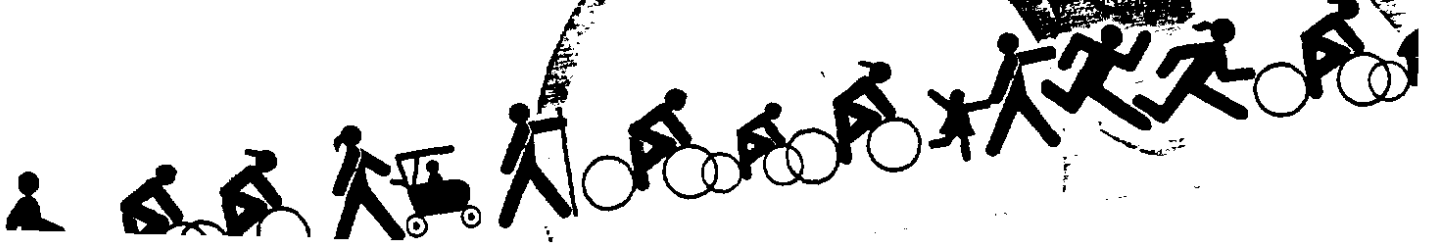
Case Study No. 4

Measures to Overcome Impediments to Bicycling and Walking

National Bicycling And Walking Study

U.S. Department of Transportation
Federal Highway Administration



Foreword

This case study was prepared under contract for the Federal Highway Administration by Gary H. Zehnpfenning and Design Ventures, Inc. with James Cromar and Sara Jane Maclennan.

Notice

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Federal Highway Administration
400 Seventh Street, S.W.
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Executive Summary

A recent analysis of the 1990 National Personal Transportation Survey (NPTS) noted that "between 1969 and 1990, the number of households, drivers, workers, and vehicles grew at a much faster rate than the population."[1] From 1983 to 1990, daily vehicle miles traveled per household increased by nearly 29 percent. This trend confirms the fact that the demand for personal mobility is increasing beyond the ability to accommodate it through new highway construction alone. Increasing the viability of options to the personal automobile is urgent. Public and private interests are becoming more interested in giving more priority to motorized and non-motorized alternatives, including bicycling and walking. Responding to a request from the U.S. Congress, the Federal Highway Administration (FHWA) has initiated the National Bicycling and Walking Study to identify ways to increase the use of these modes as integral parts of the transportation system. This case study is a resource to assist Federal, State and local decision-makers in efforts to increase bicycling and walking. It is a guide to policy, facility, funding, and program initiatives intended to remove barriers to these modes.

The Problem

In recent years, the FHWA has realized that the ability to fund and maintain a growing surface road system cannot keep pace indefinitely with consumer demand. Extensive development of the roadway system has permitted more dispersed land use patterns, generating more vehicle trips, and requiring the construction of more roads. The problem is augmented by Americans' preference for living outside the center city. Historically, the development of transportation technologies in the U.S. tied outlying areas to the center city, and Americans did not have to live within walking distance of downtown. In the 1920's, zoning policies contributed to dispersed settlement and longer trips. Regulations that encouraged the separation of residential and commercial areas were enacted nationally. Since urban areas have been molded by the automobile, many functions once concentrated within walking distance are now accessible only by car.

[1] FHWA, Publication No. FHWA-PL-92-018: *Summary of Travel Trends: 1990 Nationwide Personal Transportation Survey*, (Washington, D.C.: Office of Highway Information Management, March 1992).

Bicycling and Walking: Attributes and Impediments

As nonmotorized modes, walking and bicycling are both superior to automobile travel in terms of energy conservation, physiological and psychological benefits, and environmental cleanliness. They are attractive as a means to moderate roadway congestion, because they use less space on public rights-of-way. In spite of these attributes favoring bicycling and walking as popular transportation choices, neither is as well-used as it should be. Surveys to test the market for increased walking and bicycling have identified several key barriers to greater use of these modes. Some of the most-cited factors are:

Primary Impediments to Walking	**Primary Impediments to Bicycling**
A. Distance (too far)	A. Distance/Time (too far, long, slow)
B. Time (takes too long, too slow)	B. Safety/Traffic/Danger
C. Weather	C. Bad Weather
D. Too Lazy	D. Lack of: Facilities/Bikeways/Parking/Shower
E. Hard to Carry Things	E. Need Car for Work

Concerns about distance and travel time seem to be major impediments to both bicycling and walking. Those factors are related to physical development patterns in the U.S., as well as to the availability and directness of facilities. Concerns about facility inadequacies are more often expressed in surveys dealing with bicycling than with walking.

The complex factors underlying these concerns are not well understood. Most surveys are not able to go beyond the basic public perceptions about the time, distance, and safety issues associated with the bicycling and walking experience. Based on this and the lack of analytical (before and after) field research, the true effectiveness of remedies isn't conclusive. In spite of the incomplete information and sometimes contradictory analysis results, some common conclusions emerge.

An Approach to Solving Bicycling and Walking Problems

This case study is based on an examination of survey results, successful bicycle/pedestrian programs around the country, and comparisons of perceived versus real facility conditions. The surveys do not necessarily accurately identify the underlying impediments. Virtually all the reasons cited for not bicycling or walking seem to have multiple causes within three major interrelated categories: 1) facility deficiencies; 2) information or knowledge deficiencies; and, 3) motivational deficiencies. In developing program improvements, if each impediment is analyzed from the perspective of facility, information or knowledge, and motivational factors, it is easier to accurately understand their full scope, and to develop effective and appropriate solutions.

Practical, cost-effective solutions to bicycling and walking concerns are rarely obvious or straight forward. As a result, there is considerable disagreement about what constitutes a practical, "safe" comprehensive system of bicycle and pedestrian facilities in developed urban

areas. Some facilities that novice bicyclists perceive as safe, such as sidewalks, can be more dangerous than other alternatives. Thus, responsibly removing impediments to bicycling and walking often involves consideration of both the public perception of the problem, and the problem itself. The proper physical solution could actually be contrary to preconceptions.

Removing Impediments to Bicycling

Studies indicate that many impediments to bicycling can be mitigated with strategic capital improvements and operational changes. When people are asked what should be done to improve bicycling, the top responses pertain to facility improvements: safer bicycle facilities, more bicycle paths, more bicycle lanes, safe bicycle parking, shower facilities, more convenient routes, and more direct routes. Clearly, facility improvements to fill gaps in the system, increase the reality and perception of safety, increase convenience, and reduce travel time are a priority. Physical improvements alone are usually not the complete answer. How people perceive and use facilities is important. Lack of information on the effectiveness of specific solutions, such as lane striping, is a handicap for facility planners with tight budgets.

Bicycle Facility Improvements

After assessment of facilities, an implementation strategy is needed to provide a basis for identifying and prioritizing projects. The following are general principles to consider in developing the strategic plan:

- Fill connection gaps in bicycle facilities:
  - provide safer crossings and intersections
  - widen narrow sections of on-street bicycle routes
  - add strategic bridges and underpasses
- Make connections across natural and man-made barriers to connect major trip desire lines
- Provide the most direct routes between activity centers
- Provide bicycle facility alignments that shorten travel time and distance compared to auto travel
- Continually look for ways to optimize the bicycle system
- Remove debris and provide smooth surfaces through regular maintenance
- Ensure that all roads are designed and maintained to accommodate bicyclists, and maximize the number of people within easy cycling distance of jobs, shopping, school, recreation, and entertainment

Only a few types of facility enhancements have actually been tested to determine their success in increasing ridership. From this research, *a reasonable correlation has been found between increased usage and facilities that provide a space for bicyclists to ride out of fast or heavy motor vehicle traffic.* This finding indicates acceptable options, which include:

- off-street paths completely separated from auto traffic
- safely designed on-street bicycle lanes
- wide curb lanes
- low speed/low volume streets
- bicycle connections that fill a gap in the system along a major "desire line"

Sidewalks are not included in this list of bicycle facility options because of documented safety problems.

The major opportunity for practical increases in bicycle access is through improved on-street facilities. Although many people say they need "more bicycle paths," very few opportunities to construct them exist in developed areas, and they are expensive. In established cities, corridors separated from traffic, such as a riverfront, may not be available. Converting an existing street within a traffic grid doesn't provide a separated bicycle path, since riders still have to cross traffic every block.

Bicycle Education and Promotion

Bicycle training programs need to be designed to be attractive and relevant to all bicycling age groups. Good training should be a regular part of every school program, starting in the elementary school. Even if students never become cyclists, they will most likely become drivers and can only benefit from understanding bicyclists' needs. Bicycle training programs should also be established to encourage riders who wish to commute.

Training and promotional programs need to be interwoven with a strong public relations campaign and information resources collection. Without proper public relations, the program is likely to fall short of its mark or even fail because of a lack of public support.

Bicycle Safety & Enforcement

Proper enforcement can make the bicycling experience safer, more pleasurable, and secure for both recreational and utilitarian riding. Information on riding safely and responsibly, and improved enforcement can help bicyclists and motorists function together by teaching them to share the road. It can also help off-street path users, including bicyclists, pedestrians, runners, and in-line skaters, "share the way."

Removing Impediments to Walking

The automobile orientation of the transportation system is a primary disincentive to walking. A realistic national policy for land use could effectively tap the large market of people living within reasonable walking distance of their destination. Physical improvements to make walking safe, convenient, and inviting can be helpful in encouraging greater reliance on walking for commuter and utility trips. Programs to encourage walking, and to make people aware of opportunities to walk as an alternative to driving, are an important companion to facility improvements.

Pedestrian Facility Improvements

Research indicates that the absence or poor quality of facilities is less of a disincentive to walking than it is to bicycling. However, surveys indicate that improvements to pedestrian facilities can be helpful in encouraging more people to walk for commuting and utility trips. Improving existing facilities and locating them where none exist increases the opportunities for walking. The best place for new pedestrian facilities includes places where well-worn dirt paths indicate people currently walk, or places where they would walk if it were possible.

Walking Promotion and Education

Evaluation of educational programs has shown that several programs have reduced accident rates for school-age children. Pedestrian-oriented advertisements, films, pamphlets, recorded messages, and public awareness campaigns provide supplementary reminders of basic traffic laws and educate newcomers or visitors about local conditions.

For most people, pedestrian education begins with parents, relatives, and friends teaching basic pedestrian behavior, such as looking both ways ("Left, right, left") before crossing the street. In the schools, students are presented supplementary materials and programs. Existing programs should be used, allowing for modification and improvement.

Pedestrian Safety & Enforcement Programs

Safety and convenience are cited in surveys as major pedestrian concerns. Unsafe or inconvenient pedestrian facilities around the country discourage pedestrians from following traffic rules. Certain situations are potentially dangerous and need to be prevented, such as mass crossing against the light when cars are present, and people who see other people cross against the light and assume it's safe for them to cross.

Evaluation Needs

The ability to identify effective ways to remove impediments to bicycling and walking has been handicapped by the lack of objective analysis to measure program effectiveness, especially in terms of safety and usage. Few analyses document a correlation between increased safety and ridership, and specific facility or program improvements. An accurate effectiveness evaluation should be an integral part of all major physical and programmatic improvements until there is a better basic understanding of what works and why.

I. Introduction

A. Case Study Context: National Bicycling and Walking Study

The lack of practical, attractive bicycling and walking options in the United States keeps these modes from achieving higher levels of use. Increasing the percentage of bicycling and walking trips can absorb some of the demand being put on the road system, the environment, and fuel supplies. Greater reliance on walking and bicycling can help improve the quality of life in neighborhoods by reducing traffic and encouraging more sensible land use patterns. Close examination of effective measures to remove impediments makes it possible to develop strategies to increase bicycling and walking. To foster this increase in the most responsible manner, there is a parallel need to ensure new users can enjoy them as safely as possible.

Walking and bicycling are dependable nonmotorized options available to most commuters and travelers as primary or secondary modes. Like the automobile, they provide a high degree of independence, flexibility, and freedom of choice relative to schedule and destination.[1]

Numerous surveys have noted that people would like to be able to bicycle or walk more often for commuting, recreation, or shopping. However, public and private institutional policies continue to promote land use and transportation patterns that perpetuate physical and programmatic impediments to bicycling and walking. To stimulate bicycling and walking, national and local attention must focus on the factors that influence the decision to walk or bicycle. These factors include concern for safety, lack of familiarity with routes, lack of adequate bicycling facilities, and difficulty with showering and clothing logistics.

In recent years, the Federal Highway Administration (FHWA) has realized that its ability to fund and maintain an ever-expanding surface road network cannot keep pace with the constant demand for more roads. Construction funding for the infrastructure needed to accommodate escalating vehicle trips is difficult to obtain. Adequately maintaining existing facilities is becoming more difficult. "In 1988, a California Department of Transportation Study concluded

[1]Arlene Edythe Tjart, "A Look at Changing Transportation Behavior: An Approach to Increasing Commuter Bicycle Transportation," (M.S. thesis. Denver: University of Colorado, Denver, 1980), 52.

that neither a $61 billion road building program, nor any further road building, could solve its traffic problem."[2]

B. Combination of Modal Options

This study points out the ineffectiveness of bicycle and pedestrian systems in this country, resulting from the low priority historically given them compared with automobile and transit systems. A clear understanding of the impediments to bicycling and walking and how to remove them is lacking. In response, the Federal Government must lead States and municipalities in developing programs to maximize the effectiveness of all transportation modes, thus making all practical modal choices available to the traveling public. The FHWA, through the "National Bicycling and Walking Study," is seeking ways to increase the use of these two modes as integral components of the transportation system. A combination of approaches, each operating in the best way possible, is the key to tempering and responding to travel demand now and in the future. At this point, no single mode should be relied upon to satisfy demand, and no single mode should dominate and preclude the safe use of others.

Transit, carpooling, and other motorized alternatives to the single occupant vehicle (SOV) trip are part of the formula for transportation choices. They are efficient ways to accommodate mobility needs, primarily utilizing existing infrastructure. These alternatives are often well-used and may reduce congestion, pollution, and energy use. However, carpools and transit offer less privacy, choice, and spontaneity than driving, bicycling, or walking.

Transit is an important and integral part of the entire transportation system, even though it is expensive and highly subsidized. With the assistance of the Federal Government, many locales have substantial transit infrastructure and capacity. Transit agencies, city governments, and councils of government have been working to maintain and even increase their ridership base. Transit use is a popular option in most cities (but is declining in some cases). Unlike bicycling and walking, most transit vehicles consume significant amounts of fossil fuel and produce exhaust emissions contributing to pollution.

Shared use of vehicles, as in carpooling, vanpooling, and paratransit, represents an opportunity to decrease SOV trips in areas where population density is too low for conventional transit. Most nonurban and many suburban residential neighborhoods fit this category. Carpooling is an efficient alternative because it generally uses existing, unused interior vehicle space and road space to accommodate people and trips previously accommodated in several vehicles. Carpools remove vehicles from the road. Unlike transit, carpools do not require the purchase of special vehicles. Since they have fewer occupants (usually geographically selected) carpools and vanpools can provide door-to-door service with few stops. Carpools often have pre-designated schedules for groups of people, thus offering less freedom of choice and privacy than

[2]Marcia D. Lowe, *The Bicycle: Vehicle for a Small Planet—Worldwatch Paper 90* (Washington, D.C.: Worldwatch Institute, September 1989), 18.

bicycling and walking. However, carpools do not offer a choice of departure times. Carpools, vanpools, and paratransit vehicles consume fossil fuel and produce exhaust emissions, contributing to pollution.

C. Purpose of the Case Study

This study's scope includes bicycling and walking for all purposes, with an emphasis on commuter and utilitarian trips. The greatest congestion and environmental problems occur during peak commuter periods. Therefore, bicycle and pedestrian commuting present the greatest opportunity to reduce vehicle miles traveled. Daytime walking and bicycling trips lessen the need for a car at work. Thus it is easier to commute by means other than driving alone.

This case study, "Measures To Overcome Impediments To Bicycling and Walking," is designed as a resource to assist policymakers, facility planners, and public officials in developing programs to make these modes more accessible to the general public. This study represents a compilation of research to identify and remove impediments to bicycling and walking. Findings are based on a detailed analysis of these relevant written studies, surveys, and reports, plus original surveys of several existing programs. The primary goals of this study are to:

1. present a single source summary of the safety and effectiveness of program and facility improvements;

2. determine the relative merits and deficiencies of specific improvements;

3. develop a set of strategic program philosophies based on objective and subjective assessments of critical issues in the decision to use or not use these modes;

4. provide guidance to decisionmakers and planners in developing more cost effective tools for removing impediments to increased bicycling and walking; and,

5. identify methods to induce State and local governments to objectively evaluate future improvements.

Recreational bicycling and walking are already popular in most cities. A recent survey in Seattle, which has one of the highest walking and bicycling rates for a major city in the U.S., asked "active bicyclists" (people who bicycle regularly) and "active walkers" (people who walk regularly) their trip purposes when using these modes. The percentages were extremely low for commuting when compared to recreational trips. Specifically, around 90 percent of active bicyclists ride for recreational trips, while only about 14 percent commute to work by bicycle. Respondents were allowed to select more than one trip purpose since some people bicycle for several trip purposes. The results of the Seattle survey disclose a similar emphasis on walking for recreational trips rather than commute trips. A high percentage walked for errands and personal business.

TRIP PURPOSES OF ACTIVE BICYCLISTS AND WALKERS[3]

	USE BICYCLE FOR TRIP	WALK FOR TRIP
Commute Trips	14.3%	6.7%
Recreation Trips	90.8%	78.0%
Utility Trips	21.1%	n/a
Errands/Personal Business	n/a	81.0%

While the emphasis of this case study is on commuter and utility trips, recreational walking and bicycling are not neglected. This study will be useful in developing safe, attractive pedestrian and bicycle improvement programs, regardless of trip purpose.

[3]Cy Ulberg, *Psychological Aspects of Mode Choice* (Washington State Department of Transportation: December 1989).

II. Historical Roots of the Problem

Statistics show that Americans prefer their automobiles to all other forms of transportation. Only in rare cases do alternative modes of transportation carry more than a small percentage of all trips. To better understand why walking and bicycling are not more prevalent in the United States, it is necessary to understand the development patterns of American urban areas.

Historically, cities in the United States grew in large part because of immigration from both foreign lands and rural areas. Cities were the economic magnets where opportunities were most plentiful. While each wave of urban immigration contributed to the form of American cities, the British influence was the earliest and most significant in its effect on American urban development.

Kenneth T. Jackson, in his book *Crabgrass Frontier*, wrote of "an Anglo-American culture that had never placed a high value on city life."[4] City dwelling was seen as undesirable due to noise, overcrowding, and poor health conditions. The prevailing image of urban neighborhoods was one of immorality and vice, where one found people of lower character. Racial and ethnic fears were heightened as new immigrant groups introduced different languages and customs. Even Thomas Jefferson, who greatly influenced American thought, said, "I view large cities as pestilential to the morals, the health and the liberties of man."[5]

> *Unlike the major cities of Europe, South America, and Asia, America's metropolises [of the 19th century] were centers of manufacture. Industry in the steam era, when railroads offered the best method for shipping, tended to concentrate as close to the distribution points as possible. Smokestacks belched soot into the air of every city, and nearby sections soon turned to slums. No one with options wanted to live in close proximity to important rail lines or to heavy industry. . . . As cities became larger, noisier, and more fearsome, the specter of danger replaced the earlier notion of the city as refuge.*[6]

The rapid development of transportation technologies tied outlying areas to the downtowns, and Americans no longer had to live within walking distance of the workplace. Many looked

[4]Jackson, *Crabgrass Frontier*, 68.

[5]Cited by Jackson, *Crabgrass Frontier*, 68.

[6]Jackson, *Crabgrass Frontier*, 69.

for alternatives to city dwelling. Commuter railroads and streetcars, as well as horses and private carriages, allowed first the wealthy and then the middle class to flee the city while maintaining access to employment, shopping, and cultural facilities. Urban housing arrangements were seen as temporary, to be tolerated until funds were available to move to a suburban area. "The suburban ideal offered the promise of an environment . . . that would combine the best of both city and rural life."[7]

> *Suburbia, pure and unfettered and bathed by sunlight and fresh air, offered the exciting prospect that disorder, prostitution, and mayhem could be kept at a distance, far away in the festering metropolis.*[8]

Suburban life did not necessarily remove one from city boundaries. Many residential developments sought inclusion to the city, often for the provision of city services. A prime motivation for "moving out" was to escape the higher densities and overcrowding of the inner city. The less dense character of suburban development was more desirable.

In the 1920's, zoning regulations that encouraged the complete separation of residential areas from commercial were enacted across the nation. The functions of the city were defined and separated. New development would be built according to new principles, and would therefore run more efficiently, like a machine.

> *The notion of city as machine, which is now rigidly enforced in the United States through impenetrable layers of zoning codes, relentlessly and single-mindedly separates the old from the young, the rich from the poor, apartments from town houses, and factories from offices, until the city is so sprawled out that such simple everyday tasks as getting a haircut, browsing for a novel, and picking up a half-gallon of milk require three separate automobile trips.*
>
> *According to city-as-machine thinking, all these separate activities would be easily accessible by high-speed freeways, and every citizen would be mobile and independent in his or her private automobile. The machine model of cities promised efficiency, convenience, and the tidy clarity of everything having its own place.*[9]

After World War II, traditional American downtowns lost their place as the center of the community. The pent-up demand for housing fueled the unprecedented growth of suburban housing. Shopping soon followed the outward trend, followed by major corporations and employment. The automobile-orientation of the new developments encouraged greater distances between destinations, which dispersed the urban areas even more, and made the automobile a necessity.

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[7]Jackson, *Crabgrass Frontier*, 72.

[8]Jackson, *Crabgrass Frontier*, 70.

[9]Robert Gerloff, "Rediscovering the Village," Utne Reader, 51 (May/June 1992), 94.

The automobile which was supposed to decrease the effects of time and distance now often accomplishes neither.

> *The layout of a city helps determine whether or not . . . transport options [public transport, walking, bicycling] are appropriate or even feasible. Many urban areas are designed around the automobile, with planners using road building to combat the inevitable traffic congestion. The result is a treadmill effect in which new roads fill to capacity as soon as they are completed. . . . Instead of further catering to autos, cities can step off the road building treadmill by changing land use patterns to reduce the need for driving. . . Australian researchers Peter Newman and Jeffrey Kenworthy found that low urban densities (fewer than 40 people and jobs per hectare of land) and dependence on the automobile go hand-in-hand.*[10]

A major deterrent to walking and bicycling is alluded to in Joel Garreau's exploration of suburban office development, *Edge City: Life on the New Frontier.*

> *Already, two thirds of all American office facilities are in Edge Cities (outside the traditional downtowns), and 80 percent of them have materialized in only the last two decades. . . . Most of the trips metropolitan Americans take in a day completely skirt the old centers. Their journeys to work, especially, are to Edge Cities.*[11]

The soot-belching factories that dirtied the American cities of the industrial age have been replaced by the late 20th-century office buildings housing the information and service industries that drive the economy.[12] The anti-city forces ingrained in the American culture are satisfied by the location of the new "information factories" outside of the old city centers, closer to the suburban housing so prevalent in the American landscape.

The most practical way to get around these Edge Cities is by automobile. The vast parking lots surrounding the buildings encourage driving by providing automobile storage, and increasing the distance between buildings. The absence of pedestrian facilities and the distance between buildings discourage walking. Mass transit is also more difficult to get to and to use.

Garreau makes a correlation between the growth of suburban office parks and the increasing number of women in the workplace. Since the late 1970's, American women have been joining the ranks of paid employees in record numbers. Correspondingly, in the past 15 years, the number of automobiles in the United States doubled while the population grew only at a 1 percent annual rate. Because of the needs of the dual-income family, convenience has

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[10]Marcia D. Lowe, *Alternatives to the Automobile: Transport for Liveable Cities—Worldwatch Paper 98* (Washington, D.C.: Worldwatch Institute, October 1990), 26-27.

[11]Joel Garreau, *Edge City: Life on the New Frontier* (New York: Doubleday, 1991), 5.

[12]Garreau, *Edge City.*

gained greater importance as a factor influencing the choice of transportation mode for commuting. This has created a greater sense of dependence on the automobile.[13]

> *Suburbanization cannot simply be reversed. But suburbs are most vulnerable to any future oil shortages or restraints on auto use that may be taken to curb pollution. If these communities are to enhance their future viability, they need to become more self-contained—that is, to evolve into subcenters that may be less urban in character than traditional cities, but more compact than they currently are. In the United States, even though suburbanization continues at an unhealthy pace, some town designers and developers are rejecting the dominant suburban-style residential areas in favor of a 'neotraditionalist' approach of creating more urbane, walkable communities that encourage sociability and a less frantic way of living.*[14]

Renewed emphasis on quality-of-life issues adds impetus to the need to improve the range of transportation options. The growing realization that the national road system is nearing capacity levels in many areas contributes to the need to remove impediments to bicycling and walking.

