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German “Smart-Bus” Systems

Potential for Application in Portland, Oregon

Volume 1, Technical Report

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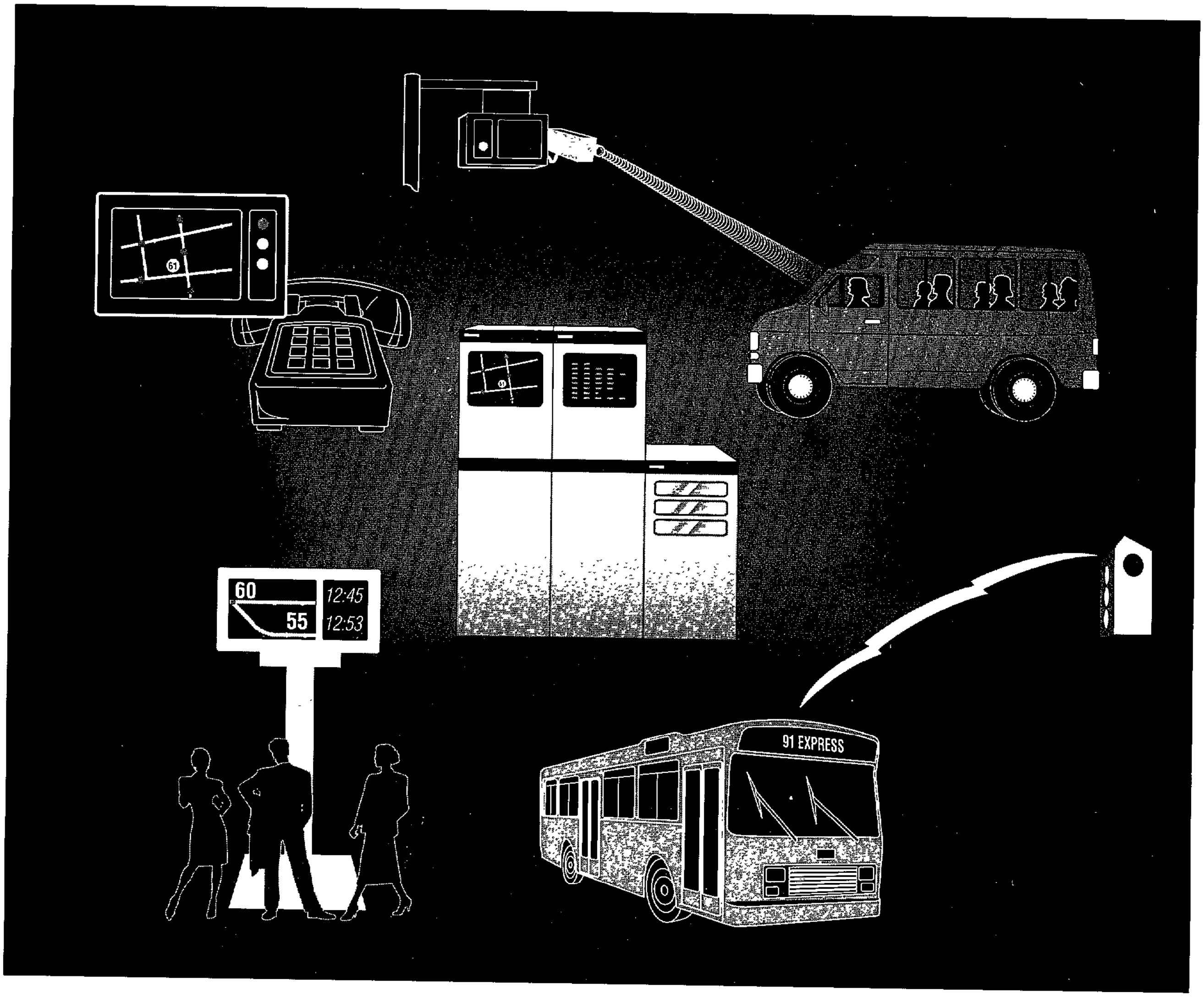

ADVANCED PUBLIC TRANSPORTATION SYSTEMS PROGRAM
A Component of the Departmental IVHS Initiative

Office of Technical Assistance and Safety

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German "Smart Bus" Systems

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ABSTRACT

The Tri-County Metropolitan Transportation District of Oregon (Tri-Met) provides transit, paratransit and ridesharing services within Multnomah, Clackamas and Washington Counties in the Portland metropolitan area. For the past two decades, Tri-Met has been investigating ways to use new technologies to improve the cost-effectiveness of public transportation services in fast-growing suburban areas.

Several publications have reported that cities and counties in Germany that have installed new computer-telecommunications "smart-bus" systems have been able to significantly increase public transportation ridership in low-density suburban and rural areas. This report describes the history of the Flexible Operations Command and Control System (FOCCS) and how it is being used in Germany to integrate flexible-route bus, minibus and microbus (i.e., taxi) services with fixed-route bus, rail and ferry services.

This report also describes how new telephone-based information services can be used to enhance the cost-effectiveness of FOCCS and other German "smart bus" concepts for use in the United States. For example, touch-tone telephones (audiotex) and computer terminals (videotex) can be used to develop single-trip carpools or parataxis to feed fixed-route transit lines, to back-up conventional carpools and vanpools, and to provide low-cost transportation services for suburb-to-suburb travelers.

Tri-Met is currently developing a strategic plan to triple transit ridership in the Portland metropolitan area over the next 15 years. This study finds that enhanced FOCCS concepts can help Tri-Met reach this goal and, at the same time, reduce costs and subsidies per passenger trip.

This study was funded in part by the Federal Transit Administration under FTA' s new Advanced Public Transportation Systems (APTS) program. APTS is part of USDOT's much larger Intelligent Vehicle-Highway Systems (IVHS) program which will use new electronics and information processing technologies to reduce traffic congestion, gasoline consumption, air pollution and mobility problems.

TABLE OF CONTENTS

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EXECUTIVE SUMMARY

The massive subsidies of the private automobile and the continued dispersion of homes and jobs into low-density suburban areas have lead to the continuing decline in the use of public transportation and ridesharing in the United States.

Although there were over 18 million (21%) more motor vehicle commuters in the U.S. in 1990 than in 1980, the latest journey-to-work data from the Bureau of the Census shows that 175 thousand (2%) fewer motor vehicle commuters in the U.S. used bus and rail transit to get to work in the U.S. in 1990 than ten years earlier. As a result, fixed-route bus and rail transit modes carried only 5.7 percent of all motor vehicle commuters to and from their jobs in the United States in 1990, down from 7.1 percent in 1980 (See Table 2A).

According to several environmental researchers (1,2,3,4,5), the U.S. spends more than $200 billion each year to subsidize the use of automobiles (including vans and small trucks). This is more each year than federal, state and local governments have spent on public transportation subsidies in all the years since the Federal Transit Administration (FTA), formerly known as the Urban Mass Transportation Administration (UMTA), was established in the mid-1960s. FTA analysts estimate (15) that as additional automobiles are added to our already crowded roadways, each new vehicle trip is subsidized more than six dollars ($6.00).

Some of these subsidies for the automobile are in the form of wasted time and gasoline due to traffic congestion. Some are in the form of additional health problems. The American Public Health Association, for example, estimates that the air pollution caused by automobiles costs over $30 billion each year in higher medical bills. Free parking provided by employers and businesses accounts for about $85 billion in subsidies, since U.S. tax codes permit employers and businesses to treat the costs of providing free parking as deductible expenses.

Some of these subsidies are in the form of more direct financial support. Federal, state and local governments, for example, spent $57.5 billion for highway construction and maintenance in 1985, but collected only $35.6 billion in gasoline taxes, tolls and other user fees. This $22 billion difference amounted to a subsidy of approximately 20 cents for each gallon of gasoline sold in the United States for automobiles in 1985. Furthermore, underspending on the maintenance of highways, bridges, etc. is a subsidy of automobiles. U.S. highway engineers estimate that taxpayers will need to spend an additional $40 billion each year to repair deteriorating bridges and highways in the United States.

The 1990 Census is expected to show that more than 50 percent of all workers in U.S. metropolitan areas now work in the suburbs and 85 percent of these workers also live in the suburbs. Fixed-route bus and rail transit systems were never designed to transport people in a cost-effective manner within low-density suburban or rural areas. Efforts to “chase” the suburban market with fixed-route transit modes have lead to longer trips, fewer transit riders per vehicle mile, and higher costs per passenger trip for the U.S. transit industry.

Furthermore, as the percentage of people who live and work in the suburbs continues to increase in U.S. metropolitan areas, the percentage of people who use fixed-route transit services for work trips and non-work trips will continue to decline. In turn, the productivity of transit systems and transit workers will continue to decline and traffic congestion will continue to increase, particularly in fast-growing suburban areas. The major traffic congestion problems in the U.S. today are not in downtown areas, but in the suburbs.

Table 1, on the following page, describes the growth of traffic congestion between 1982 and 1989 in the fifty largest U.S. urbanized areas. It was prepared by the Texas Transportation Institute (TTI) in 1992, 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. Seattle’s RCI of 1.21 in 1989 means that its traffic congestion was 13% percent worse than that of Portland, which had an RCI of 1.07 that year. Seattle is now ranked as the 5th most congested urbanized area in the United States; Portland is now ranked 15th. (6)

Transit advocates in Portland have encouraged the expansion of transit services so that “Portland doesn’t become another Seattle“, as far as traffic congestion is concerned. However, the TTI report shows that Portland’s traffic congestion level in 1988 was the same as Seattle’s in 1985. If present trends continue, Portland will have a worse traffic congestion index than Seattle has today within the next five or six years.

Table 1
Roadway Congestion Index Values
19824989

Urban Area	Year 1982	1983	1984	1985	1986	1987	1988	1989	Percent Change 1982 to 1989
Phoenix, AZ	1.15	1.16	1.10	1.13	1.20	1.18	1.00	1.03	-10
Detroit MI	1.13	1.10	1.13	1.12	1.11	1.10	1.09	1.08	-4
Houston TX	1.17	1.21	1.25	1.23	1.21	1.19	1.15	1.13	-3
Louisville KY	0.84	0.82	0.81	0.79	0.80	0.88	0.87	0.86	2
Charlotte NC	0.79	0.84	0.84	0.83	0.82	0.83	0.82	0.82	4
Ft. Lauderdale	0.95	0.95	0.95	0.95	0.94	0.98	0.97	0.99	4
Philadelphia PA	1.00	1.03	1.04	0.90	1.06	1.06	1.07	1.05	5
Pittsburgh PA	0.78	0.76	0.76	0.78	0.79	0.79	0.81	0.82	5
Memphis TN	0.86	0.10	0.76	0.75	0.77	0.84	0.85	0.91	6
Corpus Christi TX	0.67	0.69	0.69	0.71	0.71	0.72	0.70	0.71	6
San Bernardino-Riv CA	1.09	1.11	1.12	1.11	1.14	1.13	1.16	1.16	6
Oklahoma City OK	0.72	0.72	0.75	0.71	0.71	0.76	0.78	0.78	8
Jacksonville FL	0.91	1.02	1.05	1.03	1.04	1.03	1.06	1.07	9
Cincinnati OH	0.84	0.84	0.84	0.83	0.82	0.87	0.88	0.94	9
Orlando FL	0.84	0.86	0.90	0.90	0.89	0.94	0.95	0.92	10
Tampa FL	0.94	0.91	1.03	1.04	0.96	1.02	1.03	1.03	10
New York NY	1.01	1.02	0.99	1.01	1.06	1.06	1.10	1.12	11
San Antonio TX	0.77	0.79	0.82	0.87	0.90	0.85	0.86	0.87	13
Fort Worth TX	0.76	0.79	0.80	0.82	0.87	0.87	0.87	0.87	14
San Jose CA	1.02	1.04	1.06	1.08	1.09	1.12	1.15	1.17	15
New Orleans LA	0.98	0.99	1.02	1.11	1.11	1.14	1.13	1.13	15
St. Louis MO	0.83	0.87	0.88	0.89	0.93	0.96	0.98	0.96	16
Kansas City MO	0.62	0.62	0.60	0.65	0.69	0.71	0.72	0.72	16
Albuquerque NM	0.78	0.65	0.89	0.93	0.88	0.91	0.90	0.91	17
Milwaukee WI	0.83	0.84	0.87	0.88	0.90	0.95	0.94	0.97	17
Hartford CT	0.76	0.79	0.86	0.85	0.85	0.87	0.91	0.89	17
Honolulu HI	0.93	0.95	0.97	0.97	1.03	1.07	1.10	1.09	17
El Paso TX	0.63	0.64	0.65	0.70	0.75	0.71	0.74	0.74	17
Baltimore MD	0.84	0.84	0.85	0.84	0.88	0.90	0.92	0.99	18
Chicago IL	1.02	1.02	1.05	1.08	1.15	1.15	1.18	1.21	19
Cleveland OH	0.80	0.82	0.83	0.81	0.86	0.89	0.97	0.95	19
Denver CO	0.83	0.88	0.93	0.96	0.97	0.95	0.99	1.01	19
Miami FL	1.05	1.09	1.07	1.13	1.10	1.14	1.18	1.25	19
Norfolk VA	0.83	0.81	0.83	0.88	0.94	0.97	0.90	0.99	19
Indianapolis IN	0.71	0.66	0.75	0.76	0.80	0.85	0.84	0.85	20
Columbus OH	0.68	0.71	0.71	0.71	0.73	0.78	0.79	0.82	21
Boston MA	0.90	0.93	0.95	0.98	1.04	1.04	1.12	1.09	21
Dallas TX	0.84	0.89	0.94	0.98	1.04	1.02	1.02	1.02	21
Minn-St. Paul MN	0.74	0.79	0.11	0.83	0.87	0.87	0.88	0.90	22
Portland OR	0.67	0.86	0.91	0.93	0.97	1.00	1.03	1.07	23
Austin TX	0.77	0.84	0.89	0.91	0.98	0.96	0.96	0.96	25
Los Angeles CA	1.22	1.27	1.32	1.36	1.42	1.47	1.52	1.54	26
Sacramento CA	0.80	0.84	0.88	0.92	0.95	1.00	1.03	1.01	26
Washington DC	1.07	1.09	1.12	1.20	1.28	1.30	1.32	1.36	27
Seattle-Everett WA	0.95	0.99	1.02	1.03	1.09	1.14	1.17	1.21	27
Atlanta GA	0.89	0.94	0.97	1.02	1.09	1.15	1.10	1.11,	28
Nashville TN	0.74	0.76	0.83	0.81	0.86	0.95	0.99	0.95	28
Salt Lake City UT	0.63	0.63	0.65	0.68	0.68	0.70	0.72	0.81	29
San Fran-Oak CA	1.01	1.05	1.12	1.17	1.24	1.31	1.33	1.36	35
San Diego CA	0.78	0.83	0.91	0.95	1.00	1.08	1.13	1.18	51

Officials at all levels of government in the U.S. are looking for ways to improve local and regional transportation systems in order to reduce traffic congestion and many other transportation-related problems. U.S. highway officials have formally recognized that “we can’t pave or build our way out of traffic congestion”, at costs that would be acceptable to taxpayers. In fact, this has become an axiom of the new U.S. Intelligent Vehicle-Highway Systems (IVHS) program.

The IVHS program will use computers, telecommunications and other electronic devices to improve the cost-effectiveness of surface transportation systems throughout the United States. It is estimated that public and private organizations in the U.S. will spend over $225 billion on IVHS during the next 20 years (7). Japan, Germany, England, France and other countries will spend many billions of dollars more to design, develop and implement their own IVHS programs.

One of the major components of the IVHS program is the Advanced Public Transportation Systems (APTS) program. APTS will use IVHS-technologies to make public transportation more cost-effective in urban, suburban and rural areas. U.S. transit officials are slowly but surely recognizing that “we can’t plan or talk our way out of traffic congestion using only conventional transit, paratransit and ridesharing services”, at costs that would be acceptable to taxpayers. This is also expected to become an axiom of the IVHS programs within the next few years.

Three of the major goals of the IVHS/APTS program are:

1. To develop new modes of public transportation that are better suited to low-density suburban and rural areas than fixed-route bus and rail services.

2. To integrate these new modes with conventional transit, paratransit and ridesharing services to increase ridership and reduce costs.

3. To provide the public with more timely and accurate information about the full range of publicly-and privately-operated public transportation services available to them in the region.

To accomplish these goals, U.S. transportation agencies must broaden their concept of mass transit to include more flexible-route, small-vehicle services. In fact, shortly after Brian Clymer took over as the Administrator (Le., CEO) of the Urban Mass Transportation Administration (UMTA), he suggested that mass transit be redefined as anything other than a single-occupant automobile.

Tri-Met has been a national leader in evaluating new technologies and new transit concepts. In 1986, Tri-Met and Portland’s Metropolitan Service District (Metro) sponsored one of the first U.S. seminars on the German Ruf-Bus and FOCCS systems. Ruf-Bus (i.e. Call-Bus) was a sophisticated, dial-a-ride, flexible-route transit system that enabled passengers to use kiosks at bus stops in low-density suburban/rural areas to request rides to other bus-stops. Each ride request was entered into a minicomputer, which analyzed the alternatives and dispatched the most cost-effective minibus or taxi to pick up the rider. Drivers of these flexible-route transit vehicles were dispatched by radio instructions from the minicomputer to in-vehicle computer terminals.

The Flexible Operations Command and Control System (FOCCS) is a very sophisticated system for combining fixed-route buses, trains and ferries and flexible-route buses, minibuses and microbuses (i.e., taxis) into an integrated public transportation system. FOCCS eliminated the need for bus-stop kiosks, which proved to be costly to install and maintain. With FOCCS, would-be public transportation riders in low-density areas use telephones to request rides between numbered checkpoints (e.g., bus-stops). Many improvements have been made to FOCCS since the seminar in Portland in 1986.

Tri-Met has been following the improvements to FOCCS on an informal basis in order to get ideas for ways to improve the cost-effectiveness of public transportation in the Portland metropolitan area, particularly in Portland’s fast-growing suburbs. In 1991, UMTA approved Tri-Met’s request for a grant, under the new Advanced Public Transportation Systems (APTS) program, to formally evaluate German Flexible Operations Command and Control System (FOCCS) concepts for possible use in the United States. A few months later Tri-Met awarded a five person-month contract to Aegis Transportation Information Systems, Inc. for this evaluation.

Based on research in Germany and discussions with Australian transportation researchers, who are currently testing FOCCS (pronounced “FOX”) in a low-density suburban community 80 miles south of Sydney, it appears that German “smart bus” concepts could increase the cost-effectiveness of public transportation systems in the United States. However, it is doubtful that FOCCS, by itself, will be able to increase ridership significantly or reduce costs per passenger trip significantly for Tri-Met or any other U.S. transit agency.

This situation could change, however, if videdotex (including audiotex) information services, conventional rideshare matching and single-trip carpool (aka parataxi) matching capabilities were added to FOCCS. Preliminary market research surveys (8,9,10,11) indicate that a VIdeoteX-ENhanced FOCCS (VIXEN) system could reduce the use of single-occupant automobiles by work commuters over 20 percent, even in low-density suburban areas, at a low cost to taxpayers. In fact, it appears that a VIXEN system could enable Tri-Met to triple public transportation ridership and, at the same time reduce both costs and subsidies per passenger trip.

Figure 1, on the following page, describes an innovative county-wide public transportation system that was implemented in California in the mid-1970s. This system provided on-call, door-to-door, computer-dispatched, minibus transportation services in low-density Santa Clara County. As the NY Times article (12) points out, "<u>the Santa Clara dial-a-ride system failed not because it attracted too few passengers. but because it attracted too many</u>". The lack of resources to meet the demand caused delays in answering telephone calls and in delivering transportation services, which caused user dissatisfaction. Furthermore, taxpayer subsidies were on the order of $10 (in 1992 dollars) per passenger trip, and there were few economies of scale.

The improvements in the price and performance of computers and telecommunications systems since the mid-1970s enabled German transit engineers to develop FOCCS and other "smart bus" systems which are more cost-effective than the ill-fated Santa Clara dial-a-ride system. Recent technical developments in videotex and other telephone-based information services will, in turn, permit Tri-Met and other U.S. transit agencies to improve on the cost-effectiveness of the German FOCCS systems.

This study recommends that Tri-Met consider conducting an operational test of VIXEN/FOCCS concepts in the Lake Oswego-West Linn area. This area was chosen for several reasons. It is a low-density suburban area with terrain and

Figure 1

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
S-14-78

land use patterns that make it difficult for Tri-Met to supply public transport services that can compete with the private automobile for many trips. It has a large number of senior citizens and suburb-to-suburb commuters. The terrain of the Lake Oswego-West Linn area also lends itself to implementing a congestion pricing system that could help finance an operational test of VIXEN/FOCCS concepts. Through traffic can be measured quite easily along the few travel corridors.

It is estimated that an operational test could begin within 12 months of a notice to proceed. If the VIXEN system performs as projected, its use could be expanded throughout Tri-Met's service area in Multnomah, Clackamas and Washington Counties. In fact, similar systems could be installed in almost any community in the United States or overseas that has good telephone services.

The proposed VIXEN system could also be linked to general-purpose videotex systems (e.g., Prodigy, Community-Link, CompuServe) to provide local residents with home banking, teleshopping, electronic mail, home training courses, video games and hundreds of other information services. Collectively, transportation and other information services could generate new revenues for Tri-Met and help local residents save money and reduce both person- miles-traveled (PMT) and vehicle-miles-traveled (VMT). Transportation and other information services could also provide a variety of new business, employment, education and recreation opportunities to residents of urban, suburban and rural areas.

BACKGROUND

Those who believe that some mix of traditional transit, paratransit and ridesharing services can solve the traffic congestion, air pollution and mobility problems of Portland (Oregon) or any other growing U.S. metropolitan area, at terms that are acceptable to business and individual taxpayers, should read this chapter. Those who already believe that traditional transit, paratransit and ridesharing are good but not enough, necessary but not sufficient, can skip to page 30.

The Bureau of the Census recently released the first results (13) of the journey-to-work data it collected during 1990. Although there were 18.5 million (20.8%)more workers in the U.S. in 1990 than in 1980, as Table 2A shows, the number of people who used public transportation to get to work actually declined by 105 thousand (1.7%) during the decade.

