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Case Study No. 9

Linking Bicycle/ Pedestrian Facilities with Transit

National Bicycling And Walking Study

U.S. Department
of Transportation
**Federal Highway
Administration**

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Enhancing Bicycle and Pedestrian Access to Transit

Submitted to:
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Washington, DC 20590

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Table of Contents

Executive Summary

This report deals with how people get to and from public transportation by bicycling or walking, a subject which has not been extensively studied in North America. Intermodal research has attracted little attention in the modally organized transportation agencies of the United States, except where large investments were at stake, such as the construction of truck-rail, airport access, and park-and-ride facilities. Pedestrian and bicycle access to transit has been taken for granted in many communities, and frequently neglected in planning, design, and operations.

Pedestrian and bicycle planning and facilities development requires great attention to small-scale, generally lower cost elements of the built environment. Moreover, pedestrians and cyclists have been far less formally organized into economic and political interest groups than automobile and transit interests. As a result, the needs of pedestrians and cyclists have often been neglected in planning and designing the built environment, including the development of new transit systems and services.

However, without good pedestrian and bicycle access to transit, the only way passengers can be attracted out of their cars is to provide extensive and expensive parking at transit stations and stops. Indeed, this is the direction that many U.S. transit agencies have taken, encouraged by Government funding programs which for decades have favored park-and-ride lot construction over the provision of pedestrian and bicycle facilities.

New flexibility in funding under the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 and the requirements of the 1990 Clean Air Act Amendments offers new opportunities and strong encouragement for transportation agencies to work together in improving pedestrian and bicycle access to transit. Action in this area offers the potential of highly costeffective reductions in air pollution emissions, increased transit ridership, alleviation of chronic capacity shortages at many park-and-ride lots, and reduced traffic congestion near transit stations. A number of transit agencies and local and State Governments have initiated efforts to improve nonmotorized transit access, but many major problems and opportunities have not yet been addressed. This report highlights some of these efforts and opportunities.

The Historical Context

Since the earliest days of public transportation, people have relied on their feet to get to and from transit stops or stations. The urban environment of America early in this century provided a hospitable environment for pedestrian access to transit. Within that environment, public transportation rose to prominence as the shaper of growth and predominant means of travel for all but short trips.

In the latter half of this century, however, America's urban patterns shifted to radical new forms. Pedestrians and bicycles were thoroughly displaced as modem traffic engineering widened roads to speed the movement of cars. Massive infrastructure investment in highway transportation reshaped not only the streets, but also the patterns of jobs, houses and shops. Faster speeds meant longer trips, expanded separation of activities one from the other, and sprawl. More Americans began growing up in places where it was neither safe nor convenient to walk, in a culture grounded in automobile dependence.

All of these changes had a profound effect on public transportation, which suffered itself from long-term disinvestment. In a spiral of decline, transit services in mid-century lost ridership and cut services. By the 1960s, collapse was averted only when the Government stepped in to reorganize the transit industry, offering subsidies in recognition of transit's vital economic and community functions. As transit services began expanding again into newer suburban areas organized around the automobile, the share of access trips to transit by foot declined significantly. Transit agencies and State and local Governments initiated a continuing steady expansion of parkand-ride lot capacity at transit stops and stations. Today in many American suburbs and smaller cities, more than half of access trips to transit are by automobile.

Alternative Strategies for Transit Access

In sharp contrast, bicycles and walking are the predominant means of access to express public transportation services in Japan and much of Europe, where automobile park-and-ride is far less developed. Differences in transportation policy and investment strategy, urban design, and land use all account for this variation.

Japan and many European countries have invested heavily in bike-and-ride facilities, providing many guarded bicycle parking garages at major rail stations, and have adopted policies favoring bicycling and walking, with extensive use of traffic calming techniques and provision of bicycle paths and lanes leading to stations. Automobile park-and-ride facilities in Japan and Europe are far less extensive than in the United States.

High rates of bicycle theft and vandalism pose a major barrier to bicycle-transit integration in the United States. This can be overcome only by providing secure bicycle parking at transit stops and stations---lockers, unguarded shared check-rooms, and guarded bicycle parking garages----as is found in Japan and much of Europe. Bicycle-hostile street environments near most U.S. transit stops and stations also pose a significant barrier to more widespread use of bicycles for transit access. The majority of American cyclists are not comfortable riding in fast or heavy traffic unless offered separate lanes or paths. A large, but not well-connected, network of low-speed, low-volume, relatively bicycle-friendly streets exist in most U.S. suburbs. However, without penetrator bicycle paths which connect these to major transit stops, employment, and shopping centers, only a minority of cyclists will consider it attractive to bike to transit.

Access System Costs, Energy Use, and Air Pollution

Although automobiles and bicycles are both potentially important modes for transit access in low density areas, the costs of park-and-ride are far higher than bike-and-ride. Typical construction and engineering costs for a park-and-ride lot are $3,500 to $5,000 per space for surface parking and $12,000 to $18,000 for structured parking, compared to $50 to $500 per space for secure bicycle storage. Even automated bicycle parking garages, like those found in Japan, are a fraction of the cost per space ($700-$1,000) of simple automobile park-and-ride lots. Operating and maintenance costs are also far lower for most bike-and-ride systems. Experience in Germany shows that the needed operating subsidy per space for a several hundred space nonautomated guarded bicycle parking garage is roughly comparable to typical operating and maintenance costs for typical U.S. park-and-ride lots ($150-250 per space per year, while capital costs are far lower.

Moreover, park-and-ride lots typically require 30 square meters (330 square feet) of land per space, compared to 0.5 to 1.0 square meters (6 to 12 square feet) needed for ground-level bicycle storage spaces. As a result, park-and-ride lots are often constrained in size or location. Typically, they offer either inadequate capacity relative to the potential demand or they must be sited in remote locations unsuited for pedestrian access. In contrast, bicycle parking may be readily sited in congested areas around rail stations and in traffic-sensitive residential areas.

From an energy use and pollution emissions standpoint, bike-and-ride travel is far more cost-effective than further development of park-and-ride lots in most communities. A study by the Chicago Area Transportation Study found that the installation of secure bicycle parking at rail stations would reduce hydrocarbon emissions at a public cost of $311 per ton, compared to $96,415 per ton for an express park-and-ride service, $214,950 per ton for a feeder bus service, and $3,937 per ton for a commuter rail carpool matching service. Similar differentials were found for carbon monoxide reduction costs. Automobile park-and-ride trips involve cold start vehicle operation, with associated pollution emission and fuel use rates several times higher than the average for all automobile travel. In contrast, bicycle and pedestrian access trips require no petroleum and have no emissions.

As Transportation Control Measures (TCMS) for air quality attainment, park-and-ride strategies frequently offer a very low payoff at a high cost, while enhancements to pedestrian and bicycle access to transit offer a much higher payoff at a far more modest cost. Switching short auto access trips to bicycles can free up park-and-ride spaces for travelers living more than 2 miles from the lot, improving the cost-effectiveness of the overall transit access system.

Transit Markets and System Efficiency

The installation of secure bicycle parking at transit stops, combined with targeted bicycle facility investments and selective traffic calmng near stations and major stops and promotion of bike-and-ride travel, can be expected to increase suburban transit use significantly in many communities. By giving people more choices about how to get to and from transit, new riders can be drawn from those not now well served by transit. In California, surveys show that 30 percent to 68 percent of bicycle locker users at park-and-ride lots formerly drove alone to their destination before switching to bike-and-ride. Across the United States, the potential for bicycle-transit integration is large. About 100 million Americans own bicycles, and many of these people live more than a quarter mile, but less than 2 miles from the nearest public transportation route. Few of these people now use transit to get to work, in part because of the lack of an inexpensive, convenient, safe, and fast transit access system suited to trips of this distance. Further development of park-and-ride services may increase transit market penetration somewhat in areas beyond walking distance of transit, but only at a substantial cost. Bike-and-ride systems, however, offer the prospect not only of lower access system costs, but of tapping market segments untouched by the existing automobile-based transit access systems.

While park-and-ride enhances access to transit at the home end of the trip, it does nothing to get people from transit to destinations beyond walking distance of transit. Well developed bike-and-ride systems, on the other hand, can enable people to use a bicycle to get from transit to workplaces and schools located outside the immediate vicinity of transit stations. In the Silicon Valley of California, 40 percent of bicycle locker users store their bicycle overnight in their locker and use it to get from commuter rail stations to workplaces and schools not otherwise easily accessible from transit. For U.S. transit services to retain or gain market share, they must be adapted to the lower-density polycentric metropolitan land use patterns of late twentieth century America. Bicycle access and egress are both important elements in making transit services viable in such areas, where pedestrian access and egress are handicapped by lowdensity development and frequently nonexistent pedestrian infrastructure.

Improved pedestrian and bicycle access to transit is not a panacea for the problems transit agencies face in adapting to these new markets, but can be a major element in improving suburban public transportation under conditions of economic restraint. As a strategy for holding down transit costs while boosting transit ridership, saving energy, reducing air pollution and traffic congestion, slowing global warming, and preparing for future oil-supply interruptions and cost escalation, the improvement of pedestrian and bicycle linkages to transit is among the most cost-effective approaches.

Figure 1. Walking is the most environmentally friendly and lowest-cost way to get people to and from public transportation. When given sidewalks or traffic-calmed streets to walk along, safe and convenient ways to cross streets, and a comfortable and attractive environment, most people are willing to walk farther to reach public transportation.

Figure 2. Portland, Oregon, offers an outstanding example of linking pedestrian facilities to public transportation. Reallocating street space in the downtown to transit and pedestrians has helped keep the central business district healthy, retaining a much higher share of regional retail activity than in other cities, where downtowns have declined.

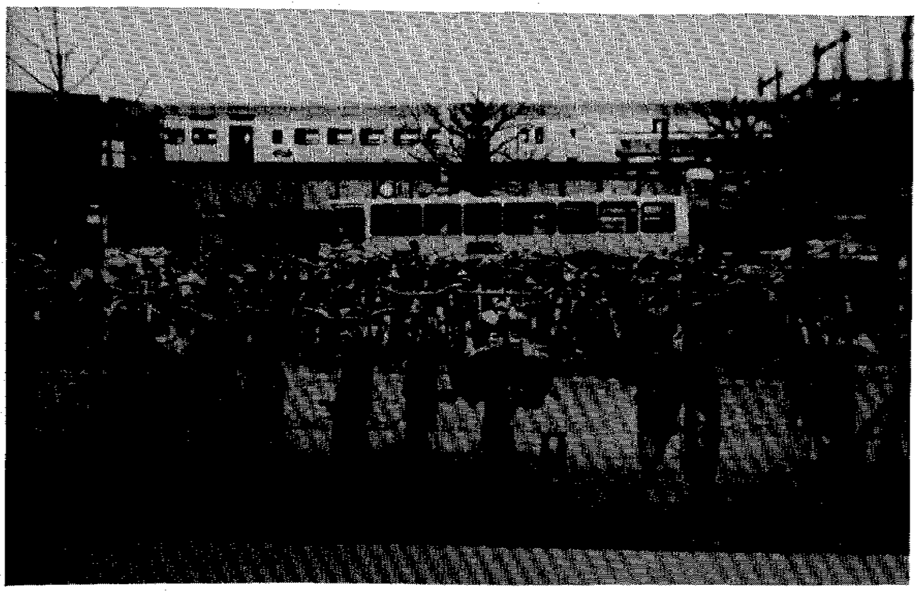

Figure 3. Next after pedestrian access, bicycles are the most environmentally friendly and low-cost way to get people to and from public transportation. With the bicycle's higher speed and private transportation convenience, it has the potential to dramatically increase the market area served by transit stops. This is particularly important in low and moderate density suburbs, where transit route spacing is greater. Leiden, in the Netherlands, shown in the photo above, has a fully developed multimodal transit access system with bike paths and traffic calmed streets leading to the station, a guarded bicycle parking garage with 4,300 spaces, 1,535 open air bicycle spaces, bicycle rental and repair services, good bus and taxi services, and 360 automobile park-and-ride spaces, to serve the 15,000 train passengers who board here daily.

Figure 4. Guarded bicycle parking garages, like this one in a suburb of Amsterdam, account for the majority of bicycle parking spaces at rail stations in the Netherlands and Japan, where the integration of bicycles with public transportation is most fully developed, and where bicycles account for a quarter to a half of suburban rail transit access trips. Guarded, or even automated, bicycle parking facilities are far less expensive to construct per space than automobile park-and-ride lots, while occupying less space and generating fewer traffic problems near transit stations. Guarded bicycle parking is attractive to new users who wish to try out the alternative for the first time, while protecting expensive bicycles against both vandalism and weather, a combination not achieved with either racks or lockers.

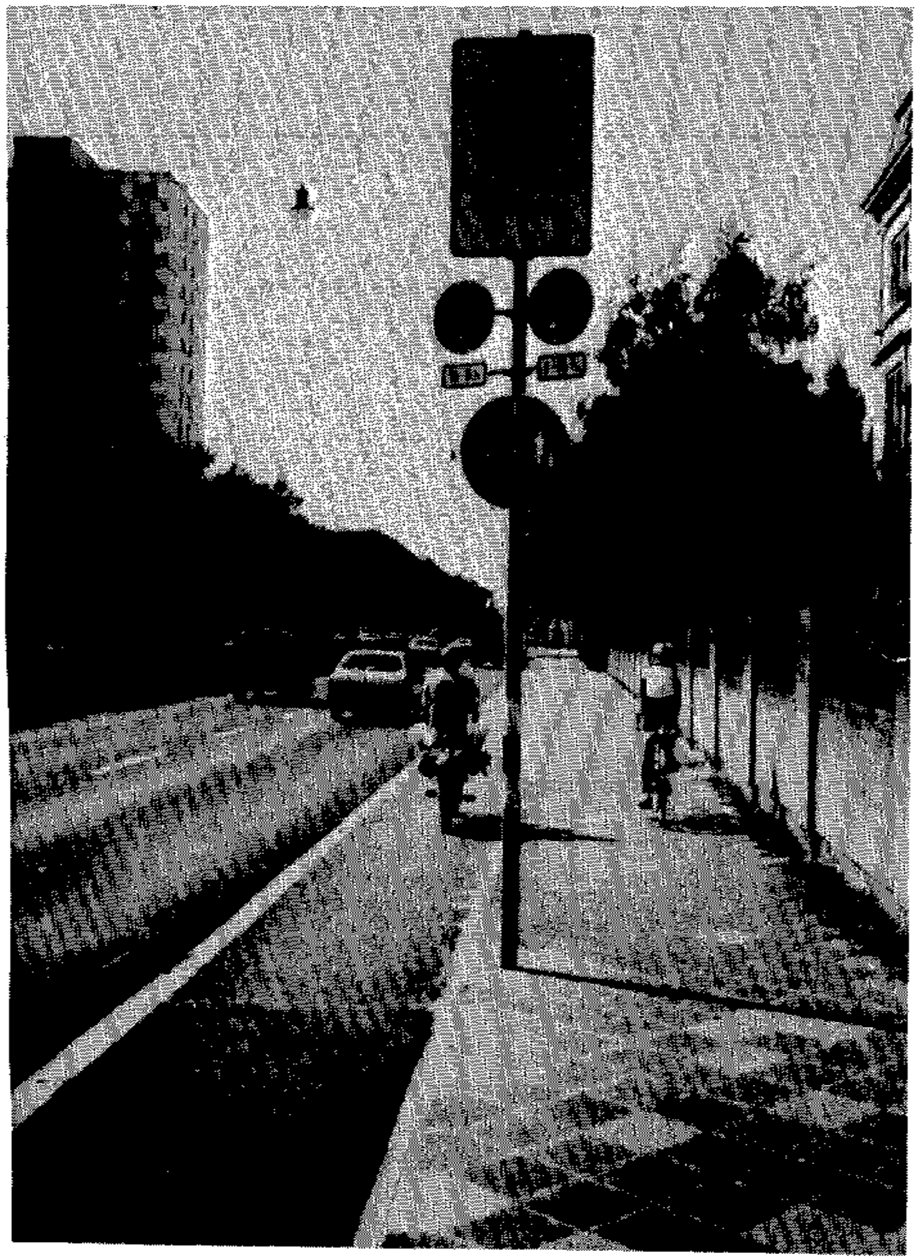

Figure 5. Effective bicycle and pedestrian access to public transportation requires attention to the passenger's entire journey, from home-to-station and station-to-final-destination. Low-cost designs to separate pedestrian, bicycle, and motor vehicle traffic along busy roads leading to transit stops and stations, as here in Karlsruhe, Germany, can be very effective in enhancing transit access, particularly when such facilities form a complete network.

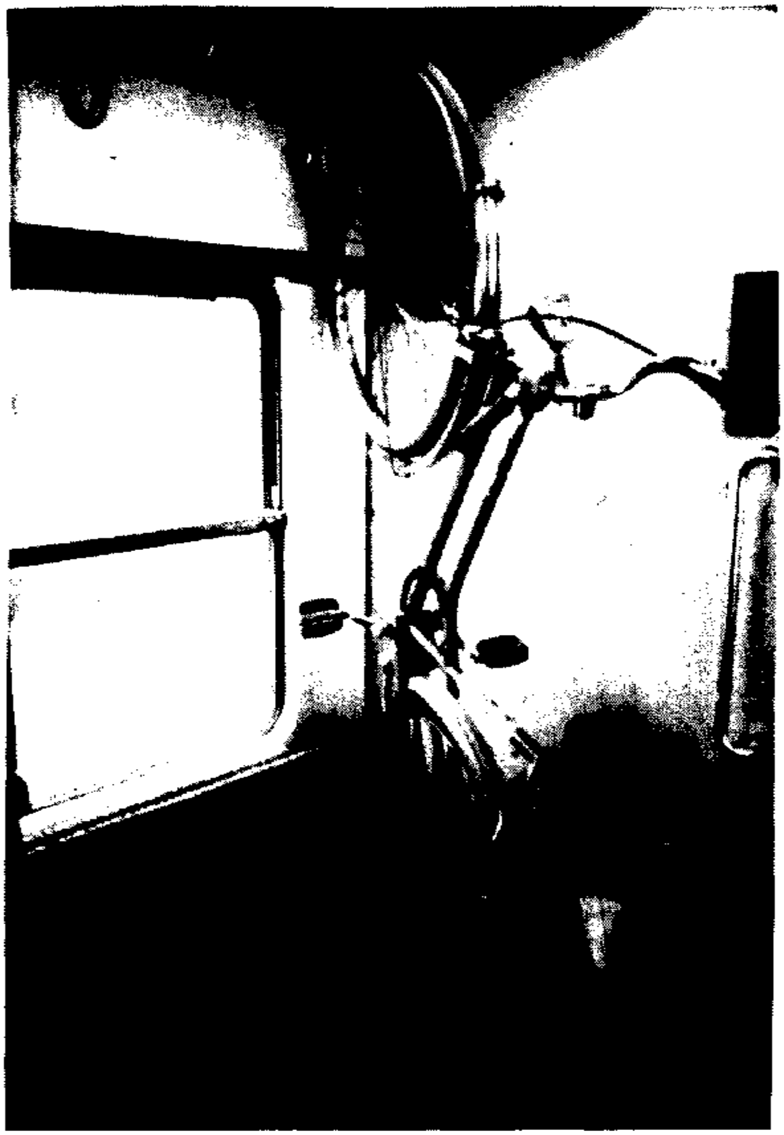

Figure 6. By allowing bicycles on transit vehicles, transit agencies can gain additional revenue at virtually no added cost during times of nonpeak demand. In Europe, bicycles are allowed on many railways and metros by paying a small fare surcharge; no permits are required. This ceiling hook and fold-up bench seat configuration found in Austrian commuter rail and light rail vehicles is one of the best designs for space efficiency and user friendliness. This system can be retrofitted into existing rail vehicles at a cost of several thousand dollars per car. Incorporated into new car design, it adds nothing to capital costs.

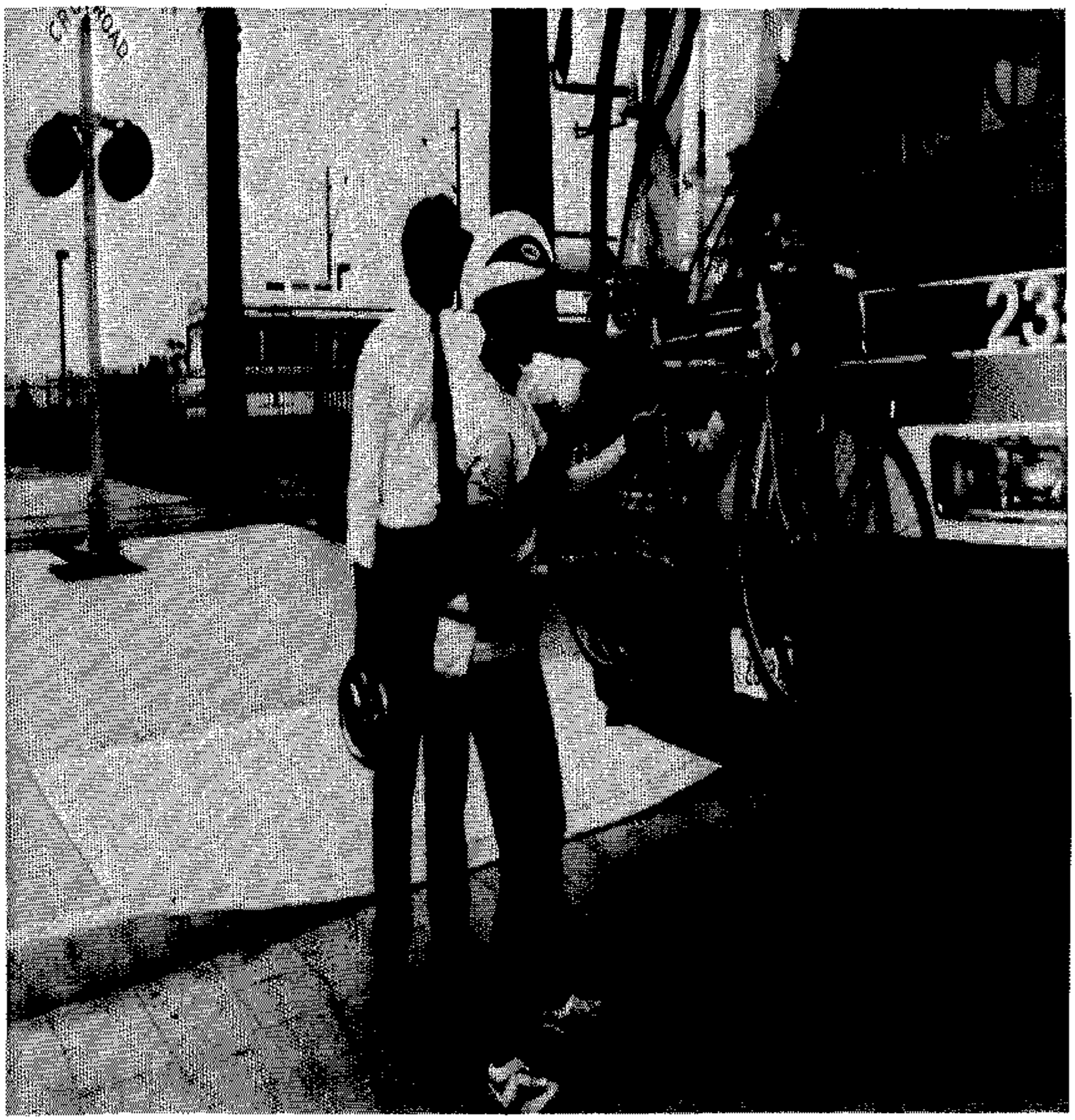

Figure 7. Bike-on-bus programs use a number of different approaches for bicycle storage. Front-mounted bicycle racks holding two or three bicycles are popular in a number of cities, such as here in Los Angeles, California. Such racks are inexpensive and can be observed by the bus operator.