[13]Garreau, *Edge City*, 111-113.

[14]Michael Renner, *Rethinking the Role of the Automobile—Worldwatch Paper 84*, (Washington, D.C.: Worldwatch Institute, June 1988), 52.

III. Identification of Impediments to Bicycling and Walking

Concerns about safety, travel time, and distance are generally accepted as major impediments preventing or discouraging people from bicycling and walking. The effect of these apparently obvious factors, along with several other commonly cited barriers, is difficult to measure or prioritize. A definitive basis to evaluate responses to types of improvements does not exist, because there are no good domestic "before and after" evaluations measuring their effect. Evaluations that have been done are usually incomplete, or the results are contradictory or inconclusive. A clear correlation between specific improvements and increased bicycling and walking has not been established, although some analytical relationships have been drawn between improved facilities and increased bicycling and walking.

An excellent investigation to identify the primary factors influencing people's decisions to walk or bicycle is contained in FHWA Publication No. FHWA-PD-92-041, *Reasons Why Bicycling and Walking Are and Are Not Being Used More Extensively as Travel Modes.*[15] This comprehensive analysis of potential motivations, disincentives, and behavior associated with facility variables is a valuable resource to the transportation community. In spite of his insightful examination of known information on factors influencing use of these modes, Case Study No. 1 identified only a few limited relationships between usage levels and types of improvements.

Bicycle-Related Impediments and Attributes

Bicycle users value the advantages of bicycling. Like the automobile, the bicycle is a personal vehicle offering individual choice of route and travel schedule. It does not require the user to share the trip with others, and it provides a degree of personal privacy not found in public transit or carpools. "Bicycles are also popular because, like cars in industrial countries, they offer the luxury of individual mobility and door-to-door travel, without detours or extra stops for other passengers."[16] It rivals average automobile travel time for most intra-urban trips. As a nonmotorized mode, it is superior to automobile travel in terms of energy conservation, physiological and psychological benefits, and environmental cleanliness.

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[15]FHWA Publication No. FHWA-PD-92-041, The National Bicycling and Walking Case Study No. 1: *Reasons Why Bicycling and Walking Are and Are Not Being Used More Extensively as Travel Modes* (Washington, D.C., 1993).

[16]Lowe, *The Bicycle*, 8.

In spite of these significant advantages, a broad range of real and perceived impediments discourage most people from bicycling regularly. Surveys and speculations have tried to determine why people don't bicycle more. A few reasons why people consistently say they don't ride are:

A. Distance and time
B. Safety concerns
C. Weather
D. Lack of facilities: bikeways/parking/showers

In addition to the primary impediments already cited, dozens of underlying problems deter people from bicycling. A comprehensive list of impediments to bicycling can be found in the appendix located at the end of this case study. The study's comprehensive examination of preference surveys produced throughout the country was consistent with the general findings cited below.

Percent Active Bicyclists Citing Following Reasons For Not Bicycle Commuting[17]

REASON	Phoenix	Seattle	Portland	Orange County
Too far to ride	31%	41%	21%	45%
Too dangerous	19%	22%	12%	n/a
Lack of facilities	17%	15%	12%	n/a
Need car for work	14%	8%	n/a	7%
Inconvenient	6%	8%	17%	4%
Weather	n/a	11%	7%	n/a

> *Faced with riding a fixed distance, under time constraints and work requirements, with road conditions far from ideal for the majority, most riders opt out of bicycle commuting. . . . All in all, available survey data point to one clear fact: with a few notable exceptions, bicycle commuting continues to play a minor role in the commuter transportation scheme. Only 1 in 60 Americans use their bicycles to get to work.*[18]

Several surveys have explored important factors in choosing a commute mode. Probably the most exhaustive, in-depth study is *Feasibility of Demand Incentives for Nonmotorized Transportation*,[19] based on a comprehensive 16-18 page questionnaire designed to identify

[17]FHWA Case Study No. 1, *Reasons*, 20.

[18]FHWA Case Study No. 1, *Reasons*, 21.

[19]*Feasibility of Demand Incentives for Nonmotorized Transportation*, FHWA-RD-80-048, (Washington, D.C.: U.S. Department of Transportation, 1980).

motivations for use of alternative modes. Of the factors mentioned in the survey, the provision of a more compact land use pattern (reducing commute distance to under 2 miles) produces the highest potential for increased bicycling and walking, and decreased automobile use. The analysis noted, "Separate facilities play an important role in people's preference of nonmotorized modes, second only to compact land use. . . .Facilities can play a prominent role in increasing nonmotorized travel, particularly if they are provided in the context of compact land use configurations."[20]

A contemporary analysis of factors influencing bicycle use is *Bicycling Magazine*'s Harris Poll on Bicycle Commuting.[21] It provided optimistic indications of the potential to increase ridership through facility improvements and incentives. Many large towns and cities have done their own surveys and have shown mixed results but some common trends.

Distance is the most common reason people claim they don't walk or bicycle. Survey results in *Feasibility of Demand Incentives for Nonmotorized Transportation* claimed that up to 33 percent (currently 7 percent) of the respondents would bicycle commute if development patterns changed so that respondents lived within a 2-mile commuting distance from work.[22] Based on the survey, decreasing distance would have the greatest single effect on the number of people bicycling or walking. One must note that the distance people claim as a reasonable walking or bicycling distance is not necessarily the distance they are willing to walk or ride.

Even though the emphasis of the survey condition statement was on reduced commuting distances, it also included provisions for improved bicycle and pedestrian facilities. Improving bicycle facilities was predicted to boost usage to 18 percent. However, other surveys and case studies indicate that there is a great difference between what people speculate they will do based on certain improvements, and what they actually do.

Concerns about the danger and unsafe quality of bicycle riding is voiced as a frequent and major impediment to greater usage. Statistics on bicycle/automobile accidents generally support this concern as being valid. Studies here and in Europe show that riding a bicycle can be from 3.5 to 10 times as dangerous as driving a car.[23] Both the risk and fear of the risk can be reduced through a combination of facility improvements, rider training, and public education.

> *Studies show that experienced club bicyclists and bicycle tourists are clearly much less likely on a per mile basis to be involved in a bicycle accident of any type than are children or the average untrained adult cyclist, despite (or maybe because of) the fact their exposure is much greater than average. There is a*

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[20]*Feasibility*, 3-5.

[21]Bicycling Magazine, *A Trend on the Move: Commuting by Bicycle—Special Media Report*, (Emmaus, PA: Rodale Press, 1991).

[22]*Feasibility*.

[23]Michael Everett and John Spencer, "Empirical Evidence on Determinants of Mass Bicycle Commuting in the United States: A Cross-Community Analysis," *Transportation Research Record 912*, (Washington, D.C., 1983).

> *higher accident rate for bicyclists traveling on bike paths than on roadways and the rates are higher on major arterials than on local streets and minor arterial roadways.*[24]

Virtually all of the surveys offered general choices, and many results contradicted each other. None of the surveys provided sufficient insight to identify underlying causes and provide a basis for actual problem-solving. The surveys helped identify perceived impediments and gave general direction about causes for not riding, but they were often not useful in determining actual problems because many nonbicyclists were surveyed. Even so, this information is still useful because perceived problems must be addressed as much as real ones.

Walking-Related Impediments and Attributes

Walking seems to be more prevalent than bicycling for both recreational and utilitarian purposes. "Limited survey data suggests that there are more than twice as many utilitarian walkers as there are bicyclists."[25] In fact, census figures indicate that about 5.3 percent of the population regularly walks to work, compared to 1.4 percent who bicycle to work.[26] Additionally, almost everybody is a pedestrian at some time. Walking is part of virtually every trip, regardless of the primary mode of transportation, and can be regarded as supplemental, rather than alternative, as is generally the case with bicycles.

Walking offers several advantages that make it a popular alternative transportation mode. It is a natural physiologic function and requires minimal special equipment. Therefore, inducing people to commute by foot is more a question of increasing and confirming the exercise of an already-used mode. Like bicycling, walking offers a great deal of personal choice of departure times and routes. In most cases, walking also provides a degree of personal privacy, direct door-to-door travel, and freedom from having to abide by set schedules and routes. As a nonmotorized mode, walking is superior to automobile travel in terms of energy conservation, physiological and psychological benefits, and environmental cleanliness.

Despite these advantages, many real and perceived impediments discourage walking as a primary mode for commuter and utility trips. Surveys to test the market for increased walking have identified several key impediments. The section of FHWA Case Study No. 1 concerned with investigating reasons why people don't choose to walk includes a good summary of recent surveys on this issue.[27]

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[24]New Jersey Bicycle Advisory Council, *New Jersey Bicycle Advisory Council Report on Bicycling in New Jersey: Findings and Recommendations*, (Trenton, NJ: New Jersey Department of Transportation, 1987), 21.

[25]FHWA Case Study No. 1, *Reasons*, 29.

[26]1980 U.S. Census Journey to Work data, (December 1980). Note: Census information was collected in March, which is not a peak period for walking or bicycling.

[27]FHWA Case Study No. 1, *Reasons*, 27. (Parenthesized figures pertain specifically to work commute.)

Reasons for Not Walking	Seattle	Toronto	Ottawa
Distance	33.0%	47% (45%)	56% (43%)
Too slow; takes too long	14.0%	12% (26%)	14% (24%)
Weather	8.7%		
Dislike walking; lazy	6.4%		
Difficult to carry things	5.7%	50%	48%
Inconvenient	5.7%		
Fear of crime	3.3%		
No time	2.0%		
Darkness	1.7%		
No sidewalks	1.3%		

Factors associated with commute length and travel time are clearly the major reasons stated against walking. Together, distance and time factors account for almost half the objections. Wendy Hawthorne said, "The most common reasons people cite for not walking to work are that they 'live too far away' and 'walking takes too much time.'"[28]

Facility-related issues are noted as less important reasons for not walking. Case Study No. 1 found that "although a number of people thought certain enhancements to the pedestrian environment might induce more walking or make it more appealing, few identified the lack of such amenities as a personal disincentive for walking more often."[29]

The results of *Feasibility of Demand Incentives for Nonmotorized Transportation* also support the perception that distance is the most common reason people don't walk. Approximately 34 percent of the respondents said they would walk to work if development were made more compact (work trips of 2 miles or less). However, the study also indicated that improving pedestrian facilities alone might increase commuter walking to a 30 percent level.[30]

The absence of safe, direct pedestrian links between and within major activity centers is a deterrent to increased walking. Gaps in the pedestrian system or circuitous routes can make trip distances appear greater. Facilities that don't reinforce the rights of pedestrians at intersections are a primary impediment to walking and are a safety problem. Thus, the problem of inadequate facilities requires individual solutions based on local conditions.

[28]Wendy Hawthorne, *Why Ontarians Walk, Why Ontarians Don't Walk More: A Study into the Walking Habits of Ontarians*, (Toronto: Energy Probe Research Foundation, June 1989), 4.

[29]Case Study No. 1, *Reasons*, 29.

[30]*Feasibility*, 54.

IV. Deficiencies in Measured and Predicted Success

Current sources on facility and program improvements, usage patterns, travel preference surveys, models for removing impediments, demographics, and case studies do not lend themselves to developing successful policies for bicycling and walking. Very little research offers controlled analysis of program effectiveness or user needs. "In short, there is little information that helps in assessing the market for utilitarian cycling or in designing effective strategies for shifting travelers to the bicycle mode."[31] However, rationally reconciling and integrating diverse perspectives from several studies helps identify a comprehensive set of strategies and a philosophical approach for removing impediments.

This case study is based on an examination of survey results, successful bicycle and pedestrian programs around the country, and comparisons of perceived versus real facilities. Stated impediments to bicycling and walking are not necessarily the real impediments. Reasons for not bicycling, for example, do not translate directly to a list of improvements that would increase bicycle usage. All reasons cited for not bicycling or walking seem to have multiple causes within three major categories:

1) facility deficiencies;
2) information or knowledge deficiencies; and
3) motivational deficiencies.

It is easier to determine the exact problem if each perceived impediment is analyzed from the perspective that it is caused by a combination of these three factors. Since impediments are multifaceted, solutions should tap the appropriate responses from the three categories. If the situation is defined this way, appropriate solutions are more likely.

Quantitative Effectiveness Evaluations

Of the many improvements in bicycle and pedestrian systems made every year, only a few have been evaluated to determine if they fulfill the purposes for which they were intended. Few increases in bicycling are scientifically correlated with specific facility or program improvements. Almost none of these have been measured in a truly objective "before and after" manner. Lack

[31]Elizabeth A. Deakin, *Utilitarian Cycling: A Case Study of the Bay Area and Assessment of the Market for Commute Cycling*, (Berkeley, CA: Institute of Transportation Studies, University of California, 1985), 4.

of funding is the most common reason given for not objectively evaluating improvements, although this information could ensure that the facility improvements that are funded have proven to be effective.

In the few instances where there was reasonable quantitative analysis, basic facility and training programs have shown indications of attracting new users and promoting safety. (Improvement options arising from this research are discussed in Parts VII and X of this case study.) Very few promotion or enforcement programs have been evaluated.

Public Opinion Surveys

The numerous public preference surveys designed to determine motivations to increased bicycling and walking are of limited value. Many of the findings from these surveys contradict each other or exaggerate the effects of potential improvements. Commonly, the surveys describe various improvements, and then ask respondents if these changes would influence their modal choice. This approach often yields unrealistically high numbers of people claiming they would be willing to ride or walk if one or all of the program improvements were implemented.

Bicycling Magazine provided an example where only half of the expected increase in ridership was achieved. "In the '70s, Madison, Wisconsin, surveyed its residents and found that 21 percent would ride to work if there were better facilities. So special lanes and paths were provided, and the share of bikes in traffic rose from 4 percent to 11 percent."[32]

The reliability of survey results predicting bicycle ridership levels of 20 percent or more is questionable when compared with ridership levels in cities that have the facilities, programs, and land use patterns suggested in the surveys. In fact, actual bicycle commuter mode shares are well under 5 percent in *major* cities regarded as already having good programs:

Tucson, AZ:	3.5%
Phoenix, AZ:	2.4%
Seattle, WA:	2.3%
Portland, OR:	2.0%[33]

With the sole exception of Davis, CA (25 percent share), which has strict disincentives to on-campus automobile use, even the college towns located in smaller cities with "model" facilities and programs (such as Madison, WI; Gainesville, FL; Boulder, CO; and Eugene, OR) have bicycle commute mode shares of 11 percent or less. In most cities, the proportion of commuters who regularly bicycle to work is under 1 percent.

[32]Bicycling Magazine, *Media Report*, 20.

[33]Case Study No. 1, *Reasons*, 82.

Surveys that imply a cause/effect relationship between bicycling and walking, and improved facilities can be misleading. *Bicycling Magazine*'s Harris Poll on Bicycle Commuting is a good source for identifying the *relative* importance of popular types of bicycling improvements. However, in response to a question asked of occasional bicyclists (who had ridden a bicycle at least once during the last year), nearly 50 percent said they would sometimes bicycle commute if "there were safe bike lanes on roads and highways." About 45 percent said they would commute by bicycle based on employers providing financial incentives, 43 percent if showers and secure parking were provided, and 38 percent if gas prices continued to increase.[34]

All the stated choices in this and most other questionnaires are incentives external to the bicyclist. None of the choices included remedies to personally assist bicyclists to better prepare *themselves* for bicycling. Options, such as training for safe bicycling, tips on bicycle commuting, suggestions on finding or creating safe bicycle parking, and advice on selecting equipment for safer, more confident riding in urban conditions, were not among the choices.

The study's comprehensive survey[35] also generated potential user figures higher than currently exist in any city in the U.S. with the exception of Davis, CA. The survey concluded that:

- if pedestrian facilities were improved, 15-20 percent would walk;
- if bicycle facilities were improved, 15-20 percent would bicycle;
- if land uses were more compact, 30 percent would walk or bicycle; and,
- if drivers were charged a $2.00 congestion fee, automobile trips would decline by 35 percent.

There are many problems with improvement conditioned nonmotorized market survey results if they are represented as reliable estimates of potential increases in bicycling and walking. First, many people are predisposed to base their responses on "doing the right thing" for the environment, for conservation, and for reasons of conscience, especially if it actually costs nothing. They want to convey that they don't walk or bicycle more because of reasons purely external to themselves, such as facility problems, bad weather, distance, inadequate parking, etc. Seemingly to accommodate this mindset, surveys usually offer choices that are predominantly oriented to facility development. The choices are not insightful, and tend to be general rather than probing.

Finally, most survey participants are not experienced bicyclists. Their opinions are important since they are the primary new market for bicycle commuting. However, "the hazards new bicyclists perceive are usually not the real hazards they encounter on the road."[36] Although the perceptions of potential bicyclists may prove to be different than the realities they experience

[34]Bicycling Magazine, *Media Report.*

[35]*Feasibility.*

[36]John Forester, telephone interview, June 19, 1992.

as bicyclists, these perceptions must be dealt with if these potential bicyclists are ever to become actual bicyclists.

Thus, the results of general population surveys must be analyzed with the clear understanding that the results indicate perceived and not necessarily real impediments to potential users. Likewise, survey results can be important in assigning relative importance to perceived impediments, but should not be relied upon to guide actual facility and program specifics.

An analytical basis to evaluate the success of improvements is urgently needed as a companion to bicycle and pedestrian market surveys. Methodically testing the success of all classes of physical and programmatic improvements will provide a basis to cross-check and calibrate survey findings, making surveys more relevant as tools for bicycle and pedestrian program policy decisions.

V. Identification of Significant Factors in Bicycle Usage

Numerous surveys indicate the set of factors significant in the decision to ride for recreation are different from the deciding factors of commuting and utilitarian bicycling. Recreational riders are primarily concerned with exercise, pleasure and enjoyment, the environment, and lastly, cost.[37] The primary factors in the decision to bicycle commute are travel time, distance, safety, work requirements, and other practical factors. "Cyclists want to use the shortest, most direct route for 'transportation' cycling."[38] Based on reactions to program improvements in several American cities, such as Eugene and Portland, OR, Missoula, MT, Seattle, and Denver, the following factors appear to be the major determinants of commuter bicycling:

- Distance to the destination/travel time
- Route directness and system coverage
- Safety
- Secure parking
- Destination facilities: clothing logistics, showers, on-site parking, etc.
- Predisposition to try it/make it work
- Driver attitude
- Day trip/errand convenience[39]

> *Those things most widely associated with bicycling—exercise, recreation, and environmental protection—are far from the minds of most commuters. Conversely, the things which inspire commuters in their mode selection—travel time, convenience, the need for a car during the day—are not advantages ordinarily associated with bicycles.*[40]

Either people do not see bicycling as a viable commute option, or they regard it as inappropriate for a variety of personal, institutional, or facility-related reasons. Since the bicycle can be appropriate for a number of reasons involved in the commute decision—convenience, travel time comparable with a car for many commuters, flexibility—educational programs and

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[37]Case Study No. 1, *Reasons*, 18.

[38]Florida Department of Transportation, *Bicycle Sketch Plan* (July 1989).

[39]Design Ventures, Inc., *Montgomery County Growth Policy Study—Interim Report*, (Denver: 1989).

[40]Case Study No. 1, *Reasons*, 19.

personal training directed at commuters living within a reasonable bicycling distance offer tremendous opportunities. Other deterrents, such as traffic safety concerns, parking, and road conditions must be addressed. Occasional bicycle riders indicate similar concerns, but give added priority to trip distance.

The responses from a survey in Phoenix, where 2.4 percent commute by bicycle, are typical.

REASON RESPONDENT NEVER RIDES A BICYCLE TO WORK[41]
[Sample Base = the 63 percent of bicyclists who never ride a bicycle to work]

REASON	PERCENTAGE
Too far to ride	31%
Too dangerous	19%
Lack of facilities	17%
Need car for business	14%
Inconvenient	6%
Work at home	4%
Other	6%
Don't know	1%

The numerous surveys produced are very useful in disclosing the general concerns perceived as impediments to bicycling. These same surveys, however, are not very helpful in identifying underlying causes and solutions behind these concerns. What appears to be an educational issue may in fact be a facility issue or vice-versa. The choices surveys offer are often not sufficiently specific or candid to provide a reliable basis to identify improvements needed.

Based on virtually all the surveys, direct, safe, and convenient physical bicycle facilities are important to increased ridership. Summarizing the results of extensive surveys and available analytical studies, Case Study No. 1 noted, "Removing perceptions of danger and lack of good routes is fundamental to tapping the existing potential of bicycling. If bicycling facilities are designed to allay safety concerns and are linked in such a way that access matches the access motorists have come to expect, then utilitarian bicycling will increase."[42]

When facilities are provided for the purpose of attracting new riders, they must be safe. Documented information demonstrates such facilities are associated with higher levels of bicycling. Michael Everett identified a correlation at 200 school locations between facilities that allowed bicyclists to ride out of direct, high-speed automobile traffic, and increased bicycling.[43]

[41]O'Neil Associates, *An Evaluation of the Clean Air Force "Don't Drive One-in-Five" Campaign* (Maricopa County-Phoenix RPTA, 1991), 39.

[42]Case Study No. 1, *Reasons*, 3.

[43]Everett and Spencer, "Empirical Evidence."

Many prospective bicyclists say they consider striping bicycle lanes to be an inducement because they regard them as being safer.

The effect of facility improvements is increased when combined with training and promotion. Based on surveys of experienced bicyclists, the manner in which facilities are used and perceptions of the experience are important to ridership levels and personal safety. A recent bicycle user survey in Denver determined that to improve bicycling, the priority of serious bicyclists is to provide better training and educational programs.[44] Training and education to prepare bicyclists to use on- and off-street facilities safely, efficiently, and enjoyably is an often neglected companion to the provision of discrete facilities and support systems. If training is available, it should be provided in a format that is concise, practical, and requires only a small amount of time.

Successful Approaches: Significant Factors from Case Studies

As noted previously, of the many bicycle improvements, some have been examined subjectively and only a few have been evaluated objectively. Included among those domestic studies of use in evaluating and recommending improvements are an evaluation of facility improvements in Madison, WI, the Anderson Road project in Davis, CA, a study of a training program used by League of American Wheelmen members, Michael Everett's evaluation of a class of physical improvements, and two improvement correlation analyses in Case Study No. 1, *Reasons Why Bicycling and Walking Are and Are Not Being Used More Extensively as Travel Modes.*

Madison, WI

A number of physical facility and support program improvements in the central area of Madison were credited with increasing the city's commute bicycling ridership from 4 percent to 11 percent during the 1970's.[45] These projects included the provision of additional width for bicycles on three major downtown streets, and several lane striping projects.[46]

The documented Madison projects involved some form of bicycle lane. They were located on University Avenue, Gorham Street, and Johnson Street. University Avenue improvements involved the conversion of a designated bus lane to two discrete bicycle lanes. Bicyclists previously had to weave in and out of bus traffic. This project is considered an overall success except for a temporary increase in the number of accidents. In the first year of operation,

[44]*City of Denver Bicycle Master Plan Survey* (1991).

[45]Bicycling Magazine, *Media Report*, 20.

[46]Tom Walsh, telephone interview, June 5, 1992.

there was a 34 percent increase in intersection accidents on Johnson Street attributed to initial, short-term user confusion with a "left side" bicycle lane.[47]

Davis, CA

The Anderson Road bikeway study in Davis, CA, was originally intended as an evaluation of the effectiveness of new bicycle lane striping in attracting more users. In reality, the project evaluated the effect of providing adequate on-street space for bicyclists where little existed before. The project was located on a collector road between the University of California at Davis and a nearby residential area. Although the pre-construction conditions described the road as having "wide curb lanes" on each side, the calculated width remaining for bicycles, after accounting for space for traffic and an on-street parking zone, was less than two feet, an inadequate width for bicycling when even a moderate amount of traffic is present and cars are parked. In spite of this, Anderson Road was a popular bicycling route for students going to and from the University, with an average of 255 bicycle trips per day.

