S. will spend over $222 billion on IVHS, including APTS, during the next 20 years (1). Japan, Germany, England, France and other countries will spend many billions of dollars more to design, develop and implement their own IVHS programs.

Some people are skeptical about investing huge sums on "new-fangled" IVHS programs when "tried-and-true" highway departments and transit agencies need more money. This skepticism appears to be more pronounced among transit advocates. There are several reasons for this.

Firstly, many highway industry leaders have formally admitted that we can't build (or pave) our way out of traffic congestion. They and their followers recognize that there is not enough money or land to expand urban highway construction programs and they are actively looking for new approaches that can help them do more with existing resources.

Secondly, the name and nicknames of the IVHS program turn-off many transit advocates. In fact, most of these advocates believe we have already spent too much money on cars and highways. They don't like the idea of spending a great deal of more money on smart (or other) vehicles, highways or vehicle-highway programs. Brian Clymer, FTA Administrator, summarized the feelings of those who consider themselves both transit and IVHS/APTS advocates when he stated "the only thing I don't like about the IVHS program is its name" (2).

Thirdly, very few U.S. transit managers have been willing to state publicly that we can't plan (or talk) people out of their single-occupant vehicles using only traditional transit, paratransit and ridesharing approaches. However, market research surveys conducted by

Table 1
1989 Roadway Congestion Index Values
From "Roadway Congestion Estimates and Trends - 1989" (Report 1131-4) by The Texas Transportation Institute (TTI).

URBAN AREA	ROADWAY* CONGESTION INDEX	RANK
Los Angeles, CA	1.54	1
San Francisco-Oakland, CA	1.36	2
Washington D.C.	1.36	2
Miami, FL	1.25	4
Chicago, IL	1.21	5
Seattle-Everett, WA	1.21	8
San Diego, CA	1.18	9
San Jose, CA	1.17	10
San Bernardino-Riverside, CA	1.16	11
Atlanta, GA	1.14	11
Houston, TX	1.13	13
New Orleans, LA	1.13	14
New York, NY	1.12	14
Boston, MA	1.09	16
Honolulu, HI	1.09	17
Detroit, MI	1.08	17
Jacksonville, FL	1.07	19
Portland, OR	1.07	20
Philadelphia, PA	1.05	20
Phoenix, AZ	1.03	22
Tampa, FL	1.03	23
Dallas, TX	1.02	23
Denver, CO	1.01	25
Sacramento, CA	1.01	25
Baltimore, MD	0.99	25

URBAN AREA	ROADWAY* CONGESTION INDEX	RANK
Ft. Lauderdale, FL	0.99	25
Norfolk, VA	0.99	25
Milwaukee, WI	0.97	28
Austin, TX	0.96	29
St. Louis, MO	0.96	29
Cleveland, OH	0.95	31
Nashville, TN	0.95	31
Cincinnati, OH	0.94	33
Orlando, FL	0.92	34
Albuquerque, NM	0.91	35
Memphis, TN	0.91	35
Minneapolis-St. Paul, MN	0.90	37
Hartford, CT	0.89	38
Fort Worth, TX	0.87	39
San Antonio, TX	0.87	39
Louisville, KY	0.86	41
Indianapolis, IN	0.85	42
Charlotte, NC	0.82	43
Columbus, OH	0.82	43
Pittsburgh, PA	0.82	43
Salt Lake City, UT	0.81	46
Oklahoma City, OK	0.78	47
El Paso, TX	0.74	48
Kansas City, MO	0.72	49
Corpus Christi, TX	0.71	50

Notes:

* The expected delay due to traffic congestion per mile of travel

Commuter Transportation Services (CTS) in Los Angeles in 1991 found that 71 percent of commuters would not even try taking rail and 75 percent of commuters would not even try taking the bus to work.

One purpose of this paper is to describe the decline in the cost-effectiveness of fixed-route bus and rail transit services in U.S. cities, to discuss some of the reasons for this decline, and to outline how IVHS technologies can increase the cost-effectiveness of public transportation services in the future.

Table 1 on the preceding page ranks the 50 largest U.S. urbanized areas according to the severity of their traffic congestion problems. It shows that five of the ten most congested urbanized areas in the U.S. are located in California. Sacramento is the only large urbanized area in the State that is not in the top ten. It ranks 23rd on the list. Table 1 was obtained from a report prepared by the Texas Transportation Institute (TTI) in 1991 (3), using data submitted to the Federal Highway Administration (FHWA) by state transportation agencies.

The Roadway Congestion Index (RCI) presented in Table 1 is a measure of the expected delays due to traffic congestion per mile of travel in an urbanized area. Los Angeles' RCI of 1.54 means that its traffic congestion was 52% percent worse in 1989 than that of Sacramento, which had an RCI of 1.01 that year.

The cost of traffic congestion in Table 2 is made up of three components: (1) time wasted due to congested roadways and incidents, (2) increased fuel consumption, and (3) increased insurance premiums. Wasted time due to traffic congestion accounted

Table 2
1989 Traffic Congestion Costs

Urban Area	Congestion Cost Per Capita Rank in U.S.	Annual Congestion Cost Per Capita	Roadway Congestion Index Rank in U.S.
San Bernadino-Riverside	1	$680	9
San Francisco	2	$630	2
Los Angeles	4	$550	8
San Jose	5	$520	1
San Diego	19	$240	7
Sacramento	19	$240	23

for the largest (approximately 65 percent) of annual congestion costs. In 1988, the total annual cost of congestion in the U.S. exceeded $34 billion (3). Los Angeles and San Francisco accounted for more than $9.2 billion (27%) of this national total by themselves (3).

The U.S. Census Bureau recently released (4) the first results of the journey-to-work data it collected during 1990. Although there were 18.5 million more workers in 1990 than in 1980, as Table 3 shows, the number of people who used public transportation to get to work actually declined during the decade.

Table 3 also shows that the percentage of workers who used transit declined from 6.4% in 1980 to 5.3% in 1990. This should not be surprising, however, because transit's share of work trips in the U.S. has been declining for decades. Note also the large decline in

Table 3
Means of Transportation to Work in the U.S.
1980 and 1990

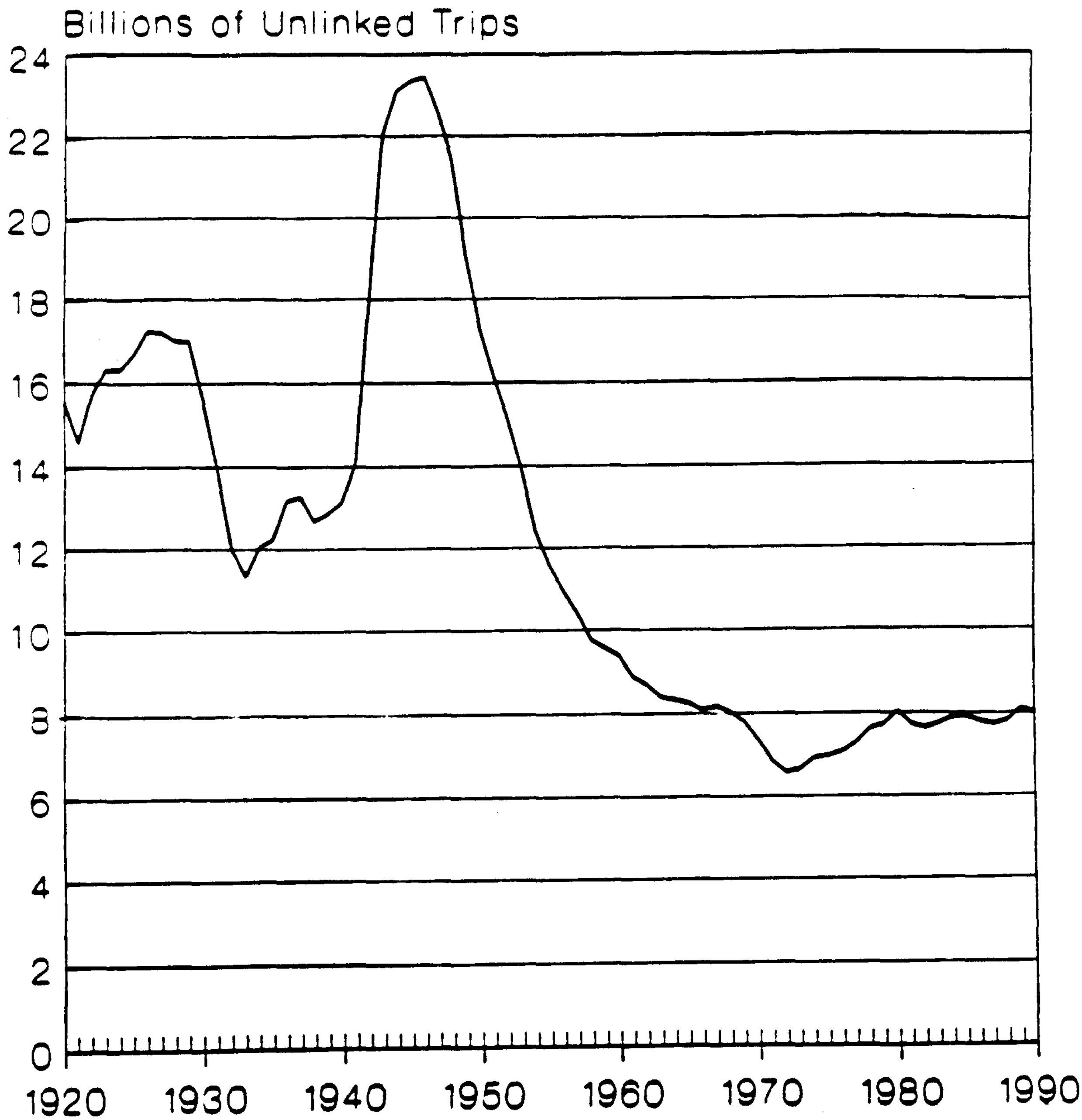
	1990 Census		1980 Census	
	Number	Percent	Number	Percent
Drive Alone	**84,215,298**	**73.2%**	**62,193,449**	**64.4%**
Ride Share	**15,377,634**	**13.4%**	**19,065,047**	**19.7%**
Public Transportation	**6,069,589**	**5.3%**	**6,175,061**	**6.4%**
Other	**9,407,753**	**8.1%**	**9,183,739**	**9.5%**
Totals	**115,070,274**	**100%**	**96,617,296**	**100%**

the use of carpools and vanpools nationally between 1980 and 1990. The decline of ridesharing in the U.S. will be discussed later in the report.