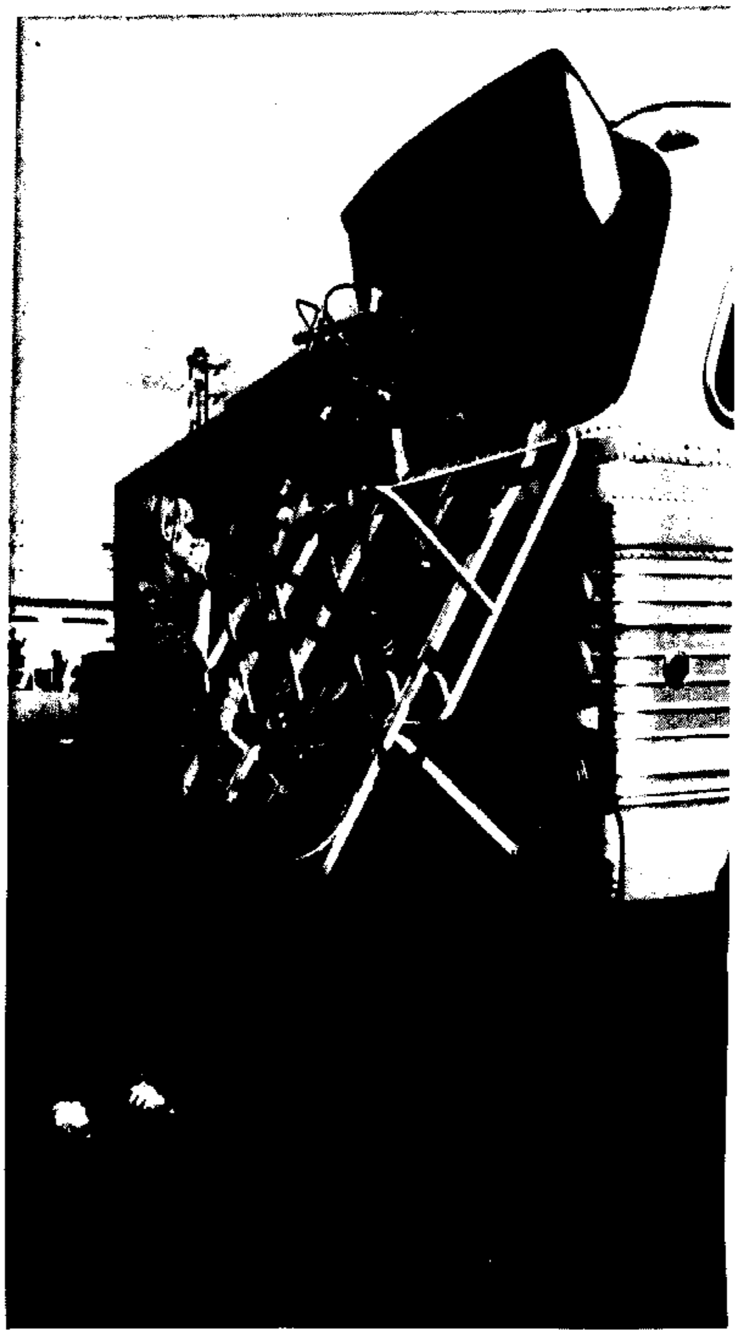

Figure 8. Rear-mounted bicycle racks for buses, like this one in San Diego, California, are also very popular among U.S. transit agencies. Such racks can usually accommodate five or six bicycles, and are of modest cost.

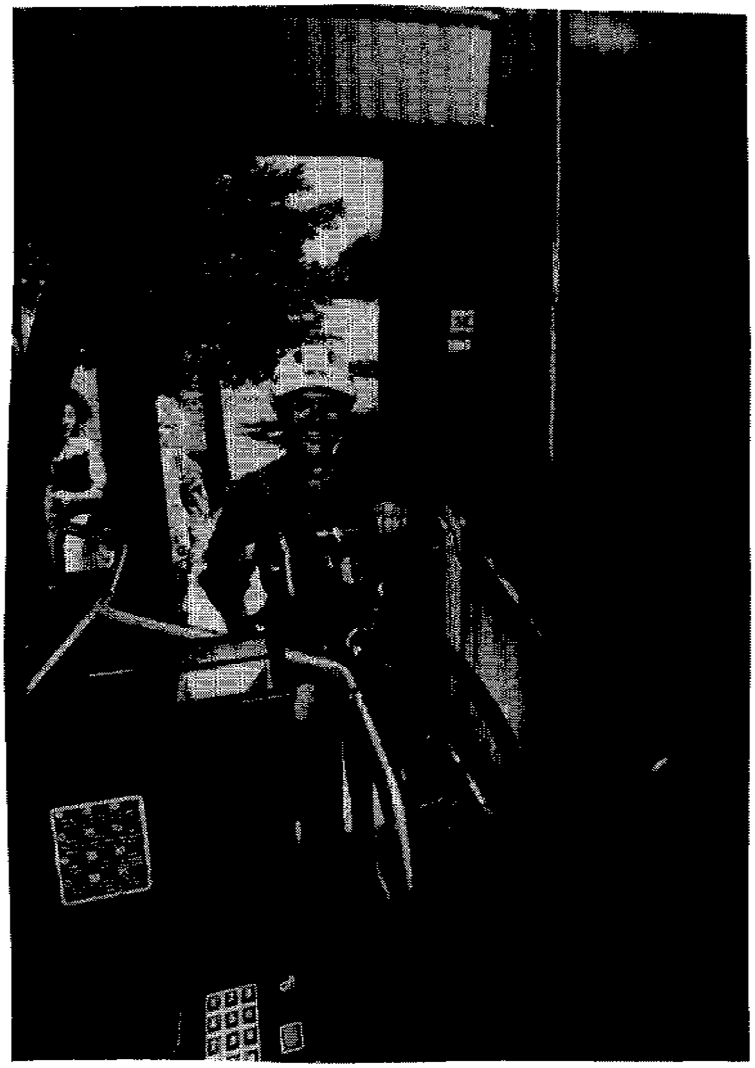

Figure 9. The simplest, cheapest, and easiest to implement bike-on-bus strategy is to simply permit transit passengers to bring their bicycle on board the bus, as shown here in Santa Clara County, California. Since the late 1970s, Westchester County, New York's, transit operator has said that "Everyone's Welcome Aboard!"—including passengers with grocery carts, baby strollers, wheelchairs, and bicycles. All of these fit readily into wheelchair storage areas on their buses.

Figure 10. Hannover, Germany, has a highly effective multimodal transit access system in both urban and suburban areas, which has helped enable this city of 750,000 to attain an auto driver mode share of less than one-third of all trips, despite high levels of automobile ownership. U.S. transportation planners and policy makers searching for ways to meet clean air goals, manage congestion, and improve the cost-effectiveness of public transportation under tight fiscal constraints could gain valuable strategies by adapting some of the best practices found in the modern and efficient transport systems of Europe and Japan.

1. A Brief History of Transit Access in the United States

Walking or riding a bicycle to access mass transit once played a predominant role in American cities, only later eclipsed and virtually abandoned to automobile commuting and auto access to transit stations. In recent years, a combination of factors are focusing national attention on the inadequacies, inequities and high cost associated with the unbalanced, auto-dominated transportation system that has developed in the United States. Highway congestion, Federal mandates to restore healthy air quality, concerns about energy consumption and a declining quality of urban life underscore the need to bring greater modal balance and integration to the U.S. transport system.

Added to these factors is the challenge facing mass transit systems to provide cost-effective and efficient service to the expanding low-density suburban developments and to serve the increasing share of metropolitan area trips that are suburb-to-suburb rather than suburb-todowntown. Legislators, transportation professionals, planners, concerned citizens and others are taking a renewed interest in the economic and environmental benefits that would result from improvements to bicycle and pedestrian access to mass transit.

Transit Access Prior to and During World War II

In the late nineteenth and early twentieth centuries, compact American cities began to expand outward along new railroad and electric trolley corridors. Walking was virtually the only means of access to public transportation. Homes and businesses in urban areas sought locations where transit service was within walking distance.

By the 1920s, however, development started to extend beyond easy walking distance of transit stations. Automobile park-and-ride lots and bicycle racks appeared at suburban commuter rail stations. . Cars were used more frequently to get to rail stations, but commuting by auto to downtown had not yet become popular. Walking remained the dominant means of transit access.

During World War II, gasoline rationing and scarce supplies of rubber and other auto needs almost eliminated automobile access to rail stations; people walked or used bicycles to get to the station. Bicycles were considered vital enough during the war to merit rationing in 1942,

with preference given to defense workers. In response to increased demand for bicycle parking, a large number of bicycle racks were installed at stations.

Rise of the Automobile In the Aftermath of the War

A shift in commuting patterns toward the automobile and away from transit began in the years following World War II and greatly accelerated in the decades following. A combination of factors, including Government policies, rising persona) income, increased automobile ownership and suburbanization played a crucial role in this commute change. New U.S. Government programs ensured massive capital investment in highways and suburban housing, and fostered the development of a web of institutions at different Government levels to promote automobile-oriented investments and policies.

At the end of World War II, the U.S. Government established major programs to promote economic recovery. The 1944 Defense Highway Act was part of this economic program and launched the Federal Government, in partnership with the States, on a major highway construction program. Enactment in 1956 of the Highway Trust Fund and Interstate Highway Defense System significantly expanded and elevated the nation's highway building agenda.

Capital investment to modernize and expand public transportation systems and inner city housing, on the other hand, was not forthcoming. In fact, streetcar lines in cities across the country were converted to diesel bus operations. These conversions were due not only to declining ridership in the face of rising auto ownership, but to illegal collusion by major corporations in the automobile and petroleum industries. By the time the corporations were found guilty of criminal conspiracy in Federal court, they had succeeded in scrapping and replacing more than 100 electric rail transit systems with diesel bus operations in cities across the United States.' Even in cities where electric trolley lines were owned by local governments or local utilities, competition from the automobile, changing land use patterns based around highways and inadequate capital for maintenance and expansion led to service deterioration and ridership loss.

Federal Government Recognizes the Need to Support Transit

In the early 1960s, with many American transit companies on the verge of collapse, the Federal Government stepped in and established an emergency loan program for transit capital needs. However, it was not until 1964, two decades after passage of the first Defense Highway Act, that the Urban Mass Transportation Act was enacted, providing Federal grants to transit agencies. Early Federal support for the nation's mass transit systems, though highly insufficient to meet capital needs, helped transit systems make necessary investments that led to service improvements.

Federal mass transit legislation that followed over the years substantially boosted and expanded Federal support for transit capital needs and operations, though still falling far short of transit investment needs and far below levels of Federal funding for highway construction and maintenance. Federal support of mass transit, in partnership with State and local Governments, has been a crucial factor in reversing the transit ridership losses of the 1950s and 1960s and putting transit ridership on an upward trend.

Early Federal Support for Transit Access: Park-and-Ride Lots

The beginnings of Federal support for transit access are found in the Federal Aid Highway Act of 1968, Section I 1, which funded a demonstration program for automobile park- and-ride lot development. Local authorities had to provide 50 percent match for the Federal funds and were required to set any parking fees for use of the lots below the level needed to fully cover operating and maintenance costs of the facilities. The Federal Aid Highway Act of 1970 moved park-and-ride out of the demonstration phase by creating in Section 134, a program of Federal funding for park-and-ride facilities, with 66 percent Federal share. The requirement that parking fees remain below full market price was continued.

U.S. transit agencies used this new Federal program to make major investments in parkand-ride facilities. The new transit access system addressed a clear need. Expansion of transit route mileage had fallen far behind the expansion of urbanized land area, leaving a large percent of the population beyond easy walking distance of bus or rail transit lines. Park-and-ride lots were viewed as the only way to tap growing suburban markets without providing expensive transit feeder services.

Bicycle parking and safe pedestrian and bicycle access routes were rarely, if ever, incorporated into the park-and-ride facility designs. The potential of bicycle and pedestrian access systems appears not to have been on the minds of American transportation planners and transit system operators, in clear contrast to their Western European and Japanese counterparts.

By the early 1980s, well over 1,000 park-and-ride lots had been created throughout the United States, some with capacity for more than 1,000 vehicles. Many suburban transit systems had become automobile-dependent, as the automobile became the primary means of reaching many, if not most, suburban express bus and rail transit services. Since then, park-and-ride lot construction has continued at a substantial pace, and lots holding several thousand vehicles are increasingly common. However, the high cost of parking construction, limitations on land area available near transit stations, and opposition from residential neighborhoods near proposed parkand-ride lots constrain parking capacity provision or expansion at many locations.

Neglect of Multimodal Transit Access In America

Local and feeder buses play an important role in many American metropolitan areas in extending access to express bus or rail transit. However, these feeder bus services are constrained by the same factors that inhibit further development of line-haul transit routes in the suburbs: low population densities and dispersed travel patterns. The higher cost and higher subsidy required to provide such feeder services usually result in less frequent service than desirable and/or sparse geographic coverage, leaving much of the population outside their service area. In many suburban areas and small cities, budget constraints prevent such services from being offered at all.

These limitations of feeder bus services and park-and-ride access make it increasingly important to focus planning, design, and operating strategies for transit on improved pedestrian and bicycle access. Until recently, little attention or spending has been directed towards these more humble modes in American cities and suburbs. It is not surprising, therefore, that such modes today play a much smaller role in U.S. transit station access than only several decades ago. This neglect has not only failed to capture a cost-effective opportunity to enhance transit's market area in the suburbs but also missed an environmentally sound and economical means of improving the efficiency of our transport system.

As the following chapters demonstrate, this situation is changing. Spurred by environmental mandates and concerns, the need to relieve costly highway congestion and the successful experience in Western European and Japanese cities, localities throughout the United States, in conjunction with their transit agencies, are beginning to implement policies and programs to encourage bicycling and walking and better linkages between bicycling and walking and mass transit. Now in its early stages, the effort to improve bicycle and pedestrian access to transit in the United States shows clear signs of growth.

Federal Funding Availability for Bicycle and Pedestrian Facilities

Federal support for bicycle parking facilities has been made available through surface transportation reauthorization bills in recent years. Although Federal funding was available for bike-and-ride facility development starting in the mid-1980s, few transit agencies and local governments took advantage of the availability of such funds.

The Surface Transportation and Uniform Relocation Assistance Act of 1987 (STAA of 1987) amended Sec. 326 on Bicycle Facilities, made eligible for Federal mass transit funding (under Sections 3, 9 and 18), at a 90 percent Federal match, projects that provide access for bicycles to mass transportation facilities, including shelters and parking facilities for bicycles in or around mass transportation facilities, and racks or other equipment for transporting bicycles on mass transportation vehicles.

Passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) also provides the opportunity for State and local Governments and transit agencies to increase their investments in projects that provide bicycle or pedestrian links to mass transit. For example, approximately $1 billion per year for 6 years is earmarked for a Congestion Management and Air Quality Program (CMAQ), to be spent on programs or projects that must or are likely to contribute to attainment of the national air quality standards. Eligible projects for CMAQ funds include secure bicycle storage, construction and reconstruction of paths and lanes for bicycle and pedestrian use, and purchase of racks for use on transit vehicles. Bicycle and pedestrian improvements, particularly those linked to mass transit, offer some of the most cost-effective opportunities to improve air quality by eliminating cold starts and hot soaks of short trips by automobile.

On February 20, 1992, the Federal Highway Administration issued interim guidance on implementation of the CMAQ Program which encourages States and metropolitan areas to invest in bicycle and pedestrian facilities and program activities. While the program is aimed at areas in nonattainment of the clean air standards, all States will receive at least $4 million annually.

Surface Transportation Program (STP) funds are also clearly eligible for use on bicycle and pedestrian facility improvements. Moreover, some 70 percent of available funding authorized by ISTEA can be "flexed" to other categories, such as the STP, enabling it to be used for bicycle and pedestrian facilities.

Under ISTEA, for the first time, States are required to develop a long-range bicycle and pedestrian plan, to include consideration of bicycles and pedestrians in their long-range and annual transportation improvement plans (TIPs) and to appoint a bicycle and pedestrian coordinator in their transportation department. Metropolitan areas are subject to similar planning requirements. These requirements indicate the higher priority Congress clearly intends State and local Governments to give to bicycle and pedestrian projects.

The dedication of a much larger share of Federal transportation assistance to metropolitan planning under ISTEA offers an important opportunity for improved planning of transit access systems. This could include, for example, the development of new regional inventories of sidewalks and bicycle facilities, based on Geographic Information Systems (GIS) and the regional TIGER file, a computerized representation of the entire street and road network prepared by the U.S. Bureau of the Census for the 1990 census and available for every jurisdiction in the U.S. GIS, which has only recently become widely available, provides a framework for using these data to better measure the pedestrian and bicycle friendliness of areas, and to identify gaps in networks. When combined with tax assessor parcel files, GIS can also be used to identify the proximity of housing and employment to transit stops and neighborhood retail services, providing planners with better indicators of the market area of transit stops by foot and bicycle, enabling better multimodal access system planning.

Continued Federal funding of all transportation activities in many regions which are in noncompliance with the Clean Air Act (CAA) standards will be dependent on the local implementation of Transportation Control Measures (TCMs). Improving bicycle and pedestrian access to transit can be an important and effective TCM, promising significant reduction in emissions. To properly account for emission reductions from pedestrian and bicycle programs, however, requires the use of models which separately estimate running emissions, trip-based emissions (cold starts/hot soaks), and diurnal emissions. It also requires travel demand models which estimate both work and nonwork person travel, appropriately accounting for mode choice changes between automobiles, transit, walking, and cycling. Federal metropolitan planning funds can be used to improve the quality of regional air quality/transportation/land use models and information systems to meet such needs.

II. Bicycle and Pedestrian Access to Transit in the United States

"Bicycle-related matters are not yet accepted as a legitimate part of the duties and functions of many agencies and by many professionals. This needs to change. The responsibility for bicycle considerations should be fully vested in all appropriate agencies and organizations concerned with transportation, education and law enforcement." ----Florida Bicycle Sketch Plan, 1990

Over the past two decades there has been substantial growth in bicycling in cities and States across America. Bicycling has become one of the most popular recreational diversion for Americans of all ages and a means of transportation for increasing numbers. A comparison of bicycle and automobile ownership for various industrialized countries, shown in Table 1, however, shows that Americans remain far more dependent on their cars and far less on bicycles than citizens of other industrialized nations.

Table 1. Bicycles and Automobiles In Selected Countries (1985)

Country	**Bicycles (millions)**	Automobiles (millions)	Bicycle:Auto Ratio
Netherlands	11.0	4.9	2.2
Japan	60.0	30.7	2.0
West Germany	45.0	26.0	1.7
Argentina	4.5	3.4	1.3
Australia	6.8	7.1	1.0
United States	103.0	139.0	0.7

Increased interest in the United States by State and local transportation professionals and planners in providing better bicycle and pedestrian facilities and improving bicycle and pedestrian access to mass transit systems is evident in many parts of the country. Planning studies and transportation demand management programs are beginning to include nonmotorized links to mass transit and to examine the environmental benefits and potential gains in transit ridership that would result from providing better intermodal connections.

Investment in bicycle lockers and racks at transit stations has increased but remains inadequate and a key deterrent to increased bicycle access to transit. A growing number of transit systems have implemented or are looking at bike-on-bus and/or bike-on-mil policies, but many urban and suburban systems have yet to explore bicycle-transit potential. While progress in improving bicycle facilities and bicycle access to transit has occurred, observations in a 1980 U.S. Department of Transportation report to Congress on bicycling and energy conservation remain relevant:

> *"Many of the disincentives to increased bicycling are the result of the low level of integration of bicycling into the U.S. transportation system. Three root causes account for this situation: (1) lack of awareness and understanding of bicycling concerns among transportation professionals; (2) fragmentation of transportation planning and management, and (3) relatively low level of funding commitment to support bicycling. Combined, these causes produce a situation common in Federal, State and local transportation agencies: bicycling is simply overlooked. "*

Actions and policies put into place since that time are promising and indicate that the country is beginning to understand and tap into the potential of nonmotorized modes to bring greater efficiency, equity and environmental benefits to the U.S. transportation system. Yet, the United States lags far behind Western European nations and Japan and a real commitment of funding and policy from the highest levels of Government on down is needed in the years ahead.

Mode Shares for Access to Transit In U.S. Cities

Studies that document the extent of transit access trips by nonmotorized modes and examine the untapped potential to increase the nonmotorized share of trips have been conducted by a number of transit authorities but are not yet common practice by most transit agencies. The extent of nonmotorized access in many metropolitan areas can only be inferred based on use of bicycle parking facilities at transit stations. However, Tables 2 and 3 illustrate typical access modes shares for various selected locations.

Studies have found motorized access-by automobile or bus-is the predominant means of access to suburban rail transit stations, with park-and-ride or kiss-and-ride (passenger is dropped off by automobile) constituting the vast majority of trips. This comes as no surprise given the substantial investments in park-and-ride facilities that have been made by transit agencies as a key strategy to entice commuters from the suburbs to take public transit rather than drive to work.

Table 2. Mode of Access to Four Northern Virginia Metrorail Stations (n=1,060)[2]

Metro Station	**Mode.of Access to Metro Station**					
	Auto Park-and-Ride	**Auto Passenger**	**Bus**	**Walk**	**Bicycle**	**Other**
Vienna	69.3	13.7	11.4	2.4	0.5	2.7
Dunn Loring	70.5	15.6	5.3	3.6	0.7	4.3
W. Falls Church	68.2	14.8	7.2	5.0	0.4	4.4
E. Falls Church	50.0	10.7	8.0	21.4	0	9.8
TOTAL	67.4	14.1	8.4	5.5	0.5	4.1

Table 3. Mode of Access to Various U.S. Rail and Bus Systems

Transit System	**Transit Access Mode Share (%)**					
	Auto	Bus	LRT	Walk	Bike	
Sacramento, CA Bus System	1.0	17.0	8.0	68.0		6.0
Sacramento, CA Light Rail	26.0	28.0	n/a	38.0		8.0
BART (1987)	32.7	17.1	48.1	1.0		1.1
Rail Transit						
Columbus,OH (Bus)	28.3	n/a	n/a	71.7	n/a	n/a
SMART-Detroit (Bus)	30.1	n/a	n/a	68.7	0.5	0.7

While this strategy has proven successful to a large extent, failure by Government and transit agencies to also provide and seriously invest in bicycle parking and improved pedestrian access to transit stations results in adverse environmental and economic consequences. A large portion of parking spaces are occupied by cars that have been driven very short distances-many 3 miles or less-trips that are energy-inefficient and contribute disproportionate amounts of air pollution due to the cold start phenomenon. The typical solution to overcrowded parking lots is to expand parking, which is both expensive and land-consuming. Nonmotorized access could eliminate many of these short automobile trips if proper investments were made in bicycle parking and in bicycle and pedestrian paths from residential neighborhoods to the transit stations.

NORTHERN VIRGINIA RAIL TRANSIT ACCESS STUDY

A study of access to four Northern Virginia rail transit stations, conducted 1988 by the Metropolitan Washington Council of Governments, in cooperation with U.S. DOT, FHWA and the Virginia Department of Highways and Transportation, found 81 percent of the Metrorail users accessed the stations by automobile.

Park-and-ride was the predominant mode of access, used by 67 percent of Metrorail users at the four stations. Another 14 percent were either dropped off at the Metrorail station or passengers in cars parked in the lot. Access by other means totaled: 8.4 percent by bus; 5.5 percent walked and 0.5 percent bicycled. Auto access was higher than for Metrorail system-wide (40%) due largely to the means of selecting survey households, which was based on vehicles parked in the four Metrorail parking lots.

The study found 66 percent of the available parking spaces at the four Metrorail park- and-ride lots occupied by people living within 3 miles of the stations. The study concluded that, *"this is a misuse of this scarce resource. From a transportation system perspective, these [automobile parking] spaces would be better used by long-distance auto driver trips."*

The main reasons cited by survey respondents who could be potential bike users but are not, were: danger from auto traffic, lack of bike lanes, trails or bike storage and insufficient security. Chief reasons for not walking by potential walkers were similar: danger from auto traffic, no sidewalks and inadequate lighting.

Extrapolating the findings of survey respondents to the total 3,060 people who live within 3 miles of the lots and drive to them in the peak hour, the study projected a potential diversion of almost 1,300 auto drivers or 42 percent to bus and nonmotorized modes.

Source: Metropolitan Washington Council of Governments, *Metrorail Orange line Bicycle/Pedestrian Access Study, Northern Virginia*, October 1988.

Along with automobile access, walking is a key means of transit access. Walking tends to be the predominant means of access to bus stops and, where residential neighborhoods are located in close proximity to downtown or suburban rail stations (i.e., within easy walking distance), walking is an important or dominant means of access to rail transit as well.

Mode of access can vary significantly by time of day and by location. For example, during the evening peak and off-peak hours in the San Francisco region, bicycling constitutes a larger percent of BART access and egress trips than daily average. Walking accounts for 80.6 percent of morning egress trips and 68.4 percent of afternoon access trips, compared to a 48 percent daily average. Bicycle access to BART is twice as high in the East Bay as in the West Bay or the region as a whole (1.6% vs. .8%). Walking, on the other hand, makes up a larger percent of total access trips in the West Bay than other areas or the region as a whole. These regional differences reflect the various factors which influence the extent of nonmotorized access to a station, such as the relative pedestrian and bicycle friendliness of the area, availability of bicycle parking facilities, topography, and the pattern of land use and overall urban design.

Wide variation is also seen in the means of access to the Metrorail transit system in the Washington, D.C. metropolitan area by time of day and by station. A 1990 Metrorail passenger survey found walking to be the predominant means of access, used by 61.4 percent of riders. The automobile is the second most prevalent means of station access-auto driver, auto passenger and auto-drop-off is used by 17.8 percent of transit riders and only 0.2 percent of riders access Metrorail by bicycle. Yet, in the AM peak period, bicycle access is higher than the daily average (.34% vs. .2%) and is substantially higher at some stations: Braddock Road (1.8%); Clarendon (1.4%); Dunn Loring (1.3%); Medical Center (2.0%); Takoma (1.2%); Virginia Square (1.3%) and West Falls Church (1.2%). Walking access, like bicycle access, also varies significantly by station.

A survey of 73 people who bicycle to Montgomery County, Maryland, Metrorail stations found that bike-and-ride travelers are overwhelmingly male (86% in this survey) and employed full-time or are full-time students. The typical individual bicycling to Metro in Montgomery County arrives at the station between 6:30 and 8:30 AM (75%) and returns to the station to pick up his bicycle between 4:30 and 7:00 PM (66%). Nearly three-fourths of these travelers are between 31 and 50 years old. Most bicycle to the Metro station at least 4 days a week in the spring, summer, and fall. Winter months reduce the use of bicycles to reach the station by half Four out of ten travel 1/2 to 1 mile to reach the station, one-fourth travel 1-1.5 miles, and one out of 10 travel farther than 2.5 miles. Median bicycle access trip lengths for different stations vary considerably, from 0.8 to 2.0 miles, reflecting differences in land use, the friendliness of the bicycling environment, and topography. Roughly a fourth of those surveyed use an automobile to reach the station if not bicycling, while half walk, and the remainder use the bus. One out of 20 said they would not make the trip if not using a bicycle. Only 7 percent use a bicycle primarily because they have no automobile available.