The construction project consisted of reconfiguring the street to provide a 4-foot wide striped space for bicyclists in each traffic direction. After completion, ridership increased to an average of 477 bicycle trips per day. "Some people shifted to this improved route from adjacent streets. Cyclists rated the street as a much improved bicycle route, and both the mapping interview studies and the traffic counts demonstrated that many of them shifted their route selection to take advantage of the bicycle lanes."[48]

Bicyclist Training

A study of bicycle association members reported a significant reduction of personal accident rates among participants in a special bicycle training course. The analysis done by Jerrold Kaplan[49] showed an accident rate of 113 per million bicycle miles among trained League of American Wheelmen (LAW) members. This compares with a rate of 500 per million bicycle miles for college students as a group in a similar study done by Schupack and Driessen.[50] The accident rate of the trained group was said to be one quarter that observed for the general student group. This may be an indication of the potential for effective training programs to reduce accidents. Because this was just a single study and focused on the behavior of association members with a commitment to bicycling, it does not offer concrete evidence of training's effectiveness for the general population. Nor does it evaluate public receptivity to the training

[47]Robert L. Smith, Jr., and Thomas Walsh, "Safety Impacts of Bicycle Lanes," *Transportation Research Record 1168* (Washington, D.C.: 1988), 53.

[48]Dale F. Lott, Timothy Tardiff, and Donna Y. Lott, "Evaluation by Experienced Riders of a New Bicycle Lane in an Established Bikeway System," *Transportation Research Record 683,* (Washington, D.C.: 1978), 40.

[49]Jerrold A. Kaplan, *Characteristics of the Regular Adult Bicycle User,* (Springfield, VA: National Technical Information Service, 1976).

[50]S. A. Schupack and G. J. Driessen, *Bicycle Accidents and Usage Among Young Adults: Preliminary Study,* (Chicago, IL: National Safety Council, 1976).

regimen. But it indicates that further testing may demonstrate the effectiveness of training in reducing bicycle accidents.

Everett and Spencer

In their study, "Empirical Evidence on Determinants of Mass Bicycle Commuting in the United States: A Cross-Community Analysis," Michael Everett and John Spencer make a strong analytical case for the identification of "mass bicycling" (bicycle mode share levels of 10 percent or more) associated with "facilities separated from high-speed, high-volume traffic" (HSHVT). Their definition of these kinds of "bicycle facilities" is very broad, ranging from separate paths to shared space on low speed/volume local streets. Also included are bicycle lanes and unstriped routes on streets wide enough for bicycles and cars to travel side-by-side. They found that in most of the school areas studied, there was a high relationship between the presence of these types of bicycle facilities and the existence of mass bicycling conditions in the community.

Their investigations identified the presence of mass bicycling in school areas only; they were unable to identify instances of mass bicycling for commuter purposes. Everett and Spencer concluded that "the overwhelming majority of schools with mass bicycle commuting (10 percent or more of the students cycling to class regularly during good weather) have bicycle access separated from HSHVT. Separation does not necessarily mean a separate bicycle facility. Although most schools with mass cycling did have separate facilities, many relied on low-speed, low-volume, residential-type roads and 20 or so may have relied on moderate-speed, moderate-volume arteries."[51]

Case Study No. 1

In the study *Reasons Why Bicycling and Walking Are And Are Not Being Used More Extensively As Travel Modes*, Case Study No. 1 substantiates Everett and Spencer's work with evidence of mass bicycling among nonstudent workers for commuting purposes. In Davis, CA, 27 percent of university staff bicycle to work. In Madison, WI, the figure is 11.7 percent.[52] The study notes a weaker correlation between the provision of bicycle lanes and mass bicycling, which may be a result of the study's narrower definition of bicycle facilities. Because of unreliable information, the study does not to include either bicycle routes or shared low-speed/low-volume roads as "bicycle facilities" for purposes of analysis.[53] The analysis also includes only five college towns, in contrast to Everett's sample of 300 school communities.

[51]Everett and Spencer, "Empirical Evidence," 33.

[52]Case Study No. 1, *Reasons*, 47.

[53]Case Study No. 1, *Reasons*, 45.

Conclusions

The Everett and Spencer study offers evidence that improvements providing discrete space for bicycling out of the direct flow of high-speed, high-volume traffic (including the use of provisions to reduce motor vehicle traffic) are associated with higher levels of bicycle ridership. In communities that are predisposed to bicycling, like Davis and Madison, studies empirically support the same conclusion. On a case-by-case basis, appropriate facility improvements can help relieve impediments to bicycle use.

Based on a close examination of the information presented, neither the Davis-Anderson Road analysis, nor any other known domestic analysis, offers definitive evidence that bicycle lane striping, in and of itself, can increase ridership or improve safety. Bicycle lanes are not proven to be more or less effective in increasing ridership than adequately sized "wide curb lane" bicycle routes or standard low-volume, low-speed local streets. Many people think that a stripe between automobile traffic and bicycle space symbolizes a safe on-street facility. This is borne out by the fact that 45 percent of the increased ridership on the Anderson Road bicycle lane was traffic shifted from adjacent roads.[54]

Among the bicycling improvement methods analyzed, an effective user-training program was judged to have merit in reducing accidents. This indicates the potential value of training programs, a facet of bicycling often neglected in favor of physical improvements. Unfortunately, bicyclist training has not been adequately tested to determine its potential effectiveness in promoting ridership.

In spite of the low number of quality analytical studies, there is a strong indication that a well-conceived program of physical improvements, training, and encouragement is associated with increased bicycle ridership. Again, the improvements satisfy the basic needs of bicyclists identified by most surveys: reasonable travel time and distance, directness of travel, and facilities seen as being safe. In particular, physical improvements that free bicyclists from having to ride constantly in the midst of high-speed traffic seem to encourage people to ride.

[54]Lott, "Evaluation," 42.

VI. Bicycle Commuter Tendencies and Preferences

People continue to use their cars for almost every trip for a variety of reasons. These reasons relate to three basic personal considerations: *habit, ease*, and *safety*. Most motorists are in the *habit* of driving with no reason to consider changing mode. The transportation system in this country for more than a half century has been designed to make car use *easier* than any other mode. People in this country view nonrecreational bicycling as *unsafe* for both body and bicycle. Effectively replacing a substantial number of automobile trips with bicycle trips requires positive actions to present regular bicycling as an easy, safe alternative.

Attitudes and preconceptions play a big role in each individual's decision to bicycle. Josh Lehman wrote, "If you're intent on commuting by bicycle, you'll probably manage to do just that, come hell or high water. If you're dead set against the idea, any of the several factors will provide ample reason to abstain. 'Too hilly; too cold; too many cars; I'll get sweaty; people will laugh.'"[55] The National Bicycling and Walking Study adds, "(Some) people will continue to choose not to bike or walk because they perceive these modes to be unsafe, too physically demanding, or inefficient, or because they feel that others will view them as 'unprofessional' or 'uncool.'"[56]

Identifying the most desired bicycle system attributes and determining how they affect use contributes to a better understanding of the personal factors bearing on the decision to bicycle. These tendencies and preferences have a profound influence on whether bicycle facilities and programs attract or discourage new riders. The following stand out as the primary motivating tendencies:

- Bicycle commuters are motivated by directness and convenience. They will use a combination of streets and separated paths to create the most direct, timesaving routes; usually they will ride only a short distance out of way to find signed bicycle facilities.[57]

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[55]Bicycling Magazine editors, *Bicycle Commuting*, (1980), 9.

[56]*National Bicycling and Walking Study—Interim Report* FHWA-PD-92-003 (Washington, D.C.: U.S. Department of Transportation, November 1991), 15.

[57]Daniel T. Smith, "Planning and Design of Bicycle Facilities: Pitfalls and New Directions," *Transportation Research Record 570*, (Washington, D.C.: 1982), 3-8. "But more important, cyclists simply were unwilling to ride out of their way to use a signed bike route that appeared to offer no obvious travel or safety advantages."

- Most commuters choose to bicycle for exercise, enjoyment, and environmental concerns, instead of for economic reasons.

- Bicycle commuters tend to be under age 45, and have either lower incomes or higher levels of education and income.

- The average bicycle commute distance in the U.S. is 2.1 miles,[58] and the practical maximum distance is up to 5 miles.[59]

- Bicycle commuters are generally experienced riders who have confidence in their ability to ride in traffic; they don't choose a separated path over an on-street path unless it saves time.

- Inexperienced riders tend to be intimidated by motor vehicle traffic, especially at intersections, and often choose striped bicycle lanes, sidewalks, or separated paths.

- Separate paths, often preferred by inexperienced bicyclists, are safer than on-street routes only if they are completely separated from automobile traffic, with no cross streets or driveways.[60]

- Difficult topography and weather are factors that can influence ridership, but generally do not permanently discourage serious, experienced commuters.[61]

Strategies to remove impediments to bicycling should be based on accommodating bicyclists preferences and tendencies as much as possible. A commuter-oriented bicycle system should consist of a comprehensive system of bicycle facilities offering convenient geographic coverage.

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[58]*Summary*, Table 5.7, (5)14.

[59]Deakin, cited in Case Study No. 1, *Reasons*, 7.

[60]Steve Cochrane, Bob Horn, and Arlene Tjart, *A Neighborhood Study of Bicycle Demand and Attitudes in Boulder, Part I*, (Boulder, CO: City Department of Transportation). "Apparently it is perceived that the bikeway will make it safer to ride an bicycle. It is questionable how much safer a new bicyclist will be on a bikeway if he or she has not had the opportunity to learn the skills necessary to deal with such things as intersections, crossing streets, or merging with traffic where the bikeway ends."

[61]Design Ventures, *Montgomery County*.

VII. Strategies to Remove Impediments to Bicycling

In the United States, driving an automobile is more convenient than bicycling, walking, or riding transit. Common values, development patterns, and the automobile-oriented transportation system make it difficult to use these other modes efficiently and safely.

To identify methods for relieving impediments to bicycling and walking, it is necessary to examine successful approaches to bicycle facilities, training, encouragement, enforcement, and land use issues. Successful measures should include those that increase usage and safety, both real and perceived.

Almost every community in the country has areas that present unsafe or unpleasant choices to the bicyclist. Some towns have virtually no physical accommodations to allow bicycling as a practical option. Other typical problems include the lack of adequate off-street paths between major activity and residential centers, streets barely wide enough for automobile traffic, the absence of safe bicycle passage across natural barriers or major roads, off-street paths with vehicular crossings (including sidewalk bikeways), shared paths where various uses conflict, and streets with many curb cuts and turning traffic.

The risks are compounded when high-speed and/or high-volume motor vehicle traffic is present, and there is little or no space for the bicyclist to ride or maneuver. These conditions are worst for on-street bicycle facilities at intersections and their approaches.[62] Most serious deficiencies can be mitigated with strategic capital improvements and operational changes, but facility improvements alone may not be the complete answer. In each community facility, training, encouragement and enforcement solutions tailored to specific bicycling needs, strengths and weaknesses need to be developed.

Safety is a major concern to bicyclists, especially in relation to automobile/bicycle accidents. Many impediments are based on real or perceived worries about personal safety while riding a bicycle. "English officials estimate that bicyclists face a fatal-accident risk 10 times greater per mile than drivers."[63] However, some feel that proper training and equipment can reduce or eliminate this disparity. "Considering all bicycle accident types, the trained bicyclist who obeys the rules of the road and uses the proper safety equipment (lights at night, helmets)

[62]John Forester, *Bicycle Transportation* (Cambridge, MA: M.I.T. Press, 1983), 255.

[63]Michael Everett, "Bicycles, Cars, and Energy," *Traffic Quarterly* 28:4 (October 1974).

is essentially as safe as the average motorist on a per mile basis and may even be safer on a time exposure basis. On the other hand, children and untrained adult cyclists are at considerably greater risk."[64]

Of course, collisions with motor vehicles are not the only type of accidents that concerns bicyclists. Bicyclists can be injured colliding with stationary objects, slipping, falling over, and hitting pedestrians. "Although these types of accidents are generally much less severe than accidents involving motor vehicles, they do account for the vast majority of accidents in which bicyclists are involved."[65]

Overall Bicycle Program Improvements

Several general strategies are helpful in increasing bicycle usage and safety, two concepts which reinforce each other. "Apparently, the more bicycles in the traffic stream, the lower the accident risk for bicycle riders."[66] Therefore, bicycle improvement strategies should provide:

- a network of convenient, regularly spaced on-street bicycle facilities with extensive coverage;
- new streets designed with adequate bicycle space, configured as wide curb lanes or safely designed bicycle lanes;
- bicycle paths serving major destinations, shared by both commuting and recreational riders, completely separated from automobile traffic where possible, such as along creek channels, transit rights-of-way, abandoned railroad corridors, etc.;
- bicycle parking that is both secure and perceived as such;
- direct, safe bicycle linkages with public transit and with convenient all-day parking;
- use of public construction projects to fill gaps in the existing bicycle system and provide a nucleus of new routes;
- policies to consistently incorporate adequate bicycle facilities in new capital improvement projects and reconstructions;

[64]New Jersey Bicycle Advisory Council, *Report on Bicycling*, 21.

[65]"Bicycling and Bicycle Facilities Research Problem Statements," *Transportation Research Circular 337*, (Washington, DC: National Research Board, 1988), 16.

[66]Allan Katz, "Some Characteristics of Bicycle Travel and Accidents in Towns," *Transportation Research Record 683*, (Washington, DC: 1978), 30.

- year-round bicycle encouragement and education programs to ensure targeted prospective riders receive accurate information on the merits of bicycling compared with driving, especially in areas of time, cost, convenience, safety, fitness and independence, and information to dispel misconceptions about bicycle issues;
- increased employer-supported bicycle commuting facilities, programs, and campaigns;
- a public and private system of incentives and preferential programs based on primary factors motivating a person to bicycle;
- educational programs to help prospective bicycle commuters ride safely in traffic, and address route selection, dress/appearance, and logistics;
- bicycle commute problem-solving assistance, using proficient commuters to train prospective bicycle commuters (like "Bicycle Buddies" programs);
- strong policies promoting mixed use activity centers to decrease the need for a car;
- land use policies to achieve more compact development; and,
- policies to develop housing next to activity centers.

A. Facility Improvements

Most people think that the best way to remove impediments to bicycling is by improving facilities. Survey findings consistently identify safer bicycle facilities, more bicycle paths, more bicycle lanes, safe bicycle parking, shower facilities, more convenient routes, and more direct routes as impediments to bicycling. For example, "The Seattle survey provides more evidence that people believe inadequate facilities are the key impediment to expanding ridership. When respondents (bicyclist and nonbicyclist alike) are asked to rank three sets of policy options in order of importance, improved facilities easily comes out on top."[67]

Policy Option	Most important	2nd	3rd
Expand/Improve Facilities	67%	17%	16%
Educate Bicyclists & Motorists	21%	45%	34%
Enforce Bicycling Traffic Laws	19%	35%	46%

According to the recently published "Pathways for People" survey sponsored by Rodale Press, 59 percent of the randomly selected U.S. adults questioned said they would like the "government to devote more funds specifically for safe and secure bike and pedestrian paths." In addition, 53 percent of people who rode a bicycle last year at least once said they would sometimes commute to work by bicycle or commute more often, "if there were safe, separate

[67]Case Study No. 1, *Reasons*, 22-23.

designated bike paths to use," and 45 percent said they would bicycle if "there were showers, lockers and secure bike storage at work."[68]

These surveys indicate the general public perception that inadequate bicycle facilities are a significant impediment to bicycling. One could conclude that if bicycle facilities are made "safer and more convenient," a significant increase in bicycling would follow. But as noted, survey results are questionable for estimating actual ridership increases.

General Facility Principles

To ensure the adequacy of community bicycle facilities and to provide a basis for identifying and prioritizing projects, an assessment and implementation strategy is needed. The following are general principles to apply in developing the strategic plan.

- Fill connection gaps in bicycle facilities:

  - add strategic bridges and underpasses
  - provide safer crossings and intersections
  - widen narrow sections of on-street bicycle routes.

- Connect destinations across natural and man-made physical barriers.

- Provide the most direct routes between activity centers.

- Where possible, provide bicycle facility alignments that shorten travel time and distance compared to automobile routes.

- Continually look for ways to optimize the bicycle system.

- Remove debris and provide smooth surfaces through regular maintenance.

- To maximize the number of people within bicycling distance of school, employment, shopping, recreation, and entertainment, ensure that roads designated for bicycle use are direct, bicycle-friendly, and close by.

For a bicycle facility to be effective, safety and usage should increase. As mentioned previously, only a few facility enhancements have been tested to determine their success in increasing safe ridership. From this research, a reasonable correlation has been found between increased usage and facilities that allow bicyclists to ride out of the constant flow of fast/heavy automobile traffic.[69] A general list of safe facility options includes:

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[68]*Pathways for People,* (Emmaus, PA: Rodale Press, 1992), 2, 9.

[69]Everett and Spencer, "Empirical," 30. Case Study No. 1, *Reasons,* 46. Lott, Tardiff, and Lott, "Evaluation," 40.

- completely separated off-street bicycle paths
- safely designed on-street bicycle lanes
- wide curb lanes or adequate roadway shoulders
- low-speed/low-volume streets
- bicycle connections along "desire lines" to fill gaps in the system.[70]

Off-Street Facilities

New riders, recreational bicyclists, and timid riders tend to prefer off-street paths because usually they are completely separated from automobile traffic. New riders are the major market to be attracted for the purpose of increasing bicycle usage; their perceived needs should be considered for both off-street and on-street bicycle facilities. Bicycle commuters also use paths if they offer a direct, convenient route. (For example, the placement of major paths in Denver makes them practical for commuting.) Off-street bicycle paths are desirable if they meet priorities based on community bicycling needs and are reasonably cost-effective.

Paths should meet basic rational criteria: they should be located where people want to go, they should offer complete separation from traffic, and their construction costs need to be reasonable. New paths in established towns are usually on existing rights-of-way, and are generally separated or grade-separated from the street system. Typical candidates include water courses, railroad rights-of-way, waterfronts, parks and open space, and rapid transit corridors.

Off-street paths often accommodate a range of users (bicyclists, walkers, joggers, in-line skaters, animals, etc.), and should be planned and designed to reduce conflicts. Seasoned bicyclists may avoid off-street paths for time and safety reasons. "Bikeway use by experienced riders is often less rewarding . . . since they have to worry about the erratic moves of slower, less experienced riders and of nonbicycling users of the bikeway who follow no rules."[71] Signage and operation policies should encourage 'sharing the path' safely. Entrances and exits should be designed to require a deliberate stop/look/go, rather than a merging movement so that bicyclists are not encouraged to enter into cross traffic without looking.

Unlike scenic trails, bicycle trails should be designed or redesigned to be geometrically safe. "Historically, the design of trails in parks and green belts has focused on pedestrian considerations and the trail as a feature of the landscape. Unfortunately, this has led to facilities with grade profiles, curvatures, sight distances, pavement widths, and pavement surfacing inappropriate for use by bicyclists."[72] Creating parallel paths for users going at different speeds should be considered when widening an existing path.

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[70]City of Eugene Public Works, *Greenway Bike Bridge: Evaluation Report—Phase II*, (October 1979), 2.

[71]Richard K. Untermann, *Accommodating the Pedestrian: Adapting Towns and Neighborhoods for Walking and Bicycling*, (New York: Van Nostrand Reinhold Company, 1984), 63.

[72]D. Smith, "Planning and Design," 4.

Off-street bicycle facilities should be continuous paths without traffic crossings. If crossings cannot be eliminated, they should be well marked. Unexpected traffic crossings can be surprising and dangerous to bicyclists and motorists. Paths located near arterial streets and highways can be practical where there are fewer street crossings, and the crossings can be safely designed.

Research on accident locations and severity indicates that bicycle paths may be particularly useful as alternatives to riding on major high-speed arterial streets and highways. "Wheatley and Cross, in their rigorous and well-funded nationwide study of bicycle fatalities found that the largest group of *fatal* accidents (more than 37 percent of the total) entailed motor vehicles overtaking bicyclists. By definition, a separate bicycle facility should substantially reduce that type of fatal accident. . . . The overwhelming majority of fatalities still occurred on the roads. Moreover, the fatalities on the general road system apparently occurred on arteries or collector streets. None was reported on noncollector residential streets."[73]

Sidewalk Bicycle Facilities and Partially Separated Bicycle Paths. Sidewalks are generally not recommended as bicycle facilities. Because they "increase bike-car conflicts at intersections and are designed for pedestrian speeds, sidewalk bikeways actually make things worse."[74]

In Eugene, OR, "the average accident rate for the three sidewalk bicycle route sections is 1.8 accidents per 100,000 bicycle miles per year. This is nearly three times the average for the signed lanes or striped lanes. These facilities are significantly more hazardous for bicycle-motor vehicle accidents."[75] In Palo Alto, CA, "although only 15 percent of the bicycle travel occurred on streets with sidewalk bicycle paths, 70 percent of the reported bicycle/motor vehicle accidents on the bikeway system occurred on such streets."[76]

> *Considerable unsatisfactory experience with sidewalk bikeways is now being reported. The reasons for this are quite evident.*
>
> *1. At driveways the sight distances and visibility relationships are often poor. Landscaping, shrubbery, and fences tend to impair sight distances at driveways. Compounding the problem are the poor visual relationships that result when motor vehicles back out of and turn into driveways.*
>
> *2. Poor visual relationships between cyclists and motorists also occur at intersections. The emergence of a high-speed bicycle (as opposed to pedestrian speed) into the crosswalk area is often unanticipated by motorists, particularly those completing turns.*

[73]Everett and Spencer, "Empirical Evidence," 32.

[74]John Williams and Poody McLaughlin, "10 of the Questions We Hear Most," *Bicycle Forum*, 30 (August 1992), 7.

[75]Regional Plan Consultants, Inc., *Evaluation of the Eugene Bikeways Master Plan*, (Eugene, OR: 1979).

[76]*Final Report on the Palo Alto Bikeway System*, (Palo Alto, CA: 1974), 11.

3. Sidewalk bikeways tend to be used bi-directionally despite signs and warnings to the contrary. Bi-directional operations compound the sight distance-visual relationship problems at driveways and intersections noted above.

4. Sharing space with pedestrians creates a number of problems. Pedestrians are extremely mobile directionally and often change direction unpredictably. This factor, coupled with the difference in travel speed . . . leads to a high conflict potential. . . . Older pedestrians and blind persons are particularly uneasy at meetings with cyclists along sidewalks.[77]

Ironically, many nonbicyclists and beginners think riding on sidewalks is safer. Sidewalks and partially separated bicycle paths can be relatively safe only if users exercise extreme caution at every crossing.[78] However, separated paths can present a challenge because bicyclists often must ride on the road to get to off-street paths.

The accident rate increase on sidewalk bicycle paths indicates that previous conflicts and problems between motorists, pedestrians, and bicyclists have been aggravated and compounded. The accident rate reduction along streets with bicycle lanes tends to support the need for more bicycle lanes, and fewer exclusive bicycle paths and shared sidewalk bicycle paths in urban areas.[79]

On-Street Facilities

In new towns, separate bicycle and pedestrian facilities should be and are being planned into the layout of the development. However, as a general principle for most developed areas, the greatest opportunity for practical increases in bicycle access is most likely through improved on-street facilities. "There [is] no way to create a separate bikeway system that would provide the same convenience and access as the existing street system."[80]

Although surveys indicate a desire for off-street bicycle paths, corridors separate from automobile traffic, such as a riverfront, are often not available in established cities. Devoting resources to creating a few major paths, making existing streets exclusive bicycle pathways, or building grade-separated bicycle and pedestrian facilities cannot provide the geographic coverage to satisfy the needs of the community. "The focus on bikeways has shifted since the early 1970s, from physically separating bikes from motor vehicles by constructing bike paths, to the current trend toward roadway bikeways."[81]

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[77]D. Smith, "Planning and Design," 5.

[78]Cochrane, Horn, and Tjart, *Neighborhood Study.*

[79]Palo Alto, *Final Report,* 11.

[80]Steven R. McHenry and Michael J. Wallace, *Evaluation of Wide Curb Lanes as Shared Lane Bicycle Facilities,* (Maryland State Highway Administration, July 1984, revised August 1985), 10.

[81]"A Look at What Some States are Doing: Oregon's Bike Program," *AASHTO Quarterly,* (October 1990), 12.

The goal of on-street facilities is to provide adequate bicycling space within the street right-of-way. "Previous studies have concluded that lateral travel space is the most important consideration."[82] The bicycle space must be designed to simultaneously:

- provide sufficient clearance for safe midblock bicycle operation;
- encourage bicyclists to be active, predictable, and visible players within the traffic flow at all times; and,
- prompt bicyclists to make appropriate preparations and maneuvers for safe turning and through-traffic movements at intersections (such as encouragement not to ride against the curb at approaches to intersections).