Table 2A also shows that the percentage of workers who used transit to get to work declined from 6.4 percent in 1980 to 5.3 percent 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 even larger decline in the use of ridesharing during the past decade. In 1980, 19.7 percent of all workers commuted in carpools and vanpools. In 1990, only 13.3 percent shared rides to get work.

Table 2B shows that there were 97 thousand (19.8 %) more workers in 1990 in the Tri-County Area, that is, in Multnomah, Clackamas and Washington Counties of Oregon, than there were in 1980. Although ridesharing dropped slightly less in the Tri-County Area than in the United States as a whole, transit ridership dropped much more. In 1980, 47 thousand workers (9.6%) used transit to commute to work. In 1990, only 36.7 thousand workers in the Tri-County area used transit to get to work, a decline of 21.9 percent.

Table 2A
Change in Means of Transportation to Work
1980-1990
In The United States

	Workers in 1990			Workers in 1980			Differences			Percent Change Since 1980
	Millions	**S%**	**T%**	**Millions**	**S%**	**T%**	**Millions**	**S%**	**T%**	
Drive Alone	84.215	79.7	73.2	62.193	71.1	64.4	22.022	+ 8.6	+ 8.8	35.4
Rideshare	15.378	14.6	13.3	19.065	21.8	19.7	- 3.687	- 7.2	- 6.4	- 19.3
Transit	6.070	5.7	5.3	6.175	7.1	6.4	- .105	- 1.4	- 1.1	- 1.7
Subtotal	105.663	100	91.8	87.434	100	90.5	18.229	0	+ 1.3	20.8
Other	9.408	—	8.2	9.184	—	9.5	.224	—	- 1.3	2.4
Total	115.070	—	100	96.617	—	100	18.453	—	0	19.1

Note 1: S% is the percent of the Subtotal (i.e., only workers who use private or public motor vehicles to travel to work).
T% is the percent of the Total (i.e., including workers who work at home or who walk, bike, motorbike, etc. to work).

Table 2B
Change in Means of Transportation to Work
1980-1990
Tri-County Area (Multnomah, Clackamas and Washington)

	Workers in 1990			workers in 1980			Differences			Percent Change Since ‘1980
	Thousands	S%	T%	Thousands	S%	T%	Thousands	S%	T%	
Drive Alone	427.2	79.6	72.7	313.3	69.9	63.9	113.9	9.7	8.8	36.4
Rideshare	72.5	13.5	12.4	87.8	19.6	17.9	-15.3	-6.1	- 5.5	- 17.4
Transit	36.7	6.9	6.3	47.0	10.5	9.6	- 10.3	- 3.6	- 3.3	- 21.9
Subtotal	536.4	100	91.4	448.0	100	91.4	88.4	0	0	19.7
Other	50.8	—	8.6	42.0	—	8.6	8.8	—	0	21.0
Total	581.2	—	100	490.0	—	100	97.2	—	0	19.8

Note 1: S % is the percent of the Subtotal (i.e., only workers who use private or public motor vehicles to travel to work).
T% is the percent of the Total (i.e., including workers who work at home or who walk, bike, motorbike, etc. to work).

percent. In 1980, 313.3 thousand workers drove to work alone. In 1990, 427.2 thousand workers in the Tri-County area drove to work alone, an increase of 36.4 percent.

The following statement is from the June 1992 Report to Congress by the Secretary of Transportation (15):

> "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."

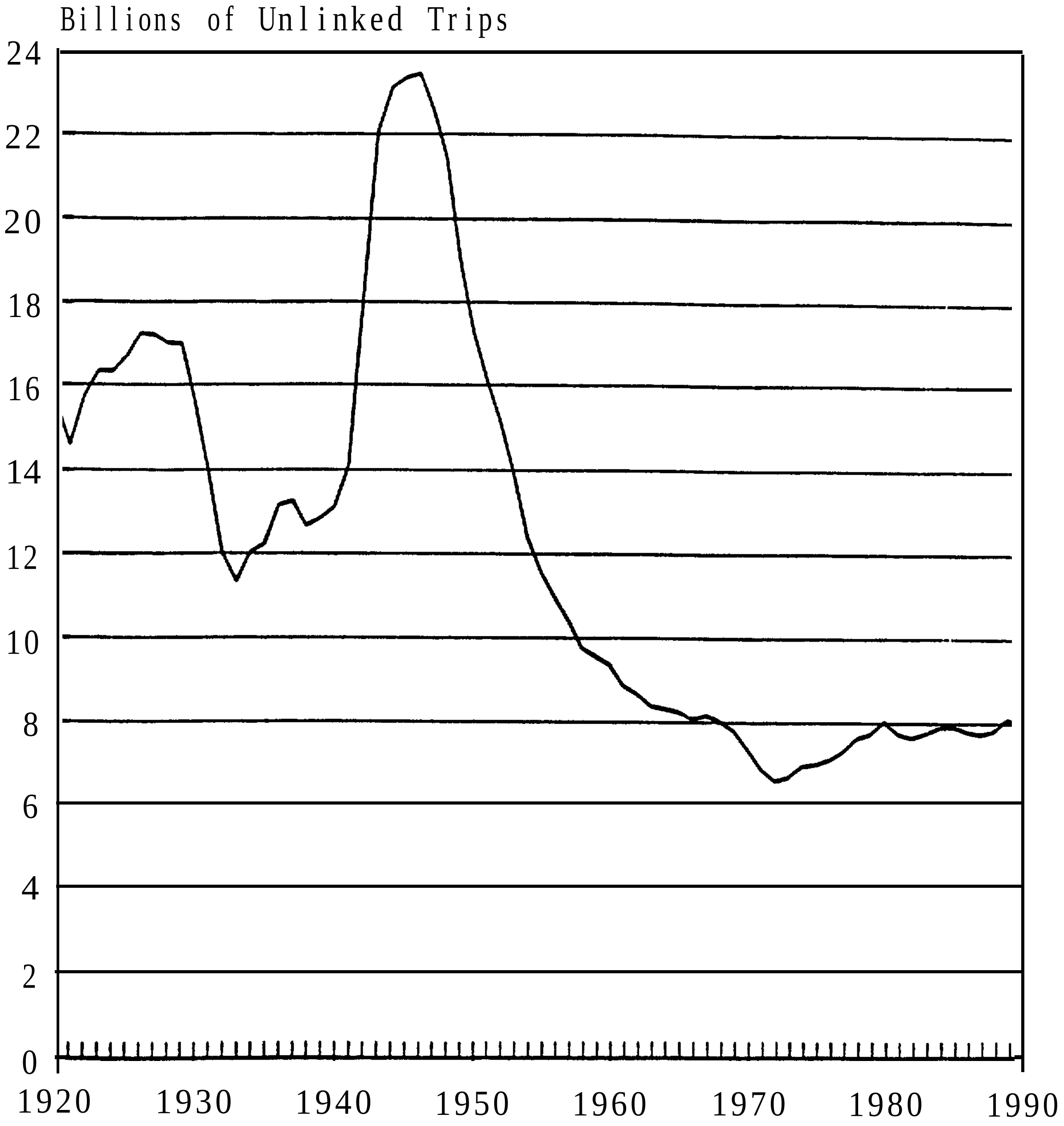
Figure 2, which was also obtained from the June 1992 Report to Congress (15), shows this flat ridership since 1980.

The following statement is also from the Report to Congress (15):

> "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. Although these are not true annualized capital costs they are good approximations. It should be noted that the June 1992 Report to Congress (15) discusses the need to spend an additional $1.8 billion per year on capital improvements to the U.S. transit industry. These funds would be used "to eliminate the backlog of deferred investment in transit ($17.6 billion) over a lo-year period." Perhaps deferred capital investments should be included in capital spending totals.

Figure 2
U.S. Transit Patronage
1920 to 1990



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

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 3 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 (15).

Table 3
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	l00 %	$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 in Table 4. There are many transit trips in the United States, particularly those in low-density areas, late at night or on weekends and holidays, that have subsidy levels well over $10 per one-way trip and energy consumption levels per passenger mile that are higher than those of single-occupant automobiles.

Table 4
Energy Consumption Rates

	BTU/Passenger Mile
Automobile	3,598
Transit Bus	3,415
Transit Rail	3,585
Commuter Rail	3,155

These estimates were prepared by the U.S. Department of Energy in 1988. A BTU (British Thermal Unit) is a measure of energy consumption regardless of whether it is fossil fuel, nuclear, electric, etc. (14).

Table 5, which was derived from the AFTA Transit Fact Book (14), 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. As currently used in the United States, therefore, big buses do not save a great deal of energy over many new automobile models, particularly when operated in low-density areas.

Table 5
Energy Use by Transit Motor Vehicles

Mode	Passenger Miles (millions)	Gallons Fuel (millions)	Passenger Miles (Per Gallon
Motor Bus (Fixed-Route)	21,127	569.2	37.1
Urbanized Areas	20,129	526.6	38.2
Non-Urbanized Areas	998	42.6	23.4
Demand Response	468	54.0	8.7

Source: APTA Transit Fact Book - 1991

Note the high energy consumption rates of demand-responsive transit services. Almost all automobiles are more energy-efficient than demand-responsive vans and minibuses.

Figure 3 shows that passenger fares have increased 60 percent more than inflation over the past 25 years. In fact, fares increased more than 30 percent in real terms between 1979 and 1987, according to the June 1992 Report to Congress (15). Nevertheless, fares now cover only 33 percent of the total costs of the average transit trip in the United States. The reason, as Figure 3 shows, is costs and taxpayer subsidies per transit passenger trip rose 180 percent and 120 percent (in real terms) between 1965 and 1988.

As previously discussed, one of the reasons for the increases in costs and subsidies is the decline in productivity of the U.S. transit industry. As Figure 4 shows, the number of passenger trips per transit vehicle revenue mile has dropped more than 25 percent since 1965. Figures 3 and 4 were derived from the February 1991 report by the U.S. Secretary of Transportation to the Congress (17).

Figure 3
Change-s in Transit Revenues, Costs and Subsidies
Per Passenger Trip, Adjusted for Inflation
1965-1988 (17)

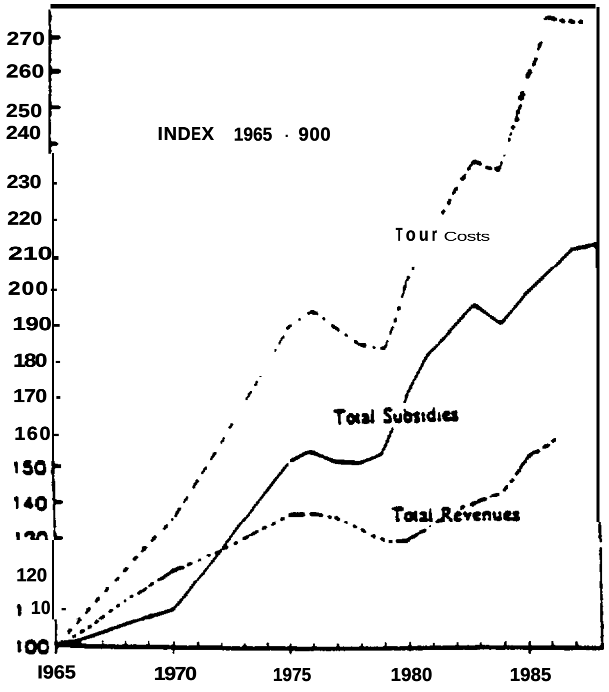
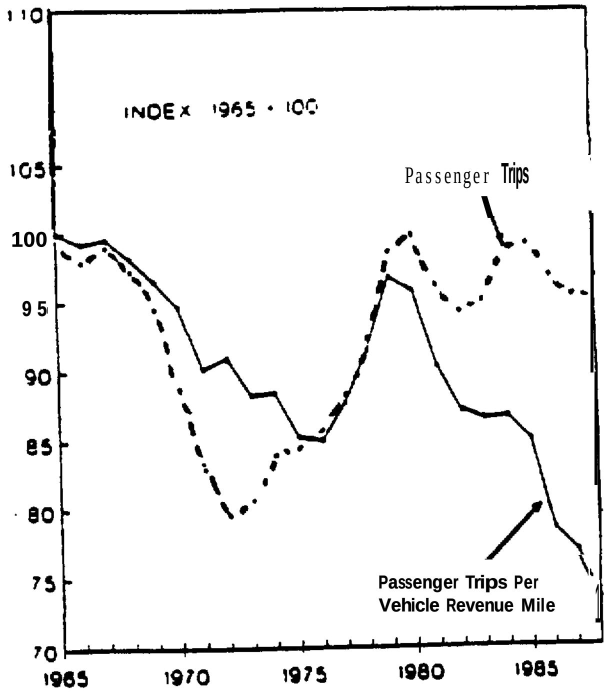


Figure4
Changes in Passenger Trips and Passenger Trips
Per vehicle Revenue Mile 1965-1988 (17)



What has caused this decline in transit productivity? One of the reasons is higher fares. Another is 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.

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

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 U.S. metropolitan areas now work in the suburbs, and more than 85 percent of these workers also live in the suburbs.

Since suburb-to-suburb travel 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, less than 2 percent of **U.S.** suburb-to-suburb commuters used public transportation to get to work in 1980. Tri-Met obtained similar results in its Suburban Transit Study (28) of 1989. With the rapid growth of homes and jobs in the suburbs and the high rates of single-occupant commuter vehicles, it should not be surprising that traffic congestion is continuing to increase in suburban areas.

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

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.

It should be noted, that Tables 6 and 7 were obtained from a study by Dr. Philip Fulton of the U.S. Bureau of the Census (16).

Table 8, on the following page, provides an estimate of the costs of traffic congestion in 1989 for the 50 largest urbanized areas in the United States. Like Table 1, it was obtained from a study by the Texas Transportation Institute (6) in 1991. Table 8 shows that on a cost per capita basis, traffic congestion cost each resident of the Portland area $250 in 1989. Traffic congestion in the Seattle area cost each man, woman and child $520, more than twice as much as Portland in 1989.

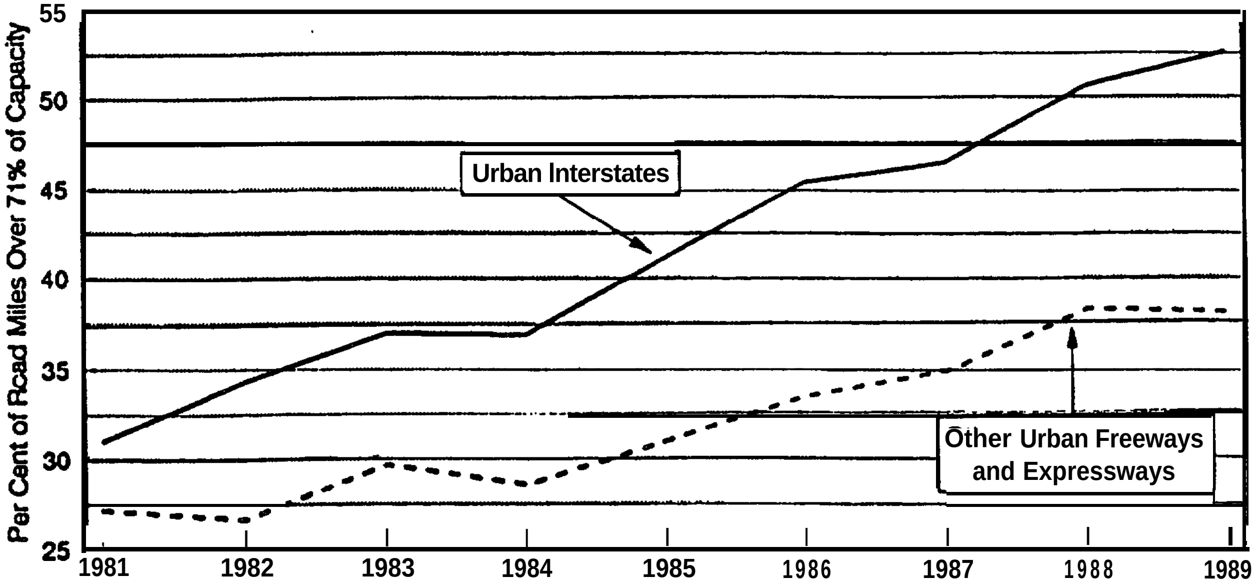
Table 8 also shows that on a cost per vehicle basis, traffic congestion in Portland and Seattle cost $380 and $690, respectively, in 1989. These costs were made up of 1) the costs of wasted time to vehicle occupants, 2) the costs of wasted fuel and, 3) higher insurance costs. Wasted time due to traffic congestion accounted for the largest (approximately 65 percent) of annual congestion costs.

Table 8
Estimated Impact of Congestion in 1989

Urban Area	Cost Per Registered Vehicle Total Congestion (Dollars)	Cost Per Registered Vehicle Delay & Fuel (Dollars)	Cost Per Capita Total Congestion (Dollars)	Cost Per Capita Delay & Fuel (Dollars)
Northeastern Cities				
Baltimore MD	390	390	200	200
Boston MA	720	720	400	400
Hartford CT	210	210	180	180
New York NY	850	850	310	310
Philadelphia PA	290	290	190	190
Pittsburgh PA	280	280	190	190
Washington DC	1,060	1,060	570	570
Midwestern Cities				
Chicago IL	390	390	210	210
Cincinnati OH	140	140	120	120
Cleveland OH	100	100	80	80
Columbus OH	170	170	150	150
Detroit MI	400	400	300	300
Indianapolis IN	80	80	50	50
Kansas City MO	120	120	70	70
Louisville KY	110	110	70	70
Milwaukee WI	260	260	110	110
Minn-St. Paul MN	190	190	160	160
Oklahoma City OK	130	130	90	90
St. Louis MO	440	440	220	220
Southern Cities				
Atlanta GA	490	490	410	410
Charlotte NC	280	280	240	240
Ft. Lauderdale FL	220	220	180	180
Jacksonville FL	240	240	200	200
Memphis TN	90	90	60	60
Miami FL	500	500	380	380
Nashville TN	260	260	240	240
New Orleans LA	270	270	220	220
Norfolk VA	300	300	270	270
Orlando FL	360	360	320	320
Tampa FL	200	200	190	190
Southwestern Cities				
Albuquerque NM	130	130	110	110
Austin TX	300	300	300	300
Corpus Christi TX	40	40	50	30
Dallas TX	570	570	430	430
Denver CO	270	270	240	240
El Paso TX	80	80	50	50
Fort Worth TX	320	320	270	270
Houston TX	590	590	450	450
Phoenix AZ	430	430	270	270
Salt Lake City UT	60	60	60	60
San Antonio TX	240	240	170	170
Western Cities				
Honolulu HI	370	370	280	280
Los Angeles CA	750	750	520	520
Portland OR	380	380	250	250
Sacramento CA	200	200	240	240
San Bernardino-Riv CA	980	980	680	680
San Diego CA	370	370	240	240
San Fran-Oak CA	740	740	630	630
San Jose CA	760	760	550	550
Seattle-Everett WA	690	690	520	520

Figure 5 shows the growth of traffic congestion on both urban interstates and other urban freeways/expressways in the U.S. during the 1980s. Urban congestion, as measured by the percent of road miles over 71% of capacity, grew 20 percent in the U.S. between 1981 and 1989. Table 1 indicates it grew considerably faster in both Portland, Seattle and the major California cities.

Figure 5
U.S. **Urban Congestion Growth** 19814989
(Percent of Road Miles Over 71% of Capacity)



Source: APTA, Issue Paper, June 1991 (from FHWA data).

At present growth rates, Portland will reach the levels of traffic congestion that Seattle has today within the next 5 to 6 years.

Federal Highway Administration (FHWA) engineers have estimated that taking only 20 percent of the cars off the road in 1987 would have reduced traffic congestion delays by 68 percent. To accomplish this by expanding public transportation services, however, would have required increasing transit ridership in the U.S. by over 300%. This estimate was developed in the following way.

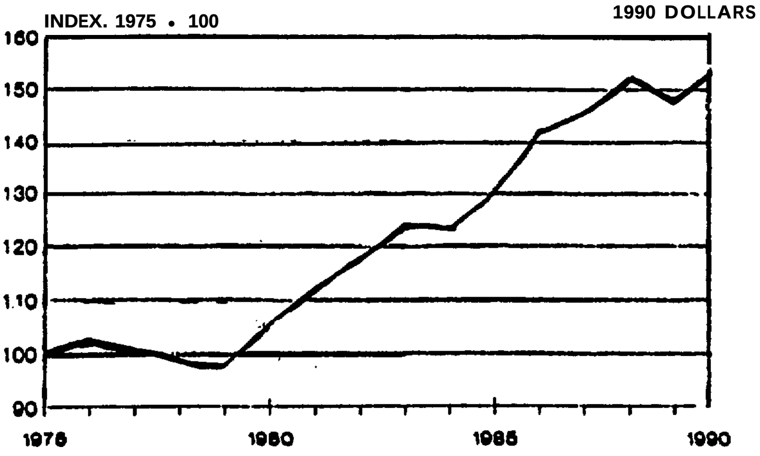
The 1990 Census (See Table 2A) shows that public transportation carried 6.07 million (5.7%) of the 105.66 million people who commuted to work in motor vehicles in the U.S. in 1990. To have taken an additional 20 percent of these workers out of their private vehicles would require more than quadrupling transit ridership in 1990.

Unfortunately, expanding conventional transit services enough to take 20 percent of the single-occupant cars off the road in 1991 would have been 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 (15).

The statement on page 11 by the Secretary of Transportation, that transit ridership in U.S. urbanized areas was 8.0 billion in 1980 and 1990 implies that it was more than 7.950 billion in 1980 and less than 8.050 billion in 1990. At most, therefore, the annual transit ridership in 1990 was .l00 billion (100 million) higher than it was in 1980.

Figure 6, from the June 1992 Report to Congress (15) 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

Figure 6
Change in Operating Cost Per Passenger
1975 - 1990



(passenger) trip length in 1980 was 4.4 miles and in 1990 was 4.8 miles" (15). 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 were also 23 percent of total transit costs, one can use these facts to analyze the financial performance of the U.S. transit industry in 1980.

Table 9
1980 Pro Forma 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 9 with Table 3 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 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 2 and the Secretary of Transportation's statement on page 11 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).