When asked for their opinion about what bicycle improvements are most needed, those surveyed ranked bicycle paths separated from vehicle traffic first, followed closely by provision of additional and more secure bicycle parking, along with more bicycle-compatible roadways and lower prices for secure bicycle parking. Employer provision of showers was ranked lowest as a need, likely because those bicycling to transit typically travel short enough distances to avoid extensive perspiration. Indeed, 42 percent travel 5-9 minutes by bicycle to reach the station, 33 percent travel 10-14 minutes, and fewer than a quarter travel more than 15 minutes.

A number of studies, such as a mode split study conducted in Columbus, Ohio, have found that people's willingness to walk drops off rapidly with distances beyond 2 blocks or a quarter mile. The study notes that the steep drop-off in ridership leaves the transit system with *an "unrealistic mandate to provide stops within two blocks of homes in the service area."* Information provided by METRO Transit, a bus transit system in Oklahoma City, similarly indicates that most bus riders walk no more than 1/4 mile. Bicycle access to bus stops would appear to hold significant potential to expand the transit market area in a cost-effective manner.

An analysis of the *1977 National Personal Transportation Study,* for example, found that 13 percent of U.S. workers living within 1/4 mile of a transit stop use transit to get to work, but this falls to 8 percent for those 1/4 to 1/2 mile from a stop, and to 4 percent for those living between 0.5 and 2.0 miles from a stop.[3]

Bus Stop Shelters

The vast majority of U.S. transit systems use buses only, and for these the predominant means of access is by walking. Transit authorities have, therefore, paid a fair amount of attention to providing sheltered stops on main bus routes, especially in regions which experience extensive precipitation, extreme cold, or blazing heat and sun for some months of the year. Most transit agencies have a policy threshold to determine whether a shelter is warranted at a particular location. For example, in Charlotte, NC, shelters are generally provided at stops that board 50 or more passengers per day.

A number of transit systems plan to significantly increase their budget for shelters. MARTA in Atlanta is about to initiate a new program of bus stop shelters that is expected to add at least 1,000 shelters over the next 2 years. The shelters will be provided and maintained by companies who sell advertising to cover costs. Regional Transit of Sacramento, CA is also considering an advertising/shelter program that would greatly increase the number of bus stops with shelters. The Memphis Area Transit Authority (MATA) will add approximately 500 new shelters over the next 5 years, supported by advertising revenues. Table 4 shows the extent and cost of bus stop shelters in a number of cities.

Bicycle Parking Facilities at Transit

Cities and transit authorities across the country are beginning to recognize the crucial role of secure bicycle parking at transit stations in promoting increased bicycle access to transit. A number of the nation's commuter rail and rail transit systems are investing in bicycle parking but many lack a more comprehensive strategy that looks at the environment beyond the station. Frequently the quality of the parking provided is inadequate, leaving most bicycles vulnerable to theft and vandalism. The majority of suburban bus transit systems, which could expand service area and ridership through bicycle-transit interface, appear to pay little, if any, attention to bicycle parking facilities at bus stops.

There is wide variation in the use of bicycle racks and lockers between rail stations and also between transit systems. A crucial factor appears to be the degree to which the environment leading to the station is bicycle-friendly and the quality of the bicycle parking provided. In areas

Table 4. Passenger Shelters at Bus Stops

Transit System	Number of Sheltered Stops	Total Number of Bus Stops	% Sheltered	Average cost per shelter
Central Ohio Transit Authority (COTA)	329	4,040	8.1	$6,600
Charlotte, NC	70	350	2.0	$3,500
Memphis Area Transit Authority (MATA)	157	*5,000*	3.0	
Metro Transit, OK	72	750	10.0	
Milwaukee County Transit, WI	760	6,260	12.1	$3,800
MARTA, Atlanta, GA	138	20,000	0.6	
Niagara Frontier Transit Auth, NY	272	4700	5.8	$4,000
METRO, Houston, TX	1,000	10,000	10.0	$3,500
SMART, Detroit, MI	260	7,000	3.7	$3,000-8,000
Santa Clara County Transit, CA			10.0	$2,000-3,000
Sacramento Regional Transit	85	3,855	2.0	$3,000-5,000
RTD, Boulder, CO	50			$4,500

where separate bicycle paths or bike lanes on streets have been implemented, facilitating connection to rail or bus services, the ease and safety of access by bicycle is greatly enhanced. Access to many stations is on streets where little or no thought has been given to bicycle safety, curtailing the extent of bicycle access. The degree to which a transit agency actively promotes its bicycle parking facilities, and more broadly, promotes the environmental and social benefits of bicycle access vs. auto access also impacts upon the use of bicycle lockers and racks.

In 1990, the commuter rail authority in Chicago, METRA, conducted a survey of bicycles parked at METRA stations. A total of 809 bicycles were found to be parked at the 88 METRA rail stations with bicycle parking. Of these, 564 were parked in officially designated locations and another 245 at nondesignated locations (locked to poles, trees, signs, etc.). As Table 5 indicates, there is significant variation in bicycle access among stations. Some 66 out of 88 stations had less than 10 bicycles parked at them and most of these, less than 5. Only 13 stations had more than 20 bicycles parked. Table 6 shows the characteristics of bicycle parking at a sample of North American transit systems.

Table 5. Number of Bicycles Parked at METRA Stations, Chicago, Illinois

No. of Bicycles Parked	No. of Stations
30 or more bikes	8
20-29 bikes	5
10-19 bikes	13
5-9 bikes	22
Less than 5 bikes	40
Total	88 stations

Vandalism: A Perplexing Problem

Vandalism and abuse of bicycle racks and lockers are a problem experienced not only in this country but other countries as well. The degree to which it occurs in the United States varies between metropolitan areas and transit stations within a city. It has caused some transit authorities to remove lockers at troublesome locations and undoubtedly is a concern weighed by potential bicycle riders. It is important Chat transit authorities work to minimize vandalism through the type of bicycle lockers and racks they select and through the location and security provided for bicycle parking at the station. Vandalized bicycle parking equipment is a dramatic advertisement of the risks facing those who would contemplate parking their bicycle at a transit stop, particularly for cyclists with bicycles costing many hundreds of dollars.

BART learned from its early mistake in installing cheap lockers made of pressed board construction. The lockers proved to be poorly resistant to vandalism and subject to malfunctions. Vandalism remains a vexing problem at various locations and prompted BART to remove the lockers at the Richmond station. Locker break-ins average about two a month throughout the system and seem to come in clusters, with a vandal targeting a particular station and hitting all the lockers there-although the bikes are not necessarily stolen.

Table 6. Bicycle Parking at a Sample of North American Transit Systems

Transit System	Number of Racks	No. of Lockers	Usage
BART, CA	1,368	600; 470 usable	352 lockers rented
Boulder, CO	50+	38 (76 bike capacity)	
CalTrain, CA		374	75%
COTA, Ohio	0	0	
Charlotte, NC	15	2 (5 to be installed)	
CTA, Chicago	0	0	
SCRTD, Los Angles, CA	installing racks	and lockers at 50 stations	
MBTA, Boston	racks @ 20 stations		200-250 bikes/day at some stations
Metro-Dade Transit, FL		325: user pays $70/year or $45/6 mos.	40% rented
METRA, Chicago, EL	88 of 244 rail	stations have bicycle parking	
MARTA, Atlanta, GA	posts or racks at all 29 stations		
MATA, Memphis TN	Planned for new trolley line endpoints		
MTA, Baltimore, MD		removed from METRO stations; planned for MARC commuter rail stations	
METRO, Houston, TX	I park&ride with 2 racks; adding 2 more		demand exceeds capacity
NFTA, Buffalo, NY	3 stations with racks		Univ. station rack get 50% occupancy
NJ Transit	at 39 stations	at 5 stations	
RT, Sacramento, CA	racks at most stations	60 lockers at 10 LRT stations; $15/6 mos.	90% occupied
San Diego, CA		800 at govt bldg., P&R lots, LRT stations	
Santa Clara Cty Transit, CA		10% of bus and LRT stops	75% rented
SMART, Detroit, MI	1 @ park and ride lot		
SEPTA, Philadelphia	30	removed due to vandalism	
WMATA, Washington DC	900	650 (about 64 broken); $70/yr; $25/3 mos.	286 lockers rented; wait lists at many stations
Toronto Transit, Canada	at 32 stations (20 bike spaces ea)	0	

Misuse of bicycle lockers has been a problem in many cities. In Washington, DC, there have been problems with street vendors renting bicycle lockers to store their supplies and equipment, frequently in neighborhoods where there are long wait lists for bicycle lockers. In 1986, a homeless man lived in one of the BART 4-foot lockers at the Lake Merritt station in Oakland, decorating it with magazine cut-outs. Although he paid the $30/year rental fee, he was evicted after 6 months.

BARTS COMMITMENT TO BICYCLE PARKING FACILITIES

Funding of bicycle parking by Bay Area Rapid Transit (BART) in the San Francisco region dates back to 1972 when BART first started service. Twenty-four coin-operated bicycle lockers were administered by a concessionaire. Vandalism, however, led to change to a locker rental policy after four months. BART worked with local bicycle groups to develop a locker installation program and took over ownership and administration of the lockers from the concessionaire. Over the years, BART has installed 600 lockers, of which 470 are currently in usable condition, with 352 rented. In addition, 1,368 bicycle racks have been installed at suburban and urban rail stations. Lockers can be rented at a cost of $15 for a 3-month period or $30 per year, with a $25 deposit required.

Today, lockers at BART stations are almost at capacity and there are locker waiting lists at certain stations such as the Union City Station. BART officials are pushing to add capacity, contingent on obtaining additional funding through a Federal Transit Administration grant for the next fiscal year. BART actively promotes its bicycle parking facilities, in brochures and through electronic messages on station destination signs.

Vandalism has resulted in other large and smaller transit systems removing bicycle lockers, including SEPTA in the Philadelphia region; MARTA in Atlanta, WMATA in Washington, DC, and the Milwaukee County Transit System in Milwaukee. The Central Oklahoma Transportation and Parking Authority maintains 8 lockers but notes that vandalism of lockers and racks has occurred at various locations.

Guarded bicycle parking, as is commonly found in European and Japanese cities and suburbs, offers the best solution to vandalism problems, particularly in crime-prone areas. Even if formal guarded parking cannot be provided, vandalism can often be reduced by locating bicycle parking in locations usually supervised by station personnel, parking attendants, or small retail services near station entrances and making the surveillance of bicycle racks an explicit part of the responsibilities of such personnel whenever possible. Station security can be enhanced while making transit more attractive by strongly providing space for convenience retail kiosks in and near transit stops. Such kiosks are barred by some transit systems in the United States, such as WMATA in Washington, DC, due to concerns about littering in stations.

Fragmented Institutional Authority

While U.S. transit authorities have expended considerable planning and engineering to meet pedestrian needs in station design, in many cases, little attention has been devoted to either the pedestrian or bicycling environment to and from stations. Poorly developed interjurisdictional and interagency cooperation often impedes consideration of the door-to-door experience of using public transportation. It is not unusual for several different agencies to maintain independent and poorly coordinated control over the various facilities that are used by someone walking or cycling to and from a single transit stop.

Unless these agencies agree to cooperate together in assessing, planning, and enhancing nonmotorized transit access, major impediments to pedestrian and bicycle access may persist or grow in severity with no notice from Government authorities. Local and State Governments with authority to manage, maintain, and construct pedestrian and bicycle facilities and roads need to cooperate with transit agencies and interested citizens in developing action programs to reduce barriers to bicycle and pedestrian access to transit.

METRO of Seattle, Washington, for example, is working to integrate nonmotorized access to transit from the beginning in plans for new regional transit services, rather than as an "add on" to already designed transit projects as frequently occurs in many parts of the country. In December 1991, METRO published a "Nonmotorized Access Study," a study conducted to assess the potential of and make recommendations for incorporating bicycle and pedestrian access, with a focus on bicycle access, into the system plan for Seattle's Regional Transit Project.' The' Regional Transit Project examines two future rapid transit alternatives for the region-a transitway alternative (bus and HOV facilities) and a rail system alternative (light rail). The study notes:

> *"The potential 'commuter travelshed surrounding a transit line can be increased by adding station and vehicle amenities to allow easier interface between bicycles and the transit system.*"

Among the study's key findings are the following:

- Approximately I million people live within a 2-mile (desirable biking distance) radius of the proposed rapid transit system stations; a significant potential transit market;
- Agencies that have made improvements for bicycle access to stations see substantial increases in bicycle ridership at those stations;

- Transit vehicle [bus and rail] modificat ions and facility access requirements can be accommodated at relatively modest capital cost.

BICYCLING AND BICYCLE-TRANSIT LINKAGE IN LOS ANGELES

Plagued by the nation's worst air pollution and by long hours of traffic congestion, the Los Angeles region is making substantial investments in alternatives to driving, such as light rail, commuter rail and bicycling. As part of this effort, the Southern California Rapid Transit District (SCRTD), the major transit provider in Los Angeles, is demonstrating a new commitment to bicycling and bicycle access to transit.

As rail transit expands in the Los Angeles region, bicycling needs are being considered and incorporated. SCRTD recently received funding for bicycle lockers and racks at five stations with park-and-ride facilities on the Blue Line (the light rail line linking Long Beach with downtown L.A.), serving a total of 120 bicycles. Fees for locker rental will be $25 for 3 months, $45 for 6 months and $70 for one year.

A total of 36 lockers, serving 72 bicycles will be installed on the Green Line, a new line due to open in several years. These lockers will be incorporated into the original station designs and located close to the station entrances. The Gateway Center, which will be constructed over the Red Line and where SCRTD will be moving its headquarters, will also include bicycle lockers. The Gateway Center is being planned as a model of pedestrian access and orientation, as well as a major multi-modal transfer point between walkers, bicyclists, rail and bus transit users and auto drivers.

SCRTD will also select an experimental site at which coin-key lockers will be provided. These coin-key lockers may reduce administrative costs and increase revenues, but may also present problems in terms of cost of the coin-key mechanism, maintenance and vandalism. They will be carefully evaluated to assess costs and impacts. Class II bicycle racks will also be provided free of charge at the same stations, with the thought that the lockers will serve bicycle commuters and the racks more casual users. Since bicycle parking is being added to existing stations, it will be sited where space allows. Preferred sites, however, are locations closer to the station entrances than the park-and-ride lots.

The plans for secure bicycle parking at transit stations in the Los Angeles are part of a comprehensive regional program of expanded bicycle paths and trails, better bicycle and pedestrian access to transit, provisions in rail station design to accommodate nonmotorized modes and bike-on-transit vehicle policies.

The Way to the Station or Bus Stop

A lack of attention to pedestrian and bicyclists needs beyond the bounds of the transit station seems fairly common. The location of park-and-ride lots is often not amenable to nonmotorized access. One transit agency commented that all of their park-and-ride lots are located near freeways and/or shopping areas where residential housing is quite far away and there are no bicycle paths or facilities located near the park-and-ride lots.

Some U.S. transit agencies and State and local Government transportation departments, however, are showing a growing and promising awareness of the need to focus on the larger environment that surrounds and leads to transit stations and bus stops.

Florida. Florida has established itself through legislation and programs as one of the nation's leading States in bicycle activities. Findings of the Governor's Bicycling Activities Advisory Committee in 1980 led to implementation of several major initiatives, including establishment of a State Bicycle Coordinator in Florida DOT and development of a Bicycle Element in the State Transportation Plan.[5] Building upon the State's commitment to bicycling, *a Bicycle Sketch Plan* was developed in 1989 for the Florida Department of Transportation under a grant from the Governor's Energy Office. The Sketch Plan sets forth a framework for a comprehensive approach to the development of bicycling in Florida and details the policies and programs that need to be implemented by State and local Governments. The Plan notes the significant potential of bicycling to help alleviate major urban and environmental problems facing the State. The Plan estimates that oil savings in the range of 58,000-367,000 gallons of gasoline/day could be realized if good bicycle programs were implemented in areas covering Florida's 21 Metropolitan Planning Organizations (MPOs) and resulted in modest increases in bicycling for transportation purposes.

Among the objectives identified as crucial to achieving a comprehensive bicycle program, Objective 4, "Ensure the provision of support facilities to accommodate and enhance bicycle use" is of particular relevance. Key programs listed to achieve this objective include:

A. Local governments should amend their site-plan and zoning procedures to require the routine provision of bicycle parking facilities;

B. The Florida DOT should prepare a manual detailing procedures for selection and placement of bicycle parking;

C. Commercial establishments, especially malls and shopping centers, should be encouraged to provide bicycle parking; and

D. Employers should be encouraged to consider providing showers at work to accommodate bicycle commuters.

Charlotte. The city of Charlotte, North Carolina, began a project in 1981 to encourage walking and bicycle access to bus transit along its heavily travelled Central Avenue Corridor which contains seven intersections at Level of Service E or F in the peak hours. To help address bicycle access needs, 20 bicycle racks and three lockers were installed at key bus stops. To maximize safe storage, bicycle racks were placed near bus benches and shelters. Pedestrian access was improved by installing 114 pedestrian signals and 115 push-buttons at key intersections and sidewalks were constructed with curb cuts to provide access for children on bicycles and persons with disabilities.

Los Angeles. The Southern California Rapid Transit District (SCRTD) has developed an interactive computer demonstration of the sidewalk "level of service" (LOS) effects of pedestrian overcrowding.' This was used in a successful effort to n-mitigate a plan by the Los Angeles Department of Transportation to take sidewalk space away from a rail station area that will serve the intersection of the Red and Blue rail transit lines. SCRTD has also commissioned a planning study of the Hill Street Metro portals as a blueprint for directing Red Line rail transit passengers to significant areas of downtown Los Angeles. The plan includes widening Hill Street sidewalks, creating pedestrian short-cuts to key destinations, planting trees along Hill and intersecting streets and a pedestrian walkway connecting the Museum of Contemporary Art with the newly installed "Angel's Flight" cable railway (funicular).

Houston, Texas. METRO of Houston recently entered into a program to implement sidewalks along major roads to provide access to their transit facilities. In addition, METRO will be seeking in the 1993 legislative session authority to construct bicycle paths and lanes, which METRO currently lacks authority to build.

Many of the new light rail transit (LRT) systems that have opened in recent years in U.S. cities are attempting to integrate bicycles both at the station and in the surrounding environment.

San Diego. The city of San Diego has added "destination plates" to its bike routes----green and white signs that serve to direct bicyclists to LRT stations. Plans are under way to plan for linkages between the new bicycle path and light mail extension planned for the Mission Valley Corridor.

Santa Clara County. In Santa Clara County, CA, bikeways along the rail right-of-way have been incorporated into the system. They are heavily used and very successful. The new Tasman Corridor light rail extension will incorporate bikeways into the project design.

Sacramento. All light rail stations in Sacramento, except one which is located in a freeway right-of-way, provide at grade pedestrian and bicycle access. Some 17 of the system's 28 stations are within three blocks of a city or county bikeway facility. Linkages at most stations are via residential or connector streets with low traffic volumes, presenting little or no problem for bicycle access. Four LRT stations are located on pedestrian/transit malls.

Use of GIS to Support Pedestrian Planning

In Montgomery County, Maryland, a municipality of 750,000 people immediately north of Washington, DC, the County Government is undertaking new initiatives to increase sidewalk construction and more fully incorporate the needs of pedestrians into transportation planning. To support these efforts, the Montgomery County Planning Department (MCPD) has developed

BOULDER, COLORADO: A PEDESTRIAN-FRIENDLY CITY

In 1991, *Walking Magazine* included Boulder, Colorado as one of America's 10 Most Walkable Cities. Magazine author, Dan Zevin noted in his article, "What distinguishes a great walking city from your everyday Ameritropolis. In short, an environment that makes it more compelling to stroll the sidewalks than to see it from behind a steering wheel."

Boulder has worked hard to earn its pedestrian-friendly reputation. The *Transportation Master Plan for Boulder Valley, 1989,* adopted by the Boulder City Council, sets forth an ambitious goal to achieve a shift of 15 percent of all trips currently made by single-occupant auto to other forms of transport such as bicycle, walking and transit. The *Pedestrian System* Plan states, *"The City and County shall improve the status of pedestrians by increasing the convenience, comfort and safety for pedestrians. "* To this end, Boulder has made significant investments in sidewalks and pedestrian pathways, hosted an annual International Pedestrian Conference for the past 12 years; funded an Alternative Transportation Center and a Pedestrian Systems Coordinator and taken other important steps to make Boulder a city where people want to stroll rather than drive.

There are two heavily used pedestrian facilities in Boulder: the Boulder Creek multi- use path which winds through the center of Boulder, parallel to Boulder Creek for 4 miles, and the Downtown Pearl Street Pedestrian Mall, a gathering place for shopper, strollers and entertainers.

Pedestrian needs are incorporated in the planning and design of transit facilities. "In Boulder, the design of the transit station environment takes pedestrian needs into consideration, as all bus riders are pedestrians waiting for transit," GO Boulder notes. At the central transit station, a person can easily get schedule information and bus passes/tokens and sit in a natural light, comfortable environment while waiting for his/her bus. Sidewalk connections to transit are being explored as part of the Neighborhood Transit Center concept, currently under study.

Maintenance of existing sidewalks, installation of handicap ramps and new sidewalk construction is part of Boulder's "Sidewalk Program," to bring Boulder sidewalks up to code in an efficient and effective manner. The program, estimated to cost approximately $11 million over 7 years, will receive $600,000 in FY 1993 from the Transportation Capital Improvement Program budget.

The City of Boulder's Alternative Transportation Center (known as GO Boulder, for "Great Options" in transportation) has developed and begun to implement an innovative comprehensive marketing program designed to change citizen's mobility habits. The program seeks to both educate the public of their mobility choices and to encourage use of alternative modes of transport.

a computerized geographic information system (GIS) database on sidewalks.[7] This data flow is important to the County's efforts in growth management, master planning, transportation analysis, and capital improvements planning.

Until the development of the Montgomery County sidewalk database, there was only limited and fragmentary information available on where sidewalks existed and where they were lacking across the County. A quick and low-cost comprehensive survey, collected by two summer interns who spent 6 weeks driving on nearly every road in the County, provided raw data for the inventory. These interns marked up small-scale street maps with a dozen colors of ink to code each road segment for the presence or absence of sidewalks on one or both sides of the street, sidewalk width (under or over 3 feet), and the presence or absence of a buffer between street and sidewalk (of under or over 3 feet). Open and closed section roads were also coded. With these data, GIS software is now used to produce maps of roads by sidewalk status at various scales of resolution, as well as sorted listings of street blocks by sidewalk classification. The foundation of the database is the TIGER file used to enumerate households in the 1990 U.S. Census, a low-cost product available from the Census Bureau, which describes nearly all roads in the United States. Figure 11 shows an example of a sidewalk map for one part of the County.

The inventory revealed that nearly 60 percent of the road links in the County have no sidewalks and only 37 percent of road links have sidewalks on both sides of the street, and that there is wide variation in the availability of sidewalks in different parts of the County. This information should help explain some of the variation in walking and walk-to-transit access between areas.

The database is being used to support a variety of MCPD work program activities. A key application is to support administration of the County's Adequate Public Facilities Ordinance through development of the Annual Growth Policy (AGP). This is a regulatory system which limits the number of new subdivision approvals for housing or employment based on the forecast level of traffic congestion in an area, given transportation facilities that are fully funded in the County and State capital improvement programs. Higher levels of traffic congestion are considered acceptable in areas where people have more freedom to choose alternatives to the automobile.

A number of measures are used to ascertain the quality of alternative modes to the automobile in the 23 policy areas used for AGP regulation. Since 1990, these include the share of housing and employment within a quarter-mile of bus stops or one-half-mile of rail stations, the frequency of bus and rail services, the share of trips made by automobile drivers, the number of park-and-ride and secure bicycle parking spaces at transit stops, and the ratios of sidewalk and bikeway length to street length. Transit coverage and frequency account for much greater weight than access and use factors, but all contribute to determining a weighted index of transit availability.

To support this new measurement system, a preliminary sidewalk ratio was calculated in 1990 by MCPD staff by coding to traffic zones a County street maintenance inventory which contained data on the presence or absence of sidewalks on many streets in the County. These data had shortcomings which prevented them from being efficiently converted into map data, but they provided an approximate measure of the sidewalk ratio. The sidewalk inventory has replaced this earlier database to provide a much more accurate measurement of the sidewalk ratio for the AGP.

Including Pedestrian and Bicycle Factors In Travel Demand Modeling

The sidewalk ratio has been found to be a statistically significant factor in explaining whether people walk to transit, drive to transit, or drive a car to work, and is thus used in the transportation forecasting model that supports AGP traffic congestion analysis. An AM peak hour work trip logit mode choice model used by the MCPD for the past several years also incorporates an "Index of Pedestrian and Bicycle Friendliness." This Index is a score independently assigned to all traffic zones in the region based on the availability of sidewalks, bicycle paths, and bus stop shelters, the extent of building set-backs from the street, and the heterogeneity of land use at a local level.[8] This Index was found to be highly statistically significant and explained much of the variation in auto-transit mode choice not accounted for by another mode choice model which focused solely on travel time and cost factors, ignoring transit access conditions at the home and work-place trip ends.