Figure 1, on the following page, shows that the number of passengers carried by the U.S. transit industry in 1990 is approximately the same as it was in 1965. It was obtained from the June 1992 Section 308 Report to Congress by the Secretary of Transportation (5). However, the population of the U.S. increased significantly since 1965. As a result, per capita transit ridership today is only one-half of what it was in 1965.

Declining market share of both commuting and non-commuting trips are not the only

Figure 1
U.S. Transit Patronage
1920 to 1990



Source: ATA/APTA, Transit Fact Books
(1920-1979 Data)
Section 15 (1980-1990 Data)

troubles of the U.S. transit industry. Costs, particularly costs per vehicle mile, increased much faster than inflation since 1965. Transit agencies also increased the total number of vehicle miles of transit services they provided since 1965. As a result, the productivity of the U.S. transit industry declined in terms of annual passengers per employee or passengers per vehicle mile of service.

The following statement is from the June 1992 Report to Congress (5):

> "Transit patronage in the United States has been relatively stable since 1980. It rose to 8.0 billion trips in 1980, but economic recession resulted in a decline by 1982 to about 7.6 billion rides. Total patronage then rose to 7.9 billion in 1985 and 8.0 billion in 1990."

Figure 1 displays this ridership trend.

The following statement is also from the June 1992 Report to Congress (5):

> "In 1990, the cost to operate mass transit service in the United States was approximately $14.7 billion, compared to $13.8 billion the previous year. Capital expenditures by Federal, State and local governments in 1990 were reported as $4.3 billion; they were $3.6 billion in 1989. Adding capital and operating expenses in 1990 produces an overall mass transit expenditure of $19.0 billion. . . . . . . Fares and other revenue collected from direct transit customers, amounting to $6.3 billion, covered about 43 percent of operating costs in 1990."

This statement indicates that capital spending was 26 percent ($3.6 Billion/$13.8 Billion) of operating expenses in 1989 and 29 percent ($4.3 billion/$14.7 billion) in 1990. Few U.S. transit studies provide data on annualized capital costs. This estimate is supported by a study of transit operators in the San Francisco Bay Area (7) by Brian Taylor of UCLA using data collected by MTC in Oakland.

The following statement also appeared in the June 1992 Report to Congress (5):

> "Based on survey data, it is estimated that the 8 billion unlinked transit trips translate into approximately 5.9 billion linked trips. In other words, about 47 percent of transit trips involve at least one vehicle change within the transit system. The proportion of "linked" to "unlinked" trips may have changed over time in systems that have become more complex. .... For example, to adjust to new rapid rail services, transit managers transform many bus routes into feeder services for rail stations,

thus adding a transfer to a formerly one vehicle trip. However, because of market shifts and the general aversion of customers to transfers, it is not evident that in the aggregate there were more transfers in 1990 than in 1980".

This statement indicates that linked trips were 26 percent less than unlinked trips in the U.S. transit industry since 1980. Table 4 summarizes the financial performance of the U.S. transit industry in 1990 based on the statements of the Secretary of Transportation in his June 1982 Report to Congress (5).

Table 4
1990 Financial Performance of the U.S. Transit Industry In Urbanized Areas

Description	Total (billions)	Percent of total	Per Unlinked Passenger Trip	Per Linked Passenger Trip
Operating Costs	$14.7	77 %	$1.84	$2.49
Capital Costs	4.3	23 %	.54	.73
Total Costs	$19.0	100 %	$2.38	$3.22
Passenger Revenues	6.3	33 %	.79	1.07
Total Subsidies	$12.7	67 %	$1.59	$2.15

It should also be noted that these are average values, just as the energy consumption figures of 3,415 BTUs per transit bus passenger- mile, 3,515 BTUs per rail transit passenger-mile and 3,598 BTUs per automobile passenger-mile (See Table 5). There are many transit trips, particularly those in low-density areas, late at night, or on weekends and holidays, that have subsidy levels over $10 per one-way trip and energy consumption levels per passenger mile that are higher than those of single-occupant automobiles.

Table 5
Energy Use by Passenger Vehicles, 1988 (6)

	ENERGY USE (TRILLION BTUs)	LOAD FACTOR (PMT/VMT)	BTU/ PASSENGER MILE
Automobile	8,968.6	1.7	3,598
Transit Bus	73.0	11.4	3,415
Transit Rail	42.2	21.9	3,585
Commuter Rail	21.9	34.5	3,155
Intercity bus	22.3	----	965
Intercity Rail	14.0	20.5	2,462
Air Certificated Route	1,608.9	89.5	4,814

Source: U.S. Department of Energy, Transportation Energy Data Book: Edition 11, Table 213.

The 1990 APTA Transit Fact Book (6) shows that buses operated in urban areas get 38.2 passenger miles per gallon and those operated in non-urban areas get 23.4 passenger miles per gallon. Public transit vehicles do not save a great deal of energy over many new automobile models, particularly when operated in low-density suburban and rural areas.

Figure 2 shows that the costs and taxpayer subsidies per transit passenger trip rose 180 percent and 120 percent (in real terms), respectively between 1965 and 1988. Fares per passenger transit trip are also much higher (in real terms) than they were in 1967. Figure 2 shows that fares per passenger trip have increased 60 percent more than inflation between 1965 and 1988. In fact, fares increased more than 30 percent in real terms between 1979 and 1987 (7). Nevertheless, passenger fares now cover only 33 percent of the total costs of the average transit trip in the United States.

Figure 2
Changes in Transit Revenues, Costs and Subsidies Per Passenger Trip, Adjusted for Inflation 1965-1988 (8)

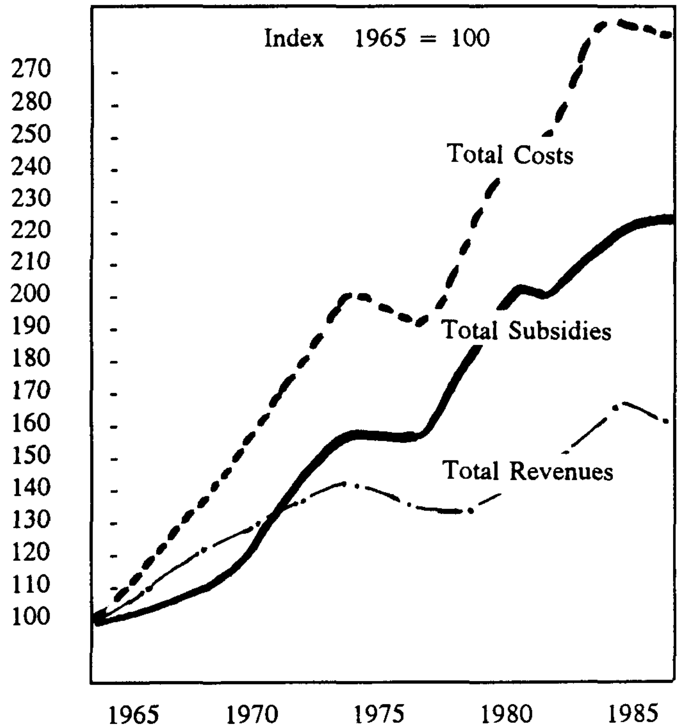
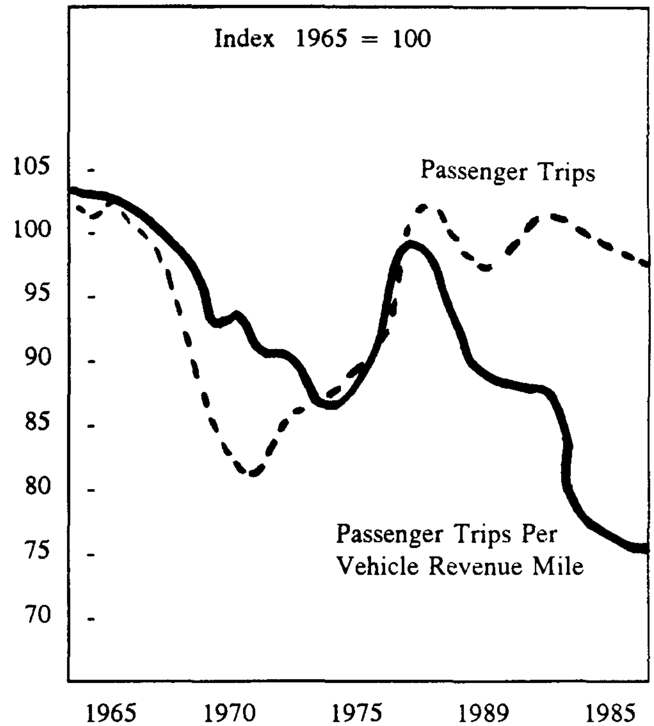


Figure 3
Changes in Passenger Trips and Passenger Trips Per Vehicle Revenue Miles 1965-1988 (8)



Both Figure 2 and 3 were obtained from the February 1991 Report to Congress by the Secretary of transportation (8).

As previously discussed, one of the reasons for the increases in transit subsidies is the decline in the productivity of the U.S. transit industry. As Figure 3 shows, the number of passenger trips per transit vehicle revenue mile has dropped more than 25 percent since 1980. One of the major reasons for this decline in transit's productivity has been the rapid growth of jobs and residences in low-density suburban areas.

Table 6 shows that in 1960 only 35.7 percent of workers who lived in medium- and large-sized metropolitan areas (SMSAs) in the United States had jobs in the suburbs. By 1980, however, 48.5 percent of workers in these SMSAs had jobs in the suburbs (9).