It is recommended that the Federal Government encourage State and local public works departments to adopt standards requiring all nonhigh-speed arterial roads have adequate space for bicycle operation. These standards should apply when any road is restriped, modified, or reconstructed. New roads should be designed and constructed to accommodate bicycles. Existing roads with low-speed traffic probably will continue to work without modification until traffic increases.

It is extremely important that the foregoing standards be an integral part of all accepted national engineering manuals such as The AASHTO Guide, *The Manual of Uniform Traffic Control Devices* (MUTCD), *The Highway Capacity Manual*, and CalTrans Standards. They should also be adopted and located in State and local standards manuals for traffic engineering and roadway design. These bicycle standards should be integral components of these standards, and not just placed in separate bicycle sections of ordinances.

Local bicycle interests should encourage public works departments to provide wide, well-maintained outside curb lanes shared by bicycles and motor vehicles. Vehicle lanes located next to the right curb should have a 14- to 15-foot-wide section of smooth pavement.[83] Strategies designed to produce safer intersections and signalization for bicyclists should be considered. If bicycle lanes are painted, markings should be deleted before intersections to avoid trapping left turning and straight-through bicyclists against the curb, and to encourage bicyclists to shift position to be more visible at intersections.[84]

On-Street Operational Conflicts. The street systems of virtually all American cities are organized in a grid pattern. Because this network is continuous and interconnected, it needs a

[82]McHenry and Wallace, *Evaluation*, 18.

[83]John Williams, ed., "Reviewing the '81 AASHTO Guide," *Bicycle Forum*, 26 (November 1990), 8. "John Clark: 15 feet makes more sense for a wide curb width. Reason: in the future, a 15-foot wide curb lane can be restriped for a 11-foot motorized lane with a 4-foot bicycle lane."

[84]American Association of State Highway and Transportation Officials (AASHTO), *Guide for Development of New Bicycle Facilities*, (Washington, DC: 1981), 14.

unified set of operating rules to minimize conflicts. Safety problems occur when individuals operate according to conflicting rules. Encouraging bicyclists to ride adjacent to, but act separate from, street traffic flow also encourages drivers and riders to disregard each other. While this disharmony usually doesn't cause much of a conflict in midblock locations (except where there are driveways and alleys), it is extremely dangerous at intersections. "Previous studies have found that the majority of serious bicycle accidents occur at or near intersections."[85]

An example of this problem is bicyclists who stay against the curb to the right of automobiles at intersections, when they want to turn left or continue forward. "By hugging the right curb, you encourage the kind of accident in which an overtaking motorist passes a cyclist and then cuts the cyclist off by making an abrupt right turn."[86] The practice of always riding close to the curb is a frequent cause of bicycle/automobile turning accidents. This would not be a problem if it were possible to "grade separate" (or perhaps "time separate") bicycles and automobiles at every street crossing.

Therefore, on-street bicycle facilities should be configured recognizing that bicycles and motor vehicles should follow nonconflicting operational rules, especially at intersections. To make this happen requires three conditions:

- the road system should be improved to safely accommodate bicyclists so they don't have to ride directly in high-speed traffic;
- new bicyclists should be encouraged to participate in training courses to help them safely, confidently, and lawfully use on-street and off-street bicycle facilities; and,
- motorists and bicyclists should be trained and held accountable to observe each others's legitimate rights.

Bicycle Lanes. Surveys report that "safe bicycle lanes" are regarded as an important addition to bicycle facilities, especially by occasional riders. The *Bicycling Magazine* 1990 Harris Poll found that 49 percent of active bicyclists would commute by bicycle more often if "there were safe bicycle lanes on roads and highways."

Bicycling Magazine Harris Poll [87]

Improvement	Active Riders	Percent All Adults
Safe Bicycle Lanes	49.0%	20%
Financial Incentives	44.5%	18%
Showers & Storage	43.5%	17%
Rise in Gas Prices	38.0%	15%

[85] *Transportation Research Circular 337*, 15.

[86] Bicycling Magazine editors, *Bicycle Commuting*, (Emmaus, PA: Rodale Press, 1980), 21.

[87] *Bicycling Magazine* (April 1991), 44. [Cited in Case Study No. 1, *Reasons*, 21.]

As mentioned previously, analysis of the effectiveness of striped bicycle lanes in promoting more ridership is lacking. The Davis-Anderson Road analysis[88] and the study of facility improvements in Madison, WI,[89] addressed bicycle lanes. However, in both cases the improvements also involved the provision of extra space for bicycle riding where almost none existed before, in addition to the painted bicycle lane dividing line.

Opinions differ about the best ways to make on-street bicycle facilities safer and more attractive to would-be bicyclists. The importance of a discrete width for bicycles is acknowledged by all. Both striped bicycle lanes and wide curb lanes provide this width. The primary purpose of both facilities is to provide adequate space for motorists and bicyclists to safely overtake and pass each other, necessitated by the speed differential between the two modes.

Striped and unstriped bicycle lanes each have several advantages. Many people support bicycle lanes based on the idea that striping will encourage higher ridership levels, because it encourages safer interaction between bicycles and automobiles. The opposite view is that striped lanes encourage bicyclists to ride in an unsafe location at intersections, that lanes present a false sense of security, and that striping lanes has not been proven to attract additional ridership. No definitive analysis has proven either claim. It appears that the best choice depends on what is most appropriate for the particular application and its location.

Proving the specific value of striped bicycle lanes is difficult. Some towns that have high bicycle usage also have many bicycle lanes, such as Davis, CA, where 25 percent of work trips are by bicycle, and Gainesville, FL, with 10 percent. Other cities such as Madison, WI (11 percent commute by bicycle), and Boulder, CO (9.3 percent commute by bicycle), have good bicycle ridership, but fewer miles of striped bicycle lanes.[90]

Based on case study research, the advantages of bicycle lanes are:

- bicycle lanes provide a place for bicyclists to ride out of high-speed/high-volume traffic, except at intersections;
- survey results show people say they want more "bicycle lanes," which may indicate more people would ride if lanes were provided;
- painted lane lines seem to make inexperienced riders feel more secure;
- if properly used, lanes help legitimize the presence of bicycles on the road;

[88]Lott, Tardiff, and Lott, "Evaluation," 22.

[89]Smith and Walsh, "Safety Impacts," 21.

[90]Case Study No. 1, *Reasons*, appendix.

- lanes may help make motorists more alert for bicyclists;
- installation of bicycle lanes generally ensures adequate width for bicycles, which is not the case on many bicycle routes;
- painted lanes may help to ensure the space will not be usurped by future traffic lanes;
- lanes help guide riders around curves in road;
- painted lanes may make more drivers comfortable about passing a slower-moving bicyclist; and,
- lanes may reduce wrong-way riding if properly marked with directional arrows.

The disadvantages of bicycle lanes are:

- lanes may position bicyclists in an unsafe location for safely negotiating a traffic intersection;
- lanes may constrain bicyclists against the right curb where they are less visible to motorists;
- bicyclists needing to ride outside the lane (when turning left) may be regarded as "outlaws" by motorists;
- lanes may present a feeling that on-street bicycling is safer than it actually is, and lead to lack of caution;
- the "sweeping" motion of cars may cause debris to accumulate in the bicycle lane, making the lane less desirable to use;
- lane markings are subject to wear by automobile tires because of their location; and,
- some lane marking materials may become slick when wet.

Wide curb lanes are considered a good alternative to striped bicycle lanes. They are usually about 15 feet wide and are designed to accommodate one lane each of bicycle and motor vehicle traffic side by side. Wide curb lanes have no stripes to delineate a place for bicycles, but bicyclists usually ride along the right, except where it is appropriate to merge left for safe riding at intersections. Wide curb lanes tend to have none of the disadvantages of bicycle lanes listed above, but neither do they have the advantages attributed to striped lanes. One exception is that like bicycle lanes, they provide a place for bicyclists to ride out of high-speed/high-volume traffic.

Bicycle lane designs have evolved to reduce some of their disadvantages. These changes include provisions to encourage bicyclists to follow traffic flow principles at intersections. All States and cities should apply the improved standards to relieve hazards associated with bicycle lanes.

Striped bicycle lanes may encourage inexperienced bicyclists to ride more. That is a legitimate reason for considering them in a community, a long as the bicycle lane does not promote safety problems. "Bike lanes tend to normalize lateral placement of vehicles during midblock passing situations, and provide a perception of safety to the cyclist, encouraging cycling to some degree."[91] That is, they aren't necessarily safer, but they encourage use because they seem safer. They may alert motorists to the presence of bicyclists, but also may position bicyclists next to the curb where they are not very visible.

In considering bicycle lanes or wide curb lanes, it is useful to evaluate their strengths and weaknesses based on their compatibility with local conditions. If street maintenance is very good, the problem of debris build-up on riding surfaces associated with bicycle lanes may be inconsequential. If local bicycle training programs are effective, the "feeling of safety" striped lanes provide may not be necessary. Lanes may also be more appropriate in some parts of the city than in others.

A Hybrid Bicycle Lane. Based on a combination of the assets of both bicycle lanes and wide curb lanes, a hybrid bicycle lane could be a better choice. With the same cross section as the wide curb lane, bicycle symbols with directional arrows are painted in the *center* of the bicycle lane. The pavement markings are regularly spaced along the length of the bikeway, except at approaches to intersections, where bicycle traffic should position itself to properly negotiate the intersection. No lane stripe is needed between automobiles and bicycles. Advantages of the concept are:

- it provides a space for bicyclists to ride out of high-speed/high-volume traffic, except at intersections;
- the markings indicate and designate an area for bicycling where new bicyclists may feel more secure;
- it legitimizes the presence of bicycles on the road;
- it helps motorists be more alert for bicyclists;
- it generally ensures adequate width for bicycles, which is not the case on many existing bicycle routes;
- it helps ensure the space will not be usurped by a future traffic lane;

[91]McHenry and Wallace, *Evaluation*, 18.

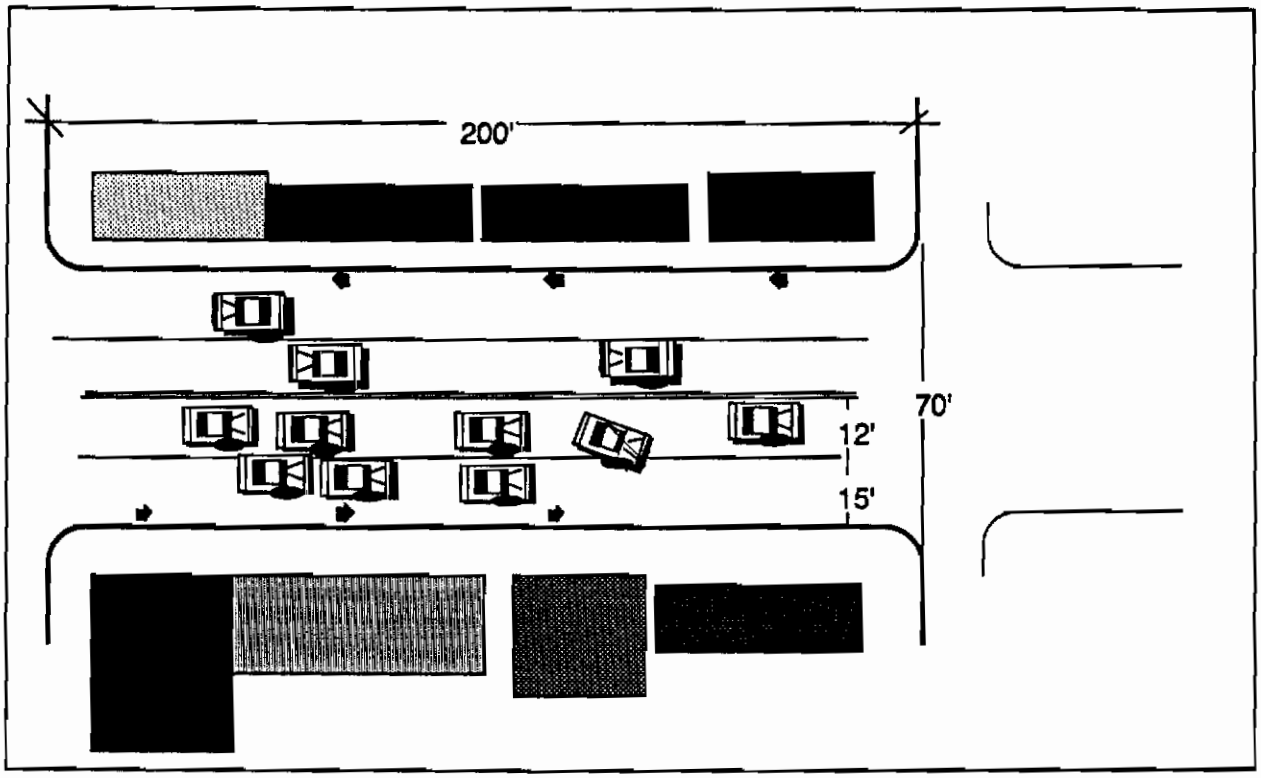
- markings can help guide riders around curves in road;
- directional arrows may reduce wrong-way riding;
- incorrectly painted lines do not lock bicyclists in an unsafe location for safely negotiating a traffic intersection;
- it does not constrain bicyclists against the right curb where they are not visible to motorists at intersections;
- it does not promote the perception that bicyclists are "outlaws" if they change road position for safety;
- it does not present a feeling that on-street bicycling is safer than it actually is, and lead to lack of caution;
- it does not discourage the "sweeping" motion of cars; and,
- markings are less likely to be worn by car tires because of their location.[92]

Bicycle Parking

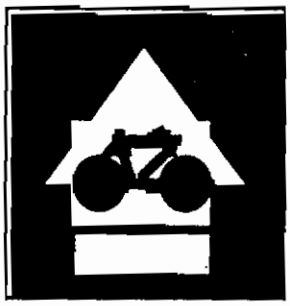
"More secure parking" is continually one of the top three choices in surveys as a way to induce more bicycle commuting. What constitutes secure bicycle parking depends on who is asked. For seasoned riders, figuring out where and how to park with relative security seems to be easy; for others, parking needs are never satisfied, regardless of the parking provided. Based on bicycle theft statistics, interviews and research, secure bicycle parking includes user perceptions and knowledge as much as it does facilities. For parking to be secure, a combination of factors must be present:

- sturdy racks or other fixed devices that provide good support of the bicycle frame;
- reliable locking hardware;
- knowledge of how to secure a bicycle to a rack;
- proper use of locking devices;
- the visibility of the parking site;

[92]Design Ventures, Inc., *1992 Denver Bicycle Master Plan.*



HYBRID BICYCLE LANE CONCEPT



BICYCLE ARROW STENCIL

- knowledge of where parking is available;
- parking close to the destination; and,
- the perception that the parking is secure.

Bicycle parking facilities should include options that range from basic racks to lockers and attended parking arrangements for expensive bicycles. Informing bicyclists how and why to lock bicycles securely is a big part of deterring theft. Accurate information on the probability of bicycle theft may reduce exaggerated fears of theft and promote more bicycling. Information on the location of parking facilities should be readily available. Bicycle parking should not be neglected at transit stations. "Recent research by the Chicago Transportation Study found that bicycle parking installation at rail stations was 300 times more cost-effective in reducing pollution than park and ride development."[93]

Public Transit and Bicycles

Accommodating bicycles at transit facilities encourages bicyclists to use public transit for part of the trip, extends the practical commute range for bicyclists, provides a way for bicyclists to transport their bicycles on transit so they can use them at the other end of the trip, and facilitates an arrangement where bicyclists can "station" their bicycle(s) at one or both ends of the trip for easy mobility without a car. Accommodating bicycles by transit usually includes some or all of the following.

- Ensure that bicycle access to transit terminals is safe, convenient, and direct.
- Provide bicycle parking that is secure for long-term parkers.
- Accommodate bicycles in or on transit if there is a cost-effective market for this service.

Integration of bicycles with transit can increase use of both modes and decrease automobile trips. "Halfway through a six-month test period, Phoenix's experiment with bike racks on about 30 buses has surprised city and county officials. Not only is the program attracting more and more bicyclists, it is attracting people who didn't regularly use the buses, a survey shows."[94]

> *It was pleasing to find out that there was such a sizable market of people wanting to travel by bus with their bike. The Bike-on-Bus Demonstration Program proves that combining two modes of transit, biking and bus riding, can be an effective method of reducing automobile trips with a minimum amount of expenditure. . . . The program demonstrates that transporting bikes with passengers can be done safely, while maintaining the quality customers expect.*[95]

[93]Michael A. Replogle, "Cutting Transit Costs and Traffic Problems with Bicycle Access," *TR News*, (September-October 1985), 5.

[94]Mike Padgett, "Encouraging Cycle: Use of Bike Racks on Buses Impresses Phoenix Officials," *The Phoenix Gazette*, (July 12, 1991), B1.

[95]Phoenix Transit System, *Bike-on-Bus Demonstration Program*, (1991), 2.

An apparently successful and cost-effective example of bicycles on buses began in Santa Barbara, CA, in November 1978. "In 1981 the Santa Barbara Metropolitan Transit District carried over 40,000 passengers on its bus trailer system in a highly successful demonstration. . . . Such services can be extremely cost-effective."[96] More than 30 percent of these passengers were attracted from their automobiles trips. This federally funded demonstration project attracted new riders to several transit routes, as well as accommodating the needs of bicyclists who wanted to carry their bicycles with them on the bus trip. "Between November 1978 and November 1979, ridership rose 218 percent from a pre-demonstration level of 153 to 487 passengers after six months of demonstration services."[97] The cost of the bicycle trailers was $37,500 and annual operating cost were $44,000. This translated to a cost per passenger of 56 cents (plus 48 cents for insurance). "The demonstration services . . . significantly increased the coverage of existing transit services to bicycle-users.[98]

Some cities have demonstrated success in increasing transit use by bicyclists simply by improving bicycle parking. "Most transit agencies that have installed secure bicycle parking have attracted significant numbers of bike-and-ride passengers. . . . Bike-and-ride patrons account for 5 percent to 7 percent of passenger boardings at several commuter rail stations in Connecticut and Chicago-area suburban towns where secure parking is provided."[99]

> *An example of growth in commuter cycling as a result of parking facility improvements was produced by an Illinois Department of Transportation experiment with bike racks at commuter rail stations. They put a number of bicycle racks (enough for 457 bikes) at nine commuter rail stations in July of 1979 in an attempt to mitigate congestion on the Edens Expressway. By August of the same year they recorded 333 additional bicycles parked in the newly installed racks. . . . The 333 new bicyclists were estimated to have replaced 1,739 motorized vehicle miles traveled per day or over 400,000 miles per year.*[100]

Facility Recommendations to Remove Impediments to Bicycling

The following is a summary of physical bicycle facility improvements that may increase usage and safety. Also included are types of facilities to avoid. The best strategies are those that work to reinforce local conditions already favorable to bicycling.

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[96]Replogle, "Cutting Transit Costs," 4.

[97]Urban Mass Transportation Administration, *Integrating Bicycles and Transit in Santa Barbara, California,* (Washington, DC: U.S. Department of Transportation, 1983), 6-7.

[98]UMTA, *Integrating Bicycles,* 83.

[99]Michael A. Replogle, *Bicycles and Public Transportation: New Links to Suburban Transit Markets,* (Washington, DC: The Bicycle Federation), 27.

[100]Michael J. Erickson, "Bicycle Commuting in the Chicago Metropolitan Environment: Potentials, Benefits, and a Planning Approach," M.A. Thesis, (Northeastern Illinois University, 1991), 8.

Strategic Improvements. In most cities, the most effective way to use bicycle funds is to concentrate on projects that fill strategic gaps in the bicycle system or provide connections between major trip generators. These improvements complete bicycling corridors that would probably be used more often except for a critical missing section or the presence of a barrier. For prospective bicyclists, gaps in a corridor could mean the difference between riding a bicycle or driving a car. An example of a successful project of this nature is the Greenway Bicycle Bridge in Eugene, Oregon.

> *The Greenway Bicycle Bridge has resulted in a reduction of at least 665 automobile trips per week. This estimate was made before the gas shortage of 1979 and the corresponding increase in the price of gasoline. . . . Approximately 30 percent of all bicyclists surveyed would not have made the trip by bicycle if the Greenway Bridge had not been built.*[101]

Travel Time and Distance Advantage. Commute distance and time constraints are cited as major impediments to bicycle commuting. "On congested streets . . . the bicycle is faster and more dependable than any other mode. Bicycles can go where automobiles cannot, and they arrive sooner with less effort than pedestrians."[102]

Opportunities to construct bicycle facilities where bicycling distance is equal to or less than that for the automobile should be identified. Such advantages could occur by providing a connection across barriers river, railroad tracks, etc.), creating a bicycle right-of-way that bypasses or cuts through areas of traffic congestion, or locating bicycle parking closer than automobile parking to building entrances. "It may often be possible to provide a link that makes walking or biking faster than a car trip. An example would be a pedestrian bridge crossing a freeway that separated a corporate park from a shopping mall.[103]

The Eugene Bicycle Bridge is a good example of a facility that reduces time and distance by providing bicycle and pedestrian access over a river. "Approximately 30 percent of those bicycling thought it was as quick or quicker to make the trip by bicycle (using the new bridge) than by automobile.[104]

Adequate Width for Bicycles. Since on-street bicycle facility improvements represent the greatest opportunity to provide a comprehensive, direct, and cost-effective municipal bicycle network, traffic lane width must be adequate for a motor vehicle and a bicycle to ride abreast. The preferred width for travel lanes adjacent to the curb is 15 feet. This is narrow enough not

[101]City of Eugene, *Greenway Bridge*, 2.

[102]Erickson, *Bicycle Commuting in Chicago*, 74.

[103]*FHWA Draft*, 7.

[104]City of Eugene, *Greenway Bridge*, 2.

to encourage use as a double lane for cars.[105] Since wide curb lanes are unstriped, they don't restrict bicyclists to a position adjacent to the curb.

The pavement width of off-street bicycle trails should be adequate to accommodate the variety of path users. Since wide, smooth pavement tends to encourage faster speeds, if the width is already reasonable, it is usually better to add a parallel path to separate high- and low-speed users and to discourage high speeds.

Roads to Accommodate Bicycling. Fix and maintain road surfaces and provide adequate space for safe bicycle operation. Street design standards should be adopted by cities and States to ensure that all new and reconstructed nonhigh-speed arterial roadways are built to accommodate bicycles as an integral part of vehicular traffic. All the streets of a city's bicycle network should be given priority for reconstruction or alteration to physically accommodate bicycles.

Striped Bicycle Lanes. Painting a white line along bicycle lanes can help legitimize the presence of bicyclists on the road. "The experience of the bicycle lane/path system indicated significant reductions in confrontations and antagonisms between bicyclists and motorists."[106] The effectiveness of bicycle lanes to establish increased use or safety has not been well tested.

A real problem in evaluating the performance of bike lanes is the lack of convincing before and after accident experience data. One part of the problem lies in obtaining statistically significant data on accident incidence and causal factors in true before and after situations.[107] Bicycle lane configurations should be designed to discourage unsafe riding near intersections. Plans for lanes should encourage bicyclists to make themselves visible and their intentions understood by other vehicles at intersections.

Off-Street Bicycle Paths. Currently, cities with a high number of bicycle path miles do not have high levels of commuter and utility bicycling.[108] When off-street paths are the main component of a town's bicycle system, access and geographic coverage is usually very limited. Bicycle paths can be attractive to commuter bicyclists when they offer separated rights-of-way that give bicycles an advantage over cars in congested areas.

Although opportunities for new or extended bicycle paths may be limited in developed communities, these opportunities should be pursued because of their attractiveness to recreational and inexperienced riders. These bicyclists prefer off-street bicycle paths because they are continuous, separate from motor vehicle traffic, and are usually located in scenic areas. Paths are usually costly compared with other options because of grade separation, and they should not be built in areas requiring frequent at-grade street crossings.

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[105]Williams, "Reviewing the '81 AASHTO Guide," 8.

[106]City of Palo Alto, *The "Urban Bicycle Route System" for the City of Palo Alto,* (Palo Alto, CA: 1972), 2.

[107]D. Smith, *Planning and Design,* 7.

[108]Case Study No. 1, *Reasons,* 41.

Bicycle Facility Information. Based on analysis in Denver and elsewhere, an impediment to bicycling is poor knowledge of a city's bicycle system. Some respondents indicate they would like to bicycle but don't know of facilities, even when good bicycle facilities are located nearby.[109] Clearly, better bicycle facility information such as easy to understand route signs and maps is needed.