A similar "Pedestrian Environment Factor (PEF)" is being used in transportation modelling in Portland, Oregon, by the METRO planning agency. The PEF was defined by local planners who scored each zone on a I to 3 scale for sidewalk continuity, ease of street crossings, local street characteristics (grid vs. cul-de-sac), and topography. These were summed up to indicate overall pedestrian environment conditions, with scores ranging from 4 (poor) to 12 (good). The PEF proved to be a significant factor in determining automobile ownership, which itself is a powerful factor influencing transit ridership. It was found that in an area where walk trips can be more easily made, the need for an automobile is less. The use of the PEF also improved the ability of Portland's mode choice models to estimate walk and transit trips. Residential and employment density and proximity factors, such as retail employment within I mile, enter into Portland's models separate from the PEF and are also important indicators of mode choice and automobile ownerships.[9]

In most U.S. cities, transportation models consider only travel time and cost of competing modes, ignoring the quality of the pedestrian and cycling environment and frequently treating the proximity of jobs and households to transit in at best crude manner. This recent research and model development in Montgomery County and Portland provides strong evidence that regional transportation models could improve their forecasting methods by including more indicators of pedestrian and bicycle friendliness. Such enhancement will likely be needed in many regions to evaluate air quality effects of transportation plans and programs.

Figure 11. GIS-based Sidewalk Inventory for North Bethesda, Montgomery County, Maryland

With the more widespread adoption of GIS, detailed inventories of sidewalks and street crossing conditions can be anticipated to come into wider use. Immediate applications are possible in master plan development and in identifying key gaps in the sidewalk network. Once coded, such data enable rapid production of sidewalk maps and can support a variety of data analysis. The sidewalk inventory in Montgomery County, for instance, has been used to help develop recommendations on where new sidewalks are needed to connect affordable housing developments to nearby schools, transit stops, and shopping centers. Future model development efforts are expected to rely extensively on such data. Street address/intersection GIS-based georeferencing of household and employer-based travel survey records, along with the use of real estate parcel databases and TIGER-based inventories of bus stops and pedestrian/bicycle systems will enable more effective analysis of the influence of pedestrian and bicycle environmental quality and urban design on travel behavior.

Marketing and Promotion of Bicycle and Pedestrian Access

Some transit systems do an excellent job of promoting their bicycle parking facilities or bike-on-rail and/or bike-on-bus programs, while other systems do little, if anything, to promote nonmotorized access to transit.

The City of San Diego exemplifies a city that does an excellent job promoting its bicycle and other alternative transportation programs. San Diego maintains a separate phone line, 231- BIKE, that is widely publicized as a resource for information on bicycling. The city provides free bicycle maps that indicate: city bicycle routes; bus stops where bikes can be loaded and unloaded; location of bicycle lockers and bicycle parking at park and ride lots and bike-on-bus routes. The San Diego trolley schedule provides transit users with information on bicycle parking facilities and bike-on-rail policies.

San Diego is also promoting bicycling with private employers in the region. Commuter Computer, which operates the bicycle parking facilities in the San Diego region, recently started a bike locker loan/purchase program under which lockers are loaned to private companies for a 3-month trial period. After this time, the company has the option to purchase the lockers at cost price (currently $942 for four bikes). To date, lockers have been installed at 18 locations and Commuter Computer has received payment at nine sites. Only two firms have requested that the lockers be removed following the trial period.

By contrast, the Southeastern Pennsylvania Transportation Authority (SEPTA) in the Philadelphia region, which initiated its bike-on-rail program in July 1991, does not actively promote the program, leaving promotion thus far to be done by the Bicycle Coalition of the Delaware Valley, a nonprofit citizen's coalition that worked closely with SEPTA in developing its bike-on-rail program.

Ill. Bike-on-Transit Programs

Bike-on-Rail Programs

A growing number of transit systems in U.S. cities allow bikes to be brought on train___commuter, light rail and heavy rail transit services. In Europe, Japan and Canada, bikeon-rail policies are more widespread, though still growing, and tend to be structured in a manner that facilitates bike on rail use not only by regular commuters but occasional bicycle riders and tourists as well. Bike-on-bus programs are also spreading, especially in the United States.

The marriage of bicycles and transit, which forms an important part of the increased use of bicycles for access and egress to suburban transit services, combines many of the best features of each mode-using the bus or rail transit mode for the long haul and the bicycle for distribution to and from dispersed destinations at both ends of the trip.

Moreover, bike-on-rail services can provide high-quality metropolitan and intercity mobility completely independent of petroleum-based transportation. In the United States, as well as other oil-importing nations, these services contribute to efforts to reduce dependence on imported sources of oil and to reduce the outflow of capital from the country. The United States paid $51 billion for imported oil in 1991, constituting 75 percent of the U.S. foreign trade deficit. And, these programs can play an important role in urban strategies to meet Federal mandates to reduce air pollution.

The Historic Precedent

The original impetus for carrying bicycles on railroads came from railroad companies in the late nineteenth century, which hoped to attract additional passengers. These companies welcomed bicyclists and allowed them to bring their bicycles on board at no cost. As bicycling became more popular, however, many rail operators began to charge cyclists an extra fare for their vehicles, a policy that provoked strong political opposition from bicyclists.

In February 1896, public pressure led to introduction and nearly unanimous passage of legislation requiring railroads to carry bicycles free as personal baggage. Following New York's example, similar legislation was introduced in other States. By early 1897, the Passenger Committee of the Trunk Line Association, a railroad management association, announced that its member railroads would not charge for carrying bicycles. Free bike-on-rail policies were subsequently enacted in Pennsylvania, New Jersey, Ohio, Michigan, Indiana and parts of Illinois, California and Colorado.

Throughout the rest of the country, railroads and many streetcar lines offered bike-on-rail services, but imposed a surcharge. The Market Street Railway Company of San Francisco carried in 1897, an average of 1,800 bicycles per month on one route alone, with up to 6 bicycles suspended from hooks at the front and rear of the trams. The bicycles generated additional revenues of $180 per month without incurring any increase in rail operating costs. In Pittsburgh, Pennsylvania, seats were removed from one side of a number of trolley cars to accommodate bicycles inside. Bicycle hangers were installed in the baggage cars of many commuter rail services in the 1890s.

However, as transit services moved towards collapse in the mid-part of this century, bike-on-transit programs were abandoned, disappearing almost completely until the 1980s.

Bikes-on-Rail Programs In the United States Today

The first American commuter rail system permitting bicycles in passenger coaches in recent years was the Southern Pacific Railroad (SP), serving San Francisco and San Jose. A 4_month demonstration project in 1982, sponsored by the California Department of Transportation (Caltrans), allowed cyclists to secure their bicycles in the aisles of the rail cars at no charge during nonpeak hours. No permit was required. Southern Pacific's management, however, showed little enthusiasm for the project and demanded payment of $73,000 by Caltrans to indemnify SP for potential accidents. While there were no schedule delays, injuries or inconveniences to other passengers during the 4-month demonstration, lack of publicity and a short program duration, resulted in low bicycle use-only about 100 users a week. SP management's demand for costly insurance payments----over $100 per bicycle trip----resulted in the program being dropped.

At the time of the Caltrans demonstration project, only two other North American rail systems had carried bicycles for more than I year: BART, the rail rapid transit system in the San Francisco Bay Area and the Port Authority Trans-Hudson (PATH) in New Jersey which started its bike-on-rail program in 1962. BART's program enjoyed strong public support; by 1980, BART had issued more than 9,000 bike-on-rail permits. Community support and the excellent safety record of the program prompted BART to relax restrictions on the bike-on-rail service and permits were made available through the mail. By 1984, the number of permits had more than tripled to 28,000; this had grown to 71,000 permits by 1992.

BART's success prompted other rail systems to institute bike-on-rail programs.

Today, they exist on many commuter rail, heavy and light rail transit systems in cities across the country and other transit agencies are planning bike-on-rail service. Table 7 provides information on some of these programs.

Table 7. North American Bike-on-Rail Programs

Rail System	**Permit**	**Max. Bikes/ Train**	**Time Restrictions**	**Number of Riders/Permits**
***METRO* SYSTEMS**				
BART, San Francisco	Yes-$3	7 (last car)	nonpeak weekday; some reverse commute; weekends	7,445 July 90-June 91; 71,000 permits issued since 1974
SEPTA, Philadelphia	Yes-$5	2/train last car)	nonpeak weekday; weekends	167 permits
MARTA, Atlanta	.No	no rule (last car)	nonpeak weekday; weekends	
Metro-Dade, Miami, FL	Yes-$5	4 last car)	nonpeak weekday; weekends	2,000 permits
WMATA, D.C.	Yes-$15	(4 last car)	weekday evenings; weekends	4,800 permits active; 9,000 since 1980
PATH, N.J.	Yes-free	2/car	nonpeak weekday; weekends; midday with restrictions	
Toronto Transit (metro/LRT)	No	Veh. op. discretion	nonpeak weekday; weekends	
Montreal (rapid transit)	No	4 (last car)	weekday evenings; weekends	
MBTA (Red, Blue, Orange lines) Boston	Yes-$5	2/train (last car)	nonpeak weekday; weekends; some reverse commute	
COMMUTER RAIL				
Metro-North, NYC-CT	Yes-$5	4 (north cars)	nonpeak weekday; weekends	
MBTA, Boston	Yes-$5	6/train max.	nonpeak weekday; some reverse commute; weekends	

LIRR, New York	*Yes-$5*	4/train (end cars)	nonpeak weekday; weekends; some summer restrictions	
Caltrans, CA			Starting up program	
SEPTA, permits (6/91-Philadelphia 296 permits 7/92)	Yes-$5	2/train	nonpeak weekday; weekends	167 12/91); (1/92-
MARC, Baltimore, MD			Program under development	
NJ Transit, Atlantic since 1990 City line	Yes	Conductor Discretion		220

TABLE 7: North America Bike-on-Rail Programs *(Continued on next page)*

Rail System	Permit	Max. Number of Bikes/Train	Time Restrictions	Riders/Permits
LIGHT RAIL (LRT) SYSTEMS				
San Diego Trolley, CA	Yes-$3	2/car	nonpeak weekday; weekends; some Saturday restrictions	
TRI-MET, Portland, OR	Yes-$5		nonpeak weekday; weekends	
RT, Sacramento	Yes-$5	2/car	nonpeak weekday; weekends	1,439 permits issued
SCRTD, Blue Line, L.A.	Yes-$6	2/car	nonpeak weekday; weekends	400+ permits issued in Ist full year
Santa Clara County, San Jose	No	4/car (pk hr 2/car)	bikes permitted at all times; 2 bikes/vehicle in rush hours; 4 bikes/vehicle in nonrush times	

- At least five U.S. commuter railroads allow bikes-on-rail, including: the Long Island Railroad (LIRR) (since 1983), Metro-North Commuter Railroad between New York and its Connecticut suburbs (since 1984), MBTA in Boston (since 1987), Caltrain and the Southeast Pennsylvania Transportation Authority (SEPTA, since 1991). SEPTA's bike-on-rail program followed a yearlong lobbying effort by the Bicycle Coalition of the Delaware Valley. With SEPTA's new program, the country's three largest commuter systems (LIRR, MetroNorth and SEPTA) now all provide bike-on-rail service. While Caltrain currently only permits folding bikes in a carrying case, changes are in progress. A new operator will have taken over July 1, 1992, and a limited number of bicycles are now permitted on certain runs. In Maryland, meetings are currently taking place between local bicycle activists and the Mass Transit Administration to develop a bike-on-rail program for the MARC commuter rail services in Maryland.

- At least 12 U.S. heavy rail and light rail transit systems have bike-on-rail programs that generally operate only in the off-peak period. When the Washington Metropolitan Area Transit Authority (WMATA) began a bike-on-rail demonstration program in 198 1, following 5 years of steady and patient lobbying by local bicycle activists, *Washingtonian Magazine* awarded the program its "Best Idea of 1981." To date, 4,700 permits have been issued by WMATA.

New light rail systems that have opened in some U.S. cities in recent years are integrating bicycles with their systems, providing bicycle parking at stations, and permitting bikes-on-rail. These include LRT systems in Santa Clara County, San Diego, Portland, Sacramento and Los Angeles. In mid-1992, Portland, Oregon, initiated a more comprehensive bike-on-transit program, including bikes on the LRT, regional buses and increased bicycle parking facilities at stations.

Permits. Most U.S. transit authorities with bike-on-rail service require a cyclist to obtain a valid permit. Costs for the permit generally range from $3-5 and are valid for varying lengths of time: some systems, especially those with newer programs require annual permit renewal while on other systems, permits may be valid from 3-5 years and on some, for an unlimited period. While the permit process provides a means of assessing use of the system and ensures that bicyclists are familiar with the program rules and regulations, permits severely constrain demand, generally excluding tourists and potential occasional users. A few simple billboards or signs in transit vehicles and near stations, as found in Europe, would provide an alternative means of communicating rules of operation.

It is notable that not a single European bike-on-rail program requires a permit for the carriage of bicycles. A large number of rail systems across Europe allow bicycles on trains. Some offer this service for free, while others charge a fare supplement for the bicycle. Eliminating permits allows them to attract a larger pool of users, generate added revenues, and avoid the often considerable costs associated with permit administration. Santa Clara County Transit, in California, is the first U.S. transit agency to take a more European attitude towards the bicycle, allowing them on board without a permit at no extra charge.

Time Restrictions. The U.S. bike-on-rail services are almost all restricted to times outside the weekday peak hours. The exceptions are BART in San Francisco and the MBTA commuter rail system in Boston, MA, which allow bicycles to be carried during peak hours in the "reverse commute' direction only. Restrictions on most systems prohibit bicycles on rail weekdays before 9:00 a.m. or 9:30 a.m. in the morning (some allow bikes before 6:00 a.m.) and from 3:00 p.m. or 3:30-6:30 p.m. Weekend policies vary, with some systems having no restrictions and some blocking out certain hours when there is substantial shopping, work or recreational travel. Several European bike-on-rail systems, including Oslo and Amsterdam, have no time restrictions on the time when bicycles can be brought on board. Without any restrictions, cyclists, using their own common sense, tend to naturally avoid bringing bicycles into rail cars during crowded rush hours. Santa Clara County Transit again leads the United States in adopting the most European attitude towards bike-on-rail, allowing two bicycles per car in peak hours, and four per car in nonpeak hours.

Rail Car Design Constraints. Restrictions on the number of bikes permitted on each rail transit system vary: some systems permit two bicycles/car and others allow bicycles only on the last car of the train with a maximum of four bicycles/train. In Santa Clara County, the bike-on-rail program is so popular that the number of bikes far exceeds the limit. Passengers are expressing concerns about access problems caused by bicycle overcrowding and efforts are under way to try to resolve this.

Rail transit system restrictions on the number of bicycles permitted are based in part on rail car designs in this country, in which bicycle accommodation has not been a consideration. On the MARTA system in Atlanta, and on other systems, cyclists hold their bikes in a fold-up seat area near the backdoor of the rail car.

In California, design of the new "California Car," mandated and funded by Proposition 116, requires accommodation of a reasonable number of bicycles carried on board by passengers for both intercity and commuter application. The California Car is a bi-level car that superficially resembles Amtrak's Superliner, but with significant design differences including bicycle storage on the lower level of the car. The new rail car, which will be used on State -sponsored Amtrak and local commuter rail services, is a promising new development in the United States. Its specifications could be adapted by other rail agencies to enhance bicycle-rail linkage.

Bike-on-Bus Programs In U.S. Cities

At least 18 American transit systems have instituted bike-on-bus services, many in the past 4 years. Bike-on-bus programs are functionally similar to bike-on-rail programs but often operate in much lower density corridors than rail transport. By expanding a bus line's access and egress service area, bike-on-bus programs can attract many passengers who would not otherwise be able to use transit for their trip, particularly to reach suburban destinations where transit coverage is often sparse.

There are three means of accommodating bicycles on buses--rear-mounted racks, front- mounted racks, and allowing bikes inside the bus. Rear-mounted racks were the earliest type of racks used by U.S. bus transit systems. While these continue to be used by a number of transit systems, preferences appear to have shifted towards front-mounted racks. At least three transit systems now use rear-mounted racks-San Diego Transit, Humboldt Transit Authority in northern California, and Santa Cruz Transit District. Two agencies that previously used rear-mounted racks-North County Transit in northern San Diego County and Windham Regional Transit in Willimantic, CT----have changed their policies; the former to front-mounted racks and the latter to a policy that permits bikes inside the buses.

Development of Bike-on-Bus Service. The impetus for the first bike-on-bus services, started in the 1970s in cities such as San Francisco, San Diego and Seattle, was the lack of bicycle access to many major highway bridges. In the early 1970s, bicycle activists in the San Francisco Bay area pressed local transportation officials for bicycle shuttle services across the Oakland Bay Bridge which was closed to cyclists. AC Transit, a local bus agency, removed half of the seats from a bus to make room for up to 24 cyclists and their bicycles, initiating the "Pedal Hoppers", which offered limited weekend services across the bridge.

California cyclists pressed ahead and won the attention of the State Legislature which in 1974 required Caltrans to develop solutions to the problems of bicycle and pedestrian access to State-owned toll bridges. Shuttle van services using bicycle trailers were introduced by Caltrans at several locations, including the Oakland Bay Bridge and the San Diego-Cordonado Bay Bridge. Although these services were popular and well used, the costs were considered excessive.

Seeking a cheaper way to provide bicycle access across the Coronado Bay Bridge, Caltrans provided a demonstration grant to San Diego Transit to replace the bike shuttle with a bike-on-bus service starting July 1, 1976. Rear-mounted bike racks were put on three buses that operated on Route 9 over the Coronado Bridge. In 1977, service was expanded to other routes serving the beach communities and two major universities. The service began with a 10 cent fee that was later eliminated due to the continual maintenance problems associated with the coin mechanisms. Today, 50 buses operating on 3 routes are equipped to carry racks. There are 16 racks in daily service with 3 spares available. The racks cost $1,250 each and the mounting brackets, which are manufactured in-house, run $150/bus. New buses are specified to have the brackets included. Table 8 shows the growth in level of use in this system, which by FY87 had reached over 9,000 bike-on-bus riders a year.

Table 8: San Diego Transit: Average Daily Bike Rack Use FY 85-87

	Weekday Use			Saturday Use		
Route	**FY85**	**FY86**	**FY87**	**FY85**	**FY86**	**FY 87**
9	**2**	**5**	**4**	**0**	**0**	**5**
41	**5**	**8**	**12.4**	**5**	**0**	**4**
80	**15**	**11**	**11.2**	**6**	**5**	**8.5**
Total	**22**	**24**	**28**	**11**	**5**	**17.5**

In Seattle, limited access highway bridges across Lake Washington posed major barriers to cyclists. Local bicycle activists pressured the city's transit agency and in 1978, Seattle Metro installed rear-mounted bicycle racks onto their buses that cross the lake. A year later, front -mounted racks were substituted because of unconfirmed reports that children were hitching rides on the rear racks.

The transit system in Santa Cruz, CA carries 400 bicycles a month on average. In mid1992, they recently received a $45,000 grant from California's Proposition 116 and Clean Air Transportation Improvement funds to redesign their bicycle racks and build new ones. Santa Cruz has had a few liability claims annually, involving minor damage to bicycles.

Some transit systems, such as AC Transit in Oakland and SCRTD buses in Los Angeles, have reported low usage of the bike racks. Implementation of bike-on-bus service in Humboldt County, CA was troubled first by prolonged implementation and then by rack functioning problems that raised liability insurance concerns. Humboldt's experience provides a perspective on the unexpected difficulties encountered by rural transit authority, which despite its difficulties, modified and continued its bike-on-bus program (see box).

Most U.S. bike-on-bus services do not require a permit, in contrast to most U.S. bike-onrail services. While most U.S. transit systems accommodate bikes only on designated routes, a few cities----such as Phoenix, AZ, Aspen, CO, and Sacramento, CA-have no route restrictions and have opened their entire system to carrying bicycles.

The City of Phoenix began a 6-month bike-on-bus demonstration program from MarchAugust 1991 to assess potential use of the service. Bicycle racks were mounted on the front of buses operating on 3 routes, selected based on criteria developed in coordination with the bicycle community. Two-thirds of the $15,000 program cost came from a grant by the Arizona Department of Environmental Quality. During the demonstration program, 5,500 bicycle trips were taken and ridership steadily increased. At the end of the first month, 153 riders had used the service. By the end of the third month (May), this jumped to 1,109 riders per month and by the end of the 6 months there were 1,404 riders per month. Phoenix Transit reported no safety problems associated with the new service. The service not only attracted increasing numbers of bicyclists, but attracted to transit people who did not previously use the buses. A Bike Rider Survey found that the vast majority (90%) of the bus riders used the bike racks for commuting. An evaluation of the demonstration concluded:

> *"From the response received, it would not be a stretch to say that the program was overwhelmingly popular among transit riders and hailed as an excellent idea by bike riders. For bus patrons it is an added option, for bike riders it is an opportunity and for public transit it is another step toward reducing the number of vehicles travelling on the road.*

As a result of the successful demonstration, the Phoenix Transit bike-on-bus program will be expanding system-wide in July 1992.

Although most transit agencies offering bike-on-bus services have relied on various devices outside the bus, a few agencies have decided that added hardware is unnecessary and allowed bicycles inside their buses. Westchester County Department of Transportation (WCDOT), located near New York City, simply adopted a permissive "welcome aboard" policy towards bicyclists and other potential users beginning in the late 1970s. The space provided for wheelchair-bound passengers can be used by those traveling with baby carriages, shopping carts, bulky packages, or bicycles. This policy applies only to handicapped-accessible Advanced Design Buses, and only in nonpeak periods. Wheelchair users are given priority over bicycles at all times. No problems have been reported with the service.

Table 9. Bike-on-Bus Services in the United States

Transit Agency	Year Started	Permit?	Route/Time Retrictions	Use
REAR-MOUNTED RACKS				
San Diego, CA	1976	No	3 routes; designated stops ony	8 bikes/ day
Humboldt Transit, CA	1984	Yes	designated stops only	898/month in 85; 264 permits in 87
Santa Cruz, CA	1980	No	3 routes; spec. load/unload stops	400 bikes/mo
FRONT-MOUNTED RACKS				
Seattle	1978	No	45 racks on 12 routes	no survey
SCRTD, Los Angeles, CA	July 1991	Yes-$6	1 route only; 6 buses/day	1 bike/day
Phoenix, AZ	March 1991	No	3 routes; going system-wide 7/92	Heavy
Roaring Fork Transit, Aspen, CO	1980	No	System-wide; no restrictions	High use
Tri-Met, Portland, OR	July 1992	Yes-$5	Weekdays: 4 routes; Weekends: 5-6	
North Cty Transit, San Diego	1980 (began with rear racks; 1989 switched to front)	No	75% of routes equipped; load/unload at designated stops	Week in Aug 91: 292 users

TABLE 9: Bike-on-Bus Services in the United States. **(Continued on next page)**

Table 9 (cont'd)

BIKES IN BUS				
Santa Clara Cty, CA	July 1988: front-rack demo route; 1990: demo inside bus on 7 routes; 1991, system-wide	No	Weekday: 2 routes; Weekends: 7 routes	
DART, Dallas, TX		No	All routes; nonpeak hour weekday; weekends all day	
Toronto Transit, Canada		No	All buses; nonpeak hour on weekdays	
RTA, Sacramento,CA	1990	Yes-$5	All buses; nonpeak on weekdays	
Windham Reg. Transit, CT	1980: demo rear racks; discontinued. in 1984; switch to inside bus	No	1 route (only route in system); load at designated stops	Popular in community
Sonoma Transit, CA	April 1991 (use disabled tie-down space)	No	3 routes to University; no stop restrictions	10-15 bike trips/day
Metro-Dade, Miami, FL	FY 1993 Capital Project		Estimated cost: $2,000/bus	
BUS AND TRAILER				
SF Bay Area (Caltrans Bridge shuttles)	1991: Benicia-Martinez Bridge (14 bikes); 1977: Oakland Bay Bridge (14 bikes)	No		6-8/day on Benicia Bridge but high on Oakland Bridge (13,154 in 1991)
Santa Barbara Transit, CA	1979-83: demo; discontinued due to budget cuts		Equipment wore out; too costly to repair and maintain; no bike/bus service now	

HUMBOLDT COUNTY, CALIFORNIA:

OVERCOMING THE BUMPS TO KEEP BIKE-ON-BUS SERVICE ROLLING

Bike-on-bus service for Humboldt County, CA was first conceived in July 1982 by the Humboldt Bay Bicycle Commuters Association (HBBCA), which wanted to use funds provided by California's Bicycle Lane Account to benefit college students and other residents of this northern rural region of the state. The letter writing and newspaper campaign launched by HBBCA and the leadership of some of group members were instrumental in getting HTA to adopt the bike-on-bus program. From the start, there were problems: delays in obtaining the Sunshine U-Lock rear-mount racks and discovery that the new Gillig Phantom coaches just ordered by the transit agency did not easily accommodate the rear-mount racks. This required fabrication of special mounts by a local manufacturer. The program was finally started in July, 1984, and ridership in the first complete year of use --1985-averaged 898 bike users per month.

Problems related to the racks and to users began to trouble the program. The racks suffered from the effects of weather, diesel exhaust, vibration and wear and tear. The spring -loaded "ball detent" pins which secure bicycles at the down tube were prone to gumming up. The original design assumed use of a lock by riders and a hasp was provided for this purpose. However, many riders ignored the feature and would make the ball detent the only means of securing their bicycles. The bike-and-ride brochure distributed to bike users failed to mention that the hasp had to be aligned with its corresponding hole in the mounting clamp or else the ball detent would not engage, allowing the pin to vibrate out and release the bike from the rack. The location of the racks in the back of the bus was also a problem as it prevented the bus driver from watching the loading/unloading process or from watching for potential bicycle theft at bus stops.