Table 6
Change in Journey-to-Work Trips by Workers Who Live and Work Within SMSAs With a Population of 250,000 or More (9)

Type of Journey-To-Work		Percent of Workers		
Place of Residence	Place of Employment	1960	1970	1980
Central City	Central City	47.2%	37.6%	31.7%
Central City	Suburbs	5.2%	7.5%	6.6%
Suburbs	Central City	17.1%	18.6%	19.8%
Suburbs	Suburbs	30.5%	36.3%	41.9%
	SMSA TOTAL	100.0%	100.0%	100.0%

The 1990 Census is expected to show that over 50 percent of all workers in the SMSAs now work in the suburbs, and more than 85 percent of these workers also live in the suburbs.

Since suburb-to-suburb service tends to be very costly for U.S. transit agencies, on a cost per passenger-trip basis, the quality of bus and rail transit services for most suburb-to-suburb trips is low. As a result, as Table 7 shows, only 1 - 2 percent of U.S. suburb-to-suburb commuters used public transportation to get to work in 1980. This situation has not changed.

Commuter trips between the suburbs and central cities and between central cities and the suburbs have also increased since 1960 (9). Although these commuting trips have much higher transit ridership rates than suburb-to-suburb trips (See Table 7), they also tend to be very costly, on a passenger-trip basis, for U.S. transit agencies.

One reason for this is the loads tend to be highly directional. Three times as many workers commute from suburbs into jobs in central cities as vise versa (See Table 6) and, therefore, average transit vehicle occupancy rates tend to be low. In addition, seating is limited and travel by transit is uncomfortable for many commuters in the peak direction.

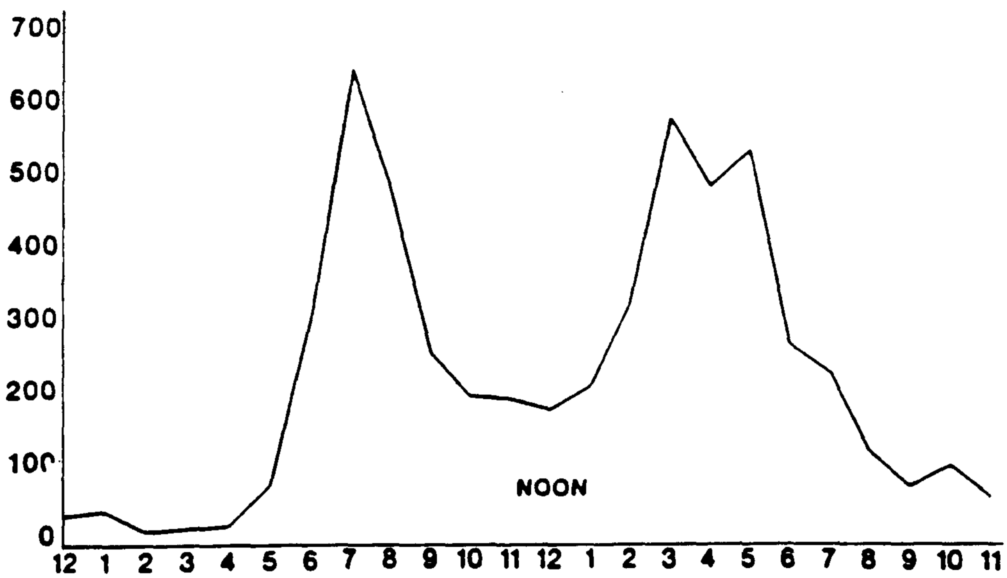
Table 7
The Means of Transportation for Each Type of Journey-To-Work Trip By Workers Who Lived and Worked in SMSAs in 1980 (9)

Type of Commuter Work Trip		Percent of Workers For Each Mode				
Place of Residence	Place of Employment	Drive Alone	Ride Share	Public Transportation	Other Means	Total
Central City	Central City	56.1%	16.3%	16.1%	11.5%	100.0%
Central City	Suburbs	69.3%	22.1%	5.6%	3.0%	100.0%
Suburbs	Central City	68.1%	22.2%	8.0%	1.8%	100.0%
Suburbs	Suburbs	69.7%	17.8%	1.6%	10.9%	100.0%
	SMSA Average	64.9%	18.4%	8.0%	8.7%	100.0%

(1) Other Means includes walk, bike, motorcycle and work at home.

A second reason for the high costs of these trips is that personnel, vehicles and facilities that are required for peak commuting hours are often under utilized at other times. Figure 4 shows this peaking problem.

Figure 4
Transit Trips by Time of Day* - 1990
Millions of Transit Trips



*Trips Originating in Following Hour
Source: Nationwide Personal Transportation Study, 1990

A third reason is trips between the suburbs and downtown tend to be longer than other transit trips. Since transit agencies throughout the U.S. have been under political pressures to provide good transit services for suburb-to-downtown commuters, transit cost and subsidy levels have skyrocketed during the past 25 years. Several prominent transportation researchers in California

> "have noted the role transit subsidies have played in the expansion of suburban public transit (Dr. Martin Wachs of UCLA (10)). Subsidies have helped keep fares low, and encouraged the growth of flat fares and unlimited ride passes which favor long-distance, suburban commuters (Dr. Robert Cervero of UC-Berkeley (11)). Wachs observed (12) that a growing number of suburban representatives on transit boards and commissions consistently demand increased transit service in the areas they represent ... (thereby) effectively representing their constituencies, who do contribute a growing proportion of transit subsidy support. Their advocacy results in systematic shifts of transit service toward relatively expensive and highly subsidized peak-hour runs between suburbs and downtown, and toward relatively lightly used suburban local services" ... The result is a proliferation of new, well-funded and expanding suburban transit operators that attract few patrons while older, central city transit operators, in spite of heavy ridership, are forced to cut service because of funding shortfalls." (7)

Table 8 shows how transit operating subsidies per passenger trip increase as one moves from the central city to suburban areas. Table 8 also shows how transit ridership per capita declines as one moves from the central city to established suburban areas where large operators provide transit services, and then to newer, fast-growing suburban areas where small operators provide transit services. It is almost certain that operating subsidies per passenger trip would rise significantly if small suburban operators had to match the annual ridership per capita of the Bay Area's large suburban operators.

Appendix A compares and contrasts the journey-to-work travel modes in 1980 and 1990 for seven of California's most traffic congested counties and for the United States. Table 9 was prepared from the data in Appendix A. It shows that the total number of workers who lived in each of these counties grew dramatically (i.e. between 21.7 percent and 44.1 percent) during the 1980s. Table 9 also shows that the percentage of these workers who drove to work alone grew even more dramatically (i.e. between 24.1 percent and 59.9 percent) during the 1980s.

Table 8
Public Transit in the San Francisco Bay Area
Fiscal Year 1987-1988

	Annual Ridership Per Capita	Passenger Trips Per Vehicle Hour	Annual Operating Subsidy Per Capita	Operating Subsidy Per Passenger Trip
Central City Operators				
San Francisco Muni	329.2	78.2	$222	$ .68
AC Transit	56.5	32.5	72	1.27
Average	167.0	55.3	133	.80
Trunk-Line Rail Operators				
BART	NA	54.3	NA	1.45
CalTrain	NA	NA	NA	3.00
Average	NA	NA	NA	1.58
Large Suburban Operators				
Santa Clara Transit	24.8	25.5	65	2.61
Sam-Trans	27.8	30.1	41	1.48
Golden Gate Transit	28.3	24.6	76	2.68
Average	27.0	26.7	62	2.29
Small Suburban Operators				
CCCTA	8.5	15.7	20	2.40
Vallejo Transit	14.0	25.8	14	1.03
Santa Rosa City Bus	9.9	20.9	14	1.39
Sonoma County Transit	6.2	15.1	17	2.80
Tri Delta	3.3	10.3	11	3.40
Napa VINE	7.5	18.6	10	1.39
Wheels (LAVTA)	3.0	8.3	16	5.20
Union City Flea	7.9	15.3	18	2.34
Fairfield Transit	3.0	15.4	6	1.92
WCCCTA	3.8	6.5	16	4.32
Average	6.7	15.2	15	2.22

NOTES:

(a) Taylor (7) shows this value as 192.8

(b) Taylor (7) shows this value as $153

(c) USDOT/FTA Section 15 Report Data (1987) provided this value of passenger trips per vehicle revenue hour (13)

(d) These exclusive guideway rail systems have much higher capital subsidies per passenger trip than bus and light rail transit operators.

Note that the number of residents in each county who chose to drive to work alone increased faster than the number of workers who lived in each county. Orange County was the only one of the seven counties in which transit showed an increase in market share. In 1980, 2.1 percent of Orange County residents commuted to work by public transit. In 1990, 2.5 percent of these workers used transit. However, the decline in the use of carpools and vanpools in Orange County offset the gains in transit ridership. As a result, the percentage of residents of Orange County who drove to work alone increased from 74.7 percent in 1980 to 76.7 percent in 1990. The percentage of workers who shared rides to work declined in all seven counties.

Table 9
Growth Rates in Selected California Counties
1980-1990

County Name	Increase in Workers Who Live in County		Increase in Drive-Alone Commuters	
	Number	Percent	Number	Percent
Los Angeles	735,100	21.7	560,000	24.1
Alameda	126,000	24.8	110,400	35.3
Orange	316,400	32.9	262,200	36.5
Contra Costa	101,800	34.0	85,600	42.5
Sacramento	141,100	41.4	126,400	52.9
Ventura	100,300	42.7	91,900	56.4
San Diego	376,700	44.1	326,900	59.9

STATEMENT OF THE PROBLEM

In December 1989, the Institute of Transportation Engineers (ITE) Journal (14) published an article "Urban Freeway Congestion Problems and Solutions: An Update". The article contained the following table which shows that a relatively small reduction in the number of single-occupant automobiles on the highways could provide dramatic reductions in traffic congestion delays.