Examination of Figure 2 also shows that annual ridership the U.S. transit industry in 1975 was 7.0 billion unlinked passenger trips. Figure 6 shows that operating costs per unlinked passenger trip in 1975 were 65 percent (100/153) of those in 1990, or $1.20 (in 1990 dollars). Analysis of APTA data (14) shows that passenger fares and other revenues covered 59 percent ($2.043 billion/$3.451 billion) of transit operating costs in 1975. Assuming that capital costs were also 23 percent of total transit costs, one can prepare an analysis of the financial performance of the U.S. transit industry in 1975.

Table 10
1975 Pro Forma 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	$8.4	77%	$1.20	$1.63
Capital Costs	2.5	23%	.35	.47
Total Costs	10.9	10096	1.55	2.10
Passenger Revenues	5.0	46%	.71	.96
Total Subsidies	5.9	54%	.84	1.14

The gain in annual ridership between 1975 (7.0 billion) and 1990 (8.0 billion) was 1.0 billion. Comparing Table 10 with Table 3 shows that annual subsidies for the U.S. transit industry jumped $6.8 billion (in 1990 dollars) from $5.9 billion in 1975 to $12.7 billion in 1990. The average subsidy per new unlinked passenger trip between 1975 and 1990, therefore, was $6.80. The average subsidy per new linked passenger trip between 1975 and 1990 was $9.23.

It should be noted that the 1970's was a time of gasoline shortages in the United States. As a result, transit ridership grew much faster than it did in the 1980s (See Figure 2) and the costs to taxpayers (i.e. transit subsidies) per new transit trip were lower than they were in the 1980s. Unless the U.S. is faced with another oil crises, it appears that $10 (in 1990 dollars) is a reasonable value to use for the subsidies per new unlinked passenger trip, and $13.50 (in 1990 dollars) is a reasonable value to use for the subsidies per new linked passenger trip, in order to significantly increase conventional transit ridership in the United States.

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 2010, for example, would be $5,940 (440 trips at $13.50 per linked trip). Alternatively, the increased annual transit subsidies required to increase ridership 20 percent by 2010, for example, would be $10 for each unlinked passenger trip added since 1990.

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 PTA'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 11
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.**

Table 11 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 FTA/UMTA 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 1993 dollars). In addition, the subsidy per new rider on Tri-Met's new Westside LRT line is projected to be well over $10, according to the Supplemental DEIS (21).

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.

Table 12 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 the dial-a-ride 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 in suburban areas would almost certainly generate subsidies per new trip well-above $10 (in 1993 dollars).

It should 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-bus services in the same service area. However, these demand-responsive transit systems would tend to have low ridership rates (i.e. under 15 unlinked transit trips per capita per year).

Table 12
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
l00-249	15.37
All Systems	9.72

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

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 either 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 for 1990 to 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 1990 it was 4.8 miles." "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 rise at the same rate as capital costs per passenger trip for up to 550 million additional passengers, than 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), than 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 11 and Table 12, and the information in the June 1992 Report to Congress (15), 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, if most of the increases in ridership would be for suburb-to-suburb trips and for suburb-to-downtown trips.

Table 13
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	26.6 19 Billion	$ 10.00	$ 266 Billion
Total	35,492 Billion	$ 7.90	$ 280 Billion

Table 13 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. Using a very optimistic value of $5 per new trip would still make the costs prohibitive for most U.S. cities and counties.

Table 2 and Figure 5 show that traffic congestion in the U.S. increased steadily during the 1980s. Using the same Highway Performance Monitoring System (HPMS) data base that was used to develop Table 2 and Figure 5, the Federal Highway Administration (FHWA) prepared estimates on the cost of traffic congestion in the U.S. to the year 2005 (26).

Using data through 1984, FHWA engineers projected that the costs of traffic congestion in the U.S. would grow from $9.2 billion in 1984 to $50.5 billion in 2005. A few years later, FHWA engineers went back to reevaluate their projections in the light of the additional data that had collected from state transportation agencies. They found their projections for 1987 were too low. As a result of the finding, they increased their projected costs of traffic congestion in the U.S. in 2005 from $50.5 billion to $88.2 billion. This was an increase of approximately $30 billion (75%) in the projected costs of traffic congestion in 2005.

Although future projections of the costs of traffic congestion in the U.S. are alarming, they may be underestimated. This is easy to do when relatively small increases in the number of vehicles on the roadways can increase traffic congestion a great deal, just as small relatively small reduction in the number of vehicle can reduce traffic congestion a great deal.

What can be done to increase transit ridership and reduce traffic congestion, particularly in fast-growing suburban areas? One approach would be to try to increase population densities so that fixed-route transit services are more cost-effective. This approach will take many years and will require that many Americans abandon their dreams of living in a detached single-family home on a suburban cul-de-sac. This long-term approach should be encouraged, but shorter-term approaches are also needed because of growing traffic congestion, air pollution and other problems.

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. for 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 2A) 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 (See Table 7). In fact, suburb-to-suburb commuters still use carpools and vanpools ten times as much as they use transit to get to work.

Other government leaders have turned to publicly-operated or privately-operated 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 (17) summarizes the situation as follows:

> "In 1980, only two percent (2%) of suburb-to-suburb journeys-to-work 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. "

STATEMENT OF THE PROBLEM

By any yardstick, Portland and all other growing U.S. metropolitan areas are losing their long-term battles against traffic congestion. Improvements to bus and rail transit services and highway networks during the past decade have slowed, but not stopped, the growth of traffic congestion. The most serious congestion problems are now in low-density suburban areas, where most people now live and work. Portland and many other metropolitan areas are not in compliance with all federal air quality standards. Something must be done soon to reduce the number of single-occupant vehicles (SOVs) for both work and non-work trips in order to get into compliance.

Analysis of efforts during the past few decades to get more Americans to use multi-occupant vehicles (MOVs) instead of single-occupant vehicles (SOVs), strongly suggests that a change in direction is needed. Conventional transit, paratransit and ridesharing modes are good, but not enough. Buses, trains, dial-a-rides, carpools and vanpools are necessary but not sufficient. The conclusions are obvious. Something else is needed to compliment and supplement conventional public transportation services.

The aging of our population and the passage of the Americans with Disabilities Act (ADA) will place new financial burdens on public transportation agencies. Providing door-to-door transportation services is costly within American cities and very costly within suburban and rural areas. It is becoming increasingly clear that major changes are needed in the way public transportation services in the United States are delivered, financed and managed.

GENERAL METHOD OF APPROACH

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 transit vehicles and automobiles 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.

The availability of new computer and communications technologies will permit the development of new types of information systems that will permit public transportation agencies to better manage existing transit, paratransit and ridesharing resources. The availability of new computer and communications technologies will also permit the development of new types of services that could increase the cost-effectiveness of public transportation in low-density suburban and rural areas. In the words of USDOT/FTA:

> “Affordable personal micro-computers (and touch-tone telephones) could facilitate matching the increasingly individualized mobility demand of urban residents with a diverse range of specialized mass transit services and private ridesharing arrangements. Such matching services -- known as transportation brokerage -- could stimulate greater use of transit services and could increase the independence of persons with transportation handicaps through faster, more convenient, and more sensitive match-ups between individuals and a variety of prescheduled or on-demand services. Eventually these computers could coordinate and manage a region-wide network of individual decentralized (transportation) services offered by a variety of different providers.” (19)

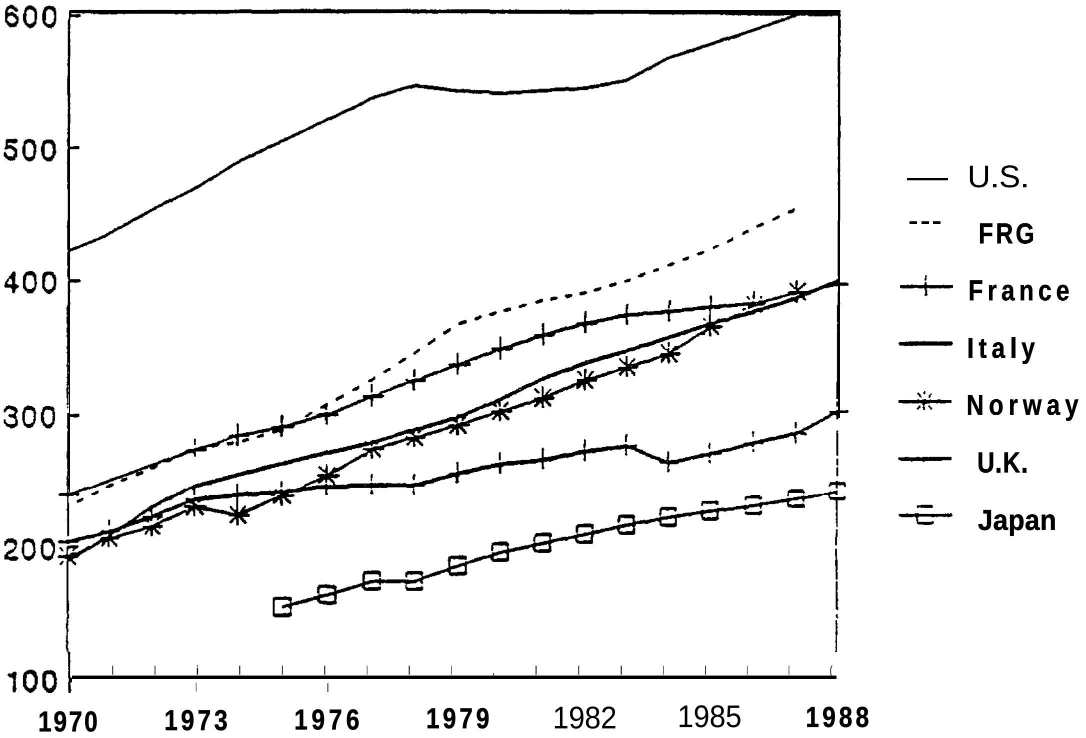
The following discussion of the German “smart-bus” systems was prepared to inform U.S. transit agencies about the potential of new technologies to increase the cost-effectiveness of their operations. Analysis of promising foreign technologies is also part of USDOT’s new strategic plan. In the words of UDSOT:

> “The Department of Transportation is in a unique position to learn of and share information about innovative transportation technologies and operations being developed around the world . . . The Department will step up its efforts to make certain that the U.S. transportation community is aware of and has access to emerging technological advances.” (22)

A HISTORY OF RUF-BUS

In the early 1970s, it became clear to West German government leaders that per capita automobile ownership, per capita vehicle-miles-traveled (VMT) and traffic congestion were increasing (See Figure 7). In addition, much of the new growth in population and employment were occurring in low-density suburban and rural areas, and per-capita transit ridership was declining. Unfortunately for transit agencies, fixed-route bus and rail transit services had much higher costs per passenger-mile in low-density areas than in urban areas. Continuing transit as usual was clearly not an attractive long-term strategy.

Figure 7
Automobile's Per 1000 Persons



A research and development program was launched in the early-1970s by West Germany's Federal Ministry for Research and Technology (BMFT) to determine how new computer and communications technologies could be used to improve the cost-effectiveness of public transportation systems, particularly in low-density areas. A number of German high-tech companies (e.g., Dornier, Messerschmitt-Bolkow-Blohm (MBB), Siemens, Daimler-Benz) were involved in the R&D program. Several general principles emerged from their work:

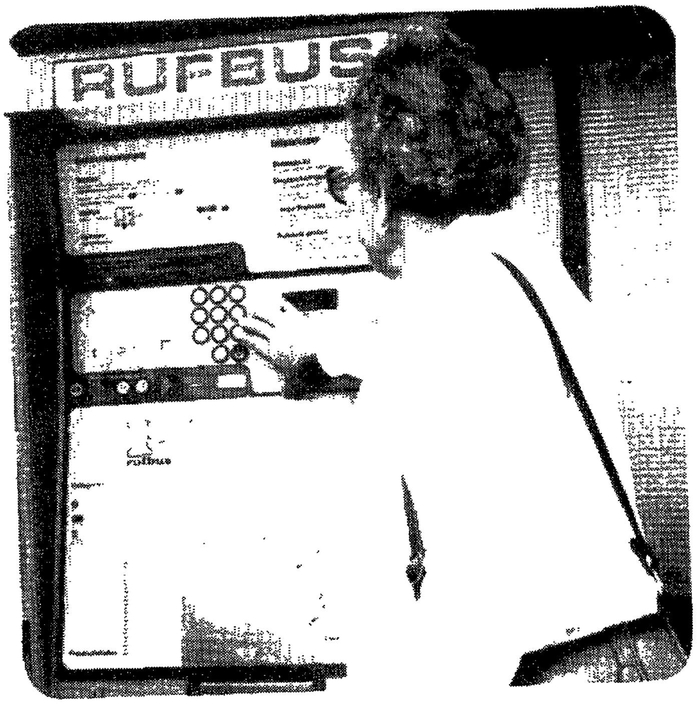
1. The term "buses" should include large buses, minibuses and microbuses (i.e., three or four passenger buses with no standing room, commonly known as taxis).
2. Small, flexible-route "buses" could be more cost-effective in low-travel situations than big, fixed-route "buses".
3. To manage a fleet of "buses" efficiently, a central computer should know the location of each vehicle at all times.
4. Each "bus" should be equipped with a computer terminal and a digital radio to permit regular data communications to and from the central computer.
5. The system should focus on checkpoint-to-checkpoint (i.e., bus stop-to-bus stop) service rather than door-to-door service for the general public.

These general principles were developed after analyzing the experiences of many voice-dispatched, door-to-door, dial-a-ride systems in the United States and Europe.

One of the first operational tests of these general principles was started in Friedrichshafen in 1977. Friedrichshafen is located on Lake Constance (aka Bodensee), which forms part of the border between Germany and Switzerland. Friedrichshafen is also the location of the corporate headquarters of Domier, one of Germany's leading high-technology firms and a private sector partner in the operational test. This first system was named Ruf-Bus (i.e., Call-A-Bus) and it provided demand-responsive transportation services to residents of Friedrichshafen and also residents of surrounding communities in Lake Constance County (aka Bodenskreis).

Figure 8
Ruf-Bus Kiosk I

Figure 9
Ruf-Bus Kiosk II



The Ruf-Bus system had a number of important features. One of these were the call-boxes that were installed at frequently-used “bus-stops”. Figure 8 and 9, on the preceeding page, show two of the call-box models built by Domier that were used in Friedrichshafen.

To request a ride via a call-box, a would-be passenger would go through the following steps:

1. Enter the three-digit code number of the destination bus stop with the keypad on the call box. Figure 10, on the following page, is a map of the service area and lists of the three-digit bus-stop numbers in Markdorf and Friedrichshafen.

2. When prompted by the call-box, enter the number of passengers in the traveling party with the key pad.

3. Insert a DM 0.20* coin or a Ruf-Bus card into the call-box. The DM 0.20 “toll” was to discourage nuisance calls. The Ruf-Bus card, which was the same size as a magnetic-stripe Visa or American Express card, could be purchased by frequent Ruf-Bus riders for a one time charge of DM 5. It was a second important feature of the Ruf-Bus system. As soon as the coins or card were entered, the call-box would transmit the trip request via telephone lines to the central computer.

4. After l0-15 seconds, the call-box displays the number of the bus (or bus line) and the departure time recommended by the central computer. The user is then asked to press the “Accept” or “Reject” key.

5. If the “Accept” key is pressed, the call-box prints out a confirmation ticket. If the “Reject” key is pressed, the trip request is canceled.

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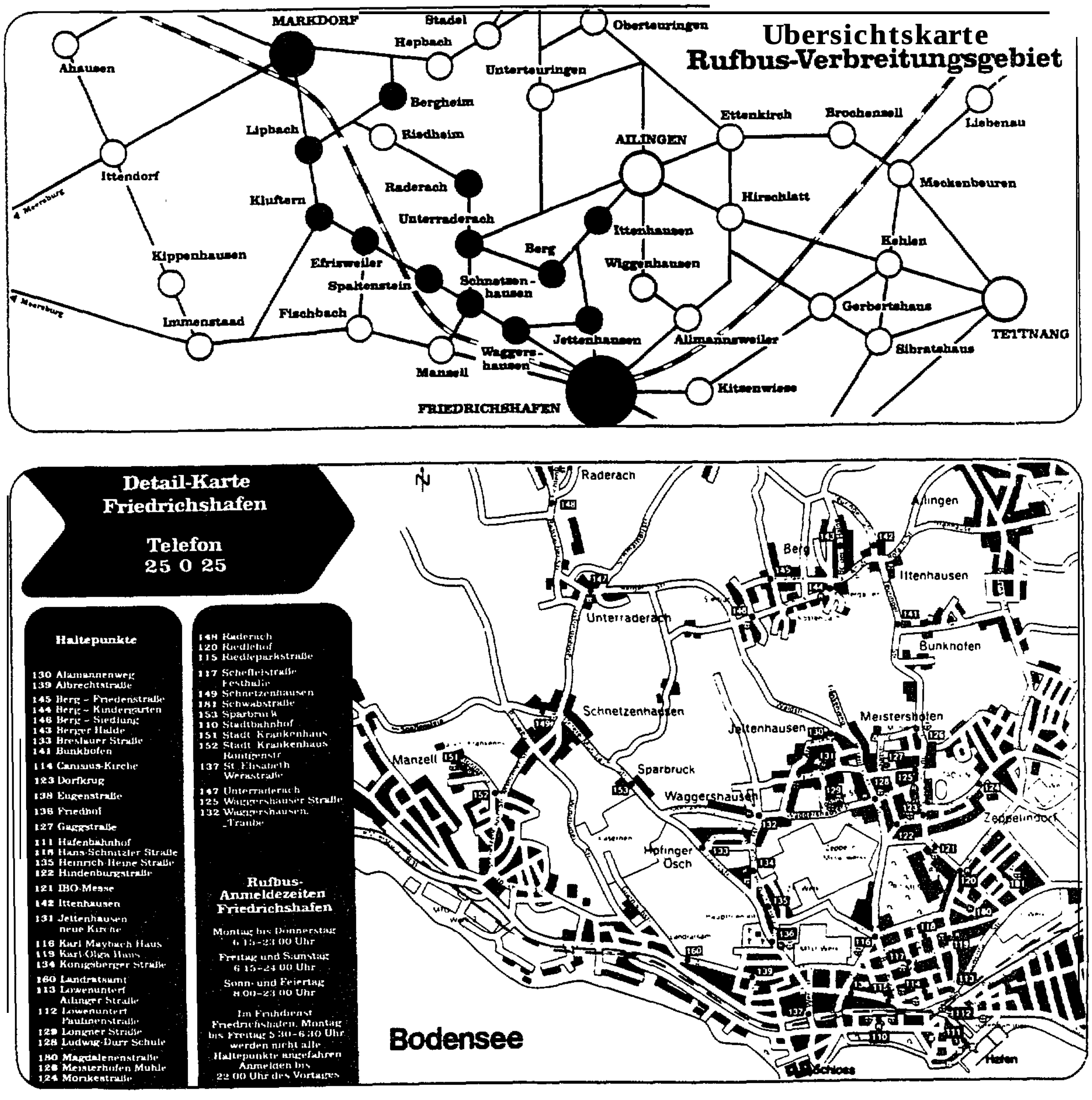
*1 DM on June 19, 1992 equalled US $0.64.

Figure 10
Ruf-Bus Service Area in 1981



Haltepunkte

130	Alamannenweg
139	Albrechtstraße
145	Berg – Friedenstraße
144	Berg – Kindergarten
146	Berg – Siedlung
143	Berger Halde
133	Breslauer Straße
141	Bunkhofen
114	Canisius-Kirche
123	Dorfkrug
138	Eugenstraße
136	Friedhof
127	Gaggstraße
111	Hafenbahnhof
118	Hans-Schnitzler Straße
135	Heinrich-Heine Straße
122	Hindenburgstraße
121	IBO-Messe
142	Ittenhausen
131	Jettenhausen neue Kirche
116	Karl Maybach Haus
119	Karl-Olga Haus
134	Königsberger Straße
160	Landratsamt
113	Löwenuntert Ailinger Straße
112	Löwenuntert Paulinenstraße
129	Longner Straße
128	Ludwig-Dürr Schule
150	Magdalenenstraße
126	Meisterhofen Mühle
124	Mörikestraße
148	Raderach
120	Riedlehof
115	Riedleparkstraße
117	Scheffelstraße Festhalle
149	Schnetzenhausen
161	Schwabstraße
153	Sparbruck
110	Stadtbahnhof
151	Stadt. Krankenhaus
152	Stadt. Krankenhaus Röntgenstr.
137	St. Elisabeth Werastraße
147	Unterraderach
125	Waggershauser Straße
132	Waggershausen, Traube

Rufbus-Anmeldezeiten Friedrichshafen

Montag bis Donnerstag 6.15–23.00 Uhr

Freitag und Samstag 6.15–24.00 Uhr

Sonn- und Feiertag 8.00–23.00 Uhr

Im Frühdienst Friedrichshafen, Montag bis Freitag 5.30–6.30 Uhr werden nicht alle Haltepunkte angefahren. Anmelden bis 22.00 Uhr des Vortages.

The map in Figure 10, on the preceding page, shows the service area of the Ruf-Bus demonstration project in the Friedrichshafen area in 1981. Demand-responsive (i.e. Ruf-Bus) services were offered only in Markdorf and Friedrichshafen (i.e. the two large black circles in Figure 10). Early tests of the route-deviation concepts were made on trips between Markdorf and Friedrichshafen (i.e. in the communities designated by smaller black circles). The communities designated by large and small white circles (i.e. Ailingen, Tettnang, Riedheim), in Figure 10, were not provided with either demand-responsive or route-deviation transportation services in 198 1.

The following describes the flow of information from the central computer to a bus. As soon as the "Accept" key on the call-box is pressed by the user, the central computer updated all its files and prepared a "digital telegram" (i.e., message) that would be sent to the computer terminal on-board the assigned "bus" . Figure llA, on the following page, shows a typical terminal for a bus and Figure 11B shows a typical terminal for a taxi used in the Ruf-Bus system. These on-board computer terminals were a third important feature of the Ruf-Bus system.