By June 1986, six bicycles had officially disappeared from the HTA bike racks----one was found beneath a car following the bus that had carried it. Fears of liability caused some rethinking of the service. Rather than abandon the service, HTA required bike users to sign a liability waiver and to pass a test at the transit agency offices to demonstrate their knowledge of correct use of the racks. A $3 permit was required. After the new permit system went into effect in mid-September 1986, bike/bus ridership dropped 40 percent and in November, another 28%. A fare increase in the winter of 1987 caused a further decline. The bike-on-bus service continued, albeit at a much reduced level of use compared to 1985.

The accommodation of bicycles on public transportation vehicles appears likely to grow in the 1990s as efforts are made to expand transit markets in maturing automobile-oriented areas in response to air quality and other concerns. New rail car designs, improved bus bicycle racks, and GIS-based transit access planning and analysis will likely aid this growth.

IV. Transit Access in Europe

Introduction

Bicycles and walking typically account for one-fourth to one-half of all person trips in European cities, as well as for the vast majority of all public transportation access trips, even in lower density suburban areas. This stands in sharp contrast to the United States, where the share of person trips made by nonmotorized means fell in recent decades to less than 10 percent, and where automobile park-and-ride accounts for a major share of suburban transit access. There are many reasons for these differences, including infrastructure investment and transport policies, urban design and land use patterns, and commuter subsidies.

Compared to the land use patterns found in America, land development throughout most of Europe is more clustered around public transportation nodes and offers greater diversity of land uses within small neighborhoods. A larger share of jobs and housing are located within walking distance of higher quality public transportation in Europe. One can also find within these clusters of compact development the small-scale retail services residents and workers need to meet most of their daily needs. An extensive railway network links most major centers of development to each other with frequent and rapid services. In larger centers, automobile parking supply is frequently both limited and costly to users, particularly for long-term parking. Free workplace parking, which is the norm in America, is far less commonplace in Europe.

Many European communities encourage walking and cycling through extensive use of traffic calming to improve safety and comfort, complemented by a comprehensive network of bicycle paths and lanes, secure bicycle parking at major activity centers and transit stations, and extensive automobile restricted areas in town and city centers.

Together, these factors of land use, urban design, infrastructure, and pricing have been used by European public policy makers as powerful instruments for shaping traveler mode choice. Despite high levels of automobile ownership, walking and cycling remain the dominant mode for short trips, which themselves make up a somewhat larger share of daily trip-making in European cities, compared to American communities. For longer trips, both within and between metropolitan areas, railways retain a significant share of the travel market in Europe, in sharp contrast to the United States, where the automobile has become the predominant mode of travel for both short and long trips.

Europe's relatively well-developed bicycle and pedestrian transit access systems are a crucial part of the overall mobility system, enabling many mom people to choose public transportation over the automobile to meet their daily travel needs, particularly for longer trips in metropolitan areas. This situation is one of the major reasons why, on average, residents of European cities use 4.5 times less gasoline than residents of U.S. cities.[10]

This report focuses particularly on the nonmotorized public transit access systems of the Netherlands, Denmark, and some communities in Germany, which provide prime examples of how best to integrate bicycles and public transportation for mutual advantage. Many strategies used in these countries to enhance nonmotorized transit access have not yet been applied in America and should be seriously considered for pilot testing and evaluation.

Although it is beyond the scope of this report to provide greater detail and analysis of the full international experience in integrating cycling with public transportation, those interested in learning more from the experience of others may find other examples worth emulation.[11] Switzerland offers some of the best conditions for carrying bicycles on transit vehicles. The Swiss railways (SBB) have included bicycles in their marketing policy as the initial and final mode of transport, with a rail journey in between. Bicycle parking facilities and bicycle rental services at rail stations are becoming more widespread. At most stations, a variety of vehicle types can be rented, including mountain bikes, racing bikes, and children's bikes. Bike-on transit programs for regional trains are free of charge on weekends. On congested inter-city trains, SBB requires that bicycles travel as checked baggage."

Other forms of inter-modal transportation should not be overlooked either. A new type of "park-and-ride" system was recently introduced in Parma, Italy. Eleven "park-and-ride" lots along the Parma ring road have been constructed, where motorists can park their cars and continue their journey into the town center on a bicycle provided by the local authorities. Extensive bicycle lanes and parking in the city have been provided, and all main roads inside the. city, including one-way streets, are accessible to cyclists in both directions. As a result of these measures, Parma has achieved a high level of bicycle use, accounting for 27 percent of all commuter trips."

Integration of Bicycles with Public Transport In the Netherlands

Transportation planners, engineers, and policy makers interested in promoting alternatives to the automobile can learn mom from the experience of the Netherlands than nearly any other country in the world. This is particularly true in the area of integrating bicycle and pedestrian

modes with public transportation. As an April 1992 report of the Netherlands Railways on its policy toward the bicycle notes, nationwide,

> *the bicycle is used as transport to the station for almost half of all train journeys. On average, the bicycle is regarded as by far the most important means of transport to the station."*

Mode of Access to Rail Stations. Changes in transit access in the Netherlands in recent decades are indicative of general trends in much of Northwestern Europe. In 1960, four out of 10 railway passengers in the Netherlands used buses or trams (LRT) to get to their originating station, and these together constituted the predominant means of access to railways. Walking accounted for about 36 percent of access to railway stations, bicycles for 21 percent, and the automobile for about 7 percent. By 1978, the share of access trips to rail stations in the Netherlands made by buses, trams, and metro had been reduced by nearly one-half and the bicycle had become the most important access mode to rail stations, accounting for 39 percent of all access trips. Pedestrian access to rail stations showed a steady decline to about 24 percent[15]. Since 1978, bicycles have continued to increase in importance as an access mode, gaining several more points of market share, mostly at the expense of walking and bus/tram/metro access, as growth has continued to shift a larger share of population and employment to smaller cities and suburban centers, with some decrease in overall housing and employment densities.

Although bicycle use in the Netherlands fell dramatically between 1950 and the mid 1970s, bicycle and moped use for rail station access increased.* Many short trips formerly made by bicycle were replaced by longer distance automobile or bike-and-ride transit trips as people and jobs moved from cities to suburbs.

As Figure 12 shows, the prime distances from the station where bicycles are used for access and egress are 2 to 4 km (1.25 to 2.5 miles). However, the average distance traveled leaving destination stations by bicycle at the work or school end of train trips is longer than the average distance traveled from home to the station.

The modal composition of station access trips has not changed uniformly. Rather, walking continues to predominate in dense central areas, while the bicycle predominates in moderate and lower density suburban communities. The proportion of rail journeys originating in more recently developed moderate and lower density areas has increased with suburbanization.

* Most data from the Netherlands combine bicycles and mopeds. Although mopeds were a significant share of this combined total in 1960 (accounting for one-fourth to one-sixth of the combined bike-moped total for station access trips), by 1978 mopeds accounted for only 3.4 percent (out of 39 percent of access trips made by bike or moped) of station access journeys, according to Dutch transportation officials. New mandatory helmet laws for moped riders and safety concerns

were the primary reasons for the shift from mopeds to nonmotorized bicycles. For the purposes of ease of discussion in this report, this small share of moped trips mixed with bicycle trips is otherwise neglected.

Buses have retained a substantial access trip mode shares in the urban centers, but these centers now account for a somewhat smaller share of population, employment, and transit trips. According to oficials of the Dutch National Railways (NS), growth in passenger traffic on trains nationwide has risen by 8 to 10 percent since the mid-1980s, while bike-and-ride travel has grown by some 15 percent in the same period.

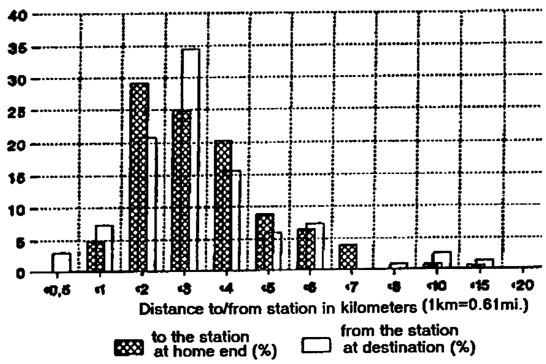

Figure 12. Distribution of Bicycle Access Trips to/from Dutch Rail Stations by Access/Egress Trip Length (Source: *Beleidsplan FIETS MrAR*, Dutch National Railway, Utrecht, April 1992)

Table 10 shows the relative use of different access modes to Dutch railway stations in 1987, including other public transport modes, which are themselves usually accessed by walking or cycling. Bicycle access to railways typically accounts for roughly three times as large a number of access trips as automobile driver and automobile passenger access combined.

Bicycles are most important for shorter distance trips on the railways, which typically originate at local stations, where 44 percent of access is by bicycle. At such stations, average population and employment densities are lower, as is the corresponding level of public transportation services. Such local stations are also the places where there is the greatest use of automobile park-and-ride for station access, although such trips account for only 13 percent of

Table 10. Mode of Access to Dutch Railway Stations at Home End, 1987[16]

Access Mode to Rail Stations	Stations In 4 Large Cities	Other Inter-City Stations	Inter-Regional Stations	Local Stations
Walk	21	32	30	25
Bike/Moped	23	34	42	44
Bus/Tram/Metro	48	24	12	10
Auto Park & Ride	3	*5*	11	13
Auto Kiss & Ride	4	4	4	*5*
Taxi	1	1	1	nil

Note: In this and other associated tables, the Dutch term "Agglo-regio stations" has been translated as "Local Stations." These are stations serving principally short distance travel within metropolitan areas. Inter-City stations serve **a** longer distance trip market at higher speeds than Inter-Regional stations. Minor adjustments made to data from Dutch language report to ensure shares add to 100 percent.

access. Trips originating at the largest city stations rely more on public transport and walking for access, since these are located in high density centers with very high levels of bus, tram, or metro public transport services.

Mode of Egress from Stations. Walking is naturally the predominant mode used to get from rail stations to destinations at the non home end of trips in the Netherlands and elsewhere. However, the provision of a high-quality bicycle access system and secure bicycle parking at stations has led roughly one out of 10 Dutch rail passengers to use a bicycle to get from the station to workplaces or schools that are beyond easy walking distance of the station, as table 11 shows. Usually, such passengers park a second bicycle overnight at the rail station for such purposes. This is of greater importance in lower density suburban areas where bus, tram, and metro services are less frequently available to serve destinations beyond walking distance of the railway station. Park-and-ride, naturally, is completely unsuited to serve as an egress mode, as it would require the considerable expense of parking a second car near the station.

Parking at Rail Stations. Every Dutch railway station has a place to park bicycles. In one out of 10 urban-regional and around three quarters of all Intercity rail stations, supervised bicycle parking garages are in operation, with a total of almost 100,000 places. Where there are not guarded garages for bicycles, especially at urban-regional stations, there are bicycle lockers, numbering some 10,000, which can be rented by the month or year. At virtually all stations where there is no supervised parking for bicycles, covered racks are available, numbering 59,000 places on urban-regional stations and 6,000 on Intercity stations. Finally, on urban-regional

Table 11. Mode of Egress from Dutch Rail Stations at Destination End, 1987

Egress Mode at Destination Station	Stations In 4 Large Cities	Other Inter-City Stations	Inter-Regional Stations	Local Stations
Walk	39	41	43	38
Div	5	8	9	12
Bus/tram/Metro	38	36	35	26
Auto Park & Ride	0	0	0	0
Auto Kiss & Ride	8	8	6	11
Taxi	1	1	1	1

Note: In this and other associated tables, the Dutch term "Agglo-regio stations' has been translated as "Local Stations." These are stations serving principally short distance travel within metropolitan areas. Inter-City stations serve a longer distance trip market at higher speeds than Inter-Regional stations.

stations, there are a further I 1,000 bicycle racks and on Intercity stations 14,000. In total, therefore, the NS provides almost 200,000 bicycle parking places. This does not count private bicycle parking garage capacity or the thousands of additional bicycles parked informally near stations. For example, according to NS officials, there are some 15,000 bicycles parked at the main mail station in Utrecht, at four different guarded locations.

Figure 13 shows the distribution of parking spaces at Dutch rail stations by the volume of station boardings. Stations with over 5,000 boardings per day have an average of 2,000 guarded bicycle parking spaces, while stations with 2 to 5 thousand boardings a day offer on average nearly 800 guarded bicycle spaces. The mean and median capacity of guarded bicycle parking garages at Dutch rail stations is about 1,000 bicycles. Fourteen stations can accommodate over 2,000 bicycles in guarded spaces, 21 stations accommodate between 1,000 and 2,000 bicycles in their guarded bicycle garages, 29 stations accommodate 500 to 1,000 bicycles in their garages, and only seven guarded bicycle parking garages are smaller than 500 spaces, including two that have a capacity of only 60 bicycles each.

Guarded bicycle parking spaces are relatively uncommon at stations with fewer than 1,500 boardings per day. At such stations, roofed bicycle parking is the most common form provided, usually accommodating 300 to 800 bicycles, except for stations with fewer than 500 daily boardings, where roofed bicycle parking capacities of 70 to 300 are typical, and usually complemented with 10 to 50 bicycle lockers. Six stations offer more than 100 bicycle lockers and no stations offer more than 190 lockers.

Guarded bicycle parking garages work with check tags, so that users can be assured that someone else will not ride off on their bicycle. Repair services are available at every guarded

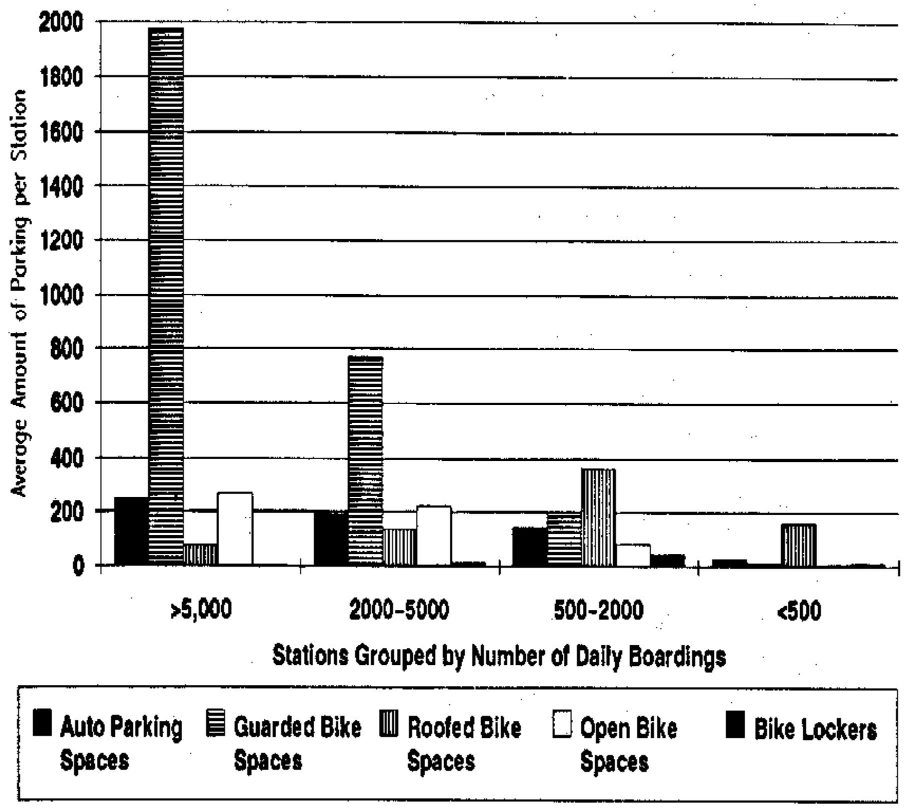

Figure 13. Average Number of Parking Spaces by Type at Rail Stations in the Netherlands.

bicycle parking garage, offering users the opportunity to have their bicycle kept well maintained with a minimum of lost time. There are a number of private guarded bicycle parking facilities near rail stations, although their number is decreasing, due to the significant Government subsidies offered to public bicycle parking garages. Figures 2 and 3 illustrate typical Dutch bicycle parking facilities at rail stations.

Increasingly, new guarded bicycle parking garages at Dutch rail stations are being located under the stations to maintain close proximity to station entrances while reducing consumption of valuable land near stations. NS has found that even expensive underground bicycle parking is more than 10 times cheaper per space than automobile park-and-ride construction.

Bicycle rentals are also available at every bicycle parking garage, at a cost to users of several dollars a day, providing out-of-town visitors an inexpensive and comfortable way to access most destinations and supporting extensive recreation and tourism. Commuters holding a monthly rail pass can also purchase a monthly bicycle rental ticket offering a deep discount.

Because automobile park-and-ride systems are the most expensive way to attract transit ridership, NS has provided less than 25,000 automobile parking spaces across the Netherlands, a figure barely one-fourth the number of guarded bicycle parking spaces. Since 1977, special park-and-ride lots have been constructed at 42 stations across the Netherlands, providing about I 1,000 new automobile parking places. About three-fourths of these spaces are used on the average workday. The median number of park-and-ride spaces at Dutch rail stations is 48 automobile parking spaces, while the average is 102 spaces per station. Only four stations have more than 500 automobile parking spaces, while 17 stations offer 300 to 500 spaces, and 55 stations offer 100 to 300 spaces. At 91 other stations, motorists are offered between 25 and 100 parking spaces; 42 stations offer II to 25 spaces; the remaining 55 stations have 10 or fewer automobile parking spaces. This reflects the official priority in station access modes adopted more than a decade ago by Dutch authorities: pedestrians first, as they have the lowest access system cost; bicycles next, with parking located as close to station platforms as possible, as they are a highly cost-effective and environmentally sound means of access; and lowest priority to automobiles, as they require the greatest capital investment, operating costs, and land area, while causing the greatest damage to the environment.

Despite the extensive available bicycle parking, the growing use of both railways and bicycles makes the parking supply inadequate, forcing many people to leave their bicycle locked to fences and poles near stations. Bicycle theft, particularly from unguarded spaces, remains a major problem, leading to growing use of high-strength bicycle locks by Dutch cyclists. Vandalism is less of a problem than in many communities in the United States.

Government Support for Bicycle-Transit Integration. Dutch transport policy towards the bicycle has undergone significant policy swings over the past several decades. Bicycle use declined sharply in the 1950s and 1960s, thanks in part to the gradual displacement of bicycle traffic by automobiles as a part of a pro-highway transport policy. However, after 1973, the national and local Governments began to provide strong support for bicycle infrastructure, including bicycle parking at railways and paths to the stations. Federal spending for construction of bicycle facilities increased by a factor of more than 16 times between 1975 and 1982, while funding for highway development fell. Federal assistance for bicycle transportation in 1982 was equal to more than 10 percent of the capital outlay for roadways. These expenditures, combined with strong support for public transportation, mild restrictions on automobile use in central city areas, and a culture supportive of cycling reversed the decline of bicycling in the late 1970s and 1980s, despite growing automobile ownership and use. [17]

Although local support for bicycle transportation has remained strong in many communities, in the last half of the 1980s, the national Government shifted to a passive policy towards the bicycle, with the absence of both new policy initiatives and significant funding. However, rising concerns over global warming, traffic congestion, and the environment, combined with growing public appeals to restrain car traffic in towns have begun to move national policies again towards favoring bicycles. In 1990, the Dutch Ministry of Transport initiated a Dutch National Master Plan for the Bicycle, which was adopted by the Parliament in June 1991. As part of this, spending for bicycle transportation is being increased significantly at the national level, to over US $30 million per year for bicycle infrastructure subsidies plus another US $6 million per year for bicycle-related research, demonstration projects, and non-infrastructure activities. This is expected to leverage an additional US $165 million per year in spending for bicycle infrastructure by local and provincial authorities across the Netherlands.

Spending by the Dutch National Railways (NS) on bicycle parking at rail stations amounted to US $1.8 million in 1988 and 1989, but fell to US $1.1 million in 1990. Spending in 1991-92, however, has grown six-fold to US $7.1 million a year. Between 1991 and 1995, NS expects to spend US $12.8 million expanding and upgrading guarded bicycle parking garages, and over US $11 million on bicycle lockers and other types of parking facilities. By 1996, this will result in an additional 13,500 covered bicycle racks and 5,000 lockers at stations to better meet demand.[18] NS also intends to test and evaluate both daily rental bicycle lockers and an automated bicycle parking system of a carousel design, holding 88 bicycles, as is used in Japan.

Cost of Bicycle Parking Facilities. According to the Dutch National Railways, the typical cost of providing a single guard for one of the Netherlands' 84 bicycle parking garages at a rail station is about US $36,000 per year, including overhead. Each major station typically requires three persons to staff it from 5:00 AM to 1:00 AM. Smaller stations are usually open from 6:00 a.m. to 9:00 p.m. and require only two staff persons per day. Parking attendants usually also rent, repair, service, and sell bicycles, providing a full-service center for bicycle transportation. User costs for parking at Dutch rail stations are about US $0.75 per day or US $75 per year, for either guarded parking or individual lockers. Revenues from parking are reported to cover roughly 40 percent of the operating costs, and are augmented by income to the franchise operator from bicycle repair and other services.[19] Current cost and revenue data are not readily available for this report, but in 1982, the cost of guarded bicycle parking garages in the Netherlands was about US $63 per bicycle parking space. [20] A relatively new and relatively small (320 spaces) guarded bicycle parking garage in Wunstorf, Germany, near Hannover, in

1991 had total operating costs of US $335 per space per year (see box). Table 12 gives a breakdown by cost category.

Table 12. Cost of Operating "Bicycle Station" Guarded Garage In Wunstorf, Germany

Cost Category	Annual cost US $	Government Share Monthly Cost Percent	Government Share Monthly Cost US$	Contractor Share Monthly Cost Percent	Contractor Share Monthly Cost US $
Personnel (82.7%)	**$ 88,615**				
Bike Mechanic	$ 18,000	0%	$ 0	100%	$1,500
2 Attendants	$ 67,500	100%	$ 5,625	0%	$ 0
Part-time Assistants	$ 1,882	100%	$ 157	0%	$ 0
Cleaning Staff	$ 1,233	100%	$ 116	0%	$ 0
Facilities (4.6%)	**$ 4,974**				
Electricity, water	$ 1,852	75%	$ 116	25%	$ 39
Telephone	$ 112	100%	$ 9	0%	$ 0
Maintenance	$ 2,057	100%	$ 171	0%	$ 0
Insurance	$ 953	68%	$ 54	32%	$ 25
Equipment (3.3%)	**$ 3,478**				
Fare instruments	$ 978	100%	$ 82	0%	$ 0
Office supplies	$ 250	100%	$ 21	0%	$ 0
Rental Bike maintenance	$ 2,250	0%	$ 0	100%	$ 188
Other Expenses (9.5%)	**$10,128**				
Advertising	$ 625	100%	$ 52	0%	$ 0
Administration	$ 5,753	100%	$ 480	0%	$ 0
Contingency	$ 3,750	75%	$ 234	25%	$ 78
Total	**$107,195**		**$ 7,100**		**$ 1,830**

Source: Heide Moeller and Thomas Dittert, *Fahrradstation Wunstorf. Zur Notwendigkeit Eines Neuen Betriebskonzeptes,* Zweckverbands Grossmum Hannover, July 1991, Hannover, Germany, p. 14.

Bicycle and Pedestrian Access Conditions. A key factor supporting the Netherland's high level of bicycle and pedestrian access to public transport, and high overall levels of use of public transport, bicycles, and walking, is the great attention that has been given by local governments to making streets pedestrian and bicycle friendly. Especially within the past 20 years, a major focus of local government traffic planners has been the introduction of more widespread traffic calming measures in both residential and commercial areas, where automobile traffic has been slowed down to give greater priority to pedestrians, bicycles, and traffic safety. In many places where it has not been possible to slow down car traffic, bicycles and pedestrians have been given their own separate right-of-way, with careful attention to the design of network intersections.

Many communities, following the excellent example of Delft, have developed well-integrated comprehensive bicycle networks, with exclusive regional bicycle roads or paths on a third- or half-mile grid within the denser urbanized area, and with a sub-regional and local grid of bicycle-friendly streets, paths, and lanes on even tighter grids of a fifth to a tenth of a mile. At the local grid level, this network is composed almost exclusively of *woonerf*-type streets, where cars are allowed, but only at a speed of 5 mph. In such streets, pedestrians, cyclists, cars, playing children, and chatting neighbors all share the same space, making a living street *(woonerf.* Combined with the provision of neighborhood-level retail services within walking distance, this street pattern has produced a very high level of walking and cycling for short trips of all kinds-shopping, access to public transportation, and daily recreation-while reducing automobile dependency.

Across the Netherlands, the ratio of exclusive bicycle path length to total road length is 1:8.6, reflecting the degree to which bicycle facilities have been developed into more comprehensive networks. [21] The network is of a far better quality in the western part of the Netherlands than in the eastern part. Similar data for sidewalks and pedestrian infrastructure are not readily available, but these are generally as good and extensive as anywhere else in the world.

Bicycle Transit Integration In ***Denmark***

About 25 to 30 percent of passengers arriving at commuter rail stations in Denmark at the home end use a bicycle to reach the station, as do about 2 to 5 percent of passengers departing stations at their workplace end. With substantial housing and employment clustered in satellite centers served by rail, a very large share of trip ends are within the 10-minute cycling distance of rail stations shown in Figure 14.