Table 10
Demand Reduction Analysis

	Total Delay (million vehicle-hours)	Delay Reduction (%)
Base Conditions	2,015	---
Demand Reduction 1 of every 10 Single-Occupant Vehicles Removed	1,038	48
1 of every 5 Single-Occupant Vehicles Removed	644	68

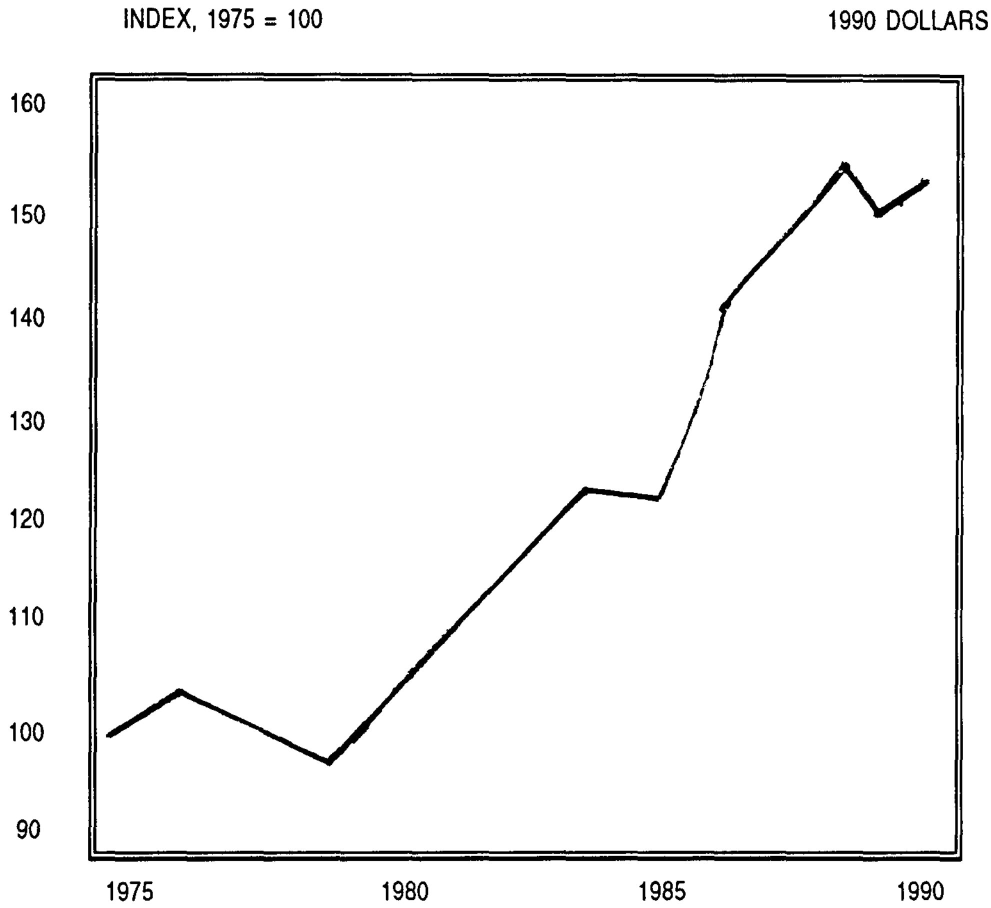
The ITE article was written by Jeffrey Lindley, a highway research engineer with the Federal Highway Administration (FHWA), using data provided by state transportation agencies for FHWA's Highway Performance Monitoring System (HPMS) database.

Table 10 indicates that if improved public transportation services, could have taken 20 percent of the single-occupant vehicles off U.S. highways in 1987, it would have reduced traffic congestion delays by 68 percent. Table 10 also shows that reducing the number of single-occupant vehicles on U.S. highways by only 10 percent in 1987 would have cut traffic congestion delays almost in half.

Unfortunately, expanding conventional transit services enough to take 10 percent or 20 percent of the single-occupant cars off the road in 1995 or 2000 would be very costly for taxpayers. To estimate how costly, consider how much subsidies and ridership increased after transit services (i.e. revenue vehicle hours) were increased 20 percent in the U.S. between 1980 and 1990 (5).

The statement on page 12 by the Secretary of Transportation implies that transit ridership in U.S. urbanized areas as more than 7.950 billion in 1980 and less than 8.050 billion

Figure 5
Change in Operating Cost Per Passenger
1975 - 1990



in 1990. At best, the annual transit ridership in 1990 was .100 billion (100 million) higher than it was in 1980.

Figure 5, from the June 1992 Report to Congress (5) shows that operating costs per passenger trip rose 48 percent in real terms between 1980 and 1990. "Aggregate real fare revenue per passenger mile increased by 38 percent between 1980 and 1990, from 11.8 cents to 16.2 cents ... The average (passenger) trip length in 1980 was 4.4 miles and in 1990 was 4.8 miles" (5). Consequently, fare revenues increased from 53 cents per passenger trip in 1980 (in 1990 dollars) to 79 cents per passenger trip in 1990. Assuming that capital costs in the U.S. transit industry were also 23 percent of total transit costs, one can use these facts to prepare a financial profile of the U.S. transit industry in 1980.

Table 11
1980 Financial Performance of the U.S. Transit Industry In Urbanized Areas (In 1990 dollars)

Description	Total (billions)	Percent of Total	Per Unlinked Passenger Trip	Per Linked Passenger Trip
Operating Costs	$9.9	77%	$1.24	$1.68
Capital Costs	2.9	23%	.36	.49
Total Costs	$12.8	100%	$1.60	$2.17
Passenger Revenues	4.2	33%	.53	.72
Total Subsidies	$ 8.6	67%	$1.07	$1.45

Comparing Table 11 with Table 4 shows that annual subsidies for the U.S. transit industry jumped $4.1 billion (in constant 1990 dollars) from $8.6 billion in 1980 to $12.7 billion in 1990. Even with a maximum gain of 0.1 billion passenger trips per year between 1980 and 1990, the average subsidy per new (i.e. additional) unlinked passenger trip was over $40 (in 1990 dollars). The average subsidy per new linked passenger trip was over $54 (in 1990 dollars).

Examination of Figure 1 and the Secretary of Transportation's statement on page 12 shows that the lowest annual ridership in the U.S. transit industry between 1980 and 1990 occurred in 1982 when it dropped to about 7.6 billion passenger trips. The gain in annual transit ridership between 1982 and 1990, therefore, was 0.4 billion passenger trips. Even with a "best case" gain of 0.4 billion passenger trips per year between 1980 and 1990, the "best case" subsidy per new (i.e. additional) unlinked passenger trip would be just over $10 (in 1990 dollars). The "best case" subsidy per new linked passenger trip would be just over $13.50 (in 1990 dollars).

Assuming that a typical commuter makes 220 round trips per year, the increased annual transit subsidies required to take each additional single-occupant vehicle off the road between 1980 and 1990 was $5,940 (440 trips at $13.50 per linked trip). This is the "best case" value of the increased costs to taxpayers.

Although costs or subsidies of $10 or more per new passenger trip may surprise some readers, they should not surprise those who are familiar with FTA's Alternatives Analysis procedure for evaluating proposed new projects, such as new rail lines. These procedures were instituted to highlight the projected cost per new trip for decision-makers, because it is such an important factor in evaluating the cost-effectiveness of a proposed transit project.

Table 12
Total Cost Per New Transit Trip For Recent Rail Transit Projects (in 1988 dollars)

HEAVY RAIL	
Washington	$11.97
Atlanta	29.47
Baltimore	13.56
Miami	(Note 1)
LIGHT RAIL	
Buffalo	(Note 1)
Pittsburgh	$34.64
Portland	9.49
Sacramento	(Note 1)

Note 1: The cost per new transit trip could not be computed for this city because transit ridership declined after the introduction of the new rail service.

Source: "Urban Rail Transit Projects: Forecast Versus Actual Ridership and Costs", USDOT/UMTA-October 1989 (15).

Table 12 shows the cost per new transit trip (in 1988 dollars) of all of the new rail transit systems built in the U.S. with federal aid since 1975. These data were obtained from an UMTA/FTA sponsored-study known as the Pickrell Report. One can easily see that the average cost per new passenger trip for each of these rail projects was well above $10 (in 1990 dollars).

It should be noted that each of the above rail projects was built in a well-defined, highly-traveled corridor after alternatives analysis showed that each would have a lower cost per new trip than an expanded bus system. It should also be noted that suburb-to-downtown trips tend to be less costly than suburb-to-suburb trips for U.S. transit agencies. Expanding suburb-to-suburb bus services, therefore, would tend to be very costly on a cost per new passenger trip basis.

Table 13
Demand-Response Transit Operating Costs
Per Passenger Trip (in 1987 dollars)

NUMBER OF VEHICLES IN MAXIMUM SERVICE	
Under 25	$8.40
25-49	$8.65
50-99	11.30
100-249	15.37
All Systems	9.72

Source: "National Urban Mass Transportation Statistics" - 1987 Section 15 Report USDOT/UMTA - September 1989 (13).

Table 13 provides the average costs, rather than the costs per new trip, of dial-a-ride services in the United States in 1987. It shows that average costs per trip tend to increase as these curb-to-curb demand-responsive systems get larger and, presumably, cover larger areas. It also shows that the average costs of dial-a-ride systems with 50 or more vehicles is above $10 per trip (in 1987 dollars).

Expanding the size of these dial-a-ride services significantly would almost certainly generate costs per new trip well-above $10 (in 1990 dollars). Table 13 includes both specialized (i.e. for the aged or those with disabilities) and community (i.e. general purpose) dial-a-ride systems.

It should also be noted that most community dial-a-ride systems in the U.S. were installed after analysis showed that they would have lower costs per passenger trip than fixed-route bus services in the same service area. However, these demand-responsive transit systems would also tend to have low ridership rates (i.e. 3 to 14 unlinked transit trips per capita per year), like the Bay Areas small suburban transit operators listed in Table 8.