People may be familiar with off-street paths while being unaware of the network of bicycle facilities in their cities. They don't know where bicycle routes are located nor where they go. "There are many reasons for accidents . . . but a great many are due to the bicyclist's lack of knowledge of the safest roads on which to ride."[110] This uncertainty is one reason many people don't seriously consider bicycle commuting.

Prospective bicycle riders usually don't know how to get information. Therefore, an effective bicycle facilities program should make bicycle information readily available, easy to understand, and convenient to use. This resource should identify the location of facilities, and tell where they go and how to get around on them.

Information should be provided through a highly visible route signage system and user-friendly bicycle facility maps. Signage should provide a clear understanding of the layout of bicycle facilities, and how they connect. Up-to-date bicycle system maps should be provided to the public. Maps should be: available at commercial, community, and government locations, easy to read, easy to handle, inexpensive to produce and update, and free of charge (or very low cost).

'Direction of Travel' Markings in Bicycle Lanes and Wide Curb Lanes. Arrows marking the proper direction of travel for bicyclists, corresponding to automobile traffic direction, should be provided and maintained for on-street riding surfaces.

> *Riding against traffic has been identified as a significant causal factor in midblock and intersection bike-motor vehicle accidents. And provision of properly marked bike lanes has been demonstrated to significant effect in decreasing wrong-way riding. In Santa Clara County, CA, before and after observations on three bike lane facilities showed a 21 percent decrease (after marking).*[111]

Arrows indicating turning movements permitted for each traffic lane should be clearly displayed for bicyclists and motorists. This is so that bicyclists can understand where they should position themselves on the road to negotiate intersections more safely. "On multilane roadways,

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[109]Design Ventures, Inc., 1992 *Denver Bicycle Master Plan.*

[110]Curtis B. Yates and Mary Paul Meletiou, "North Carolina's Bicycling Highways," *Transportation Research Record 653,* (Washington, DC: 1978), 47.

[111]D. Smith, "Planning and Design," 7.

the destination of each lane (i.e., left, straight through, or right) should be made clearer through overhead signs and/or pavement markings."[112]

Adequate Parking. Surveys indicate that the fear of bicycle theft, related to "inadequate parking," is a major impediment to bicycling.[113] This concern arises from a number of factors:

- riders may not know where to securely park their bicycles;
- many bicyclists don't lock their bicycles properly, if at all;
- bicycles thieves steal even securely locked bicycles;
- many bicycle racks are poorly designed for secure bicycle parking;
- parking supplies may be inadequate;
- parking facilities may be poorly located for security;
- many people are unsure where to securely park expensive bicycles;
- many people think their bicycle won't be safe unless it is secured in a bicycle locker, under guard, or hidden behind locked doors; and,
- there are not a lot of those types of facilities available.

Meeting the expressed need for "adequate, safe bicycle parking" requires that several conditions be met simultaneously:

- an abundant supply of bicycle parking;
- a means to inform bicyclists of parking locations;
- sturdy parking fixtures, on which bicycle frame and wheels can be secured properly;
- a perception that parking is relatively secure; and,
- proper and secure use of parking facilities by bicyclists.

To satisfy bicyclists' need for adequate parking, a combination of facility improvements, information, and encouragement may be necessary.

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[112]Robert G. Thom and Alan M. Clayton, "Low-Cost Opportunities for Making Cities Bicycle Friendly Based on a Case Study Analysis of Cyclist Behavior and Accidents," 20.

[113]Case Study No. 1, *Reasons*, 20.

Bicycling and Transit. Experience in several cities, such as Santa Barbara, CA, has shown that accommodation of bicycles with transit can be effective in increasing the use of both modes. Given proper bicycle connections and secure parking (or bicycle racks on transit vehicles), bicycling can be a very efficient and convenient distributor mode to extend the range of bicycle commuting between transit stations and destinations. Michael Replogle states, "Providing bicycle parking at mass transit stations—an option known as 'bike and ride'—may be the most cost-effective way for authorities to conserve fuel and reduce vehicle emissions.[114]

Bicycling Magazine's Nelson Pena advocates, "L.A.'s proposed rail system should include bike lockers or even bike rentals at stations. Result: an increase in bike-and-ride commutes, which transportation studies show are the second most cost-effective method for cities fighting pollution. (Cycling the entire way is the first.)[115]

Bicycle-Activated Traffic Signals. Provisions can be made to allow riders to activate the green phase of traffic signals when there are no cars present. Without this feature, bicyclists may disregard traffic signals because they regard the system as being unresponsive to their needs. Bicycle activation signals may encourage lawful and safe riding behavior by discouraging the habit of riding through red lights, and relieving the aggravation of waiting a long time for the signal to change.

Signal Timing for Bicycles. Adjust traffic signals to accommodate the special needs of bicyclists. "Advanced traffic-light systems have been applied in order to give cyclists as much priority as possible."[116] Provide an all-red phase after green and yellow in the traffic light sequence to give slower moving bicyclists time to clear the intersection.

Stop Signs. Bicyclists want to travel on streets that present a minimum of delays and don't cause loss of riding momentum. One criteria for selecting streets for bicycle route designation is a minimum number of stop signs along the route or the removal of unnecessary signs. In Palo Alto, CA, "upon implementation of the 'bike boulevard' . . . stop signs were either removed or reversed at most of the intersections along the demonstration route, leaving only four stops along the entire 2-mile route. In addition, two barriers were installed along Bryant in order to dissuade increased through traffic and create a safer environment for bicycling. . . . Traffic on Bryant has increased dramatically during the demonstration period."[117]

Evaluation of Construction Designs. Prior to the construction of any road project, the safe accommodation of bicycling needs should be ensured. "Review the designs of all structures and the table of roadway and lane widths to determine which are too narrow for side-by-side lane sharing. Compare this list with known or realistically estimated traffic volumes to determine

[114]Replogle, "Bicycles and Public Transportation."

[115]Nelson Pena, "How the Bike Can Save L.A.," *Bicycling Magazine*, (August 1990), 36.

[116]J. Hoekwater, "Cycle Routes in The Hague and Tilburg," *Cycling as a Mode of Transport*, (1980), 65.

[117]City of Palo Alto, "Staff Report," (Palo Alto, CA: December 9, 1982), 1.

which deficiencies present capacity problems."[118] Examine designs and modify for hazards such as diagonal railroad crossings or abrupt grade changes.

Sight Distance. Design bicycle facilities to allow motorists and bicyclists adequate sight distance to see each other at intersections. Views should not be blocked by parked cars, street furnishings, or landscape features. A relatively high number of accidents occur at stop-sign intersections where the total number of signs is high. "In addition, the present data indicated that the signs that predominated at these intersections were larger, private signs."[119]

Sidewalk Bicycle Facilities. Despite the perception of safety, bicyclists riding on city sidewalks put themselves in a hazardous position because of automobile traffic at intersections, driveways, and alleys. Bicyclists riding on sidewalks may emerge quickly into the path of turning or on-coming traffic, surprising motorists. In Dane County, WI, "about one-quarter of bicycle accidents in 1988 occurred while a bicyclist was using a sidewalk or intersection crosswalk."[120]

Avoid Streetside Two-Way Bicycle Paths Unless absolutely necessary, do not locate paths for two-way bicycle operation adjacent to city streets. This includes on-street bicycle lanes, sidewalks as bicycle facilities, or off-street paths closely paralleling streets. Fast-moving bicycles traveling against traffic can be surprising to motorists. "Dutch data for a two-way sidepath intersection show that 92 percent of car-bike collisions occurred with wrong-way cyclists and only 8 percent with right-way cyclists, despite no obvious directional imbalance in the traffic."[121]

Expressway Exit Ramps. Where bicycle facilities cross exit ramps, replace unsigned right turn or yield provisions for automobiles with stop signs and warning signage, if possible.

Bicycle Facilities Between Parking Lanes and the Curb. For safety reasons, bicycle lanes should not be located between parked cars and the street curb. "Bicycle lanes between the curb and the parking lane create hazards for bicyclists from opening car doors and poor visibility at intersections and driveways, and they prohibit bicyclists from making left turns; therefore, this placement should never be considered."[122]

Bicycle Facilities Routed Around Intersections. Avoid designs configured to route bicyclists around, rather than through intersections, unless separate traffic lights are provided for

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[118]Forester, *Bicycle*, 214.

[119]Charles J. Holahan, Michael D. Campbell, Ralph E. Culler, and Celia Veselka, "Relation Between Roadside Signs and Traffic Accidents: Field Investigation," *Transportation Research Record 683*, (Washington, DC: 1978), 3.

[120]Dane County Regional Planning Commission, *Bicycle Transportation Plan for Madison and Dane County*, (1991), 5.

[121]Forester, *Bicycle*, 133.

[122]Williams, "Reviewing the '81 AASHTO Guide," 9.

the bicycle path. The problems are similar to those encountered with both streetside two-way bicycle paths and sidewalk bicycle facilities noted above.

Railroad Crossings. To minimize the possibility of falling, ensure that all facilities used by bicyclists cross railroad tracks at an angle as close to 90 degrees as possible. Install warning signs and filler flanges at crossings to reduce gap between the pavement and the tracks.

Drainage Grates. Replace or modify street drainage grates to be safe for bicycles. Grate designs that use closely spaced inlet vanes to capture water are both safe for bicycles and hydrostatically efficient.

Bicycle Facility Lighting. Standard street lighting does not necessarily properly illuminate bicycle facilities, especially on off-street paths. For security reasons, lights to specifically illuminate the path may need to be added to augment existing ambient light. Lighting of bicycle facilities should not be considered a substitute for safety lights mounted on bicycles.

Suitable Bicycles. Bicycle commuters should use bicycles and equipment suitable for the conditions found in most urban areas. Mountain bicycles, for example, may give a safety edge on rough or poorly maintained roads, reducing the need to swerve to avoid potholes and other minor hazards.

> *Mode shifts to bikes in the U.S. may be a product of technical innovation from mountain biking. Innovations include frames and tires that can handle potholes, powerful brakes, and gear systems that do not require the rider to take his or her hands off the handle bars. All of these have resulted in a flood of bicycles onto the market that are ideal for commuting.*[123]

Maintenance. In many cities, novice riders have cited gravel, sand, glass, snow, ice, and uneven pavement on bicycle facility surfaces as impediments to bicycling. Pavements should be regularly swept, plowed, patched, and resurfaced to present a smooth, clean surface.

> *Allowing pavements throughout 10 cities (in Wisconsin) to deteriorate from smooth to rough riding surfaces would cause a reduction of 38,000 bicycle work trips on nice days—a 42 percent reduction in total bicycling in the summertime. Thus, local street maintenance practices should pay particular attention to keep pavements on popular bicycle routes in good condition to avoid loss in bicycle ridership.*[124]

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[123] *FHWA Draft Report*, 5.

[124] George Kocur, William Hyman, and Bruce Aunet, "Wisconsin Work Mode Choice Models Based on Functional Measurement and Disaggregate Behavioral Data," *Transportation Research Record 895*, (Washington, DC: 1982), 31.

Setting up a mechanism for citizens to report maintenance needs is also helpful. If path and road maintenance is a chronic problem, avoid designs that exacerbate these problems. For example, striping bicycle lanes tends to reduce the sweeping action of cars in adjacent lanes. Other actions to improve facility maintenance include:

- filling potholes;
- providing anti-skid treatment on exposed metal surfaces;
- improving drainage to reduce surface ponding;
- making railroad grade crossings as smooth as possible; and,
- maintaining a smooth roadway surface, including resurfacing and repairing pavement joints when needed.[125]

B. Accommodating New Bicyclists

It is usually difficult and intimidating for untrained beginning and youthful bicyclists to ride in traffic and to operate according to the rules of the road. Accommodating new bicyclists should be done as safely as possible. A system of classroom and on-road training should be institutionalized into the school, law enforcement programs, and community organizations. The form of training should be such that it requires a modest time commitment, divided into easily understood, "bite-sized pieces."

Some bicyclists will always find it difficult to ride on the street and mix with traffic at intersections. However, flexibility in the system can accommodate timid riders if certain rules are followed. Inexperienced or timid riders should be afforded the opportunity for "user-friendly" training to enhance their riding skills and increase confidence. An emphasis should be placed on achieving proficiency bicycling with traffic on the road. Informational material should encourage novice riders to be especially watchful at intersections, and to recognize dangerous accident situations and what can be done to prevent them.

C. Promotion and Training Programs

Some bicycle training and promotion programs are currently conducted in schools, through private organizations, and by municipalities. It remains difficult to quantify the advantages because there is no common, reliable evaluation tool. Therefore comparison among programs, or their effectiveness, cannot be substantiated.

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[125]*National Bicycling and Walking Study—Interim Report,* FHWA-PD-92-003, (Washington, DC: U.S. Department of Transportation, 1991), 30.

The League of American Wheelmen (LAW) has over 300 advocates nationwide who work with State and local authorities to influence government policy. LAW runs a thirty-hour adult training course called "Effective Cycling." It is generally given on weekends in ten three-hour sessions: one hour of class work and two hours on the road. They have also produced a manual for study. John Forester reports that "while 80 percent of collisions might be attacked by this program, perhaps . . . 50 percent can be prevented."[126] Some professional bicycle planners believe that evaluation of this training program has not been comprehensive enough to conclude that training is as critical as is implied by the current evaluation.

Another novel approach is to pair a new or less-experienced bicyclist with a more-experienced one for a training period. The more-experienced bicyclists can point out riding techniques for negotiating traffic, crossing heavily traveled roads, and turning at intersections. They are also likely to know the best routes, short-cuts, and streets with the least traffic. Experienced bicyclists can offer suggestions to less-experienced bicyclists on routes to work or errands, how to deal with clothing at work, avoiding dangerous situations, and bicycling efficiently.[127] However there has been no test of its effectiveness.

According to John Forester, properly training new bicyclists could be the single most effective way to reduce accidents and increase bicycling. Over 75 percent of all bicycle/car accidents occur at intersections, and bicyclist error accounts for 52 percent of the collisions.[128] Forester reports that most bicyclist errors could be prevented through proper on-the-road and classroom training programs. Since many bicyclists are also drivers or future drivers, a by-product of a comprehensive training program is that it can also make drivers more aware of bicyclists.

There are many bicycle-training programs in use. Some are simply offered as volunteer programs to schools. The American Automobile Association has a "Bicycle Skills Test" used by groups who want to have a "Bicycle Rodeo."

Some State bicycle organizations also offer training programs. For example, the North Carolina Bicycle Program makes "Basics of Bicycling" training program available statewide. "It appears that the injury experience of those children who were not exposed to The Basics of Bicycling curriculum was somewhat worse than that of the children who were exposed to the curriculum. However, it is not possible to draw definitive conclusions from this data, due to the small number of injuries and large number of nonrespondents."[129] No comprehensive evaluation was found to verify the effectiveness of this program.

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[126]Forester, *Bicycle Transportation*, 88.

[127]Bicycling Magazine, *Media Report*, 22.

[128]Forester, *Bicycle Transportation*, 61.

[129]Jane C. Stutts, and William W. Hunter, *Evaluation of a Bicycle Safety Education Curriculum for Element School Age Children*, (Chapel Hill, NC: University of North Carolina Highway Safety Research Center, 1990), 35.

However, training programs are intrinsically less interesting to the news media and the general public than cutting a ribbon on a new bicycle path. Because training and promotion do not represent a tangible, physical improvement, it is difficult to attract the political support necessary to fund them. Nonphysical improvements usually don't give politicians as much political mileage. Bicycle training is sometimes included as a part of the school curriculum. However, it is not consistently included.

A good example of the institutionalization of standards that might otherwise be ignored is the recent legislation passed in support of persons with disabilities. Now, any time a facility is built or remodeled, needs of the people with disabilities must be incorporated as a matter of course. Without this type of legislation, it is unlikely that local public works departments or developers will consistently include accommodating bicyclists in the plans. While they may at first resist and resent the additional requirements, eventually these accommodations will become routine.

One way to increase political support and funding for more effective training, promotion and enforcement is to provide a strong community constituency to support bicycle programs. This constituency should include respected business and public leaders. An alternative strategy to increase support for these bicycle programs is to make them more high-profile. This will produce public recognition that makes it easier for officials to support programs, as well as physical improvements.

Among bicyclists, divergent factions contradict each other's findings. "To stripe or not to stripe" a bicycle lane is one example of their differing opinions. Each faction gives different advice for the best ways to cycle and the best ways for cyclists to be accommodated. Each sounds convincing and the various factions often compete for the same listener, a city public works official for instance, and together they give the impression of no clear direction from the bicycle community. This often undermines all efforts to improve the bicycling experience, including promotional and training efforts. The lack of substantiated data for comparing different approaches makes it virtually impossible to make informed decisions about the best facilities, training techniques, or promotional efforts. Planners and bicycling promoters should establish consistent and reliable evaluation tools to test the effectiveness of their facility improvements and programs.

In summary, the primary issues of bicycle promotion and training are:

- lack of hard data to justify facility improvements of program strategies;
- limited monies for training and promotional campaigns;
- lack of regular, timely promotion and training;
- unfamiliarity with routes, methods, and logistics of bicycling to work;
- the discretionary inclusion of bicycle needs in development plans;
- uncoordinated distribution of materials;
- isolated efforts that cannot benefit from lessons learned elsewhere;
- the inability of training programs to attract political and financial support;
- lack of a clear and consistent message about bicycling; and,

- no single organization that is the accepted "voice" for bicyclists.

Examples of Promotional and Training Strategies

Each of these ideas has its own merit. Combining them into a coordinated overall effort is the most desirable approach. Budgets for training and promotion programs should become an institutionalized part of the municipal budgeting process.

Promotion. Training and promotional programs need to be interwoven with a public relations campaign and a data collection effort as described above. It is not enough to run a good program that increases bicycling and reduces accidents. Without proper public relations, the program is likely to fall short of its mark or even fail because it is not supported by the general community. Nurturing this support is critical to the continuation and expansion of any training program.

Media programs should not be hard-edged or an offensive attack. While this approach may appeal to some avid bicyclists who think that change is too slow, it often antagonizes people. Those who might otherwise support bicycle programs could develop a negative attitude because they simply don't want to listen to material presented in an unpleasant or scolding tone. Even those who don't bicycle could benefit from a public relations effort, and change their driving habits to accommodate bicyclists' needs. These people will not be persuaded to do so if they find the public relations attitude offensive.

Employer Incentives. Employers and municipalities can provide bicycles for use on business trips or in areas where congestion is a problem. "Boulder, Colorado, keeps 100 bikes and 50 helmets on hand for the free daily use of tourists and residents. All you have to do is leave your credit card number as a security deposit. Result: fewer cars on the road and more people try cycling.[130]

Information Clearing House. A central network for collection, distribution, and evaluation of bicycling information and data should be established. This would help those wishing to start training and promotional programs, and to provide standardized educational materials.

Training. Bicycle training programs should be a regular part of every school program, starting in the elementary school, and continuing through high school. Motivational techniques, such as earning badges, could supplement the program.

Training Materials. Materials for training and promotions should be made available with enough flexibility to conform to local conditions. This would greatly reduce the number of hours spent re-inventing the same information. The training and information materials should be based on widely accepted standards. Since there are currently greatly diverse opinions about these standards, this is probably an effort that should be implemented after an evaluation tool has been used to test alternatives.

[130]Pena, "How the Bike," 36.

Bicycle Coaches. Establish programs for riders who wish to commute. Matching experienced with unexperienced riders from the same area could be accomplished through bicycle clubs with cooperation from local car-pooling organizations. The newly trained riders could then recruit other novices and a truly "grass-roots" effort could be launched.

D. Enforcement Programs

Proper enforcement, combined with good facilities, encouragement, and education can be helpful in making the bicycling experience safer, more pleasurable, and secure. Enforcement and information on riding safely and responsibly can help to make bicyclists and motorists function together in the same environment, by teaching them to share the road. It can also help off-street path users, including bicyclists, pedestrians, runners, and in-line skaters, to "share the way" responsibly. For path users in particular, the enforcement and security provided by bicycle patrol officers and/or volunteer monitors can be a well-appreciated service to new riders in less secure stretches of those bicycle facilities.

> *The widespread violation of traffic laws by bicyclists, and the general lack of enforcement of these laws has been instrumental in the development of a negative image of bicycle users. There are several possible reasons for the number of violations that commonly occur: lack of bicyclist knowledge and skill; inconvenience and impracticality of the law for bicyclists; bicyclist attitudes of being immune from the law; and repeated occurrences of bicyclists "getting away" with the violations. These reason can be attacked by a combination of education, awareness of bicyclists needs in the development and modification of traffic laws, and enforcement.*[131]

Illegal, careless, and inappropriate bicyclist behavior is a primary cause of automobile-bicycle accidents.[132] These faults contribute heavily to the bad image of bicyclists, and the poor relations between motorists and bicycle riders. The hostile and disrespectful attitude of motorists toward bicyclists is also to blame for the latter problem. People who ride recklessly also set a dangerous example for children who are just beginning to learn how to bicycle. Any type of accident contributes to the general perception that bicycling is unsafe. This image is a major impediment to increased bicycling, especially for commute and utility trips. Disobedience of the rules of the road has been blamed for over 50 percent of all car-bicycle accidents.[133] These problems can be addressed through a combination of training, enforcement, and educational campaigns. Enforcement may be the most important part, as police officers are out on the streets in a position to discourage inappropriate behavior that can lead to accidents.

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[131] *Transportation Research Circular 337*, 25.

[132] Forester, *Bicycle*, 59.

[133] Forester, *Bicycle*, 59.

Unfortunately, many bicyclists feel they don't need to obey most traffic laws, because they trust that they can avoid accidents. They think that traffic control devices don't apply to them and they have the right to coast through intersections because otherwise they will lose their momentum. This behavior doesn't take into account that there are dangerous traffic conditions that are outside the personal control of the individual bicyclist. Safe operation of the traffic system is possible only when people drive or ride following the same operating rules. Problem: Bicyclist fails to slow or stop for stop signs at road intersections. . . . The motorist saw the cyclist but expected him to stop for the stop sign. By the time the motorist recognized that the rider was violating the law, it was too late."[134] The animosity between bicyclists and motorists is compounded when drivers see riders disregarding laws. This can diminish any respect motorists may have for bicyclists' rights.

The goals of enforcement in relation to removing impediments to bicycling are:

- to improve real and perceived bicycle safety by:

  - requiring behavior that improves visibility of bicyclists to motorists
  - encouraging bicyclists to behave in a predictable manner
  - ensuring bicyclists don't cut in front of other traffic dangerously;

- to ensure adult bicyclists set the proper example for younger riders;

- to require motorists to respect the rights of bicyclists as operators of legitimate road vehicles;

- to encourage new and timid bicyclists to observe safe riding practices so that they don't unknowingly put themselves into even more dangerous situations than ones they are trying to avoid; and,

- to correct illegal behavior through equitable enforcement, a policy of training program attendance in lieu of fines, or use of bicycle offense fines to pay for training programs.

Traffic law enforcement is an indispensable part of these programs because it helps promote the safe bicycling principles learned through practical training and education. Limited police manpower can be more effectively used by concentrating on enforcement of serious violations of bicycle laws, such as riding without lights after dark, riding in the wrong direction, and running stop signs and traffic signals. Bicycle-mounted police should be assigned to patrol bicycle facilities regularly. These patrols are particularly effective in pursuing and catching bicycle law violators. Civilian bicycle monitor programs, such as in Madison, WI, have been

[134]Bicycling Magazine editors, *Bicycle Commuting*, 28-29.

very successful providing assistance in bicycle law enforcement and giving information to bicyclists when needed.[135]

Many bicyclists underestimate the need for enforcement of bicycle laws. Knowledgeable bicyclists appreciate the value of reasonable enforcement in support of the mutual goals of the transportation community for safer, less congested traffic operations. Lawmakers and police officials should be taught to take bicycling seriously and to respect the rights of bicyclists to use the road as legitimate operators of vehicles. This requires that the bicycle community actively involve top public safety officials and legislators in the development of bicycle programs and policies.

E. Voluntary-Involuntary Actions, Incentives versus Disincentives

In a country where the preference is to act through choice rather than through mandate, transportation professionals and concerned environmentalists have been searching for ways to reduce energy use and pollution by voluntarily attracting people away from cars. The public feels "more comfortable being given choices in making their decisions. In addition, these choices should be opportunities to save energy rather than being a punishment for using excessive energy."[136]

Behavioral research advises that incentives offer more lasting changes in commuter values than do disincentives.