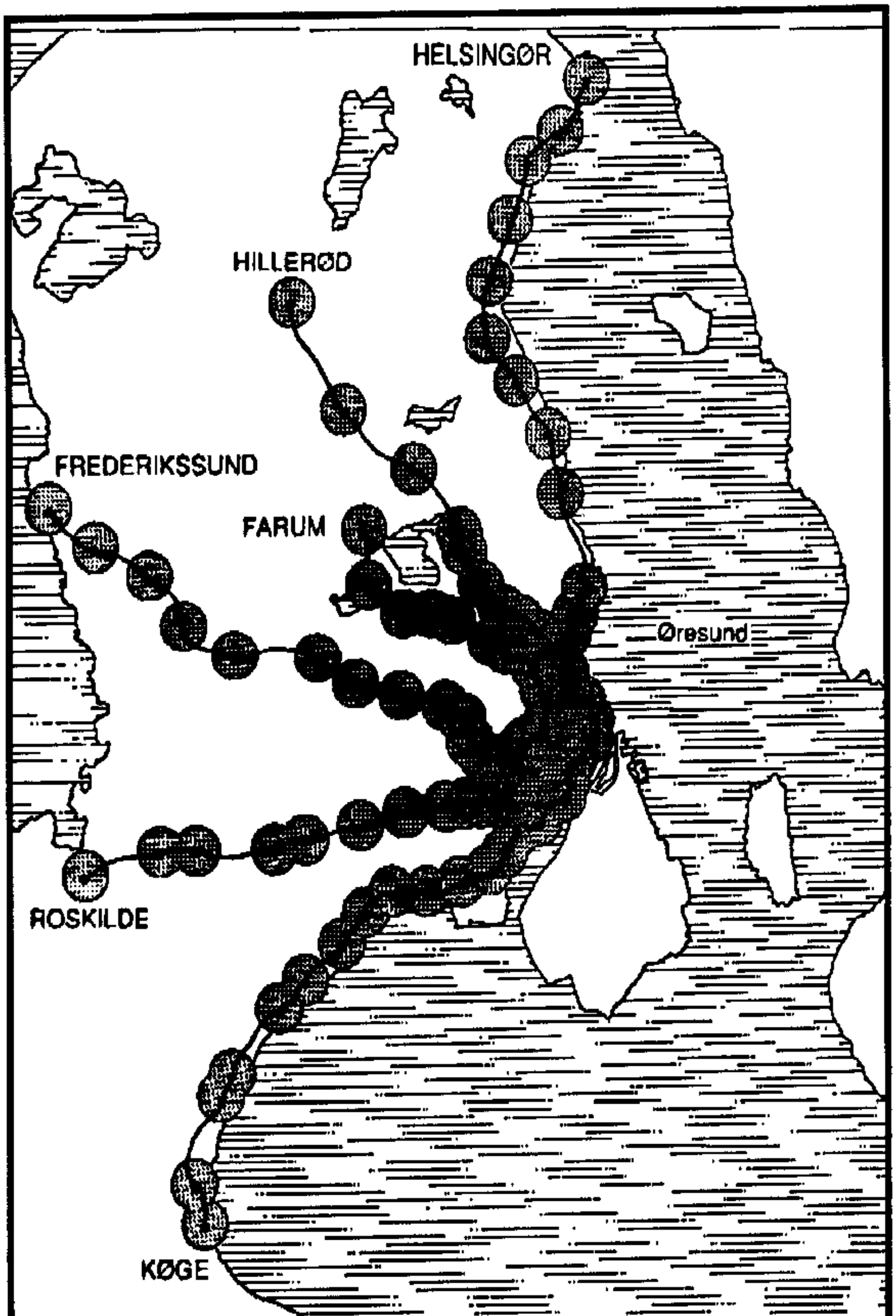

Figure 14. Areas within 10 minutes bicycling time from rail stations around Copenhagen, illustrates the marketing advantage of bike-and-ride for regional rail systems.

ECONOMICS OF A GUARDED BICYCLE PARKING GARAGE IN GERMANY

Since July 1989, in Wunstorf, Germany, near Hannover, local authorities, working with a private bicycle shop owner, have developed a "Bicycle Station," to provide 320 guarded bicycle parking spaces at the railway station, along with bicycle rental and repair services.In the first 22 months of operations, the number of bicycles parked at the rail station increased four fold to about 160 each day, with growth continuing at a rate of 20 to 30 percent a year. Since the second year of operation, some 60 to 90 bicycles were rented each month in the warmer months of the year, mostly on weekends.

The facility and rental bicycles are in public ownership but operations are handled under a private franchise contract. User fees for parking have been set at US $1.85 per week, $5.60 per month, or $56 per year for those with a weekly, monthly, or yearly railway pass; without a railway pass, parking fees are one-third higher. Single-use parking costs US $0.75 per day. The vast majority of users buy monthly parking cards to obtain the discount they offer.

Bicycle parking fees comprise two-thirds to three-fourths of the revenues in any given month, with bicycle repair work comprising most of the remainder, except in the warmer months, when bicycle rentals, mostly for recreational use, provide up to a fifth of revenues. The franchise operator is guaranteed minimum receipts by the local authorities of US $750 per month, but as of May 1991, monthly revenues from the operation were US $1,650 and continuing to increase at a steady pace, so this guarantee was not being exercised.

Total cost of the operation is about US $8,900 per month. The government provides a fixed subsidy of about US $7,100 per month (or about US $22 per bicycle parking space) and the franchise operator pays the remaining costs of about US $1,800. The franchise operator is responsible for the cost of providing a bicycle mechanic, insurance and maintenance of rental bicycles, and a portion of utilities and building insurance, while the government supports other costs as a means of encouraging the use of transit and bicycles. With a continuation of the fixed contract subsidy, the franchise operator was anticipated to achieve profitability in his activities at the "Bicycle Station" by the end of 1991. A breakdown of the costs of operation are shown in Table 12.

The "Bicycle Station" is open 108.5 hours per week and is staffed by three people over the course of a typical day. Labor costs comprise 83 percent of the costs of operations. A study which examined the possibility of semi-automating the bicycle parking garage using a system found in Japan and the Netherlands estimated that the full cost of conversion would be about US $121,000 to provide a 168-bicycle capacity system, or $720 per unit capacity.

A 1991 study by the Danish State Railways (DSB) of all of its stations found substantial opportunities for expanding the use of bicycles for station access. The study found that most of the problems at stations were connected with damaged bicycle racks, too few bicycle racks, a wish for covered racks and for lockable parking spaces.[22]

Guarded bicycle parking facilities have been constructed recently at a number of the larger stations, such as the Central Station and Osterport Station in Copenhagen, frequently holding more than 1,000 bicycles each.[23] These facilities are managed by private firms that operate the facilities under contract to the railway. As in other countries, these usually offer bicycle repair and rental services as well. At smaller stations, free covered or open air bicycle racks are found in great number, sometimes complemented with special lock-up areas with a special key arrangement for regular patrons, who can park their bicycles in a usually locked room which remains unguarded. The typical cost of establishing new covered and locked bicycle racks is on the order of US $300 to $500 per space.

According to DSB,

> ***the solution to the bicycle parking problem is not just to establish more bicycle racks but to establish more attractive bicycle parks where it is possible to place one's bicycle as close to the platforms as possible, locked and under cover .. In recent years people have tended to acquire bicycles that are so expensive and exclusive that they dare not park these bicycles at stations. S-stations have a reputation for being the place where one's bicycle is stolen. Some customers experience this several times a year. Therefore, quite a few cyclists choose to have an old bicycle at the station at one end of the journey and another category of otherwise dedicated cyclists choose not to use the bicycle at all as a daily means of transport. It is the latter group which is especially interesting as a customer group. In general an increase in the standard of bicycle parking facilities at stations will thus encourage people to use better bicycles which will result in a general improvement in the transport experience. This is true of both ends of the journey... Bicycle plus train means increased revenues and equals a better business foundation.***[24]

The Danish State Railways has adopted the following basic principles for making bicycle parking attractive:[25]

1. ***The bicycle must be parked as close to the platform as possible.***

2. ***It must be possible to place the bicycle in a locked area.***

3. ***The rack must be user-friendly and easily accessible.***

4. ***The bicycle must as far as possible be under cover from the weather.***

5. ***The bicycle parking must be safe and secure.***

SOLVING RAIL STATION BICYCLE PARKING PROBLEMS IN HUNDIGE, DENMARK

Nearly 900 bicycles a day are parked at the Danish State Railways station at Hundige, where nearly one out of five passengers bicycles to the station. The station has a large surrounding area with scattered houses at relatively low density and a well-developed system of bicycle paths crossing the railway on the same level as the platform entrances. While covered and uncovered racks provide 738 spaces, this is a fourth less than the number of bicycles parked daily in the station area. DSB plans a two-stage project to improve bicycle parking and has estimated the economics of this as follows:

Finances Stage 1	
1. Removal of half the present covered racks (240 spaces)	$ 3,200
2. Establish new covered and locked racks (480 spaces)	$230,000
Total investment stage I	$230,000
Investment per space	***$ 475***
Annual income from locked spaces assuming 100% use @ $4/month rental	$22,970
Income from 55 completely new customers attracted by improved parking	$26,315
Income from I 10 customers attracted from bus to bicycle for access	$21,050
Total Increase in annual income	$70,300
Return on investment in stage 1	***30%***
Finances Stage 2	
3. Removal of remaining covered racks	$3,200
4. Establishment of 240 new covered racks	$153,100
Total investment in stage 2	$156,300
Investment per space	***$320***
Income from 15 completely new customers	$7,175
Income from 25 passengers diverted from bus to bicycle access	$4,785
Total increase in annual income	$11,960
Return on investment in stage 2	***8%***

Source: Danish State Railways, *Action Plan to Improve Bicycle Parking at S-Train Stations,* August 1991, p. 10-11.

DSB considers the ideal distance of bicycle parking from station platforms to be within 30 meters (100 feet), and considers any parking which is more than 60 meters (200 feet) from the platform to be completely undesirable.

To develop more space-efficient and user-friendly bicycle parking systems, DSB has established a bicycle parking laboratory to test a number of different bicycle racks and systems. Two-tiered racks, as used in the Netherlands and Japan, are favored for areas where space is a problem or where it is desirable to compress more bicycle parking capacity into the area immediately close to the station platform. Such racks also generally ensure orderly parking.

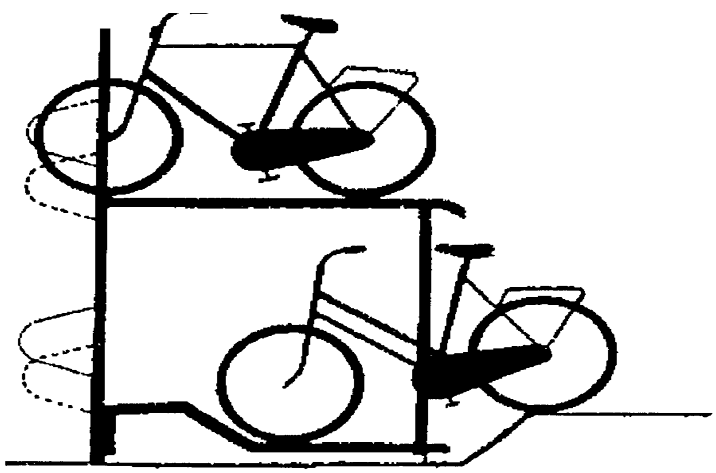

Figure 15. Bi-level bicycle storage racks are the predominant equipment type found in guarded bicycle parking garages in Europe and Japan. They offer high storage density, which reduces land costs for parking.

DSB's action plan for bicycle parking focuses on a number of measures to improve bicycle integration with the railways. These include-----

- improving access path conditions to the station for cyclists, including better lighting on access roads to stations and in the bicycle parking areas, and ensuring maintenance of vegetation in these areas,

- retrofitting bicycle wheel ramps along the edge of stairways to eliminate the need to carry the bicycle when climbing or descending,

- establishing bicycle repair shops at stations, along with coin-operated tire pumps,

- improving directional signs leading to stations to show the location of the bicycle parking facilities and nearest bicycle dealer/mechanic,

- preparing leaflets describing bicycle parking facilities at stations and their price, and

- promoting bike-on-train services by showing on the outside of rail cars which cars are set up to accommodate bicycles and ensuring that cyclists can secure their bicycles within rail cars, so the cyclist can leave their bicycle during their journey.

V. Bicycle-Transit Integration In Japan

Even though Japan is now approaching the U.S. ratio of private car ownership, which is the highest in the world, local governments have been successful in reducing motor traffic in the nation's major cities by more than 10 percent over the past 3 years. More and more people are now riding bicycles to suburban railway stations where they catch trains to their jobs in the city.. The new environmental nuisance now being complained about is the absolute mess created by bikes in front of the train stations. The regular parking spaces are pitifully inadequate; desperate owners in a hurry to catch their trains for downtown will leave their bike any place, and other comes along and throw theirs on top, clogging pedestrian paths and creating a king-size chaos...
---- Institute of Transportation Engineers Journal, August 1978, Washington, DC.

Rapid Growth In Bicycle Access to Railways

In Japan, as in much of Europe, walking and bicycling account for a major share of trips in cities and towns, despite rapid growth in the number of motor vehicles and suburbanization. Since the early 1970s, the use of bicycles for access to public transportation has been growing at an astounding rate across most of Japan, accompanying suburban growth.

As Table 13 shows, by 1987, there were nearly 3 million bicycles parked at Japanese rail stations on typical November weekdays. Bicycle access to railways has gained market share at the same time that bus and walk access has decreased.

Table 13: Growth In Use of Bicycles to Reach Japanese Rail Stations

Year	Number of improperly parked bicycles	Number of bicycles in parking lots or garages	Total bicycles parked at railway stations
1977	675,000	598,000	1,273,000
1979	852,000	929,000	1,781,000
1981	988,000	1,245,000	2,233,000
1983	864,000	1,430,000	2,294,000
1985	827,000	1,697,000	2,524,000
1987	799,000	2,089,000	2,888,000

The growth of bicycling for access to transit and other short trips in Japan has been facilitated by compact development patterns, high costs associated with the use of automobiles, well-developed transit networks, and substantial investments in pedestrian and bicycle facilities and traffic-calming measures.[26] Low rates of bicycle theft and crime made it possible for Japanese bicyclists to leave their bicycles in any open area near station entrances without securing the bicycle to a fixed object, relying on nothing more for theft prevention than a small metal lock that prevents someone from wheeling the bike away casually. Seeking lower housing costs, more people moved to distant lower density suburbs around major Japanese cities over the past two decades, in many cases beyond easy walking distance of rail stations. With the environmental movement in the early 1970s, attitudes towards the bicycle as a mode of transport for the poor began to be replaced by new attitudes viewing it as appropriate for middle and upper middle class mobility.

By the early 1970s, the demand for bicycle parking in station squares began to outstrip designated capacity, leading to the "bicycle pollution problem," caused by thousands of disorderly parked bicycles near station entrances. A model cities program for the development of bicycle parking at rail stations was initiated in Japan in 1973 under the *Act Concerning the Construction and Improvement of Bikeways.* Between 1974 and 1976, more than 22,000 bicycle parking spaces were created under this program at 107 locations in 57 cities. However, this and other efforts to develop new bicycle parking in the mid-1970s proved inadequate to meet burgeoning demand. The number of bicycles parked at rail stations more than doubled between 1975 and 1977, overwhelming both old and new bicycle storage facilities and occupying growing space in station plazas.[27]

Bicycle Parking Facility Characteristics

Changes in Bicycle Parking Industry in Japan. Until 1978, the majority of official bicycle parking facilities at rail stations in Japan was owned by private sector concerns. In that year, the Japanese Ministry of Construction initiated a major program to expand bicycle parking supply at stations. Bicycle parking capacity grew steadily from 598,000 spaces in 1977 to 1,333,400 in 1981 and 2,382,000 in 1987, and has continued similar growth since then. Municipal ownership of bicycle parking facilities at stations now accounts for three-fourths of the parking supply, as Table 14 shows.

Average Facility Size. The average bicycle parking facility at a Japanese rail station holds more than 275 bicycles. Facilities owned by noncommercial public corporations are on average the largest, with over 600 spaces per facility. Privately owned facilities are the smallest on average, at less than 125 spaces. In 1987, there were 55 bicycle parking garages holding more than 2,000 bicycles each, providing about 6 percent of total parking capacity. Another 380 facilities accommodated 1,000 to 1,999 bicycles and these provided another 21 percent of total parking capacity. A quarter of all parking capacity is in the 953 facilities that provide between 500 and 999 spaces, which make up a tenth of all facilities. Half of all facilities hold 100 to 499 bicycles and the remaining third accommodate less than 99 bicycles.

Table 14: Ownership of Japanese Bicycle Parking Facilities at Rail Stations, 1987

Type of Ownership	Number of Facilities	Percent of Facilities	Bicycle Parking Capacity	Share of Bicycle Capacity
State, local, community, etc.	4,639	53.7	1,707,641	71.7
Railway owner	515	6.0	112,096	4.7
Noncommercial Public Corporation	121	1.4	73,032	3.1
Private Commercial	2,805	32.5	348,253	14.6
Large-scale shop	327	3.8	109,093	4.6
Other	22	2.6	33,071	1.4
Total	8,635	100.0	2,383,186	100.0

Source: Ryozo Tsutsumi, *Safety Measurement and Parking System* of *Bicycle in Japan*, Japan Bicycle Promotion Institute, Tokyo, 1990.

Average Occupancy of Bicycle Parking. The occupancy level of all bicycle parking facilities at Japanese rail stations was about 88 percent in 1987, with nearly 2.1 million users a day. Occupancy rates were highest, at over 92 percent for parking facilities within 100 meters (330 feet) of the station entrances, which accounted for 68 percent of the parking facilities. Occupancy rates were observed to be lower at greater distances from the station and fell to less than 75 percent for parking facilities more than 300 meters (1,100 feet) from station entrances.

User Fees. Nearly two-thirds of bike-and-ride users park their bicycles for free at Japanese rail stations. One-sixth of users pay between 1,000 and 1,999 yen (US $8 to US $16) per month for their parking, one-eighth pay between 2,000 and 2,999 yen (US $15 to US $32) per month, and the remaining 7 percent pay other amounts. User fees are most common when higher quality parking is offered close to the station entrance.

Facility Types. Table 15 shows the composition of bicycle parking facilities in Japan by type. Half of all facilities are simple ground-level parking structures with a roof for weather protection. These provide 30 percent of total capacity. Half of all capacity is provided in surface parking lots without weather protection and these account for 43 percent of parking facilities. Two- or three-story bicycle parking garages with ramps between levels and bi-level racks such as those shown in Figure 15 account for 16 percent of total parking capacity, in 516 garages. In 1987, there were 31 automated bicycle parking systems in place, with an average capacity of 636 spaces. Underground bicycle parking facilities, with an average of 615 spaces each, are found in 33 locations. Underground and automated bicycle facilities each account for about I percent of total bicycle parking capacity at stations across Japan.

Table 15: Bicycle Parking at Rail Stations by Facility Type In **Japan, 1987**

Type of Structure	Number Of Facilities	Share of Parking Facilities	Bicycle Parking Capacity	Share of Parking Capacity
Ground-level with roof	4,237	49.1	716,184	30.1
Ground-level without roof	3,743	43.3	1,231,790	51.7
Multi-story garage	516	6.0	380,440	16.0
Mechanical and automated systems	31	0.4	19,729	0.8
Underground garages	33	0.4	20,305	0.9
Other	75	0.9	14,738	0.6
Total	**8,635**	**100.0**	**2,383,186**	**100.0**

Source: Ryozo Tsutsumi, op. cit.

The Japanese have developed a wider array of innovative bicycle storage systems than any other country, spurred by high land costs to find space-efficient ways to accommodate more bicycles close to station entrances. Even the most expensive fully computerized and automated bicycle parking systems developed by the Japanese have capital costs of less than US $2,000 per parking space. This compares favorably with the cost of constructing typical U.S. automobile park-and-ride spaces, which typically amounts to $4,000 to $18,000 per parking space.[28]

Automated bicycle parking facilities in Japan include merry-go-round storage systems, dry-cleaner type circulating racks, vertical rotating palate systems, multiple-layer suspension systems, and several types using cranes or robots to lift bicycles into overhead storage areas that may be 60 feet or more in height.

Rent-a-Cycle Ports at Rail Stations

The Japanese have also developed extensive bicycle rental facilities at railway stations, known as Rent-a-Cycle Ports. These employ fleets of identical minicycles, which are bicycles with

20-inch wheels, a front basket for parcels, a built-in locking device, light, and bell. Seat height is easily adjustable over a wide range, so that users of different stature can ride comfortably. All vehicles are painted bright lime green for easy recognition and theft deterrence.

The largest bicycle rental operations are managed by the Japan Rent-a-Cycle Association, a business consortium consisting of three bicycle parking companies, the manufacturer of the rental bicycles, land leasing companies, bicycle parking facility manufacturers, and an insurance company. Ownership of Rent-a-Cycle Ports is quite varied, from the Japan National Railways to a green tea company.

Most customers contract for rental privileges on a monthly basis. They are then entitled to take a bicycle whenever they wish from the Rent-a-Cycle Port, although it will often be a different bicycle than they used before. There are several advantages to this type of operation:

- Storage density of bicycles can be greater than is possible in other bicycle parking, since no room for access to a particular bicycle needs to be provided.
- A vertically movable floor technology for bicycle storage can be employed, with access only on the ground level, since all bicycles are the same.
- The bicycles used by clients commuting in the peak direction can be rented, at least in part, to clients involved in reverse commuting. Thus a higher level of vehicle utilization over the course of the day can be achieved.

People who rent bicycles are given a magnetic card which they can use to take a bicycle from the facility. The exit gates feature optical beams at chest height and wheelbase height connected to an alarm for security. Users removing or returning bicycles run their magnetic card through a card reader at the gate. They are notified at the gate by this device if their rental agreement needs to be renewed.

Impacts of Bike-and-Ride Travel In Japan

As in Europe, access to public transportation in Japan has been undergoing a structural change as a by-product of suburbanization. While in the early 1970s walking and collector buses comprised the major elements of the access system to suburban rail stations, by the late 1970s the bicycle had begun to penetrate the suburban rail access trip market on a footing nearly equal to or exceeding that of collector buses. Although walking continues to be the almost sole means of railway access in the central areas of Japan's major cities, bicycles account for roughly one- tenth or more of station access trips in suburban areas. In the newer suburbs at the fringe of Japan's metropolitan regions, where much growth is being experienced, bicycle access trips account for as much as half of all station access trips while walking and bus access shares continue to fall.

Limited automobile park-and-ride services have been developed at Japanese rail stations in some distant suburbs and fringe areas, but congestion and land costs limit their usefulness in much of Japan. Significant diversion of bicycle access trips to automobile park-and-ride would entail large investments of capital and land, worsen air pollution and traffic problems near rail stations, and increase the use of imported oil. Increased congestion would, in turn, impede feeder bus services already suffering from traffic delay. Diversion of bicycle trips to collector buses would similarly raise the cost of the metropolitan transportation system, requiring more peak capacity and higher subsidies for bus operation. As rail transportation continues to grow in Japan, due to longer trip lengths and increased suburbanization accompanied by rail service expansion, bicycles serve an ever more important role in rail station access.

Bicycle access to rail stations has produced mixed, but generally positive effects on bus services in Japanese suburbs. While urban rail services in Japan remain relatively viable financially, bus operations have been increasingly unprofitable since the mid-1960s. Buses have lost riders to the expanding rail networks and to increased competition with both the automobile and the bicycle. Rising fuel and labor costs have affected bus services more than rail operations. Suburbanization has reduced the concentration of travel demand in areas not served by rail. Increased automobile use and accompanying traffic congestion have reduced travel speeds and productivity. In response to these forces, the quality of bus services has declined while fares and subsidies have risen, causing additional ridership loss.

Surveys in Japan show that deficiencies in bus service were the principal reason why many people began using bicycles to get to rail stations. While the bicycle certainly accounts for some of the bus ridership loss in Japanese urban areas, many Japanese transport planners believe that bicycles have helped to alleviate overcrowding in the highly concentrated peak periods of demand. Reduction of peak period bus ridership reduces the demand for additional vehicles and drivers that would be employed only in the peaks with very high marginal costs. Since bicycles require no operating subsidy and are socially beneficial in terms of pollution, energy use, and congestion, their use as a peak period supplement to transportation system capacity appears to be highly desirable.[29]

The attitudes of Japanese bus transit managers towards the bicycle are quite mixed. Many display open hostility to bicycle transportation, viewing it as a direct threat to their market position. However, some bus transit managers perceive that the markets for bus and bicycle travel are complementary rather than competitive, and feel that each mode should serve its function where it is most effective. One Japanese transit manager has suggested that bus services should concentrate more on rail access trips over 2 km (1.2 miles) length and station-to-station services between parallel rail lines.

While the experience of Japan with bicycle-transit integration is not directly transferable to the United States, there are many useful elements in this experience that could help transportation planners, transit managers, and policy makers in diversifying transit access systems in America.

VI. Costs, Benefits, and Market Penetration

Impact on Transit Service Area and Penetration

The portions of a trip spent getting to and from public transportation are called the access" and "egress" portions. Just as each transit trip possesses an access and egress portion, so each transit station or route possesses an access and egress service area-the service area of a transit line being the area from which its patronage is drawn or to which its passengers are traveling. It is common to discuss a transit route's overall service area, but far less common to analyze the impact on service area by mode of access or egress. Yet, the mode of access has a significant impact on the definition of service area. Enhancing the potential for bicycle access to rail transit stations or bus stops can play an important role in expanding a transit system's service area in a cost-effective and environmentally sound manner.