Figure 6
Operating Cost Per Passenger Conventional Bus and Dial-A-Ride At Different Ridership Levels

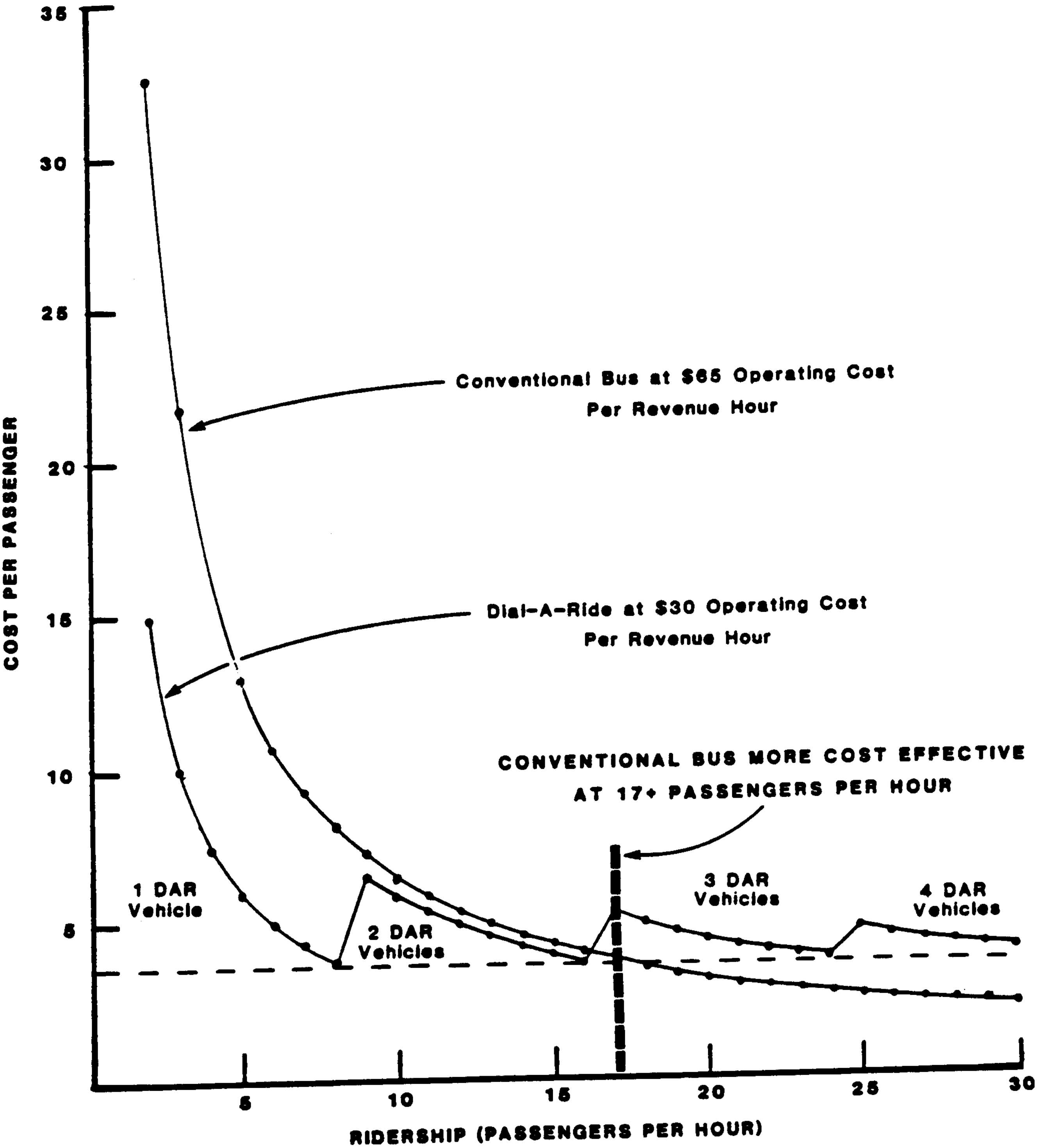


Figure 6 shows that demand-responsive services are more cost-effective than fixed-route transit in low-demand areas. For example, the operating costs of providing dial-a-ride services in areas where productivities are on the order of eight passengers per vehicle service hour is $3.75 per passenger**. On the other hand, the operating cost of providing fixed-route services with conventional buses in areas where productivities are in the order of eight passengers per vehicle service hour*** is $8.13. Figure 6 was obtained from the April 1989 "Suburban Transit Study" by Crain and Associates for Tri-Met in Portland, Oregon (16).

Figure 6 shows that the minimum operating cost for dial-a-ride services is $3.75 per passenger. If total costs are $36 per hour (i.e. 20 percent higher than annual operating costs) the minimum cost for dial-a-ride services is $4.50. Figure 6 shows that dial-a-ride services are more cost-effective than fixed-route buses if the demand is less than 17 passengers per hour. If total costs are $80 per hour (i.e. 20 percent higher than annual operating costs in 1992 dollars), conventional fixed-route bus services would need to attract more than 8 passengers per hour to keep costs per passenger trip under $10.

Taking one single-occupant commuter automobile off the road requires approximately 440 linked transit trips or 600 unlinked transit trips per year. Increasing per capita transit ridership rates within low-density suburban areas enough to take a significant number of single-occupant, suburb-to-suburb commuter automobiles off the road will tend to be very costly for taxpayers. In fact, the cost per new trip of expanding intra-suburban bus or dial-a-ride services to this level will almost certainly be more than $10 (in 1990 dollars).

This $10 subsidy rate per new passenger trip is also supported by USDOT/FTA projections of transit ridership and costs in the United States between 1990 and 2010. The June 1992 Report to Congress (5) contains the following points:

1. "The use of mass transit in the United States increased by 8 percent between 1980 and 1990." However, this was based on increases in passenger miles traveled rather than increases in passenger trips. "The average trip length in 1980 was 4.4 miles and in 1980 it was 4.8 miles."

** This is based on an operating cost of $30 per vehicle service hour for an eight passenger van/minibus.

*** This is based on an operating cost of $65 per vehicle service hour for a full-size bus.

"Transit patronage has been relatively stable since 1980".

2. Between 1980 and 1984 operating costs per passenger trip increased 17 percent in real terms. "Between 1984 and 1990, unit operating costs per vehicle mile stabilized, but service utilization continued to decrease, resulting in a continued rise in both real operating cost per passenger trip (25 percent) and real operating cost per passenger-mile (17 percent)." In real terms, therefore, operating costs per passenger trip increased 42 percent between 1980 and 1990.

3. "The cost to <u>maintain</u> current conditions and performance (on U.S. transit systems) is estimated at $3.89 billion per year (in capital spending)...... at this level of investment the amount of transit service provided would increase at the rate of 0.8 percent per year, consistent with the total rate of increase in transit use (i.e. increase in passenger miles rather than in passenger trips) of the last 10 years. In 20 years this would result in an increase in carrying capacity of 17 percent."

4. "The cost to <u>improve</u> conditions and performance (on U.S. transit systems) is estimated to require an additional $3.61 (93%) billion per year (in capital spending) ...... This is the additional investment needed to increase market share (in terms of passenger miles rather than passenger trips) by 24 percent over a 20 year period". This is a compounded annual growth rate of slightly over 1.0 percent per year for bus and rail transit systems.

5. Of this additional $3.61 billion in capital spending per year, $1.47 billion (41%) is to be used to expand transit use and the remaining $2.14 billion (59%) is to be used to take care of the backlog of deferred investment in transit. These are in constant 1991 dollars.

Based on experiences between 1980 and 1990, a 1.0 percent annual growth rate in passenger miles traveled would provide less than a 0.3 percent annual growth rate in passenger trips for the U.S. transit industry. This would generate a growth of less than 550 million new passenger trips (6.17%) between 1990 and 2010.

Assuming that operating costs per passenger trip only rise at the same rate as capital costs per passenger trip for up to 550 million additional passengers, then the total increased cost in 2010 would be $7.35 billion in constant 1991 dollars - $1.47 billion (20%) in increased capital costs and $5.88 billion (80%) in increased operating costs. This is approximately $7.07 billion in constant 1990 dollars. The cost per new passenger trip over 1990 levels, therefore, would be $12.85 (in 1990 dollars). Assuming that average fares remained at 1990 levels (i.e. $0.66 per passenger trip), then taxpayer subsidies would be over $10 (in 1990 dollars) per new passenger trip attracted to the U.S. transit industry.

Based on the data in Table 12 and Table 13, and the information in the June 1992 Report to Congress (5), it appears that using a value of $10 for the subsidy per new transit trip would be a reasonable way to estimate the cost of doubling or tripling transit ridership in the U.S., using conventional transit and paratransit modes.

The 1990 Census (See Appendix A, Table A8) shows that public transportation carried 6.07 million (5.7%) of the 105.66 million people who commuted to work in motor vehicles in the U.S. in 1990. Single-occupant automobiles, vans and small trucks carried 84.22 million (79.9%) of these 105.66 million commuters. Ridership would have almost had to quadruple in order to have carried 16.84 million (20%) of these single-occupant commuters on public transit in 1990.

How much would it have cost to increase transit ridership by 300 percent in 1990, when most of the increases in ridership would be for suburb-to-suburb trips and for suburb-to-downtown trips?

Table 14 shows, increasing transit ridership 300 percent (at a $10 subsidy per new passenger trip) in 1990 would have increased taxpayer subsidies for transit in the U.S. at least 2,000 percent, from $14 billion per year to $280 billion or more per year. This would be more than a $1,000 per year increase in transit taxes for each man, woman and child in the United States.

Table 14
Pro Forma Analysis of Expanded U.S. Transit System
For 1990

	Ridership	Avg. Subsidy Per Trip	Total Subsidy
1990 Base	8,873 Billion	$ 1.60	$ 14 Billion
300% Increase	26,619 Billion	$ 10.00	$ 266 Billion
Total	35,492 Billion	$ 7.90	$ 280 Billion

It is doubtful that California cities or other U.S. cities would have been able to get the public or their elected officials to approve even half of these increased transit subsidies to reduce traffic congestion and related problems. Furthermore, the costs of reducing traffic congestion by conventional public transit modes will continue to increase as the population and workforce increase. It should be noted that transit services (in terms of revenue vehicle hours) increased by 20 percent (5) and the workforce increased by 19.1 percent between 1980 and 1990. However, Table 3 shows transit ridership by commuters was flat, while the number of single-occupant commuters in the U.S. increased by 35.4 percent.