> *The social science literature suggests that any serious attempt to change commuting patterns and thereby resolve the problems of automobile-dependency should employ incentive and reward techniques. . . . Positive consequences, enjoyed as a result of choices freely made, are more likely to accomplish desired individual behavior changes (automobile-to-bike mode shifts), and transform them into acceptable social norms.*[137]

Incentives can include a range of basic improvements that motivate people to bicycle: safe places to ride, direct routes, good parking, employer support, security, and transit accommodations for bicycles. But more often, incentives are perceived to be those provided by employers to encourage bicycling: secure on-site bicycle parking, showers, lockers, changing areas, a relaxed dress policy, preferential parking, and even financial rewards for bicycling. They are like discrete benefits to the individual for preferred behavior.

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[135]Madison Police Department, *Bicycle Licensing/Bicycle Monitor Program: 1989 Final Report*, (Madison, WI: 27 June 1990), 4, 5.

[136]Tjart, "A Look," 27.

[137]Erickson, "Bicycle Commuting in Chicago."

Disincentives are more like punishments to discourage unwanted choices. Typical disincentives to automobile travel intended to increase the use of other modes including the bicycle are: parking supply and parking location limitations, parking surcharges, gas tax increases, vehicle use or congestion fees, automobile-free zones, and driving limitations. "Pricing, either through congestion fees or increases in fuel prices, has the potential for causing significant shifts from the automobile. However, transit absorbs a large portion of the shift, thus reducing to potential nonmotorized share.[138]

A decade ago, there was an on-going debate about the merits and practicalities of incentives and disincentives to motor vehicle users among transportation demand management experts. Most people wanted to conclude that there is a practical and effective basis for successful use of incentives to encourage increased use of alternative modes. On the other side, some of the more pragmatic specialists were convinced that the only tools that could make a significant change in motorists' behavior are disincentives. To investigate this issue and to encourage the more politically-desirable strategy of incentives, the Urban Mass Transportation Administration and private business interests helped organize and fund several Transportation Management Organizations (TMOs) around the country. Other TMO-type arrangements were primarily initiated through private actions.

At the institutional level, TMOs asked member companies to attempt to reduce demand and increase the use of alternative modes through cooperative, voluntary actions. Their policies usually favored incentives, rather than disincentives. Some of these organizations had exceptional early success, including ones in Hartford, CT, and Southern California. Recent evaluations of these TMOs by FHWA contractors have indicated that the voluntary nature of these organizations has been a major handicap. "To inspire use of the key TDM [Transportation Demand Management] actions, either some type of legal pressure is necessary, or the individual firm must have a readily apparent, economic self interest in adopting these measures.[139]

Recently, there has been a major shift in emphasis toward legislated, mandatory controls. Preliminary indications are that these programs are more effective and longer lasting. However, these approaches are politically unpopular, especially if directed at the individual. For the programs to be successful, the municipality must already have very serious congestion and pollution problems. More success has been observed when legislation is directed toward institutions. An article in *Bicycling Magazine* titled "An End to Free Parking" explained:

> *Japan and much of Europe make parking expensive and unavailable. But in the U. S., 75 percent of all commuters have a parking space waiting for them every morning. For employers, the spaces are a tax-deductible expense; for employees, an indirect subsidy. Instead, employees should be given their subsidy and provided with no free parking. Result: the Environmental Protection Agency*

[138] *Feasibility*, 86.

[139] FHWA Publication No. FHWA-SA-90-005: *Evaluation of Travel Demand Management Measures to Relieve Congestion*, (Washington, DC: U.S. Department of Transportation, February 1992), 27.

> *estimates that public transit and bike use would increase and auto use would decline by 25 percent.*[140]

In areas where there is not such a feeling of urgency, disincentives are politically impractical, and often may be undesirable from the perspective of urban economic viability. Many center cities are already badly strapped to maintain a share of regional commercial markets. Disincentives working to increase bicycle usage in Davis, CA, like restricting automobile parking and automobile access, could threaten the economic life in some urban core areas.

Ultimately, disincentives may be necessary on a wider basis. For example, unavoidable natural market disincentives, like the upward trend of fuel prices, are exerting themselves. The fact remains that disincentives seem to be much more effective than incentives. The survey results of *Feasibility of Demand Incentives for Nonmotorized Travel* showed that a mandatory congestion fee would be more effective in causing a shift away from automobile use than a comparable fuel price increase.[141]

An incentive approach seems to be more feasible than disincentives. However, disincentives are difficult to focus toward the goal of increasing bicycle use, and are difficult to implement unless there is an urgent public health or safety problem. Disincentives, such as parking restrictions, may spell economic disaster for subareas such as traditional downtowns, and encourage urban sprawl. For institutions, corporations, and employers, mandatory requirements seem to be necessary to maximize participation. "To realize the invaluable potential of TDM (Transportation Demand Management) . . . will require legal impetus in most all cases."[142]

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[140]Pena, "How the Bike," 35.

[141]*Feasibility*, 5.

[142]*Evaluation*, 29.

VIII. Identification of Significant Factors in Walking

Generally speaking, everyone is a pedestrian. Whether walking to work, or crossing the parking lot on the way to the store, walking is a common activity. Most people do not realize the extent of their walking, nor consider themselves to be pedestrians.

The health benefits of walking are well-documented. Special walking shoes and walking publications indicate a wide-spread interest in walking. Shopping malls routinely open their common areas for early morning exercisers. Walking is recognized as a beneficial recreational activity, suitable for all ages.

In low-density land use areas, walking for utilitarian reasons is generally difficult. The automobile orientation of the culture has encouraged spread-out destinations. To adequately address the issue of walking for commuting or running errands, it is necessary to recognize that utilitarian walking is impractical in many areas.

The low density, spread-out character of development is not conducive to pedestrian activity. The provision of adequate facilities is compounded by the expense of placing them over a more extended area. Compact land uses encourage more walking because there would be places within walking distance. A U.S. DOT survey showed that, of a selection of reasons, compact land uses would be more likely to encourage pedestrian activity.[143]

But things can change. Health and environmental concerns make it imperative to adjust the focus of transportation planning from automobile dominance to multimodal integration.

Regardless of location, several factors emerge that seem to matter most to people as they choose to walk or not. These are:

A. Distance—real and perceived
B. Safety
C. Directness, coverage, and convenience
D. Security
E. Interest, pleasantness (scale, low traffic, etc.) and maintenance
F. Attractive, compact destinations

[143]F.O. Robinson, J.L. Edwards, and C.E. Orne, "Strategies for Increasing Levels of Walking and Bicycling for Utilitarian Purposes," *Transportation Research Record 743*, (Washington, D.C., 1980).

G. Residential population close to activity center

A. Distance: Real and Perceived

Because of urban and suburban sprawl, walking from origin to final destination is often not a realistic option. The automobile-orientation of American cities today is both a cause and effect of the distance between daily destinations. The average daily home-to-work trip is 11.0 miles.[144] The distance between home and shopping or errand-running destinations is more easily covered by car than on foot.

In areas of the country where the distance between daily destination makes walking possible, the time and inclination to walk become factors. While most people can easily walk a mile, many are not accustomed to thinking of walking. Walking is not seen as an attractive option to driving unless driving is more difficult.

B. Safety

Walking is good for the health but can be dangerous to the body. Most streets are designed for automobile traffic flow, and quite often, pedestrians facilities are lacking. In a contest between a car and people, the car is more likely to emerge the winner.

Most automobile/pedestrian accidents occur at intersections. Half the accidents involve cars going straight through the intersection. Of the rest, more accidents involve left-turning than right-turning vehicles.[145] Studies have shown that many pedestrian accidents can be prevented. Pedestrian education is important, as is physically improving where pedestrians and vehicles interact, and increasing law enforcement efforts.

C. Directness, Coverage, and Convenience

Pedestrians seek the most direct path, and a direct path will attract more walkers than a circuitous one. If the officially recommended route is not sufficiently direct, pedestrians will often make their own, more direct path. Some examples are pedestrians crossing the street at midblock, or well-worn dirt paths where there are no sidewalks.

In many areas, walking is impeded by natural and man-made obstacles. Some destinations are separated by barriers such as fences, walls, landscaping, waterways, or interstate highways that make walking distances longer. The lack of a convenient, direct path may influence some people not to walk.

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[144]*Summary*, 18.

[145]Untermann, *Accommodating the Pedestrian*, 30.

Even where there are no sidewalks or pedestrian facilities, some people walk nonetheless. The dirt paths mentioned above indicate places where pedestrian activity is occurring, and which should be addressed, either by providing new facilities or improving existing conditions.

D. Security

The belief that walking is safe but not necessarily secure needs to be addressed. For many people, the thought of walking alone at night carries images of dark streets where dangerous criminals wait for victims. These perceptions are a mix of fact and fancy, yet they do inhibit walking.

Security is a vital element in a well-used pedestrian system, but the overall perception of walking danger is exaggerated. Besides walking from the parking lot to work or shopping, most people have limited walking experience. As with bicycling, many false perceptions are eliminated when one actually walks.

People recognize there is security in numbers, and they tend to seek out areas where there are other people. By encouraging more people to be out on the streets, the area tends to police itself better.

Efforts to address security perceptions could be better focussed on identifying and remedying actual security problems. Selecting streets as pedestrian connections and focusing security efforts can be a productive use of limited resources.

E. Interest, Pleasantness, and Maintenance

Many areas of the country are built to accommodate automobile travel and access. Walking through parking lots or along busy streets can be an unpleasant experience. Pedestrian activity and human scale dimensions mutually reinforce more pedestrian activity.

Traffic levels also contribute to the walking experience. High traffic volumes are generally less pleasant for pedestrians, yet many destinations need to be accessible somehow, either by walking or by vehicle. Methods to accommodate the different means of access can determine if pedestrians (and bicycles) will try to arrive by means other than automobile.

The physical appearance of a walking path is a supporting factor in inducing people to walk. Safety and security improvements can serve double-duty and make walkways more inviting. Pleasant walkways are more likely to attract recreational and utilitarian walkers.

F. Attractive, Compact Destinations

The spread-out nature of many American communities makes it difficult for people to walk to their destination. But once people get where they are going, it is possible to induce people to walk by providing an attractive pedestrian-oriented area.

The physical character of a location determines if walking will occur. If a person drives to a particular destination, once the car is parked, many facilities within close proximity can make walking a suitable option. Modern shopping malls have perfected this concept. Office developments can be built so that employees within are also able to walk to appointments or meetings.

> *Walking and biking are part of a tripod that supports alternatives to SOV (single occupant vehicle) commuting. The other legs of the tripod are good transit, and high density, mixed use development. These three components together make it easy to get people out of their cars. Logically, it makes sense to start where one or more of these components already exist.*[146]

G. Residential Population Close to Activity Center

Mixed-use developments where residential units are within walking distance of office buildings may not result in a high number of people living close to their workplace. Studies have shown that no more than 6 to 7 percent of employees in a major mixed-use development walk to work. But such developments can reduce automobile use levels.[147] The combination of workers and nearby residents can create a critical mass of people that make neighborhood scale commercial activities work. Mixed-use developments can also encourage a greater number of midday trips on foot.

Locating activity centers within walking distance of where people live can be a factor that encourages more foot trips, lessening the need for parking facilities. Having the option of walking is basic for people to be able to walk for utilitarian purposes.

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[146] *FHWA Draft Report*, 17.

[147] S. A. Smith, et al., *Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas—Research Report*, National Cooperative Highway Research Program Report 294A (Washington, DC: Transportation Research Board, June 1987), 40.

IX. Pedestrian Commuter Tendencies and Preferences

To make utilitarian walking a viable option, patterns of pedestrian use must be understood. A wide variety of sources substantiate these principles as common elements of good pedestrian planning. Since almost everyone walks, many of these ideas are intuitively logical.

- Primarily, commuting pedestrians select the route perceived to be shortest and quickest. If the distance is too great, they won't walk. Other criteria, such as attractions, crowding, security, and street crossings, are rated as much less important.

- Pedestrian commuters will use the most direct, convenient path provided that it is reasonably safe and secure. If this is not available, they won't walk.

- A sidewalk system is basic to the needs of pedestrian commuters; special pedestrian malls and plazas are an added attraction to encourage midday and recreational walking trips.

- During the day, pedestrian paths that are heavily used attract more pedestrians to them. Pedestrians enjoy "people-watching" as they walk. If the path becomes too crowded, pedestrians tend to define other routes which have inviting characteristics, but are less crowded.

- Heavily used pedestrian paths in a developed activity center have active first floor uses, windows that allow pedestrians to see into the buildings, multiple entrances along block faces, and a scale of development that is not overwhelming. If the building is tall, there are mitigating design details (awnings, cornice lines, articulation, and windows to see into the building) within the first 20 feet. Large expanses of blank walls along block faces discourage pedestrian activity.

- Intermediate goals or destinations along pedestrian paths act as points of orientation, and psychologically shorten the distance.

X. Strategies to Remove Impediments to Walking

Facility Improvements

One goal of this project is to remove impediments to walking. Many people cite the absence or poor quality of pedestrian facilities as a primary reason for not walking. Improving existing facilities and locating facilities where none exist increases the opportunities for walking. But improvements do not guarantee facilities will be used.

The best place for new pedestrian facilities is where they are most likely to be used. This includes places where well-worn dirt paths indicate people currently walk in spite of the obvious deficiency of designated facilities, or places where they would walk if it were possible. Strategic placement of facilities makes it possible to create a pedestrian environment where walking is safer, more pleasant, or more inviting. The interim report of *The National Bicycling and Walking Study* provides a list of features that must be included in an effective pedestrian system.

- *Widened paved shoulders to allow safer travel for pedestrians.*
- *Sidewalks, paths, or walkways which are wide, relatively clear of obstructions, and separated from traffic lanes.*
- *Grade-separated pedestrian crossings which are clearly justified, since such facilities go unused by pedestrians if not properly planned, designed, and located.*
- *Pedestrian malls which are well-planned with respect to commercial development, traffic circulation, and visual appeal.*
- *Proper design and operation of traffic and pedestrian signals, including pedestrian push buttons, where appropriate.*
- *Traffic calming techniques, such as narrowed streets to lower vehicle speeds and create safer pedestrian crossing, cul-de-sacs, and limiting motor vehicle speeds or movements.*
- *Barriers that physically separate pedestrians from motor vehicle traffic at selected locations.*

- *Prohibiting curb parking, especially near intersections.*
- *Lighting of streets, walkways, and bicycle paths.*
- *Facilities for the people with mobility and visual impairments, including curb ramps, audible pedestrian signals, longer WALK intervals for slower pedestrian walking speeds, and clearing sidewalks of poles and street furniture.*
- *Signing and marking, including pavement edgelines and pedestrian warning signs where needed.*
- *Adequate provisions for pedestrians and bicyclists in highway work zones.*[148]

This long list is not included as a recipe for every town and city. "The only general solution appears to be a wide variety of alternatives to driving alone that together attract enough people out of SOVs to reduce congestion and pollution."[149] All of the recommendations need to be adjusted to the needs of the community.

Different sections of a community will also have specific needs. For example, in sections where there are many older pedestrians, providing more time for walkers to cross the street is probably appropriate. Grade-separated crossing may be desirable where there is heavy automobile and pedestrian usage. Facility improvements should be judged according to the specific locations within an individual community.

A strategy for improving the pedestrian facilities should begin with an inventory of the existing system. The strengths and limitations indicate where initial efforts should be focused. Pedestrian desire-lines that currently are not addressed should be carefully considered. Working with what is already in place, priorities can be established for accomplishing more extensive improvements. Landowners can be encouraged to create pedestrian-friendly developments through economic or zoning incentives.

In many cases, the needs of the automobile, such as quick and easy movement, are at odds with the needs of the pedestrian, such as safety in crossing at intersections or adequate walking space. Walking (and bicycling) facilities completely separated from major vehicular corridors are generally safer than sidewalks in terms of avoiding automobile/pedestrian conflict. However, in developed areas, allocating the space for separated facilities is difficult. Where space permits, separated facilities will be most useful as transportation corridors if routes connect destinations, such as schools, residential areas, stores, and employment centers.

Crosswalks and pedestrian signals encourage use of facilities by making walking safer and more convenient. The average pedestrian needs 16-20 seconds to cross a six-lane (72-feet-wide)

[148]*National Bicycling and Walking Study*, 32-33.

[149]*FHWA Draft Report*, 5.

street, necessitating adequately timed signal light cycles to meet safety needs.[150] Widening of the sidewalks adjacent to crosswalks, pedestrian islands or refuges halfway across the street, and other pedestrian safety measures can shorten the intersection crossings. A pedestrian signal reactivator in a midstreet refuge can be useful.[151]

Midblock crossings can shorten the distance between crosswalks in areas of wide arterial roads with high speeds, limited sight distances, and few intersections.[152] Extra caution is necessary to ensure that drivers are aware of the possible presence of pedestrians where they are not expected.

Overpasses and underpasses must only be located where they will be used. Better design will address lack of use. Sloping access, transparency (seeing through to the other side), and making the overpass or underpass the easiest path are factors that can encourage greater use. Grade separation (overpasses/underpasses) may be particularly successful in areas where there are disabled or older adult populations, or where land uses or grade are favorable so a direct connection is made without a lot of up and down grade changes. Otherwise, it may be necessary to eliminate paths other than the overpass or underpass (by fences or barriers), which may make people avoid the area altogether.

Educational Programs

For most people, pedestrian education begins with parents, relatives, and friends teaching basic pedestrian behavior, such as looking both ways ("Left, right, left") before crossing the street. In the schools, students are presented supplementary materials and programs. "Pedestrian (and bicycle) public education of all age groups within the community, and through the school system should be integral to any comprehensive community traffic safety program. Programs, such as the WALK ALERT Pedestrian Safety Program of the Federal Highway Administration and the National Highway Traffic Safety Administration, can be tailored to meet the individual needs of each community."[153] To avoid wasting time and resources reinventing educational strategies, existing programs should be used, allowing for modification and improvement.

Evaluation of educational programs has shown that programs such as WALK ALERT have reduced accident rates for school-age children. Adult awareness through films, pamphlets, recorded messages on buses, and public awareness campaigns provide supplementary reminders of basic traffic laws and educate newcomers to the area or visitors of local conditions.[154]

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[150]Operation Green Light, *Development Guidelines That Promote Pedestrian Access and Safety,* (Northeastern Illinois Planning Commission, August 1990), 3.

[151]Dan Burden, "The Older Pedestrian: Special Problems and Need," *Proceedings—10th Annual Pedestrian Conference* (Boulder, CO: September 13-16, 1989), 220.

[152]Operation Green Light, *Pedestrian Access,* 5.

[153]Operation Green Light, *Pedestrian Access,* 7.

[154]*National Bicycling and Walking Study,* 34.

Enforcement Programs

Many pedestrian laws and laws pertaining to motor vehicle operations that affect pedestrians are not enforced even though traffic laws generally encourage safer conditions. Safety should be a major concern for pedestrians, but pedestrian convenience wins out more often. The condition of many pedestrian facilities around the country discourages following traffic rules. "Although lack of compliance [to traffic laws] is rampant, impacts are not necessarily negative."[155] Many minor transgressions of pedestrian laws occur daily and usually result in no accidents. If these laws were too stringently enforced, some pedestrians might be discouraged from walking.

Specific situations are potentially dangerous and need to be prevented. These include large numbers of pedestrians crossing against the light and blocking motor vehicles, and inattentive people who, seeing other people crossing against the light, assume it's safe for them to cross.

Incentives and Disincentives. The automobile orientation of the transportation system is a primary disincentive to walking. "People will continue to choose not to bike or walk because they perceive these modes to be unsafe, too physically demanding, or inefficient, or because they feel that others will view them as 'unprofessional' or 'uncool.'"[156] A survey of existing studies shows:

> *We have come to think streets should be built first and foremost for the convenience and speed of moving cars, overlooking the fact of the matter—that the point is to move people, not cars. We have set in motion an endless need for more and bigger roads, because residents of suburbs are given no viable alternatives to driving. . .*
>
> *Making streets more inviting to pedestrians and bicycles will first require reducing the speeds which cars can safely travel. . . In most communities residential streets are overdesigned, allowing cars to move much faster than they safely should. For example, many subdivisions codes require right-of-way distances of 70 to 80 feet for local streets. If the objective of these streets is to carry only local traffic, it is not really necessary to design them so generously. . .*
>
> *Street design can . . . help to minimize the dominance of cars. Reducing the distance that pedestrians must traverse to cross a street at an intersection is important.*[157]

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[155]FHWA Publication No. FHWA IP-88-019: *Handbook on Planning, Design, and Maintenance of Pedestrian Facilities*, (Washington, DC: Federal Highway Administration, March 1989), 214.

[156]*National Bicycling and Walking Study*, 15.

[157]Lloyd W. Bookout, "Neotraditional Town Planning: Cars, Pedestrians, and Transit," *Urban Land*, 51:2 (February 1992), 12-13.

Examples of Strategies

■ Configure destination activity centers to be dense, compact and pedestrian-friendly with a good land use mix and supplementary transit (shuttles, fare-free transit, etc.).

In many places, the workplace is not within easy walking distance of any shopping or restaurants that could be lunch-hour destinations. In a survey of an automobile-oriented suburban office area, "approximately 15 percent of the auto trips were less than one half mile in length. . . . The fact that many short trips are still made by car reflects the importance placed on travel time by the trip maker. Whatever can be done to increase the compactness of land use will encourage greater pedestrian travel for personal business trips and for other trip purposes.[158]

There are many destinations where once people arrive by car, they can be encouraged to leave the car parked while they get around on foot. Of the people who drive to work in downtown Orlando, FL, 37 percent use their cars one time or less each week during the workday. Twelve percent (12 percent) never use their cars during the workday.[159] These are the people who are more likely to be encouraged to walk during their lunch hours to retail and food outlets, services and medical offices within walking distance of activity centers.

On the other hand, 43 percent of automobile commuters in the Orlando survey stop on the way to work for errands, and 77 percent stop on the way home.[160] These people could be encouraged to leave the car parked during the day, and possibly run some of their errands by walking to nearby establishments.

Pedestrian-friendly development can also make a difference when and where people walk. A shopping center or grocery store that is accessible to the pedestrian only after crossing a vast parking lot does not invite pedestrian access. This is not out of a desire to exclude pedestrians but from an economic necessity to make the business accessible to customers, who mainly arrive by automobile because of less compact land uses. Several methods of inviting pedestrian access are possible, from building close to the street line, where zoning regulations allow, or providing a delineated path for pedestrians. The authors of The National Cooperative Highway Research Program report Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas discuss other methods of improving pedestrian access.

"Effective pedestrian-oriented land-use planning will have the most significant impact on pedestrian travel of any pedestrian strategy. Compact higher density land use is recommended where environmentally compatible with surrounding uses. The 'urban village concept' is set forth

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[158]S.A. Smith, *Research Report*, 9.

[159]Downtown Orlando Transportation Management Association, *Commuting in Downtown Orlando: Survey Results*, (Orlando, FL: 1991), 14.

[160]*Downtown Orlando*, 14.

as a desirable development form in which access to the area may be predominantly by automobile, but circulation within the area would be largely on foot."[161]

- **Target promotional programs to people living within 20-25 minute walk from work centers.**

The people who are most likely to walk to work are those who live within walking distance. Therefore, a logical place to focus efforts is where they are more likely to be used. Improving pedestrian connections from residential areas to work centers may not initially encourage great numbers of people to commute by walking, but over time the improved pedestrian environment may encourage an improved level of pedestrian activity.

- **Put continuous, adequately sized pedestrian sidewalks on all streets or as frequently as possible.**

Basic facilities go far to encourage walking. In many communities, the absence of sidewalks makes walking such an unpleasant activity that any improvements would make walking safer and more inviting. Untermann says the presence of sidewalks along the roadway reduces accidents by 35 percent.[162] They are least beneficial when constructed too close to high-speed roadways.[163]

The presence of sidewalks indicates that the community is concerned for the safety of the pedestrian. Patrick Hare proposed "Low Cost/High Response Improvements: Scarce dollars for walk/bike improvements should be spent on short facilities that connect areas where it is already relatively safe to walk and bike, such as single family neighborhoods, corporate parks, and shopping centers."[164]

"Pedestrian ways need not be concrete sidewalks in all cases. Limestone screening and wood chip surfaced paths have proven to be operationally acceptable and offer significant cost savings."[165] New A.D.A. legislation makes it necessary to modify these suggestions to meet the needs of persons with disabilities. Creative thinking is necessary to meet the new standards in an economically feasible manner.