Access Trip Lengths

In the United States, typically half of all pedestrian access trips to urban and suburban local bus services are less than 0.09-0.12 miles (150-200 meters) in length. For commuter rail and rapid transit stations outside downtown areas, median walking distances are significantly greater, but rarely exceed 0.3 of a mile (480 meters).[30]

Automobile access can dramatically expand transit route service areas. Typical median automobile driver trip lengths for public transit access range from 2.3-2.5 miles (3,750-4,100 meters). Auto passenger access trips, typically referred to in the United States as "kiss and ride," are generally shorter than park-and-ride trips, with median lengths ranging between 1.3-1.6 miles (2,075-2,640 meters). People will typically drive slightly longer distances to reach rail stations than to reach express bus stops.

The median bicycle access trip length in Japan and Europe is typically about 1.1-1.4 miles (1,700-2,200 meters). Information on characteristics of bicycle access trips to transit in the United States is limited, but median bicycle access trip length to American transit services appear to be significantly greater than this. A survey conducted in sprawling Phoenix, AZ as part of the evaluation of the bike-on-bus demonstration, revealed that bus bike rack users were commuting an average of 6.97 miles to access the bus. The survey also found that males, ages 16-66, were the predominant users of the bus-bike racks. A survey of 145 bicycle locker users in San Diego found the average locker user at park-and-ride and San Diego trolley stops bikes 3.6 miles to the locker, then travels another 11 miles by transit to reach his or her destination.

This reflects several factors-spread out low-density land development patterns in U.S. suburbs, with greater transit line spacing, and differences in the demographic characteristics of cyclists. In large part because the cycling environment is more hostile to bicycling in the United States and Australia, compared to Japan and Europe, United States and Australian nonrecreational cyclists tend overwhelmingly to be more adventuresome young and middle-aged males; in Japan and Europe, nonrecreational cyclists more closely reflect the demographics of the general adult population, including far mom women. Significant improvement of the cycling environment within a 1- or 2-mile radius of transit stations, with separate bicycle paths, bike lanes, or traffic- calmed streets, can be anticipated to reduce the average and median bicycle access travel distance and to reshape the demographics of typical bike-and-ride travelers. Lower levels of bicycle use for nonrecreational purposes by women in the United States may also be related to the higher levels of rape and other violent crimes committed against women in the United States, compared to Europe and Japan, as bicycles provide less personal security than automobiles against assault.

For all transit access modes, local factors play an important role in shaping transit route service areas. Competition between adjacent stations and different transit routes have a major impact on local access trip lengths. If travelers have two stations to choose from for transit access, they will usually prefer the station closer to their ultimate destination, even if it is a bit farther access distance. This typically results in off-centered egg-shaped station service areas, particularly for automobile and bicycle access. Bicycle and pedestrian access trip lengths may also vary as a result of local differences in topography, weather and access route conditions.

Table 16 shows the effects of various modes on access trip length distributions on effective transit route service area. Both bicycles and automobiles offer substantial expansion of transit access opportunities. Median bicycle access service areas are more than an order of magnitude larger than median pedestrian service areas. There is significant overlap between automobile and bicycle service areas. In many cases, 40 percent or more of auto access trips to transit are shorter than typical median bicycle access distances. Clearly, there is substantial potential for bicycles to substitute for autos in transit access.

Network Patterns, Connectivity, and the Effects of Barriers

It is important to consider network patterns and barriers when planning for pedestrian and bicycle access to transit. As Figure 16 shows, barriers in orthogonal grid networks typically cause pedestrians or cyclists to travel three times farther than the spacing, or mesh density, of the grid. In diagonal networks with circumferential links, this detour factor is only twice the mesh density. In the cul-de-sac street patterns commonplace in American suburbs, lack of network connectivity frequently imposes a high detour penalty on pedestrian and bicycle trips, promoting greater dependence on the automobile for access.

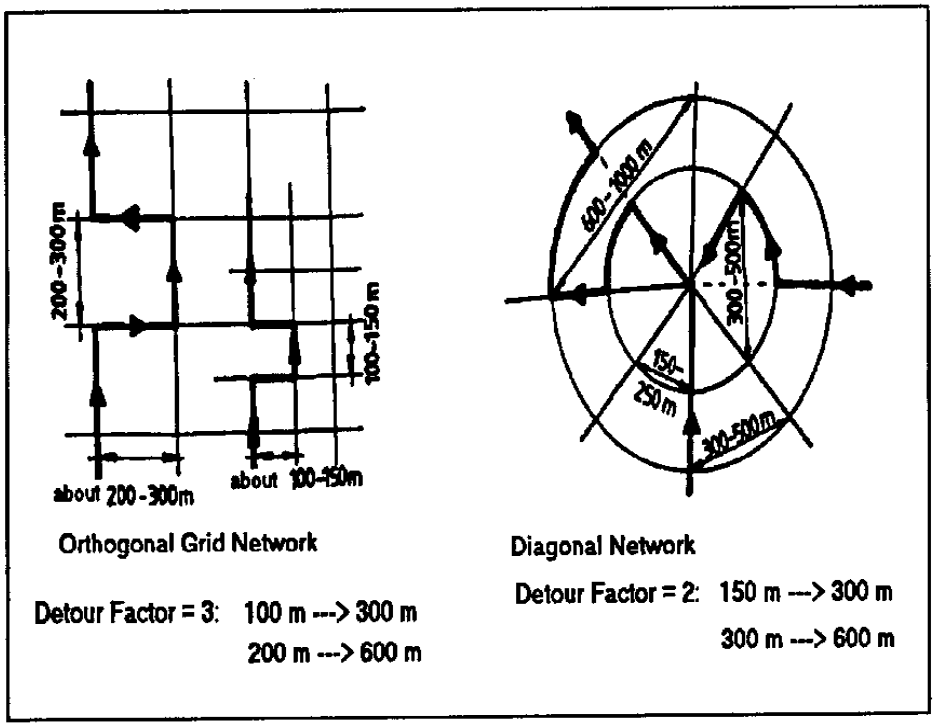

Figure 16: Effect of Missing Links in Orthogonal and Diagonal Networks on Pedestrian and Bicycle Travel Distance (Source: Bevordering fietsgebruik vervoerregio Eindhoven, Grontmij nv, Utrecht, Netherlands, 1990)

Table 16. Transit Service Area Characteristics of Access Modes 31

		Typical Access Trip Length (km)		**Service Area (sq. km.)**	
Access Mode	**To Transit Mode than**	**50% of trips less than**	**80% of trip less market)**	**Median (50% of market)**	**Outer Bound (80% of**
Walking	Suburban Local Bus	0.15	0.35	0.08	0.4
	Suburban Express Bus	0.15	0.43	0.07	0.5
	Commuter/ Rapid Rail	0.48	n.a.	0.72	n.a.
Automobile Driver	Suburban Express Bus	3.75	10.0	44.2	314.2
	Commuter Rail Stations	4.10	9.8	52.8	301.7
Automobile Passenger	Suburban Express Bus	2.08	5.9	13.6	109.4
	Commuter Rail Stations	2.64	5.7	21.9	102.1
Bicycle	Rail Stations (Japan)	1.70	3.1	9.1	30.2
	Rail Stations (Netherlands)	2.20	n.a.	15.2	n.a.
	Rail Stations (Illinois)	2.40	n.a.	18.1	n.a.
	EXPRESS Bus (San Diego)	5.00	8.2	78.5	211.2

A very effective strategy for promoting walking and cycling is the provision of shortcuts for pedestrians and cyclists to overcome network barriers. Such shortcuts are needed to connect low-speed, low-volume suburban residential streets into an effective network, which may dramatically reduce the actual walking or cycling distance from homes to bus stops, stations, schools, and stores at low cost. The addition of diagonal shortcuts for pedestrians and cyclists in the vicinity and direction of the stations has been found by the Dutch to be a very effective strategy for expanding the area from which pedestrian and bicycle access trips are made, as these shorten both trip distance and trip time for non-motorized access.

Accomplishing this requires taking advantage of opportunities as they arise, as in redevelopment or through the subdivision process. However, in U.S. communities that were designed for automobile dependence, creating such shortcuts to create network connectivity may at times require the creation of special programs to purchase easements for pedestrian and bicycle access at the edge of or through already subdivided residential and commercial land parcels.ss.

Effects of Service Area Size on Potential Transit Use

The overwhelming dependence of most Americans on the automobile, the dramatic drop in the density of transit routes in American metropolitan areas since 1950, and the widespread neglect of pedestrians in designing streets and communities together have sharply reduced the share of the population enjoying easy pedestrian access to transit. By 1970, 42 percent of U.S. households with incomes over $15,000 per year and 18 percent of low-income households lived farther than six blocks from a transit route.

As Figure 16 shows, barriers in orthogonal grid networks typically cause pedestrians or cyclists to travel three times farther than the spacing, or mesh density, of the grid.

Encouraging increased bicycle and pedestrian access to transit stations and stops offers a cost-effective and environmentally sound means of expanding the transit market area and diversifying the market segments to whom it is attractive. While park-and-ride facilities have attracted many suburban riders to transit, they have, by definition, proven less useful to nondrivers and proven more costly and land-consuming than would investment in nonmotorized means of access.

Research by Patrick Moriarity, [32] working in Melbourne, Australia, examined the potential effects of expanding the service area of fixed-rail systems by improving the access opportunities, particularly for bicycles. Melbourne's central business district has lost population to surrounding suburbs, similar to the trend in cities in other industrialized nations. Yet, Melbourne retained a 136-mile light rail network, concentrated in the city's central area and an extensive commuter railroad system, totaling 310 miles (500 route kilometers) throughout the metropolitan region. As Melbourne's population became more dispersed and dependent on the automobile, rail ridership fell and employment growth was strongest in the suburbs with only slow growth in the central core and inner/middle rings. This is a situation common in U.S. cities.

Moriarity found that a doubling of the effective fixed-rail service area radius from 1 to 2 kilometers would increase the potential transit market from 6 percent of all people in the outer ring to 33 percent; in the middle ring, a similar change in access radius would boost the potential transit market from 65 percent to 87 percent of the population. By increasing the effective service area radius of rail stations in Melbourne to 2 kilometers-through greater reliance on bicycle access---he estimated that over 33 percent of all trips in the metropolitan region could conceivably be made by rail.

Beyond the findings of significant potential for substituting nonmotorized transportation for auto trips, the study found that the combination of nonmotorized access with transit had important energy conservation implications, stating that:

> *fuel savings resulting from the shift to fixed-rail are far more important than those resulting from the direct shift of shorter car trips to walking and cycling. The most important role of nonmotorized transport from the fuel-saving viewpoint is, therefore, the ability to gain access to the fixed-rail system.* [33]

Moriarity's energy consumption analysis indicated that if all auto trips potentially served by rail transit-with a maximum access/egress distance of 2 kilometers---were diverted to rail transit, auto fuel consumption would decline 47 percent in the Melbourne region. While this theoretical analysis ignores several important factors affecting modal choice, such as comparative travel time and cost, physical ability to walk or cycle 2 kilometers and the need for some travelers to carry baggage or passengers, the analysis points out the strong synergism between transit and supporting access modes---that expanded transit service areas yield larger transit markets and can result in energy savings previously not fully considered by most transportation and energy analysts.

Bicycle-Transit Potential for Chicago Commuter Rail

Research published in 1991 by Michael Erickson,[34] previously with the Chicagoland Bicycle Federation and now with the Division of Public Transportation', Illinois DOT, points to a substantial latent demand for bicycle access to Metra, Chicago's commuter rail system. Approximately 186 of 208 (89%) Metra stations have park-and-ride lots and at a usage rate of 84 percent, the entire system of 58,000 spaces is only I percent shy of parking deficiency. At least 85 of 109 stations (78%) specifically labeled as "parking deficient" are above 90 percent full (Knight and Ghandi, 1989). Surveys of park-and-ride lot users at 41 stations found that almost 20 percent cannot find parking in any given month, prompting some to taken an earlier train in order to obtain a space and others to drive to a farther station.

Yet, many current park-and-ride patrons could be shifted to bike-and-ride if proper bicycle infrastructure investments were made. For example, the Chicago Area Transportation Survey (CATS) in 1988 found half of all park-and-ride rail users live less than 2 miles from the closest rail station with available parking. Surveys undertaken by the Federal Highway Administration of commuters in five urban areas (1980) and by the Northern Illinois Planning Commission [35] of commuters asix Metra stations who hold monthly rail passes, indicate that many people who are driving would rather use a bicycle for access if proper bicycle facilities were provided. Moreover, surveys show that bicyclists access 12 Metra stations with park-and-ride lots, despite a lack of designated bicycle parking spaces. Another 23 stations have as many bicyclists parked in nondesignated spaces as are parked in designated areas.

Erickson points out that Metra has financed ridership growth over the past 5 years with heavy investment in new park-and-ride facilities, but that funding is becoming a problem, threatening continued growth.[36] Research suggests that most Metra parking spaces built in the last few years at a cost of $14 million are now filled.[37] Erickson notes that,

> *encouraging and facilitating people to bicycle to Metra stations, instead of driving them to the auto, is the appropriate economic activity for mitigating parking needs, congestion and air pollution.*

Yet, only 85 of 217 Metra stations (39%) have bicycle parking and of the 109 rail stations ranked "parking deficient," only 51----less than half-have bicycle parking.

Erickson projects mode shift goals toward which Metra might profitably commit itself, shown in Table 17. In a 1- to 5-year period, a goal of 3,700 to 6,700 Metra commuters (5 to 9% of auto access) could be reasonably shifted to bike-and-ride. The low end of the estimate (3,700) is based on research by Ohm, who conservatively estimated that 10 percent of the less than 2 mile trips to the station could be shifted to bicycle. The higher end of the short-term estimate (6,700) is based on the number of passengers who would access Metra stations by bike if, as in some other U.S. cities, 5 percent of all station access was by bicycle.

Table 17. Metra Access Modal Shift Goals: Reductions In VMT and Air Pollutants

Time Horizon	#Shifted automobile to bicycle	VMT Reduction per day	Total Emission Reduction per day (tons)*	VMT Reduction per year (millions)	Total Emission Reduction per year (tons)*
Short-term goal	5,763	23,052	38.0	2.977	5,226
Midterm goal	14,062	56,251	92.8	7.312	12,753
Long-term goal	37,800	182,952	301.9	36.590	41,496
Long-term Kiss-n-ride diversion	2,700	14,904	24.6	2.980	3,380

* Total emissions include C02, HC, CO, NOx

In the long term, with promotion and training, high goals for shifting auto drivers to bicycles could be achieved. The low end of the long-term estimate (33,750) represents bicycle access averages in many cities of Europe and Japan, extrapolated to Metra passenger figures of 1989. The likelihood, however, is that Metra will experience continued ridership growth over the next 20 years. If 50 percent growth were realized in 20 years, the number of auto drivers

living less than 2 miles from the station--- 37,125 new bike-and-riders-would equal 33 percent of auto station access or 18 percent of Metra's future ridership totals. Including kiss-and-riders, the future potential bike-and-riders increases to 42,525.

Erickson's research notes that each automobile-to-bicycle mode shift results in a quick and cheap increase in available parking at a rail station. The automobile commuter who now drives to work can reduce his or her vehicle miles traveled (VMT) by becoming a Metra parkand-ride passenger, due to the space made available by those who have shifted to bike-and-ride. Erickson estimates that within 20 years, improved bike-and-ride access to Metra could reduce regional VMT by nearly 40 million VMT per year and CO_2 emissions by nearly 45,000 tons per year. This would be accompanied by significant reductions in CO, hydrocarbons, and NO_x, due to reduced vehicle trip start, evaporative, and running emissions.

Bicycle Egress: Opportunity for Developing New Transit Markets

While greater use of bicycles to access transit stations increases the transit market area, the use of bicycles for transit egress has the effect of multiplying the level of transit accessibility in suburban areas, helping to overcome a notable limitation of automobile park-and-ride services. As one American report noted:

> *With the automobile, access to stations at the end of the trip where the automobile is available is possible from any location, but of course, once the passenger transfers to the (transit) line, his automobile would no longer be available for use at the other end of the trip, restricting possible destinations to points reachable by either walking or other local transit. Since other local transit is intensively provided only in (central city) areas, this limits possible destinations considerably.* "[38]

This limitation is one reason public transportation accounts for such a small portion of intrasuburban travel in the United States. Yet, the growth of suburban employment has made suburb-to-suburb travel the fastest growing aspect of travel growth in U.S. metropolitan areas. The promotion of bicycle egress (along with access), particularly near suburban employment clusters, can help transit agencies attract more nonpeak direction riders, reducing directional imbalances in transit passenger loads and increasing transit revenues without raising operating costs. Improved bicycle egress systems can provide expanded employment opportunities for low income inner city residents who are now often cut off from access to a large share of suburban employment. Enhancing multi-modal access to low density suburban employment can help employers by expanding the pool of workers who can fill lower wage jobs.

Bicycle egress from transit can be both practical and economical if secure bicycle parking or rental bicycles are available at the destination transit stop or if bicycles are permitted aboard transit vehicles. Where bicycles can be used for both transit access and egress, the effective service area of a transit system expands dramatically for bicycle-transit users. Destinations previously unreachable by transit become accessible; the use of more direct or faster transit routes not directly serving either the travelers origin or destination in many cases becomes feasible. By "sandwiching" a transit trip between two bicycle trips, the bicycle becomes a vehicle suited for a greater variety of trips, both long and short. Similarly, public transportation becomes suitable and competitive for many more trips, particularly in lower density suburban and rural areas, typically more challenging and costly for transit to serve.

Indeed, Caltrans found in surveys in the early 1980s that 40 percent of those using bicycle lockers at Southern Pacific commuter rail line stations in the Silicon Valley of California were leaving their bicycles overnight in the lockers, and using bicycle egress to travel each morning from the station to nearby employment and schools otherwise poorly served by transit.

Bicycle/Pedestrian vs. Auto Access to Transit

Complementary Access Modes. Bicycles, walking and automobiles are all well suited to meeting the needs for improved access to suburban public transportation. Automobiles can quickly traverse distances of many miles, carry passengers and offer comfort regardless of weather or topography, but cars are a major source of air and water pollution and are expensive to own and operate. Bicycles, by contrast, are cheap to own and operate, consume only renewable energy, emit no pollution and are suitable for both access and egress distances of up to 3 or more miles. On the other hand, bicycles expose the rider to the weather and require strenuous physical activity to traverse hills. Bicycling can also pose real, but surmountable problems, in terms of the rider's clothing and personal appearance at the workplace or trip-end. Walking shares many of the above-mentioned attributes of bicycling, but is significantly more limited in terms of the distance the average person is willing to walk to access public transportation.

Transit agencies and local governments can and do influences the relative use of bicycle, walking and automobile access at individual transit stops by providing or failing to provide parking for automobiles and bicycles and safe paths and access for bicycles and pedestrians. As with automobiles, availability of parking infrastructure is required for bicycles if they are to function as an access mode. If parking is only provided for automobiles, many potential bike and-ride trips will be diverted to park-and-ride trips, while others will be diverted to automobile commuting.

Both European and Japanese transportation planners have recognized the complementary roles of bicycle, pedestrian and auto access to transit and have sought to develop each where most appropriate. In stark contrast to the United States, bicycles are given priority in the Japanese and European transit access systems in most circumstances, for the benefit bicycles provide in less land and energy consumption and lower capital costs are understood and appreciated.

Land Use Implications of Nonmotorized Vs. Auto Access. Park-and-ride lots typically require 330 square feet (30.7 sq. meters) of land per parking space. By comparison, ground-level bicycle storage spaces require only 6-12 sq. feet (.6-1.1 sq. meters). The minimal space requirement for bicycle parking allows it to be more easily sited in congested areas around rail stations and in traffic-sensitive residential areas.

Too frequently, park-and-ride lots provide either inadequate parking capacity relative to the demand for private vehicle access to a transit station or must be sited in remote locations unsuited for access by foot. In the former case, potential transit ridership will be lost---most likely to auto commuting-and in the latter case, many former pedestrian access trips to transit may be replaced by park-and-ride trips, adding unnecessary vehicle travel and worsening transit access for households without cars.

The development of expansive park-and-ride lots at suburban railway stations, moreover, often compromises the potential for office, retail and high-density residential housing development at these sites of high transit accessibility. By foregoing such possibilities for joint-development projects, transit agencies often reduce their ability to capture revenue from land value increases related to the improved transit accessibility and local governments lose significant potential real estate and other tax revenues that would be generated by higher value uses of land near transit stations. These amount to hidden costs of park-and-ride development related to rail transportation. Thus, by maximizing the use of bicycle access, transit agencies and local governments can increase revenue opportunities while reducing access system costs.

Because bicycle parking facilities can be developed at a small scale in residential neighborhoods without generating significant noise, traffic congestion or other adverse neighborhood impacts, they can supplement pedestrian access systems, rather than supplant them, as park-and-ride services often do. In circumstances where park-and-ride facilities cannot be developed due to insufficient or inappropriate land for the parking lots, small-scale bicycle parking facilities could fill the gap, tapping new market areas not now served by transit systems.

I In many communities, park-and-ride lot construction proposals have been resisted by local residents fearful of more traffic, the loss of open space, or opposed to loss of wetlands. Expanded bicycle parking provides a sound alternative to the almost exclusive reliance on automobile park-and-ride of the past.

Capital and Operating Costs. Park-and-ride lots vary widely in their costs. Although some lots operate on a joint-use basis with suburban shopping centers, churches or other private businesses, most have been constructed at considerable expense by transit agencies, local and State Governments.

The typical construction cost of the simplest surface park-and-ride lots ranges between $1,500 and $5,000 per space, excluding land acquisition, engineering, insurance and inspection. Inclusion of these costs, other than land acquisition which varies widely by location, can more than double this capital cost. If extensive cut-and-fill excavation and drainage structures for storm water management are required, this can boost costs even more. Structured parking lots typically cost $12,000 to $20,000 per space.

For example, a proposed expansion of the structured park-and-ride facility at the Shady Grove Metro Station in Montgomery County, Maryland, is projected to cost about $18,000 per space for 900 additional spaces. In the Chicago region, the 6,700 auto park-and-ride spaces planned or under construction in 1990 for Metra were estimated to cost between $11-13 million or $1,641-1,920 per space. Metra has estimated a 20-year need for 34,000 additional park-and- ride spaces, which are projected to cost $125.8 million by the year 2010, excluding inflation, operation and maintenance costs, or about $3,700 per space. In contrast, installed secure bicycle storage spaces, except for fully automated or underground facilities-not yet found in U.S. cities-cost between $50-500 each.

Maintenance and operating costs for bicycle vs. auto parking show a similar differential. Annual maintenance and operating costs for an unattended auto park-and-ride amount for $150 or more per space. In stark contrast, bicycle parking operating and maintenance costs range from a few dollars to a high of $70 annually for parking garages (not found in the United States), based on discussions with a number of U.S. and foreign transportation officials. Covered and guarded bicycle parking at 80 rail stations in the Netherlands was reported in the early 1980s to cost about $6.8 million per year or $64 per space, including all operating, maintenance and labor costs. This figure also includes profits made by some bicycle garage operators.

Using these data, it is possible to view the comparative total costs of bicycle vs. automobile parking over time. Even if one assumes that the life of bicycle parking facilities is half that of auto park-and-ride lots, secure bicycle parking is still many times less expensive than auto parking, even for fully guarded and covered bicycle parking.

Energy Use and Air Pollution Emissions. Park-and-ride lots usually result in some energy savings and air pollution reductions by diverting auto commuters to transit for part of their trip, but current analysis methods often overestimate these effects. According to several studies, 40-60 percent of park-and-ride transit users in the United States previously commuted to work as auto drivers. When these automobile drivers substitute transit for part of their trip, they are reducing their pollution emissions and fuel use somewhat.

The decrease in pollution emissions and fuel use is not proportionate to the reduction in automobile trip length, however. The running emissions from motor vehicles typically make up less than half of the total motor vehicle emissions in metropolitan areas. Evaporative emissions (related to the number of motor vehicles), and trip-start related emissions (cold starts/hot soaks), together typically account for the major share of motor vehicle emissions. [39]

The emissions from short 1- to 2-mile automobile trips is nearly as great as the emissions from typical 5- to 10-mile automobile commuter trips. A California Assembly Office of Research paper noted that for a 7-mile trip, 90 percent of the emissions occur in the first mile. For a typical trip of 5-20 miles, approximately 50 percent of the emissions come from the cold-start stage, which occurs in the first minutes after the engine is started. This is because petroleum- fueled motor vehicles usually combust their fuel much less efficiently when their engines are at cold, rather than at warm operating temperatures. Each time after a petroleum-fueled motor vehicle is used, whether for I mile or for 10, the vehicle continues to give off hot soak emissions, as gasoline remaining in the engine when the key is turned off evaporates from the engine.

As a recent report by the Environmental Defense Fund noted:

> *Because cold starts generate such a significant share of the pollution for most trips, auto use reduction strategies should eventually given greater emphasis to reducing the number of vehicle trips taken, rather than simply reducing total miles travelled.*

By switching longer automobile driver trips to park-and-ride, there may be significant reductions in VMT but only small reductions in air pollution emissions-the reduction in running emissions is small compared to the remaining cold start and hot soak emissions. On the other hand, by shifting short automobile trips to the bicycle or walking, there may be an insignificant reduction in VMT but a substantial reduction in emissions, through elimination of cold start and hot soak emissions. These facts make park-and-ride lot expansion a relatively ineffective strategy for air quality improvement, compared to strategies that reduce the number of motor vehicle trip starts, such as enhanced pedestrian and bicycle access to transit.