As soon as a Ruf-Bus driver completed picking up or delivering a passenger to a checkpoint, the driver would look at the on-board computer terminal to find out what checkpoint to go to next. The central computer maintained the planned route and schedule file for each bus. As new trip requests came in from call-boxes and other sources, the central computer updated the route and schedule file for each bus and transmitted the updated "next stop number" to each bus at the appropriate time. The Ruf-Bus drivers had no need for written trip sheets that constantly needed to be modified.

In addition to accepting trip requests from call boxes, the Ruf-Bus system also accepted trip requests via both postcards and telephones. Postcards were usually used by passengers to enter standing orders for multiple rides (e.g., "I want to be picked-up at bus-stop number 435 at 8:30 A.M. each weekday and transported to bus-stop number 365", "My husband, our two children and I want to be picked up every Sunday morning at 8:30 A.M. and delivered to bus-stop number 104; one of my children is in a wheelchair. We also want a return trip at 11:45 A.M.".)

Figure 11A
Terminal in Minibus

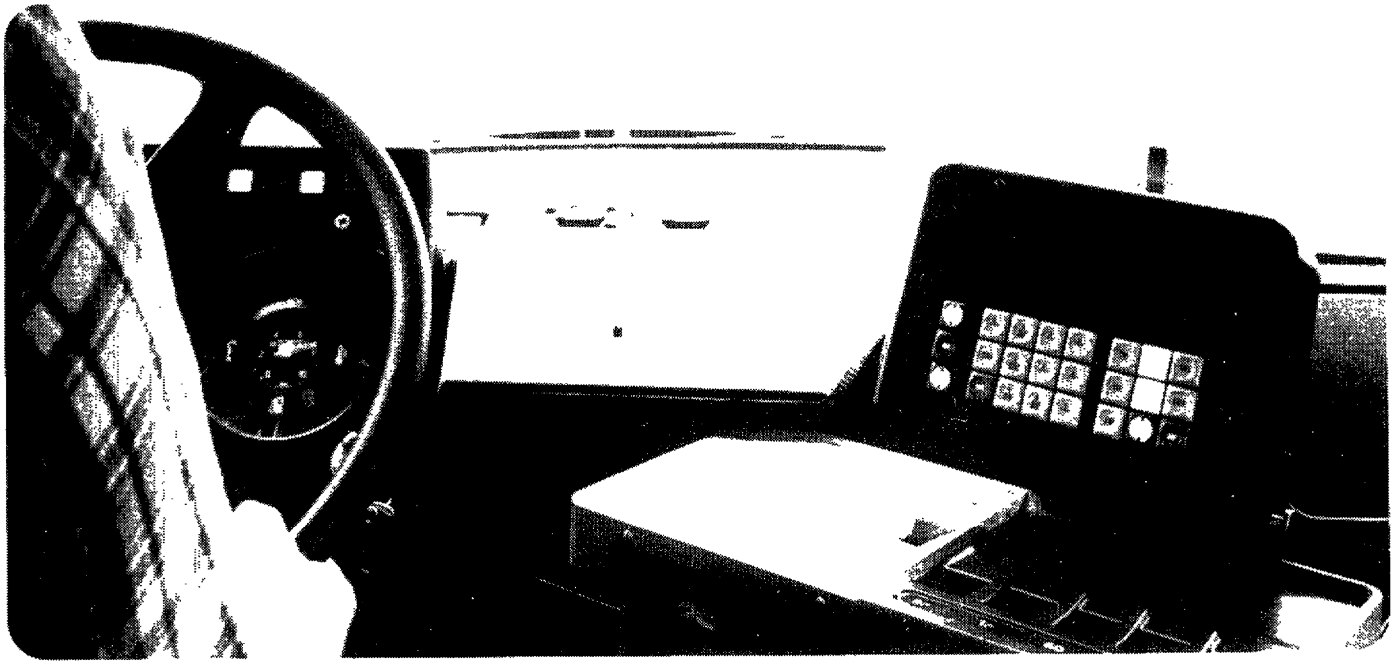


Figure 11B
Terminal in Taxi

Telephones were also used to enter trip requests. The Ruf-Bus system had one or more telephone operators with computer terminals at the central computer center whenever the buses were on the road. These operators would enter a caller's trip request, pressing the appropriate buttons on a computer terminal rather than on a call-box. It should be noted that of the 29 bus-stops in the pilot Ruf-Bus system, 16 were equipped with call-boxes. It should also be noted that the telephone operators used their terminals to enter information into the computer from postcards when they were not busy with telephone calls.

The Ruf-Bus system was continuously expanded in the Friedrichshafen area until, by 1981, it covered a large service area. The following are the key statistical features of the Ruf-Bus service area in 1981:

- Area size - approximately 75 sq. km.
- Population - approximately 36,000
- Number of bus-stops - 90
- Number of call-boxes - 16
- Maximum number of vehicles - 24
- Average number of passengers per month (1981) - 44,300 in 1981

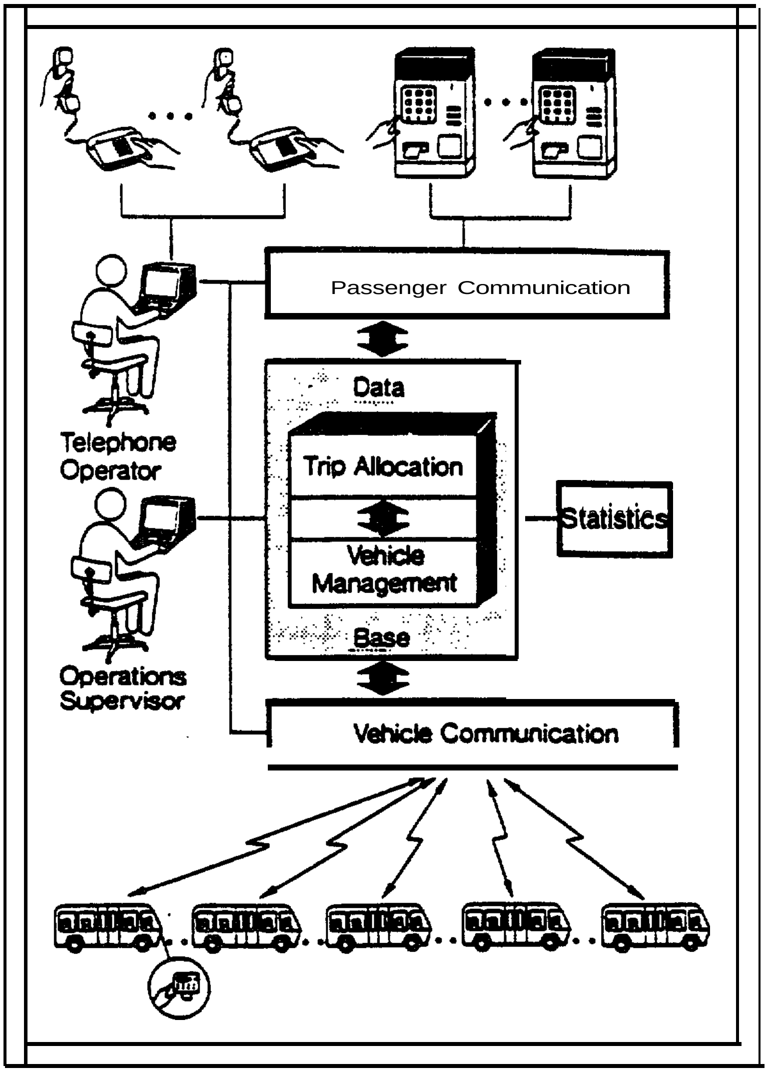
The ridership of 44,300 per month on Ruf-Bus represented an increase of 36 percent over the fixed-route bus services it replaced in the test area.

Similar increases in ridership were reported in the RETAX operational test in Wunsdorf, a suburb of Hannover, in northern Germany. The RETAX system was developed by MBB rather than Domier. It was very similar in concept to the Ruf-Bus system in that it used call-boxes, and a mix of minibuses and taxis equipped with on-board terminals that could communicate with a central computer. The following are the key statistical features of the RETAX (aka R-Bus) service area in 1979:

- Area size - approximately 100 sq. km.
- Population - approximately 40,000
- Number of bus-stops - 92
- Number of call-boxes - 48
- Maximum number of vehicles - 23

- Average number of passengers per month (1979) - 20,000

Figure 12
Overview of the Ruf-Bus System



This was "a ridership increase of about 80 percent over the line buses it replaced" (23). Approximately 85 percent of trip requests on the RETAX system were made via call-box. This is somewhat higher than that experienced in the Ruf-Bus operational test. The average waiting time was between 6 and 8 minutes and 90 percent of all passengers had waiting times less than 13 minutes. This is approximately the same as for the Ruf-Bus system.

The RETAX system also had a productivity of 13 passengers per vehicle-hour in 1979. This is much higher than for demand-responsive systems in the U.S. which in 1987 had productivity rates of 3.2 passengers per vehicle-hour (24). However, it must be remembered that most U.S. demand-responsive systems are for specialized E&H door-to-door service, rather than non-specialized checkpoint-to-checkpoint service like RETAX and Ruf-Bus.

Figure 12 provides a schematic description of the first generation German “smart-bus” system. It applies to the RETAX system in Wunsdorf as much as to the Ruf-Bus system in Friedrichshafen. Although Figure 12 shows all of the vehicles in the Ruf-Bus and RETAX systems were minibuses, microbuses (i.e. taxis) were also used.

A HISTORY OF FOCCS-PART I

Although Ruf-Bus had more passengers per month in 1981 than the fixed-route bus system it replaced in 1977, monthly revenues increased less rapidly (in real terms) during this period. Analysis of the increased ridership showed that monthly pass holders made more trips per month because of the improved service, so monthly revenues did not increase as fast as monthly ridership.

Monthly operating costs increased much more rapidly (in real terms) than ridership during this same period. As a result, the Ruf-Bus system proved to be too costly. The decision was then made to transform Ruf-Bus, a pure checkpoint-to-checkpoint demand-responsive system, into a multiple-mode public transportation system. It was named Flexible Operations Command and Control System (FOCCS). Although the central computer hardware and the on-board computer terminals remained much the same, the concept of operations and the software of the Ruf-Bus system were modified extensively to create FOCCS, which is pronounced "FOX".

In addition to the checkpoint-to-checkpoint demand-responsive mode, FOCCS included a fixed-route mode and an innovative route-deviation mode, which was partly fixed-route and partly demand-responsive. A bus, minibus or microbus, equipped with an on-board computer terminal (similar to those in Figure ll), would be assigned a series of compulsory stops and a number of optional stops within a travel corridor.

Figure 13 shows a circular "bus" route with eight (8) compulsory stops (i.e. filled in black circles) and sixteen (16) optional stops (i.e. white circles with three-digit numbers inside). After picking-up or delivering a passenger to any stop, the on-board computer terminal would tell the driver which bus stop to go to next. The central computer would only divert a "bus" to pick-up a passenger at an optional stop if that passenger had previously submitted a ride request-by call-box, telephone or postcard - to tell the transit agency and its FOCCS computer that he or she wanted to be picked up at the optional stop at that time.

Figure 13
Circular Corridor Route-Deviation Service

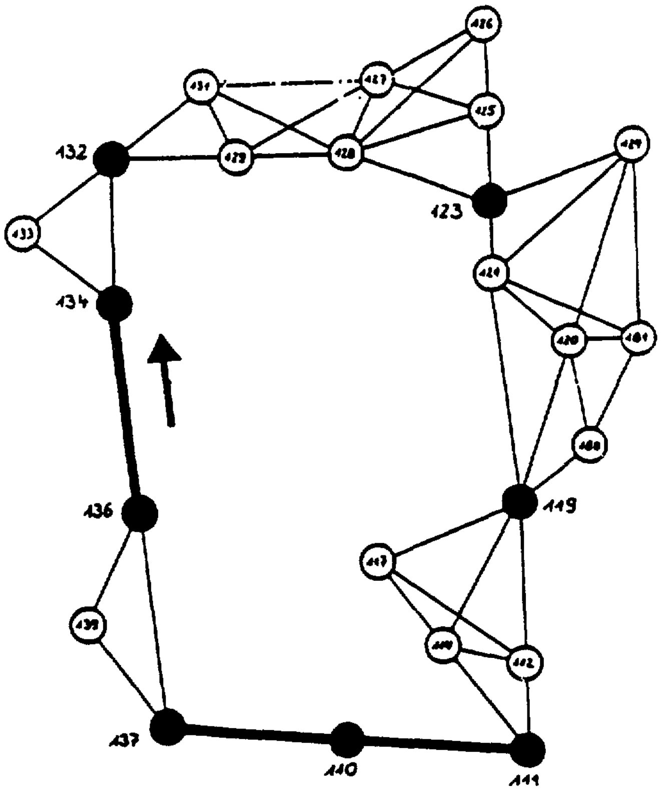
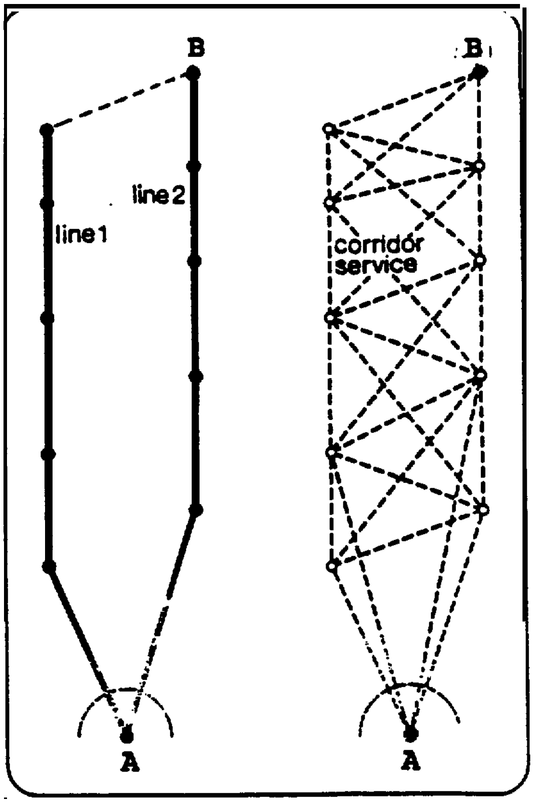


Figure 14 shows how two parallel fixed-route bus lines in a low-density area can be replaced by a single route-deviation “line”. Except for the two end stops marked A and B, all of the stops on fixed-route Line 1 and Line 2 (i.e. on the left side of Figure 14) became optional stops on the route-deviation line (i.e. on the right side of Figure 10). Instead of having one-hour headways, for example, on fixed-route lines 1 and 2, residents of the corridor could have half-hour headways on the route-deviation “line” without any increase in the number of buses or drivers. This improved service level would tend to attract more riders in low-density areas. It would also not cost much more.

Although route-deviation “buses” are a flexible-route service, they may also be a fixed-schedule service. In Figure 14, for example, the FOCCS system may have the arrival at Stop B set at 30 minutes after the departure from Stop A in order for passengers to have a short wait before transferring to a ferry, rail line or express bus at Stop B. If an unexpectedly high demand for rides comes in from the optional stops, between A and B, the FOCCS computer will notify one

Figure 14
Linear Corridor Route-Deviation Service



or more demand-responsive minibuses or taxis in the area to pick up some of the passengers in order to maintain the schedule of the route-deviation “bus”,

Using the flexibility of the FOCCS system, a transit agency could operate the same vehicle in (1) fixed-route mode during the morning and afternoon peak commuting periods, (2) route-deviation (aka corridor or corridor-deviation) mode during the midday, and (3) demand-responsive mode during evening hours or on weekends and holidays. The bus, minibus or microbus needs to be equipped with a computer terminal and a data radio, of course, to operate in either of the two flexible-route modes.

In addition to the availability of both fixed-route and route-deviation modes in the FOCCS system, there was another important difference between the Ruf-Bus and FOCCS systems. Because of the high cost of installing, operating and maintaining call-boxes at outdoor bus-stops, the use of call-boxes was de-emphasized and the use of ordinary telephones was encouraged in the FOCCS system. The reason for this was the German telephone company required that each call-box be billed as a metered business phone and that each call-box be connected to the central computer facility by wire rather than wireless links.

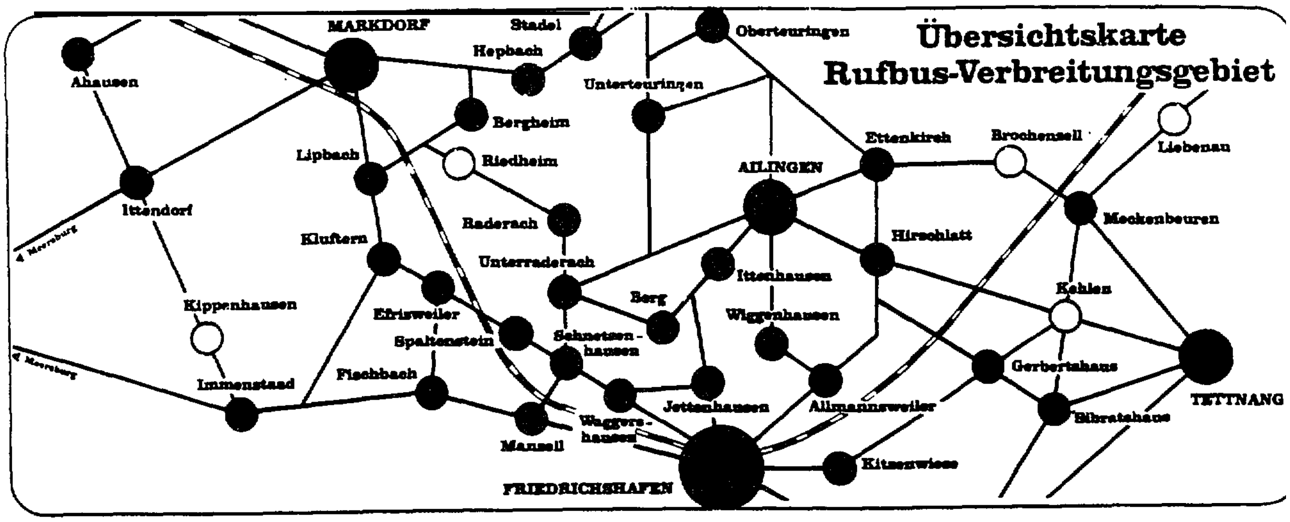
The monthly cost of the leased line and the monthly telephone charges for each call-box made the call-box approach much more costly than the wireless approach used to connect on-board computer terminals with the central computer. In the United States, telephone companies allow wireless communications between two fixed sites, so the decision to phase out call-boxes should be re-evaluated for “smart-bus” installations in this country.

By 1987, the service area for the FOCCS system in Friedrichshafen was much larger than the service area of the Ruf-Bus system in 1981. The following are the major characteristics of the service area:

- Area size - approximately 300 sq. km.
- Population - approximately 100,000
- Number of bus-stops - 180
- Number of call-boxes - 13
- Maximum number of vehicles - 40 (excluding vehicles of “external bus lines ")
- Average number of passengers per day - 5,000 in 1987.

Figure 15 is a map of this expanded service area. As in Figure 10, the black circles represent the communities served by FOCCS buses. In addition to ferry services and railway lines within Lake Constance County, there were four (4) "internal bus lines" operated by the FOCCS transit agency, seven (7) "external bus lines" operated by other agencies, and two (2) school bus lines.

Figure 15
FOCCS Service Area in 1987



The replacement of the pure demand-responsive services of Ruf-Bus with the multi-modal FOCCS reduced monthly ridership and monthly fare revenues (in real terms) slightly. However, it reduced monthly operating costs significantly (in real terms) between 1981 and 1987.

Although the FOCCS technology has become more and more powerful since 1987, it would be useful to interrupt the discussion of the history of FOCCS at this time to evaluate the performance of Ruf-Bus and FOCCS in the Friedrichshafen test area between 1977 and 1987.

The data presented in the following section are not for the entire Friedrichshafen area. They are only for the test area that was covered by the Ruf-Bus system in 1981 (See Figure 10). This is important because the line haul system covered the entire Friedrichshafen area in 1977 and its total ridership was much higher than shown in the tables in the following section. In like fashion, the FOCCS system in 1987 covered a much larger service area and had a much higher ridership than shown in the tables in the following section.

A COST-BENEFITS ANALYSIS OF RUF-BUS AND FOCCS OPERATIONAL TESTS IN FRIEDRICHSHAFEN, GERMANY

Most of the quantitative data in this section about the performance of Ruf-Bus and FOCCS were obtained from a five-volume study, "The Shellharbour Transport Feasibility Study" (25), by a joint Australian-German consulting team. On the basis of this study, the Municipality of Shellharbour decided to conduct an operational test of FOCCS in Australia. On the basis of this study, public and private organizations provided funding for this operational test.

Table 13 shows that the replacement of fixed-route (aka line haul) bus transit services with demand-responsive Ruf-Bus services in the test area led to a dramatic increase in the number of vehicle-miles of service per month between 1977 and 1981. In turn, the replacement of Ruf-Bus services with multi-modal FOCCS services led to a significant reduction in the number of vehicle-miles of service between 1981 and 1987.

Table 13
Comparison of System Performance in Line Haul, Ruf-Bus and FOCCS Operation

Year	Operation Mode	Monthly Performance Vehicle Kms	Comparison (%)
1977	Line Haul	29,300	100
1981	Ruf-Bus	83,000	283
1987	FOCCS	47.200	161

The following points should be noted in analyzing the data in Table 13.

- Ruf-Bus and FOCCS had many more bus-stops than the line haul service, which made transit more convenient to residents of the test area.

  Ruf-Bus and FOCCS used many more vehicles than the line haul service in the test area, but these vehicles tended to be much smaller vehicles, with lower costs per vehicle-mile.

> Ruf-Bus and FOCCS were part of an operational test which included many extra vehicle trips to test new hardware and software features.

"The reduction in the FOCCS vehicle kilometers, compared with that of Ruf-Bus, was a result of the integration of all public transport vehicles into the system. This made it possible to eliminate marginal services and to adopt the operation mode (i.e. fixed-route, route-deviation, or demand-responsive) best suited to individual circumstances" (25)

Table 14 shows that the residents of the test area preferred Ruf-Bus demand-responsive services to both the line haul services and multi-modal FOCCS services. It also shows that the residents preferred the multi-modal FOCCS services to line haul services.