What can be done to increase the ridership and reduce the cost and subsidy levels for travel on public transportation to, from and within suburban areas? Some government leaders have turned to ridesharing as a way to reduce the use of single-occupant automobiles for commuter trips, since carpools and vanpools usually require much lower subsidies (e.g. computer matching services, advertising) per passenger trip than transit services. Unfortunately, efforts to increase the use of conventional carpool and conventional vanpools have not been very successful in the U.S. during the past decade.

The 1990 Census (Table 3) shows that conventional ridesharing's share of commuter work trips dropped from 19.7% in 1980 to 13.4% in 1990. In fact, 3.7 million fewer workers used ridesharing to get to work in 1990 than in 1980 even though there were 18.4 million more workers in the U.S. in 1990 than in 1980. Nevertheless, carpools and vanpools still carry 200 percent to 300 percent more commuters to work than bus and rail systems. Suburb-to-suburb commuters still use carpools and vanpools ten times as much as they use transit to get to work. (See Table 7)

Other government leaders have turned to paratransit services. Although the use of dial-a-ride vans and other paratransit services have been useful in reducing costs per passenger trip in low-density areas and in selected low-travel demand situations (e.g., late at night, weekends, holidays) when conventional fixed-route transit services would have cost more, the costs of these paratransit services are too high for widespread use as a measure to reduce traffic congestion.

The following statement from the February 1991 Report to Congress (8) states the problem as follows:

> "In 1980, only two percent (2%) of suburb-to-suburb journeys-to-work trips were by transit, down 50% from 1970. In Fairfax County (Virginia), the proportion of workers who carpooled dropped from 27 percent in 1980 to 15 percent in 1987, reflecting a very strong national trend. ..... Because of the dispersion of origins and

destinations in suburban travel, (conventional) public transit and (conventional) ridesharing offer very little potential for improving the passenger capacity of existing suburban highways."

Commuter Transportation Services (CTS), the large ridesharing agency in Los Angeles, prepared a "State of the Commute" survey report in 1991. The CTS surveys found that:

> "53% of commuters said they would not be willing to try carpooling, 61% would not try vanpooling, 71% would not try commuter rail and 75% would not try taking the bus."

The available evidence strongly suggests that new approaches must be found to reduce the use of single-occupant automobiles, traffic congestion and air pollution in urbanized areas and to provide cost-effective transportation services in low-density suburban and rural areas. Conventional transit, paratransit and ridesharing modes are necessary but not sufficient to do the job at costs that would be acceptable to taxpayers and their elected representatives. Something else is needed to complement and supplement conventional public transportation services.

DISCUSSION

The availability of new computer and communications technologies will permit the development of new types of services that could increase the cost-effectiveness of public transportation in urban, suburban and rural areas.

Over the years, many transportation experts have pointed out that the traffic congestion, gasoline consumption, air pollution and mobility problems of most U.S. communities are not caused by a shortage of transportation resources.

Most communities have enough roadways, transit vehicles, and automobiles to handle their existing travel demands, without congestion, using only the front seats of their automobiles. Most communities also have enough automobiles and other transportation resources to provide good public transportation services for all their existing residents, including the poor, the aged and the disabled. The transportation-related problems of most U.S. communities are largely the result of not having an information system that will permit them to utilize their existing transportation resources effectively.

Some German cities have introduced innovative telephone-based information systems and "smart-bus" systems (e.g. Ruf-Bus, R-Bus, FOCCS) that permit residents to request "bus" rides between any two checkpoints (e.g., bus-stops) at any time. The would-be rider does not need to know the route number, the schedule of the "bus", or the fare structure. He or she merely calls a telephone operator at the transit agency to request a ride.

The telephone operator enters the following information for each trip request into a computer terminal: 1) origin checkpoint (i.e. bus stop) number, 2) destination checkpoint number, 3) requested departure time (including ASAP) 4) number of people traveling together, and 5) special needs (e.g., wheelchair, blind, baby stroller). A computer analyzes this trip request and assigns a bus, minibus, or microbus (i.e. taxi) to pick-up the rider and his or her traveling companions.

The telephone operator tells the would-be rider when and where to catch the "bus" and the number and type of vehicle (e.g. bus, van, taxi). The "bus" can operate in either fixed-route, route-deviation or demand-responsive mode. A would-be passenger can also request a ride via a special-purpose kiosk located at selected (i.e. busy) bus stops.

The December 1989 issue of "Public Innovation Abroad" (15) described the performance of R-Bus, one of the German "smart bus" systems as follows:

"Developed in several stages with help from the Federal Research Ministry, the R-Bus system has been used along low density corridors in Wunstorf (pop. 18,000) and Neustadt (pop. 14,000) within the Greater Hanover region. In Wunstorf, where it was first deployed, the dial-a-bus system brought a ridership increase of about 80% over the line buses it replaced, in Neustadt, the number of passengers increased by 50% over the first eight months of operations.

The software developed for the R-Bus has the advantage of flexible operation. The system can be operated with regular line buses that call at stops with a pre-determined frequency, or in the dial-a-bus mode in response to telephone requests. There is a further wrinkle: The minibuses can be operated as a route-deviation, fixed-schedule service when called from phone automats (i.e. kiosks) located at auxiliary demand stops, or as a pure demand service aided by a central dispatch computer in periods of low demand."

Similar claims have been made about both the FOCCS and Ruf-Bus "smart bus" systems in Germany.

Appendix B contains a cost-benefits analysis of Ruf-Bus and FOCCS operational tests in Friedrichshafen, Germany. It is a chapter from a report for FTA/Tri-Met on German "Smart-Bus" systems. Tri-Met is the largest transit, paratransit and ridesharing agency in Portland, Oregon.

This cost-benefits analysis suggests that "smart-bus" systems will probably be able to pay for themselves out of increased revenues or reduced operating costs, but not much more. It is unlikely that basic "smart-bus" technologies will provide transit agencies with any breakthroughs in reducing average passenger trip costs. In order to reduce costs, the California Smart Traveler project has focused on adding conventional rideshare and dynamic (i.e. "single-trip") rideshare matching to the German "smart-bus" approaches.

In addition, the German "smart-bus" systems now handle all inquiries and ride requests with telephone operators. Although this may be the most economical approach for small operational tests, since a "help desk" will always be required, it will be too labor intensive if real-time rideshare matching is added or if the system provides a variety of different information services to drivers and riders in areas with large numbers of people.

In order to increase productivity, the California Smart Traveler project has focused on adding "direct" inquiry via touch-tone telephones, personal computers (PCs), videotex terminals, fax machines, etc. Just as U.S. telephone companies charge a lower rate for "direct dial" calls than they do for "operator-assisted" calls, the California Smart Traveler system should plan to add a surcharge for "operator-assisted" trip requests to cover the additional labor costs.

The first California Smart Traveler report (17), which was prepared during Phase 1A of the project, contains user-specifications for a telephone-based information system for an integrated transit, paratransit and ridesharing system. It builds on the concepts developed for processing operator-assisted requests for transit/paratransit service in the German Flexible Operations Command and Control System (FOCCS) and adds capabilities such as:

1. Conventional rideshare matching

2. Single-trip carpool (aka parataxi) matching

3. Direct (i.e. without operator assistance) access to the central computer by touch-tone telephone, personal computer (pc), videdotex terminal, etc. to:

    a. request rides or ride information
    b. offer parataxi rides
    c. find the best ways of getting between two points via:

        (1) public transportation
        (2) driving

The **VI**deote**X-EN**hanced FOCCS system (VIXEN) also adds door-to-door dispatching to checkpoint-to-checkpoint dispatching and "autodialer" features. A user can request a ride by pressing just one or two buttons on a touch-tone telephone on a computer terminal which will retrieve the prestored trip specifications from computer files.

Two of the objectives of Phase IB of the California Smart Traveler project are to:

1. Prepare financing plans for operational tests of California Smart Traveler systems in:

    a. San Ramon/Pleasanton/Livermore

    b. UCLA/Westwood

c. North City/San Diego

2. Develop and evaluate alternative public-private partnerships to conduct these operational tests.

Since few, if any, comprehensive operational test of "smart bus" systems have been conducted in the United States, this report will rely heavily on data obtained from Australia and Germany. These data were obtained from a five-volume report (18) prepared by a

Table 15
Summary of Pilot Project Costs
Shellharbour, Australia

1		2	3
ITEM		Total Costs (DM)	Total Costs ($)
81	5.1 Management and Control Room Hardware, Software, etc.	56,150	35,838
82	5.2 Garages and Vehicles	273,850	174,798
83	5.3 Service Area	23,000	14,681
84	5.4 Options	48,300	30,821
85	5.5 Pilot Project Production	1,613,490	1,029,891
86	5.6 FOCCS Overhead	208,800	133,277
87	5.7 Operational Costs	113,400	72,383
88	5.8 Public Relations and Personnel Training	113,560	72,485
	GRAND TOTAL:	2,450,550	1,564,175

team of Australian and German transportation experts to determine if it made economic sense to conduct an operational test of German "smart bus" technologies in Shellharbour, New South Wales. Shellharbour is a fast-growing, suburban area approximately 80 miles south of Sidney.

Table 15 is a summary of the costs to conduct a one-year operational test of the Flexible Operations Command and Control System (FOCCS) in Shellharbour, Australia. These estimates are given in both Deutch-Marks (DM) and in U.S. dollars. Appendix C contains an Australian magazine report which discusses the Shellharbour project.

Each of the line items in Table 15 is broken down into more detailed items in Appendix D, which also provides an explanation of each line item. The cost breakdown includes the costs of a 3-6 month installation and training period prior to the operational test and a 3 month evaluation period prior to the operational test and a 3 month evaluation period after the operational test. The operational test includes 20 "smart-buses" equipped with on-board computers. The two major privately-owned and privately-operated bus companies in Shellharbour will each operate half (10) of the "smart-buses".

Appendices E, F and G contain a brief description of each of the three proposed test sites, a list of the number of vehicles to be equipped with on-board computers (e.g. GSI's IBIS units), and the estimated cost of a one-year operational test. The line items listed in each of these appendices are the same as those given for the Shellharbour operational test (Appendix D) cost estimates.