However, many regional transportation/air quality modeling studies in the United States have assumed that changes in mobile source emissions are all attributable to changes in the VMT and operating speeds of roads, ignoring changes in the number of cold starts, hot soaks, and in trip length. This error can result in substantial overestimation of emission reductions and cost-effectiveness of park-and-ride lot development. This is important, as many States and regions are planning to use substantial amounts of their Congestion Management and Air Quality (CMAQ) funding under ISTEA for park-and-ride lot construction, with a primary air quality improvement objective.

Transportation/air quality models in use are largely insensitive to both the supply and demand for nonmotorized transportation, including walking and bicycling to transit. There has been a lack of sensitivity in most transportation models to the factors influencing whether people will make short nonmotorized trips or instead travel by automobile or transit. The nonmotorized modes have simply not been represented in the analysis process. This has made it impossible for regional planners to estimate how different land use, urban design, bicycle, and pedestrian policies could affect air pollution emissions

In considering emissions reduction strategies, it is important to consider the potential for diversion between modes and other changes in travel behavior as a result of new transportation investments, services, and pricing changes. Typically, 25 to 45 percent of park-and-ride users previously used transit to commute. Whereas, typically, 5 to 10 percent of transit riders boarding vehicles at park-and-ride lots walk to the lot, 15 to 20 percent formerly walked directly to transit routes before fringe parking was available.

Increased local auto use is often induced by new park-and-ride facilities, yet, few studies have considered the effects of these induced auto trips in estimating energy and air pollution savings associated with park-and-ride. In some cases, these induced emissions and adjustments for cold starts and evaporative emissions may make park-and-ride system expansion a net new contributor to emissions growth. Thus, such projects should undergo careful scrutiny and analysis in air quality planning.

Finally, most evaluations of planned park-and-ride lots neglect the substantial indirect energy costs associated with facility construction. A 1981 study by the North Central Texas Council of Governments estimated the indirect energy consumption for creation of a 500-car capacity park-and-ride lot as 20.7 billion BTUs, the equivalent of 166,400 gallons of gasoline (630,000 liters). Maintenance costs were estimated to be 630 BTUs per square foot annually or an added 1,160 gallons (4,400 liters). When considering net energy savings from park-and-ride lots, this study found that, on average, it took 1 1/2 years to recover indirect energy costs from Dallas-Fort Worth area lots (with 15 mpg average automobile fuel economy). In some cases, park-and-ride lots needed to operate for 3 to 10 years before saving any energy, accounting for cold start fuel economy and energy investment in lot construction. Moreover, as the fuel efficiency of cars increases, the net energy savings from park-and-ride systems decreases. The Texas study found that an increase in the fleet fuel economy from the assumed 15 mpg to 25 mpg (which is more typical in the United States in the mid-1990s) would more than double the energy payback period for a typical Texas park-and-ride lot.

Bicycle access to transit reduces fuel use and emissions proportionally more than it reduces vehicle miles of travel, since cold starts, hot soaks, operating emissions and fuel use are all eliminated when bike-and-ride trips substitute for automobile travel. Even at modest usage levels-5 to 10 percent of modal share-bicycle access to and egress from bus and rail transit can make a significant contribution to air pollution reduction. As Table 18 shows, for each park-and-ride commuter diverted to bike-and-ride, an average of 150 gallons (550 liters) of gasoline per year can be saved. A similar analysis shows that by diverting auto commuters to bike-andride, an average of 400 gallons (1,500 liters) of gasoline may be saved for every new bike-and-ride commuter.

Although diversions shifted to bike-and-ride travel would likely result in some additional home-based use of automobiles by other household members, reducing fuel savings somewhat, the net energy savings would remain substantial. If only 0.5 percent of U.S. workers who now live 1/4 - 2 miles (400-3,200 meters) from a transit route and commute by auto could be attracted to bike-and-ride travel, nationwide gasoline savings of approximately 20-50 million gallons (75150 liters) per year could likely be achieved. The diversion of 10 percent of park-and-ride commuters to bike-and-ride could result in gasoline savings of over 2.2 million gallons (8 million liters) per year nationwide.

A shift of auto trips to walking trips also has substantial direct, beneficial impacts on air quality, with auto emissions per trip reduced 100 percent. As with diversion of short auto trips to bike-and-ride trips, diversion of short auto trips to walking produces a greater reduction in air pollutants per mile than if longer trips were diverted because of the disproportionate amount of pollution produced by the cold start.

A 1980 study by the Chicago Area Transportation Study and the Illinois Department of Transportation of newly installed bicycle racks at rail stations provides one of the few qualitative evaluations of bike-and-ride effects on emissions. IDOT installed bicycle racks with a capacity of 457 bicycles at nine commuter rail stations near Chicago in July 1979 to help mitigate traffic on the Edens Expressway. By August 1979, they recorded 222 additional bicycles parked in the new racks. This was estimated to have reduced VMT by 1,739 per day, with a reduction of 1.99 tons of hydrocarbons per year, and a reduction of 22.45 tons of CO per year. Evaluated along with other emissions reduction strategies, bike-and-ride was found to be by far the most cost- effective means of reducing hydrocarbon emissions at a cost of $311/ton reduced, as Table 19 shows.

As both a fuel conservation and air pollution emissions reduction strategy, promotion of bike-and-ride service appears to be more cost-effective than almost any other politically feasible transportation systems management strategy.

Table 18: Estimated Potential Energy Savings of U.S. Bike-and-Ride Development

	Shift Park-and-Ride Commuter to Bike. and-Ride	**Shift Automobile Commuter to Bike-and-Ride**
Average 2-way commute (or access) distance	4.0 miles	22 miles
Fuel use rate (assume fleet fuel economy of 17 mpg & cold start factor)	x .147 gallon/mile .59 gallons/day	x .074 gallon/mile 1.63 gallons/day
# workdays/yr	x 250 days	x 250 days
Potential Fuel savings/year for each auto user	147 gallons/year	407 gallons/year

Table 19: Cost-Effectiveness of Various Strategies for Reducing Hydrocarbon Emissions

Strategy	**Cost/ton of HC avoided**
Secure bicycle parking at rail stations	$311
Commuter rail carpool matching	$3,979
Express Park-and-ride service	$96,415
Feeder bus service to stations	$214,959

VII. Recommendations

A limited, but growing, number of U.S. transit agencies have taken actions to facilitate improved bicycle and pedestrian access to public transportation. For the vast majority of U.S. cities and transit agencies, however, the potential economic and environmental benefits of enhanced bicycle and pedestrian access remains both untapped and unconsidered.

The new transportation direction embraced by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), with its focus on intermodalism and enhanced efficiency of existing transportation infrastructure, combined with the mandates of the Clean Air Act Amendments of 1990 to reduce automobile-generated pollutants and growth in vehicle miles of travel, will accelerate interest and investment by State and local Governments in bicycling and walking and bicycle/pedestrian access to transit as sound alternatives to automobile commuting. In a climate of scarce budget resources, improved nonmotorized transit access is seen by many as one of the most cost-effective ways to improve air quality and manage traffic congestion.

As a means of encouraging and facilitating State and local Government investments in bicycle/pedestrian access to transit, the Federal Government can play a needed and important role in technology sharing and development of guidelines for nonmotorized access to transit.

Need for a Clearinghouse

Currently, there is no central location in the United States to which interested State or local transportation planners, engineers, and transit agency staff can turn to obtain accurate and up-to-date information on development and implementation of improved bicycle and pedestrian access to transit. Information on the best types of bicycle lockers and racks, costs of various options, experience of other cities in implementing bike-on-rail, bike-on-bus services and in creating more pedestrian- and bicycle-friendly environments, and the successful experience of other countries, must be gathered by each city, transit authority or State as best they can.

The establishment of a Nonmotorized Transit Access Clearinghouse would greatly facilitate efforts of those interested in encouraging such intermodal connections and help ensure that future efforts build on the past experience of others. Such a Clearinghouse could be housed within the Department of Transportation or funded-at least initially-by a DOT grant to an existing private or nonprofit organization knowledgeable about bicycle and pedestrian issues. A clearinghouse could gather and disseminate information about nonmotorized transit access, prepare case studies of successful experiences, and evaluate relevant pilot projects in the United States. If established by DOT with a start-up grant, such a center could within several years become self-sufficient through provision of contract technical assistance to transit agencies, municipalities, and State Governments, including help in planning and evaluating alternative strategies for cost-effective multi-modal transit access system development.

Development of Guidelines for Nonmotorized Transit Access Development

Because there are relatively few U.S. transportation professionals who have received extensive training in how to integrate the pedestrian and bicycle modes into policy, operations, or planning, guidelines are needed to help ensure more effective progress in these areas. U.S. transportation engineering and planning courses and textbooks should be revised to focus more attention on intermodalism between motorized and nonmotorized modes, and U.S. universities should be encouraged to carry out research in this area.

The following section provides comments and recommendations that might provide a basis for development of more detailed planning guidelines on bicycle and pedestrian access to transit. Further work is needed to fully develop such guidelines and make them available to cities, transit agencies and others interested in implementing bicycle and pedestrian linkages to transit.

Selection of Bike-and-Ride Transit Locations. Virtually all passenger railroad stations should offer secure bicycle parking, as a basic prerequisite to encouraging bike-and-ride connections. Suburban stations have the greatest potential demand, particularly for access trip parking. For inner city locations and suburban areas with substantial employment, secure overnight bicycle storage is essential to enable bicycle egress from stations. At rural transit stations, bicycle racks and lockers provide access to those without cars living nearby, particularly where other public transportation is nonexistent.

The highest priority should be placed on developing bike-and-ride services in areas with the greatest demand potential. For both rail and bus public transportation, demand will tend to be higher where:

- Many people live in a range of 1/2 - 3 miles from the transit boarding point and where feeder bus service is less than frequent or unavailable at all;

- Express service or frequent local service is provided by transit from the station or stop to destinations more than 5 miles distant;

- An attractive cycling environment is found in the area, with relatively flat terrain and safe routes to the stop;

- An inadequate supply of automobile parking is available at the station or stop;
- Major public transportation transfer points support frequent services to many locations; and
- There is a substantial population favorably disposed towards bicycling.

Siting of Bicycle Parking Facilities. Bicycle parking facilities should be placed as close as possible to the transit boarding point, but should not impede pedestrian flows or station operations. Bicycle parking is best placed on both sides of rail stations where passengers board from outside platforms rather than a central platform. This minimizes delay for bike-and-ride patrons and reduces potential problems of bicycles being wheeled across bridges, subways or other track crossings provided for pedestrian traffic. Where dual outside platforms are found and parking can be provided only on one side of the station, it should be placed on the side most used by morning commuters to minimize total perceived delay.

At bus stops, bicycle racks can often be placed adjacent to transit shelters on public right-of-way. Parking lots at convenience or retail shops located close to the bus stops also offer good locations for bicycle parking if the landowner is amenable.

Close proximity to the bus stop shelters or busy shops enhances the security of the parked bicycles by placing them within easy view of other transit users or pedestrians. Good visibility of bicycle parking facilities also serves to alert new transit patrons and potential cyclists to their existence. Bicycle parking should be well lit at night to minimize vandalism and theft and enable users to operate locks and keys easily. Protection for the bicycles from rain and snow is also most desirable.

Equipment Selection. When it comes to selection of bicycle racks or lockers, the old adage against being "penny wise and pound foolish" holds true. Investment in high quality racks and lockers is well worth the extra expenditure that may be incurred, as experience has shown that lower quality facilities are more subject to vandalism and theft and can undermine bicycle-transit program goals by bringing about lower levels of use than would be the case with better quality parking facilities. In locations with high crime rates, only secure bicycle lockers or guarded parking are feasible; secure racks and coin-operated lockers are likely to be prone to vandalism. Several reports are available that evaluate bicycle parking equipment. The *Bicycle Parking Cookbook* is a good recent resource on bicycle parking siting and equipment. [40] Development of guarded bicycle parking garages and bicycle check rooms at transit stations should be considered for higher potential demand locations.

Bicycle Access Route Improvements. Although secure parking is the most important element in the bicycle-transit access system, transit agencies and local governments seeking to encourage bicycle-transit linkage should also evaluate access route conditions. Barriers and bicycle safety hazards in the area of transit stops and stations should be identified and improvements made where possible. Access route improvements should be concentrated in the area within I mile or less of transit stops, where there is the greatest concentration of potential bicycle travel demand. It is important to evaluate the connectivity of the bicycle and pedestrian network, identifying missing links, and locations where it is hard to cross major streets, roads, or other barriers. Where possible, opportunities to create bicycle/pedestrian exclusive shortcuts should be explored, as these can form the most important elements in the transit access system, particularly when they are in the immediate vicinity of stations or major Stops. [41]

Often, minor improvements can make a major difference in the cycling environment. By widening curb lanes to 14 feet (4.25 meters), for example, motor traffic can pass slower cyclists with reduced conflict or threat. By narrowing motor vehicle lanes and creating parallel bicycle lanes, additional legitimacy can be conferred for the cyclist's place on the road, although careful attention must be given to pavement surface quality and maintenance, sight distances, driveways, and intersection crossings to design a safe facility.

Implementation of traffic calming and neighborhood traffic management programs, which keep through traffic off residential streets and reduce the speed of motor vehicles on minor streets, can be a major aid to bicycle and pedestrian access. Such actions, when combined with the targeted creation of pedestrian/bicycle shortcuts, can link together the low-speed, low-traffic volume streets into an interconnected network for safe and comfortable nonmotorized travel. Such actions are often undertaken as part of broader strategies to upgrade the quality of urban and suburban life. The resulting enhanced bicycle and pedestrian access is but one element in a larger scheme of progressive urban/suburban planning. Traffic calming should be considered not only for residential streets, however. In Europe, Japan, and Australia, traffic calming is also being applied to larger streets adjacent to transit stations and major retail and commercial centers. Designating these as areas of pedestrian, bicycle, and transit priority can be an important step in creating or restoring a balance of different modes in the overall urban travel environment. [42]

Traffic control devices for bicycle and pedestrian crossing can be installed at relatively low cost to make it easier to cross streets with high traffic volumes or speeds. Giving cyclists and pedestrians a 10-second advance green phase, with motorized traffic held by a red stop signal, can help nonmotorized travelers to secure their place in the roadway as they cross and proceed, reducing safety problems. This is widely done in European cities.

Bicycle paths and lanes, when developed as part of a well-designed bicycle network, can aid cyclists in areas of fast-moving traffic, often reducing the frequency of serious accidents.[43] The City of Delft, Netherlands, for example, created an extensive network of bicycle facilities, with a subdistrict network of mostly shared (bicycle and automobile) traffic-calmed streets on a 100-150 meter (310-450 feet) grid, a district network of smaller bikeways and bikelanes at a 200-300 meter (620-900 feet) grid, and a city network of higher capacity, segregated bikeways designed for longer distance bicycle trips with a 400-600 meter (1,240-1,800 feet) grid. This led to a 20 percent decrease in the likelihood of cyclist injury, while increasing overall cyclist mobility by 12 percent.' In communities where bicycles are widely used and where appropriate provisions have been made for the bicycle, accident rates for bicycles can be expected to be higher than for the automobile on a per distance traveled basis, but proportionate to actual exposure time in the transportation system. In the Netherlands, for example, 26 percent of all person trips are made by bicycle, 30 percent of all travel time is spent bicycling, and 22 percent of traffic fatalities and 25 percent of recorded traffic injuries involve bicyclists.'

Planning of new bicycle paths in metropolitan areas should, wherever possible, link to major transit stations and/or bus stops. The provision of signs along the bicycle path that direct cyclists to proximate transit stations, as is done in San Diego, also serves to enhance the bicycle transit linkage.

Bike-on-Transit Programs. The greatest untapped potential for bike-on-bus service is in low-density suburban and rural areas where transit serves only a small portion of all origins and destinations. In these areas, bike-on-bus programs can significantly expand mobility for many people who lack automobiles and for those who live too far from available bus stops. Bike-on-bus programs can be a cost-effective means to overcome barriers to bicycle traffic, such as limited access on bridges and tunnels, and can stimulate bicycle and transit use where they aid cyclists in surmounting major topographic barriers such as long hill climbs.

Transit agencies and local governments should evaluate their services to identify the most appropriate routes for initiation of bike-on-bus service. The successful experience of many U.S. transit agencies with bike-on-bus services should allay concerns about service delays that the bicycles might cause and potential liability problems. Moreover, the existing bike-on-bus services provide a good basis of information to transit agencies considering bike-on-bus service on the pros and cons of front-mounted vs. rear-mounted bike racks vs. the easiest and most cost effective method: allowing bikes to be carried on board transit vehicles.

Bike-on-bus services should be considered for express bus routes travelling distances of roughly 6 miles (10 kilometers) or more, especially where there are intermediate stops in low to moderate density suburban areas and connecting bus service is infrequent. Unless there are intermediate barriers to bicycle traffic, shorter routes will not offer a significant travel time advantage to dual-mode travelers.

Bike-on-rail services should also be evaluated by transit agencies that do not yet provide them. As with bike-on-bus programs, transit agencies considering such services can benefit from the successful experience of many rail transit operators in cities across the country. It is encouraging to see that most of the new light rail systems that have opened in recent years have incorporated bike-on-rail services and are aware of the need for good bicycle parking facilities and paths leading to the stations. The Santa Clara County Transit system offers perhaps the best U.S. 'example for other agencies, with its no-permit-required, bikes-welcome-aboard-at-all-times policy.

Additional rail ridership revenue can be gained through incorporating bike-on-rail services at no cost by permitting bicycles aboard rail vehicles in the nonpeak direction during peak hours and system-wide during nonpeak hours. New rail car purchases should require provision of bicycle and hand luggage storage bays in rail cars to facilitate the growth of bike-on-rail services. Design of the new "California Car," mandated by California's Proposition 116, to accommodate bicycles is a promising development and similar requirements should be incorporated into the design of all new commuter, light rail and intercity railcars.

Secure bicycle parking is a basic prerequisite to successful bike-on-transit services, whether provided by the blessings of a low crime rate or the conscious provision of secure facilities. Such parking should always be available along bike-bus routes and at railroad stations to serve passengers who use a bicycle only for transit access.

Safety concerns of many transit managers about bike-on-transit service appear to be unfounded, based on the positive experience in U.S. cities and abroad. Although American bikeon-rail programs generally require users to obtain permits and take safety courses, the European experience demonstrates that such measures are not needed to ensure safety. Such artificial barriers merely inhibit the usefulness of bike-on-rail travel for infrequent users and out-of-town visitors. Placement of signs in prominent locations in rail stations to notify potential bike-on-rail travelers of safety rules and regulations can communicate the needed safety information and serve to maximize use of the system.

If permits are required, efforts should be made to maximize the ease with which cyclists can obtain the permits. Rather than requiring cyclists to go only to one central location to obtain the permits, as is often the case, transit agencies should allow cyclists to obtain permits by mail (as some transit agencies do) and have the permits available for sale at many or all stations on the system, facilitating access for tourists and ocassional users.

Marketing and Promotion. The number of Americans that use a bicycle to access public transportation is small compared to the potential that exists for such service. Bike-and-ride remains a relatively new concept in the United States and will only achieve its full potential market penetration with active promotion and marketing. The likelihood of program success is maximized by concentrating initial improvements and promotion in locations where substantial potential demand for bike-and-ride exists.

Information and marketing at railroad stations, park-and-ride lots, outside and inside transit vehicles and in transit schedules is useful in diverting existing transit users to bicycle access. While this may free up capacity in overcrowded park-and-ride lots, it will not attract many new riders to transit that are not already transit users.

More effective strategies are needed to attract nontransit riding cyclists. These include: marketing efforts through employers, ride-sharing coordinators, and transportation demand management programs, advertising in community newspapers, distribution of leaflets in bicycle shops and neighborhoods within the bicycle access service area of the transit stop or station and other such means. Major new bicycle parking programs or facility openings can sometimes be turned into community-level media events to attract attention of the local press and potential users.

Marketing programs must be targeted to specific audiences for maximum impact. An Australian report on bicycle-transit linkage discusses the characteristics of the most likely convert to bike-and-ride services. This market profile is readily applicable in many American contexts.[46]

- The trip the individual is taking must be of some length, where fuel and other costs become a factor;
- the trip may involve severe traffic congestion giving rise to unpredictable delays, perceived dangers and considerable irritation;
- There are at least moderate parking problems or costs at the end of the trip;
- The family is, ideally, a single-car family living in an area with infrequent or not easily accessible public transport, so there is pressure for the car to be available for other household members;
- The individual lives more than a 6-7 minute walk from the transit stop or station but no more than a 10-minute bicycle ride away;
- The individual already owns a bicycle and is disposed to cycling; and
- There are no steep hills or serious hazards that the individual would have to negotiate going to and from the station.

Special offers should be tried for new bike-and-ride programs so people can try out the system with little risk or expense for a short period of time. A 2-week trial lease, for example, for bicycle lockers might be offered. Various giveaways can encourage mode change behavior and sometimes attract media attention.

Management and Operations. The management of bicycle parking facilities at transit stops varies widely. In some cities, the transit agency takes the lead; in others, local or State agencies are responsible. Private businesses also play a role in cities in Japan and Europe and are beginning to enter into this market in America. For example, in San Diego, Commuter Computer installs and manages the city's bicycle parking facilities.

The tasks involved in managing bicycle storage facilities depend on the type of parking provided. However, all types of operations must be concerned with maintenance and monitoring of use. While most bicycle racks and lockers are designed for at least a 10-year life, without a responsive maintenance program, minor equipment problems can lead to unused or nonfunctional bicycle parking. The settling of locker pads can cause doors to stick or reduce the security of the enclosure. Unattended drainage problems can cause premature rust-out of equipment. Vandalized bicycle racks can indicate the need for parking relocation. Monitoring of use is important to determine the adequacy of bicycle parking capacity and effectiveness of marketing programs.

Many bicycle parking programs at U.S. transit agencies are run with centralized administration. However, since parking facilities are dispersed, decentralization of some functions could result in more convenient use and more responsive operations. This approach appears to have worked well in Japan, Europe and Australia. In Melbourne, Australia, for example, station attendants can rent lockers to local users, handle minor problems such as lost keys and quickly report maintenance problems to the appropriate office. At locations where no transit staff are based, the Australians are considering delegation of these functions to agents adjacent to the site.

Decentralization may make it much easier to attract new users who are dissatisfied with their current mode of travel but who are not strongly enough committed to the idea of bike-andride to pursue more elaborate procedures for obtaining a bicycle locker or permit. People are often more inclined to talk to a local station agent or shopkeeper than they are to phone or write an impersonal bureaucracy. The management and operation of bike-and-ride programs should seek to reduce artificial barriers to change of behavior and decentralization of certain functions could be very beneficial. Fundamentally, U.S. transit agencies need to cultivate a greater customer-service orientation in their operations and system design, recognizing the need to offer services tailored to the many different potential market niches than exist in metropolitan transportation.

Recommendations for Future Research and Pilot Projects

The integration of bicycles with public transport in the United States has been constrained by many factors, including the lack of information, analysis and evaluation of linkage strategies. Although advances have been made over the past decade, many potentially fruitful measures have yet to be tried or adequately evaluated. Given the promise shown by experiences to date, both in the United States and abroad, there is an immediate need for transit agencies, local and State Governments and U.S. DOT to undertake additional research and pilot projects related to bicycle-transit linkage.

It is important that State and locally sponsored pilot projects related to bicycle-transit linkage include an evaluation to ensure that maximum learning occurs regardless of project success or failure. Evaluation of the Phoenix bike-on-bus demonstration service showed demand and acceptance of the new service far higher than anticipated and helped move the project to an expanded system-wide service.

A general need for research and sharing of technology on transit access exists. Several specific areas that could be most productive include:

- Research and evaluation on factors affecting bike-and-ride demand in the United States, particularly the impacts of local area crime rates, the price of bicycle parking, different parking technologies and improvements in access to route conditions;

- Research and evaluation of marketing techniques for bike-and-ride promotion;

- Research and demonstration of guarded bicycle parking garages, bicycle check-rooms, rental bicycle facilities, and bicycle transportation service centers at rail stations near major suburban employment centers and near major tourist and recreational activity centers;

- Research and evaluation of the effects of comprehensive bicycle-transit integration action programs in metropolitan areas of different sizes, involving both rail and/or bus services. Such programs would include major investments in bicycle parking facilities at rail and bus stops, implementation at widespread stations, selected improvements in station access conditions and multifaceted marketing programs directed to various appropriate market segments; and

- Research and demonstration of enhanced transit access planning and analysis tools that integrate Geographic Information Systems with conventional transportation models.

Conclusions

Improved linkage of bicycles and pedestrians with public transit cannot alone alter the future of American transit services. In all likelihood, it will contribute modestly to the growth or stabilization of U.S. suburban public transport. However, as this report has shown, bicycle and pedestrian linkages open up new opportunities for U.S. transit agencies at low cost in growing markets that have until now been neglected or penetrated only by relying on the more expensive and air pollution-intensive strategy of park-and-ride services.

The problems of urban and suburban congestion, air pollution and demands for cost effective transportation services in the 1990's demand new approaches to transit development and the application of low-cost, locally appropriate strategies to promote better coordination between different transportation modes. Bicycle and pedestrian linkages to transit have an important role to play in this larger context by helping to adapt transit to its modem nemesis, the suburb.

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