"(One factor) to be taken into account (in analyzing the data in Table 14) is the general decline of passengers available for public transport in the Lake Constance County due to the general changes in the population structure. Several years of declining birthrates (also) had an impact on the school bus service. The continuous increase in car ownership, especially in the rural areas, also should be considered. In most transport areas of (West Germany) this growth amounted to about 3 % per annum." (25)

Table 14
Comparison of Numbers of Passengers in Line Haul, Ruf-Bus and FOCCS Operation

Year	Operation Mode	No. of Passengers per Month	Comparison (%)
1977	Line Haul	32,600	100
1981	Ruf-Bus	44,300	136
1987	FOCCS	37,800	116

"After the service change over from Ruf-Bus to FOCCS the number of passengers declined to only 85% of the Ruf-Bus figures. However, this was still 116% of the number of passengers carried by the line haul service. This increase over the line haul service is remarkable considering the fact that there has been a decline in potential passenger numbers throughout the Federal Republic since 1977. The reasons for the increase can be traced to the more user-friendly service offered by FOCCS with regard to transfer synchronization and the level of individual service provided by demand-responsive and corridor service. The wide availability of information and the trip disposition service provided by the FOCCS centre were also important factors. It has also been observed that the greater bus stop density of the corridor service mode has improved the image of the service. Passengers prefer shorter walking distances to and from the bus stops." (25)

Table 15
Comparison of Costs in Line Haul, Ruf-Bus and FOCCS Operations

Year	Operation Modes	Monthly Cost (in current DM)	Comparison (%)
1977	Line Haul	95,000	100
1981	Ruf-Bus	229,000	241
1987	FOCCS	130,000	137

Table 15 shows the change in monthly operating costs* between 1977 and 1987 in current DM. In Table 16 the actual cost data have been deflated by 2.9 percent per annum, which is the rate that fares increased over this same decade. This was recommended by the Australian consultants.

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*The monthly costs include the monthly costs of capital equipment (i.e. building and vehicle depreciation) but exclude the Ruf-Bus or FOCCS hardware, software, personnel, etc. costs.

Table 16
Comparison of Costs in Line Haul, Ruf-Bus and FOCCS Operations

Year	Operation Modes	Monthly Cost (in constant 1977 DM)	Comparison (%)
1977	Line Haul	95,000	100
1981	Ruf-Bus	203,600	214
1987	FOCCS	96,900	102

"The heavy cost increase (114% in real terms) in moving from line haul to Ruf-Bus services can be traced back almost exclusively to the increase in vehicle-kilometers (See Table 13)". . . . . .

"In the FOCCS operation, the rate of increase in operations costs was also lower (up 2% in real terms) than the increase in operational performance (up 161%) when compared with the line haul service of 1977. This is because it was possible to operate some of the demand-responsive, corridor services and line haul services with cost-effective minibuses. These vehicles had been taken over from the Ruf-Bus operation, but they were not available for the line haul service of 1977." (25)

Table 17
Comparison of Costs per Trip in Line Haul, Ruf-Bus and FOCCS Operations

Year of Operation	Operation Modes	Costs Per Trip (in current DM)	Comparison (%)
1977	Line Haul	2.91	100
1981	Ruf-Bus	5.18	178
1987	FOCCS	3.44	118

Table 17 shows the changes in the cost per trip in the test area between 1977 and 1987 in current DM. In Table 18, once again, the actual cost data have been deflated by 2.9 percent per annum, which is the rate that fares increased over this same decade.

Table 18
Comparison of Costs per Trip in Line Haul, Ruf-Bus and FOCCS Operations

Year of Operation	Operation Modes	Costs Per Trip (in constant 1977 DM)	Comparison (%)
1977	Line Haul	2.91	100
1981	Ruf-Bus	4.60	158
1987	FOCCS	2.56	88

Table 18 is important for Tri-Met and other U.S. transit operators because it shows that using new technologies (e.g. FOCCS) to integrate flexible-route paratransit services with fixed-route transit services may be able to both increase ridership and reduce costs per passenger trip in their service area.

In fact, if one divides the increases in monthly costs* between the Line Haul and FOCCS (1,900 in constant 1977 DM) by the increases in monthly ridership (5,200), the cost per additional passenger is only DM 0.35. This is only 12 percent of the average cost per passenger of the fixed-route bus system. As a result, the average cost per passenger of the FOCCS "bus" system dropped from DM 2.91 to DM 2.56 (12%) in constant 1977 DM.

Note, however, the cost per additional passenger in going from the Line Haul system to a Ruf-Bus (i.e. dial-a-ride) system was DM 9.28. This is 218 percent higher than the average cost per passenger of the fixed-route bus system. As a result, the average cost per passenger of the Ruf-Bus system increased from DM 2.91 to DM 4.60 (58%) in constant 1977 DM.

However, the following caveats should be noted by U.S. readers about the data:

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*This includes both annualized capital costs and operating costs. It does not include the costs of the FOCCS hardware, software, personnel, facility, etc.

“As the FOCCS system has been operating with several evolutionary changes in Germany for over a decade, there are operating statistics available and documented . . . . . from which some conclusions can be drawn, which relate to the potential for financial viability.

In Friedrichshafen, on the face of it, deflated revenue per passenger decreased from DM$0.92 to DM$0.90 with the introduction of call-bus services but recovered to DM$1.06, slightly higher than its previous value, as the system was modified to the FOCCS mixed line-haul and call-bus system. Inflated operating costs per passenger increased from DM$2.91 to DM$5.17 with the introduction of call-bus but recovered to DM$3.44 with the introduction of the FOCCS system.

However, these raw statistics do not provide an accurate basis for financial conclusions to be drawn as they need further processing to extract true comparative data and there were many extenuating circumstances for the apparently poor financial performance in Germany (e.g. when current rather than constant DM are used) and, in addition, some circumstances are different in Shellharbour for which adjustments should be made.

The FOCCS service concepts were experimental in Friedrichshafen and, while research grants were limited to certain components of the operation, the services were provided in an environment of experimentation rather than with close attention to financial efficiency. Concessions given to pensioners and other issues in the fare structures were not normal and the composition of the bus fleet changed dramatically with the introduction of smaller buses with different performance characteristics.

German bus companies are directly subsidized and do not attempt to recover their operating and capital costs completely from the fare box (i.e. as they do in Shellharbour, Australia). Policies relating to the extent and nature of these subsidies vary in different places in Germany. (NOTE: In Lake Constance County, government agencies subsidize approximately 15% of the operating and annualized capital costs of public transportation services). Some transit companies are restricted to a longer term fixed-amount subsidy, whereas others are supported by a

> certain percentage of costs which may itself vary according to variations in policy.
>
> In Friedrichshafen, therefore, it is quite clear that the FOCCS system was not intended to recover its marginal costs from marginal revenue from the fare box. Even so, as shown later in this section, it is probable that deflated marginal revenue exceeded deflated marginal cost."

The preceding statement was made by an Australian transportation consulting firm, R. J. Nairn & Partners Ltd. In brief, the available financial and ridership data indicate that changing from fixed-route to multi-modal FOCCS services was a good business decision in Friedrichshafen. R. J. Nairn and Partners also stated that replacing fixed-route services with multi-modal FOCCS services also looked like a good business decision for Shellharbour.

A HISTORY OF FOCCS - PART II

The German Flexible Operations Command and Control Systems (FOCCS) has undergone many improvements since 1987. One of these improvements was to redesign the in-vehicle computer terminal in order to give it greater processing capabilities. The redesigned on-board computer terminal, known as IBIS, is shown below.

It contains a microcomputer chip and slots for controllers to manage a variety of in-vehicle peripheral devices.

Standardized IBIS Vehicle Terminal
With Integrated Radio Equipment

One of these in-vehicle peripheral devices is a memory module, a solid-state device that provides up to five million bytes of non-volatile data and program storage. It may be considered to be a non-rotating floppy disk which fits into the verticle slot on the left of the IBIS terminal (shown in the Figure above). The removable memory module is a card that has the same width and length as a standard Visa or American Express card, but is four or five times thicker than these traditional magnetic-stripe cards.

The memory module contains the data base required for a days activities for a "bus" driver under FOCCS. This database contains the number, location, and scheduled arrival time at all compulsory bus-stops along each fixed-route or route-deviation line that was assigned to the driver for the day. This database also includes the number and location of optional bus-stops or decision-points along any route-deviation lines. A decision-point is a place where the on-board IBIS computer would ask the central computer whether it should deviate to an optional bus-stop.

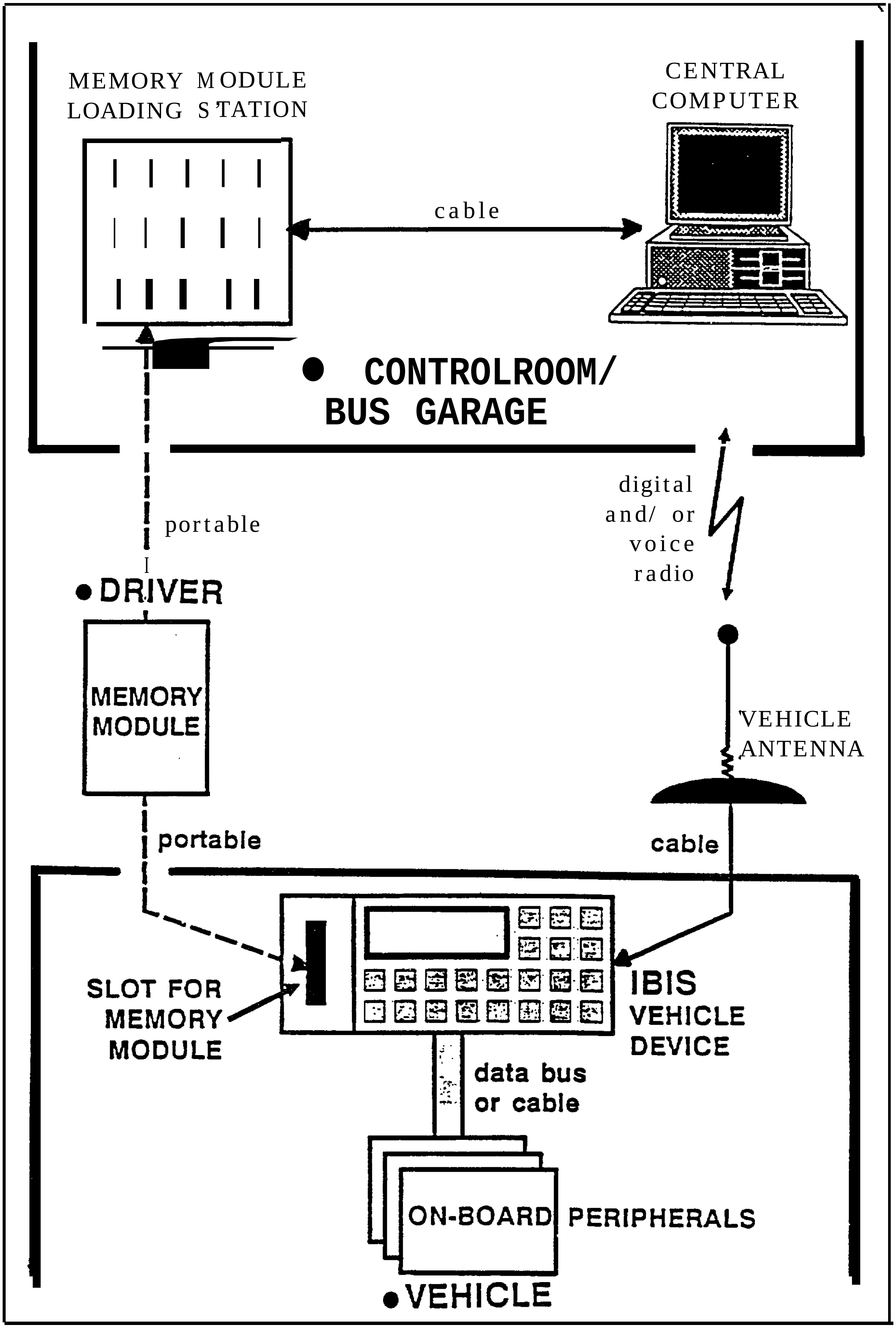
The memory module is also used to store information collected by a driver's vehicle during the course of the day. This information could include data on when and where riders got on and off the "bus". This is necessary for distance-based fares and useful for evaluating how well the transit system is meeting passenger demand. This information could also include fare collection data, engine or transmission temperature data, and data about the scheduled and actual arrival times at each bus-stop.

At the start of work each day, a driver under the FOCCS system would pick up his or her updated memory module from the loading station on the wall of the "bus" garage or control room. (See the upper left hand corner of Figure 16). The driver would then hand-carry the memory module to the "bus" and insert it into the slot on the on-board IBIS terminal. During the course of the day, the central computer sends and receives information from the IBIS microcomputer which updates the driver's memory module. Other sensors (e.g. passenger counters, fare boxes, temperature gauges) also send data to the IBIS microcomputer which updates the driver's memory module.

At the end of the workday, the driver would take the memory module from the in-vehicle IBIS terminal and hand-carry it back to the control room or garage and insert it into the loading station. During the time prior to the start of the driver's next shift, the central computer extracts information from the driver's memory module for processing and then sends the next days data base to the driver's memory module in the loading station. The cycle starts over on the next work day.

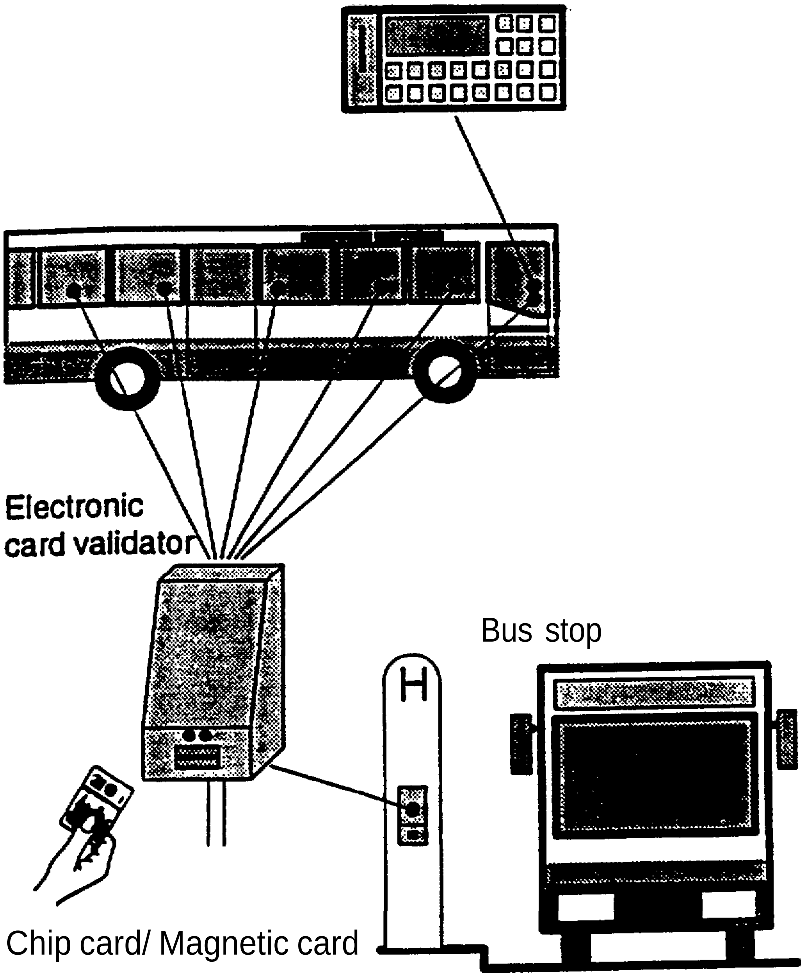
Another in-vehicle peripheral device is a "smart-card" fare collection machine. A smart-card is a card exactly the same size and shape as a magnetic-stripe

Figure 16
FOCCS Memory Module Information Flow



Visa or American Express card. However, it has one or more small electronic chips for storing information imbedded in the plastic. In some FOCCS installations, smart-cards may be used by passengers to pay their fares. In some cities, smart-cards are treated as credit cards and the passenger is billed monthly for public transportation services by a bank, telephone company, credit card company, etc.

Figure 17
Smart-Card Information Flow



In other cities, smart-cards are treated as debit cards, like farecards on San Francisco's BART system or Washington D.C .'s METRO system. Passengers would use a smart-card kiosk, located at or near a bus stop, shop, bank, etc., to prepay, for example, $20 worth of fares. The read-write unit in the kiosk would increase the fare balance in the smart-card. Each time the passenger uses the card, the on-board computer would reduce the balance in the smart-card by the amount of the fare and increase the "fares collected" balance in the driver's memory module in the IBIS unit.

The smart-card allows transit operators the flexibility of setting up distance-based fares, like those of BART or METRO. Passengers would insert their smart-cards into an electronic card read-write or validator unit on boarding or leaving the vehicle. Fares would be computed by the on-board IBIS computer, based upon the distance travelled. An operational test of smart-card, distance-based, fare collection systems in Blois (France), found out they not only made public transit more convenient for passengers and drivers, they also increased ridership. Apparently, many residents of Blois would not use the former bus service for short trips, because they considered the flat fare to be too expensive. Distance-based fares eliminated this objection and ridership increased.

Figure 17 shows that a bus can have more than one smart-card reader on board. It also shows that in some transit systems a passenger could insert his or her card into a validator located in a kiosk at the bus stop. This is a desirable feature when the buses are crowded, but these bus stop units tend to experience more vandalism problems. Figure 17 also shows that fare collection data from smart-cards, cash payments, etc. are stored by the on-board IBIS computer in the driver's memory module.

The on-board IBIS computer unit can also perform a variety of other valuable functions. These include the following:

1. Automatic Vehicle Location (AVL) - Storing the daily schedule for each bus in its on-board computer permits the bus to use its electronic odometer to accurately estimate where it is at any time and to report delays to a central control center on an exception basis. The location of the bus is re-initialized at every stop, when the door opens and closes, to prevent location errors from

cascading. The reporting of delays on an exception basis minimizes radio traffic congestion.

2. Traffic Light Preemption - When a bus is running late it can send a signal to set traffic lights to green as it approaches an intersection, in order to help make up time. Some systems only allow full buses to use this feature.

3. On-board Passenger Information - By using the daily schedule in the on-board computer, each transit vehicle can display or announce (via synthetic speech or prerecorded messages) the names of the next stop or transfers to other lines. New riders do not need to bother the driver for information or try to read street or station signs from the vehicle.

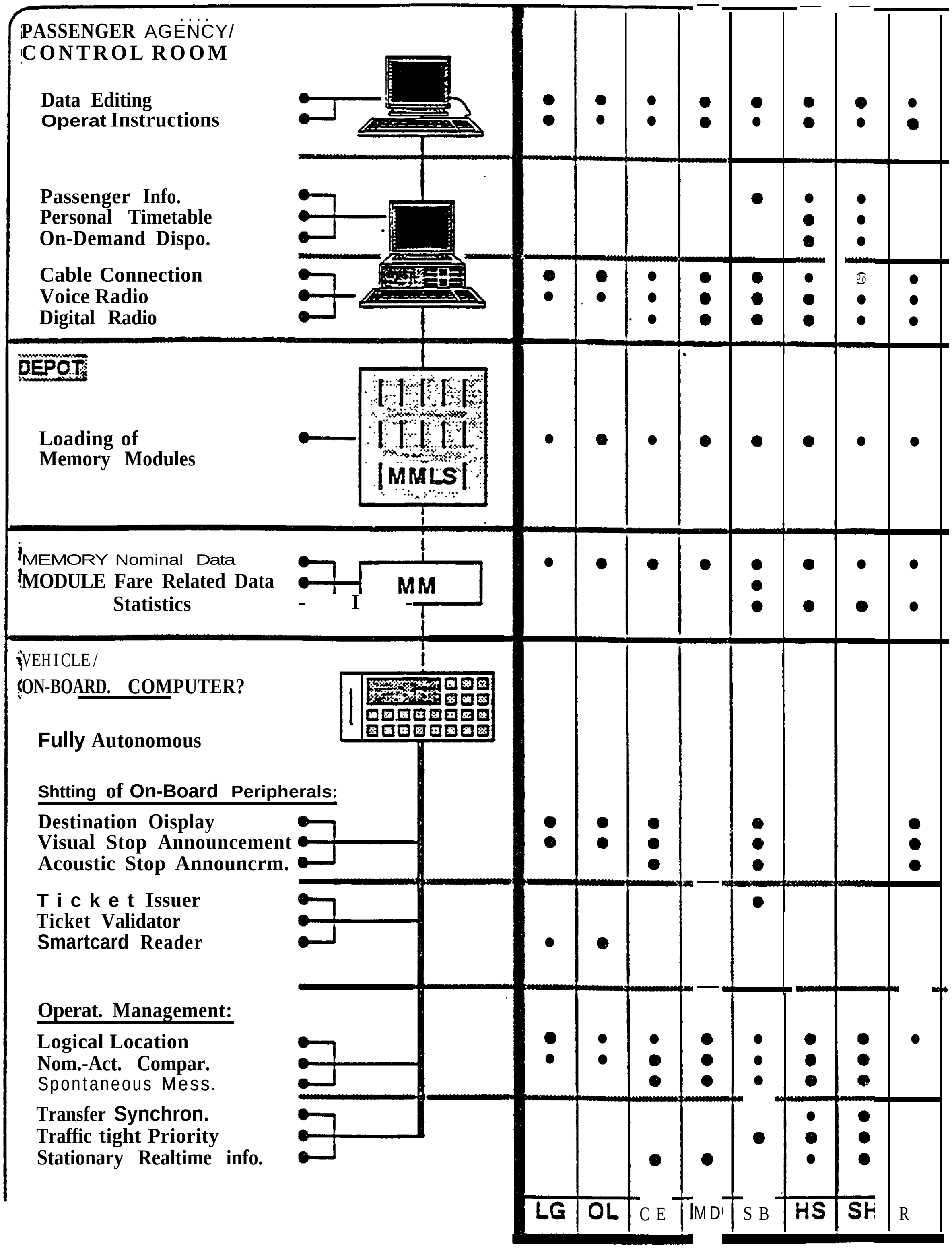
4. Station Passenger Information - Buses can transmit scheduled and estimated arrival times to "smart" displays at bus stops, LRT stations, etc.