CONCLUSIONS

Caltrans has identified a number of sites in California that would be attractive places to conduct operational tests of promising Intelligent Vehicle-Highway Systems (IVHS)/Advanced Public Transportation Systems (APTS) concepts. This report analyzed the costs of conducting operational tests of California Smart Traveler systems in the following suburban sites:

- San Ramon/Pleasanton/Livermore
- UCLA/Westwood
- North City-San Diego

The following three pages contain a brief description of each of these three sites and the estimated costs of conducting a one-year or a longer operational test there.

In these three sites, the primary means of carrying additional public transportation riders will be single-trip carpools (aka parataxis). Although most of the large fixed-route buses and some of the mini-buses/taxis serving each area will be equipped with on-board computers (e.g. IBIS units in Germany) to make them "smart", these improvements are not expected to increase overall ridership on these vehicles more than a few percent.

The reason for adding on-board computers to the existing transit and paratransit vehicles is to develop a fully integrated fixed-route, flexible-route public transportation system at each site.

The cost of adding on-board computers to additional transit or paratransit vehicles in each area would be approximately $6,000 per vehicle. These additional costs should be added to the first year costs of a FOCCs-type "smart-bus" system in Tables 16-18. It should be noted, however, that the costs of adding 10 additional on-board computers to the North City-San Diego site would only raise the first year costs by 4.4%. The financial impact on larger test sites would be even less than this.

Neither ridership, nor the operating costs or annualized capital costs of the existing public transportation system in each area are included in Tables 16-18. The ridership values given in these tables represents additional (new) riders on each of these public transportation systems. Likewise, the costs/subsidies given in these tables represent costs/subsidies over and above those of the present systems.

Table 16

San Ramon/Pleasanton/Livermore (Tri-Valley) Test Site

Site Description

This low-density suburban area in San Francisco's East Bay includes the communities of San Ramon, Pleasanton, Dublin and Livermore. The Tri-Valley area contains the intersection of I-580 and I-680, which are both experiencing growing traffic congestion problems. Major employers in the Tri-Valley area include UC Lawrence Livermore Laboratory, Sandia Corporation, Chevron USA, Pacific Bell and AT&T. Other important employers in the area include EG&G and USWEST's Public Safety Group, which designs and develops 9-1-1 systems. Because of (a) the high-tech background of the employee base and the high density of personal computers, (b) the innovativeness of local governments (e.g. Pleasanton and San Ramon were among the first communities in the U.S. to adopt traffic mitigation ordinances), and (c) the lack of good suburb-to-suburb transportation services, the Tri-Valley area would be an excellent test site for audiotex-based and/or videotex-based parataxi services involving up to 20,000 employees and their families.

Tri-Valley - Operational Test

Number of Participants	15,000
Number of Vehicle Trips/Year	16.42 million
Number of Parataxi Trips/Year (6%)	.99 million
Number of Parataxi Trips Per Day	2,700
Number of "Smart" Vehicles	12
First-Year Cost FOCCS-type System	$1.48 million
Subsequent-Year Cost FOCCS-type System	$ .28 million
First-Year Cost Voice-Response System	$ .35 million
Subsequent-Year Cost Voice Response System	$ .04 million
Annual Parataxi Subsidy (@$1.00 per trip)/Year	$ .99 million
Subsidy for First-Year Operational Test	$2.82 million
Subsidy Per Passenger Trip - First Year	$2.85
Subsidy Subsequent Year Operational Test	$1.31 million
Subsidy Per Passenger Trip - Subsequent Year	$1.32

*3 one-way vehicle trips/day x 365 = 1,095 one-way vehicle trips/year

Table 17

UCLA/Westwood-Los Angeles

Site Description

This high-density suburban area lies within the city limits of Los Angeles, near the intersection of the San Diego Freeway (I-405) and the Santa Monica Freeway (Highway 10). Both of these freeways and the neighboring arterials have major traffic congestion problems. In fact, the City of Los Angeles has limited the growth of UCLA until Westwood's traffic congestion problems can be reduced. Because of the high ownership of personal computers (PCs) by UCLA's faculty, staff and student body, this area would be an excellent test site for operational tests of "smart" buses, mini-buses, vans and taxis and audiotex/ videotex-based Advanced Traveler Information System (ATIS) concepts involving up to 30,000 local residents, employees and students.

UCLA-Westwood Operational Test

Number of Participants	30,000
Number of Vehicle Trips/Year	32.85 million
Number of Parataxi Trips/Year (10%)	3.29 million
Number of Parataxi Trips Per Day	9,000
Number of "Smart" Vehicles	25
First-Year Cost FOCCS-type System	$1.56 million
Subsequent-Year Cost FOCCS-type System	$ .28 million
First-Year Cost Voice-Response System	$ .59 million
Subsequent-Year Cost Voice Response System	$ .05 million
Annual Parataxi Subsidy (@$1.00 per trip)/Year	$3.29 million
Subsidy for First-Year Operational Test	$5.35 million
Subsidy Per Passenger Trip - First Year	$1.63
Subsidy Subsequent Year Operational Test	$3.62 million
Subsidy Per Passenger Trip - Subsequent Year	$1.10

*3 one-way vehicle trips/day x 365 = 1,095 one-way vehicle trips/year

Table 18
North City-San Diego

Site Description

This rapidly-growing, medium-density, suburban employment and residential area in San Diego is bounded by Highway 52 to the South, the Pacific Ocean to the West, Del Mar Heights Road to the North and Camino Santa Fe to the East. Major employers include SAIC, UC-San Diego, University Town Centre, Scripps Memorial Hospital and First Capital Life Insurance. These and other employers have established the North City Transportation Management Association (TMA), which provides collectively-financed products and services designed to meet the needs of over 40,000 employees in the area. Because of (a) this hard-working and imaginative TMA, (b) the lack of good public transportation for suburb-to-suburb travel, and (c) a large retirement community in LaJolla, the North City area could provide several groups of 5,000-10,000 people to test audiotex/videotex-based parataxi services for both commuter and E&H transportation services. Regulation XV-type ordinances are also in the process of being implemented throughout San Diego, which will provide incentives for employer participation in operation tests of innovative concepts.

North City-San Diego Operational Test

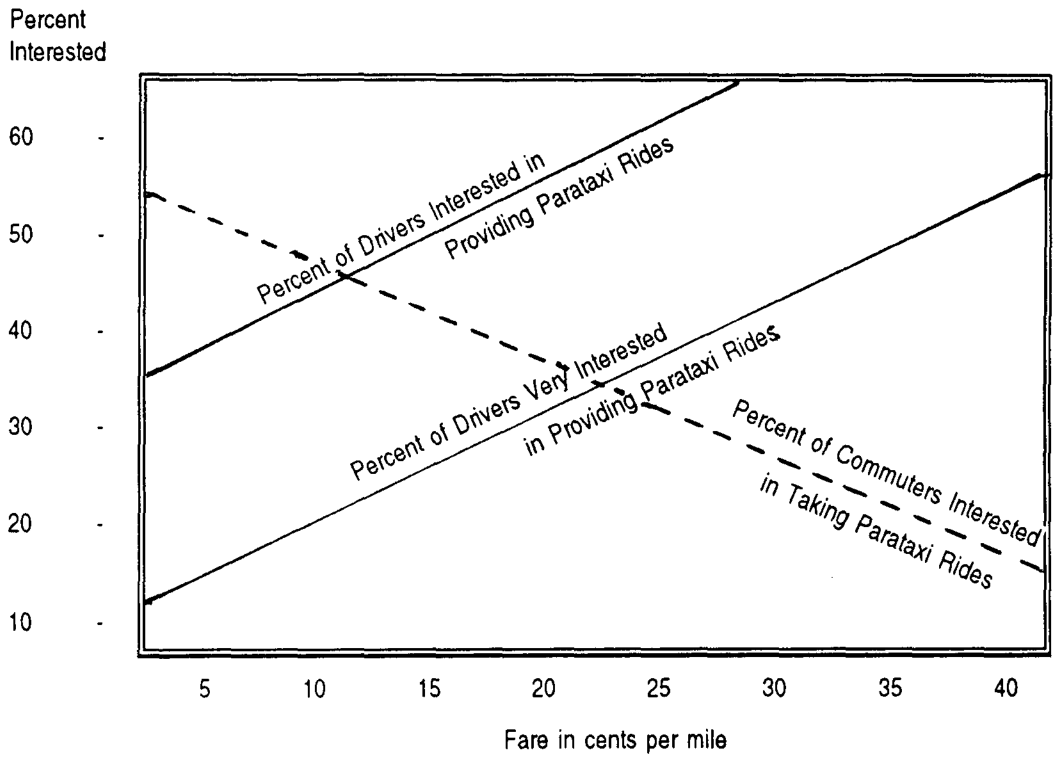
Number oi Participants	8,000
Number of Vehicle Trips/Year	8.76 million
Number of Parataxi Trips/Year (10%)	.53 million
Number of Parataxi Trips Per Day	1,440
Number of "Smart" Vehicles	14
First-Year Cost FOCCS-type System	$1.37 million
Subsequent-Year Cost FOCCS-type System	$ .23 million
First-Year Cost Voice-Response System	$ .25 million
Subsequent-Year Cost Voice Response System	$ .03 million
Annual Parataxi Subsidy (@$1.00 per trip)/Year	$ .53 million
Subsidy for First-Year Operational Test	$2.15 million
Subsidy Per Passenger Trip - First Year	$4.06
Subsidy Subsequent Year Operational Test	$ .79 million
Subsidy Per Passenger Trip - Subsequent Year	$1.50

*3 one-way vehicle trips/day x 365 = 1,095 one-way vehicle trips/year

Market research studies conducted by the State of Hawaii have found that the availability of ubiquitous parataxi services, at fares of 20 cents per passenger mile, could attract approximately 30% of work commuters out of their single-occupant vehicles (see Figure 7). Since each of the proposed demonstration sites will only be able to provide parataxi services in a limited area, these services should be able to attract less than one-third (10%) of this 30% share in the Tri-Valley and North City-San Diego test sites, where free parking is readily available and less than one-half (15%) of the 30% share in the UCLA/Westwood test site where free parking is in short supply.