[161]S.A. Smith, *Research Report*, 3.

[162]Untermann, *Accommodating the Pedestrian*, 32.

[163]*Handbook—Appendix C*, 217.

[164]*FHWA Draft Report*, 6.

[165]Operation Green Light, *Pedestrian Access*, 3.

Develop safe pedestrian crossings at all intersections.

This is stated as a basic dictum. The long-range goal is to make *all* streets safe for pedestrians, but for now, it may be necessary to focus efforts on the most used areas, or areas where pedestrian activity should be encouraged.

"A signalized intersection becomes advantageous to vehicular traffic when pedestrian flows reach about 700 per hour. . . . Pedestrians usually prefer no more than a 20-second delay. Any longer delay increases frustration and may prompt some pedestrians to cross against the light."[166]

The risk of an accident while crossing at a signalized intersection is less than that of crossing between intersections or at an uncontrolled crossing. Eliminating delayed WALK signals that allow right-turning vehicles to turn before pedestrians cross improves pedestrian safety.[167] A combination of clearly striped crosswalks and advisory signs warning pedestrians to watch for turning vehicles and warning cars can be effective.

Allowing a scramble system where pedestrians cross in all directions at once reduces pedestrian accidents. Vehicles must wait for pedestrian light cycle to finish (and vice versa). It should be noted that this system increases the delay for both pedestrians and motor vehicles. However some cities have found it to be a way of making pedestrian activity more safe in areas of high pedestrian activity.

"However, marked crosswalks may present a false sense of security to pedestrians at other locations, such as at uncontrolled midblock crossings with high vehicular speeds and limited sight distances."[168] Crossing one-way streets is safer than crossing two-way streets unless the one-way speeds increase.[169]

Integrate pedestrian facilities and development to shorten perceived distance and add interest.

Focusing on the strengths of the pedestrian system can help a community make better use of limited resources. Sometimes pedestrian pockets are located where they do not connect with each other in a pleasant or inviting manner. Pedestrian-oriented development can be encouraged through zoning codes or other legal incentives.

Parking lots can be adjusted to mixed-use, higher density uses. Sprawling fields of cars in conventional parking lots can be dauntingly impassable to the average pedestrian. Creatively

[166]Untermann, *Accommodating the Pedestrian*, 37.

[167]Untermann, *Accommodating the Pedestrian*, 32.

[168]Operation Green Light, *Pedestrian Access*, 5.

[169]Untermann, *Accommodating the Pedestrian*, 32.

developing unused parking space with shops or services, plus pedestrian-scale access can make previously unattractive areas inviting.

Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas offers a list of principles to guide development of pedestrian-oriented land-use plans.

- Focus commercial development on activity centers that are concentric (rather than linear) in nature.
- Within activity centers, provide for the highest densities that can be accommodated by the transportation network.
- Consider use of compact parking structures to minimize distances.
- Designate residential areas surrounding activity center for higher density development, decreasing density with distance away from center.
- Avoid bisecting the area with high-volume vehicular thoroughfare. Provide major vehicular access from the circumference.
- Provide a complementing mix of uses.[170]

■ Identify ways to reduce the perception of distance on pedestrian routes.

Visual interest makes a trip shorter. Reduce the perception of a long distance by making the walking trip more interesting and pleasant. Add intermediate destinations, focal points, such as fountains and art work, or paving patterns to help pedestrians measure the distance travelled.

■ Maintain (some) vehicle traffic adjacent to pedestrian facilities.

The presence of other people alleviates security concerns. If there is not enough traffic in a pedestrian area to make it feel secure, people may avoid the area, making it less safe. Allowing limited vehicle traffic in pedestrian areas can help to minimize the feeling of desertedness or isolation.

One reason many pedestrian zones are kept free of automobiles is that some vehicles overwhelm the pedestrians with their noise and size. One solution is to maintain a balance between pedestrian and vehicle space. None of the mobile elements will look or feel out of place in the pedestrian district.

■ Clearly delineate pedestrian and vehicle area and provide prominent pedestrian signalization or signage.

[170]S.A. Smith, *Research Report*, 29.

As it is, pedestrian space quite often is compromised by driveways and other forms of automobile access. If land use patterns make it necessary for the two systems to intersect, signs indicating to pedestrians and motorists to watch for each other should be placed as a courtesy. Clearer signage for pedestrians may encourage compliance with traffic laws if pedestrians feel they are an accepted element of the traffic system.

Automobile/pedestrian accidents decreased 50 percent or more after the opening of the Portland Bus Mall due to a combination of sidewalk improvements, simplification of traffic patterns and concentration of pedestrians on the mall streets having fewer vehicular turning movements.[171]

■ Design residential areas so they have safe, convenient pedestrian connections with shopping, services, and transit.

There are many residential areas that abut shopping centers or office buildings, but for various reasons, they are separated by fences or other barriers. These barriers make it necessary for residents to have to walk further to get around the barrier. Crossing the barrier is much easier by automobile. Creating pedestrian (and bicycle) connections can facilitate walking to these desired destinations by shortening the distance.

"Property owners who reduce congestion and parking demand through Transportation Demand Management (TDM) measures should have the right to surplus parking land for high density mixed use development."[172]

Neotraditional town planners champion the concept of pedestrian-oriented housing developments, allowing automobile access but giving priority to pedestrian connections between residences and the important destinations in the community, such as schools, stores, recreational centers and parks. "As Victor Mirontschuk explains, 'The neotraditional concept is not radical—it acknowledges that Americans have a love affair with their cars. But it also acknowledges that Americans should be given a choice and not forced to use their cars for every travel need.'"[173]

Peter Calthorpe promotes housing organized as Transit-Oriented Development. "Calthorpe believes that the size of a community should be limited by easy walking distance to a transit station—about a quarter of a mile, he figures. The community would then be designed around the station. Retail, office, and manufacturing spaces would be closest. Just beyond that area would be a mix of town houses and semidetached houses. This layout would ensure that jobs and most day-to-day goods and services, including day care and recreation facilities, would be

[171]Kenneth J. Dueker, Pete Pendleton, and Peter Luder, *The Portland Mall Impact Study*, (Washington, DC: Urban Mass Transportation Administration, December 1982), 48.

[172]*FHWA Draft Report*, 6.

[173]Bookout, "Neotraditional," 11.

available to community residents; they also would be easily accessible to others who might arrive by transit, such as people working in the nearby offices."[174]

■ Initiate strong policies to promote development of housing next to activity centers.

People who live within walking distance of employment, entertainment, or shopping are more likely to walk to these destinations. Studies have shown that higher density land uses incorporating residential areas can reduce automobile dependence: "A Natural Resources Defense Council/Sierra Club study by John Holtzclaw looked at five San Francisco areas of different densities. The study, which was based on odometer recordings from annual car inspections, showed very clearly that for each doubling of density in households/acre, VMT (vehicle miles travelled) is cut by 30 percent."[175]

"Effective land use planning is another key to a viable new transportation system. Several studies suggest that there is a threshold level of urban density—30 to 40 people per hectare—below which reliance on the automobile soars. . . a 60 percent decrease in density corresponds with a 285 percent increase in gasoline use per person."[176]

Furthermore, "Zoning amendments should allow property owners to use TDM measures to create additional development rights by reducing trips and the need for parking. This would put the profit motive behind trip reduction. Zoning that encourages reuse of surface parking for the creation of urban villages will not only suppress auto trips directly, but also create the conditions that enable people to make trips without cars. The clearest example is the case of suburban shopping malls."[177]

[174]Todd W. Bressi, "The Neotraditional Revolution," *Utne Reader* 51 (May/June 1992), 102.

[175]*FHWA Draft Report*, 24.

[176]Lowe, *Alternatives*, 38.

[177]*FHWA Draft Report*, 17.

XI. Distance Factors in Bicycling and Walking

In spite of the fact that over 50 percent of Americans live 5 miles or less from work, 76 percent of all commuters drive alone in motor vehicles. Additionally, 50 percent of all car trips are under 5 miles.[178] About three-fifths of all vehicle trips are less than 5 miles and four-fifths are less than 10 miles.[179] The 1990 National Personal Transportation Survey reports that the average commute trip is only 10.7 miles. Even in Los Angeles which has a reputation for its spread out development patterns, 40 percent of commute trips are 5 miles or less.[180] In Chicago, 42 percent were 5 miles or less.[181]

The perception that the distance is "too far to ride or walk" is the most commonly cited impediment to commuting by occasional users. Since actual and perceived travel distance are considered to be very important, the problems and solutions associated with these distances deserve special examination.

Investigations of ways to increase bicycling and walking consider travel distance solely as a fixed parameter of settlement and land use patterns. Most studies respond to this in two ways:

1. Land use patterns are accepted as a given and the emphasis is shifted to other factors over which greater, more immediate control is possible.

2. Analysts confront the land use/travel distance problem by proposing policy-based strategies to try to bring about more compact development future for urban America in the long range future.

Both of these responses are important in reducing motorized vehicle use. However there is another dimension to travel distance worthy of deeper consideration because of its large user market potential. It has been estimated by the Motor Vehicle Manufacturers Association that 54

[178]Bicycling Magazine, *Media Report*, 15.

[179]*Summary*.

[180]Pena, "How the Bike," 34.

[181]Erickson, "Bicycle Commuting in Chicago," 124.

percent of all Americans live within 5 miles of their jobs.[182] This national statistic is a "miles by car" distance, which is currently (in most cases) a shorter trip than "miles by bicycle" or "miles on foot." To induce more commuters to bicycle and walk, facilities need make commute distance by those modes as short or shorter than by car.

The opportunity to increase bicycling and walking by achieving this goal was identified through a critical examination of an apparent contradiction in results found in many travel characteristics studies such as: *The Metrorail Orange Line Bicycle/Pedestrian Access Study* in northern Virginia, *Bicycling Magazine's* Harris Poll, *The Feasibility of Demand Incentives for Nonmotorized Travel, Why Ontarians Walk, Why Ontarians Don't Walk More* and *The National Personal Transportation Survey*. These surveys revealed that although most commute distances are actually pretty short, most commuters say that "it is too far to ride" (or walk).

For example, in a recent study of four transit stations in northern Virginia, over 73 percent of area residents surveyed lived within 3 miles of the stations (46 percent lived less than 2 miles away, and 14 percent less than 1 mile away), but 82.7 percent felt it was too far to walk (33 percent felt it was too far to bicycle).[183] Either the distance referred to in the most commonly cited impediment "too far to ride or walk" is not the same as actual "distance to work" in most cities, or else people are not willing to walk or ride as far as experts think.

The acceptable *limit* for walking commute distance is thought to be about 2 miles. However, the estimated average walking distance nationally is currently .8 miles.[184] In another North American example, 26.8 percent of the residents in Thunder Bay, Ontario, said they live within walking distance of work, but less than half of these actually walk.[185] Although practical walking distance is less than that of bicycling, there is a huge potential for increasing use of this mode because average trip distances are so short. However, improvements are needed to ensure actual walk distance on safe, acceptable facilities is as short as measured trip distance.

There is a difference of opinion on the acceptable bicycle commute distance. Bicycles have been found to be competitive with all other modes for distance up to 3 to 4 miles in urban areas. Five miles is often cited as a reasonable commute distance *limit* for bicyclists.[186] The average commute trip length revealed in a 1980 Bicycling Magazine study of subscribers who bicycle commute was 4.7 miles,[187] (although the average bicycle commute distance nationally among all riders is 2.1 miles[188]). Based on the fact that people taking part in many surveys

[182]Andy Clarke, "Gridlock 2020," *TR News* (January-February 1990), 13.

[183]Cristopher Neumann, *Metrorail Orange Line Bicycle/Pedestrian Access Study*, (Washington, DC, 1989).

[184]*Summary*, 5-14.

[185]Hawthorne, *Why Ontarians Walk*, 9.

[186]Deakin, *Utilitarian Cycling*.

[187]Forester, *Bicycle*, 23.

[188]*Summary*. The current average bicycle commute distance is 2.1 miles.

said that trip distance is the primary factor in choosing to bicycle (or walk), more people could bicycle than currently are.

Factors Increasing Apparent Bicycling and Walking Distance

The distance-to-work figure cited above is the distance driven by motorists on the general street system. Since there are more available roads designed for motor vehicle use than there are safe routes for bicyclists and pedestrians, the actual distance by bicycle or walking is almost always longer than the distance to work by car. This is because of:

- an absence of reasonably safe routes on most streets;
- people's fear or lack of training in riding close to traffic;
- lack of sidewalks; and,
- gaps and discontinuities along the preferred route.

All these factors produce a longer, more circuitous trip, which is likely to discourage bicycling and walking. For most prospective users, these factors effectively move them out beyond practical bicycling or walking commute distance. If the actual distance to the destination was within 5 bikeable or 2 walkable miles, distance would probably be much less of an impediment.

Distance-Related Opportunities to Increase Bicycling and Walking

Experience with facilities in many cities shows that actual commute distance along safe, convenient bicycle and pedestrian facilities often is longer than commute distance figures identified nationally and locally. To more effectively tap the huge market of people living within theoretically reasonable bicycling and walking distance, local and regional policies should target development patterns that are logical. Walking and bicycle facilities should provide direct, convenient connections between homes, businesses, and work sites for people who live within suitable distance. These policies should:

- ensure that routes that are easy to use for bicycling and walking are as direct and accessible as existing streets;

- implement projects to fill critical system gaps and discontinuities; and

- provide a means to educate the general population to bicycle safely on the road.

Actions to ensure that city streets are bicycle-friendly should be coupled with the development of cost-effective off-street paths. A national and local priority must be given to providing adequate, smooth, and well-maintained space on virtually all streets for bicycles and pedestrians. Intersections must be configured so they are as safe as possible to minimize the actual distance to be covered by bicycle or foot. Implementing an information program can help commuters determine the most direct route for their commute trip. Advice on finding one's way around and the logistics of a bicycle or pedestrian commute routine should also be included.

Through this system, a more attractive bicycling and walking option can be provided to all who live within practical distance of their destination. The actual bicycling and walking distance will be closer to the driving distance and through special linkages routed directly through developments, sometimes closer. If the trip can also be made less stressful and more pleasant, it will seem shorter. "The impact of travel time can be reduced if rides can be made as comfortable as possible."[189] Thus these modes can be more competitive with the automobile. This is particularly important for trips where bicycling time is comparable to driving time. Bicycling 5 urban miles, for example, can be as fast or faster than the car.[190]

[189]Ulberg, *Psychological Aspects*, 19.

[190]Forester, *Bicycle*, 23.

XII. Importance of Coordinated Strategies Tailored to Local Conditions

The effectiveness of any strategies identified here to remove impediments to bicycling and walking are dependent upon their appropriateness to specific locales. Strategies that are effective under one set of local conditions can be ineffective under other conditions. For example, striped bicycle lanes tend to keep cars from driving in the striped area, reducing the sweeping action of the cars, and requiring increased street maintenance to keep the bicycle lane clean. Striping bicycle lanes is a highly-regarded solution in Davis, CA, but would be less satisfactory in a city where street maintenance is less frequent.

In considering bicycle program and facility strategies, an objective look at local characteristics including goals for bicycling, physical conditions, and institutional strengths and weaknesses can help with designing a good program. Physical factors to consider include land use distribution, density, population concentrations, and the street system layout and connections. Municipal policies and priorities to consider include the effectiveness of maintenance programs, maintenance equipment capabilities, enforcement attitudes, capital and funding. Social considerations include general levels of driver awareness, compliance with laws, environmental commitment, and bicyclist sophistication.

Programs to remove impediments to bicycling and walking should include a coordinated set of strategies that reinforce each other. "Reasons for not bicycling or walking are varied, and no single approach will result in significant increases. A coordinated approach involving several components is required: public education, promotional campaigns, facility development, and supportive public policy."[191] If on-street facilities are improved to attract more use, an aggressive training program to prepare new bicyclists to use them safely and confidently is a logical companion to the physical changes. Special promotions, tied to the improvement would further enhance usage. This might include Bike-to-Work Day activities targeting the new improvement, a ribbon-cutting ceremony, or a guided commute ride that includes the new facility.

Combining mutually-supportive actions to make land use patterns and transit service more compatible with bicycling and walking can be very effective, as stated earlier in the report.

[191] *National Bicycling and Walking Study*, 15.

Patrick Hare stated that walking and bicycling, good transit, and high-density mixed use development all work together to reduce the habit of driving alone.[192]

To make the most efficient use of municipal resources, a full-time bicycle and pedestrian program planner should be hired. The planner can be the key to opening serious communications between the bicycling and walking community, and engineering staff. "Nothing affects the well-being of the pedestrian like decisions of traffic engineers. Traffic engineers accommodate elected officials where necessary, but overall, the engineer rules, with traffic counts and standards."[193] The planner becomes the monitor for policies that encourage bicycling and walking in all aspects of community planning.

[192]*FHWA Draft Report*, 17.

[193]Joel Woodhull, "Transit Agency as Pedestrian Advocate," *Proceedings: 12th International Pedestrina Conference* (Boulder, CO: October 2-5, 1991), 47.

XIII. Developing a Basis to Judge the Effectiveness of Measures to Remove Impediments

This case study has drawn from some of the best national and international research on bicycle and pedestrian programs. The effort has been handicapped by the lack of objective analysis to measure program effectiveness, especially in terms of safety and usage. As noted previously, there are very few instances of documented success stories correlated with specific facility or program improvements. Almost none of these have been measured for effectiveness in true "before and after" fashion. Some studies of programs in Europe are useful. However, because of the major differences in values, economy, culture and development patterns, the relevance of these evaluations to conditions in the United States is questionable.

The lack of a good basis to judge and select from potential bicycle and pedestrian improvements is, in itself, an impediment to increased usage. Knowledge of which measures work and don't work is critical to choosing the most cost-effective solutions. Many of the decisions to improve bicycling and walking are based on speculation rather than analysis. This situation is a problem because it reduces the credibility of the field.

Because of the low priority given to walking and bicycling programs, funds for improvements are scarce. It has been noted that there is not enough money available to pay for evaluations of effectiveness. However, since funds are limited, spending these few dollars wisely should include choosing the most cost-effective programs and projects. When this is done, the new programs can increase usage, and in turn give walking and bicycling a greater priority for municipal funds.

Requiring an evaluation of the effectiveness of all major improvements will contribute to a greater understanding of what works and why. The Federal Government can be the catalyst by requiring specific types of evaluations for selected projects involving government funds. Together with State governments, they can provide funding credit to municipalities including these studies in their implementation programs.

The evaluations need to have a consistent and methodical study design to produce useful information. This begins with a clear definition of the purpose of the project, the planned approach, data to be gathered, and the measures of effectiveness. The first data-gathering step in the evaluation is documentation of "baseline" conditions, including safety and use patterns

before implementation. This should be comprehensive enough to provide a basis for comparison against the post-project conditions.

Other variables, such as "spill-over" effects (riders diverted from or to adjacent streets) and overall usage trend changes, should be separated from usage impacts from the particular improvement. Choosing "stand alone" projects and programs that can be evaluated without confusion from multiple components will yield clearer evaluation results. "Cycle schemes may increase the number of cyclists on a route but not necessarily by increasing the number overall in an area. Cyclists may divert to a new route from less attractive alternatives in the 'corridor.' . . . Routes may fail to generate new bicycling trips but may still be worthwhile because they provide safer alternatives."[194] The post-project evaluation, like the baseline study, must also be carefully structured to capture the true impacts of the improvements.

The post-project evaluation identifies the project effectiveness because usage or safety changes must be given time to stabilize after the novelty has worn-off. Documentation of the findings and conclusions derived should be fair and unbiased. This is the information that may be the guide for similar improvements throughout the country, so the implications of the need for accuracy are profound.

[194]Hugh McClintock, "Getting in Gear: The Riders Right of Way." *Surveyor* 168: 4946 (28 May 1987), 16.

XIV. Governmental Policies to Increase Bicycling and Walking

The U.S. Department of Transportation has a leadership role in creating a balanced, complementary transportation system, including a more significant and appropriate role for the bicycle and pedestrian modes. Because it sets the example for certain State and local transportation policies, the FHWA can have a strong positive influence on the priority given bicycling and walking throughout the country. There is now a greater understanding of the potential of these two nonmotorized modes to help achieve national transportation goals for congestion relief, fuel conservation, and environmental protection. In this light, a careful re-evaluation of Federal, State, and local transportation funding priorities should ensure they are in line with the expectations being placed on these modes. Although this re-evaluation may not mean that there will be more money for bicycling and walking programs, it can provide the proper perspective of the potential value of these modes to America.

A key component of a national initiative on improved bicycle and pedestrian programs should be formal recommendations of program policies and design standards for facilities. These standards should state, for example, that adequate width is included in the recommended cross-section of any street construction or reconstruction. "To varying extents, bicycles will be ridden where they are permitted. All new highways, except where bicyclists will be legally prohibited, should be designed and constructed under the assumption that they will be used by bicyclists."[195] The policies should be inclusive to promote the need for a coordinated group of strategies drawing from training, facilities, promotion, and education.

Governmental policies can be effective in resolving difficult local institutional, economic, and legal issues impeding the broader use of bicycling and walking. These policies can help to:

- make institutions more sensitive to community needs;
- reduce public agency resistance to accepting these modes as legitimate parts of the transportation system;
- increase respect for bicyclists and pedestrians by motorists;

[195]AASHTO, *Guide.*

- produce adequate standards for facility design;
- increase bicycle and pedestrian community influence on transportation priorities;
- ensure complete coverage and bicycle/pedestrian accessibility through routine institutionalization of facility requirements into design standards;
- reinforce the importance of a bicycle/pedestrian coordinator at the local level;
- ensure adequate maintenance of bicycle facilities and walkways;
- provide for signal and crosswalk standards to create a balance of motorized and nonmotorized transportation access and safety; and
- support the allocation of funds to the more cost-effective bicycle/pedestrian program options.

Funding Opportunities and Policies

Significant improvements to the pedestrian and bicycle systems in this country are possible through a combination of policies designed to tap both public and private development opportunities. There are a range of traditional funding sources that can be utilized to make improvements to the pedestrian and bicycle systems. They include:[196]

Resources Available to Local Governments

- General revenues
- Special district funds (if allowed by State law)
- Motor fuel tax funds
- Developer contributions
- Intermodal Surface Transportation Act (ISTEA) funds
- Parks and recreation funds
- Designated bond funds
- Lottery funds (if applicable)

Regional Level

- Federal Transit Administration funds

[196]Operation Green Light, *Development Guidelines that Promote Bicycle Use*, (Northeastern Illinois Planning Commission, August 1990), 14.

Available to Counties and Townships

- Forest Preserve/Open Space Districts
- General Transportation funds

Available at the State Level

- State Department of Transportation/Highway Dept. funds
- Bicycle/pedestrian improvements, in conjunction with road projects
- ISTEA funds

Municipalities should adopt development policies to provide bicycle and pedestrian improvements. These should be an integral part of existing ordinances to share the costs of infrastructure improvements necessitated by new private development. In facilitating this, private developers should be informed of the value of these improvements to the viability of their projects.

> *Probably the most important single "sell" that the alternative modes planner can make is to convince the developers in his or her community that the installation of quality bicycle/pedestrian facilities is a profitable investment that is the interest of the builder to make. Evidence is starting to come forth showing that well designed and built bikeways enhance the value of nearby real estate holdings. This same type of argument holds true for other types of facilities, such as bike lockers and showers.*[197]

As stated previously, an increasing emphasis is being placed on motorized and nonmotorized alternatives to the personal automobile, including bicycling and walking. A commensurate funding priority should be given to bicycle and pedestrian programs. The new Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 provides a major opportunity for local governments, in coordination with their State and Councils of Government, to fund strategic components of comprehensive bicycle and pedestrian programs.