5. Real-Time Trip Planning - Telephone receptionists can instantly retrieve the latest arrival-departure information for any bus stop from the central control center computer.

6. Improved Timed-Transfers - The central computer can notify selected vehicles to delay their departure if sufficient feeder services are running late because of bad weather, traffic congestion, etc. Waiting passengers know when to expect their next bus from display devises at bus stops or by calling an audiotex (i.e. voice response) rider information number.

8. Vehicle Occupancy - Sensors attached to the vehicle's springs can tell the on-board computer that the vehicle is 20, 40, 60, 80 or 100 percent full. This is important because so many passengers use monthly passes and do not use the fare machines. Infra-red passenger counters that interface with the on-board computer are now in testing.

Figure 18
FOCCS Installations and Configurations



	LG	OL	CE	MD	SB	HS	SH	R
PASSENGER AGENCY/ CONTROL ROOM								
Data Editing	●	●	●	●	●	●	●	●
Operat Instructions	●	●	●	●	●	●	●	●
Passenger Info.					●	●	●	
Personal Timetable						●	●	
On-Demand Dispo.						●	●	
Cable Connection	●	●	●	●	●	●	●	●
Voice Radio	●	●	●	●	●	●	●	●
Digital Radio			●	●	●	●	●	●
DEPOT								
Loading of Memory Modules	●	●	●	●	●	●	●	●
MEMORY MODULE								
Nominal Data	●	●	●	●	●	●	●	●
Fare Related Data					●			
Statistics					●	●	●	●
VEHICLE/ ON-BOARD. COMPUTER?								
Fully Autonomous								
Shtting of On-Board Peripherals:								
Destination Oisplay	●	●	●		●			●
Visual Stop Announcement	●	●	●		●			●
Acoustic Stop Announcrm.			●		●			●
Ticket Issuer					●			
Ticket Validator								
Smartcard Reader	●	●						
Operat. Management:								
Logical Location	●	●	●	●	●	●	●	●
Nom.-Act. Compar.	●	●	●	●	●	●	●	
Spontaneous Mess.			●	●	●	●	●	
Transfer Synchron.						●	●	
Traffic tight Priority					●	●	●	
Stationary Realtime info.			●	●		●	●	

9. Ermine. Transmission. etc. Monitors - Temperature, pressure and other sensors can send data to the IBIS computer which can alert the driver or central computer of potential engine, transmission or other problems.

From the preceding discussion, one can see that FOCCS has been designed to be a modular system that can be configured in many ways to meet the diverse needs of various types of transit agencies. In fact, Figure 18 on the preceding page shows that transit agencies in Germany and Australia have installed a different mix of FOCCS features to meet their own special needs.

The two letter code at the bottom of Figure 18 identifies the FOCCS installation - LG is Luneburg, OL is Oldenberg, SH is Shellharbour (Australia), etc. New hardware and software features are still being designed and developed for FOCCS.

Public Sector Systems (PSS), a newly-formed subsidiary of Bell-Atlantic, signed a licensing agreement with GSI of Salem, Germany in June 1992 to sell and service FOCCS throughout North America. Preliminary discussions with the management of PSS indicates that they plan many more improvements to FOCCS. PSS also plans to have most of its FOCCS hardware components manufactured in the United States.

POSSIBLE EXTENSIONS TO FOCCS FOR THE U.S. MARKET

Although the FOCCS communications/control center in Saarbrucken features custom consoles and cabinetry, most of the German “smart-bus” control centers are large offices filled with four or five standard-sized desks and one or two tables. Radio equipment and microphones for voice communications with vehicle drivers are located on a table or on one of the desks along with a CRT terminal or a personal computer (PC) for communications with the FOCCS central computer. All of the other desks have a telephone for voice communications with would-be passengers and a CRT terminal or a personal computer (PC) for communications with the FOCCS central computer.

In the current FOCCS design, both the on-board (IBIS) computer and the central computer know the scheduled location and the actual* location of the “bus” at all times. As soon as a bus starts to run two or three minutes behind schedule, the on-board IBIS computer automatically sends a digital telegram/message to the FOCCS central computer so it can update its vehicle location files. Satellite-based global positionings systems (GPS) are now being evaluated for FOCCS vehicles to provide more accurate information on the actual location of the vehicle. A FOCCS telephone operator can use his or her desk-top computer/terminal, which is connected to the FOCCS central computer, to enter or change trip requests for a caller or to retrieve current transit information for a caller. The FOCCS telephone operator could, for example, tell a caller that the l0:15 bus to Friedrichshafen will arrive at checkpoint 146 at 10: 18, three (3) minutes late,- because of weather problems.

The FOCCS telephone could also tell the caller that there will be enough time to catch the 11 AM train or ferry, or help the caller make alternative travel arrangements. In many respects, a FOCCS telephone operator provides the same type of information services for local or regional transit passengers that a telephone reservations agent provides for airline passengers.

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*In the present FOCCS system the actual location of each vehicle is estimated by using the time that has elapsed since leaving the last checkpoint, whose location is known, and the planned route and scheduled time of arrival at the next checkpoint, whose location is also known.

The following statements, by the joint Australian-German consulting team that evaluated FOCCS for the Municipality of Shellharbour (25), describes the growing importance of this information provider function:

> “The importance of the FOCCS control room as a passenger service centre has increased considerably over the operating life of the system. Its availability as a contact point is greatly appreciated by passengers and also potential public transport users. Because of the constant availability of these phone services and because of their well-known phone numbers, the FOCCS control rooms in Friedrichshafen and Wunstorf have reached a service quality which is usually only achieved in large city transport operations. This is documented by the great number of calls which are made not for trip requests but to obtain public transport information.
>
> Time table information and trip recommendations are generally requested by those passengers who either do not have a timetable, do not trust timetables, cannot read them or who are not familiar with the public transport organization. Through the use of EDP, it is now possible to have all timetables, published and unpublished, (including school bus and railway time tables) on the computer. It is, therefore, possible to provide a fully automatic information service. This means that it is no longer necessary to search timetable books or tables, the operator only has to read the required data from the monitor screen. Such systems for the provision of information to passengers via telephone or at a ticket or information counter exist in many places. A wide spectrum of information is available for future projects.
>
> A considerable advantage of the automated timetable information system is the fact that it is easy to add additional information into the system. This makes it possible to convey precise information for transfer connections to railways and to other service areas. On passenger request, it is possible to provide computer printouts showing personal timetables for such purposes as trips between home and work if various (transfers) are required.
>
> The operational control features, especially the nominal-actual timetable comparison for the purpose of passenger information, has proved to be advantageous. If, for example, timetable information is given, then the

> passenger wants to be sure that he can rely on the information received. From the passenger’s viewpoint, information about a transfer connection is only worth something if the transfer is achieved. Information should therefore be determined from current ACTUAL data. Delays, for example, should be taken into account. This is possible within the framework of operational control as the actual operational status is centrally monitored and diversions from the nominal schedule are observed and processed. ”

Telephone operator-assisted telephone information services are popular with FOCCS passengers and relatively inexpensive to provide at a small operational test site, such as Friedrichshafen or Wunsdorf,’ where the telephone operators have spare time between transit trip bookings. However, as FOCCS systems are installed in larger areas, the costs of providing free operator-assisted transit information services to callers could become very costly for transit agencies. It may be useful, therefore, to briefly review how another industry, the U.S. telephone industry, handled the increasing costs it faced with operator-assisted long-distance calls and operator-assisted directory information calls.

During the 1940s and 1950s, both residential and business users would use a special “long-distance” telephone operator to place all long-distance telephone calls. In order to handle the growing volume and highly-peaked characteristics of long-distance calls, AT&T introduced area codes and direct-distance dialing to let users, in effect, become their own long-distance telephone operators. To provide an economic incentive for “do-it-yourself” long-distance calling, AT&T made direct-dialed long distance calls less expensive than operator-assisted long distance calls. The strategy worked and today almost all long distance calls in the U.S. are made without the use of an operator.

Until the 1970s, telephone subscribers could make an unlimited number of (telephone directory) “information” calls each month. The cost of “information” services was, like the cost of printed telephone directories, included in the monthly subscription fee. Unfortunately, this approach provided little or no financial incentive for subscribers to either consult their printed telephone directories before calling “information”, or to write down telephone

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*Approximately 30 percent of the calls to the Wunsdorf telephone operators are to request information on schedules, arrival times, etc., not to request rides.

numbers for future reference. As a result, the costs of providing “free” information services continued to grow for telephone companies.

In order to reduce the average number of “information” calls a subscriber made each month, U.S. telephone companies began to charge for this service after a subscriber had made his or her quota of “free” information calls in a month. The approach worked. The number of information calls per subscriber declined as more and more users made efforts to minimize monthly surcharges for information services. In turn, U.S. telephone companies were better able to assign the costs of providing information services to callers who used (or abused) this service.

The government-owned telephone company in France took a different approach to controlling the costs of information services. As part of a national program to improve telecommunications services, France Telecom gave its subscribers the choice of “free” printed telephone directories or a “free” Minitel computer terminal, which could serve as an electronic telephone directory. Just as U.S. telephone companies let callers reduce their costs by letting them serve as their own long-distance operators with direct-dialing, France Telecom let callers reduce their costs by letting them serve as their own information operators with the use of Minitels. These terminals gave Minitel users access to the telephone company’s computerized directory data base, so they could look up telephone numbers just like the telephone company’s information operators.

There were other reasons for the creation of the Minitel videotex system. France could reduce imports of paper for telephone directories and it could reduce the cost of printing and distributing these directories, which were out of date as soon as they went to press. Equally important, the widespread distribution of Minitel terminals throughout France could create a market for a variety of new, privately-operated information services (e.g. home-shopping, telebanking, video games, electronic greeting cards, auto-instructional training courses, electronic mail, joke-of-the-day, travel reservations), which would increase telephone usage and profits for the telephone company. Both local calls and long-distance calls are metered in France.

The Minitel strategy worked and this public-private partnership has been a success. There are now over 12,000 information services in France and they generated millions in profits in 1990. Furthermore, over 7 million terminals and personal computers are now connected to the Minitel system and more are being added every day. Profits are growing for both the telephone company and for information providers. The telephone company also earns a commission for billing subscribers and for paying information providers for Minitel information services. Thousands of new information service jobs have been created in France because of the Minitel system.

Because of legal problems related to the breakup of AT&T in the early 1980s, the U.S. has trailed behind France and other countries in the development of videotex services. This may change in the next few years, however, as AT&T, Prodigy (a joint venture of IBM and Sears), the Regional Bell Holding Companies (RBCs) and others collectively invest billions of dollars in videotex systems and services in the United States. If they are successful, videotex will change the way we shop, bank, work, learn, and travel in the United States.

Although the term “videotex” was once applied exclusively to interactive services that used CRT (video) screens to display information, like the French Minitel system, the definition has been broadened in recent years. The term videotex is now usually defined as any user-friendly, interactive, computer-based information service. This definition is broad enough to include:

1. CRT terminal-based services, such as CompuServe, Prodigy and Community-Link in the United States and Minitel in France.

2. Touch-tone telephone-based services, such as the United Airlines “frequent flyer” information system, Charles Schwab’s on-line brokerage system, and the Sacramento Bee’s “BeeLine” information service. Newspapers in Sacramento, Seattle, Vancouver (Washington), Portland (Oregon) and hundreds of other U.S. cities have installed voice-response or audiotex services to provide sport scores, results, trivia questions, news highlights, etc. to their readers/subscribers via telephone.

3. Kiosk-based services, such as bank automatic teller machines (ATMs), City-Guide in Chicago hotel lobbies, and the Ruf-Bus and R-Bus transit systems in Germany.

4. Other types of interactive devices, which include Huntington Bank's new information service in Ohio (which uses AT&T's new "smart-phones") and TV Answer's interactive video data service (which uses ordinary TV sets and a controller manufactured by Hewlett-Packard) to deliver information or process transactions on request. Some analysts include Nintendo video games in the videotex industry.

After the breakup of AT&T in the 1980s, the newly created Regional Bell Holding Companies (RBHCs) - US WEST, Pacific Bell, Ameritech, Bell-Atlantic, etc. - were prohibited from (1) manufacturing, (2) providing long-distance services, and (3) offering information services. In October 1991, after years of effort by the telephone companies, and opposition by the newspaper industry, Judge Harold Green freed the RBHC's from the prohibition against providing a full range of information services. As a result, Bell-Atlantic has set up a subsidiary that will market, among other things, the German FOCCS system. U.S. WEST is working with Minnesota's Department of Transportation to develop transit information systems using Community-Link, US WEST's Minitel-based videotex service. Many new videotex information services are being planned by telephone and other companies. In addition, many improvements are being made to videotex (including audiotex) technologies to make them more "user friendly".

Tri-Met's existing, first-generation, telephone-based bus and rail schedule information service, does not provide estimated arrival times. It is also cumbersome and time consuming to use. To find the scheduled time of departure of the first bus after 7 AM on a weekday on Route 56 between Washington Square and downtown Portland, for example, requires entering the following type of information with a touch-tone telephone keyboard:

1. Computer says: "Route 56-Scholl's Ferry Road Line. Press 1 if you are calling from a touch-tone phone; wait if you are calling from a rotary dial phone". (Pressed " 1 ")

2. "Press 3 if you are heading to downtown Portland or 9 if you are heading away from downtown Portland." (Pressed "3")

3. "Press the following for the schedule information desired: 1 for weekdays, 2 for Saturdays, 3 for Sundays and holidays. For travel times on Route 56, press 9." (Pressed " 1")

4. "For wheelchair accessible trips, press 1, otherwise press 2.'" (Pressed "2")

5. "For destinations beyond Burnside and 6th, press 1, otherwise press 2." (Pressed "2")

6. "Press 1 if your origin bus stop is between Washington Square and Beaverton-HillsdaleHighway. Press 2 if it is between Sunset and Capital Highway and Front and Harrison, etc." (Pressed " 1 ")

7. "Press 1 if your origin bus stop is Washington Square." (Pressed " 1")

8. "Enter the hour closest to your departure time. (e.g. enter 7 for either 7 AM or 7 PM." (Pressed "7")

9. "Press 1 for AM, Press 2 for PM. " (Pressed " 1 ")

10. "Departure times are 6:50; 7:20; 7:50. Press " 1" to repeat departure times. " (Pressed " 1 'I)

To speed up the inquiry process, some audiotex systems have added "magazine" features for frequent-users. These are similar in concept to the autodialers used by travel agencies, for example, to dial airlines reservations agents using only one or two keystrokes on their touch-tone telephones. After a frequent-user calls a special telephone number, the information system asks the subscriber to enter his or her account number and password. If this is done correctly, the system presents the answers to a set of the subscriber's prestored inquiries, such as: (a) "What was the score of the most recent Portland Trailblazer's game? " (b) "What was the last price of the common stock of NIKE, INTEL and Tektronix?" (c) "What is the weather forecast for today?" (d) "What is the latest traffic congestion report on I-5?" .... without any additional keyboard input by the caller.

The "frequent-user" can add, modify or delete inquiries in his or her "magazine" at any time. The use of prestored inquiries greatly simplifies the use of audiotex systems for the public. The use of a password or personal identification number (PIN), provides improved security features for sensitive information or business transactions (e.g. to request checking account, savings account, credit card and frequent flyer balances or to make airline, hotel or restaurant reservations), particularly when combined with Automatic (telephone) Number Identification (ANI) and other security procedures.

The ability to prestore commonly used codes, requests for information, etc. in modern voice response systems and the wide- spread availability of touch-tone phones makes this technology a powerful tool for transportation agencies. IBM has set up a demonstration of the features of its new Direct Talk voice processing system. Readers are encouraged to use this demonstration (Call l-800-IBM-4211) to get a better understanding of the capabilities of modem voice processing systems. Adding videotex (including audiotex) access capabilities to FOCCS would enable the public to request rides directly from the FOCCs central computer via touch-tone telephones or computer terminals, as well as through a telephone operator. This would increase the productivity of the operators in large systems and reduce the cost of processing each ride-request transaction. The touch-tone telephone or the computer terminal would play the same role that the call-boxes did in the original Ruf-Bus System.

To request a ride, a would-be passenger would enter the following information into a touch-tone telephone or computer keyboard:

1. Origin code
2. Destination code
3. Number in party
4. Requested time of departure/arrival
5. Special requirements (e.g. blind, wheelchair, etc.)

These parameters would be sent to the FOCCS computer for processing. A complete description of the processing of this trip request by VIdeoteX-ENhanced FOCCS (VIXEN) is contained in Appendix A.

Using the "magazine" or prestored data features of a videotex system, would permit each VIXEN frequent-user to have his or her own "short list" of checkpoints. Instead of entering "0023", for example, for a checkpoint near the rider's home, the rider could enter "H". The VIXEN system would translate the mnemonic code "H" into the proper checkpoint number (i.e. "0023"). The use of mnemonic codes instead of numbers would make the VIXEN system easier to use than FOCCS. The origin and destination codes would be easier to remember and entering mnemonic codes would require fewer keystrokes and cause fewer input errors.

The use of mnemonic or symbolic codes instead of the number of an origin or destination checkpoint will permit VIXEN to handle door-to-door trips as well as checkpoint-to-checkpoint trips. Any location in a community could be geocoded and assigned a mnemonic code (e.g. "H" for home, "W" for work, "D" for doctor's office) by a VIXEN user. The map coordinates of each of these locations would be prestored in the user's own "magazine" file.

The VIXEN system would translate the mnemonic code "D", for example, into the map coordinates of the office of the user's doctor. These coordinates would then be used by the VIXEN system to dispatch the most cost-effective vehicle available to satisfy the user's trip request. The passage of the Americans with Disabilities Act (ADA) makes the capability of providing door-to-door transportation services very important to U.S. transit agencies. Appendix A discusses, in greater detail, how a user would request door-to-door transportation services with the VIXEN system.

Using the "magazine" or prestored data features of the VIXEN system would also permit users to store short-hand codes for frequently-made trips. For example, prestored trip code "HW" could mean: "I, John A. Smith, would like a ride from home to work as-soon-as possible. I am blind and traveling with my seeing-eye dog". The use of mnemonic codes for frequently-made trips will simplify the entry of trip requests and will make the VIXEN system more user-friendly.

Readers with a background in computers may recognize parallels in the evolution of ways to encode origin/destination addresses in the VIXEN system and ways to encode memory storage addresses or locations in programming computers. When digital computers became commercially available some forty years ago, programmers gave the numeric address of a storage location in each instruction, much the way a user would enter actual checkpoint numbers at a Ruf-Bus kiosk.

Symbolic/mnemonic addresses were added a few years later to make computers easier to program and a symbolic assembly program (SAP) was used to convert symbolic/mnemonic addresses to numeric addresses, much as “H” would be converted to “0023” by the VIXEN system for a specific user.

More user-friendly languages, like FORTRAN, were developed a few years later to make computers even easier to program. A brief instruction like “y = ax + b” in FORTRAN would be converted into many basic machine-language instructions by a computer, in much the same way that trip code “HW” was converted to basic map coordinates for the origin and destination points, the time (i.e. ASAP) and the number of passengers traveling together (i.e. John A. Smith and Rex, his seeing-eye dog).

The computer industry is now developing a variety of hand-held, keyboard-less interactive computers. Some of these will recognize voice commands and will translate them into machine-language instructions with numeric addresses. Similar devices could be used by the VIXEN system. They would permit frequent-riders to say “Home, James!” or “Home, Jane!” to request ride on public transportation. This trip request would be translated into more basic instructions for each user sent by radio to the VIXEN computer which would dispatch the most cost-effective vehicle available to satisfy the user’s ride request.

Information about traffic conditions will eventually be stored in the VIXEN computer in order to better estimate the travel time by buses, minibuses and microbuses between any two points in the service area. The VIXEN computer will also recommend the best route between two points in light of the most current information about accidents, road construction, traffic conditions, etc.

Drivers of commercial delivery vehicles, taxis or even private vehicles may be willing to pay a fee for this information, which they could access with a videotex terminal, touch-tone phone, cellular phone, in-vehicle terminal, etc. By using the "magazine" or prestored data features of the VIXEN system, a driver would only need to enter an origin code and a destination code or a trip code in order to access this trip planning information.

Alternatively, the VIXEN system could require the caller to listen to a brief commercial message before receiving the requested traffic congestion/trip planning information. The operators of the VIXEN system would obtain the funds necessary to provide traffic congestion/trip planning information to drivers from advertisers, in much the same manner that radio and TV broadcasters finance "user free" programs today. The inclusion of driver information services in the VIXEN system is discussed more fully in Appendix A.

Another modification of FOCCS that would be useful in VIXEN would be the capability to allow qualified drivers to use their own privately-owned vehicles to offer rides to others who were traveling in the same direction as the driver. The procedure for submitting trip offers by drivers would be very similar to the procedure for submitting trip requests by riders in the VIXEN system. In fact, the procedures for entering origin and destination checkpoint numbers and time would be exactly the same as previously described for requesting a ride.

Instead of entering the number of seats required (i.e. the number of passengers), however, the driver would enter the number of seats available. The VIXEN software could treat these single-trip carpools (aka parataxis) as special route-deviation vehicles. Adding this capability to VIXEN would greatly increase the carrying-capacity of a public transportation system in the U.S. at a low cost to taxpayers. Participating drivers could be reimbursed for some of their costs and, perhaps, for some of their time. Alternatively, they might receive tax-free incentives, parking, use of HOV lanes, reduced tolls, etc.

Parataxi drivers could use all the labor-saving data entry techniques for VIXEN that were previously discussed for riders. For example, these drivers could use mnemonic codes like "H" and "W" for origins and destinations. They could also use codes like "HW" for frequently-made trips to minimize data entry chores. Appendix A discusses the procedures that will be used by the VIXEN system to incorporate single-trip carpools/parataxis. This includes a discussion of the special security features that will be used by parataxi drivers and riders for their mutual safety.

The FOCCS system has the capability to store any trip request as a “standing order”. For example, a person who wishes a ride from work (e.g. checkpoint “0143”) to home (e.g. checkpoint “0043”) at 5:15 each weekday would only need to submit this request once. If the rider had a change in travel plans because of sickness, vacation, out-of-town business travel, etc., he or she would call a FOCCS operator to put a temporary (e.g. one-day, one-week) hold on the standing order. The VIXEN system will have a similar capability for entering standing orders for riders and for parataxi drivers.