Figure 7

Commuter's Interest in Providing and Taking Parataxi Services, By "Fare" Per Mile (1991 Dollars)



Caltrans should also be able to reduce parataxi ridership and subsidy levels by raising "fares" to 30 cents per mile, for example, but continuing to pay drivers 20 cents per mile. The extra monies collected for parataxi services by Caltrans would be used to reduce taxpayer subsidies for transaction processing and backup taxi/dial-a-ride services. It should be noted that even at "fares" of 30 cents per mile, parataxis would be only 25 percent of the costs of most taxi services in U.S. metropolitan areas.

As mentioned earlier, the unit costs used to prepare the cost estimates for each of the three California sites in this report are the same as those used to prepare the cost estimates for the Shellharbour, Australia operational test. Since that time, the costs of microcomputers and other electronic devices have dropped and new technologies (e.g.Global positioning Satellites (GPS)) have become available which can provide better performance. These changes suggest that the cost estimates contained in Tables 16-18 and in Appendices E-G for the California sites are too high.

On the other hand, the hardware/software/system supplied for the Shellharbour site does not include conventional or dynamic rideshare matching, or the capability for users to enter and retrieve information directly (i.e. without going through a telephone operator "help desk") via touch-tone telephone. Caltrans is also upgrading its facilities and will be able to provide more comprehensive traffic information to drivers. The cost of these additional features will offset some of the cost-reductions discussed above. The Shellharbour cost estimates, therefore, should be quite accurate for the three proposed California sites, even though the latter will have greater capabilities, including GPS location subsystems for "smart" vehicles at each test system.

It should also be noted that the costs for the first year operational tests in Tables 16-18 contain all of the hardware, software, installation and training costs, as well as the annual operations and maintenance (O&M) costs. In a multi-year operational test, these capital costs should be distributed proportionately to each year of the trial. For example, the average annual cost of a seven (7) year trial in the Tri-Valley (i.e. San Ramon, Pleasanton, Livermore) area would be $1.526 million (($2.82 + 6 x ($1.31)) ÷ 7), and the average subsidy per new additional passenger trip would be $1.54 ($1.526 million ÷ .99 million new passengers).

For a seven (7) year trial in the Tri-Valley area, the estimated $1.00 subsidy per parataxi trip for transaction processing and backup taxi/dial-a-ride services would represent 65 percent of the average $1.54 average subsidy per parataxi trip. These subsidies are significantly below those that would be required by expanding conventional transit/paratransit services in this outer-ring suburban area.

For a seven (7) year trial in the UCLA/Westwood area, the average annual cost would be $3.87 million (($5.35 + 6 x ($3.62)) ÷ 7), and the average subsidy per new or additional passenger trip would be $1.18 ($3.87 ÷ 3.29 million passengers). In this case, the estimated $1.00 subsidy per parataxi trip for transaction processing and backup taxi/dial-a-ride services would represent 85 percent of the average $1.18 subsidy per parataxi trip. Again, this subsidy is significantly below those that would be required by expanding conventional transit/paratransit services in this inner-ring suburban area.

It is anticipated that the $1.00 taxpayer subsidy per parataxi trip for transaction processing and backup taxi/dial-a-ride services will be reduced, if not eliminated, as the following occur in the future:

1. The number of parataxi drivers increases.

2. The average waiting time for a parataxi ride or other types of public transportation rides decreases.

3. The probability of obtaining a seat on a public transportation vehicle increases.

4. The weighted**** door-to-door travel times for public transportation trips decreases via door-to-door dispatching, use of HOV lanes, traffic light pre-emption, etc.

5. The ratio of backup taxi to dial-a-ride trips (with subsidy levels of $5 to $10 per passenger trip) to parataxi trips (with much lower subsidies per passenger trip) declines.

6. The costs of computers, telecommunications and other electronic devices and transaction processing costs continue to decline.

7. Other information services (e.g. home banking, teleshopping, electronic and voice mail, video games, distance leaning) are added to the system and generate revenues for computer time used during off-peak periods for transportation information service.

8. As the business community provides funds for advertisements for transit information, traffic congestion information, etc.

9. Single-occupant vehicle (SOV) drivers area asked to pay "congestion pricing fees" for their use of the highways during peak travel times.

10. Subsidies for automobile and other motor vehicle users are reduced or eliminated via higher gasoline taxes, higher parking fees, road pricing "tolls", etc.

Each of these steps will help make public transportation (i.e. "anything other than single-

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**** The time spent walking to or from checkpoint (e.g. bus stop, subway station) waiting transferring are weighted two to three times as much as in-vehicle travel times.

occupant automobile," according to FTA Administrator Brian Clymer) more attractive for more Americans than driving alone.

The California Smart Traveler concept offers a great deal of promise in reducing traffic congestion, gasoline consumption and air pollution, particularly in low-density suburban communities. The proposed operational tests are being designed to test the cost-effectiveness of the concept and alternative implementation approaches.

RECOMMENDATIONS

The proposed operational tests of the California Smart Traveler system should be set up for as long a period as possible. Residents of the test area would be less willing to give up their second or third cars and increase their ridership on public transportation if they knew that their improved public transportation system would only last for a year or two.

If the Federal government is only able to fund operational tests for a maximum of three (3) years, Caltrans should seek maximum federal participation (e.g. 90%) during the first three years in exchange for a commitment from Caltrans and local sources to continue the operational test without federal funding for the following four (4) years.

The first three (3) years of a seven (7) year operational test in North City-San Diego, for example, would cost $3.73 million ($2.15 + 2 x (.79)). The final four years would cost $3.16 million (4 x (.79)) for a total of $6.89 million. If Caltrans and local public and private agencies contributed $.373 million (10%) of the $3.73 million cost of the first three (3) years and 100% of the cost of the last four (4) years, the federal government would pay $3.357 million (49%) and state and local services would pay $3.533 (51%) of the $6.89 million total costs of the seven (7) year operational test.

Operational tests of the proposed California Smart Traveler system should include not just work trips but all trips. In the words of Alan Pisarski,

> "While work travel is a crucial transportation function, it is no longer dominant and is a declining component of trips made - probably around 26% of passenger vehicle trips. Even in the peak periods, its share is between 40% and 60%... Peak travel is spreading from many reasons - congestion, the shift to service industries, flexible schedules - today no single hour contains more than 30% of work trips. In many areas, Saturday morning is the new peak period."

Alan Pisarski, a Virginia-based transportation consultant, is the author of the Eno Foundation's "Commuting in America."

The recommended initial "fare" for parataxi services at each of the proposed operational test sites should be at least 30 cents per mile, with a three (3) mile minimum. This "fare" would cover up to three adults. In effect, the parataxi driver would be "leasing" the entire back seat of his or her vehicle. This fare structure should encourage family members, neighbors and co-workers to travel together. It should provide ample space for grocery bags and other packages and encourage the use of parataxi services for non-work trips.

FAILURE OF EXPERIMENT

By Robert Lindsey

SAN JOSE, Calif. - Less than six months after it opened, the nation's largest "dial-a-ride" mass transit system - a door-to-door service regarded as an innovative model for scores of other cities - was recently abolished.

Curiously, it failed not because it proved the popular axiom that mass transportation can't compete with the automobile - but because it was more successful in luring riders than its originators expected it to be.

Santa Clara County, Calif., has abolished its "dial-a-ride" mass transit system. The innovative program attracted too many riders for the budget.

San Jose's costly experience demonstrated the enormous difficulty facing city planners in providing mass transportation in the great majority of American cities that are more akin to horizontal Los Angeles than vertical New York. And, it appears certain to cause other cities to be more cautious before embarking on mass transit ventures that look attractive ... but in practice prove to be much more difficult to execute than to plan.

"I THINK the lesson we learned," said Frank Lara of the Santa Clara County Transit District, "is that you shouldn't try to play baseball with a toothpick."

His remark was made after county supervisors voted to kill the unusual mass transit system because experience had shown more than twice as many buses - and double the original budget - were necessary to make it work; the county did not think the cost was worth it.

Last Nov. 24, the county inaugurated what transportation authorities described as perhaps the most convenient system of mass transportation ever offered to residents of a large metropolitan area.

For 25 cents - or only 10 cents for riders over 65 or under 18 - the county provided door-to-door transportation between virtually any two locations in a sprawling urban area covering more than 200 square miles.

WITH A TELEPHONE call, any of the county's 1.2 million residents could summon a bus to their door. A computer was used to identify which of dozens of buses were cruising closest to the caller's home.

Then, the bus took the caller to the doorstep of his destination if it was not far away. If it was more than several miles away, the rider was transferred to a conventional bus traveling on regular fixed routes, taking him to a point where he could transfer to another "dial-a-ride" minibus.

Dial-a ride is considered by some transportation specialists as a promising alternative to far more expensive fixed rail transit systems, and is perhaps the only kind of transit service that can reach potential riders in today's growing number of suburb-ringed, low density, auto-oriented cities such as Los Angeles, Denver and Houston.

OVER THE PAST four years, dial-a-ride systems have been instituted in more than 40 cities in 22 states. Although virtually all of them have required large deficits, none match the magnitude of the system tried here, which was more than 15 times larger than any previous one.

It was the first to guarantee door-to-door service in a large metropolitan complex, the first to use computers extensively for sequencing pick ups, and the first to use integrated neighborhood pickups with conventional, fixed route, arterial buses.

(C)N.Y. Times Service
5-14-78

This "fare" structure and the use of low-subsidy parataxi services should minimize the cost overrun problem that occurred in the Santa Clara dial-a-ride system in the 1970s (see Figure 8 on the preceding page). According to the *New York Times*, Santa Clara's innovative, door-to-door public transportation system failed because it attracted too many riders and the County could not afford the subsidies required. Caltrans can drop parataxi fares to increase ridership and subsidy levels more easily than it can raise fares to reduce ridership and subsidy levels.

One comprehensive operational test is better and less expensive than three limited ones. To this end, it is recommended that Caltrans only start the second operational test after the first is fully funded and operating successfully and the third only after the second is fully funded and operating successfully. Each subsequent test should be carefully designed to test some important features or new concepts that could significantly improve the cost-effectiveness of California Smart Traveler systems.

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DOT-T-93-31

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