> *The new legislation reflects strategies for action as outlined in the National Transportation Policy. With the Interstate Highway System essentially complete, . . . ISTEA will focus on managing the existing network of highways, with an emphasis on reducing congestion and promoting a multimodal transportation program.*
>
> *The ISTEA makes accommodations for State Highway Agencies to obligate funds for the construction of pedestrian walkways and bicycle transportation facilities that have been located and designed in accordance with a comprehensive plan*

[197]Bruce Epperson, "Using Developer Dedication to Create Successful Bicycle and Pedestrian Facilities: A Primer for the Alternative Modes Planner," *Proceedings: 12th International Pedestrian Conference*, (Boulder, CO: October 2-5, 1991), 144.

developed by the State and the metropolitan organization. Nonconstruction projects related to safe bicycle use may also be eligible for funding. The ISTEA provides flexibility to the States for being able to fund a staff position within the Department for the position of bicycle and pedestrian coordinator responsible for promoting and facilitating the increased use of nonmotorized modes of transportation.[198]

Examples of other programs adopted or proposed to fund pedestrian and bicycle improvements are:

- "Nearly 20 years ago with the advent of the landmark bicycle bill, the Oregon Department of Transportation took the lead in the funding and development of bikeways. The legislation—the first of its type in the nation—provided at least 1 percent of State, county and city highway funds to be used for the development of bikeways and pedestrian footpaths.[199]

- *Bicycling Magazine*'s commentary on the 1990 Harris Poll called for 3 percent of Federal Aid Highway dollars (to) be spent on bicycle and pedestrian projects.[200]

- The Netherlands has for several years made a major commitment to using general roadway funds for bicycling. "In '75, the national government decided to devote at least 10 percent of its surface transportation budget to bicycling."[201]

- With the adoption of its transportation plan, Boulder, CO, has a major policy commitment to the use of general city funds for alternative transportation, including bicycle and pedestrian program improvements. They are using a spending formula to direct half of their transportation improvement funds to alternative mode projects.

Another important aspect of funding for bicycle and pedestrian improvements is to direct project priorities toward providing cost-effective solutions, regardless of mode, to achieve effective, responsible mobility.

For a growing number of transportation planners, it is clear that the bicycle must be seen as one part of the solution to these (congestion) problems. . . . We (transit agencies) may be better off spending our money on bicycle access . . . than on new parking structures. . . . While U.S. transit agencies have expended over $150 million in recent decades to build automobile park and ride lots at a

[198]George Osborne, "Accommodations of Pedestrians and Bicyclists in the Federal Aid Highway Program," *Proceedings: 12th International Pedestrian Conference,* (Boulder, CO: October 2-5, 1991), 126-127.

[199]"A Look at Oregon," *AASHTO Quarterly,* 12.

[200]Bicycling Magazine, *Media Report,* 17.

[201]Scott Martin, "The World's Best Cities for Cycling," *Bicycling Magazine,* (May 1992), 59.

cost of $3,000 to $15,000 per space, bicycle parking needs have often been neglected, despite the far lower cost of $50 to $500 per bicycle parking space.

Recent research by the Chicago Transportation Study found that bicycle parking installation at rail stations was 300 times more cost-effective in reducing pollution than park and ride development.[202]

Such decisions can be both more environmentally helpful and functionally effective than conventional and costly transportation solutions.

To capture maximum benefit from available funds, cost-effectiveness measurement should also be applied when selecting alternatives for bicycle and pedestrian projects. The costs are not often weighed against the benefits to the community in choosing projects. "A number of bikeway facilities have been constructed . . . because the right-of-way was available, but there has been little regard for the potential usefulness of the ultimate facility."[203] The money spent on one expensive project means that it will not be available to fund other improvements that may be more cost beneficial.

[202]Replogle, "Cutting Transit Costs," 5.

[203]D. Smith, *Planning and Design*, 4.

Conclusions & Recommendations

Based on the information gathered for this case study, bicycling and walking can become important components of the national transportation system. These modes can absorb some of the pressure of increasing personal travel demands on the road system, environment, and fuel supplies. To foster this increase in the most responsible manner, there is a parallel need to have facilities that new users can enjoy safely.

Measures to Overcome Impediments to Bicycling and Walking was developed to examine the root causes behind impediments to bicycling and walking and to identify ways to remove them. Although objective research measuring the success of various solutions to these impediments is limited, improvements seem to have been effective in a number of locations. Certain physical improvements combined with an integral system of education, encouragement, and enforcement can increase bicycle usage and safety. These actions include correcting legitimate facility deficiencies, training potential bicyclists to use on- and off-street facilities safely, encouraging greater use of bicycling and walking through messages designed for specific market audiences, and ensuring bicyclists and motorists understand and observe each other's rights and responsibilities.

This case study is based on an examination of survey results, successful bicycle and pedestrian programs around the country, and comparisons of perceived versus real facility conditions. Impediments to bicycling and walking expressed in surveys seem to have multiple causes lying within three major interrelated categories: 1) facility deficiencies; 2) information or knowledge deficiencies; and 3) motivational deficiencies. It is easier to define the problem if the perceived impediment is analyzed from the perspective that its cause is rooted in these three factors. If the problem is clearly defined, solutions are more likely to be appropriate.

Solutions to bicycling and walking concerns are rarely obvious or straightforward. Perceived impediments are often not the actual impediments encountered on roads or paths. For example, many entry-level riders are more concerned about having an accident with an overtaking vehicle at midblock than with a turning vehicle. Accident statistics show the opposite is true. As a result, people disagree about what constitutes a practical, safe, and comprehensive bicycle system in developed urban areas. Thus, removing impediments to bicycling and walking involves consideration of both the problem itself and the public's perception of what the problem really is. Since the perception of the problem can be greater than the problem itself, an integrated combination of information, training, enforcement, and physical improvements is needed.

Successful programs are based on satisfying the basic needs of bicyclists: reasonable travel time and distance, directness of travel, safe facilities. Improvements that provide discrete space for bicycling, out of the direct flow of high speed or high volume traffic, are associated with higher levels of bicycle ridership. This seems to be particularly true in communities that are already pre-disposed to bicycling, such as college towns. The Davis-Anderson Road and Madison studies empirically support this conclusion. On a case-by-case basis, appropriate facility improvements can be helpful in relieving a major impediment to broader use of the bicycle. Forty-five percent of the increased ridership on Anderson Road was traffic shifted from adjacent roads.[204]

Bicycle training programs may be helpful in reducing accidents and promoting more frequent bicycling, indicating the value of training programs, a facet of bicycling often neglected in favor of physical improvements. Training, especially on the road, may increase safety, which potential new riders perceive as one of the primary impediments to bicycling. Unfortunately, public participation in training programs is very limited. However, training formats that require less time commitment and that are more relevant to practical needs may have a chance of attracting more participants.

Removing Impediments to Bicycling

The key facility improvement to increase bicycling is identification and attainment of a comprehensive network of convenient, regularly-spaced, on- and off-street facilities providing extensive coverage. This can be realized through the adoption of a firm policy prompting new or reconstructed streets to be configured to include wide curb lanes or safely designed bicycle lanes, and through the construction of completely separated bicycle paths to serve major destinations, where feasible. Other necessities include bicycle parking that is secure and perceived as such, safe and direct bicycle linkages with public transit, good signage and route information, and bicycle-oriented roadway maintenance. Year-round bicycle encouragement and education programs can support facility improvements and target prospective markets to receive accurate information on real versus perceived issues, and the merits of bicycling compared with driving.

Bicycle Facility Improvements

The potential market for commuter bicycling could be up to half of the population of the country. Over 50 percent of the population lives within 5 miles of work, which is a reasonable distance for commuter bicycling. There is also a large potential market for the use of bicycles for daytime personal business trips. Community bicycle facilities should be assessed and an implementation strategy outlined. This will provide a basis to prioritize projects. The following are general principles to consider in developing the strategic plan:

[204]Lott, "Evaluation," 42.

- Fill connection gaps and link existing bicycle facilities.

  - Provide safer crossings and intersections.
  - Widen narrow sections of on-street bicycle routes.
  - Add strategic bridges and underpasses.

- Make linkages across natural and man-made barriers to connect major destinations as directly as possible.

- Provide the most direct routes between activity centers.

- Provide bicycle facility alignments that shorten travel time compared to automobile routes.

- Continually look for ways to optimize the bicycle system.

- Remove debris and provide smooth surfaces through regular maintenance.

- Ensure that bicycle-friendly roads are frequent and direct to maximize the number of people within easy bicycling distance of jobs, shopping, school, recreation, and entertainment.

Only a few types of facility enhancements have actually been tested to measure their success in increasing ridership. From this research, a reasonable correlation has been found between increased usage and classes of facilities that allow bicyclists a space to ride out of the constant flow of fast or heavy automobile traffic. This finding provides a broad general list of acceptable options from which to choose. These types of facilities include:

- Completely separated off-street bicycle paths;
- Safe, well-designed on-street bicycle lanes;
- Wide curb lanes and adequate roadway shoulders;
- Low-speed/low-volume streets; and
- Bicycle connections that fill a gap in the system between major destinations.

Bicycle Facility Recommendations

Travel Time/Distance Advantage

Opportunities should be identified to construct bicycle facilities so that bicycling distance is equal to or less than that for the automobile.

Adequate Width for Bicycles

Cities should adopt a policy that requires traffic lanes adjacent to the curb to be designed to provide adequate width for motor vehicles and bicycles to pass abreast of each other. Off-street bicycle facilities require adequate pavement width to accommodate the variety of users or a parallel path to separate high and low speed users and to discourage very high speeds. Proper signage, education, and enforcement are important in persuading bicyclists to "share the path."

Roads to Accommodate Bicycling

Adopt street design standards that require all new and reconstructed nonhigh-speed arterial roadways be built to accommodate bicycles as an integral part of vehicular traffic.

Striped Bicycle Lanes

Painting a white line along bicycle lanes can help to legitimize the presence of bicyclists on the road to motorists, and may encourage additional facility use. Exercise care in designing bicycle lane configurations so that they do not encourage unsafe riding near intersections. Use lane plans that encourage bicyclists to be seen and their intentions understood by other vehicles at intersections.

Off-Street Bicycle Paths

Opportunities for new or extended bicycle paths should be pursued because of their attractiveness to recreational and inexperienced riders. Off-street bicycle paths are regarded by inexperienced bicyclists as the most preferred facilities because they are separate from motor vehicle traffic. Paths are also well-used by experienced riders, especially if they are located for convenient commuting.

Bicycle Facility Information

An impediment to bicycling is poor knowledge of the community's bicycle system, and how to effectively bicycle. Part of an effective bicycle facilities program is the provision of a readily available, easy to understand, and convenient bicycle information system. Signage should give users a clear understanding the layout of bicycle facilities, where they go, and how they connect.

'Direction of Travel' Markings in Bicycle Lanes and Wide Curb Lanes

The provision of properly marked bicycle lanes has been demonstrated to decrease wrong-way riding.[205]

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[205]D. Smith, "Planning and Design," 7.

Adequate Parking

Meeting the expressed need for "adequate, safe bicycle parking" includes several conditions that must be met simultaneously:

- an abundant supply of bicycle parking
- sturdy parking fixtures, capable of securing bicycle frame and wheels properly
- a perception that parking is relatively safe
- proper and secure use of parking facilities
- a means to inform bicyclists of parking locations

Bicycling and Transit

Proper linking of bicycles with transit can be effective in increasing the use of both modes. This can include good bicycle access to transit facilities, secure and abundant on-site parking, and the appropriate means to transport bicycles on transit.

Bicycle-Activated Traffic Signals

Encourage safe and responsible bicycling through provisions to allow riders to activate the green phase of traffic signals. Without this feature, bicyclists tend to disregard traffic signals because they regard the system as being unresponsive to their needs.

Stop Signs

Bicyclists want to travel on streets that provide a minimum of delays and don't cause unnecessary loss of riding momentum. If practical, choose streets for designated bicycle facilities that have a minimum number of stop signs along the route, or remove unnecessary signs.

Evaluation of Construction Designs

Prior to the construction, check road designs for accommodation of bicyclists. Examine and modify designs so that there are no built-in hazards such as diagonal railroad crossings abrupt grade changes, and other fixed hazards.

Sight Distance

Design bicycle facilities to intersect with other traffic lanes, allowing safe sight distance. Clutter and parked vehicles should not block views through intersections.

Signal Timing for Bicycles

Adjust traffic signals to accommodate the special needs of bicyclists. Provide an "all red" phase after green and yellow in the traffic light sequence to give slower moving bicyclists time to clear the intersection.

Avoid Sidewalk Bicycle Facilities

Bicyclists riding on typical city sidewalks put themselves in a hazardous position. Even though they are somewhat protected from motor vehicles along the length of the block, they are forced to cross traffic at every street and intersection.

Avoid Streetside Two-Way Bicycle Paths

Avoid locating paths for two-way bicycle operation adjacent to city streets. This includes on-street bicycle lanes, sidewalks used as bicycle facilities, or off-street paths closely paralleling streets. Motorists are not expecting fast moving bicycles traveling against traffic on the "wrong" side of the road.

Avoid Bicycle Facilities Between Parking Lanes and the Curb

For safety reasons, bicycle lanes should not be located between parked cars and the street curb.

Expressway Exit Ramps

Where bicycle facilities cross exit ramps, replace "free" right turn or yield provisions for automobiles with stop signs and warning signage.

Avoid Bicycle Facilities Routed Around Intersections

Avoid designs configured to route bicyclists around, rather than through intersections. This is dangerous unless separate traffic lights are provided for the bicycle path.

Railroad Crossings

Design bicycle facilities that cross railroad tracks as close to 90 degrees as possible to reduce falling hazards. Install filler flanges at crossings to reduce gap between pavement and tracks.

Drainage Grates

Replace or modify street drainage grates so they are safe for bicycles. Vane-style grate designs are both safe for bicycles and hydrostatically efficient.

Bikeway Lighting

Don't assume standard street lighting will properly illuminate bicycle facilities. Often this is not adequate, especially for security reasons on off-street paths. Bicycle facility lighting is not to be considered as a substitute for safety lights mounted on bicycles.

Suitable Bicycles

Encourage bicycle commuters to purchase bicycles and equipment suitable for the difficult conditions found in most urban areas. Mountain bicycles for example may be safer on rough or poorly maintained roads, because riders don't have to swerve around to avoid potholes and other minor hazards.

Maintenance

In many cities, the chronic presence of gravel, sand, glass, snow, ice, and uneven pavement on bicycle facilities has been cited as a notable impediment to bicycling for novice riders. It is critical for the sake of safety and increased ridership that pavements be regularly swept, plowed, patched, and resurfaced to present a smooth, clean surface.

Bicycle Training and Promotion

The conclusion that just building improved facilities is enough to maximize bicycle use is not confirmed by research. Education, encouragement, and enforcement programs centered around convenient facilities can help to increase their usage and promote safety. These programs offer particular advantages to prospective bicyclists, if they provide accurate information to correct misconceptions about bicycle safety, parking, laws, and facilities. The primary issues of bicycle promotion and training are:

- limited monies for comprehensive training and promotional campaigns
- lack of regular, timely promotion and training
- unfamiliarity with routes, methods, and logistics of bicycling to work
- the discretionary inclusion of bicycle needs in development plans
- uncoordinated distribution of materials
- isolated efforts that cannot benefit from lessons learned elsewhere
- the inability of training programs to attract political and financial support
- lack of a clear and consistent message about bicycling
- no single organization that is the accepted "voice" for bicyclists

Appropriate and thoughtful traffic law enforcement is an indispensable part of bicycling, because it reinforces the safe principles learned through practical training and education. Knowledgeable bicyclists can appreciate the value of reasonable enforcement in support of the

mutual goals of the transportation community for safer, less congested traffic operations. They realize that illegal, careless, and bullying bicyclist behavior by a few riders hurts everyone. On the other hand, lawmakers and police officials must be taught to take bicycling seriously and to respect the rights of bicyclists to use the road as legitimate operators of vehicles. This requires that the bicycle community actively involve top public safety officials and legislators in the development of bicycle programs and policies.

Voluntary-Involuntary Actions, Incentives versus Disincentives

The incentive approach to induce shifts to bicycling and walking seems to be more feasible than disincentives. Incentives are more easily accepted by the individual, but appear to be less effective than disincentives. However, disincentives are difficult to focus specifically on the goal of increasing bicycle use and are usually politically hard to implement unless there is an urgent public health or safety problem. Disincentives, such as parking restrictions, may also be an economic disaster for subareas such as downtown. For institutions, corporations, and employers, mandatory requirements seem to be necessary to maximize participation.

Removing Impediments to Walking

A realistic national policy is needed to more effectively tap the large market of people living within reasonable walking distance of their destination. Physical improvements that are more convenient, safe and inviting to pedestrians can be helpful in encouraging greater reliance on walking for commuter and utility trips. Some of the strategies identified to remove impediments to walking are:

- promote the development of compact, mixed land use commercial and residential centers to make it easier and more practical to walk;
- target promotional programs to people living within 20-25 minute walk from work centers;
- provide continuous, adequately sized pedestrian sidewalks on all streets;
- provide safe pedestrian crossings at all intersections;
- reduce the perception of a long distance by making the walking trip more interesting and pleasant;
- maintain some vehicle traffic on pedestrian facilities;
- clearly delineate pedestrian and vehicle area and provide prominent pedestrian signalization or signage;

- design residential areas so they have a safe, convenient pedestrian connections with shopping and service; and

- initiate strong policies to promote development of housing next to activity centers.

Pedestrian Facility Improvements

Walking facilities completely separated from major vehicular corridors are generally safer than sidewalks in terms of avoiding automobile/pedestrian conflict. However, in developed areas, allocating the space for separated facilities is difficult. Where space permits, separated facilities will be most useful as transportation corridors if routes connect destinations, such as schools, residential areas, stores, and employment centers.

Crosswalks and pedestrian signals encourage use of facilities although their actual effect on pedestrian safety is not proven. Pedestrian islands or refuges halfway across the street, "bulb-outs" at corners, and other pedestrian safety measures can shorten the intersection crossings. A pedestrian signal reactivator in a midstreet refuge can be useful. Midblock crossings can shorten the distance between crosswalks in areas of long arterial roads with high speeds, limited sight distances, and few intersections. Extra caution is necessary to ensure that drivers are aware of the possible presence of pedestrians where they are not expected.

Pedestrian overpasses or underpasses may be successful in areas where land uses or grades are favorable so a direct connection can be made without requiring pedestrians to walk up and down a lot to use them. They are also more popular in areas where there are disabled or older adult populations. Overpasses and underpasses are expensive, useless fixtures if they cannot be designed and located where they will be well-used. Provisions to force people to use them by eliminating routes other than through the overpass or underpass (by fences or barriers) may make people avoid the area altogether.

Examples of Improvements to Increase Walking

- Configure destination activity centers to be dense, compact, and pedestrian-friendly with a good land use mix and supplementary transit (shuttles, fare-free transit, etc.).

- Target promotional programs to people living within 20-25 minute walk from work centers.

- Put continuous, adequately sized pedestrian sidewalks on all streets or as frequently as possible.

- Develop safe pedestrian crossings at all intersections.

- Integrate pedestrian facilities and development to shorten perceived distance and add interest.

- Identify ways to reduce the perception of distance on pedestrian routes.
- Maintain (some) vehicle traffic on pedestrian facilities.
- Clearly delineate pedestrian and vehicle area and provide prominent pedestrian signalization or signage.
- Design residential areas so they have a safe, convenient pedestrian connections with shopping and services.
- Initiate strong policies to promote development of housing next to activity centers.

Distance-Related Opportunities to Increase Bicycling and Walking

Experience with facilities in many cities shows that actual commute distance along safe, convenient bicycle and pedestrian facilities often is less direct than driving distance by car. To more effectively tap the huge market of people living within practical bicycling and walking distance, realistic local and regional policies should ensure that walking and bicycle facilities provide the most direct, convenient connections between homes and work sites for people who live within suitable distance.

Tailored, Coordinated Strategies

Strategies to increase bicycling and walking should be tailored to the specific needs, strengths, and weaknesses of each community. The effectiveness of any actions identified here to remove impediments to bicycling and walking are dependent upon their appropriateness to the specific area for which they are proposed. Strategies that are effective under one set of local conditions can be ineffective under other conditions.

In considering bicycle program and facility strategies, an objective look at local characteristics including goals for bicycling and walking, plus physical and institutional strengths and weaknesses of the municipality can help with the selection of program priorities.

Evaluation Needs

An effectiveness evaluation should be integral for all major physical and programmatic improvements undertaken until a basic understanding of what works and why is determined. Since funds are limited for pedestrian and bicycle projects, spending them wisely should include choosing the most cost-effective programs and projects. When this is done, the new programs can increase usage, and in turn give walking and bicycling a greater priority for municipal funds. The Federal Government could play a leadership role, by requiring evaluations for projects involving Federal funds.

Governmental Policies and Funding to Increase Bicycling and Walking

A key component of a national initiative on improved bicycle and pedestrian programs should be formal recommendations of program policies and design standards for facilities. These standards should ensure that adequate width is included in the recommended cross-section of any street construction or reconstruction.

Significant improvements to the pedestrian and bicycle systems in this country are possible through a combination of policies designed to tap both public and private development and funding opportunities. Municipalities could adopt development policies to provide bicycle and pedestrian improvements. These could be an integral part of existing ordinances to share the costs of infrastructure improvements necessitated by new private development. A percentage of State, county, and city highway funds could be dedicated for the development of bicycle and pedestrian facilities. The new Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 provides a major opportunity for local governments, in coordination with their State and Metropolitan Planning officials, to fund strategic components of comprehensive bicycle and pedestrian programs. The ISTEA makes accommodations for State Transportation Agencies to obligate funds for the construction of pedestrian walkways and bicycle transportation facilities that have been located and designed in accordance with a comprehensive plan developed by the State and the Metropolitan Planning Organizations.[206]

The U.S. Department of Transportation has a leadership role in striving for a balanced, complementary transportation system, including a more significant and appropriate role for the bicycle and pedestrian modes.

[206]George Osborne, "Accommodations of Pedestrians and Bicyclists in the Federal Aid Highway Program," *Proceedings: 12th International Pedestrian Conference,* (Boulder, CO: October 2-5, 1991), 126-127.

APPENDIX
A Synopsis of Stated Impediments to Bicycling and Walking

STATED IMPEDIMENTS TO WALKING

Specific issues

- Too far to walk
- Takes too long/don't have enough time
- No direct route
- No sidewalks
- Too many crossings of traffic
- Unsafe crossings
  - -too much traffic
  - -traffic doesn't yield
  - -no pedestrian signal phase
  - -no pedestrian crossing
- Bicycles dominate paths
- Fear of assault
- Fear of falling down (facility related)
  - -route too uneven, slippery
- Too strenuous
- Need car for work
  - -to carry materials
  - -for distant appointments/travel
- Need car for personal business
  - -get children to day-care
  - -shopping
  - -daytime travel
- Poor or inadequate connections to transit
  - -no bike-on-bus facilities
  - -transit connections too far
- Weather problems (too hot, cold, humid, rainy, snowy)
- Unpleasant trip
  - -surface too rough
  - -too much traffic
  - -too noisy
  - -bad surroundings
  - -not interesting/unattractive
- Don't want to walk outside in polluted air
- Health problems prohibit it

General issues

- Seems easier just to drive
- Seems inconvenient/too much hassle
- Haven't gotten around to it
- Haven't thought of it (lately)
- Don't want to
- Too lazy

STATED IMPEDIMENTS TO BICYCLING

Specific issues

- Too far to ride
- Takes too long/don't have enough time
- No direct route
- Too many stops—loss of momentum
- Don't know which routes to take
- Concern about accident with car (safety)
  - -busy intersections
  - -space for bicycles too narrow
  - -too much traffic
  - -traffic going too fast
  - -opening of parked car doors
  - -inconsiderate motorists
- General fear of riding in traffic
- Fear of falling down: safety (facility related)
  - -route too narrow, steep, uneven, curvy, slippery (gravel/ice/etc.)
- Fear of falling down: safety (age related)
- Too strenuous
- Personal cleanliness/dressing for work
  - -get too sweaty
  - -no shower at work/showering hassles
  - -get dirty/buggy
  - -clothing logistics
- Too much hassle getting bicycle ready, maintaining it and repairing tires
- No good place to park bicycle
- Don't want bicycle to be stolen
- Need car for work
  - -to carry materials
  - -for appointments/travel
- Need car for personal business
  - -get children to day-care
  - -shopping
  - -daytime travel
- Poor or inadequate connections to transit
  - -no good place to store bicycle on transit
  - -no bike-on-bus facilities
  - -transit connections not easily accessible by bicycle
- Weather problems (too hot, cold, humid, rainy, snowy)
- Unpleasant trip
  - -too much traffic
  - -too noisy
  - -bad surroundings
- Fear of assault
- Don't want to exercise outside in polluted air
- Health problems prohibit it
- Status/image of bicyclist is beneath me
- Bicycling clothes/ helmet look strange

General issues

- Seems easier to drive
- Seems inconvenient/too much hassle
- Don't know how to go about it
- Haven't gotten around to it
- Haven't thought of it (lately)
- Don't want to
- Too lazy

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