The VIXEN system will also have driver and rider matching services for conventional car-pools and vanpools. Drivers would enter a ride request for both the initial and the return trip, using procedures similar to those outlined above. The same would be true for riders. This information could either be reformatted and sent to a rideshare matching agency’s computer, or the VIXEN software could be modified to handle carpools and vanpools. It should be noted that these ridesharing modes are not in the FOCCS system at present because car-pools and vanpools are not popular in Germany.

The Flexible Operations Command and Control System (FOCCS) that was designed, developed and tested in Germany is a sophisticated system for using computers and telecommunications to combine fixed-route transit and flexible-route paratransit services into an integrated public transformation system. The proposed VIdeoteX-ENhanced FOCCS (VIXEN) system adds both single-trip rideshare (i.e parataxi) matching and conventional rideshare matching capabilities to FOCCS to make it more valuable for U.S. cities and counties.

VIXEN may be described as a sophisticated system for using computers and telecommunications to develop new modes of public transportation (e.g. single-trip carpool or parataxi services), and to integrate these new modes with conventional transit, paratransit and ridesharing modes, in order to develop more cost-effective public transportation systems for local and regional travel.

VIXEN could also include special information services for drivers. Just before a commuter leaves for work, he or she could call the VIXEN computer, enter his or her “frequent-user” number (which provides access to prestored information requests) and receive information on the best route to take this morning to get to work in light of the latest traffic conditions, weather, etc.

VIXEN, with assistance from one or more other information services, could also provide last night’s basketball scores, the opening price of selected NYSE stocks, and birthday/anniversary reminders for the next few days.

VIXEN could also suggest the driver share a ride with a co-worker or neighbor to save money or to reduce traffic congestion, air pollution, etc.

ESTIMATING THE COST-EFFECTIVENESS OF FOCCS/VIXEN SYSTEMS

Table 19 shows that reducing the number of vehicles on U.S. highways by a small percentage can reduce total traffic congestion delays by a large percentage. For example, taking 20 percent of the single-occupant vehicles off the highways in 1987, would have reduced total traffic congestion delays by 68 percent. Taking 10 percent of the single-occupant vehicles off U.S. highways in 1987, would have reduced traffic congestion delays by 48 percent.

Figure 19
Demand Management Analysis

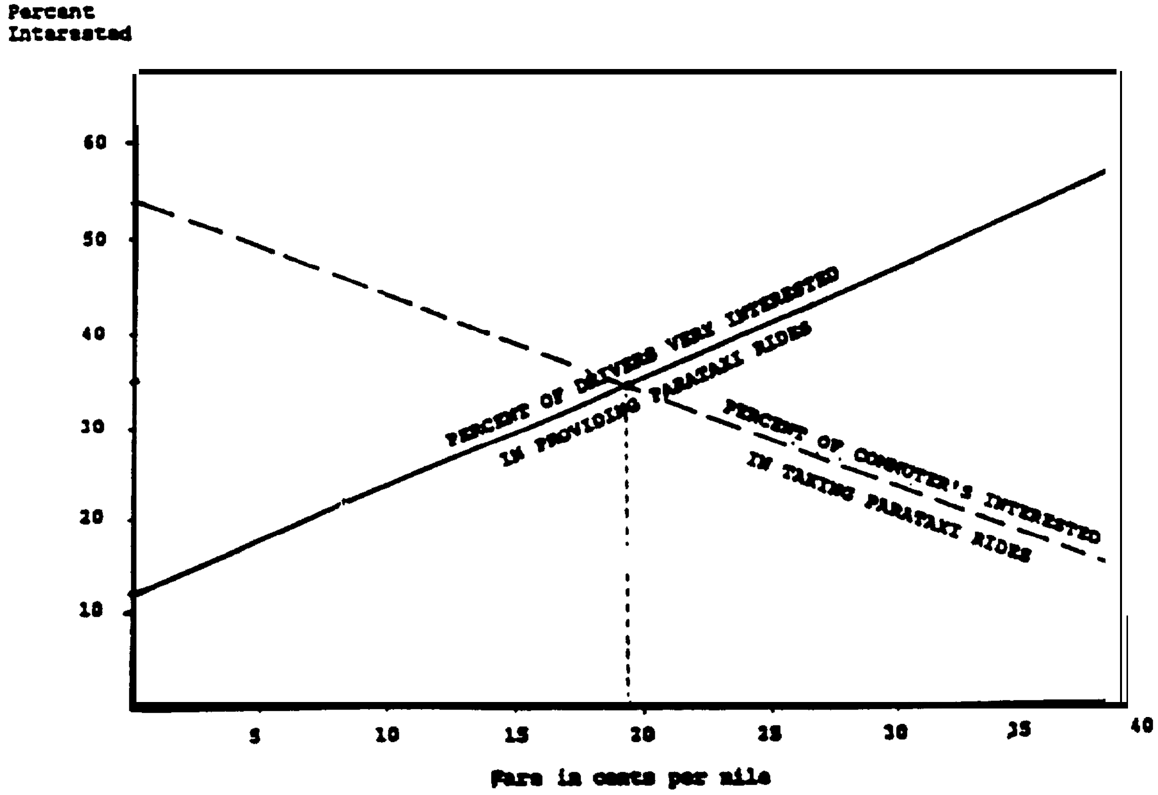
	Total Delay (Million Vehicle-Hours)	Delay Reduction %
Base Conditions (1987)	2,015	---
Demand Reaction		
1 of every 10 Single-Occupant Vehicles Removed	1,038	48
1 of every 5 Single-Occupant Vehicles Removed	644	68

Table 19 was prepared by Jeffrey A. Lindley, a highway research engineer for the Federal Highway Administration (FHWA), for the article "Urban Freeway Congestion Problems and Solutions: An Update" in the December 1989 issue of the Journal of Institute of Transportation Engineers (26). Since traffic congestion delays on urban freeways have increased significantly since 1987, reducing the number of single-occupant vehicles by ten or twenty percent would reduce traffic congestion delays even more today than it would have in 1987.

Hawaii's Department of Transportation has conducted surveys (8, 9, 10, 11) of drive-alone commuters in two large Honolulu suburbs, Hawaii Kai and Mililani, to determine their interest in switching to small-vehicle, door-to-door parataxi (i.e. single- trip carpool) services, with guaranteed seating, to commute to and from work. Figure 20, shows that only 54 percent of these suburban commuters were interested in using parataxi services even if they were free. Figure 20 also shows, as expected, that the interest in using parataxis declined as the proposed “fares” for parataxi services increased. In fact, at “fares” of $1.25 per mile (i.e. commercial taxi rates), very few commuters would give up driving alone for door-to-door public transportation services.

During the oil crises of the 1970’s, the U.S. Department of Energy conducted a survey (27) of drive-alone commuters to determine their interest in serving as carpool/vanpool drivers. Figure 20 shows that only 12 percent were “very interested” in becoming rideshare drivers if they received no additional compensation (i.e. “fares”). Table 20 also shows, as expected, that the percent of drive-alone commuters who were “very interested” in serving as rideshare drivers increased as the proposed “fares” increased. Since single-trip carpools

Figure 20
Commuters’ Interest in Providing and Taking Parataxi Services By “Fare” Per Mile (1991 dollars)



would be less restrictive on drivers than conventional car-pools and vanpools, it was assumed that interest in becoming parataxi drivers would be at least as high as those shown in Figure 20 for conventional car-pools and vanpools.

Figure 20 shows that at “fares” of 20 cents per mile (i.e. at the intersection of the supply and demand curves), approximately 35 percent of those who drive alone to work would be “very interested” in serving as parataxi drivers and 35 percent would be interested in becoming parataxi riders . This is a promising finding because it suggests that installing a VIXEN-type system, including parataxi transportation services with fares of approximately 20 cents per mile, could significantly reduce the growth of traffic congestion in Portland and other U.S. cities at a low cost to taxpayers.

Comparison of the 1980 and 1990 Census data (Table 2B) shows there were 114 thousand (36.4%) more single-occupant commuter vehicles in use in the Tri-County area in 1990 than there were in 1980. Extrapolation of the data in Table 1 shows that traffic congestion delays increased by more than 30 percent during this same period.

If VIXEN-based parataxi services were available in 1990, the surveys indicate there would have been 36 thousand fewer single- occupant vehicles in 1990 than there were in 1980. If these market-research surveys are correct, it means that traffic congestion in Multnomah, Clackamas and Washington counties in 1990 could have been less than it was in 1980 by using computers and telecommunications to make better use of the Tri-County area’s transportation resources.

These projections may seem to be very optimistic based on the 21.9 percent decline in transit use and the 17.4 percent decline in ridesharing use by work commuters between 1980 and 1990 in the Tri-County area. However, the availability of VIXEN-based parataxi services could reduce the use of single-occupant vehicles by work commuters in several other ways.

Firstly, parataxis could provide improved feeder services to Tri-Met’s light-rail and express-bus lines. Instead of having to own a second or third car just to have convenient access to these fixed-route modes, parataxi services could provide this capability at a much lower cost.

By raising the average vehicle occupancy (AVO) rate of vehicles using Tri-Met's park-and-ride lots, parataxi services could reduce the need for increasing the size of these facilities. By reducing the number of "cold starts" of vehicles using Tri-Met's park-and-ride lots, parataxis could also reduce air pollution problems in the Portland area.

Secondly, parataxi services could replace some fixed-route services in low-density areas at all times and in other areas when travel demands are low. The big buses that were replaced could be redeployed to increase the seating capacity and reduce headways along popular transit corridors in the area. These improvements to the quality of conventional transit services could increase ridership on bus and rail lines in popular corridors without increasing costs significantly.

Thirdly, the availability of VIXEN-based parataxi services could increase the use of conventional ridesharing modes by providing low-cost, door-to-door backup transportation services to or from work (or school) in the event of a change in plans by either the rider or the driver. The availability of improved taxi/parataxi "guaranteed ride home" services would remove a major concern about ridesharing for many commuters.

Parataxis would provide a variety of new alternatives to commuters who can't enjoy the benefits of carpooling because of 1) unusual schedules one or two days a week, 2) frequent out-of-town business travel, 3) requests for overtime work, etc. These commuters could travel with neighbors or co-workers in carpools and vanpools three or four days a week and use parataxi services or improved transit services on the other days.

Increasing taxes on gasoline or adding a road/congestion pricing system for travel within the Portland urbanized area during peak hours would increase the interest of the public in using multi-occupant transit, paratransit and ridesharing services instead of driving alone. The result would be less congestion, less pollution and lower costs per passenger trip for public transportation services in the Portland area.

In summary, VIXEN-based parataxi services could give Tri-Met and its users more flexibility and more freedom in their travel choices. The measure of effectiveness of the proposed VIXEN-based transit system is not how many people use parataxi services, but how many people use multiple-occupant vehicles instead of single-occupant vehicles.

TESTING “SMART BUS” CONCEPTS IN THE PORTLAND METROPOLITAN AREA

Most workers in Portland and other large U.S. metropolitan areas now work in the suburbs and eighty-five percent of them also live in the suburbs. Suburb-to-suburb travel is the fastest growing segment of both the work and non-work trip markets throughout the United States. Unfortunately for Tri-Met and other U.S. transit agencies, only l-2 percent of suburb-to-suburb commuters use bus and rail transit services to get to work. Even fewer suburbanites use transit for non-work trips.

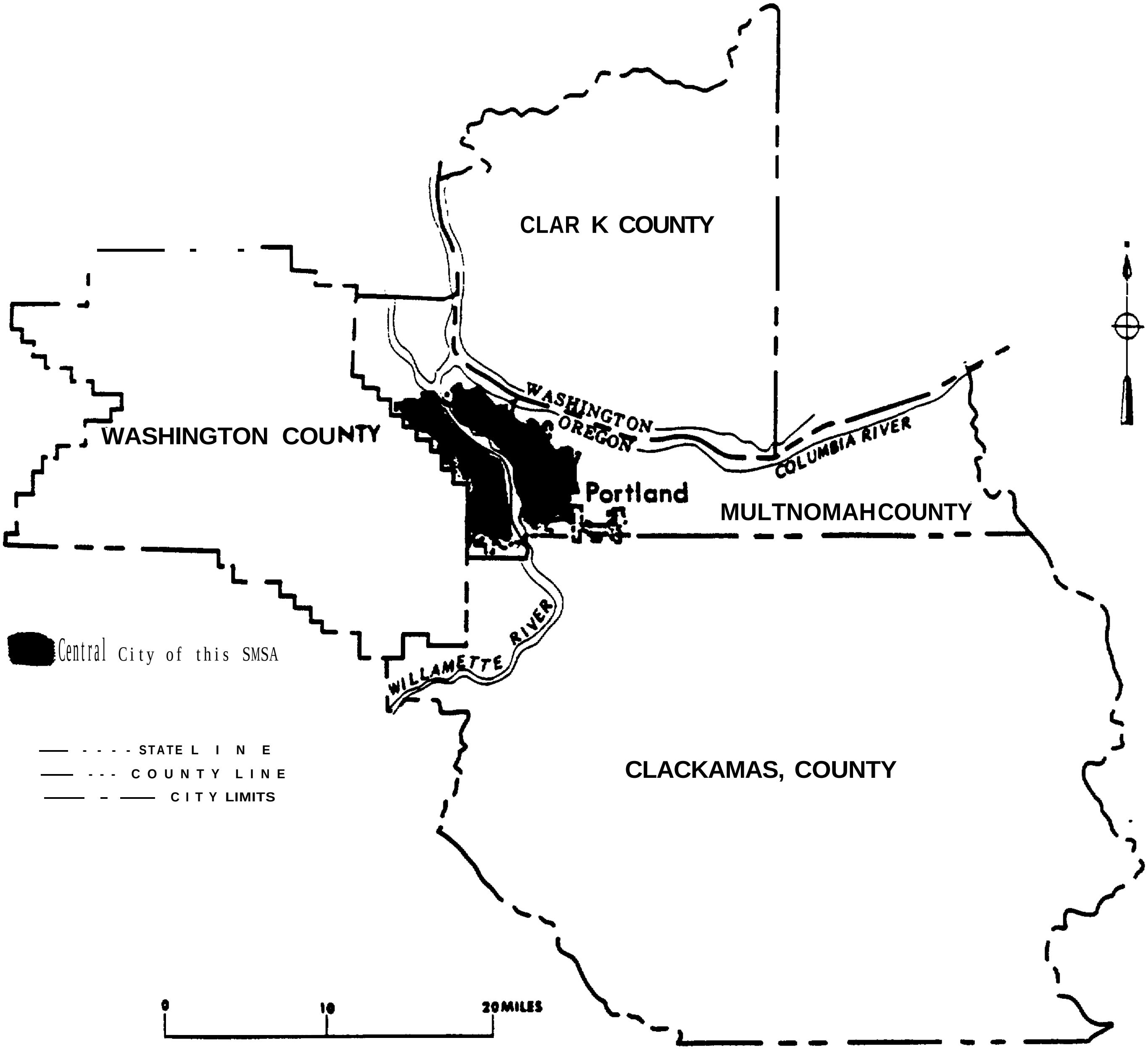
Tri-Met completed a study of transit use in suburban Washington County in 1989. Figure 18 on the following page shows the location of Washington, Clackamas and Multnomah Counties relative to the City of Portland. The Suburban Transit Study (28) “found that bus and rail transit was used in only 0.9 percent of home-based work trips and only 0.6 percent of home-based “other” trips within the County. The study recommended that Tri-Met consider replacing low-ridership bus routes with dial-a-ride and other paratransit services. To this end, it evaluated the following five sites just west of Portland within Washington County for dial-a-ride demonstration projects:

1. South Beaverton - The residential area is bounded to the south by Scholls Ferry Road (Hwy. 210), to the west by Murray Boulevard, and to the north and east by Hall Boulevard. The employment locations are located along Highway 217, between Allen and Hall Boulevard.

2. Southeast County - The residential areas are located south of Highway 99 (especially in Tigard and Tualatin). The commercial and employment sites are located around Washington Square and along Highway 217.

3. Farminaton - Cornell - The residential areas are located west of 185th Avenue and south of the Tualatin Valley Highway (Hwy. 8). The employment complexes are located south of the Sunset Highway (Route 26) and between 158th and 185th Avenue.

Figure 18
The City of Portland
Washington, Clackamas and Multnomah Counties (Oregon) and Clark County (Washington)



4. <u>Cross County</u> - The residential areas are located both north of the Sunset Highway (Route 26) and south of Pacific Highway (Hwy.99). The employment sites are located in downtown Beaverton, Washington Square and along Highway 217.

5. <u>Hillsboro</u> - Both residential areas and employment sites would be located within the city limits of Hillsboro, the Washington County Seat.

The Suburban Transit Study (28) recommended the South Beaverton site for the dial-a-ride demonstration project "to test the effectiveness of demand-responsive transit to tap new markets (28)." The reasons for selecting this site were as follows:

> "The area was chosen due to its past history with Line 87, which had a productivity similar to Dial-a-Ride service. If the same or equivalent market can be served as Line 87, there will be adequate demand to make the Dial-a-Ride experiment successful. In addition, the number of unserved trips coupled with the area's small geographic size, results in a high trip density, which would provide a more concentrated demand than the other area's with transit potential.
>
> The demonstration would focus primarily on work trip ridership, including trips to local employment locations and ridership, including trips to local employment locations and feeder trips to transit centers for Portland passengers. Service would be supplied six days a week to test a variety of markets for Dial-a-Ride service. Fares would range from $1.00 to $1.25 with discounts available for off-peak and frequent riders. Assuming Tri-Met could contract for service at $21 per vehicle service hour, the demonstration would cost $251,000 per year, would generate revenue of $65,530, cost $3.65 per passenger (net cost of $2.70 after fare credit), and achieve a 26% farebox recovery ratio."

It should be noted that the proposed South Beaverton demonstration project was projected to carry only 280 passengers per day, or 87,100 passengers per year. It would have done little to raise transit's share of work trips in Beaverton, which had a population of 52,862 at the time of the 1990 Census, or to reduce traffic congestion in Beaverton.

Figure 19
City of West Linn

It should also be noted that the proposed South Beaverton demonstration project was a basic curb-to-curb, dial-a-ride system. It involved no new approaches or technologies. In fact, the Suburban Transit Study (28) recommended against checkpoint-to-checkpoint dial-a-ride services or route-deviation services because of the lack of information about the cost-effectiveness of these systems. The experience with FOCCS in Germany suggests that this recommendation should be reconsidered by Tri-Met.

This study evaluated the same five sites in Washington County for “smart bus” trials. It found that all would be attractive sites for an operational test of a FOCCS/VIXEN system. This study also evaluated West Linn, a city of 16,300, in Clackamas County, and Lake Oswego, a city of 30,300, in Clackamas, Multnomah and Washington Counties as possible test sites. Figures 18 and 19 are maps of these two cities.

The following table provides preliminary journey-to-work from the 1990 Census for some of the communities that would be involved in the seven possible test sites:

Table 21
Means of Transportation to Work[1] - 1990
Selected Suburban Communities in Portland SMSA

City	Number of Workers	Percent of Workers Who	
		Share Rides	Use Transit
WestLinn	8,516	9.8	2.4
Lake Oswego	16,437	8.6	3.0
Beaverton	29,661	10.9	4.9
Tigard	15,686	11.6	4.2
Tualatin	8,442	10.1	3.4
Aloha	17,703	11.0	3.8
Hillsboro	18,215	15.2	3.5

Note [1] These data are for both suburb-to-central city and suburb-to-suburb work trips.

Both West Linn and Lake Oswego have higher use of single-occupant automobiles for work trips and, presumably, for non-work trips. One of the reasons is their topography: Many residents of West Linn and Lake Oswego live on relatively steep hillsides, which makes walking between the bus stop and home difficult, particularly with parcels. Many residents of both West Linn and Lake Oswego also live on narrow, serpentine streets that Tri-Met buses cannot use. Significantly increasing transit ridership in either of these two cities would be a major accomplishment for Tri-Met and for FOCCS/VIXEN concepts.

Lake Oswego has more jobs than West Linn. In addition to retail stores along State Street (Highway 43) and "A" street on the east side of town and Boones Ferry Road on the west side of town, Lake Oswego has a growing employment complex along Kruse Way. There are two Tri-Met transfer centers, one in downtown and the other near the intersection of I-5 and Boones Ferry Road.

Lake Oswego also has a growing number of retired people and an active senior citizens center.

As in Lake Oswego, most residents of West Linn make most of their day-to-day errands to the grocery store, dry cleaners, bank, post office, etc. within their own community. Most of the stores in West Linn are located along Route 43. In fact, it is very difficult to get between two points within West Linn's Highway 43 corridor without traveling on Highway 43 (formerly called Portland Ave). The competition for limited road space between local residents and through traffic between Portland/Lake Oswego to the north and Oregon City/Canby to the south causes traffic congestion problems in West Linn, particularly during peak commuting hours.

Since existing development will make it extremely difficult to widen Highway 43, alternative approaches are being sought to reduce the future growth of traffic congestion in West Linn. Because of the limited number of entrances and exits and the challenging topography, Tri-Met could develop West Linn into a laboratory for testing the cost-effectiveness of FOCCS/VIXEN and other "smart-bus" concepts. These could include:

> Adding IBIS-type computer terminals to all buses on Tri-Met Route Number 35 and displays/kiosks at all bus-stops along Highway 43

in West Linn so that would-be bus-riders can use touch-tone telephones, personal computers, bus-stop displays, etc. to learn the scheduled and estimated time of departure from any point in West Linn and the scheduled and estimated arrival time of transfer stations in either Lake Oswego or Oregon City.

Installing route-deviation minibus or microbus services anywhere within the Highway 43 corridor in West Linn (i.e. between the Willamette River on the east and the top of the hills on the west). Both checkpoint and curbside pickup/delivery services could be offered, using salaried, part-time and volunteer/piece-work drivers.

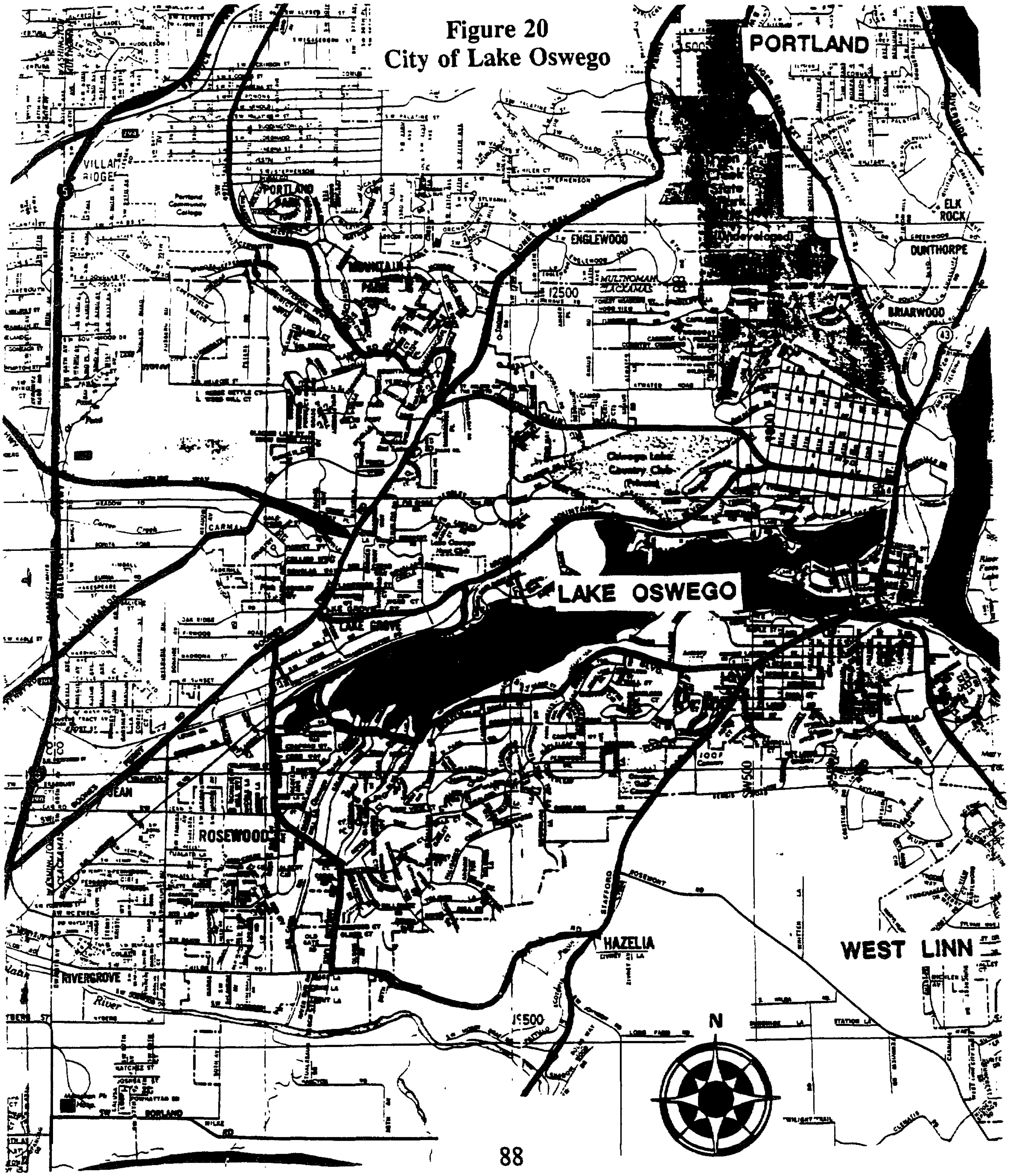
Installing demand-responsive minibus or microbus services anywhere within the Highway 43 corridor in West Linn. Both checkpoint and curbside pickup/ delivery services could be offered, using salaried, part-time and volunteer/piece-work drivers.

Both the route-deviation and the demand-responsive services would provide feeder services to Tri-Met bus-stops along Highway 43.

It is envisioned that an integrated transit, paratransit and ridesharing system would operate as follows in West Linn. Minibuses and microbuses would provide no-transfer services between any two points in the Highway 43 corridor through West Linn. An authorized/licensed resident could use a touch-tone telephone or computer terminal keyboard to request a ride, without operator intervention, using the procedures outlined for VIXEN is Appendix A. Alternatively, the resident could call a “reservations agent” to request a ride, but there would be a slight extra charge for this “operator-assisted” service.

The average waiting time these flexible-route neighborhood “buses“ would be six (6) minutes. The maximum wait would be twelve (12) minutes for either curb or checkpoint services. The recommended fare would be sixty (60 cents for the first two (2) miles plus twenty (20) cents per mile, thereafter. However, one fare would cover up to three (3) adults. In effect, the passenger would be leasing the entire back seat of a taxi/parataxi or an entire three-person bench in a van or minibus. The objective of this fare structure is to encourage family members or neighbors to ride together, to provide room for grocery bags and other packages, to reduce the demand for park-and-ride lot space, etc.

Figure 20
City of Lake Oswego



If a city “smart card” is established in the future for “neighborhood bus” fares, parking meters, public telephones, etc. for West Linn (i.e. like Luneburg and Oldenburg in Germany) and “smart card” fare machines are installed in all Tri-Met buses on Route 35, credits could be provided for part of the fares of the feeder service provided by the West Linn “neighborhood bus”.

Tri-Met, Metro and environmental groups in Portland have shown an interest in using road/congestion pricing approaches to discourage the use of single-occupant automobiles, particularly during peak commuting hours. This could take the form of installing manned toll booths on selected roadways. It could also take the form of installing transponders on vehicles, recording their passage past roadside beacons, and preparing monthly billings for the use of the road networks. This monthly billing could be mailed out to the vehicle owner, added to the owner’s utility or credit card bill, or debited from the owner’s bank account. These are important IVHS/APTS concepts.

Because of the limited number of parallel roads to Highway 43 and the limited number of ways in and out of the Highway 43 corridor, West Linn would be a low-cost site to test the cost-effectiveness of road/congestion pricing. In fact, some of the “tolls” collected by road/congestion pricing approaches could be used to finance improved public transportation systems and services for resident of West Linn.

The costs of a 20-vehicle “smart-bus” system in West Linn would be approximately the same as the costs of the FOCCS-demonstration project in Shellharbour, Australia. These are summarized in Table 22. Each of the line items in Table 22 are broken down into component line items in Appendix B. Each of these component line items is described in Reference 25. A copy of all five (5) volumes of the former were delivered to Tri-Met under separate cover.

It should be noted that the Shellharbour Operational Test consists of the following three phases:

1. Six (6) months for equipment trials, installation, training, etc.

2. Twelve (12) months of full-scale pilot operation.

Table 22
Summary of Pilot Project Costs
Shellharbour Operational Test

		2	3
ITEM		Total costs (DM)	Total costs ($)
81	1 Management and Control Room Hardware, Software, etc.	56,150	35,838
82	2 FOCCS Equipment in Garages and Vehicles	273,850	174,798
83	3 Service Area	23,000	14,681
84	4 Options	48,300	30,821
8.5	5 Pilot Project Production	1,613,490	1,029,891
86	6 FOCCS Overhead	208,800	133,277
87	7 Operational Costs	113,400	72,383
88	8 Public Relations and Personnel Training	113,560	72,485
	GRAND TOTAL:	2,450,550	1,564,183

3. Three (3) months of evaluation.

If Tri-Met wished to extend the full-scale pilot operation additional years to see what would happen to per capita automobile ownership rates, annual vehicle miles traveled VMT) per capita, journey-to-work mode split, traffic congestion levels, the additional costs would be on the order of $294,000 per year. Some of the line items in Figure 22 would be eliminated, others would be reduced. Table 23’provides a summary of the recurring costs.

The proposed estimates in Table 22 and Table 23 are for a basic "smart bus" system using FOCCS technologies. They do not include the costs of adding conventional rideshare or single-trip rideshare (aka parataxi) matching services or videotex (including audiotex) features. Based on discussions with some of the software designers of German "smart-bus" systems, adding these and other VIXEN capabilities would add another $1.150 million to Table 22, $750,000 to the initial capital costs and $400,000 to the first 18 months start-up costs, It would also add another $84,000 to Table 23, that is, to the recurring operating costs for each additional year.

The long-term objectives of a multi-year operational test of FOCCS/VIXEN concepts would be to significantly reduce VMTs and motor vehicle ownership per capita within the West Linn service area. The short-term objectives are to learn about German smart-bus technologies and how they can be improved to increase the cost-effectiveness of transit, paratransit and ridesharing services in Portland and other U.S. metropolitan areas.

All fares collected for parataxi services should be paid to parataxi drivers. To "prime the pump" for the first demonstration project in the Portland area, federal, state and local governments and the private sector should provide 50 cents for each parataxi trip. These monies would be used to provide special insurance for single-trip carpool (aka parataxi) operators and to cross-subsidize contract taxi services. Contract taxis will be used to handle ride requests that are difficult to fill with parataxi services. They will also provide a minimum level of demand-responsive services in the service area at all times.

This would add up to approximately $450,000 per year to the proposed West Linn operational test of FOCCS/VIXEN. This estimate was prepared as follows:

Daily vehicle trips = 50,000
(16,000 residents x 3 trips/day)

Daily parataxi trips = 2,500 = 5% at 50,000

Daily parataxi subsidy = $1,250 = 2,500 x $.50

Annual parataxi subsidy = $456,000 = 1,250 x 365 days

It is important that a FOCCS/VIXEN operational test in the Portland area be adequately funded to avoid the problems of the innovative Santa Clara Dial-A-Ride System, which failed because it attracted too many riders (See Figure 1).

Table 23
Summary of Annual Operating Costs
FOCCS Operational Test

1		2	3
		Total costs (DM)	Total costs ($)
81	1 Management and Control Room Hardware, Software, etc.	- - -	---
82	2 FOCCS Equipment in Garages and Vehicles	---	- -
83	3 Service Area	---	- -
84	4 Options	---	...
85	5 Pilot Project Production	189,170	120,748
86	6 FOCCS Overhead	139,200	88,851
87	7 Operational Costa	113,400	72,383
88	8 Public Relations and Personnel Training	18,800	12,000
	GRAND TOTAL:	460,570	293,982

CONCLUSIONS AND RECOMMENDATIONS

Tri-Met is preparing a strategic plan for the years 1993 to 2010. The first draft of the strategic plan contains the following statements:

> “Traffic congestion is growing. Residents in Washington and Clackamas counties who were recently surveyed listed traffic as their number one concern. Light rail on the west side will alleviate some of the traffic in Washington County, but it will mainly just keep congestion from getting worse.
>
> “Air quality is another source of concern. The number of vehicle miles traveled in the Portland region has been growing by about 6 percent a year. To keep our air clean and safe to breathe, as well as meet federal clean air guidelines, the area will need to reduce that to only 2 to 4 percent a year - or face tough federal mandates to force compliance.”
>
> “According to the Oregon Department of Transportation, the State as a whole is $19 billion short of the funding needed to restore and maintain its deteriorating roads. About half of that unmet need is in the Portland area.”
>
> “Over the next 20 years, the Portland area is expected to grow faster than the entire State of Oregon did during the 1980s.” The population will grow by 500,000 - the equivalent of another city the size of Portland.
>
> “Most disturbing is the projection that, even if the region succeeds in implementing its current land use and transportation plans, 85 percent of all growth will occur <u>outside</u> the Portland city limits and traffic congestion in the region will more than double.”

In order to deal with these and related mobility problems, Tri-Met plans to dramatically increase the use of transit, paratransit and ridesharing within its service area. According to the second and latest draft of Tri-Met’s strategic plan, which is contained in Appendix C, one of the ways Tri-Met proposes to increase transit ridership is by establishing two-dozen ”10 minute corridors” on which a fixed-route, fixed-schedule bus comes by every 10 minutes - “creating the bus equivalent of an above-ground subway system.”

One of the ways Tri-Met plans to increase paratransit ridership is by introducing flexible-route “neighborhood minibus services”. This public transportation service will provide “almost door-to-door pickup and delivery” within a neighborhood. In fact, some low-density neighborhoods in outlying areas “may not be serviced by large buses and light rail at all” in order to use available tax dollars in the most cost-effective manner.

According to the strategic plan, Tri-Met proposes to increase weekday transit ridership from 194,900 in FY1992, to 310,500 in FY1997, and to 690,000 in FY2005. Tri-Met 's management wants “the percentage of total trips taken on transit including (but not limited to) buses, light rail, shuttles and vanpools, as well as taxis - (to be) as high in the Portland metropolitan area as anywhere else in the country”.

Although Tri-Met includes vanpools and taxis in its definition of “transit”, it does not appear to include carpools. Conventional carpools carry twice as many commuters to work as bus and rail transit (See Table 2) and ten (10) times as many suburb-to-suburb commuters to work as fixed-route transit modes (See Table 7). Tri-Met’s transit ridership projections for FY92, FY93, etc. in the draft strategic plan are simply too low to include conventional carpools.

In addition, it does not appear that Tri-Met includes single-trip carpools (aka parataxis) in its definition of transit. Parataxis are a new Intelligent Vehicle Highway System (IVHS)/Advanced Public Transportation Systems (APTS) concept that could surpass conventional carpool ridership in the future. Most of the software required to implement single-trip carpool matching in Portland is already available in the route-deviation capabilities of the German FOCCS system. Unfortunately, there is no mention of the planned or possible use of single-trip carpools in the draft strategic plan.

This is an important omission for several reasons. Firstly, Tri-Met is already actively involved in carpool promotion activities and Goal 5 of the draft strategic plan calls for “more funding and staffing for carpooling programs” and for doubling the percentage of carpool trips. Secondly, most of the funds necessary for Tri-Met to test and evaluate single-trip carpool matching concepts may be available from federal, state and private sources, as part of the multi-billion dollar U.S. Intelligent Vehicle-Highway System (IVHS) program. Thirdly most of the financial, technical and marketing resources necessary to operate single-trip rideshare matching systems for urban, suburban and rural communities may be available from the private sector.

Companies like USWEST, IBM, Sears, CompuServe, Bell-Atlantic, Huntington Bank, and The Oregonian are already in the business of providing videotex (including audiotex) information services over ordinary telephone lines. Their technologies could be adapted to match would-be drivers and would-be riders to form single-trip carpools and vanpools. Market research indicates that the availability of such a parataxi matching system could reduce the use of single-occupant vehicles and traffic congestion in suburban areas at a low-cost to taxpayers.

The concept of using videotex (including audiotex)-based parataxi services is a way for Tri-Met to mobilize privately-owned and privately-operated automobiles, minivans and vans to complement and supplement Tri-Met's conventional transit, paratransit and ridesharing services. The approach is not unlike the use of "volunteer" fire fighters, police officers, ambulance drivers, etc. in communities that cannot afford the costs of using all full-time personnel for these important community services.

Furthermore, some of these companies are already in the business of marketing sophisticated computer/telecommunications systems that are used by cities and counties to dispatch vehicles, door-to-door, at the request of a telephone caller. Like FOCCS, these 9-l-l systems use on-board vehicle computers, AVL subsystems, digital radios, geographic information systems (GIS) and other sophisticated technologies to reduce response times and costs. Some of these companies have already offered to provide matching funds for IVHS/APTS demonstration projects in other cities and states.

IVHS/APTS technologies can assist Tri-Met in developing new types of transportation services (e.g. route-deviation minibus, single-trip carpool/vanpool) that can provide user-friendly and taxpayer-friendly public transportation services in low-density suburban and rural areas. In the words of the latest draft strategic plan, "buses and light rail are simply not an efficient choice for low-density, dispersed development".

IVHS/APTS technologies can also assist Tri-Met in integrating these new modes of both publicly-operated and privately-operated public transportation services with conventional transit, paratransit and ridesharing modes. With either a touch-tone phone or with a low-cost videotex terminal, a traveler would be able to find the best way to get between any two points by public transportation. Multi-occupant vehicle drivers could also find the best way to get between any two points in light of the latest traffic, weather, construction, etc. conditions.

These new flexible-route modes could increase the use of fixed-route transit ridership by providing better feeder services to and from light rail stations and major bus stops. This could also increase the effective capacity of existing park-and-ride lots. These new modes could also increase the use of conventional carpools and vanpools by providing better back-up services in the event of a change in plans by either a rider or a driver. Kenneth Orski* summarized the potential of videotex (including audiotex) systems for the public transportation industry as follows:

> “Traditional transit systems worked well in the days when most homes and jobs were located in central cities, when a large proportion of the urban population lived within walking distance of bus routes, and when travel destinations were focused sharply on the downtown. Today, we are confronted with radically different circumstances. In most contemporary communities, trip origins and destinations are widely dispersed, the largest residential and employment centers are found in the suburbs, and travel patterns resemble Brownian motion - they are random in nature and in every direction all at once.
>
> The world of urban transportation will be obliged to diversify and offer urban travelers more choice if it hopes to remain relevant in the cities of tomorrow. Traditional transit services -- buses operating on fixed routes and set schedules -- will continue to play a role, but they will no longer occupy the position of preeminence or enjoy the monopoly they have today. Regular buses will be increasingly supplemented by a range of other, more flexible services catering to the needs of different users.. . . . .

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*Kennith Orski is President of the Urban Mobility Corporation and former Associate Administrator of UMTA.

> The urban transportation market is in the process of becoming a freer market, a market in which the public transportation agency is likely to lose its monopoly position and become something of a broker with a primary responsibility to identify the region's transportation needs and ensure that those needs are satisfied in the most cost-effective manner through private as well as public operators.
>
> But, as any free market exponent will tell you, for a free market to function effectively, the consumers must have the full access to information. Only then can they exercise their freedom of choice in a rational manner. This is where I believe Videotex, with its on-line, real-time interactive capability, can make a difference.
>
> One application would be as an "urban travel agent", to provide current information on all available travel options between any two points. A second application would be parataxi (i.e. single-trip cat-pool) services, a concept that I find rich in promise and that would add yet another dimension to urban mobility." (29)

IVHS technologies (e.g. videotex, audiotex) can help Tri-Met make Portland's public transportation system "more convenient, reliable, easy-to-understand and appealing to customers", as called-for in the latest draft strategic plan.

In addition to reducing vehicle-miles traveled (VMT) for a given level of person-miles traveled (PMT) by increasing the use of multi-occupant vehicles, these new information technologies can also help reduce VMT by reducing PMT. Videotex and audiotex can eliminate the need for some trips by providing improved shop-at-home, bank-at-work, electronic mail, telecommuting "distance-learning" and related travel-substitution services.

IVHS technologies can also be used to reduce the hidden subsidies given to highway users, particularly single-occupant vehicle (SOV) drivers during peak commuting hours, and make multiple-occupant vehicles (MOV) more attractive to more people. In the words of Dr. Melvin Webber* :

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*Dr. Webber is Director of the Transportation Center at UC-Berkeley.

> “A lot has been written about the American’s peculiar love-affair with the automobile, as though it were mere affection or fascination that has led to the dominance of private cars over all other modes of urban transport. Autos are popular because they offer better transport service in more situations than do other modes.
>
> The key to the auto’s popularity is its capacity to furnish door-to-door, no-wait, no-transfer service. In competition with other transport modes in low-density places, it usually wins hands down -- mostly because travel time from origin to destination is typically shorter than via other modes and because money costs, although not low, are tolerable.
>
> Money costs are tolerable because the use of automobiles is subsidized. U.S. motorists are charged a modest gas-tax fee to cover some costs of road building, while the heavy costs of congestion and of air and noise pollution are not directly charged to the motorists who generate them. It is scarcely any wonder, given the car’s inherent advantages and the imposition of some of its operating costs on others, that it has become the preferred mode of transport for so many.” (30)

The Federal Transit Administration (FTA) estimates that the net subsidies for each additional automobile trip per annum in the U.S. is at least $6, or approximately 60 cents per vehicle mile (31). However, this is a nationwide average. The subsidies for each additional trip in urban areas is higher than this because of the higher levels of traffic congestion and air pollution, and the higher costs of land. The following points are from a USDOT report to the Congress (14):

> “An additional direct cost of driving which many motorists also avoid is the fee for parking spaces which employers commonly supply as a tax-free income supplement to employees. The cost to the employer of “free parking” averages $6 per day in the Central Business District (CBD), ranging from $2 in less densely developed CBD’s to $14 per day in the most densely developed CBD. If, through market mechanisms, more commuters were offered the choice of paying such costs and saving through transit and ridesharing, changes in travel (and traffic congestion) would probably occur. As things stand, most people prefer traffic delays to the available alternatives.. . . . .

> Increases in the degree to which transportation users are assessed the capital, operating and environmental costs of their use of transportation systems may offer alternatives to provide more equitable and efficient use of urban transportation systems.. . . .
>
> Increasingly, all levels of government, the private sector and individuals must seek to eliminate incentives that encourage the inefficient use of transportation resources.. . . . Congestion pricing of urban highway capacity and preferential treatment of high occupancy vehicles, including transit buses, could help to "level the playing field" among urban transportation modes.. . . .
>
> The logistical problems that have blocked congestion pricing in the past, (e.g. toll booth lines), could be solved in part with methods made possible by advanced electronics already available virtually "off the shelf", computer technology and the public's demonstrated acceptance and use of convenient automatic money transaction systems. Monthly billing for rush-hour tollway use, based on daily electronic scans of electronically readable codes that could be issued with existing license plates, is one example. The Department will be considering ways to encourage local implementation of congestion pricing approaches". (14)

Congestion or road pricing systems, which tend to make extensive use of IVHS technologies, could also generate substantial new revenues for transit, paratransit, ridesharing and highways projects in the Portland metropolitan area.

Tri-Met should modify its draft strategic plan to show that it is aware of single-trip cat-pools, road/congestion pricing and other IVHWAPTS concepts. It should also add a statement that it plans to use IVHS/APTS technologies when and where they can increase the cost-effectiveness of public transportation systems in Portland's urban, suburban and rural areas.

In summary, FOCCS and other new IVHWAPTS technologies can help Tri-Met:

1. Improve customer service
2. Increase ridership
3. Obtain additional funding and increase efficiency
4. Diversify services

5. Expand the transit system

IVHS/APTS technologies can also help Portland and other U.S. cities and counties reduce their transportation, energy and environmental problems at a low cost to taxpayers.

*U.S. G.P.O.:1993-343-273:80130

NOTICE

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TECHNOLOGY SHARING

A Program of the U.S. Department of Transportation